BANK FOR INTERNATIONAL SETTLEMENTS

BIS Papers
No 19

Monetary policy in a changing environment

Monetary and Economic Department

September 2003

Papers in this volume were prepared for the Autumn Central Bank Economists' Meeting held at the Bank for International Settlements in October 2002. The views expressed are those of the authors and do not necessarily reflect the views of the BIS or the central banks represented at the meeting. Individual papers (or excerpts thereof) may be reproduced or translated with the authorisation of the authors concerned.

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ISSN 1609-0381 (print)
ISBN 92-9131-649-0 (print)

ISSN 1682-7651 (online)
ISBN 92-9197-649-0 (online)

Foreword

The papers in this volume were presented and discussed at the Autumn Central Bank Economists' Meeting held at the BIS in Basel on 14-15 October 2002. The purpose of this meeting was to discuss challenges that central banks have faced in the current environment characterised by low and comparatively stable inflation, structural supply side improvements, the apparently high credibility of central banks' anti-inflation commitment and liberalised financial markets. These challenges have included learning how to deal with unforeseen potential increases in productivity growth, major expansions in credit and asset prices, and, in some cases, even financial instability and deflation. Another challenge has been the recent sudden and widespread slowdown in economic activity that, uncharacteristically, was not triggered by a tightening of monetary policy designed to quell inflationary pressures but rather by the unwinding of an investment boom. The meeting explored potential changes in the dynamics of the business cycle, in particular the ability to identify inflationary and deflationary pressures, and the implications for monetary policy, including the challenges posed by the zero lower bound on interest rates.

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Contents

A tale of two perspectives: old or new challenges for monetary policy?

Claudio Borio, William English and Andrew Filardo

Introduction[1]

Over the past decade much of the world has entered a phase of low and comparatively stable inflation. No doubt several factors have contributed to this development. Even so, it is generally agreed that central banks' strong anti-inflation commitment and increased credibility have played a critical role. The turning point is typically identified with the late 1970s or early 1980s. It was then that, underpinned by the necessary political and intellectual consensus, monetary authorities intensified their efforts to bring inflation under control.

This drawn-out battle has yielded great benefits. Low and stable inflation has laid the basis for better long-run economic performance. High and variable inflation had been a key factor inducing misallocation of resources. With economies less inflation-prone, central banks have not had to abort economic expansions prematurely in order to fight rapidly emerging inflationary pressures. And with economies seemingly less vulnerable to second-round price effects following unfavourable supply side shocks, central banks have been under less pressure to tighten aggressively to forestall inflationary developments, thereby avoiding the concomitant costs for economic activity.

At the same time, the 1990s and the initial years of the new century have not been free of challenges for central banks. Paradoxically, one challenge has been learning to deal with potential supply side improvements and the uncertainty surrounding them. Financial and real side deregulation, both within and across national borders, and, more recently, the introduction of new IT technologies are obvious examples. A second, and perhaps not unrelated, challenge has been how to factor into the monetary policy framework more virulent boom and bust cycles in asset prices, typically occurring alongside similar fluctuations in credit. Financial and banking crises have sometimes accompanied such developments. In the wake of one such episode, Japan has experienced deflation and policymakers there have struggled to reflate the economy, with policy rates reaching the zero lower bound. More recently, central banks have had to contend with an unexpected and in some cases sharp slowdown in economic activity - a slowdown that, in addition, appeared to be unusually synchronised across countries. Contrary to the prevailing experience in the postwar period, the slowdown was not triggered by a tightening of policy designed to quell rising inflationary pressures but by the unwinding of an investment boom, associated with a boom-and-bust movement in equity prices.

This paper seeks to draw some possible lessons from this set of experiences with a view to identifying the challenges that central banks might face going forward. In order to highlight the genuine uncertainty that surrounds the lessons to be drawn, the paper examines recent experience through two alternative, intentionally polarised, lenses. While agreeing in several respects, the corresponding perspectives lead to somewhat different conclusions in terms of the balance of risks faced by central banks in the current environment and the appropriate policy responses.

The first view, call it the "continuity" view, sees the current economic environment as a natural extension of that which prevailed during much of the previous inflationary period. Accordingly, the lessons drawn from that period apply with little, if any, modification to present conditions. The dynamics of the economic system have not significantly changed. The risks faced by central banks

[1] This is a revised version of the background paper for the Autumn 2002 Central Bank Economists' Meeting on "Monetary policy in a changing environment" which took place at the BIS on 14-16 October 2002. We would like to thank Jeff Amato, Palle Andersen, Joe Bisignano, Gabriele Galati, Charles Goodhart, David Laidler, Philip Lowe, Hyun Shin and Bill White for helpful comments, Henri Bernard and Les Skoczylas for their excellent research assistance and Janet Plancherel for impeccable and tireless help in putting the whole document together. Any remaining errors are our sole responsibility. The views expressed are those of the authors and do not necessarily reflect those of the BIS.

and the set of strategic and tactical policy benchmarks developed during the fight against inflation are still reliable yardsticks. This view tends to regard some of the new challenges faced during the more recent period, and the corresponding unexpected economic developments, as essentially the result of unusual "shocks". Accordingly, there is no particular reason to expect these shocks to recur. In other words, the economic environment has not fundamentally changed.

The alternative view, call it the "new-environment" view, sees the new challenges faced as inherent in the current landscape, characterised by liberalised financial markets, low inflation - underpinned by apparently high credibility of central banks' anti-inflation commitment - and uncertainty about the degree of structural supply side improvements. The challenges, that is, are in part the footprints of the gradual emergence of a new environment. A key characteristic of this new environment is that during unsustainable booms overt inflationary pressures may take longer to emerge. This can make it harder for monetary policy to be sufficiently pre-emptive. Monetary policy may thus unwittingly accommodate the build-up of financial imbalances and associated distortions in the real economy, notably excessive capital accumulation. Moreover, with inflation initially at a low level, the risk that the process may unwind in a disruptive manner could result in a subtle shift in the balance of risks, away from higher inflation and towards economic weakness and, possibly, even deflation. This view highlights the role of financial imbalances in the dynamics of the economy and suggests that central banks may need to respond in a more purposeful way to the imbalances as they build up.

The plan of the rest of the paper is as follows. Section I lays out some key facts about the unfolding economic environment since the late 1980s. Section II reviews the challenges faced by central banks during this period. Section III lays out the continuity and new-environment views, briefly interpreting economic developments through these two perspectives. Section IV explores in more detail the implications of the two views for the way in which financial imbalances should be factored into policy, as this is perhaps the key feature distinguishing between the two perspectives. Section V draws some broader implications of the new-environment view for the policy framework. The Conclusion highlights the main points of the paper.

Before plunging into the subject matter, it may be worth stressing a number of points regarding the precise objective, approach and scope of the paper.

First, the objective of the paper is *not* to provide a thorough characterisation, assessment and empirical test of the two views. Rather, it is simply to show that recent experience could *reasonably* be viewed through two quite different perspectives, or indeed combinations thereof, and that the view taken can potentially have significant implications for monetary policy. By so doing, the paper hopes to encourage further analytical and empirical work on the issues raised by the comparison of the two paradigms. Indeed, we recognise that, at least for some aspects of the new-environment view, it may simply be too early to carry out rigorous statistical tests that could command a sufficient degree of confidence. Thus, the paper does not really provide new empirical evidence, but draws on existing work and organises facts in a way intended to highlight the perspectives under consideration. In the process, however, it also points to a number of informed hypotheses that could be researched further.

Second, the polarisation of the two perspectives is simply a rhetorical device to highlight those aspects of the paradigms that deserve further attention and those convictions that may be taken too easily for granted. Focusing on the two ends of a spectrum can help us better understand and gain awareness of what we know and do not know. In practice, views within the academic and policy communities inevitably combine elements of the two perspectives to varying degrees. For much the same reasons, as shown by some recent policy statements, one could adopt some of the refinements to policy frameworks suggested by the new-environment view without accepting its most controversial elements. That view simply serves to add further support to the refinements.

Finally, the new-environment view also has important implications for prudential policies and their relationship to monetary policy. After all, the risk of financial distress with macroeconomic consequences plays a prominent role in the story. Except tangentially, however, this paper discusses only monetary policy. Other work has already extensively examined the prudential dimension.[2]

[2] See, in particular, Borio et al (2001) and Borio (2003).

I. Changes in the macroeconomic environment

Over the past two decades, the economic environment has been changing in fundamental ways. Inflation rates have generally fallen and subsequently inflation has remained low and more stable in much of the world. In many countries, the virulence of the business cycle has receded, with longer expansions and relatively brief and shallow recessions. However, at the same time asset price, credit and investment booms and busts have become a more important source of macroeconomic instability, in both developing and developed countries. In particular, financial crises with macroeconomic costs have become more frequent and severe.

These changes have taken place alongside a number of structural shifts, underpinned by modifications in institutions. One prominent shift has been central banks' stronger focus on price stability. A second has been greater fiscal discipline and reforms aimed at improving the growth potential of the economy. A third, fundamental one has been financial market liberalisation and the related deepening of the globalisation of finance and economic activity more generally.

Salient economic developments

Lower and more stable inflation

A striking feature of the economic environment over the last 20 years or so has been the dramatic change in the inflation picture. Since at least the early 1990s, much of the world appears to have entered a period of relatively low and more stable inflation. This has naturally gone hand in hand with a decline in nominal interest rates.

The disinflation process has been a global phenomenon (Table I.1 and Graph I.1). Admittedly, some cross-country differences are apparent. In the industrialised countries, inflation rates have declined fairly steadily since 1980, and are now extremely low compared to the experience of the 1970s. In

Table I.1

Inflation and deflation

Annual rates, in percentages

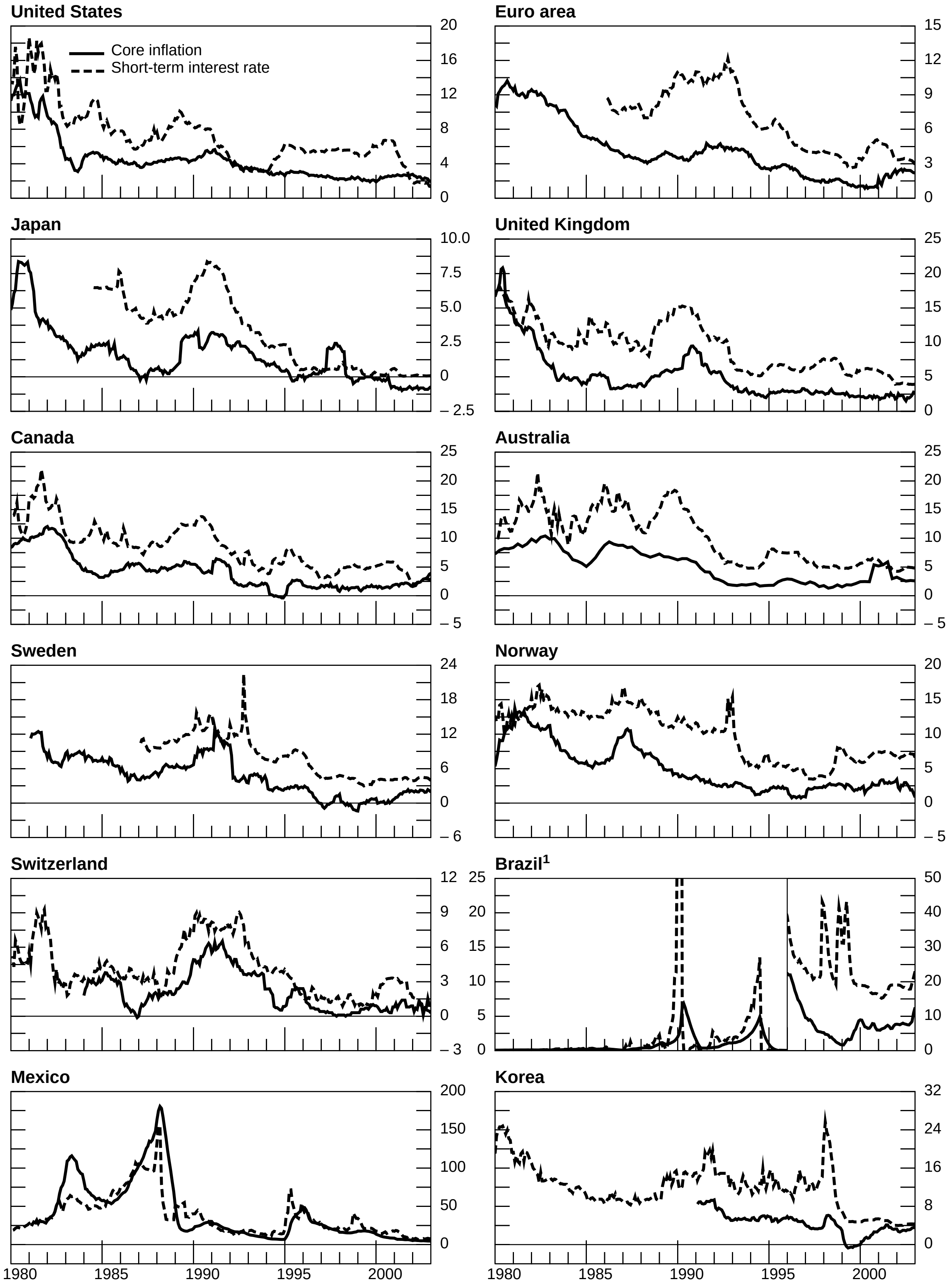
	1980-84	1985-89	1990-94	1995-99	2000-01
Large industrialised[1]					
Headline	7.8	3.3	3.5	1.9	2.2
Core	7.5	3.7	3.7	2.0	1.7
Wholesale	6.9	1.4	1.5	0.9	2.4
Services	5.8	3.9	4.6	2.4	2.6
Other industrialised[2]					
Headline	8.5	6.0	3.8	1.5	3.0
Core	7.6	6.1	4.1	1.6	2.6
Wholesale	8.4	4.6	2.0	0.9	3.5
Services	8.8	7.2	3.9	2.2	3.5
East Asian[3]					
Headline	10.9	4.7	6.8	11.1	4.4
Core				4.2	1.9
Wholesale	12.1	4.3	4.1	13.9	6.5
Services				4.7	8.3
Latin American[4]					
Headline	95.5	303.5	1,180.5	31.2	7.0
Core		84.0	17.3	24.6	8.6
Wholesale	106.0	306.9	1,202.9	32.5	10.5
Services		92.1	23.5	9.9	4.8

[1] United States, euro area, Japan, United Kingdom and Canada. [2] Australia, Sweden, Norway and Switzerland. [3] Thailand, Malaysia, Indonesia and Korea. [4] Brazil and Mexico.

Graph I.1

Core inflation and short-term interest rates

In percentages



[1] Prior to 1996, left-hand scale; in thousand per cent.

Source: National data.

developing countries, the progress has been somewhat more difficult and uneven and has generally lagged that in the industrialised world. While some regions, such as Asia, have a history of comparatively low inflation, others, notably Latin America, had to contend with very high inflation rates in the 1970s and 1980s. Moreover, even more recently, bursts of inflation have not been entirely absent, typically in the wake of collapses in exchange rate regimes. But by the end of the period, inflation rates were generally quite low, rarely exceeding 10% even in developing economies, and the cross-country dispersion had fallen dramatically.

In fact, the disinflation process has been so strong that a number of countries are actually experiencing declines in the overall price level. In Asia, prices have been declining for some time in Japan, China and Hong Kong. Inflation rates are barely positive in other parts of East Asia. Elsewhere in the industrial world, while the overall price level has been rising, it has not been uncommon for sectoral price indices to be falling, especially in manufacturing (Table I.2).

Table I.2

Deflation frequency[1]

As a percentage of country-years

	1960-69	1970-79	1980-89	1990-99	1999-2001
Headline inflation	4.1[2]	0.7[3]	1.0	3.3	8.3
Core inflation	0.0[4]	0.0[5]	0.3[6]	4.4	10.4
Services less housing inflation	0.0[7]	1.1[8]	1.3[9]	5.1[10]	13.5
Wholesale inflation	12.4[11]	5.3[12]	12.3[13]	20.0	23.9

Note: Simple average of the following countries: Australia, Canada, Brazil, euro area, Indonesia, Japan, Korea, Malaysia, Mexico, Norway, Sweden, Switzerland, Thailand, United Kingdom and United States.

[1] Defined as a percentage of negative changes in all annual changes of the price index. [2] For the euro area, 1966-69; for Thailand and Korea, 1965-69; for Indonesia, 1968-69. [3] For Brazil, 1975-79. [4] Includes only Canada, Switzerland and the United States. [5] For the euro area, 1976-79; for the United Kingdom, 1975-79; for Australia, 1976-79; for Norway, 1974-79; Sweden, Malaysia, Indonesia, Thailand, Korea, Mexico and Brazil are not included. [6] Thailand and Korea are not included. [7] For Canada, 1962-69; for Norway 1969 only; for Japan, 1961-69; the rest of the countries are not included. [8] Includes only Canada, Norway, Japan, Australia (for 1975-79) and Switzerland (for 1971-79). [9] For the United States, 1983-89; for the United Kingdom, 1988-89; for Mexico, 1982-89; the euro area, Indonesia, Korea and Brazil are not included. [10] For the euro area and Korea, 1991-99; for Indonesia, 1997-99; for Brazil, 1992-99. [11] Malaysia, Indonesia and the euro area are not included; for Brazil, 1961-69. [12] Malaysia and the euro area are not included; for Indonesia, 1970-79. [13] For Malaysia, 1984-89.

Lower inflation has also meant more stable inflation in at least two respects. First, the volatility of the inflation rate has declined. This has confirmed the well known positive relationship between the level and variance (or standard deviation) of inflation. In addition, and more subtly, there is some evidence that inflation has become "stickier" or, in technical terms, changes in inflation have become less persistent. Specifically, the univariate dynamics of inflation in the United States, Europe and Japan appear to be very different before and after 1985 (Table I.3). Before that year, inflation appeared to have a unit root in all three regions, implying that an increase in inflation in a given year led to a permanent rise. This lack of mean reversion indicates that shocks to inflation tended to persist indefinitely over time. By contrast, the data suggest that inflation was mean reverting after 1985, with increases in inflation being reversed over subsequent quarters. It is as if the inflation rate had become better anchored than in the past (see below).[3]

[3] The view that expectations are now better anchored, notably around inflation objectives, is commonly found in central bank reports and public statements. The view is typically based on survey evidence or on the information derived from yield curves. See eg Vickers (1999a) and Perrier and Amano (2000).

The decline in inflation has naturally gone hand in hand with a similar decline in interest rates. In many countries, both short- and long-term rates are rather close to, or even below, postwar lows. Indeed, in Japan, policy rates have been at the zero lower bound, except for a short period, since early 1999.

Table I.3

Changing univariate inflation dynamics

	ADF test statistic[1]		**ADF test statistic**[1]
United States		Japan	
1960:4 to 1970:4	–2.5	1960:4 to 1970:4	**–4.5**
1971:1 to 1984:4	–2.0	1971:1 to 1984:4	–3.1
1985:1 to 2001:4	**–3.9**	1985:1 to 2001:4	**–3.8**
Germany		France	
1961:1 to 1970:4	**–5.1**	1963:4 to 1970:4	**–3.5**
1971:1 to 1991:4	–2.5	1971:1 to 1984:4	–2.4
1992:1 to 2001:4	**–4.7**	1985:1 to 2001:4	**–4.3**
United Kingdom		Italy	
1960:4 to 1970:4	**–5.9**		
1971:1 to 1984:4	–2.7	1971:1 to 1984:4	–1.9
1985:1 to 2001:4	–3.4	1985:1 to 2001:4	–3.2
1993:1 to 2001:4	**–4.3**		
Canada		G7	
1960:4 to 1970:4	–3.4		
1971:1 to 1984:4	–2.1	1971:1 to 1984:4	–2.3
1985:1 to 2001:4	**–4.8**	1985:1 to 2001:4	–2.4
		1993:1 to 2000:4	**–3.5**

[1] The bold font indicates rejection of the null hypothesis of a unit root at the 5% significance level. The critical value for the test is based on the distribution of the asymptotic augmented Dickey-Fuller (ADF) test statistic (MacKinnon (1991)); in these models the critical value is –3.5. (At the 10% level, the critical value for the test is roughly –3.2.) A constant, a time trend and one lag of the change in the inflation rate are included in each ADF regression, $\Delta\pi_t = \mu A + \gamma\pi_{t-1} + \beta t + \alpha\Delta\pi_{t-1} + \varepsilon_t$.

Moderation of business cycles

Lower and more stable inflation has so far gone hand in hand with lower output volatility in large parts of the world. There is evidence that, measured either by the size of output gaps or by the variability in growth rates, output fluctuations have tended to moderate since at least the mid-1980s in most industrialised countries, even in comparison with the 1960s.[4] Across many countries, the duration of business and growth cycles has lengthened somewhat. And the average depth and height of troughs and peaks respectively have been lower than in the past (Table I.4 and Graph I.2). This broad picture of comparative stability is confirmed by a look at aggregate (PPP-weighted) G7 GDP growth (Graph I.3). If the recent sharp global slowdown is excluded (see below), output growth has been considerably less volatile since the mid-1980s.

[4] For corroborating cross-country evidence, see Dalsgaard et al (2002) and Blanchard and Simon (2001).

Table I.4

Salient features of business cycles

	Average duration (months)		Average height of GDP gap (%)		Average depth of GDP gap (%)		Standard deviation of GDP gap	
	Pre-1983	**Post-1982**	**Pre-1983**	**Post-1982**	**Pre-1983**	**Post-1982**	**Pre-1983**	**Post-1982**
United States	16	21	2.98	1.74	–3.24	–1.38	2.02	1.25
Euro area			2.30	2.00	–3.08	–1.44	1.61	1.02
Japan	18	19	3.08	2.39	–2.13	–1.91	1.88	1.21
United Kingdom	20	26	3.33	1.91	–2.41	–1.74	1.68	1.23
Canada	14	22	2.50	2.08	–2.94	–1.67	1.33	1.57
Australia	18	33	3.00	1.95	–3.58	–1.51	1.66	1.40
Sweden	33	18	2.69	1.79	–2.47	–1.94	1.47	1.39
Norway			3.81	3.75	–4.50	–2.94	1.85	1.63
Switzerland	41	27	4.75	1.79	–4.18	–1.56	2.71	1.11
Brazil				3.94		–3.86		2.75
Mexico		18		4.05		–4.34		2.35
Korea	12	19	5.88	4.33	–7.23	–4.12	3.31	2.46

Note: The average duration of each country's growth rate cycle is indicated. An alternative definition of the cycle is based on expansions and contractions. Because of the strong growth in nearly all these countries in the pre-1980 period, such cross-country comparisons are not meaningful. However, using the NBER business cycle dates for the United States, the average duration of business cycle expansions has more than doubled from 47 months in the pre-1983 period to 107 months afterwards.

This moderation has been particularly apparent in the United States, which experienced the longest expansion on record in the 1990s, following another comparatively long upswing in the 1980s and a comparatively mild recession in 1990-91. So far, the most recent recession has also been rather shallow by historical standards.

Not all countries, however, have shared this positive experience. In particular, output volatility appears to have been greater in several economies that have gone through serious episodes of widespread financial distress. In the industrial world, the most notable example has been Japan.[5] And the same has been true for several countries in East Asia. In all of these cases, the crises had been preceded by a long period of rapid and rather steady growth (Graph I.4), and hence comparatively low volatility.

Greater prominence of financial booms and busts

The negative experiences in these countries point to a more generalised feature of the economic environment since the mid-1980s: the greater size and amplitude of medium-term fluctuations in asset prices, often accompanied by rapid credit expansion.[6]

Given data availability, this phenomenon is best illustrated for industrial countries. Graph I.5 summarises the evidence for a sample of countries for which data on commercial and residential property prices were available. The behaviour of asset prices is captured by an aggregate asset price index, which weighs property and equity prices by rough estimates of their shares in private sector

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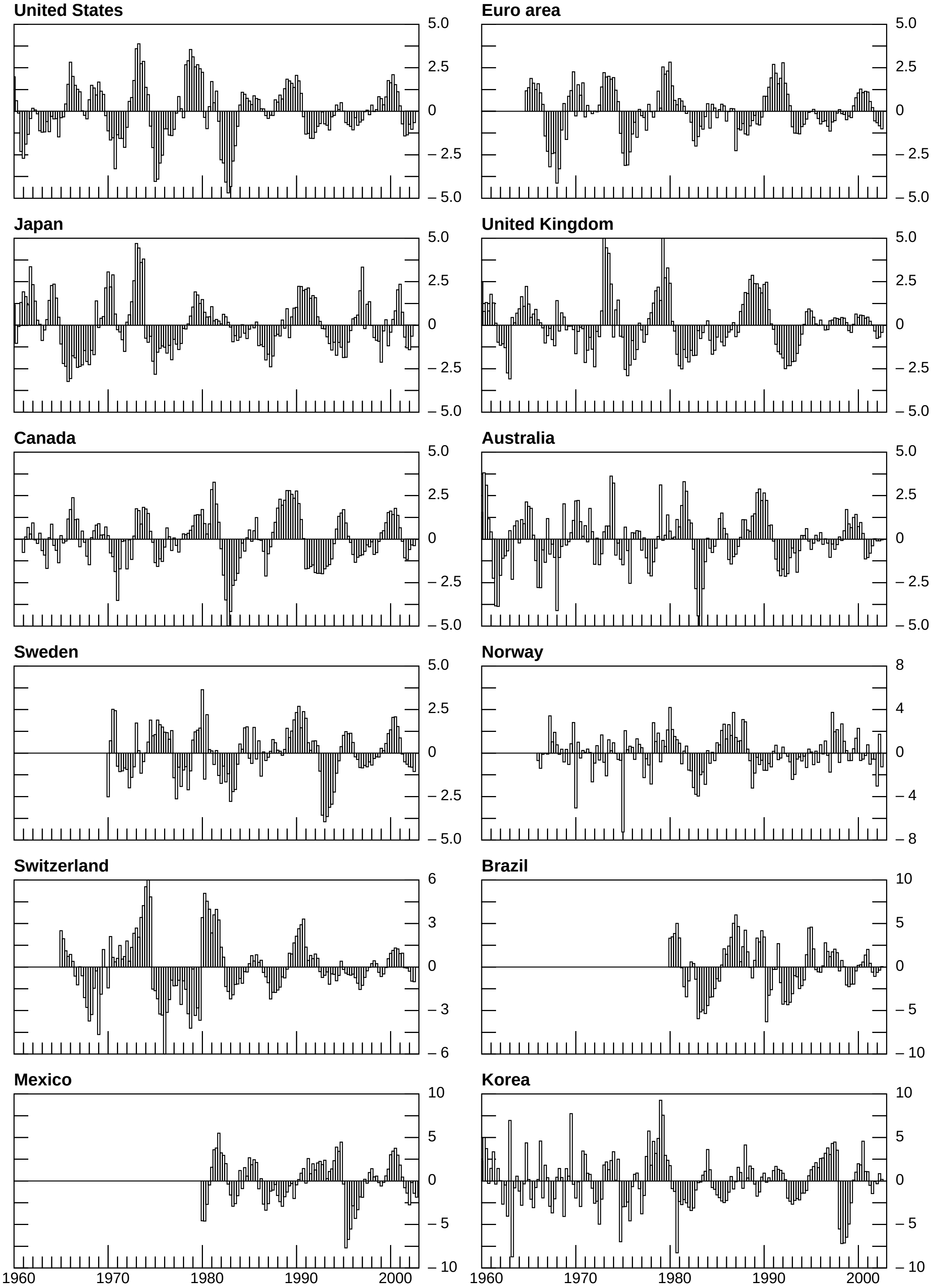
[5] This is missed in Table I.4 because of the common date chosen for the break. See Dalsgaard et al (2002) and Blanchard and Simon (2001).

[6] These are amply documented in Borio et al (1994, 2001) as well as in Borio and Lowe (2002a).

Graph I.2

Output gaps

In percentages

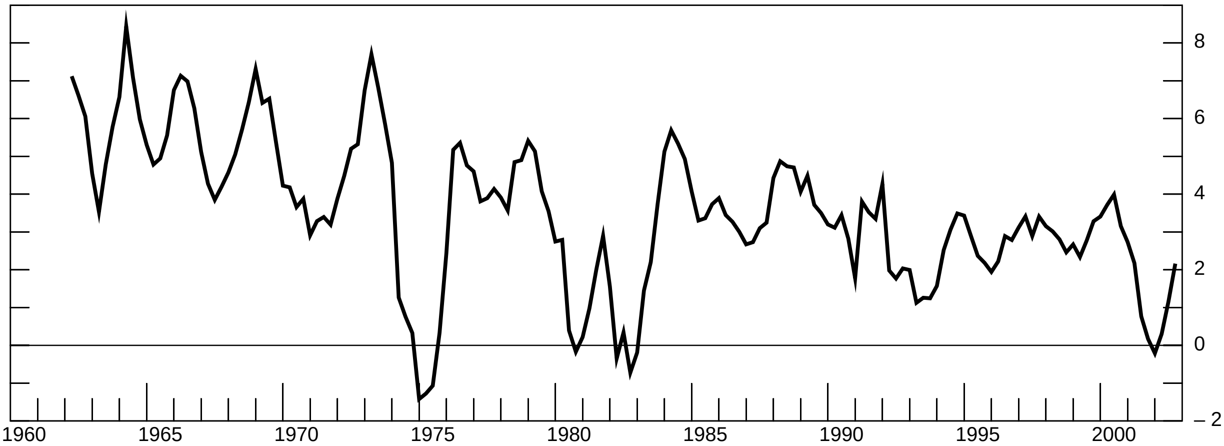


Sources: National data; BIS calculations.

Graph I.3

GDP growth in the G7 countries

Annual changes, in percentages

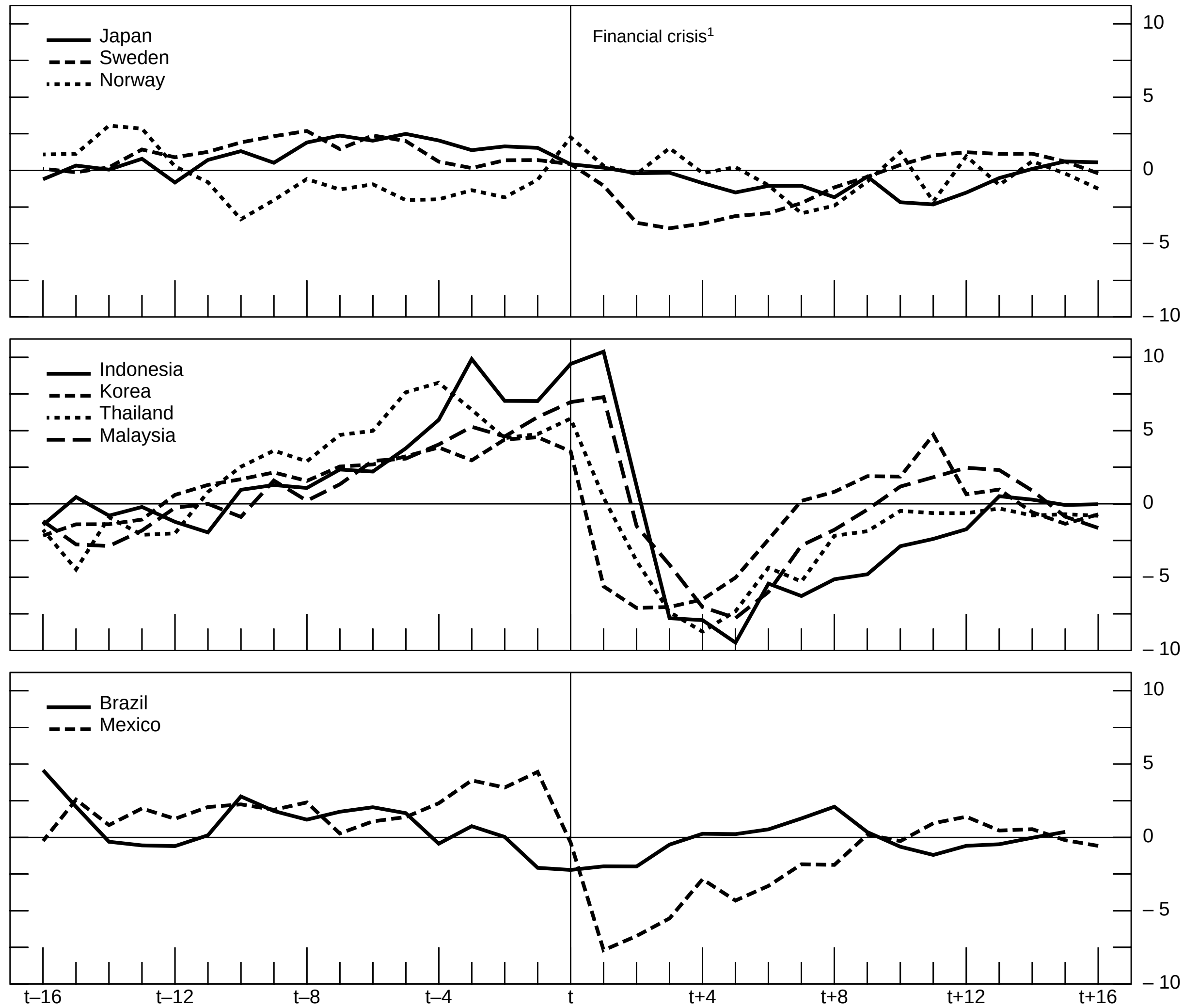


Source: National data.

Graph I.4

Output gaps and financial crises

In percentages



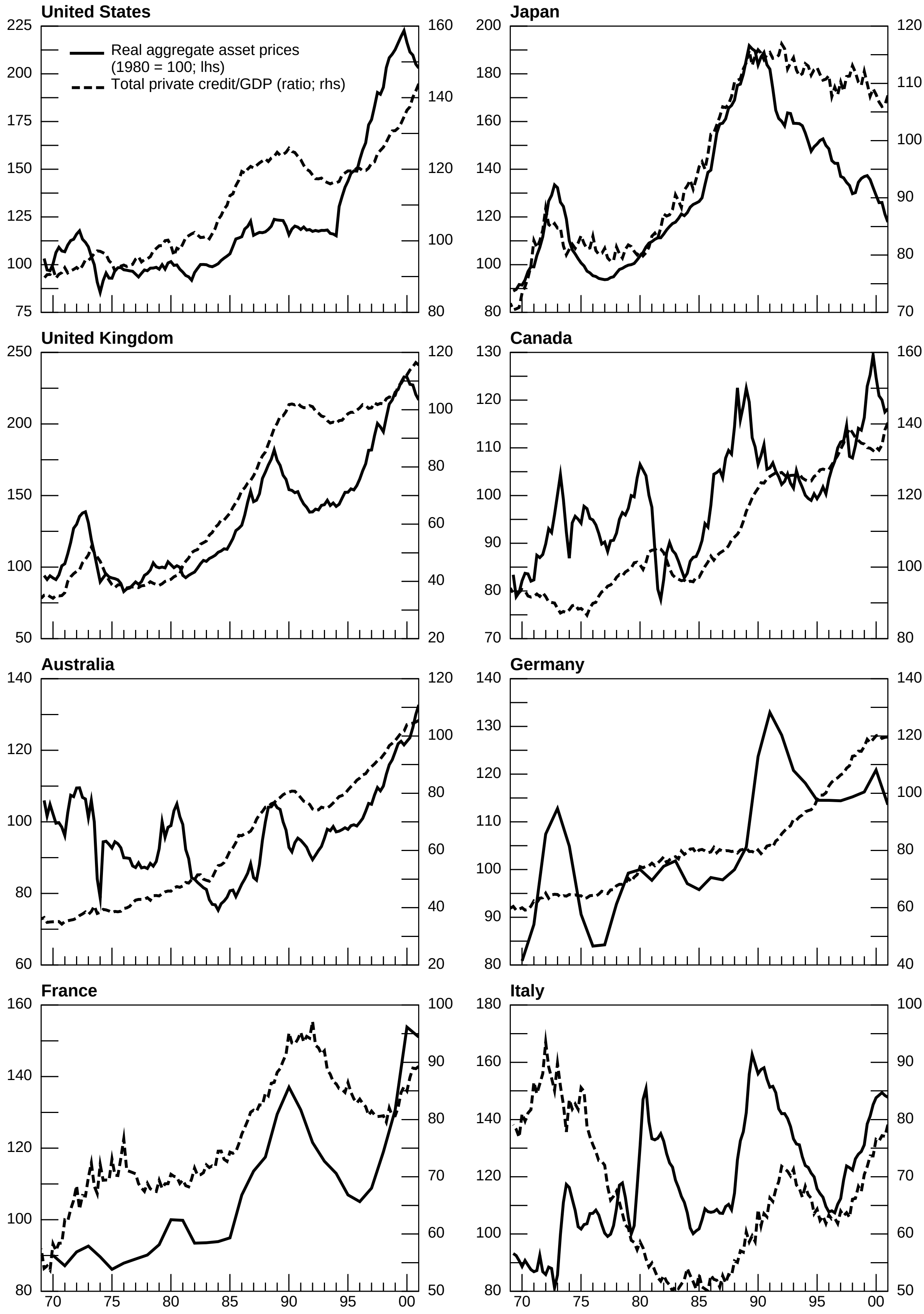
Note: t = time in quarters.

[1] The line for each country corresponds to the date of the respective crisis (Japan: second quarter 1992; Mexico: January 1995; Thailand: July 1997; Malaysia and Indonesia: August 1997; Korea: November 1997; Brazil: January 1999; Sweden: second quarter 1992; Norway: second quarter 1991).

Source: National data.

Graph I.5

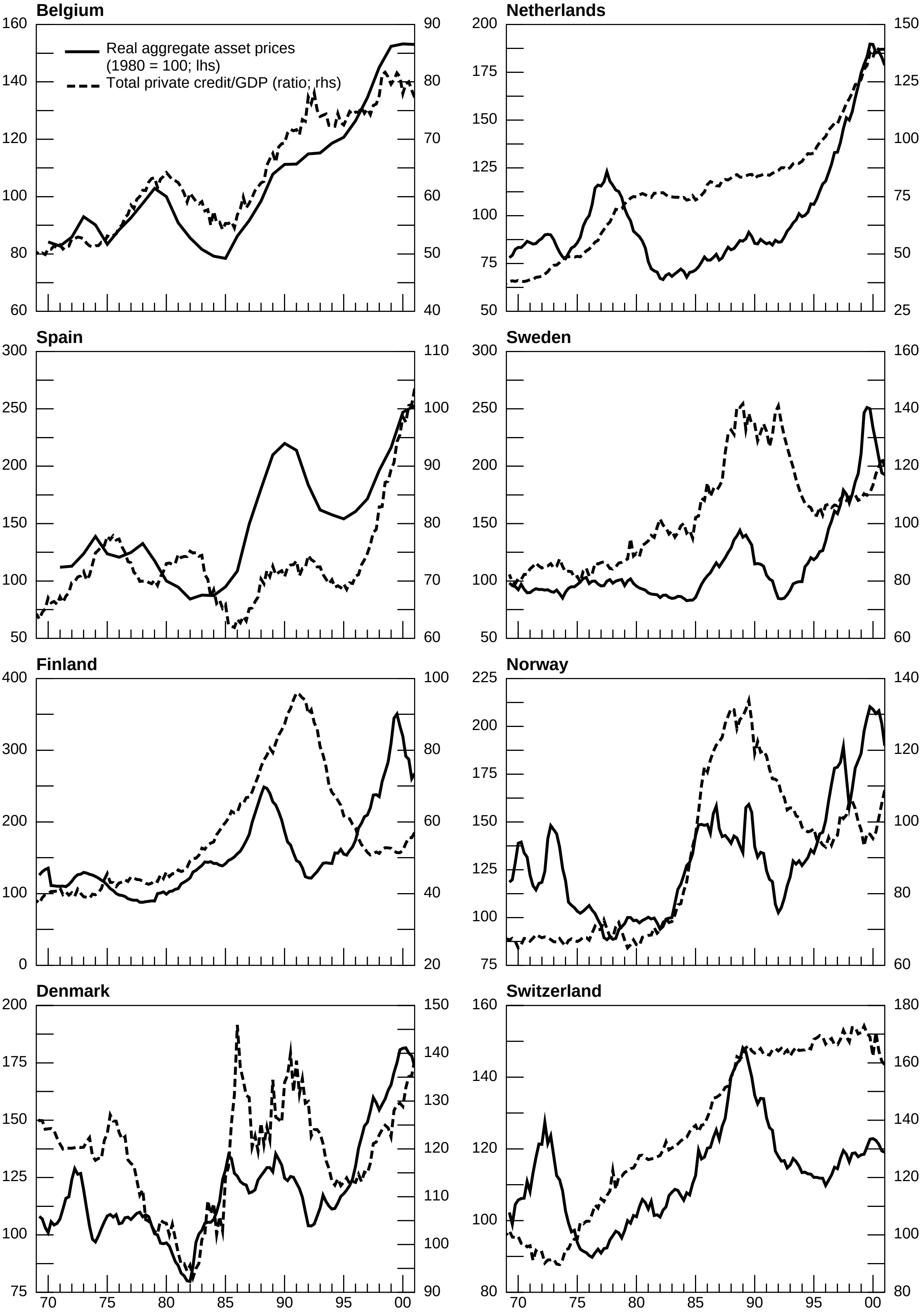
Real aggregate asset prices and credit



Sources: Private real estate associations; national data; BIS calculations.

Graph I.5 (cont)

Real aggregate asset prices and credit



Sources: Private real estate associations; national data; BIS calculations.

wealth. Country differences aside, the pictures illustrate that since the 1970s two major cycles have taken place and a third is under way, in sympathy with real economic activity. They correspond to the early to mid-1970s, the mid-1980s to the early or mid-1990s, and the second half of the 1990s to the present. Japan did not take part in the latest upswing following the bust in asset prices at the turn of the 1990s and the subsequent "lost decade". The data indicate that, if anything, the size and amplitude of the cycles is growing. A generally positive correlation between asset prices and credit expansion is also evident.

Booms and busts in credit and asset prices have been a common factor underlying another key development in the changing economic environment: the increased frequency and severity of episodes of widespread financial distress.[7] The disorderly unwinding of financial imbalances has contributed to economic downturns or economic weakness in both industrialised and emerging market countries. Starting in the late 1980s, examples include the Nordic countries, Japan, some Latin American countries and East Asia.[8] The resulting costs to the real economy have been especially high when such banking crises have coincided with currency crises.[9] Moreover, even when actual failures of financial institutions have been limited or non-existent, in some cases the unwinding of the imbalances has contributed to strains on the financial system and the real economy. The experiences of the United States, the United Kingdom and Australia in the early 1990s stand out in this respect.

Background structural changes

The rise of a focus on price stability and supporting reforms

The lower and more stable inflation performance of recent years reflects, in part, a sea change in thinking at central banks. The high inflation of the 1970s led central banks to focus policy to a much greater degree on inflation performance over the medium term.[10] Over time, this focus was underpinned by changes in the operational and institutional framework.

Operationally, initially among countries with a history of comparatively high inflation, the authorities gradually adopted structured inflation targeting regimes, including specific numerical objectives for inflation. Starting with countries such as New Zealand, Canada, the United Kingdom and Sweden, the trend subsequently extended much more widely, including several emerging market economies.[11] Among these, the adoption of the new framework not infrequently took place in the aftermath of the collapse of regimes characterised by tighter exchange rate commitments.[12] The experiences of Brazil and several East Asian countries following financial crises are obvious examples.

Institutionally, the stronger intellectual, political and social consensus to fight inflation crystallised in the trend towards endowing central banks with a greater degree of autonomy or "independence" to pursue mandates more clearly focused on price stability. The aim was to make central banks less vulnerable to possible external pressures to test the limits of monetary policy in pursuit of transient employment or

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7 The incidence and severity of banking crises is documented in a historical perspective in Bordo et al (2001).

8 See Kaminsky and Reinhart (1999) for a more systematic approach documenting the pattern of financial imbalances leading to currency and banking crises in 20 countries in Europe, Asia and Latin America since 1980. Note that there is still some controversy over whether these crises, most notably those in East Asia, reflected primarily a deterioration in fundamentals (eg Corsetti et al (1999)) or were predominantly driven by self-fulfilling creditor runs (eg Radelet and Sachs (1998)). These issues are discussed in more detail in eg Corsetti (1998) and Borio (2003). The alternative hypotheses would have implications for predictability, an issue discussed below.

9 For the costs of financial crises in terms of output forgone, see eg Hoggarth and Saporta (2001).

10 For a broad-sweep cross-country examination of the evolution of monetary policy in the postwar period, see BIS (1997) and Cottarelli and Giannini (1997). For a discussion of the reasons for the failure of policy to control inflation in the United States, see Orphanides (2000), De Long (2000) and Romer and Romer (2002).

11 See, for instance, Bernanke et al (1999a) and Schaechter et al (2000). Bernanke et al (1999a) also provide evidence that these explicit inflation targets have been followed by sustained disinflations in a number of cases. While inflation targets do not appear to have reduced the costs of such disinflations, they may help to bolster low inflation expectations once the disinflation has been achieved.

12 See Ho and McCauley (2003) for a discussion of the shift to inflation targeting in emerging market countries, with particular attention paid to the role played by the exchange rate in such frameworks.

output gains. The shift was also based on the fact that political pressures found fertile ground in a context where the short-run costs of a policy tightening were all too obvious but the long-term gains less apparent.[13] The intellectual basis for the shift was the recognition, reinforced in the high-inflation period, of the absence of a long-run trade off between inflation and unemployment.[14]

The strengthened focus on price stability by central banks was subsequently supported by broader changes in government policy. These changes, consistent with the same philosophy underlying the shift in central bank thinking, included, in particular, a trend towards greater fiscal discipline and efforts to improve the supply side of the economy, notably the functioning of labour markets.

The shift towards a medium-term and less ambitious orientation in fiscal policy was in part the offspring of disillusionment with the perceived effects of activism and growing fiscal deficits on economic growth and inflation. It was reflected in a generalised trend towards tighter fiscal positions, most clearly apparent during the 1990s, sometimes supported by binding rules (Graph I.6). In Europe, for instance, fiscal constraints were seen as instrumental in the establishment of economic and monetary union (EMU) and, subsequently, in its smooth running, as reflected in the Stability and Growth Pact. More generally, fiscal discipline arguably helped to buttress the central banks' efforts to ensure price stability, by providing a greater degree of operational freedom in, and lowering the political costs of, pursuing their primary objective.[15] And prohibitions on central bank lending to the government became a common feature of institutional frameworks securing central bank independence.

During the 1990s in particular, governments redoubled efforts to improve the supply side of the economy. Goods markets and, above all, labour markets were the preferred targets. Privatisation and labour market reforms that aimed at increasing labour market flexibility were the primary tools. These efforts were intended to raise the long-run potential growth of the economy and promote employment growth. They were seen as supporting price stability not only through the higher long-term growth potential but also by reducing the likelihood of untoward shocks in wages and prices. Such supply side efforts were regarded as especially important in economies where structural rigidities were viewed as most severe, notably in Europe and emerging market countries. Many emerging markets embarked on major reform efforts, with the added incentive of attracting badly needed foreign capital.

Financial liberalisation and globalisation

Over a somewhat longer period, there has been a widespread move towards financial liberalisation, both within and across national borders. The G7 countries typically began partial liberalisations in the mid-1970s, and then pushed such reforms considerably further in the 1980s and 1990s. By the early 1990s, their liberalisation efforts were virtually complete. Developing countries generally followed somewhat later, but made substantial progress in freeing their relatively repressed financial systems in the 1990s.[16]

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[13] A literature has developed showing, empirically and analytically, a link between central bank independence and inflation performance; see Cukierman (1992) and Berger et al (2001) for surveys. In fact, work on the inflationary bias of monetary policy under "discretion", starting with Barro and Gordon (1983), can also probably best be seen in this light. It may be more reasonable to view the bias as reflecting political pressure in the absence of clear mandates than as a *deliberate* attempt by the central bank to pursue overly ambitious employment or output objectives.

[14] This view was initially articulated by Friedman (1968) and Phelps (1968). It became much better accepted after the high-inflation period that followed (Friedman (1977)).

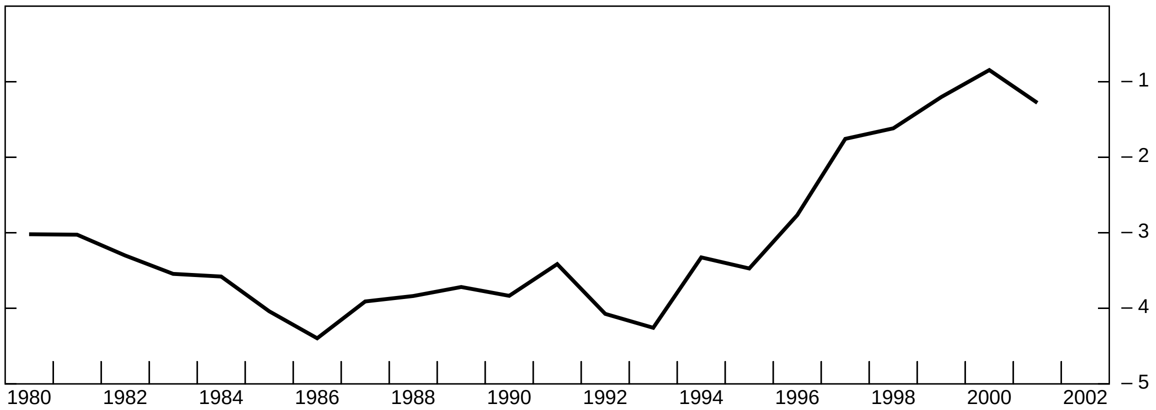
[15] In the theoretical economic literature, the link between fiscal policy and inflation has a long tradition. It was put most starkly by Sargent and Wallace (1981), and has recently been revisited by the so-called fiscal theory of the price level (eg Woodford (2001)). Operationally, recognition of the importance of fiscal discipline for de facto central bank independence has an equally long history (eg Toniolo (1988)). Especially in the 1990s, the concept of "fiscal dominance", used to denote a situation in which monetary policy could not effectively operate in the presence of large fiscal deficits, was extensively used as background to policy prescriptions in emerging market countries.

[16] The process of financial liberalisation in industrial countries is overviewed concisely in BIS (1992) and, in much more detail, in OECD (1994). Kaminsky and Schmukler (2001), inter alia, document an uneven, but ultimately substantial, trend towards deregulation of financial institutions and markets in developing countries as well. At the global level, Padoa-Schioppa and Saccomanni (1994) describe and analyse this shift, from what they call a government-led to a market-led international financial system.

Graph I.6

Cyclically adjusted government net lending[1]

As a percentage of potential GDP



[1] Weighted average, based on 1995 GDP and PPP exchange rates, of the United States, the euro area, Japan, the United Kingdom (from 1987), Canada, Australia, Sweden, Norway, Switzerland, Brazil, Korea and Mexico. For Brazil, Korea and Mexico, government budget balance as a percentage of nominal GDP; for Switzerland, central government budget balance as a percentage of nominal GDP.

Sources: IMF *International Financial Statistics*; OECD *Economic Outlook*.

The recognition of the economic costs of financial repression, and the ascendancy of a free-market philosophy, were powerful forces behind liberalisation. In addition, the link between financial liberalisation and the inflation focus was not purely coincidental. Over time the shift towards a market-led system was hastened by the consequences of inflationary tensions. These gave a significant spur to financial innovation and regulatory arbitrage. Likewise, market discipline helped to reinforce the focus on inflation. By being unforgiving of lax government policies, market forces underpinned the shift towards greater fiscal and monetary prudence.

In the wake of financial liberalisation and innovation, financial markets have become more integrated globally, especially after the temporary setback associated with the international debt crisis of the early 1980s (Graph I.7). The greater financial market integration fostered an acceleration of cross-border financial flows of both portfolio and direct investment.[17] In the 1990s, international capital flows rose to unprecedented heights. Admittedly, the Asian crisis, and more recent difficulties in Latin America and elsewhere as global growth has slowed, have trimmed global flows of late, but the stock of outstanding international investment remains very large by comparison with that of 20 or 30 years ago.[18]

The liberalisation and globalisation of finance followed, and in several respects strengthened, the greater integration of goods markets across the globe. While the process had started much earlier, it was taken considerably further during the 1990s, supported by national and multilateral policy initiatives and reinforced by the surge in foreign direct investment. The process was also supported by technological advances, which favoured a tendency towards the "atomisation" of economic processes into smaller and smaller components. Hence the growing prominence of so-called supply chains in production straddling national borders.[19]

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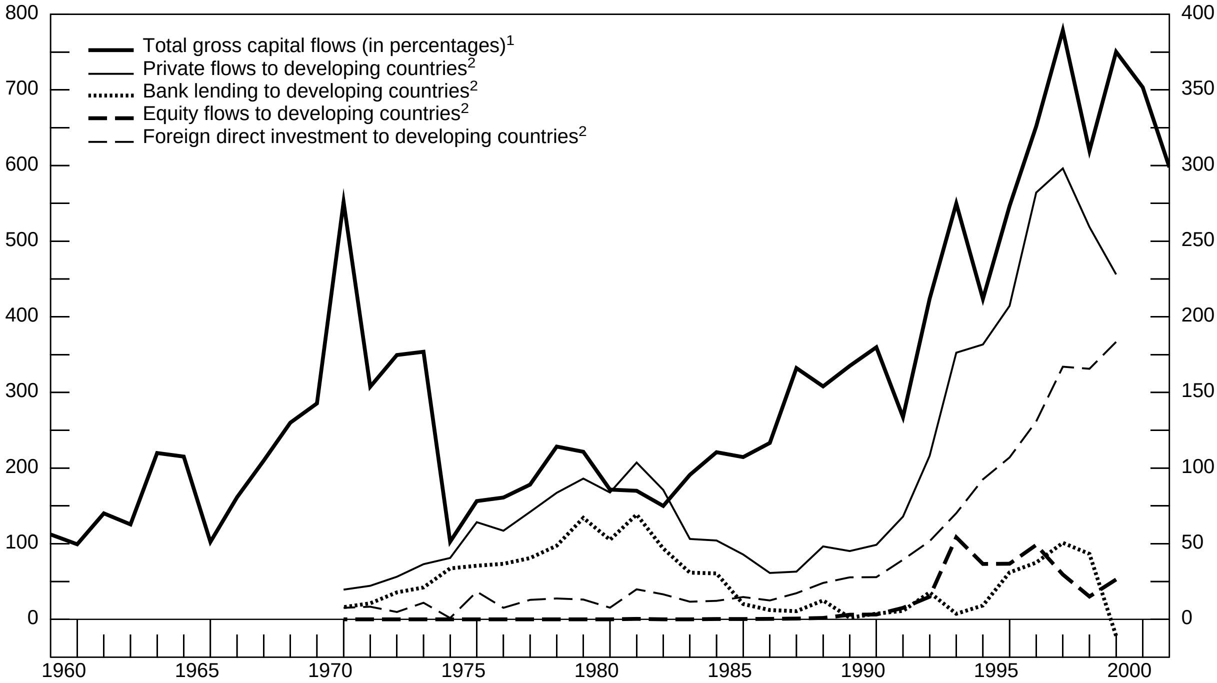
[17] In particular, foreign direct investment became a much more important source of capital flows to emerging markets in the late 1990s. For a discussion, see Mussa (2000a).

[18] Another effect of liberalisation and globalisation has been the growing importance of cross-border joint ventures and, especially in emerging market countries, mergers and acquisitions of financial organisations (Group of Ten (2001) and Hawkins and Mihaljek (2001)).

[19] Feenstra (1998) has a useful discussion of trade and the unbundling of the production process.

Graph I.7

Cross-border financial flows



[1] Total gross capital flows relative to net capital flows, left-hand side. [2] Right-hand side, in billions of US dollars, deflated by the US GDP deflator.

Sources: IMF; World Bank.

A return to the past?

As a result of these structural changes in the economic environment, notably in financial markets and monetary institutions, the configuration of global economic arrangements has come to resemble in some significant respects that prevailing in the pre-World War I period. This was the last time that liberalised financial markets coincided with a monetary regime seen as guaranteeing monetary stability. In the early decades of the 20th century, this was the gold standard; nowadays, it is a monetary framework that, while based on fiat money, is structured so as to secure the control of inflation.[20]

In fact, in some respects the resemblance may be closer with the first phase of the interwar period. This phase had either seen successful efforts to re-establish monetary stability by returning to the gold standard, as in a number of central European economies, or experimentation in how to conduct monetary policy in a context of price stability but weakened exogenous constraints on credit expansion.[21] In particular, this was the situation in the United States in the 1920s, given the abundance of its gold reserves.[22]

[20] For an elaboration on this point, see Crockett (2000a), Borio and Crockett (2000) and Borio and Lowe (2002a), who also consider obvious differences. For a detailed comparison of the degree of financial liberalisation and integration, see, for example, Bordo et al (1999), Eichengreen (1996) and Obstfeld and Taylor (1998). These contributions also discuss monetary arrangements.

[21] For a discussion of this period, see, in particular, James (2001).

[22] See, for example, Laidler (1999) for a review of the rich monetary debates at the time in the United States.

II. Challenges for monetary policy

Despite the low level of inflation and the generally less virulent output fluctuations experienced over the past decade or so in many countries, central banks have faced considerable challenges. These challenges have included possible changes in the behaviour of inflation and inflation indicators, increased uncertainty in some economies about the pace of underlying productivity growth, and difficulties caused by large asset price booms and busts and the financial crises that ensued in some cases. The nature of the recent economic slowdown, and the relatively weak and uneven recovery, also pose questions for monetary authorities.

Changes in the inflation process

One challenge facing central banks over the past decade, albeit one that reflects good news, is that inflation rates have generally fallen by more than would have been expected given the observed path of output and other inflation indicators. Real-time forecasts of inflation for a number of industrialised economies were consistently too high in the second half of the 1990s. The reasons for this development have been amply debated, although no clear conclusions have as yet emerged.[23]

A common set of interpretations has stressed changes in businesses' pricing practices. These explanations draw strength from the observation that forecasts of wage inflation were closer to the mark than those for price inflation. They are also consistent with clear evidence that the pass-through from exchange rates to prices generally declined in the second half of the 1990s.[24] While it is difficult to assess the importance of different factors, and their relative significance has probably varied across countries, a number of possibilities have been suggested.

The first possibility includes factors that could put downward pressure on firms' pricing power, inducing them to settle for smaller markups of prices over marginal costs. The demand curve for products may have become more elastic, either as a result of greater price transparency (eg the increased use of the internet and reduced information costs more generally) or of increased competition in goods markets, not least as a result of deregulation and globalisation.[25] In addition, the fact that production now straddles national borders much more than in the past would tend to make prices less sensitive to purely domestic costs.

A second possibility includes supply side developments that may have reduced firms' marginal costs, thereby leading them to trim prices.[26] A likely candidate in some countries, most notably the United States, is that more robust underlying productivity growth, reflecting both hefty investment and faster total factor productivity (TFP) growth, may have allowed firms to limit price increases for a given rise in wages while still boosting margins and profits. So long as the faster productivity growth took time to flow through to wage setting behaviour, as seems to have been the case, this would put temporary downward pressure on prices for a given level of unemployment (ie reduce the level of the NAIRU).[27] Another possible source of downward price pressure could be labour market reforms. For instance, efforts in some European countries to improve the matching of workers and firms or to reduce the attractiveness of unemployment compensation would be expected to lead to lower inflation for a given level of unemployment.[28]

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23 See, for example, Andersen and Wascher (2001), references therein and the other papers in BIS (2001a) and BIS (2001b).

24 See Andersen and Wascher (2001) and BIS (2001a). For evidence of a general decline in exchange rate pass-through in industrial countries, see also Gagnon and Ihrig (2001). For Mexico, Baqueiro et al in this volume find that the level of exchange rate pass-through has fallen with the decline in the average rate of inflation, while Minella et al in this volume find less convincing evidence for Brazil and emphasise the importance of administered prices in measuring pass-through.

25 In this volume, Amano and Hendry emphasise the role of market share considerations to help to understand the inertial behaviour of inflation.

26 This possibility is consistent with the findings of Amato and Gerlach (2000), who argue that, conditional on unit labour costs, there is no compelling evidence that the inflation process has changed in a number of leading industrial countries.

27 See Braun (1984) and Ball and Moffitt (2001).

28 Lower oil prices may also have contributed to the lower than expected inflation performance in the late 1990s, but on balance oil prices have risen over the last 15 years.

A final possibility focuses more on the dynamics of expectations and price setting at low levels of inflation. In particular, with expectations better anchored around low and stable inflation levels, possibly underpinned by stronger central bank anti-inflation credentials,[29] one-off unexpected increases in costs are less likely to feed through into prices, as they are less likely to be considered permanent.[30] For example, an increase in wages, if not accommodated by the authorities, would tend to be unwound in future through lower employment levels. Likewise, with smaller inflation differentials, changes in exchange rates might be expected to have less of a predictable drift, thereby slowing down the pass-through.[31] The presence of "menu" costs can generally contribute to this stickiness in prices.[32]

While the lower than expected inflation of recent years is surely good news, the fact that models of inflation performed relatively poorly suggests that our understanding of the inflation process is not as good as might have been thought. This realisation raises risks for central banks. On the one hand, given that policy takes time to have its effects on the economy, central banks would wish to act pre-emptively to combat expected pressures on prices or output. On the other hand, pre-emptive action is only possible if the central bank is confident of its ability to forecast such pressures. Thus, the difficulties in forecasting inflation in recent years have arguably made it more difficult to take pre-emptive actions. Other things equal, this suggests that central banks may have to wait longer before being confident enough to take action.

Uncertainty about productivity growth

A second challenge facing policymakers has been coming to grips with the uncertainty surrounding potential increases in productivity growth. By its very nature, reaching firm judgments about the *sustainable* pace of productivity growth is extremely difficult. Disentangling the sources of an increase - potentially including capital deepening, shifts in the sectoral distribution of output, cyclical effects on labour and capital utilisation, and faster TFP growth - is very hard. Importantly, judgments depend crucially on the sustainability of the capital deepening process. And experience suggests that it is the resilience of the pace of productivity growth during a recession that is critical in assessing long-run tendencies. These difficulties in reaching a firm judgment raise delicate issues for central banks, not least the risk of failing to be sufficiently pre-emptive.

Most recently, the difficulties in forming a solid view have been evident in the United States, where the underlying pace of productivity growth stepped up over the second half of the 1990s. It was not until the end of the decade that a consensus emerged on the extent and likely sources of the acceleration, and considerable disagreement remains on the likely sustainability of the pickup.[33] As the US economy has slowed, productivity has continued to post robust, if somewhat downward-revised, gains, suggesting that the faster pace of advance in the late 1990s was not simply the result of the

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29 The view that greater credibility of the central bank anti-inflation commitment, backed by changes in the operational framework, may have helped to better anchor expectations is rather common. This is found in central bank statements (eg Vickers (1999a), Dodge (2003)) and also academic work (eg Bernanke et al (1999a) and Cukierman (2002)). See also Johnson (2002) and Neumann and von Hagen (2002) for a comparison of inflation targeting and non-inflation targeting regimes in this respect.

30 Taylor (2000), for instance, discusses how perceived lower persistence of cost changes implies a lower pass-through.

31 By contrast, Campa and Goldberg (2002) attribute the smaller pass-through to changes in the composition of trade.

32 See the seminal article by Mankiw (1985) and, in this volume, Aucremanne et al (2003) and Assarsson (2003). Calpin and Spulber (1987), however, note that menu costs at the level of individual prices need not result in sticky adjustments in the overall price index.

33 For example, Jorgenson (2001), Gordon (2000) and Oliner and Sichel (2002) all suggest an acceleration in productivity growth of nearly a percentage point, reflecting both faster TFP growth and capital deepening. All three also suggest that production of, and investment in, IT products can account for much of this pickup. However, while the projections presented by Oliner and Sichel suggest that faster underlying productivity growth is likely to be sustained, Gordon argues that decreasing returns to scale in the use of computing power are likely to limit productivity rises going forward. For an international perspective on productivity growth, see Scarpetta et al (2000). The time series evidence of a structural productivity break was suggestive but not statistically significant until the late 1990s; see Filardo (1995), Filardo and Cooper (1996) and Kahn and Rich (2003).

high-tech boom. At the same time, a larger proportion of the gains has recently been attributed to capital deepening rather than total factor productivity growth.[34]

Similar uncertainties in judging developments have been encountered elsewhere. The acceleration in productivity in the United States held the promise of faster productivity growth abroad as well, as technological advances in the United States diffused to, or signalled developments, elsewhere. However, the record in other countries has been mixed thus far, with little evidence that the new economy forces have been reflected in faster productivity growth outside North America (Graph II.1).[35] For example, while Mexico and Canada appear to have shared somewhat in the acceleration in the United States, the euro area saw its productivity trend flatten.[36] In Australia, productivity growth had already picked up in the early 1990s, while in neighbouring New Zealand growth has, if anything, slowed. Brazil has seen an increase, but this growth may reflect more of a catching-up after economic crises there in the late 1980s.

Such assessments about underlying productivity growth were, and still are, complicated by statistical and country-specific developments. In Europe, for example, differences in statistical methodologies and structural policies designed to boost employment may have masked underlying improvements.[37] In addition, the experience of many economies suffering severe recessions after prolonged investment-driven booms suggests that judgments about long-term growth rates may not be robust. In these cases, initially higher estimates during the boom were revised downwards significantly after the crises. The experience of Japan and a number of East Asian countries, including Korea, illustrate this. For example, between April 1997 and April 2001, the consensus long-term (10-year) growth forecast for four East Asian countries experiencing financial crises in 1997 (Indonesia, Korea, Malaysia and Thailand) was reduced from just over 7% to 5.5%, reflecting a slowdown in productivity growth (Graph II.2).[38] More fundamentally, these observations suggest that a clear-cut distinction between an exogenous trend and cyclical movements may be misleading.

Uncertainty about the underlying pace of productivity growth makes it more difficult for policymakers to evaluate the appropriate stance of monetary policy for at least two reasons. First, it complicates the assessment of actual and prospective slack in the economy, as might be gauged from real side variables, such as output gaps.[39] Moreover, errors in the assessment may throw policy off kilter. For instance, as a result of reduced confidence in the estimates, central banks may tend to put more weight on actual inflation developments, with the risk of failing to be sufficiently pre-emptive.[40] Second, even if the change in trend productivity growth is known, the implications for monetary policy will depend in large part on the extent to which the change is permanent or temporary and is understood by economic agents. Faster productivity growth in the long run would presumably have to be matched by higher real interest rates at some point. However, in the near term, the appropriate change is unclear. For instance, if workers and firms do not immediately take account of the faster productivity growth when setting wages, there may be less pressure on prices at any given level of

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34 In an unpublished update to Oliner and Sichel (2002), the authors trim their estimate of the increase in labour productivity growth after 1995 from 0.89% to 0.71%, reflecting revisions in underlying data. Virtually all of this reduction reflects their lower estimate of the contribution of TFP growth to the acceleration in productivity, which was cut from 0.41% to 0.25%.

35 The cross-country record is reviewed in more detail in Scarpetta et al (2000) and Gust and Marquez (2000).

36 Of course, in Europe the major structural changes with possible implications for monetary policy, not only through their impact on productive potential, were German reunification at the beginning of the decade and the establishment of monetary union towards the end of it. But as productivity appeared to accelerate in the United States, searching questions were also raised in Europe.

37 On statistical methodologies, see, eg Deutsche Bundesbank (2000) and Scarpetta et al (2000).

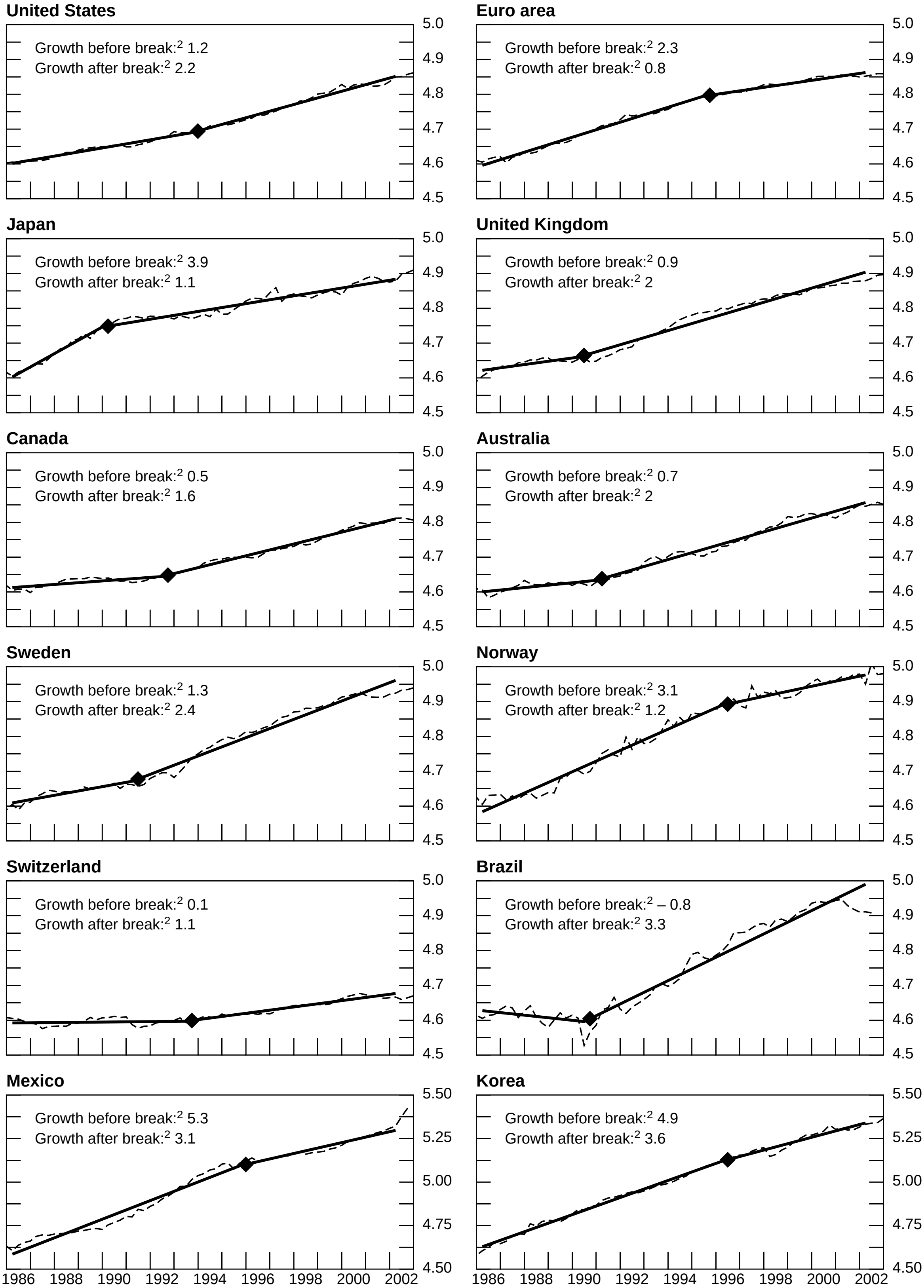
38 On Japan, see Yamaguchi (1999a).

39 These problems would come in addition to traditional ones, such as those arising from data revisions (Orphanides (2001)). See ECB (2000) for a discussion of the difficulties in assessing economic slack. A number of papers presented at the central bank economists' meeting, some of which are included in this volume, touch on this question. Gruen et al (2002) and Gali et al (2002) provide recent results in the estimation of output gaps. In this volume, Lippi discusses the implications of uncertainty about output gaps for monetary policy. Olsen et al suggest that simple rules may help avoid policy errors related to uncertainty about the output gap. And Cette and Pfister discuss the implications of innovations in information and communication technologies for the appropriate monetary policy horizon.

40 For a formalisation of this point, see, for example, Smets (1998).

Graph II.1

Productivity trends[1]

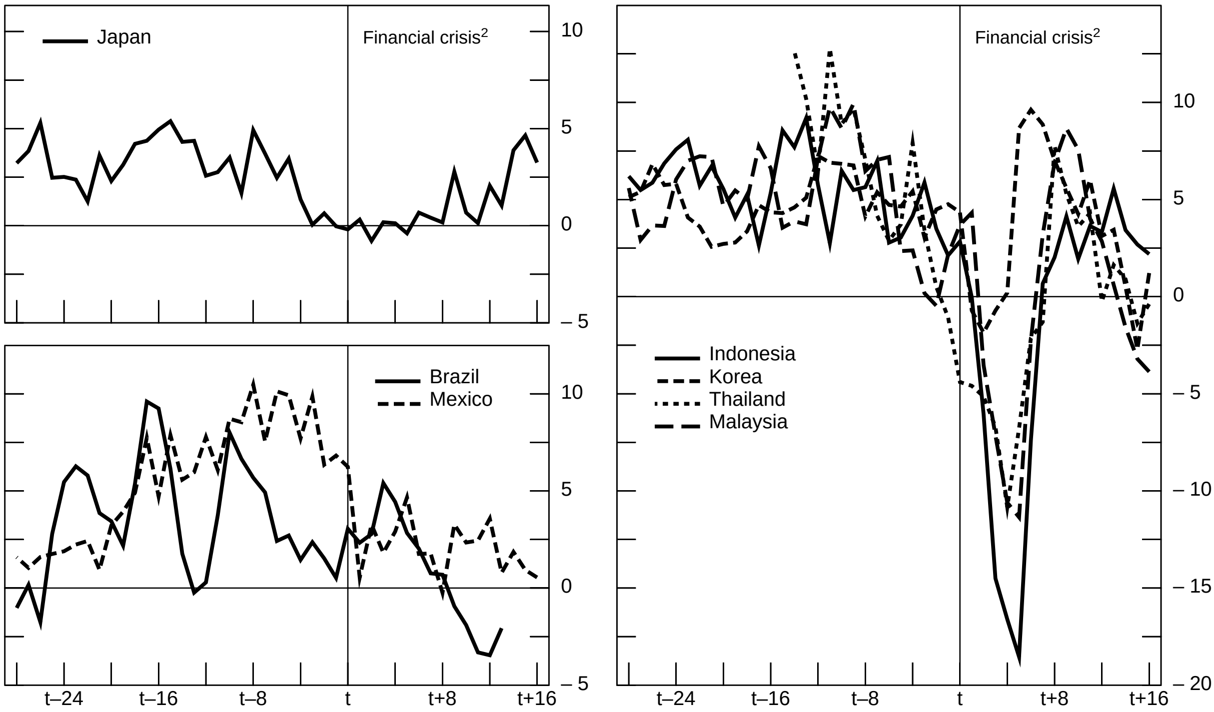


[1] Defined as GDP/employment and expressed in logs. [2] BIS estimate.

Source: National data.

Graph II.2

Productivity growth and financial crises[1]



Note: t = time in quarters.

[1] Defined as GDP/employment. [2] The line for each country corresponds to the date of the respective crisis (Japan: second quarter 1992; Mexico: January 1995; Thailand: July 1997; Malaysia and Indonesia: August 1997; Korea: fourth quarter 1997; Brazil: January 1999).

Source: National data.

employment, allowing the central bank to tighten policy less than would otherwise be the case. By contrast, quick recognition of the change, and hence perceptions of higher lifetime income and future profitability, could have such an expansionary impact on demand as to call for a sharper tightening in the short run than in the long run. This would be needed to keep aggregate demand in line with aggregate supply.[41]

Addressing financial booms and busts

A third challenge faced by several central banks has been to come to grips with the increased frequency and severity of financial booms and busts, many of which have led to widespread financial dislocations. Specifically, central banks have had to consider how monetary policy can best respond to the build-up and unwinding of such imbalances.

Arguably, the more natural first line of defence against financial imbalances is prudential regulation and supervision, an instrument that is likely to be less blunt than monetary policy. For example, if during the upswing of a boom there appears to be excessive lending to a particular sector, perhaps to fund outsized investment spending, then the lenders may well be taking on considerable credit risk. In such a case, supervisors could, perhaps through the review process, induce the lenders to limit their exposures, thereby limiting the extent of the imbalances. Even so, if excessive optimism and biases in risk assessment are widespread, supervisors may find it difficult to establish with sufficient clarity that the lending is inappropriate. In addition, in some cases, as with stock price misalignments, there is no obvious supervisory authority that can intervene. More generally, at present the use of prudential

[41] See Viñals (2000) for a useful discussion of the possible implications of supply shocks for monetary policy.

instruments to address what may be perceived as financial imbalances with an essentially macroeconomic origin remains problematic.[42]

The challenges faced by central banks in recent years have depended in part on the monetary regime in place. The room for manoeuvre was especially limited for central banks pursuing relatively tight exchange rate objectives. In such cases, faced with sizeable capital inflows, there was relatively little that monetary authorities could do, short of abandoning the objectives or reversing capital account liberalisation processes. This dilemma, for instance, was especially acute for emerging market countries, notably in East Asia. For those central banks with greater freedom with the interest rate lever, the problems were somewhat different. These related to difficulties in identifying the imbalances and in deciding on the extent to which it was appropriate to respond to them by tightening policy. Given the uncertainties involved, policymakers generally appeared to respond to the growing imbalances fairly gradually, as illustrated by experience in Japan and the United States.[43] Even here, however, external influences could act as a significant constraint. In the case of Japan in the second half of the 1980s, for instance, interest rates were arguably kept lower than would otherwise have been the case in order to prevent an unwelcome appreciation of the yen. This, in turn, may have contributed to the build-up of the imbalances.[44]

Once financial imbalances begin to unwind, policy should probably be eased to cushion the effects of that unwinding on the real economy, but questions remain about the appropriate pace of the easing, its intensity and effectiveness. In some cases, as in the United States and United Kingdom in the early 1990s, financial “headwinds” caused by problems at deposit-taking institutions and/or private sector balance sheets led to a somewhat greater easing than would normally have been expected given the levels of output and inflation. Similarly, the Federal Reserve eased rates considerably in the first half of 2001, following the collapse of equity prices in the technology sector, in order to offset the resulting negative wealth effects and the impact on investment of capital overhangs in some parts of the economy. More dramatically, the Bank of Japan ultimately cut its policy rate essentially to zero in response to the economic and banking sector problems that followed the bust in equity and property prices and the emergence of widespread financial distress.

The current economic situation

Policymakers face considerable challenges at the current juncture. These reflect a number of developments, some of which have taken central banks by surprise.

The first development has been unexpected weakness in the global economy, starting with the abrupt slowdown in the United States in the autumn of 2001. Admittedly, it is not unusual for recessions to take authorities by surprise. But by postwar standards the current slowdown has been atypical in several respects. Most notably, the slowdown was not triggered by a tightening of monetary policy designed to quell inflationary pressures. In fact, inflation remained uncharacteristically quiescent. Rather, the upswing appeared to be brought to an end by a spontaneous unwinding of an investment boom, partly in the wake of what, in retrospect at least, turned out to be a remarkably sharp medium-term swing in equity prices. Although the recession in the United States has been comparatively mild thus far, the global slowdown has been rather strong by past standards. If output is measured in PPP terms, the slowdown among the G7 ranks close to those associated with the oil price shocks of the 1970s (Graph I.3, in previous section). The marked deceleration has resulted from the unusual synchronisation of the downturn across countries. While the slowdown in Japan and emerging market countries, dependent on exports to the United States, was to be expected, the intensity of the one in Europe came largely as a surprise. The global economy has continued to be weaker than expected, and forecasts of when growth in the largest economies will return to estimates of potential have been pushed back.

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[42] These issues are discussed in detail in Borio et al (2001), BIS (2001c), Lowe (2002), Segoviano and Lowe (2002) and, in particular, Borio (2003).

[43] For a discussion of the policy response in Japan see eg Yamaguchi (1999a), Bernanke and Gertler (1999), Cecchetti et al (2000), Okina et al (2001), Okina and Shiratsuka (2001) and Ahearne et al (2002); for a comparison of the United States and Japan, see BIS (2002a).

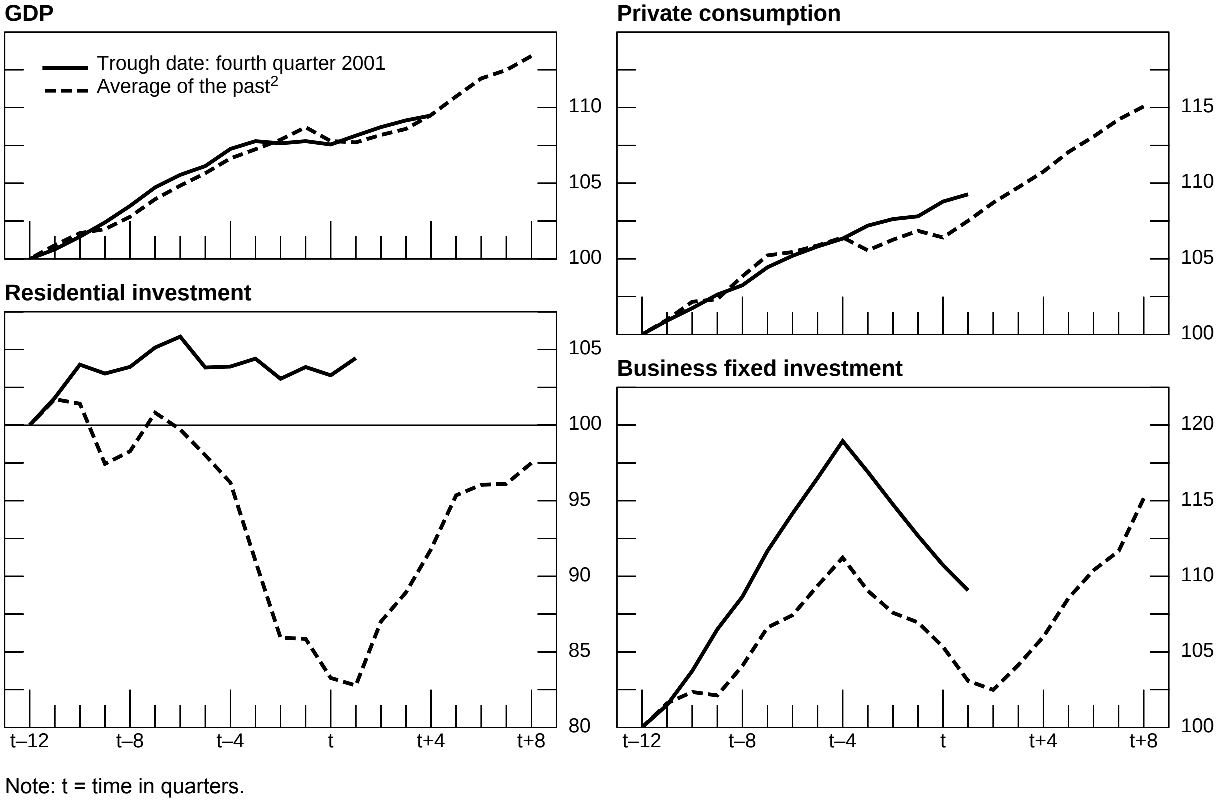
[44] This point is stressed in eg Bernard and Bisignano (2002). See also Yamaguchi (1999a).

The second development has been the unusual behaviour of key components of aggregate demand against the background of a rather uncharacteristic configuration of levels of indebtedness and asset prices. In particular, while investment spending has plummeted, household expenditure has held up remarkably well by past standards (Graph II.3). Household spending on consumption and housing has been sustained by the prompt easing of monetary policies and a continued rise in residential property prices.[45] In the light of the historically high levels of household indebtedness and comparatively high residential property prices in several countries (Graphs II.4 and II.5), questions have been raised about the sustainability of the recovery and the effectiveness of monetary policy when faced with such an unbalanced composition of spending.

Finally, generally subdued inflation rates, with prices actually falling in some sectors, and low interest rates have raised the prospect of the zero lower bound constraint becoming more of a consideration in the setting of policy. The synchronised weakness in the global economy has complicated matters further. Under these conditions, there is less scope for monetary policy to stimulate growth through the exchange rate channel, since the instrument is less effective at the global level. The reason is that a lower exchange rate for one country means a higher one for another, only reallocating demand rather than increasing it, *unless* it induces expansionary policies in those countries experiencing the appreciation.

Graph II.3

The latest G7 business cycle in perspective[1]



Note: t = time in quarters.

[1] Value of series 12 quarters prior to the trough date is rebased to 100. [2] Using third quarter 1982 and fourth quarter 1974 as the trough dates.

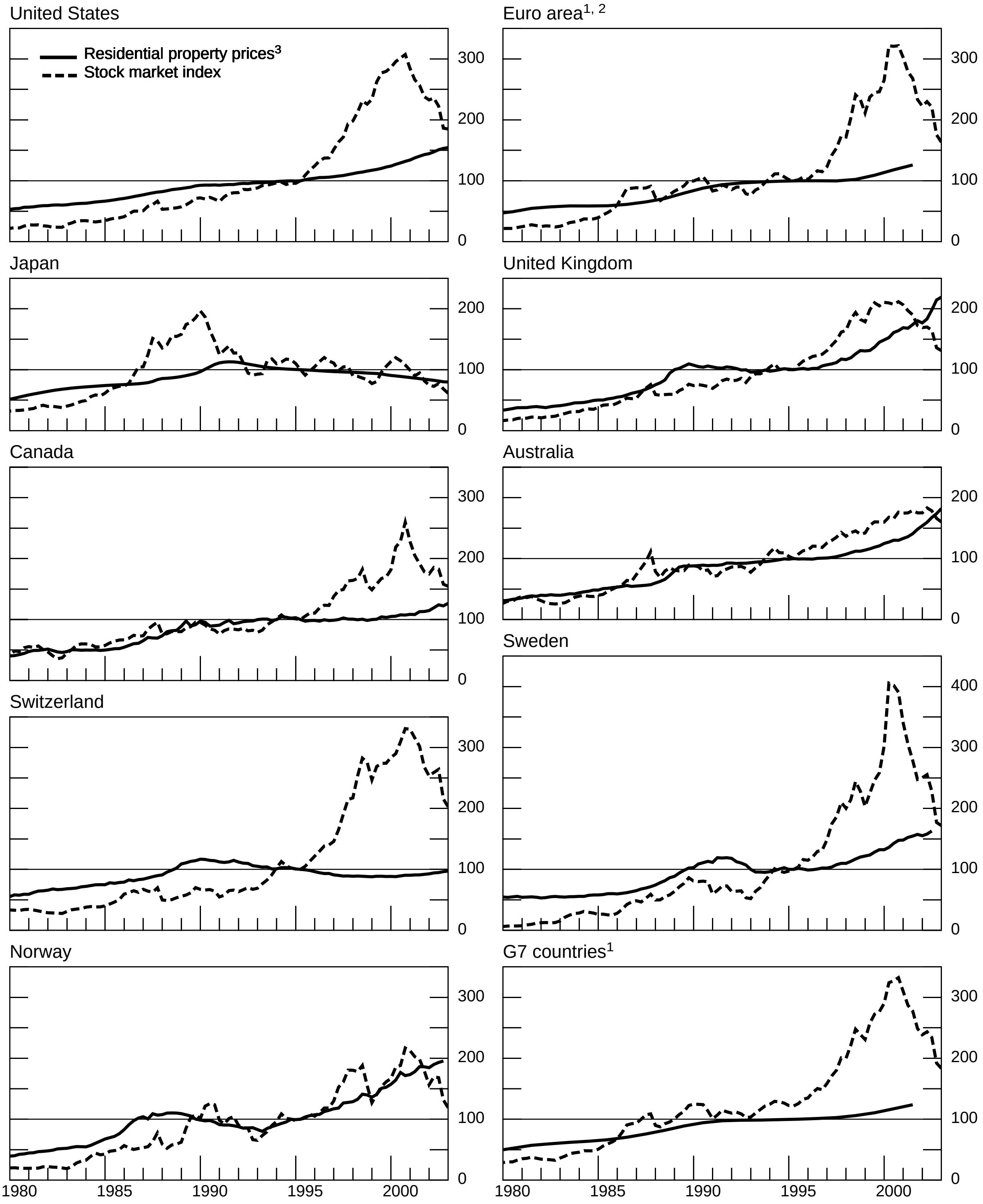
Source: National data.

[45] These issues are discussed in more detail in BIS (2002b) and, more recently, in Sutton (2002), Deep and Domanski (2002), Canner et al (2002) and Zhu (2002).

Graph II.4

Residential property prices and stock market indices

First quarter 1995 = 100



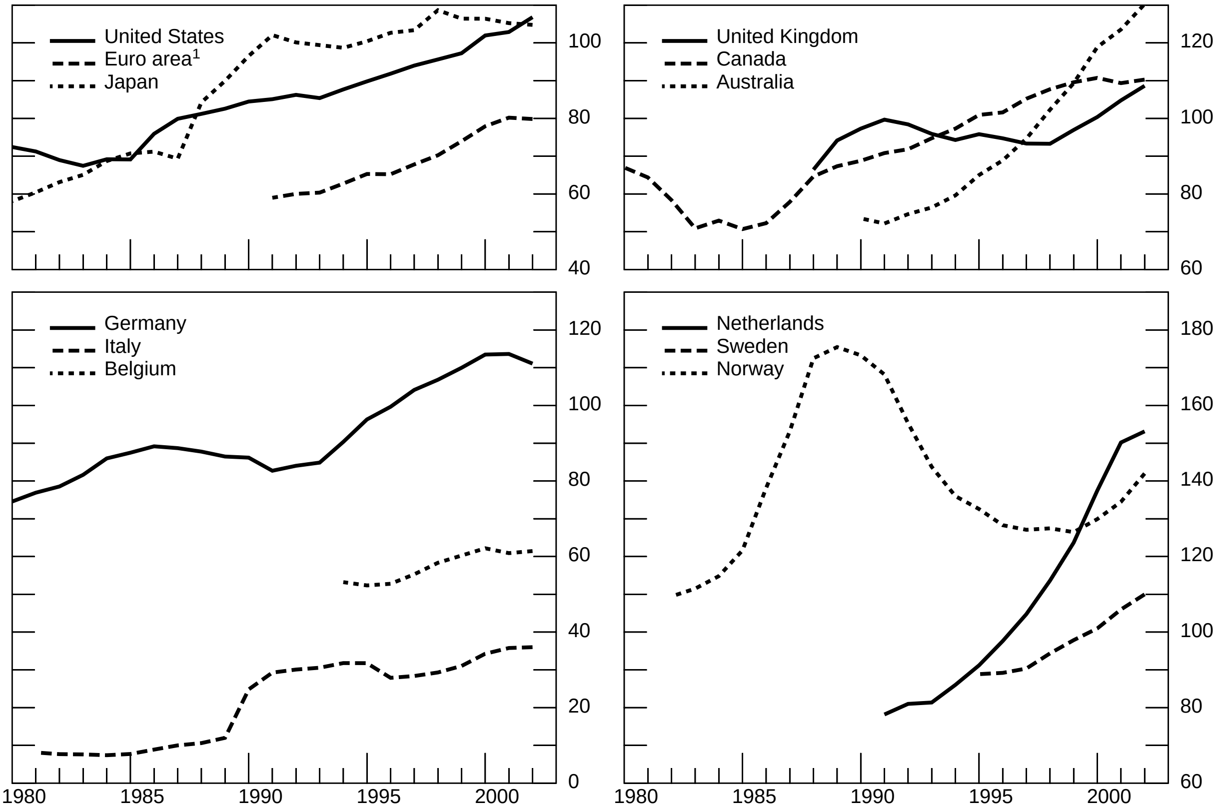
[1] Weighted average, based on 1995 GDP and PPP exchange rates. [2] Using data from Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands and Spain. [3] For Japan, residential land prices.

Sources: National data; BIS calculations.

Graph II.5

Household indebtedness

As a percentage of disposable personal income



[1] Weighted average, based on 1995 GDP and PPP exchange rates.

Sources: National data; BIS calculations.

III. Two alternative views

Central banks can differ in their evaluation of recent economic developments, structural changes and their policy implications. In order to highlight possible alternative assessments, in this section we outline two very different, intentionally polarised, views.

The first is the "continuity" view, in which the central bank, while acknowledging the changes that have occurred of late, interprets them essentially as unusual "shocks" in the context of a fairly stable macroeconomic environment or "model of the economy". Such a traditional view implies that the central bank is likely to set policy in the future rather as it has in the past, with little change in either strategic or tactical policy approaches as a result of the recent history.

By contrast, in the second, or "new-environment", view, the central bank sees recent economic developments as related to and reinforcing one another. Taken jointly, they would reflect a qualitative change in the macroeconomic environment. Such a change is not so easily captured by benchmark economic models and can point to a more significant modification to traditional policy guides. Such a central bank is more likely to adjust its beliefs regarding the operation of the economy and to make corresponding changes to its policy approach.

The continuity view

In the continuity view, the recent experience of longer expansions, more volatile financial markets and possible increases in the growth rate of underlying productivity are seen, for the most part, as simply reflecting the specific configuration of exogenous "shocks" hitting economies against the background of a broadly invariant set of structural relationships. Shocks vary in terms of their nature and the persistence of their effects. But, by and large, there is no major reason why they are likely to recur in future.[46]

In this view, the basic model of the economy through which developments are interpreted need not be changed much. In particular, growth in aggregate demand outpacing that of supply, and so a wider output gap, is seen as generating heightened upward pressure on prices. Price increases would tend to materialise with lags that, by and large, have not significantly changed. Analytically, this type of view tends to rely heavily on models where there is a close correlation between output gaps and inflation and where the inflation rate itself is a key (in some cases sufficient) statistic reflecting "distortions" in the economy.[47]

The task of the central bank in this world is well known. Simplifying somewhat, in order to keep inflation under control, around a formal or informal target level, the central bank keeps demand growing in line with potential while being mindful of possible untoward cost-push pressures. In turn, and crucially, the failure of inflation to rise or fall can be seen as a useful cross-check of estimates of excess demand and supply.[48]

In such a view, the role of financial developments in policy decisions is fairly modest. It reflects primarily the marginal contributions that such variables make to forecasts of output and inflation over a policy horizon of one to two years. For example, rapid growth of money or credit aggregates might be read as suggesting possible incipient inflation pressures, but because such indicators have been less useful in recent years as aides to forecasting, they might well be discounted. Similarly, possible financial imbalances, including rising household or business debt burdens, might be seen as suggesting downside risks to the outlook, but they would not generally be expected to play a central role. Indeed, in a period of rapid non-inflationary growth, high investment and strengthening productivity gains, faster debt growth might be seen as justified by more rapid anticipated growth in incomes and higher returns on investment.

Looking back at developments in recent years, a central bank with this view might well consider the financial booms and busts, including financial distress, and associated fluctuations in credit and investment to have been largely the result of idiosyncratic factors, specific to the countries affected. Examples include deficiencies in the economic and financial infrastructure and/or inevitably slow learning in the wake of financial liberalisation. In other words, it would probably tend to regard these developments as episodic or exceptional rather than as tied to the general characteristics of the environment.

The continuity view also has implications for the type of questions to which answers would be sought. For example, policymakers with this perspective might more naturally focus on understanding the reasons for the low output volatility in many industrialised countries in recent years than those for the increased volatility in economies experiencing severe financial strains.[49] Likewise, they might devote

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46 This very common view of the business cycle, which emphasises the size and persistence of exogenous shocks, harks back to Frisch (1933).

47 Here "distortions" should be interpreted as departures from economic efficiency, normally measured as departures from an equilibrium in which prices are fully flexible. The most popular example is the family of so-called New Keynesian models; see eg Woodford (2002) and Clarida et al (1999).

48 Given the basic model of the economy adopted, it is not surprising that central bank behaviour has often been summarised through simple rules where the policy rate responds to output gaps and inflation. In the literature, rules drawn from this family have also frequently been employed to assess the optimality of policy, as in eg Taylor (1999). Of course, even their reasonable success in approximating policy by no means implies that this is the strategy that central banks follow ex ante. The analysis of inflationary pressures goes well beyond what can be captured by such simple relationships. On these, see, in particular, ECB (2001), which addresses the role of simple rules, and ECB (2000) more specifically on the issues concerning the measurement and usefulness of the concept of the output gap.

49 There is, in fact, a considerable amount of research trying to understand the factors behind the comparatively low volatility of output in some of the industrialised countries over the last decade or so, mostly dealing with the US experience. Answers so far have focused primarily on a more favourable environment, in the form of positive or smaller exogenous shocks (eg Stock and Watson (2002) and Ahmed et al (2002)), structural changes such as better inventory management (eg Kahn et al (2002) and Edge and Laubach (2002)), better monetary policy (eg Clarida et al (2000)) and lower inflation (Blanchard and Simon (2001)). Lower inflation and better monetary policy have been stressed especially in the context of cross-country studies.

considerable attention to developing better estimates of output gaps, especially in the context of uncertainty surrounding productivity shocks.[50]

The new-environment view[51]

By contrast, the "new-environment" view sees many of the recent developments as interrelated and potentially forming a novel backdrop for policy. This view emphasises endogenous forces in the system rather than external shocks. And it stresses the conjunction of three factors taking shape over the last decade or so: liberalised financial markets, low and stable inflation - underpinned by higher credibility of central banks' anti-inflation commitment - and positive supply side developments.

According to this view, financial liberalisation has meant that the financial system can more easily accommodate, and reinforce, fluctuations in economic activity. The financial system can act as an amplifying factor as a result of powerful procyclical forces. In the wake of liberalisation, this view sees access to external finance as more plentiful and more intimately driven by perceptions of, and appetite for, risk. And these can move strongly in sympathy with economic activity. Hence the highly procyclical nature of credit, asset prices and market indicators of risk, such as credit spreads. Thus, during booms, virtuous circles can develop, consisting of higher asset prices, muted risk perceptions, weakening external financing constraints, possibly an appreciating currency, greater capital deepening, rising productivity and higher profits. These processes then go into reverse during contractions.

While such processes are a natural element of all business fluctuations, they can also go too far, if the system lacks sufficient built-in mechanisms to prevent it from becoming overstretched. In these instances, masked by benign economic conditions, financial imbalances and associated distortions in the real economy build up and the economy grows at an unsustainable pace. Unless sufficient defences are put in place during the upswing, the subsequent unwinding of such imbalances, and associated distortions in the real economy, can raise the risk of a substantial economic downturn, typically reinforced by financial strains. Ironically, this may be more likely to occur in the wake of positive developments on the supply side. These can justify the belief in permanently higher growth prospects and go hand in hand with heavy capital accumulation and hence endogenous improvements in productivity, profits and more attenuated upward pressure on prices.

In this view, the success in attaining and maintaining low inflation, and the resulting increase in the perceived credibility of central banks, play a subtle role. On the one hand, this success has eliminated an important source of misallocation of resources and of financial instability. Obvious examples include real estate booms driven by attempts to hedge inflation risk, incentives to increase debt because of the interaction of inflation with the tax code, sharp increases in interest rates aimed at quelling inflation and broader inflation-induced distortions in the economy. On the other hand, it has contributed significantly to the attenuation of the inflation process. Under these conditions, excess aggregate demand may tend to be reflected in higher inflation more gradually than in the past.[52] Not least, prices and wages may be less likely to rise if economic agents feel that the authorities will not accommodate the increases. And in the absence of overt inflation, policy rates may fail to rise

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[50] For the importance of output gaps and changes in productivity trends for monetary policy, see Orphanides (2000).

[51] Various elements of this view have been articulated more fully in Borio and Lowe (2002a, 2003) and Borio et al (2001). In fact, this view has very old roots, although some of its aspects have been formalised only recently. For example, the Austrian school, with its emphasis on the role of credit in generating or supporting unsustainable booms, through their interaction with capital formation, is relevant here (eg von Mises (1912) and Hayek (1933)). In Schumpeter (1939) innovations played a much more integral role in business fluctuations. Pigou (1929) emphasised misperceptions of risk, while Kindleberger (1996) and Minsky (1982) took the potential destabilising role of finance much further. Fisher (1932) stressed the debt deflation dynamics following booms. More recent work has formalised the amplifying role of financial factors, seen as a mechanism that increases the persistence of financial shocks, drawing on the asymmetric information literature (eg Bernanke et al (1999b) and Kiyotaki and Moore (1997)). In contrast to the Frischian view of business cycles, which focuses on exogenous shocks, the emphasis of the new-environment perspective on endogenous processes is more in line with the Burns and Mitchell (1946) NBER tradition, which highlights the interaction of profits, investment and credit (see, in particular, Zarnowitz (1992, 1999)). See also Stock and Watson (1991), Hamilton (1989) and Filardo and Gordon (1999) for empirical attempts to distinguish between these two types of business cycle using modern econometric methods.

[52] In an otherwise standard macro model, Amato and Shin (2003) show how inflation may actually provide a distorted signal of underlying developments in the economy in the presence of differential information (lack of "common knowledge").

sufficiently promptly to restrain the growth of imbalances in the economy. Moreover, there may be a risk that the very belief in the stability of the inflation process adds credence to the sustainability of the boom, by removing the most typical cause of the end of expansions.[53,54]

At least five distinguishing characteristics of this view stand out.

First, the role it assigns to financial imbalances is potentially much greater than in the continuity view, and the risks that they are seen as raising may be very different. In the new-environment view, developing financial imbalances, if they appear to be fairly large, provide critical *additional*, and hence *complementary*, information about the likely future pressures on the economy. This information would not be available from traditional indicators of inflation pressures, since those indicators generally focus on the *current and near-term* degree of pressure on resources rather than on the pressures that might develop further out in the future, as financial imbalances unwind. Indeed, because such an unwinding could have a substantial negative impact on spending by trimming asset prices and adversely affecting intermediaries and funding markets, the real risk to which large financial imbalances may point is economic weakness and, with inflation initially low, possibly deflation.

Second, monetary policy can play an important enabling role in the process. If the monetary reaction function of the authorities does not respond to financial imbalances as they build up unless excess demand pressures are seen as raising significant inflation risks, then the central bank may unwittingly accommodate an unsustainable boom in the economy. In this sense, monetary policy may fail to be sufficiently pre-emptive.

Third, from this perspective the credibility of the central bank's anti-inflation commitment can be a double-edged sword. On the one hand, the credibility reinforces other structural factors that may put a lid on inflationary pressures. On the other, with longer-term inflation expectations better anchored around the central banks' inflation objectives, unsustainable booms may take longer to show up in overt inflation. This "*paradox of credibility*" means that the central bank can be a victim of its own success.[55] Conquering inflation can contribute to changes in the dynamics of the system that can mask the risks facing the economy.

Fourth, evidence of low short-term output volatility is not necessarily inconsistent with the new-environment view. Indeed, fluctuations where financial imbalances play a larger role would typically be characterised by a prolonged and sustained upswing, which would allow and encourage the build-up of imbalances. If the data are predominantly drawn from such periods, short-term output volatility can easily be lower compared with a sequence of more traditional cycles.

Finally, in the context of business fluctuations the two views stress different sources of "distortions" in the functioning of the economy and hence of welfare costs. The continuity view emphasises those from misalignments in relative prices of goods and services at a point in time, arising, for instance, from sticky prices. These distortions would disappear if inflation was zero. In this sense, and as a first

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53 Note that this argument is quite different from the traditional one stressing the role of money illusion during the shift from an inflationary to a low-inflation environment. That argument emphasises the notion that agents may mistake nominal for real returns, and hence overestimate earnings and underestimate real debt burdens, thereby fuelling a credit-asset price boom - in effect, the mirror-image of the hypothesis used by Modigliani and Cohn (1979) to explain "excessively" low equity returns in the 1970s. This mechanism, though, may well have played a significant role during the disinflation phase and its aftermath. On this, see also McCauley et al (1999).

54 It is worth stressing that, just as the continuity view would not rule out financial imbalances altogether, so the new-environment view would by no means contend that all cycles exhibit the same characteristics. Moreover, as the historical evidence amply demonstrates, and for very good reasons, high inflation can promote financial instability, especially in the wake of financial liberalisation. Rather, the point here is that the *conjunction* of liberalised financial markets and low and stable inflation can make the system more vulnerable to booms and busts *of the kind described unless* monetary policy is somehow capable of taking into account the altered balance of risks in the new environment. Moreover, as noted, prudential policy also has an important role to play as a first line of defence, and could relieve the burden on monetary policy, but this aspect is not discussed here.

55 This paradox is discussed in Borio and Lowe (2002a, 2003), but elements can also be found elsewhere, notably in Goodfriend (2000a). See also Amato and Shin (2003), who show that in a model without common knowledge the public signal (assumed credible) provided by the central bank about the state of the economy (eg inflation outlook) could excessively condition private beliefs, thereby distorting the information that actual inflation would convey about the true underlying state of the economy (eg excess demand).

approximation, inflation could even be said to a sufficient statistic for them.[56] By contrast, the new-environment view emphasises those distortions impinging on intertemporal consumption/investment decisions, which would manifest themselves in financial imbalances.[57] These are seen as having larger costs in terms of consumption/output over time *over the region of likely inflation rates* in the current policy regime.[58]

Looking back at the experience in recent years, the new-environment view would detect the symptoms of a gradual change in the dynamics of the economy. The experiences in Japan, some countries in East Asia and, in several respects, recent developments in the United States and hence in the global economy share a common characteristic: investment-led booms that were reinforced by financial developments and that did not end up with rapidly rising inflation. In those cases where financial imbalances grew sufficiently large and unwound in a disruptive way, financial strains emerged, helping to put downward pressure on prices.[59]

The new-environment view sees the parallel with the economic environment under the gold standard mentioned earlier as far from purely coincidental or of little relevance for today. As noted, at that time, too, inflation was generally low and expected to remain low while financial markets were lightly regulated and globally integrated. And occasionally, new technologies (eg railways, the electric motor) offered large but difficult-to-estimate returns to investors.[60] In that environment, financial imbalances were a prominent feature of the economic landscape, and often led both to international and to domestic crises with significant macroeconomic effects.[61] For instance, the US stock market and real estate booms of the late 1920s - like the more recent Japanese experience - were followed by a period of protracted economic weakness and deflation.

IV. Policy implications

As can be seen, the two views of recent events and the dynamics of the economy suggest somewhat different policy prescriptions with regard to the identification of inflationary and deflationary pressures and the appropriate monetary policy response. These differences revolve largely around the role played by financial imbalances in the policy framework. They are arguably sharper, or more controversial, in the phase when financial imbalances are building up than when they are unwinding.

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[56] This is, of course, an oversimplification, which holds only in certain models. For instance, movements in output or the output gap are, to some extent, presumed to reflect distortions independently of inflation. Furthermore, wage inflation more directly can represent distortions related to incomplete nominal wage adjustment. However, to a first approximation, the absence of low and stable inflation is largely indicative of the main welfare losses in a common class of models with microeconomic foundations designed to shed light on the proper role of monetary policy.

[57] In other words, investment is put in place to meet future demand that subsequently fails to materialise. These distortions could be mainly sectoral (eg a construction boom) or more generalised. In an essay in its *Annual Report*, the Federal Reserve Bank of Cleveland (1998), drawing on work by Robertson (1926), also cautions against the risk of giving excessive weight to low and stable inflation as a signal that the economy is expanding at a sustainable pace in the presence of signs of financial imbalances. The corresponding historical debate on the value of "productivity norms" is reviewed in Selgin (1997).

[58] As a result, capturing these costs rigorously would arguably require going beyond mainstream models, where distortions in intertemporal saving/investment decisions are ruled out by the joint assumptions of a representative agent and rational expectations. Such alternative models may well be capable of representing the economic processes consistent with the new-environment view without necessarily appealing to elements of bounded rationality or even to transitional learning. For example, research indicates that rational departures of asset values from fundamentals can be sustained in the context of short horizons (linked to principal/agent problems) and lack of common knowledge (eg Allen and Gale (2000), Allen et al (2003) and Abreu and Brunnermeier (2003)). At the same time, the asymmetric nature of the boom-bust fluctuations could be grounded on features of financial markets and the economy. For example, short selling constraints (which might be justified on the basis of asymmetric information and concerns with counterparty/credit risk) may make positive departures from fundamentals more likely than negative ones (eg Carey (1990)). Similarly, the natural non-linearities linked to balance sheet constraints, the zero lower bound on interest rates and capital overhangs could explain specific characteristics of the busts. Needless to say, incorporating all of these features in a macro model represents a major challenge.

[59] This excludes the comparatively short bursts of inflation following some currency crises.

[60] For instance, see David (1990) on the importance of the adoption of the electric dynamo.

[61] Goodhart (2003) and Goodhart and De Largy (1999), among others, have stressed this point.

While the imbalances are still building, the new-environment view might well suggest a more purposeful response with a view to restraining the cumulative process. Once imbalances begin to unwind, and particularly if they do so in an abrupt and disorderly manner, the new-environment view may lead to a somewhat prompter and more intense policy easing in order to blunt the effects of the unwinding on the aggregate economy.

Policy while imbalances are developing

In the continuity view, a boom in financial markets would be seen as likely to contribute to stronger aggregate demand, leading in turn to pressures on resources that would need to be countered by monetary policy to avoid a build-up of inflation pressures.[62] The size of the appropriate policy tightening would depend on the perceived effects of the financial market imbalances on aggregate demand, primarily through cost of capital effects on investment spending and wealth effects on household expenditures.

In practice, however, the effects of the cost of capital on investment are difficult to pin down,[63] and wealth effects on household spending have also proved difficult to estimate, especially in the case of residential real estate.[64] As a result, policymakers might wish to wait until measures of resource use or actual price rises suggest increased inflation pressures. If in a particular period of rapid expansion and high resource use inflation pressures remained in check, perhaps because of well anchored inflation expectations and robust investment and underlying productivity growth, then the perceived need for policy tightening would be diminished, and policy might well remain on hold for a considerable period. Even if financial imbalances were increasing, policymakers would be unlikely to change policy so long as growth and inflation were well behaved.

If the imbalances eventually became large enough to be seen as a risk to the outlook, policymakers might wish to take actions to help support the resiliency of the financial system in the event of a rapid unwinding. Such actions might include public statements warning of the potential risks, as well as efforts to ensure the quality of prudential supervision. In addition, the central bank would be ready to ease policy if needed and to provide liquidity in the event of financial market turbulence.

At least three factors explain the central bank's reluctance to respond to the imbalances by tightening policy with a view to containing them.[65]

First, as noted, according to the continuity view it is very difficult to ***identify*** financial imbalances with a sufficient degree of confidence. The fundamental problem is that financial market participants have access to roughly the same information as policymakers and are presumably investing their funds rationally. Thus, in concluding that there were significant imbalances, policymakers would have to believe that their judgment was better than that of millions of investors who have their own money on the line. Presumably such a judgment would require a high level of proof.[66] Moreover, this view would

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[62] To varying degrees, elements of this view can be found, for instance, in Bernanke and Gertler (1999), Vickers (1999b), Meltzer (2003), Mishkin (2003), Goodfriend (2003), Svensson (2002), Greenspan (1999, 2002) and Bernanke (2002a). Not infrequently, the question is put in terms of the appropriate response to asset price "bubbles".

[63] See Clark (1979, 1993).

[64] For recent analyses of the effects of household wealth on consumer spending, see Davis and Palumbo (2001) and Dynan and Maki (2001). The effects of residential real estate are more complicated because higher house prices both raise wealth and boost the cost of housing. The effects are not necessarily offsetting, however, because some households expect to sell their houses and move to smaller ones in the future, so that they can begin to spend more now. See Lehnart (2002) and Case et al (2002) for recent estimates. Housing wealth may also affect consumption through its use as collateral (Lustig and Van Nieuwerburgh (2002)).

[65] In this volume, Lim discusses the difficulties of identifying asset price bubbles and responding to them through monetary policy in Korea.

[66] One possible exception would include cases in which the incentives of investors were distorted by government interventions or other factors. For example, mispriced deposit insurance or implicit government backing may lead some investors to provide funds to intermediaries at rates that do not reflect the risks taken by those intermediaries. As a result, intermediaries may take on excessive risk, trimming spreads on riskier credits and potentially distorting the pattern of investment. Both the intermediaries and their customers may thus be more likely to fail than would be the case without the government intervention, potentially increasing the risks of a financial crisis with adverse effects on the real economy. However, in such cases, rather than using monetary policy in an attempt to limit the growth of imbalances, a policymaker would be inclined to

stress that not all financial imbalances need be disruptive: some could unwind in a gradual and benign way if action is not taken, making the expected costs of waiting relatively small. Finally, for much the same reasons, even if the imbalances were identifiable in principle, a sufficiently firm judgment would be unlikely to be reached early enough to justify a policy tightening. Indeed, by the time this judgment was formed, the risk of a spontaneous unwinding, coupled with the lags associated with monetary policy, might make a tightening counterproductive.

A second factor militating against a response is a concern about its ***effects,*** specifically about the risk of causing more volatility in the economy, rather than mitigating it. The financial imbalance may be rather unresponsive to policy actions: speculative pressures could be too strong and expected returns too high. As a result, attempts to restrain them could derail other, more expenditure-sensitive, sectors, causing the very recession that policy was designed to avert.

This type of concern has been formalised recently in a fairly standard empirical model of the US economy, where a close relationship exists between output gaps and inflation, augmented by *exogenous* "near rational" bubbles in stock prices.[67] The results suggest that central bankers who stabilise expected inflation may be better off responding only to the anticipated effects of stock prices on expected future inflation than they would be if they respond to the size of the bubble as well.[68]

A final consideration is the very difficult ***political economy issues*** raised by a tighter monetary policy. If the central bank is successful in constraining financial imbalances, it will, by definition, disappoint the expectations of many investors, and it may be blamed for that disappointment. Indeed, given the likely effects of a tightening on output and earnings, the central bank may not be able to demonstrate convincingly, even ex post, that the action was necessary. Moreover, the decision to tighten when output growth is robust but inflation appears to remain in check would be difficult to justify to the public.[69] The conventional argument, that tighter policy is necessary to combat inflationary pressures and permit a longer expansion, might well seem inappropriate if the intent of the policy, at least in the near term, is to slow the economy and initiate the unwinding of the financial imbalances. And if the central bank indicates that it is attempting to slow the economy in order to lower asset prices, the public might well wonder why doing so is desirable given that consumer prices remain stable.

In contrast, policymakers following the new-environment view would be more likely to see growing financial imbalances as a threat to economic stability and to believe that monetary policy can be used to lean against them. Moreover, while recognising the serious political economy constraints, they would not see them as necessarily insurmountable over time.[70]

As regards ***identification***, the new-environment view would find some support in recent research[71] indicating that focusing on the question of whether an asset price bubble is in the making - the most common approach - may not be the best way of posing the problem. According to this research, more mileage can be gained by trying to identify the configuration of symptoms that may foreshadow future generalised financial distress, with significant macroeconomic costs. This work suggests that

address the distortions directly, for example by changing the faulty regulations, or to use prudential supervision to limit their effects on the behaviour of individual institutions.

67 See Bernanke and Gertler (1999, 2001). In addition, the model assumes that, conditional on the cost of capital, investment decisions are based on fundamental value considerations only.

68 Of course, even in this model, strictly speaking, fully optimal policy would include a response to the bubble, in so far as this is a state variable (Filardo (1999, 2001)). Bernanke and Gertler's conclusions are based on the evaluation of a set of "reasonable" simple policy rules. In fact, Cecchetti et al (2000), based on more general policy rules, find that better outcomes can be obtained if monetary policy responds more to stock prices than would be justified by anticipated effects on inflation alone. Bernanke and Gertler (2001), however, question the generality of the results.

69 See, in particular, Yamaguchi (1999a).

70 There is a rather separate literature, not discussed here, also suggesting that it might be appropriate to place a greater weight on asset prices. This, however, is couched in terms of a redefinition of the inflation index, going beyond an index of the price of *currently* produced/consumed goods and services. See Alchian and Klein (1973), Goodhart (1995) and, for a short review, Filardo (1999). And even if it is taken as given that the correct measure refers to current services and goods, Goodhart (2001a) has stressed that, in practice, the way housing prices are treated may deviate considerably from the conceptually correct measure, with first order effects on the corresponding price index. While not examined here, this issue deserves greater attention.

71 See, in particular, Borio and Lowe (2002a,b), building on previous work by Kaminsky and Reinhart (1999).

cumulative deviations of asset prices and aggregate private credit from historical trends, especially if also accompanied by cumulative real exchange rate appreciation, can yield reasonably reliable signals of pending financial crises (Box).[72] In turn, the financial crises considered are episodes that have been shown to be associated with large output losses.[73] In other words, this research suggests that such variables may contain useful information about the sustainability of the expansion and risks to the outlook. These findings also suggest that policymakers might be able to respond to developing imbalances with monetary policy before they reach a stage where a spontaneous unwinding is imminent. To be sure, more work needs to be done in order to make such judgments fully operational. Even so, given that this line of research is in its infancy, considerable scope for improvement would appear to exist.[74]

Moreover, from the perspective of the new-environment view, the level of proof would not need to be as high as for the continuity view. Even if it was granted that the authorities had information similar to that of market participants, they have different responsibilities and incentives. For one, market participants would not internalise the macroeconomic effects of their collective actions.[75] By contrast, the central bank would be expected to weigh the risks to the macroeconomic outlook before taking decisions. And a new-environment perspective would tend to tilt the risks towards action, rather than inaction, given that the occurrence of potentially destabilising financial imbalances is seen as an inherent feature of the economic landscape.

As regards the ***effects*** of policy action, since the new-environment view sees a role for monetary policy in accommodating the build-up of financial imbalances, it also more naturally perceives a potential for policy to contain them. The lack of evidence of rising inflation pressures, if it causes policymakers to stay their hand, can contribute to market participants' beliefs that financial market trends are sustainable. Conversely, by tightening policy pre-emptively, policymakers may be able to limit the build-up of imbalances, and so avoid later volatility. Indeed, by being *seen* as unwilling to accommodate them, policymakers may help to make such imbalances less likely to emerge in the first place.[76] Following a policy tightening, a slowdown in the economy would indeed be envisaged in order to restrain what would be perceived as an unsustainable expansion, much like when the central bank raises interest rates in response to rising inflation. And as in the case of inflation, the induced slowdown today would be seen as a way of avoiding a bigger slowdown in the future.

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72 One might also think of using the level of investment or of the capital stock to identify the imbalances. Quite apart from information lags, however, as described in Borio and Lowe (2002a,b) financial variables appear to outperform investment. Moreover, difficulties in measuring the capital stock make it much harder to rely on this variable, which, at least conceptually, would be superior to the investment flow. The fact that the imbalances may sometimes be concentrated in particular sectors (eg real estate) can complicate matters further. See also Annex 1 on the potential complementary use of measures of the natural rate of interest, possibly to cross-check developments.

73 See, in particular, the work by Hoggarth and Saporta (2001) and Bordo et al (2001).

74 A concern with these types of studies is that the "predictions" of crises are actually made ex post. There is a risk that while one can develop such indicator models after the fact, it may be much harder to do so in advance. For example, indicators of coming financial crises identified before the Asian crisis were not very helpful in anticipating it (Furman and Stiglitz (1998) and Corsetti et al (1999)). One possible reason for this difficulty is that to the degree that policymakers and market participants learn from past experiences of market excess, they would presumably be less likely to make the same mistakes again. But they may well make new ones. As a result, indicators of past crises may well not be of as much use when employed to forecast future crises. Thus, policymakers cannot focus solely on the sources of past imbalances, but also need be on the lookout for new and unexpected sources of vulnerability. Such a broader focus complicates further the identification of excesses to which policy should respond.

75 Partly because of these different incentives and constraints, a new-environment perspective would also more naturally highlight those forces in financial markets that would tend to generate destabilising behaviour and prevent the correction of overvaluations, even if perceived. The possible factors range widely, including biases in the assessment of risk, wedges between individual and "collective" rationality and constraints on arbitrage. These mechanisms may result in excessive procyclicality of the financial system. For an elaboration, see eg Borio et al (2001).

76 See eg Blanchard (2000).

Box 1

Identifying financial imbalances

In recent years, an increasing volume of work has been devoted to the development of leading indicators of financial crises. While much of it has addressed specifically the identification of currency crises, more recently greater attention has begun to be paid to banking crises too.[77] This literature, given its focus on financial stability, has had little influence on the thinking of monetary economists. As noted, much of the discussion about the role of asset prices in monetary policy has been couched in terms of identification and responses to "bubbles". The work on crises, however, can provide useful insights about the set of symptoms that signal future financial strains with macroeconomic consequences. As such, it arguably addresses more directly the set of developments that central banks should care about.

Building on a very useful approach employed by Kaminsky and Reinhart (1999), recently Borio and Lowe (2002a,b) have sought to develop sharper indicators of financial sector vulnerability in both industrial and emerging market countries.[78] For the sake of comparability with previous work, they take a standard definition of banking crisis (Bordo et al (2001)). As In Kaminsky and Reinhart, the usefulness of indicators is judged on the basis of the noise-to-signal ratio, ie in essence the ratio of wrong to correct signals. However, because of the differential costs of making incorrect predictions, somewhat greater weight is placed on predicting a minimum percentage of crises.[79]

This work departs from previous efforts in at least five respects. First, it relies exclusively on ***ex ante information***, as required by policymakers.[80] Second, it focuses on ***cumulative processes***, measured in terms of deviations ("gaps") of the key variables from trends based on ex ante data. This is supposed to capture the build-up of vulnerabilities. Third, it looks only at a very limited set of variables: private credit to GDP, real asset prices, investment and, more recently, the real exchange rate too. Because of data limitations, the only asset prices used are those of equities. Fourth, it calibrates the signal by considering the variables ***jointly***, rather than on a univariate basis. Finally, it allows for ***multiple horizons***, on the view that the precise timing of a crisis is essentially unpredictable.

Box Tables 1 and 2 summarise the main results. At least four points stand out.

- Taking indicators individually, the credit gap is the best: it has the lowest noise-to-signal ratio and correctly predicts the largest number of crises. At a 4% threshold, 80% of the crises are predicted, with about one observation incorrectly classified (crisis/non-crisis) every five or seven, depending on the horizon. By contrast, equity prices have information content, but are a relatively noisy signal (the gap is calibrated at around 40%).[81] Note that, if the output gap is included for comparison purposes, it performs more poorly.
- The noise-to-signal ratio can be considerably improved by calibrating the signals jointly, albeit at the cost of losing predictions of some crises. For example, at a one-year horizon, if credit and asset prices are taken jointly, over 40% of the crises are successfully predicted, and the noise-to-signal ratio is almost halved (one observation incorrectly classified every 12). For a horizon up to three years, some 60% of the crises are predicted, and the noise-to-signal ratio is more than halved (one in 20).[82]
- Adding the real exchange rate gap, by considering situations in which a credit gap coexists with either an exchange rate gap or an asset price gap, raises the percentage of crises predicted to well over 60%, with little change in the noise-to-signal ratio.

77 For reviews, see IMF (2002), Bell and Pain (2000), Eichengreen and Arteta (2000) and Hawkins and Klau (2000).

78 The sample covers 34 countries, the data are annual and cover the period 1960 to 1999. See those articles for further information on the methodology.

79 The noise-to-signal ratio could be reduced a lot by making the signal so conservative that hardly any crises would be predicted.

80 The information is ex ante, but not necessarily real-time. Arguably, at annual frequencies this is less of an issue.

81 In the results shown, the equity gap is introduced with a two-year lead, ie the level of the equity gap two years earlier is used. This is done because of the typical lead-lag relationships and because property prices tend to follow equity prices with a lag of around two years. In the absence of property price data, the equity price gap might then act as a proxy, at least in some cases.

82 Typically, lengthening the horizon even further increases the percentage of crises predicted while reducing the noise-to-signal ratio.

- The size of the optimum thresholds and the predictive performance are broadly similar across the group of industrial and emerging market countries. However, equity prices appear to perform relatively better for industrial countries, and the exchange rate for emerging market countries, at least over short horizons. This is consistent with the greater importance that the exchange rate tends to play in the latter group. In fact, for industrial countries, once the equity price is included, the exchange rate does not appear to add any useful information.

These set of results suggest a number of conclusions. First, focusing on asset prices per se and the question of whether a "bubble" is in train may not be the most useful way of phrasing the question. A combination of symptoms does a better job of assessing the risk of subsequent strains. Second, at least at annual frequencies, the output gap is a poor indicator of unsustainable booms and future financial distress. Since this distress tends to accompany severe economic weakness, information that may be useful to frame monetary policy decisions could be missed. Indicators of financial imbalances appear to contain such additional information. Finally, the findings could be interpreted as saying that it should be possible to form judgments about the build-up of vulnerabilities with a reasonable degree of confidence. However, obviously more work needs to be done in order to provide a sounder and operational basis for policy decisions.

Box Table 1

Indicators of banking crises: all countries

Horizon (years)[2]	Single indicators (gaps)[1]								Joint indicators (gaps)[1]			
	Credit[3] (4)		Asset price[4] (40)		Exchange rate[5] (7)		Output (2)		Credit (4) and asset price (40)		Credit (4) and (asset price (40) or exchange rate (9))	
	Noise/ signal	% crises predicted	Noise/ signal	% crises predicted	Noise/ signal	% crises predicted	Noise/ signal	% crises predicted	Noise/ signal	% crises predicted	Noise/ signal	% crises predicted
1	0.23	80	0.35	50	0.31	0.55	0.57	28	0.14	43	0.13	63
2	0.20	80	0.24	65	0.28	0.55	0.39	38	0.08	55	0.10	68
3	0.18	80	0.19	73	0.26	0.58	0.34	40	0.06	60	0.08	70

[1] A gap is measured as a percentage point or percentage deviation from an ex ante, recursively calculated Hodrick-Prescott trend; the size of the threshold is shown in brackets. [2] A signal is correct if a crisis takes place in any one of the years included in the horizon ahead. Noise is identified as mistaken predictions within the same horizon. Given the data frequency and difficulties in assigning crises to a specific date, year one includes, in addition, the current year. [3] Credit is measured as the ratio of private sector credit to GDP. [4] Real equity price index. [5] Real effective exchange rate.

Source: Borio and Lowe (2002a,b).

Box Table 2

Indicators of banking crises: industrial and emerging market countries

Horizon (years)	Industrial						Emerging market					
	Credit (4) and asset price (40)		Credit (4) and exchange rate (4)		Credit (4) and (asset price (40) or exchange rate (20)[1])		Credit (4) and asset price (40)		Credit (4) and exchange rate (5)		Credit (4) and (asset price (40) or exchange rate (13))	
	Noise/ signal	% crises predicted	Noise/ signal	% crises predicted	Noise/ signal	% crises predicted	Noise/ signal	% crises predicted	Noise/ signal	% crises predicted	Noise/ signal	% crises predicted
1	0.09	50	0.11	44	0.09	50	0.23	38	0.15	58	0.16	67
2	0.06	56	0.10	44	0.06	56	0.12	54	0.11	58	0.12	71
3	0.04	63	0.10	44	0.04	63	0.08	58	0.10	58	0.09	75

[1] Or higher.

Source: Borio and Lowe (2002a,b).

Some of these points have been formalised in models that, contrary to the more standard ones, allow monetary policy to have an impact on the course of the financial imbalances.[83] In these models, the cost of acting pre-emptively is that tighter policy and the unwinding of the current degree of imbalances may cause deviations of output and inflation from the central bank's goals in the near term. The advantage of doing so is that by ending the imbalances sooner, policymakers can reduce the expected volatility of output and inflation later on, when the by-then larger imbalances ultimately do unwind. Clearly, if the central bank has sufficient confidence in its assessments, both of the existence of the imbalances and of its ability to use policy to influence them, tighter policy could be seen as appropriate.[84,85]

Technical and operational issues aside, powerful ***political economy*** constraints on a more pre-emptive monetary policy stance vis-à-vis financial imbalances remain. From a new-environment perspective, however, these are not seen as exogenous. Rather, they are regarded as reflecting to a considerable extent current thinking about the dynamics of the economy, which determines perceptions of the balance of risks and the likely costs of alternative policy responses. These perceptions would be seen as excessively coloured by the inflationary phase of the postwar period - a phase which, in fact, may be regarded as rather exceptional from a longer-term historical standpoint.[86]

Policy once imbalances start to unwind

Assuming that imbalances unwind in a costly manner for the economy, the broad contours of the policy response are not all that different across the two views.

Under the continuity view, declines in asset prices and tightening of credit conditions would be interpreted as adverse shocks, and easier policy presumably would be deployed to offset their effects on aggregate demand. The size of the appropriate easing would depend on movements in asset prices and an assessment of the corresponding effects on spending. Any knock-on effects, such as difficulties at some financial institutions or in some financial markets, could be addressed with additional policy action or emergency liquidity provision as seems appropriate.

While the new-environment view sees insufficiently tight policy as partly responsible for the development of imbalances, once those imbalances begin to unwind it may well justify a more rapid and substantial easing of policy in response to the perceived future evolution of the economy and the associated downside risks. Rather than regarding the unwinding of imbalances as one or more isolated shocks, a new-environment central bank would perceive them as part of a sequence of closely linked events. It would see them as reflecting, and potentially leading to, a broad set of related adjustments to financial markets and spending patterns. As a result, it might be more sensitive to a number of possible downside risks to the economic outlook and to the headwinds that could numb the

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[83] See Kent and Lowe (1997) or (1998). Bordo and Jeanne (2002) reach similar conclusions about the appropriateness of a policy tightening during the boom in a simple model without an asset price bubble but allowing for the possibility of collateral-induced credit crunches and for the endogeneity of credit and asset prices with respect to monetary policy. Blanchard (2000), too, argues that a monetary response may be appropriate, stressing the compositional aggregate demand effects of the bubble and, in particular, the risk of over-investment; see also eg Chirinko and Schaller (2001) for evidence of the impact of the stock market bubble on investment in Japan. Dupor (2002) and Gilchrist and Leahy (2002) show that in microfounded models with distortions of the type discussed here inflation is not a sufficient statistic for departures from economic efficiency, so that stabilising inflation would not be optimal. Depending on the specific distortion assumed, a response to asset prices over and above their implications for inflation stabilisation may thus be appropriate. In contrast to Dupor, however, Gilchrist and Leahy tend to play down the role of asset prices, noting that other variables would contain the relevant information. Within the central banking community, more recently King (2002), Bean (2002) and Bäckstrom (2002) have not ruled out the possibility of a monetary policy response to the build-up of imbalances. See also Mussa (2003) for a similar position.

[84] Ultimately, therefore, the appropriateness of a response depends on beliefs about the "model" describing the behaviour of the economy (including the imbalances) and the degree of uncertainty surrounding those beliefs. This point is clearly illustrated in Filardo (2001).

[85] As discussed in more detail in the next section, it is important to note that using policy to respond to financial imbalances does not reflect a desire by the central bank to *target* financial markets or asset prices per se. Rather, these imbalances are used as important information variables in the context of the overall policy strategy. They are seen as reflecting, and contributing to, distortions in the real economy and, as such, as containing critical additional information about the future behaviour of output and inflation.

[86] See Borio and Lowe (2002a) or (2003) for an elaboration of this point.

effects of policy. These could include the reversal of risk perceptions among economic agents, and hence higher risk premia and a more general withdrawal from risk-taking; a deterioration in the balance sheets of borrowers and intermediaries, possibly including serious strains; and sharp declines in (some types of) investment, owing to the overhang of previous capital accumulation.

At the same time, this stronger response by the new-environment central bank would need to be predicated on the belief that the unwinding of imbalances could not be reversed but simply be cushioned by its policy actions. Otherwise, the risk of prolonging imbalances further could restrain its hand.

In fact, a possible implication of the new-environment view is that spending during the recessions and recoveries that follow unsustainable booms may well be unbalanced. To the extent that the preceding boom was investment-driven, the resulting capital overhang would weigh on investment spending once the boom came to an end. Thus, for a time spending would be very dependent on consumption. More generally, the imbalances seen during the boom could be reflected in the sectoral distribution of spending afterwards. As a result, central banks may find that the easing of policy undertaken in response to unwinding imbalances may contribute to the building of new imbalances in other sectors. For example, the rapid easing in a number of countries in past years as imbalances in the technology sector were reversed may have contributed to a run-up in house prices and so to imbalances in that sector that may need to be unwound at some stage. Such unbalanced spending patterns may significantly complicate the calibration of a policy response.

The possible importance of the zero bound

An added concern for policymakers once financial imbalances begin to unwind is that monetary policy may not be sufficiently effective to return the economy to potential because it is constrained by the zero bound on nominal interest rates. This possibility looms larger in the current environment because of the substantial decline in inflation over the past two decades. With actual and expected inflation of 5 or even 10%, as was common 20 years or so ago, the central bank could respond to adverse shocks by cutting the nominal policy rate to a low level, thereby easily generating negative real policy interest rates if (temporarily) needed. By contrast, with actual and expected inflation of only 1 or 2%, if a substantial adverse shock damps output by enough to push inflation to zero or below, and inflation expectations follow, then the central bank might not be able to engineer the required reduction in ex ante real rates even by cutting the policy rate to zero.

Such an adverse outcome would appear more likely in the new-environment view. In the continuity view, hitting the zero bound would require a series of adverse shocks that might seem improbable. By contrast, according to the new-environment view the forces generated by the unwinding of widespread financial imbalances would be expected to reinforce one another, causing a sharper decline in output and inflation. As a result, policymakers would wish to lower the real policy rate further, but with lower actual inflation weighing on inflation expectations, they might not be able to do so.

How important the zero bound constraint is judged to be depends on two assessments by policymakers. First, are very low or even negative real policy rates likely to be necessary to stabilise the economy? And second, is the zero lower bound on nominal interest rates likely to keep policymakers from achieving sufficiently low real rates, if they are called for? The actual behaviour of real and nominal interest rates during past periods of economic weakness may shed light on these two issues.

The behaviour of the real federal funds rate over the postwar period suggests that periods of negative real rates are not exceptional. Graph IV.1 shows two estimates of the real federal funds rate from the mid-1950s to the present.[87] By either measure, the real policy rate appears to have been negative during some periods of economic weakness, most notably in the 1970s. While these periods may have reflected in part a sluggish policy response to inflation pressures and, arguably, an undesirably easy

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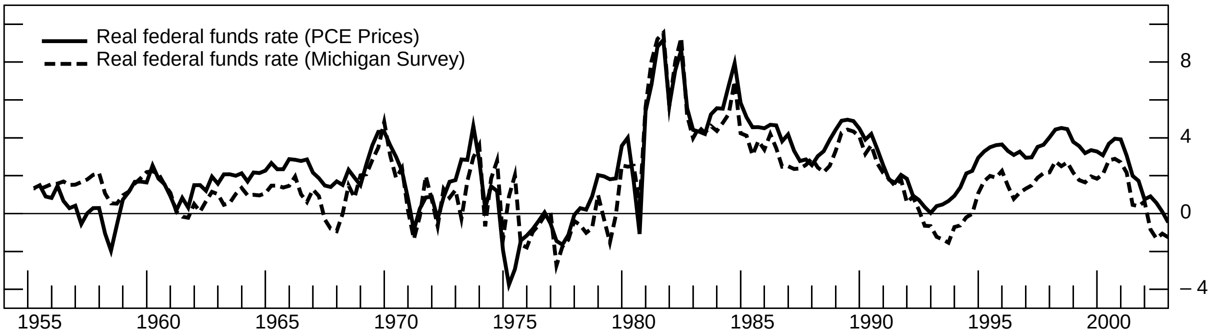
[87] One measure uses the actual lagged four-quarter change in the chain-type price index for personal consumption expenditure as a proxy for expected inflation, while the other uses mean inflation expectations from the Michigan survey. This graph and the next are from English (2000). King (1999) uses the Livingstone survey and the one-year Treasury yield. He finds fewer quarters of negative real rates over a comparable period. However, the one-year rate would fall to zero only if the real funds rate was expected to remain at zero for a year, and the term premium on the one-year bill was zero.

policy stance, they also suggest that policymakers may value the option of generating negative real rates at certain times.

Graph IV.1

Measures of the real federal funds rate, 1955 Q1-2002 Q2

In percentages



Sources: National data; University of Michigan.

Moreover, with actual and expected inflation well contained, policymakers' actions may be more likely to be constrained by the zero bound on nominal interest rates. Evidence on the possible role of the zero bound in a low-inflation environment can be gleaned from the behaviour of interest rates during the gold standard era in the United States (1879-1933). As noted earlier, this period was marked by very low average inflation, and expected inflation was probably very low as well.[88] Unfortunately, there are no data on short-term Treasury yields before 1920. As a result, Graph IV.2 shows the short-term Treasury rate from 1920 on, and the call money rate over the entire period.[89] When the Treasury bill rate was near zero in the 1930s, the call money rate was about 1%, suggesting that the risk premium demanded by those providing call money was about 1%. Over the period from 1879 to 1914, the call money rate fell to about 1% on a number of occasions, generally near NBER business cycle troughs (eg 1885 and 1894). These low call money rates suggest that the zero bound on the short-term risk-free rate may well have been binding in those periods. Of course, there was no central bank in the United States at that time, and it is possible that policymakers could have avoided the zero bound. Therefore, making any inferences about the current environment is hazardous. Nonetheless, these observations might be taken to suggest that the zero bound could constrain central banks that have built solid anti-inflation credentials.

Admittedly, even if policymakers are temporarily constrained by the zero bound, the real policy rate may be low enough to allow the economy gradually to return to potential. However, there is a risk that if the effects of the unwinding of financial imbalances are sufficiently large, the economy could get stuck in a deflationary trap, with output below potential, prices falling and the policy rate at zero.[90] To be sure, such an outcome may be unlikely: despite the relevance of the zero bound in the late 19th century, the US economy did not get caught in this way until the 1930s, when policy is thought to have been poor. Nevertheless, the recent Japanese experience suggests that a deflationary trap is more than a theoretical possibility. Such an outcome would presumably be a greater concern from the perspective of the new-environment view.

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[88] For a discussion of inflation expectations during the gold standard period, see Barsky and DeLong (1991).

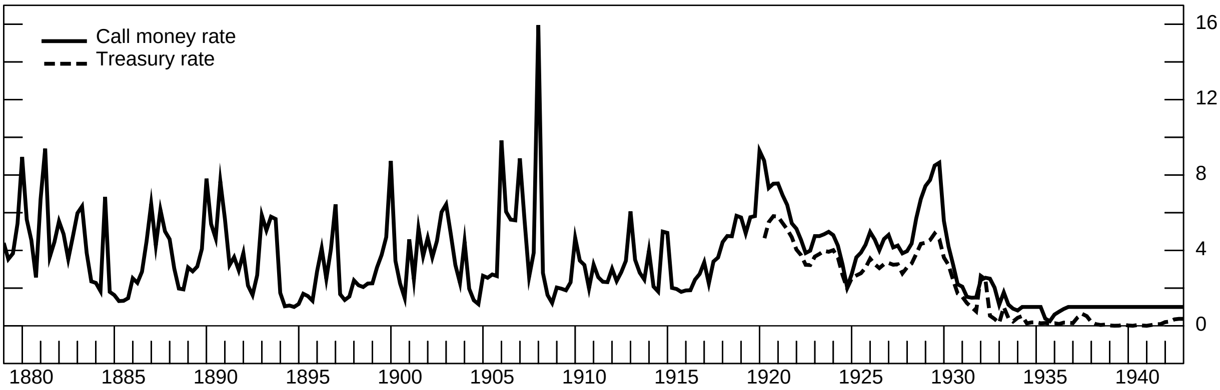
[89] The call money rate was the rate charged on short-term liquid loans backed by securities.

[90] Reifschneider and Williams (2000) have a useful discussion of what is required to tip an economy into a deflationary trap.

Graph IV.2

Call money and short-term Treasury interest rates, 1879 Q1-1940 Q4

In percentages



Source: NBER *Macro History Database.*

A deflationary trap is of particular concern because, once the economy has fallen into one, the policy alternatives are unappealing and their effectiveness less certain.

As regards monetary operations, with interest rates already at zero, the central bank can only inject additional liquidity (bank excess reserves) into the system. If this is done through short-term operations in government securities, significant effects are unlikely, since the assets involved are (nearly) perfect substitutes for reserves.[91] The central bank could also resort to possibly less conventional operations.[92] These could range from outright purchases of long-term government bonds or foreign exchange to private claims of various kinds. Through these, the central bank may even attempt to peg the prices of some of the corresponding assets, such as long-term rates. These operations could well have some expansionary effects, depending on the degree of substitutability of the corresponding instruments in private portfolios. But those effects could be small and require very large operations, thereby possibly straining markets and the balance sheet of the central bank.[93] Moreover, at least in some countries the central bank's ability to implement such policies would be limited by statutory constraints.[94]

At a more strategic level, one approach that has been suggested is that the central bank could commit to a higher inflation rate in the future in order to lower longer-term real interest rates.[95] Alternatively, a price level target could be adopted. A price level target would have the additional merit of acting as a built-in stabiliser: as deflation progressed, the expected degree of reflation would increase.[96] However, as Japanese authorities have pointed out, these proposals will the ends but not the means. A promise of higher inflation in the future at a time when prices are falling and there is considerable slack seems unlikely to be credible.[97] Moreover, investors might reasonably expect that the central bank would choose to limit future inflation once the economy had recovered.[98]

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[91] For a discussion of the Bank of Japan monetary operations, including the shift from targeting the call rate to targeting current account balances (excess reserves), see Borio (2001). For a detailed assessment of the effects of quantitative easing, see Kimura et al in this volume.

[92] See Bernanke (2002).

[93] See, for example, King (1999) and Blinder (2000). Of course, the constraint on the size of the operations may not be regarded as relevant, given the exceptional circumstances (eg Fukao (2002)).

[94] See Clouse et al (2000).

[95] See Krugman (1998).

[96] See Svensson (2002). Note that the gold standard may have served as a credible commitment to a future price level target, helping to limit the effects of the zero bound in the United States until 1933. See English (2000) for a discussion.

[97] Yamaguchi (1999a) has stressed this point.

[98] See King (1999).

Another, possibly complementary, approach would be to push down the exchange rate, or peg it at a depreciated level.[99] While the presence of financial sector strains could reduce its effectiveness by dampening the supply response, this strategy could at least boost demand for the tradable sector and improve its profitability. This strategy, however, could be perceived as of the "beggar-thy-neighbour" kind. This could cause frictions with trading partners, especially if undertaken by a large economy and in a context of more generalised economic weakness. Thus, the degree to which the business cycles in various countries are synchronised may influence the ability of a particular country to employ devaluation to combat the zero bound. And to the extent that the globalisation of financial markets has increased the likelihood that financial imbalances affect multiple countries at more or less the same time, there may be less latitude for unilateral exchange rate policy than in the past.

Other, even more extreme, policies have been suggested to escape from a deflationary trap. For example, it has been argued that a tax on the monetary base could, by pushing the bound on nominal interest rates below zero, provide policymakers with greater latitude for policy easing.[100] But taxes on currency holdings could adversely affect sentiment, and could also risk damage to the role of currency as the means of payment.[101]

Such desperate-sounding proposals highlight the potential difficulties the zero bound in the context of a deflationary trap can pose for monetary policymakers. These difficulties, in turn, suggest that other, complementary and mutually reinforcing policies may be appropriate to generate the necessary increase in aggregate demand while relieving supply side constraints.

Fiscal policy is a prime candidate. However, expansionary fiscal policy may not always be feasible or sufficient to bring about a recovery. For example, a country's ability to employ expansionary fiscal policy as well as its effectiveness would be constrained in the presence of large existing debts. In such cases, further large deficits could even raise concerns about the country's solvency, in which case the central bank might come under pressure to tighten monetary policy in order to avert a currency crisis and consequent financial market difficulties.[102] Any such policy would call for a delicate balancing act between short-run expansionary measures combined with a credible medium-term plan to ensure sustainability of the burden.

A second candidate would be the restructuring of the banking, corporate and possibly household sectors, which are likely to be in distress. Distress can severely impair the intermediation process. By the same token, it can also blunt the effectiveness of other measures to boost aggregate demand.[103] Any such restructuring would have to balance the need to redress balance sheets in the short run - calling for some form of direct or indirect recapitalisation - with that of putting in place the conditions for effective and profitable operation in the longer term. This would include, for instance, eliminating excess capacity and establishing incentives for the extension of credit at prices and terms that reflect the underlying creditworthiness of borrowers. As the experience of several countries that have faced widespread financial distress indicates, policies such as these are not easy to decide upon and implement. Quite apart from technical difficulties and the delicate economic trade-offs involved, the necessary political consensus may be lacking.

Given that the zero bound could be a significant problem, how should monetary policymakers take it into account in their behaviour? First, they may wish to set a higher target inflation rate than would otherwise be the case, to provide a buffer relative to the zero bound. Indeed, countries with numerical inflation objectives generally select targets that are above the estimated bias in measures of inflation,

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99 Drawing on the experience of the Great Depression, a number of studies have pointed to the effectiveness of exchange rate devaluations in a similar context, eg Choudhri and Kochin (1980), Eichengreen and Sachs (1985) and Campa (1990). Svensson (2000) has suggested complementing a strategy of exchange rate devaluation with a price level target.

100 See Goodfriend (2000b). The tax could be extended to all government-backed financial assets (Fukao (2002)).

101 On these points, see Mussa (2000b) and Freedman (2000), respectively.

102 In some countries, fiscal policy may also be constrained by institutional mechanisms designed to ensure a degree of fiscal discipline. The Stability and Growth Pact in Europe has been cited in this context. It should be noted, however, that the Stability and Growth Pact does allow deficits above the 3% of GDP ceiling in exceptional circumstances.

103 Moreover, from this perspective keeping interest rates at zero may even hinder the required restructuring, by reducing incentives to foreclose on insolvent borrowers. On the relationship between monetary policy and structural policies, see Shirakawa (2000) and Yamaguchi (1999b).

thereby providing such a buffer.[104] Second, they could try to ensure that the inflation target is seen as symmetrical; in other words they could try as hard to keep inflation from falling below the target as they do to keep it from rising above it. Such a symmetric strategy could help prevent inflation expectations from rapidly falling below the target in the event of an undershooting of actual inflation. To the extent that this effort is successful, inflation expectations may become more symmetrically anchored at the target value, allowing the central bank to reduce real policy rates considerably even following large adverse shocks. Third, policymakers might consider adopting a price level target. However, a significant potential drawback of this strategy is that it could force countries to have negative inflation following inflationary shocks, which could be destabilising.[105]

Finally, if adverse shocks drive inflation and the policy rate to levels low enough to make the zero bound a more immediate issue, the central bank may wish to react more aggressively to any further negative shocks.[106] Given the possibility that the economy could reach and get stuck at the zero bound, the costs of downside surprises to the outlook in such cases are likely to be considerably larger than those of similarly sized upside surprises, suggesting that a non-linear response might be warranted. Moreover, in the new-environment view the unwinding of financial imbalances would be seen as likely to impair the operation of financial institutions and markets, perhaps generating headwinds that would reduce the effectiveness of monetary policy in stimulating the economy. As a result, policymakers, taking account of these possibilities, might well choose to ease policy further than might otherwise have been expected in order to balance the risks to the outlook.

Some might argue that it could be better to hold back on policy easing when rates reach low levels in order to "keep the powder dry". This would allow the central bank to ease policy following any *additional* adverse shocks that might arise. Presumably the benefit such an approach might offer is that if a new shock were to emerge the announcement of a policy easing would provide support for consumer and business confidence *at a critical juncture*, thereby making it more effective and valuable. After all, the alternative of easing policy sooner would provide greater support for aggregate demand through the usual transmission mechanism. Even if it were thought likely that policy announcements could play such a useful role, however, holding in reserve an easing of policy that would otherwise be appropriate because of proximity to the zero bound could prove very costly if it allowed the economy to fall into a liquidity trap.[107]

V. Refining the policy framework?

What are the implications of the above analysis for the adequacy of current policy frameworks? Not surprisingly, they depend in large part on which perspective is taken when assessing the challenges faced by central banks in recent years.

According to the continuity view, no adjustments are really necessary. To the extent that economic developments have resulted from a series of *specific* shocks to an otherwise stable environment, previous policy benchmarks and guidelines are still reliable. To be sure, central banks may have been confronted with rather large swings in asset prices by past standards. But there is no reason to believe that these are particularly likely to recur in future. Likewise, in those countries most severely affected, the recent series of negative shocks to economic activity could bring the prospect of reaching the zero lower bound for interest rates closer to the radar screen. But even then the risk might be perceived as

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[104] However, the inclusion of such a buffer probably reflects, at least in part, concerns about downward wage rigidities. For an analysis, see Akerlof et al (1996).

[105] Blinder (2000) notes that the price level target could be an upward-sloping trajectory for the price level. Such a target could obviate the need to engineer a deflation in most circumstances.

[106] This possibility is discussed by Blinder (2000), Freedman (2000) and Viñals (2000).

[107] An alternative justification for staying one's hand might be for "fear of misfiring". In this case, the central bank might be concerned about the possibility that reducing interest rates to a level close to the zero bound could actually *undermine* confidence. This could occur if the public became worried that the central bank was running out of ammunition or interpreted the action as a sign that the situation was worse than anticipated. This justification, while quite distinct, might be observationally difficult to distinguish from the one outlined in the text.

relatively small. After all, historical experience might suggest that, at least given the past history of economic shocks in the postwar period, the probability of reaching the bound is rather low.

The picture looks rather different from the perspective of the new-environment view. According to this, large swings in asset prices and credit are likely to be less rare than in the past, given the conjunction of a liberalised financial environment and low and stable inflation and assuming monetary policy strategies that do not respond explicitly to the build-up of financial imbalances. This environment can make it less likely that unsustainable booms show up in overt inflation, allowing them to expand further, potentially even tilting the balance of risks from inflation towards deflation. As a result, other things equal, financial instability is a more serious concern.

According to this view, it may be important for the monetary framework to allow for a ***pre-emptive tightening*** of policy to limit the build-up of financial imbalances ***even in the absence of obvious inflationary pressures***. Could current frameworks accommodate this? In particular, would this require a redefinition of policy goals or just a change in the way present goals are pursued?

It may be natural to think that such a policy would call for the addition of an explicit financial stability objective alongside more traditional macroeconomic ones. Financial imbalances are the harbinger of financial distress down the road. Therefore, a central bank with explicit responsibility for financial stability would have a clearer mandate to respond to their build-up even if monetary stability did not appear to be under threat.

No doubt an explicit financial stability objective would tighten and make more obvious the link between the policy action and the goal. This is because it is easy to *see* an immediate relationship between financial excesses and financial strains. At the same time, such a redefinition of objectives is not necessary and might not even be desirable for at least three reasons.

The first reason why such a redefinition is not necessary is that central banks have a long-standing legitimate interest in financial stability, which in fact predates their concerns with price stability. As a result, the basis for monetary policy actions to address financial stability concerns already exists. Historically the concern with financial instability loomed large in the early evolution of central banks, if not in their establishment. It was not until the interwar period, with the gradual emergence of fiat-money standards, that price stability assumed an importance of its own. And with the Great Inflation of the postwar era, price stability became an overriding objective. More recently, with financial stability clawing its way back to the top of the policy agenda, central banks have inevitably been playing a leading role in efforts to promote it.[108]

Indeed, a consensus has emerged over some of the activities that central banks can undertake to support financial stability. Most basically, central banks should promote the establishment and operation of a safe and sound financial infrastructure. Important elements of this infrastructure include the framework of prudential regulation and supervision as well as payment and settlement systems. In addition, central banks can play a critical role in crisis management. A common instrument here is the provision of emergency liquidity assistance. Finally, from a macro perspective, price stability is seen as conducive to financial stability, as it lays the foundation for long-term sustainable growth and, in practice, is associated with lower volatility of inflation.[109]

The second reason why a redefinition of objectives may not be necessary is that traditional macroeconomic objectives can accommodate the required policy response. Arguably, financial

[108] See Goodhart (1988) for a description of the early evolution of central banking and De Kock (1974) for an explanation of the shift from financial stability to price stability objectives in central bank statutes. Laidler (2001) explains the history of the thinking on the link between monetary and financial stability until World War II; Crockett (2000a), Borio and Crockett (2000) and Borio and Lowe (2002a) provide a stylised perspective on the nexus between monetary and financial stability to the present day. BIS (1997) describes the parallel evolution of central bank involvement in the pursuit of monetary and financial stability since Bretton Woods. See also Padoa-Schioppa (2002).

[109] Admittedly, how these general principles translate into practice can differ considerably across countries. One reason is differences in the allocation of specific responsibilities in the various areas impinging on financial stability, including prudential regulation and supervision, payment and settlement systems, market infrastructure and surveillance, and crisis management. Another reason is differences in policymakers' beliefs about the effectiveness of the various policy options, which are, in turn, strongly influenced by historical experience. For example, there is no agreement on the merits of transparency in emergency liquidity arrangements. Nor, indeed, is there any on the trade-offs between financial and monetary stability responsibilities. As a result, differences in the way the responsibility for financial stability is allocated across institutions in the legal framework can appear bewilderingly large.

instability can best be factored into decisions through its implications for traditional central bank objectives, such as inflation and output.[110] Correspondingly, at least from a macroeconomic perspective, financial instability could be best defined as ***the set of disruptive financial events that could generate macroeconomic costs in terms of those objectives***.[111] For example, distress among financial institutions would not matter per se, but only if it was associated with output losses and the risk of deflation. In assessing the implications of financial strains, the risk of loss of effectiveness of monetary policy should obviously also be taken into account. As noted earlier, financial distress can generate "headwinds" and, especially if interest rates reach the zero lower bound, the efficacy of the monetary policy levers can be badly impaired, if not crippled. From a new-environment perspective, this definition of financial instability would be sufficient to accommodate a pre-emptive tightening, since financial imbalances would be seen as containing critical information about the balance of risks facing the economy in terms of inflation and output.

Finally, a redefinition of objectives may not be desirable because it could risk placing the central bank under pressure to deviate too much from its macroeconomic goals in order to avoid the possibility of causing financial strains. In particular, central banks could come under unwarranted pressure to ease (or to delay a tightening) in order to address financial strains that would have only limited implications for the macroeconomy. This could in turn raise the risk of encouraging excessively imprudent behaviour - the so-called moral hazard problem. Indeed, as argued elsewhere, and partly for similar reasons, there may be merit in prudential authorities shifting further in the same direction too, away from the pursuit of narrowly interpreted depositor or investor protection objectives.[112]

While broadly consistent with current central bank mandates, operationally the shift in perspective implied by the new-environment view has somewhat different implications for specific monetary frameworks. The reconciliation is more immediate where the central bank is not pinned down to any numerical objective for inflation over an explicit short-term horizon. At least for communication purposes, in strict inflation targeting regimes with up to two-year horizons the justification of policy actions in response to imbalances may not be straightforward.[113] To be sure, it should be well understood by now that as long as inflation is on target the central bank has leeway to pursue other objectives, not least smoothing output fluctuations. But it may be hard to rationalise a tightening in the absence of obvious inflation pressures, especially if the outcome is likely to be inflation below target over the usual horizon.

Arguably, at least two modifications would be called for in this case.[114] First, policy decisions should be articulated on the basis of a somewhat ***longer horizon***.[115] While the precise timing of the unwinding of imbalances is rather unpredictable, the processes involved tend to be drawn-out ones. For example, the notion of ensuring price stability on a "sustainable" basis might be useful in capturing the prospect of future downward pressure on prices linked with the unwinding.[116] The second modification would be to place greater weight on the ***balance of risks*** in the outlook, as opposed to central scenarios or most likely outcomes.[117] This would highlight the role of monetary policy actions in providing *insurance*

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[110] While possibly giving rise to some complications in communicating with the public at large, it is clear that even for inflation targeting central banks output fluctuations are a consideration - so called "flexible inflation targeting". These affect the gradualism with which targets are pursued (eg width of the band, length of the horizon, etc). On this, see eg Svensson (1999) and King (1996).

[111] This is broadly consistent with Ferguson (2002).

[112] See, in particular, Crockett (2000b) and Borio (2003), who contrast such a "macroprudential" perspective with a "microprudential" perspective of financial stability. Various aspects of this issue are also discussed in BIS (2001c) and Borio et al (2001). Crockett (2001) summarises concisely the implied shift in perspective on the part of both monetary and prudential authorities.

[113] For a useful discussion of communication issues in the context of an inflation targeting regime, see Friedman (2002).

[114] See also Borio and Lowe (2002a) or (2003) on this.

[115] Note that this rationale for lengthening the horizon is quite different from the one normally associated with the inflation targeting literature, namely, introducing gradualism into policy because of concerns with output fluctuations (eg Svensson (1999)). Rather, it reflects the view that the phenomena in question cannot be adequately captured over short horizons.

[116] This notion is put forward in Shiratsuka (2001).

[117] Decisions of this kind are formalised, for instance, in Svensson (1999). Less information-intensive decision rules, based on the notion of minimising the costs of worst case scenarios, have been discussed by, for instance, Courakis (1981), Hansen and Sargent (2001) and Onatski and Stock (2000), typically in the context of model uncertainty.

against costly outcomes. Central banks are already used to thinking in these terms. But the nature of the problem would put a premium on considerations of this kind.[118]

A related issue is whether policy frameworks in which monetary aggregates still play a prominent role can more naturally accommodate policies aimed at addressing the build-up of financial imbalances. The two-pillar policy of the ECB is a clear case in point. No doubt, such frameworks can make it easier to justify interest rate increases even in the absence of near-term inflationary pressures as long as the corresponding monetary aggregates are growing fast. After all, underpinning a more pre-emptive use of the monetary policy levers was an important analytical reason for the adoption of monetary targets in the first place.[119] Pillar I in the ECB strategy is rationalised precisely in terms of providing better signals about inflationary pressures beyond short horizons, complementing the assessment of more near-term inflation pressures based largely on real side indicators under Pillar II.[120] Even so, the long-standing justification for responding to rapid monetary growth is that it foreshadows *inflationary* pressures. As emphasised here, however, financial imbalances also can herald recessionary, and so potentially deflationary, pressures down the road. This could raise delicate issues of communication and transparency unless a broader set of potential outcomes was explicitly considered.

Conclusion

Old or new challenges for central banks in the years ahead? In this paper we have argued that the answer depends to a considerable extent on the interpretation of economic developments over the last two decades and, more subtly perhaps, on how far back we are prepared to cast our gaze in search of comparisons. In order to highlight the importance of the interpretation, we have told two alternative stories, corresponding to two intentionally polarised perspectives.

According to the so-called ***"continuity" view***, the economic environment facing central banks has not fundamentally changed relative to that prevailing during much of the inflationary period. To be sure, largely thanks to central banks' determined efforts, inflation has been brought under control, and is now lower and more stable than at any time since at least the 1960s. But the lessons drawn from the great inflation period about the functioning of the economy and the inflation process remain fully valid. As a result, there is little need to adjust the trusted policy benchmarks honed during this historical phase.

By contrast, according to the ***"new-environment" view***, the incremental changes that have occurred in the environment cannot so easily be accommodated within traditional paradigms. Financial liberalisation, in conjunction with the greater anti-inflation credibility of the institutional framework, may have resulted in a subtle change in the dynamics of the economy. As a result of financial liberalisation, financial markets can more easily accommodate booms and busts. And with expectations better anchored around inflation objectives, it is possible that underlying excess demand pressures may take somewhat longer to show up in overt inflation, especially during investment-driven booms, possibly triggered by supply side improvements. Thus, if the monetary authorities wait for clear evidence of near-term inflation pressures before tightening policy, they may unwittingly accommodate the build-up of financial imbalances. Booms of this kind can result in an equally subtle change in the balance of risks, away from higher inflation and towards economic weakness, financial strains and,

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118 We do not elaborate here on how this could actually be implemented. Various possibilities could be considered. One might be the use of reference ranges for the variables of key interest; methodologically, this would be similar to the analysis in Christiano and Rostagno (2001). Recently, King (2002) and Bean (2002) have discussed how a response to financial imbalances could be accommodated within an inflation targeting framework along lines similar to those outlined in the text here.

119 To be sure, the information content of credit may dominate that of monetary aggregates. Conceptually, the link between credit and asset prices is arguably stronger than that between monetary aggregates and prices. Empirically, there is some evidence supporting this conclusion (Borio et al (1994)). For instance, it is not uncommon for financial imbalances to be sustained through borrowing in the international interbank market. This financing would not show up in monetary aggregates. Nevertheless, especially for broad definitions, there would tend to be a positive correlation between money and credit expansion. The Japanese experience during the build-up of the bubble is an obvious example.

120 In particular, Issing (2002a,b) discusses how Pillar I could take into account financial imbalances of the type described here. More generally, Masuch et al in this volume consider the usefulness of money in monetary policymaking.

given the starting low level of inflation, possibly even deflation, linked to a disruptive unwinding of the imbalances. In other words, this new environment may make it harder for monetary policy to be sufficiently pre-emptive. It may be necessary to go back to the gold standard period to find economic conditions that, in some significant respects, resemble those prevailing today.

While the two perspectives look quite at odds, the operational differences in their policy implications can easily be overstated. We have argued that accommodating the new perspective would not require a change in the basic ***objectives*** of monetary policy but, rather, some modification in the ***way*** those objectives are pursued. It would call for somewhat ***longer policy horizons*** than the standard of one to two years commonly used at present and greater attention to the ***balance of risks*** in the outlook. Above all, it would call for greater weight being given to signs of the build-up of ***financial imbalances*** in deciding when and how far to tighten policy, as these imbalances would be seen as containing critical additional information about the sustainability of the economic expansion and hence the risks to the outlook.

Translating these general considerations into operational and politically acceptable guidelines for policy would obviously require considerably more work. Some empirical research has been done with a view to identifying the contours of financial imbalances. While the results may suggest that the basis for judgments about the existence of financial imbalances is there, more work would be needed to provide a sounder basis for such judgments. Likewise, as it stands, the new-environment view offers a broad outline of the economic processes at play. But more analytical work would be needed into the relationship between financial imbalances, the business cycle and monetary policy to provide the confidence in our understanding necessary to underpin policy actions. Moreover, these efforts would be indispensable to allay the political economy pressures that, at present, would in all probability make it impossible to adopt the more pre-emptive policy consistent with the new-environment view. Arguably, it was an analogous change in the climate of intellectual opinion with regard to inflation in the 1970s that provided the basis for the subsequent successful fight against it.

While not explicitly discussed in this paper, the new-environment view also has significant implications for the relationship between monetary and prudential policy. To the extent that financial imbalances are a more significant factor behind business fluctuations, the risk of financial crises with an origin in the nexus between overall financial developments and the macroeconomy increases. The difficulty in using monetary policy to address the imbalances puts a premium on prudential policy, perhaps calling for a shift in perspective among prudential authorities too. It is not uncommon for them to argue that if financial problems arise from a generalised financial cycle, then they have essentially a macroeconomic origin, and as such are best addressed through monetary policy. The new-environment view would naturally point to the need for greater cooperation between the two types of authority. Analytically, it would also highlight the desirability for greater cross-fertilisation between two intellectual traditions that have tended to develop separately over time.

Two perspectives, two paradigms, two sets of policy prescriptions, but a shared goal. Which view approximates reality more closely could have implications for the future evolution of the world economy and the art of central banking. Exploring further their relative merits is a task that would seem to deserve further attention.

Annex:
The natural rate of interest

In the past several years, central banks have become increasingly interested in the natural rate of interest as an indicator for monetary policy. Three factors explain this revival of interest. One is a greater emphasis on targeting interest rates rather than money growth or the exchange rate. In an interest rate targeting regime, the natural rate can act as a policy benchmark that provides information with which to judge the stance of monetary policy, ie to judge whether the policy rate is relatively high or low. A second reason is increased uncertainty about more traditional guides for policy, such as the output gap and the NAIRU and monetary aggregates themselves. Finally, the success of the Taylor-rule approach in monetary policy research has led to a more intensive theoretical and empirical focus on the link between the real interest rate and inflation. This has cast new light on the pioneering research of Knut Wicksell.

Conceptual issues

Wicksell (1907) described the natural rate of interest as the value of the real rate consistent with price stability in the long run. The key relationship here is the gap between the natural rate of interest and market real interest rates. If a central bank tries to maintain market real interest rates above the natural rate of interest, then asset prices will fall and consumption slow. In addition, the relatively high market interest rate will reduce the attractiveness of new capital spending, thereby reducing investment. In addition, in a flexible exchange rate regime, it would put upward pressure on the exchange rate, which would depress net exports. In sum, according to the theory, a higher market interest rate leads to lower aggregate demand and thereby reduces pressure on prices. The effects would be reversed if a central bank were to maintain the market real interest rate below the natural rate of interest, thereby putting upward pressure on prices.[121]

Friedman (1968) drew a parallel between the concept of the natural rate of unemployment that he was developing at the time and that of the natural rate of interest. By analogy with the natural rate of unemployment, a version of the natural rate of interest - which might be labelled the steady state real interest rate - could be thought of as the steady state real rate of interest that would keep inflation stable over time.

In recent years, Woodford (2002) has offered another interpretation of the Wicksellian natural rate within the context of a modern (dynamic stochastic general equilibrium) monetary policy model. In the flexible price version of the model, the natural rate is defined as the real interest rate that would keep inflation constant from one period to the next. In contrast to the notions of Wicksell and Friedman, this neo-Wicksellian rate of interest would generally be strongly time-varying, reflecting various demand and supply shocks, including fiscal and commodity price shocks. These would cause inflationary pressure to rise or fall in the absence of an offsetting change in the real interest rate.

Practical issues

The natural rate of interest may be easy to define conceptually but is difficult to implement in practice because it is not directly observable. A major problem is that the Wicksellian natural rate is conceptually linked to the risk-free real interest rate. In most bond markets, this risk-free rate must be inferred by adjusting the nominal interest rate for estimates of expected inflation, time-varying risk premia and the effect of certain market restrictions, such as impediments to capital flows.[122] More

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[121] Wicksell (1907) succinctly summed up the implications of the natural rate of interest: "If, other things remaining the same, the leading banks of the world were to lower their rate of interest, say 1% below its ordinary level, and keep it so for some years, then the prices of all commodities would rise and rise and rise without any limit whatever; on the contrary, if the leading banks were to raise their rate of interest, say 1% above its normal level, and keep it there for some years, then all prices would fall and fall and fall without any limit except Zero."

[122] In this volume, Upper and Worms argue that survey data on inflation expectations can be used to construct accurate estimates of ex ante real interest rates.

fundamentally, the natural rate is that hypothetical real interest rate that is consistent with stable inflation - over the long run in the case of Wicksell's version of the natural rate or over the short run in the case of Woodford's version. As a result, estimates of the equilibrium real rate are generally based on a specific model of the economy, making the results dependent on the explicit and implicit assumptions embedded in it.

While none of these problems is easy to resolve, the potential value of the natural rate framework for monetary policymaking can be assessed by looking at the correlation between a proxy for the real interest rate gap - ie the difference between the actual real rate and the equilibrium real rate - and subsequent changes in inflation. As Blinder (1998) suggests, a reasonable empirical proxy of the real rate gap can be estimated as the ex post real interest rate less its average value over a period sufficiently long to average out most of the effects from transitory economic shocks.[123] This approach is used in Graph A1. Two empirical estimates of the natural rate for each country are plotted - the mean of the ex post real rate (horizontal dotted line) and a time-varying measure of the trend level of the ex post real rate based on a Hodrick-Prescott filter (dashed line).[124]

The results of using these specific approximations point to at least two observations. First, it is clear that the gap between the actual ex post real interest rate and either of the proxies for the natural rate can be quite large and is variable. The time-varying estimate of the natural rate also appears to change by several percentage points over periods as short as five years. Second, consistent with the theory, there is prima facie evidence that a positive real rate gap indicates a relatively tight monetary policy that puts downward pressure on inflation, while a negative gap indicates a relatively easy monetary policy (Graph A2, using the time-varying estimates of the natural rate). Despite the small sample size and low t-statistics, the negative relationship across countries is evident.[125] This suggests that the real rate gap may contain useful information about inflation dynamics and the stance of monetary policy, as also confirmed by other recent empirical studies.[126]

Thus, the natural rate of interest might be a useful additional tool in the formulation of monetary policy, if only to cross-validate information contained in other policy indicators.[127] The natural rate could be used on its own or as an input into other policy guides, such as into a Taylor-like rule.

Goodhart (2001b) considers the strategic use of a short-run version of Wicksell's natural rate in policy deliberations, arguing that the natural rate, if informative and used appropriately, can help underpin a pre-emptive policy stance. He draws this conclusion, in part, from the actual practices of the Monetary Policy Committee (MPC) at the Bank of England. The MPC asks its staff to prepare a forecast model-based estimate of the constant interest rate consistent with achieving the inflation target over a horizon of two years. This constant interest rate path - equivalent to a short-term natural rate - then sets the

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[123] One complication is that the natural rate may vary over time owing to structural changes in the economy. For example, in recent years, policymakers have been concerned about the effect of faster economic growth on the natural rate. Theoretically, a faster trend growth rate (eg because of more rapid technological progress) would drive up the natural interest rate in a neoclassical growth model. The extent of the increase would depend on the willingness of consumers to forgo consumption in order to save and invest in the new technologies (Goodfriend and King (1997)). But other structural changes can also affect the natural rate. For instance, a structural shift in the natural rate can occur if consumers and firms change the rate at which they discount future outcomes, if there are structural changes in fiscal policy, or if there are changes in the economy's degree of openness. As a consequence, empirical estimates of the natural rate as a long-run concept would need to be calculated over a period long enough to reduce the transitory effects of shocks but not so long that the effects of structural shifts are blurred.

[124] The tuning parameter in the Hodrick-Prescott filter was set at a very high level ($\lambda = 30000$) in order to smooth the trend series. No attempt was made to adjust the nominal interest rates for risk premia. Amato (2002) uses an alternative approach based on the Kalman filter to obtain estimates of the low frequency component of the short-term real interest rate, which can be interpreted as the long-run natural rate of interest. He finds evidence of significant variation in long-run real rates in Germany, United Kingdom and United States using data on both consumption growth and ex post real rates.

[125] The sample was restricted to exclude periods of extreme financial market stress, such as currency and financial crises.

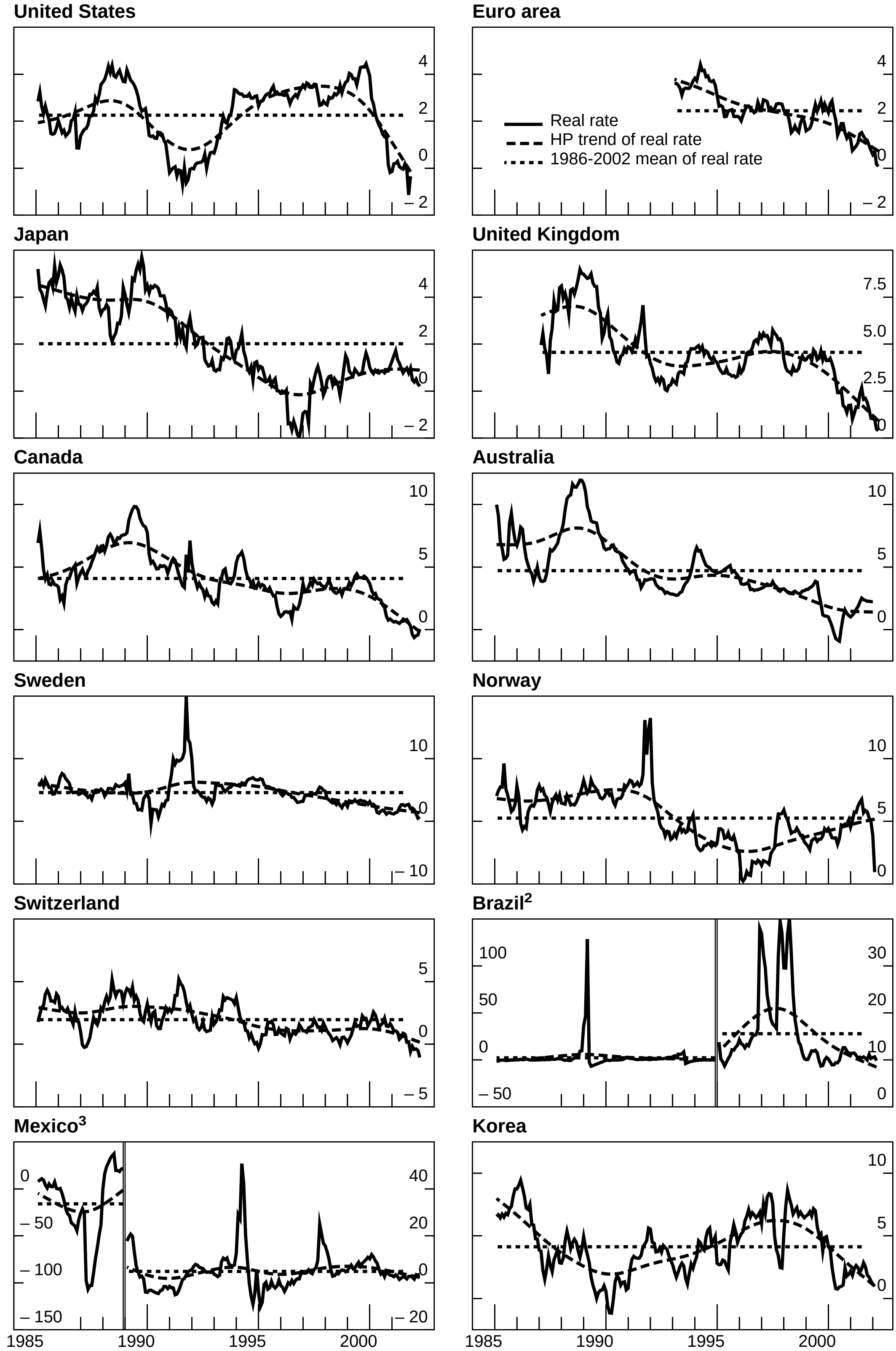
[126] See Laubach and Williams (2001) for the United States, Archibald and Hunter (2001) for New Zealand, Calderón and Gallego (2002) for Chile, Neiss and Nelson (2001) for the United Kingdom and Christensen (2002) for Denmark. These studies also find that the information content and empirical reliability of estimates of the natural rate are likely to vary with the time horizon - ie the short run, the medium run or the long run - as well as across economic regions or countries. The relative usefulness of the natural rate at different horizons deserves further research.

[127] See also Issing (2002a) and Christiano and Rostagno (2001).

Graph A.1

Natural rate of interest and real interest rate

Nominal rate minus 12-month inflation[1]

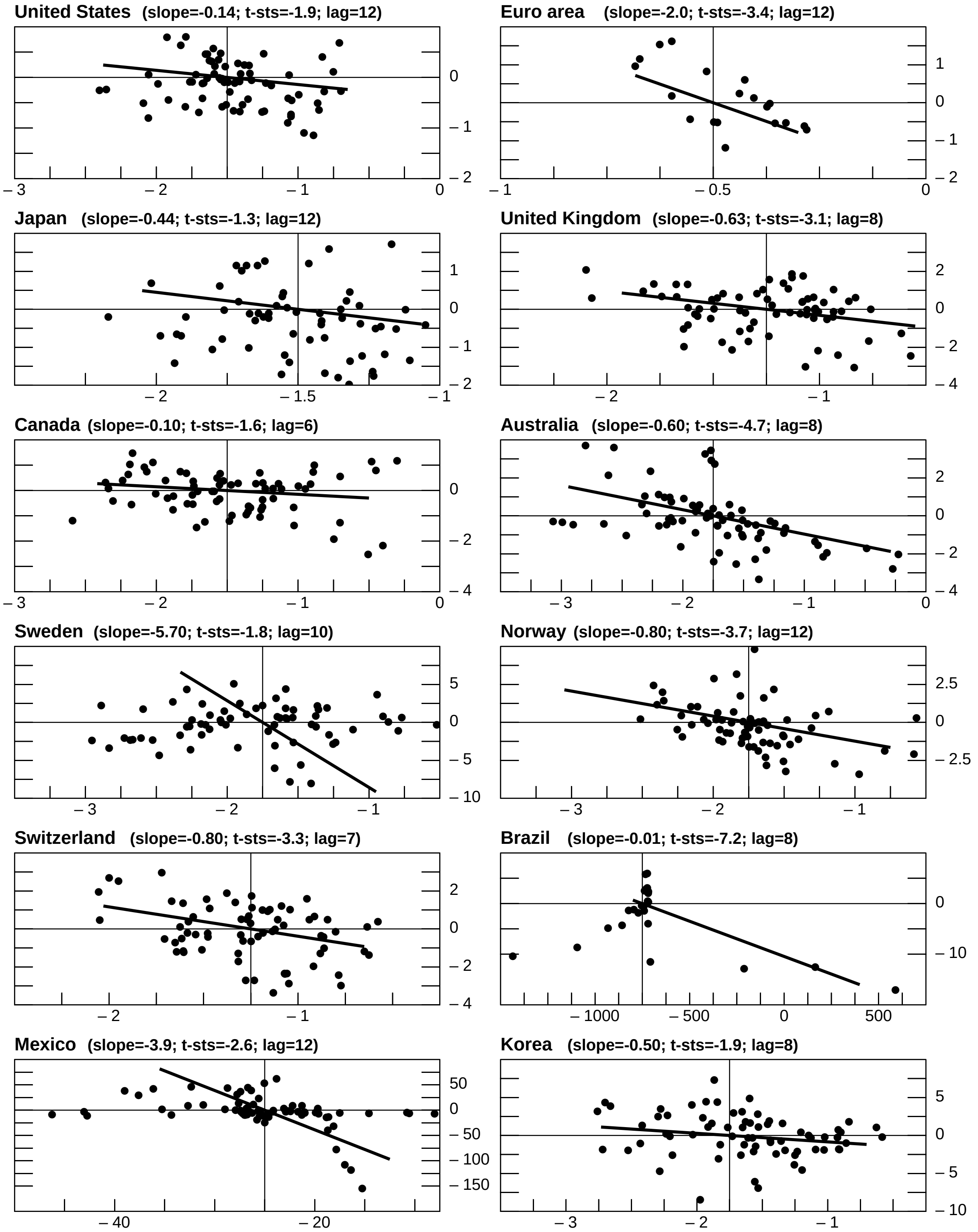


[1] United States: core PCE deflator; other countries: headline CPI. [2] Prior to 1996, left-hand scale; in thousand per cent. [3] Prior to 1990, left-hand scale.

Sources: IMF *International Financial Statistics*; national data.

Graph A.2

Information content of the real interest rate gap for inflation, 1985 Q1-2002 Q2



Note: these panels show the four-quarter change in core inflation on the y-axis against a lag of the four-quarter average of the real interest rate gap on the x-axis; the lag length is indicated in the subtitle. For the United States, an adjustment for the "financial headwinds" in the early 1990s was accomplished by raising the real rate gap by 1 percentage point for 1992-93; the euro area is a weighted average of constituent countries, based on 1995 GDP and PPP exchange rates. Data limitations: euro area, 1997 Q4-2002 Q2; Sweden excludes 1991-92; Brazil excludes 1997-98; Mexico excludes 1994-96; Korea excludes 1997-99.

Sources: National data; BIS calculations.

stage for the MPC's monetary policy deliberations. Goodhart observes that focusing the discussion on the reasons for deviations between this rate and the current policy rate naturally fosters a pre-emptive approach to monetary policy. Specifically, if the policy rate is inconsistent with the short-term natural rate, then the policy rate should presumably be changed unless there are compelling reasons for not doing so.[128]

Implications under the two views

In the continuity view, the natural rate of interest can serve as an additional tool in a monetary policymaker's toolbox, augmenting standard tools such as the output gap and the NAIRU.[129] In theory, all these concepts are largely substitutable as indicators of deviations from the economy's steady state.[130] The relative attractiveness of any one tool depends on whether it can be accurately and reliably measured, for both research studies and policymaking.

A preliminary statistical exercise on US data provides mixed evidence about the marginal predictive power of the natural rate of interest over the output gap as a predictor of future core inflation (Table A1).[131] The results depend in part on the "vintage" of data used. Those based on the latest vintage, which includes possible revisions *after* the fact, show that inflation forecasts based on the real rate gap statistically encompass the forecasts based on the output gap alone.[132] However, it appears that the relative superiority of the real rate gap (using the three-month Treasury bill rate) arises from the way the HP filter estimates the output gap during the recent expansion and the subsequent recession. The recession at the end of the sample period has the effect of pulling down the estimates of potential in the late 1990s, thereby causing the estimated output gap to be quite high during the expansion despite the fact that core CPI inflation was edging downward during the period. By contrast, the forecast encompassing tests using forecasts based on real-time estimates put the output gap in a more favourable light, as they largely abstract from the influence of the 2001 recession. Using the 10-year bond yield instead of the three-month T-bill rate does not change the basic conclusion: there may be an empirical role for using the natural rate gap, but that role needs to be more fully investigated.

In theory, however, estimates of the natural rate may be a comparatively more useful monetary policy tool in an economy where forces associated with the new-environment view may be present. Specifically, given the possibility of unsustainable asset price and investment booms and busts some measures of the real rate gap may provide less ambiguous implications for the direction of monetary policy than more traditional indicators. In the case of a boom, whether sustainable or not, the natural rate framework would be likely to prompt the monetary authority to *raise* the policy rate because measures of the natural rate based either on market interest rates or on the marginal rate of

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[128] There are, of course, many interest rate paths consistent with bringing inflation on target over the relevant horizon. Thus, Goodhart also offers a possible refinement of the MPC's current procedure, conjecturing that monetary policy deliberations could benefit from a comparison of a constant short-term natural rate with two other related paths. One such path would initially lie above the natural rate and then decline over the policy horizon, while the other would begin below and then rise. Policymakers could then more easily focus on the implications of alternative paths for output and other important policy variables such as asset prices.

[129] Indeed, a number of central banks use the natural rate in this way.

[130] To some extent, the real rate gap may be somewhat more valuable in a policy setting for several reasons. First, the monetary authority has more control over this gap than over the output gap or that between the unemployment rate and the NAIRU. Second, interest rate data are available in a more timely fashion than the unemployment rate or output statistics. Finally, as noted below, the natural rate of interest may be a more robust and informative estimator of economic conditions than the other real side measures because it can potentially be measured in (at least) three different markets. It can be inferred from consumers' intertemporal rate of substitution, from firms' marginal product of capital and from the real rates of return in the bond and equity markets. To be sure, it may be difficult to obtain reliable empirical estimates of the natural rate of interest from the marginal return on capital. But, as described below, the significance of forces associated with the new-environment view may warrant further research in this area, along the lines of Mulligan (2001) and McGrattan and Prescott (2001).

[131] The analysis is limited to the United States because of the availability of real-time output gap data, which is important for monetary policy analyses (eg Orphanides (2001), Nelson and Nikolov (2001) and Gruen et al (2002)).

[132] The output gap forecast of inflation is based on real GDP less potential output estimated by an HP filter with a sensitivity parameter of 1600. The real interest rate gap forecast of inflation is based on the ex post real interest rate less the natural rate of interest estimated with an HP filter.

substitution would presumably increase. On the one hand, if the boom was sustainable because, say, TFP had in fact accelerated, then the monetary authority would have to raise market interest rates over time to restore non-inflationary growth.[133] On the other hand, if the boom was unsustainable because, in fact, TFP had not accelerated, then a higher policy rate might be desirable to contain the build-up of imbalances in the economy, for the reasons already discussed in the main text. Similarly, once the imbalances began to unwind, measures of the natural rate would be likely to decline, leading policymakers to cut rates.

Moreover, the central bank could obtain potentially useful information about the sustainability of asset price and investment booms by comparing estimates of the prevailing return on physical capital with those of the natural rate. If the boom was not sustainable, then the increase in investment spending would be expected to drive down the risk-adjusted real return on physical capital (ie the marginal product of capital net of depreciation and taxes) relative to the natural rate of interest, which might be measured based on the long-run average of the marginal product of capital itself, on market interest rates or on estimates of the marginal rate of substitution.[134] This gap would be expected to widen so long as excessive investment continued.

In addition, a new-environment central bank might be able to use the information concerning the gap between the return on physical capital and the natural rate to corroborate measures of financial imbalances, just as a continuity-view central bank might be inclined to use the behaviour of inflation to cross-check estimates of economic slack.[135] From a new-environment perspective, this second procedure could be misleading when an unsustainable boom took place in the context of low and stable inflation, or indeed disinflation. The reason is that it would tend to lead to upward adjustments in output potential, thereby masking the signs of excessive expansion.

Table A1

Forecast encompassing tests: 1990 Q1-2001 Q2

Data vintage	**Real rate gap (using the three-month T-bill rate)**		**Output gap**	
	$\hat{\alpha}_1$	$H_0 : \alpha_1 = 1$	$\hat{\alpha}_2$	$H_0 : \alpha_2 = 1$
Latest	1.2	0.74	–0.2	0.05
Real-time	0.0	0.00	1.0	0.84
	(using the 10-year T-bond yield)			
Latest	0.0	0.30	1.0	0.96
Real-time	0.1	0.00	0.9	0.25

The forecasting encompassing equation is $\pi_{t,t+4} = \alpha_1 \hat{\pi}_{Rgap} + \alpha_2 \hat{\pi}_{Ygap} + \varepsilon_t$, where the dependent variable is the four-quarter ahead core PCE inflation rate for the United States. The forecasts are those based on the real rate gap and the output gap, respectively. All variables were de-meaned. The equation was estimated by imposing the constraint that the forecasts are unbiased, ie the coefficients are constrained to sum to 1. P-values of the hypothesis tests are reported.

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[133] In the short run, however, the natural rate might not rise initially if high capital adjustment costs are present, as pointed out by Neiss and Nelson (2001).

[134] Mulligan (2001) finds that the implied risk-adjusted rate of return on capital may deviate significantly from the benchmark risk-free return on certain financial assets, such as Treasury interest rates, in an economy with state-dependent utility. The risk-adjusted rate of return on capital in this type of environment is the appropriate measure of the intertemporal elasticity of substitution and, hence, the appropriate basis for estimates of the natural rate. While the financial return on the market portfolio for all assets such as property, human capital and business capital would also be appropriate, the return on a subset of assets in general would not.

[135] Formally, this is done by imposing the cross-checking restrictions derived from theory so as to obtain more precise statistical estimates of the output gaps (eg Kuttner (1994), Gerlach and Smets (1999) and Gruen et al (2002)).

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Searching for the natural rate of interest: a euro area perspective[1]

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1. Introduction

Estimates of the "natural rate of interest" or "equilibrium rate of interest" are a prerequisite for calculating many popular monetary policy rules and monetary stance indicators. Feedback rules such as Taylor's (1993) use the natural rate as the intercept term. Another recently much discussed indicator of the stance of monetary policy, the "real interest rate gap" (see, for example, Neiss and Nelson (2001)), is defined as the deviation of the actual short-term rate from the natural rate of interest. Obviously, to the extent that such rules were to be considered by monetary authorities, a "correct" estimate of the natural rate is central to successful macroeconomic stabilisation. This paper offers alternative estimates for the euro area, based on time series analysis, with a special focus on the complications and potential pitfalls due to the regime change and resulting break in data triggered by the inception of economic and monetary union (EMU).

The concept of the natural rate of interest goes back to Wicksell (1936), who stated that "there is a certain rate of interest on loans which is neutral in respect to commodity prices, and tends neither to raise nor to lower them". Following Laubach and Williams (2001), the natural rate of interest may be defined as the real interest rate consistent with output equalling potential and stable inflation. As the growth of potential output varies, the natural rate of interest also varies.

Woodford (2002) in his "Neo-Wicksellian framework for the analysis of monetary policy" argues that "inflation and output determination can be usefully explained … as depending on the relation between a 'natural rate of interest' determined primarily by real factors and the central bank's rule for adjusting the short-term nominal interest rate that serves as the operating target". The natural or equilibrium real rate of interest is defined as the real rate of interest that would prevail in equilibrium under fully flexible prices. It is only in an environment with sticky prices that the distinction between the natural and actual rate of interest becomes meaningful. Sticky prices imply that after a shock the actual real interest rate takes time to adjust to the new equilibrium level. The role of monetary policy in such a world with sticky prices is to speed up adjustment of the economy to shocks by accelerating the adjustment of the actual real interest rate to a changed natural rate. In other words, monetary policy seeks to replicate the flexible price equilibrium, thereby restoring the first best (Smets and Wouters (2002)).

In monetary policy regimes where the short-term interest rate is the primary policy instrument, the natural rate of interest provides a measure of the stance of monetary policy. In this context, it is useful to define the natural rate of interest in terms of the real *short-term*[2] interest rate where output

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[2] As pointed out in Laubach and Williams (2001), further advantages of using short-term, rather than bond, rates are that (i) inflation expectations are much less prone to measurement error for money market rates than for a multi-year horizon and (ii) the time preference of money and thus the term premium itself may be time-varying and would thus have to be estimated. Other studies, eg those prepared in the mid-1990s by the OECD (see Orr et al (1995) and Christiansen and Pigott (1997)) and the G10 (for a summary, see Jenkinson (1996)), addressed the evolution of long-term interest rates. These studies identified a number of economic variables (rate of return on capital and the associated level of desired investment; falling public and private savings and the level of public debt; the history of a country's inflation; and the movement of oil prices) which drive the trend change in real bond rates. However, they explained very little of the shorter-run movements, attributed by the authors to bond rates being driven by largely unobservable shifts in market expectations, including international spillovers. In addition, in the run-up to EMU, expectations about future EMU participation ("convergence plays") became a major determinant for prospective

converges to potential and inflation is stable (cf Bomfim (1997)). In such a setting, the natural rate of interest is seen as a medium-run "anchor" for monetary policy.

Various methods have been explored to estimate time-varying natural rates of interest (TVNRI). Several authors have developed estimated stochastic dynamic general equilibrium (SDGE) models with sticky prices and wages, within which the behaviour of the natural rate of interest and the real interest rate gap in the face of various shocks is simulated. The SDGE model for the euro area in Smets and Wouters (2002) generates a natural real rate that covaries strongly with the actual real interest rate, but is substantially *more* volatile. In fact, their estimated natural rate fluctuates widely between +10 and −7 during the 1990s, which appears somewhat counter-intuitive. The real interest rate gap derived from these estimates suggests that a fictitious euro area monetary policy was quite loose in the early 1990s, then turned relatively tight from 1993 onwards and became neutral to slightly expansionary from the start of EMU. However, the confidence interval around the estimates is quite wide. Therefore, the authors conclude that the scope for using the estimates of the real interest rate gap thus derived may be limited.

Laubach and Williams (2001) employed a small-scale macroeconomic model to estimate a TVNRI for the United States. By jointly estimating the natural rate of interest, potential output and the trend growth rate using the Kalman filter, they found significant variation of the natural rate of interest, driven by changes in trend growth, over the past four decades. They conclude that policymakers' mismeasurement of the NIR can substantially deteriorate macroeconomic stabilisation policy. Their estimates are shown to be sensitive to the output gap series used, and real-time estimates (with parameters, however, estimated from the entire sample) are found to perform considerably worse than "smoothed" estimates, based on the entire sample. Carrying this work further, Orphanides and Williams (2002) investigate the performance and robustness of various forms of extended Taylor-type rules in the face of an unknown degree of uncertainty about the "true" real-time values of the natural rates of unemployment and interest. As uncertainty about the unemployment gap increases, optimal policy involves far more interest setting inertia; the role of the natural rate of interest as a benchmark for policy rates diminishes sharply and converges towards zero. Instead, a "difference rule", deriving the policy rate level from its past level, the divergence of inflation from target and the change in the rate of unemployment - with no reference to the natural rates - becomes preferable. If there is uncertainty about the magnitude of misperceptions on the natural rates, they show that it is advisable to err on the side of greater uncertainty.

The present paper pursues yet another approach for estimating a time-varying natural rate of interest for the euro area, based exclusively on the statistical characteristics of the data, without imposing any conditions derived from economic theory, and aiming for a dynamic model as parsimonious as possible. Multivariate structural time series models provide a flexible framework for the dynamic specification of unobserved components (the natural rate of interest being one) and allow for exploiting the potential cross correlation across the series studied and its unobservables. Furthermore, given the fact that the general dynamic specification nests a wide variety of models, testing down to the model for which the data give more evidence can be done in a straightforward manner.

The remainder of the paper is structured as follows. Section 2 describes the data, motivates and explains the multivariate unobserved components technique, and presents a first set of estimates for the natural rate of interest and the real interest rate gap. Section 3 presents a method for constructing a risk premium adjusted three-month money market interest rate series for the euro area prior to EMU, recalculates the estimates of Section 2 with the adjusted data and interprets the resulting differences. Section 4 discusses the additional uncertainty generated by real-time estimation and the implications of relatively wide confidence bands around the estimates. Section 5 tests our TVNRI estimates for leading-indicator properties with regard to euro area inflation. Section 6 estimates feedback rules, using our TVNRI estimates, for the euro area and compares the estimates of the aggregate responses of monetary policy to changes in inflation expectations and the output gap across specifications of the pre-EMU interest rate series. Section 7 concludes.

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euro area countries' bond market rates. Obviously, using short-term rates largely avoids the latter three types of complications associated with a study of long-term real interest rates.

2. Multivariate unobserved components estimates

2.1 Data

European monetary union started just three and a half years ago, which, from an economic point of view, means that the cyclical behaviour of the euro area economy has not fully unfolded. From an econometric point of view, three and a half years do not - even with monthly data - provide a sufficient number of observations for medium-run economic analysis. Therefore, empirical work seeks to extend the time series into the past by generating synthetic aggregate euro area data. The issue is how to appropriately calculate aggregate series backwards[3] as there are a number of complications and potential pitfalls which may seriously distort econometric estimates.

For our estimates, we require output, inflation and a short-term market interest rate. We approximate output by seasonally adjusted industrial production (source: Eurostat), the reason being mainly to generate more observations, due to the monthly availability of this series, as opposed to quarterly national accounts data. For inflation, we use the euro area harmonised index of consumer prices (HICP) excluding energy and unprocessed food as published by Eurostat backwards to January 1991. Taking a measure of "core inflation" is in line with the literature and aims at eliminating - to the extent possible - price disturbances not driven by demand shocks. For the short-term interest rate, we use monthly averages of the three-month money market interest rate as compiled backwards by the ECB.[4]

For our estimates, we consider the time period between January 1991 and March 2002 (our cutoff date for the time series), for two reasons. The first is economic: treating individual euro area countries prior to EMU as a synthetic euro area is in any event a heroic exercise. However, one can argue that with the agreement on the Maastricht Treaty in the course of 1991[5] both policymakers and economic agents were gradually changing their behaviour, well ahead of the start of the third stage of EMU, towards a single monetary area. In a sense, the regime change implied by EMU did not occur abruptly but was absorbed gradually as the various provisions of the Maastricht Treaty successively entered into force and as expectations adjusted to the prospect of countries joining EMU. Exchange rate stability and monetary and financial integration were regarded by policymakers as a primary goal of monetary and economic policies, and fiscal consolidation moved centre stage from the mid-1990s, both with a view to monetary union. Price stability had become generally accepted in EU policy circles as the central banks' primary goal, and EU central banks were, in the course of the 1990s, granted far-reaching independence. Furthermore, the early 1990s marked the entering into force of the Single Market Programme, which fostered economic integration. Taken together, these developments set the 1990s clearly apart, in terms of economic integration and policy consensus, from earlier periods. The second reason for limiting our estimates to the 1990s is the availability of data: the HICP as calculated backwards by Eurostat reaches back to 1991 only.

Inspection of the raw data (Graph 1) reveals the following main features: euro area industrial production fell by close to 10% during the recession of 1992-93, then followed a more or less continuous upward path until 2000 but declined from 2001 onwards, reflecting the recent economic downturn. Core inflation followed a clear downward trend in the course of the 1990s, falling from around 4% in the early 1990s to around 1½% by the start of EMU; it recovered somewhat to around 2½% by spring 2002. Both nominal and real (ex ante) three-month money market interest rates started

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3 This question has been addressed extensively in various official fora (inter alia, Eurostat and the European Monetary Institute/ECB) before the start of EMU.

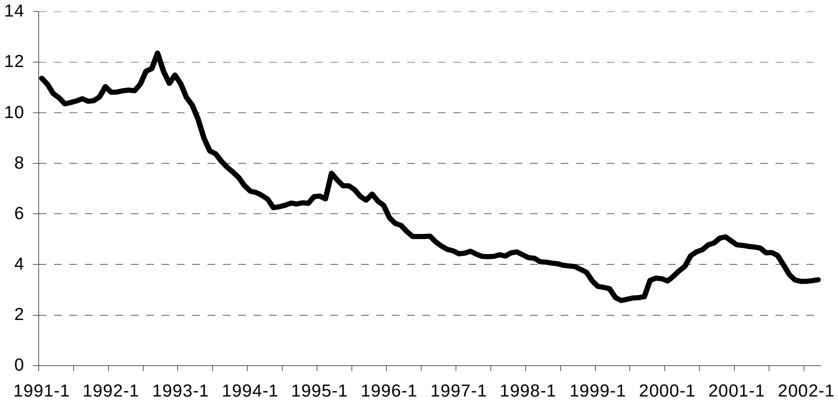
4 The ECB computes euro area three-month money market rates prior to 1999 from national data, using PPP-adjusted GDP weights (base year: 1995). We also considered a series from Reuters, which uses ECU money market rates prior to 1999. The two series differ considerably, the reasons being, inter alia, that the ECU currency basket did not coincide 1:1 (in terms of both currency basket range and weights) with the currencies included in the euro from 1 January 1999, and that the ECU market rate at times diverged - for various reasons - substantially from its theoretical value (defined as the weighted average of the rates of its basket currencies). For these conceptual weaknesses of the ECU-based series, we opted for the ECB aggregate three-month money market series (monthly averages).

5 The key ingredients of the Maastricht Treaty became clear in the course of 1991, although the Treaty was only signed in February 1992 and entered into force in late 1993.

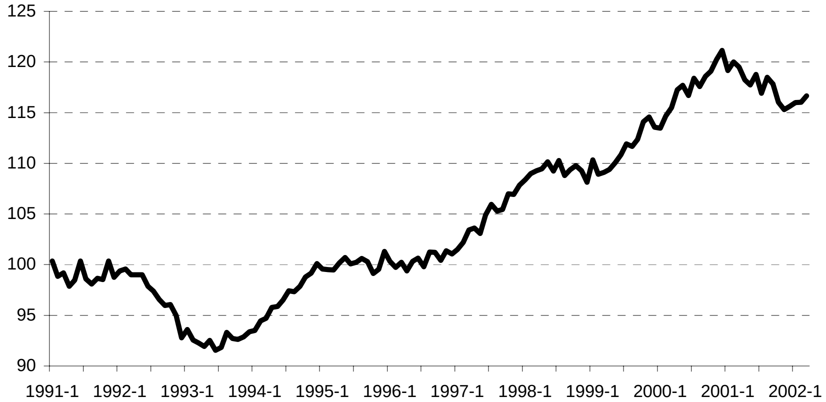
Graph 1

Economic indicators in the euro area

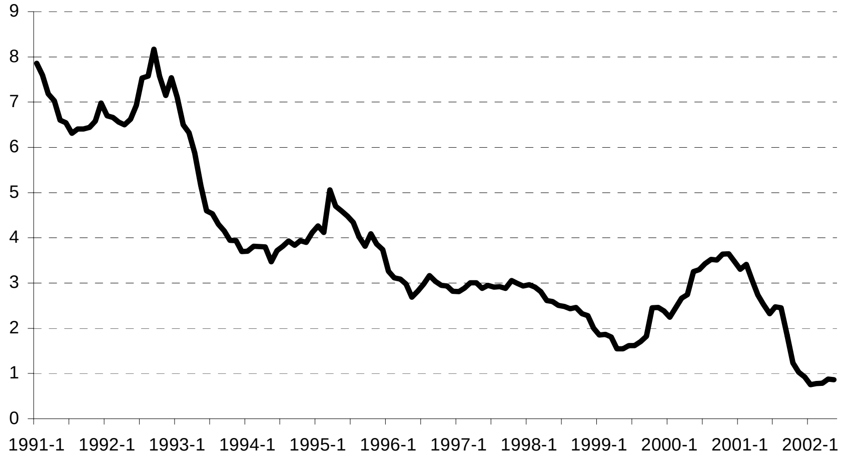
Three-month nominal interest rate



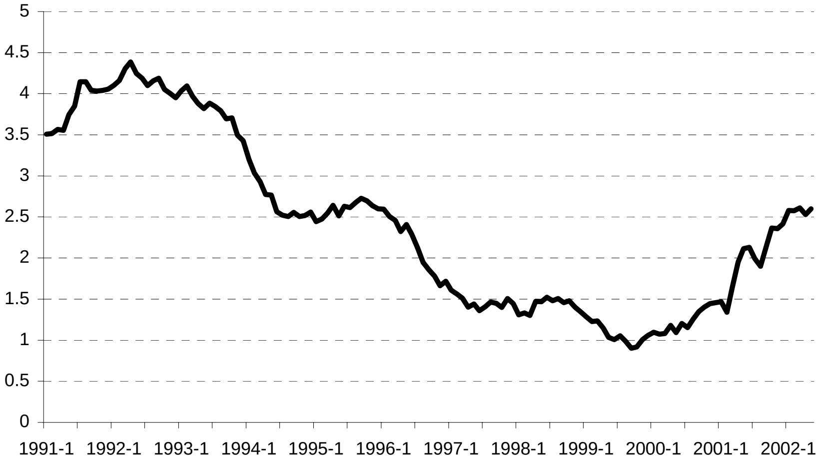
Industrial production index



Real interest rate



Core inflation



Sources: ECB; Eurostat.

from very high levels in the early 1990s and followed a strong general downward trend throughout the 1990s. The peaks around 1992 and 1995 reflected the tensions prevailing in the exchange rate mechanism (ERM) of the European monetary system (EMS). Between mid-2000 and mid-2001 the Eurosystem kept short rates high to combat rising inflationary pressures.

2.2 Specification of the multivariate unobserved components model

In the spirit of the methodology developed mainly in Harvey (1989), we specify a multivariate unobserved components model in order to extract the trend component of the ex ante real interest rate. Consider the vector $z_t = (r_t \; y_t \; \pi_t)'$ composed of real interest rates (r_t),[6] (logged) industrial production (y_t) and inflation (π_t). We are interested in decomposing z_t into a trend component, a cyclical component and an irregular component in an additive fashion, such that:

$$z_t = \mu_t + \phi_t + u_t\,; \quad u_t \sim \text{NID}(0, \Sigma_u) \tag{1}$$

where μ_t, the multivariate trend component, is assumed to follow a (multivariate) random walk with drift, where the drift itself follows a random walk, that is:

$$\mu_t = \mu_{t-1} + \kappa_{t-1} + \tau_t\,; \quad \tau_t \sim \text{NID}(0, \Sigma_\tau) \tag{2}$$

$$\kappa_t = \kappa_{t-1} + \psi_t\,; \quad \psi_t \sim \text{NID}(0, \Sigma_\psi) \tag{3}$$

The errors in the specification of the trend, τ_t and ψ_t, are assumed to be mutually uncorrelated and uncorrelated with u_t. The cyclical component is specified as a sine-cosine wave with time-evolving parameters:

$$\begin{pmatrix} \phi_t \\ \phi_t^* \end{pmatrix} = \rho\left[\begin{pmatrix} \cos\lambda & \sin\lambda \\ -\sin\lambda & \cos\lambda \end{pmatrix} \otimes I\right]\begin{pmatrix} \phi_{t-1} \\ \phi_{t-1}^* \end{pmatrix} + \begin{pmatrix} \omega_t \\ \omega_t^* \end{pmatrix} \tag{4}$$

where $(\omega_t \; \omega_t^*)' \sim \text{NID}(0, I \otimes \Sigma_\omega)$, $\rho \in (0, 1)$ and $\lambda \in (0, \pi)$. The error in the cyclical component is furthermore assumed to be uncorrelated with the errors in the other components. The cyclical frequency, λ, and the cycle damping factor, ρ, are thus assumed to be equal across variables.

The structural time series model described above is able to exploit the common statistical features of the series to be studied simultaneously by allowing correlation across the individual error processes in a given unobserved component. The estimation of the parameters of interest can be carried out using maximum likelihood methods after setting the prediction error decomposition using Kalman filtering (for details, see Harvey (1989)). The state-space representation of the multivariate structural model described above is given by:

$$\begin{aligned} z_t &= F\alpha_t + u_t \\ \alpha_t &= T\alpha_{t-1} + \varepsilon_t \end{aligned} \tag{5}$$

where the state vector is given by $\alpha_t = (\mu_t' \; \kappa_t' \; \phi_t' \; \phi_t^{*\prime})'$ and the disturbance vector of the state equation is given by $\varepsilon_t = (\tau_t' \; \psi_t' \; \omega_t' \; \omega_t^{*\prime})'$. The matrices associated with the state space representation are:

$$F = (I \quad 0 \quad I \quad 0)$$

$$T = \begin{pmatrix} I & I & 0 & 0 \\ 0 & I & 0 & 0 \\ 0 & 0 & \rho\cos\lambda I & \rho\sin\lambda I \\ 0 & 0 & -\rho\sin\lambda I & \rho\cos\lambda I \end{pmatrix} \tag{6}$$

6 We use ex ante real interest rates, defined as the prevailing interest rate in period t minus the inflation rate between period $t-1$ and t. This implies that the monetary authority assumes that inflation follows a random walk.

Given the state-space representation, Kalman filtering methods allow the computation of the likelihood function by means of the one-step-ahead prediction error decomposition and therefore the estimation of the hyperparameters of interest (the cyclical frequency, λ, the cycle damping factor, ρ, and the variance-covariance matrices of the unobservable disturbances).[7]

Furthermore, the prediction error decomposition enables us to retrieve the "smoothed" and "filtered" estimates of the unobservable states. The smoothed unobserved states are just $\alpha_t^s = E(\alpha_t \mid \{z_t\}_{t=0}^T)$, while the filtered states are $\alpha_t^f = E(\alpha_t \mid \{z_t\}_{t=0}^t)$. That is, the smoothed estimates exploit the information contained in the whole sample, while the filtered estimates form conditional expectations on the unobservable state at time t using information up to $t-1$. The filtered estimates will be also referred to as "real-time" estimates. The specification of a smooth trend in the multivariate unobserved components model (which implies that the trend component does not contain the error term τ_t) improved the fit significantly and was therefore imposed for the estimation using euro area data.

Notice that the identification - in economic terms - of the TVNRI (and of potential output as well as equilibrium inflation) is based on the notion that the estimated cyclical component should correspond to the business cycle. The starting values for the parameters of the cycle in the optimisation algorithm were thus specified to lie at intervals corresponding to plausible business cycle frequencies and persistence.[8] The three trends extracted by means of this estimation procedure can be interpreted as potential output, trend inflation and the (time-varying) natural rate of interest.

2.3 Estimation results

The estimation of the multivariate unobserved components model using the original nominal interest rate dataset isolates a cycle with a frequency, λ, of 0.18 radians, corresponding to a cyclical period of around three years. The estimated damping factor, ρ, for the cycle is 0.97, a result that matches the range of cyclical persistence of economic variables reported in the literature (see, for example, Harvey and Jaeger (1993)). While the residuals present no significant first-order autocorrelation (as measured by the Durbin-Watson test statistic) for any of the series included in the multivariate specification, the residuals from the real interest rate series reject the null hypothesis of normality for the Jarque-Bera test at any reasonable significance level.[9]

Graph 2 shows the estimated natural rate of interest in the upper left-hand panel. The natural rate reflects the trend of the actual real rate, which is strong but gradually flattening over the 1990s. Since the start of EMU, the behaviour of the natural rate is rather flat, slightly above 2%. The TVNRI contrasts sharply against a fixed estimate based on the simple sample average of 3.8%.

The amplitude of the output gap (Graph 2, upper right-hand panel) is considerably smaller than that resulting from Hodrick-Prescott filtering industrial production series. This feature has been widely documented in the literature (see, for example, Harvey and Jaeger (1993) or Cogley and Nason (1995)) and seems to be due to the fact that the Hodrick-Prescott filter tends to isolate spurious cycles.

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7 Notice that Hodrick-Prescott (HP) filtering (Hodrick and Prescott (1997)) appears as a special case of a univariate unobserved components model where the variable of interest, in our case the ex ante real interest rate, is decomposed into a smooth trend and an irregular component, where the variances of both components are linked by a smoothing parameter, q. The resulting (univariate) unobserved components model is:

$r_t = \mu_t + u_t; \quad u_t \sim \text{NID}(0, \sigma_u)$

$\mu_t = \mu_{t-1} + \kappa_t$

$\kappa_t = \kappa_{t-1} + \psi_t; \quad \psi_t \sim \text{NID}(0, q\sigma_u)$

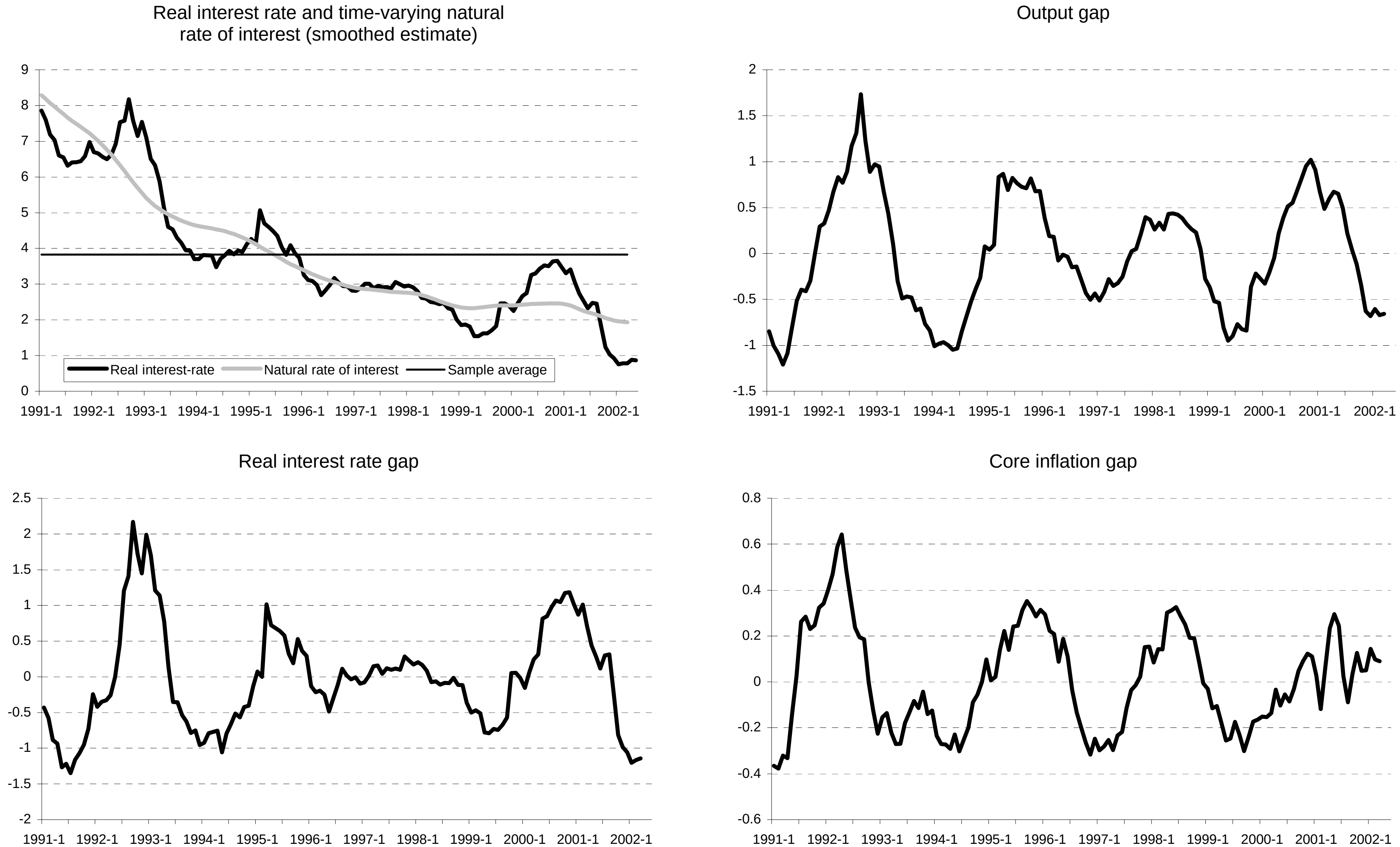
where q is usually set to 1/14,400 for monthly data. The HP trend is the smoothed estimate of μ_t, and the filtered series results from subtracting the smoothed trend from the original series.

8 Starting values for the cyclical frequency λ were set such that the corresponding cyclical period lies between three and five years, and the ρ parameter was initiated at values ranging between 0.80 and 0.99. The estimated parameters were robust to the choice of starting values for λ and ρ in this range. An unreasonably short-lived cycle was isolated if the starting values of λ were chosen to be too large.

9 For detailed results of the estimation of the structural time series models, see the Appendix.

Graph 2

Multivariate unobserved components model: estimation results



The real interest rate gap (Graph 2, lower left-hand panel), ie the difference between the actual and time-varying natural real interest rates, broadly mirrors the estimated evolution of the output gap. According to this measure, monetary policy was rather tight in late 1992 and early 1993, and less so in 1995 and 2000. It was loose in 1991, 1993-94, 1999 and from late 2001 onwards. A real interest rate gap based on the simple sample average yields a sharply different assessment: according to such a measure, monetary policy would have been mostly restrictive up to the mid-1990s and consistently expansionary thereafter.

3. Adjusting for risk premia prior to EMU

One major feature of the above estimates was a very high TVNRI in the first half of the 1990s and a much lower level subsequently. We suspect that the high level of rates in the first half of the 1990s is (at least partly) attributable to risk premia linked to the exchange rate tensions within the ERM and unsustainable fiscal positions prior to EMU. If the aim is to estimate a TVNRI and a derived real interest rate gap suitable for monetary policy analysis in EMU, risk premia which no longer exist in the new regime of EMU should be excluded from the estimation. These risk premia would be expected to include exchange rate risk premia (as experienced on various occasions within the ERM of the EMS) and default risk premia to the extent that they may have been reduced by the Stability and Growth Pact. In other words, we seek to generate a TVNRI exclusively driven by output and inflation.[10]

Both of the euro area money market series considered in Section 3 (ECB aggregated euro area series; BIS/Reuters ECU money market series) prior to 1999 can be assumed to include exchange rate driven, fiscal policy related and other risk premia. We therefore develop a method to eliminate these risk premia from national nominal money market rates, which we in turn use to construct a new, risk-adjusted synthetic time series for aggregate euro area three-month money market rates prior to 1999.

In our model, the risk premium on each national money market rate is defined to be the part of the (nominal) interest rate spread with the German short term-interest rate that cannot be explained by differentials in inflation expectations and/or business cycle desynchronisation. The adjustment of the series is done as follows. First, the risk premium (which need not be assumed to be constant through time) is extracted for each country. Given the working definition of the interest rate risk premium above, the interest rate spread with Germany is regressed on the output gap differential between the country of interest and Germany and the inflation forecast differential. That is, for country *k*:

$$s_t^k = \beta_0 + \beta_1\left(g_t^k - g_t^{GER}\right) + \beta_2\left[E\left(\pi_{t+12}^k \,\middle|\, \left\{\pi_s^k\right\}_{s=1}^{t}\right) - E\left(\pi_{t+12}^{GER} \,\middle|\, \left\{\pi_s^{GER}\right\}_{s=1}^{t}\right)\right] + \gamma_t \qquad (7)$$

where s_t^k is the interest rate spread between country *k* and Germany, g_t^k is the output gap[11] of country *k*, the inflation forecasts are obtained by computing the conditional expectation after fitting an autoregressive process[12] to the inflation data ranging up to period *t*, γ_t is assumed to be a random shock and $E(\cdot)$ is the expectation operator.

After estimating equation (7), the original series of nominal interest rates (i_t^k) are adjusted by subtracting the estimated constant and the residuals from the estimation. The adjusted series is thus:

$$i_t^{adj,k} = i_t^k - \hat{\beta}_0 - \hat{\gamma}_t \qquad (8)$$

Given the potential correlation between the error and the regressors (in the sense of correlation between inflation expectations and the exchange rate driven risk premium, for instance), lags ranging between six and 12 months of the output gap and inflation differentials were used as instruments in

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10 We abstract from modelling other general factors driving real interest rates, such as time preference parameters.

11 The output gap series used for each country corresponds to the cyclical component of industrial production resulting from estimating a multivariate unobserved components model using data on real interest rates, inflation and industrial production.

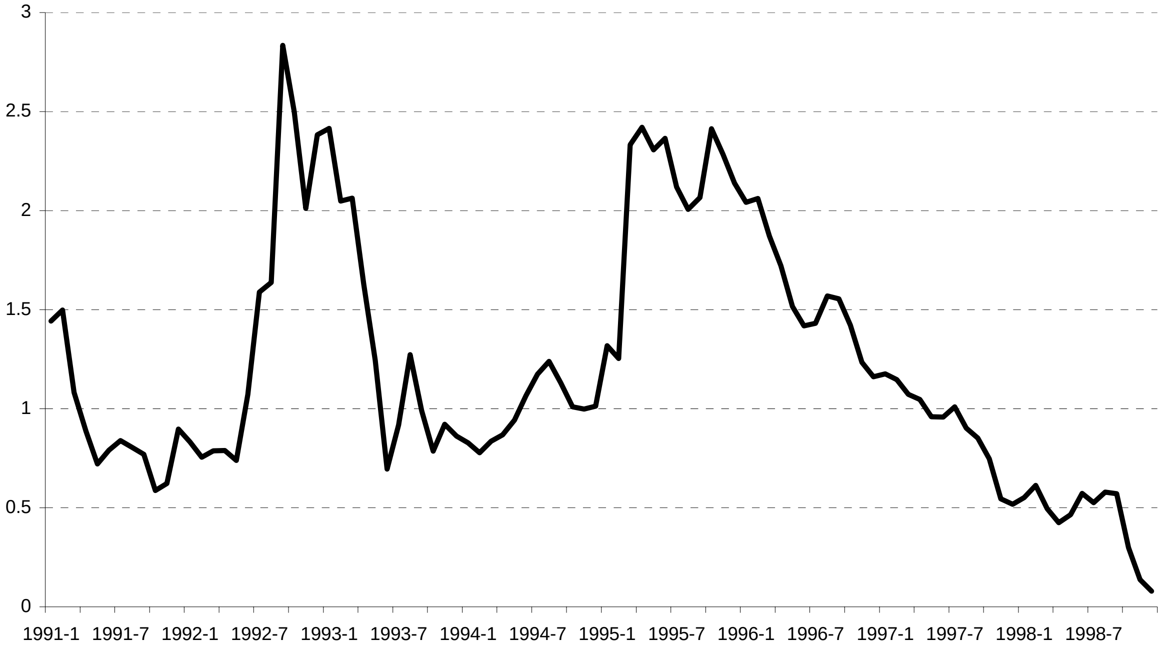
12 The lag length of the autoregressive process that is fitted to the inflation data is chosen to be the one that minimises the Akaike Information Criterion for the data available at each time point *t*. The lag length is thus revised with each realisation of inflation, so as to model changes in the persistence of inflation through time. In all cases the range of lags taken into account for the choice was between one and 12.

the estimation of equation (7). Durbin-Wu-Hausman tests and Sargan tests confirm both the need for instruments and the validity of the instruments used. The only exception is Portugal, where Durbin-Wu-Hausman indicated that no instrumental variable estimation was necessary and ordinary least squares (OLS) estimation was used. The source of national data is the BIS for the national money market rates and Eurostat for inflation and industrial production. Incomplete datasets for Portugal and Finland were augmented using data from the Bank of Portugal and the Bank of Finland, respectively.

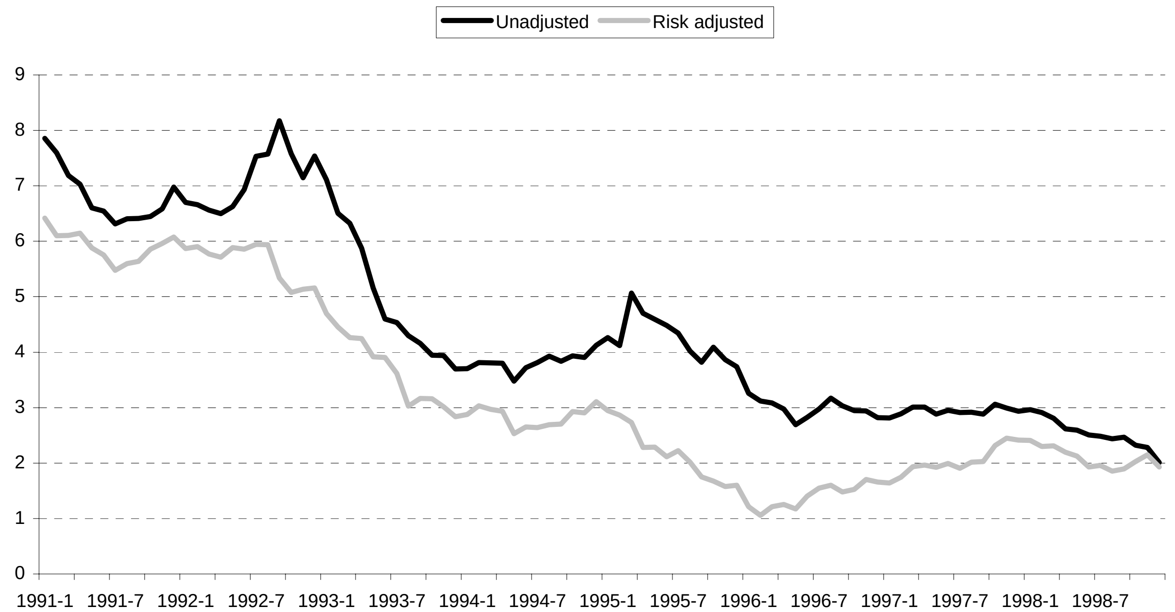
Graph 3

Interest rate risk premium and unadjusted and risk-adjusted real interest rates

Interest rate risk premium (euro area aggregate)



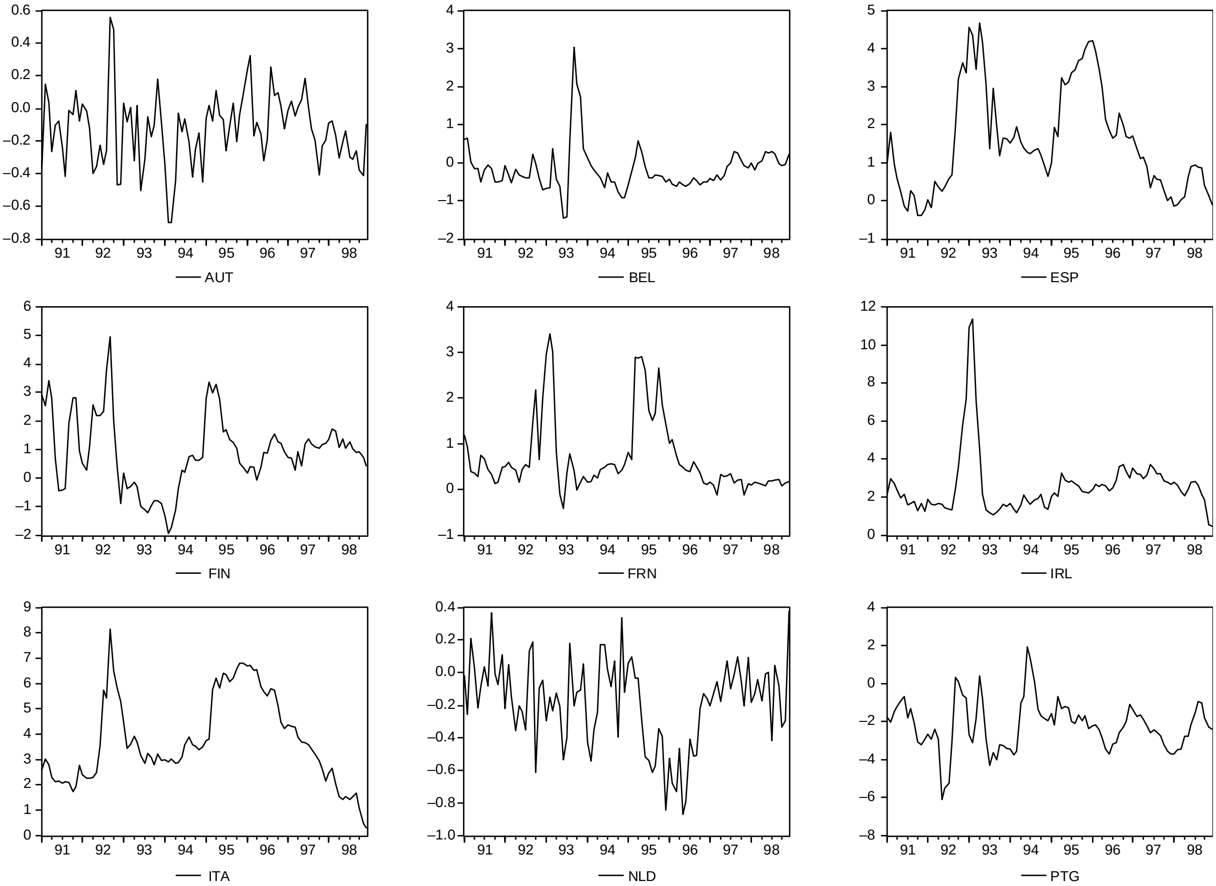
Real interest rates



The upper panel of Graph 3 shows the estimated aggregated risk premium for the countries of the euro area prior to 1999, revealing the suspected high risk premia of up to 2½% and more around the ERM crisis of 1992-93 and the exchange rate tensions of 1995. It also shows that, as to be expected, the risk premia virtually vanished until the end of 1998. The lower panel of Graph 3 compares the adjusted three-month real interest rate for the euro area[13] with the original unadjusted series. For background information, Graph 4 shows the estimated national interest rate risk premia.[14]

Graph 4

National interest rate risk premia



Using the risk-adjusted euro area three-month money market series, we re-estimate the TVNRI. The cyclical frequency estimated for the multivariate unobserved components model with the adjusted interest rate series is 0.11 radians, which corresponds to a cyclical period of around four and a half years. None of the residual series presents significant first-order autocorrelation, and the null of normal distribution of the residuals cannot be rejected at the 5% significance level for any of the series.

The risk-adjusted natural rate of interest is shown in the upper panel of Graph 5. Leaving aside the start of the estimate, the natural rate fluctuates between 1½ and 3¼% between 1994 and now. The average of the real interest rate over the sample period at slightly below 3% is much lower and more in line with rule of thumb estimates. Compared to the risk-unadjusted estimates, the TVNRI now traces

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13 The aggregation has been done using weights based on the relative GDP (at PPP prices) of each country in the EMU aggregate. The relative GDP data are annual, so they are left unchanged across months in a given year.

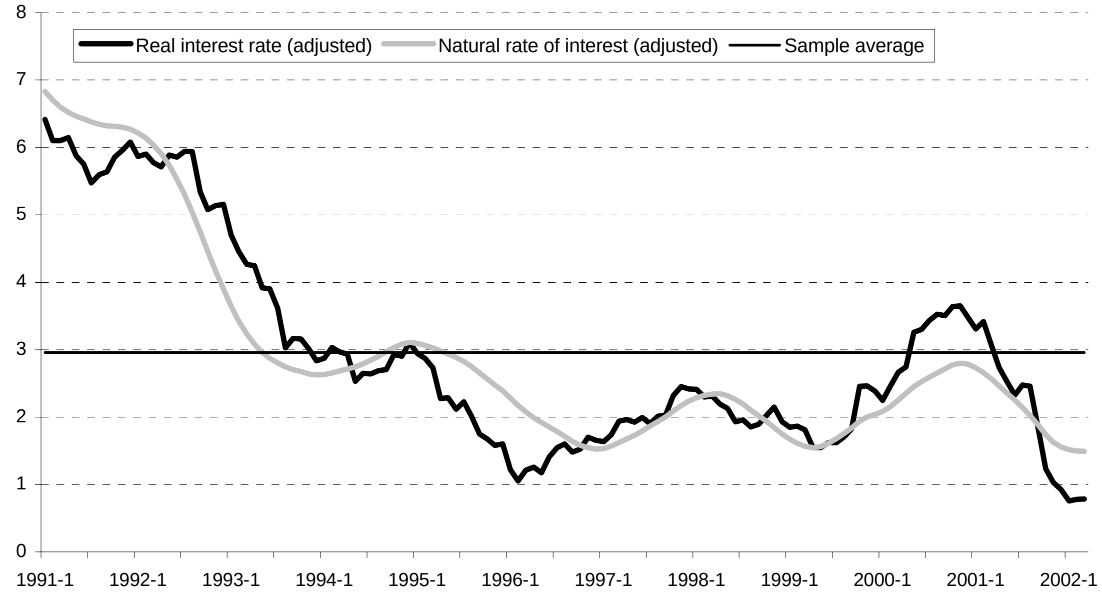
14 Remember that, given our definition of the interest rate risk premium, only premia relative to Germany are taken into account. Therefore, the aggregated series may still contain extra (potentially time-varying) risk premia with respect to the rest of the world that need not be symmetrical across countries.

the actual real market rate more closely, its cyclical behaviour is far more pronounced; as a corollary to this, the real interest rate gap fluctuates less now.

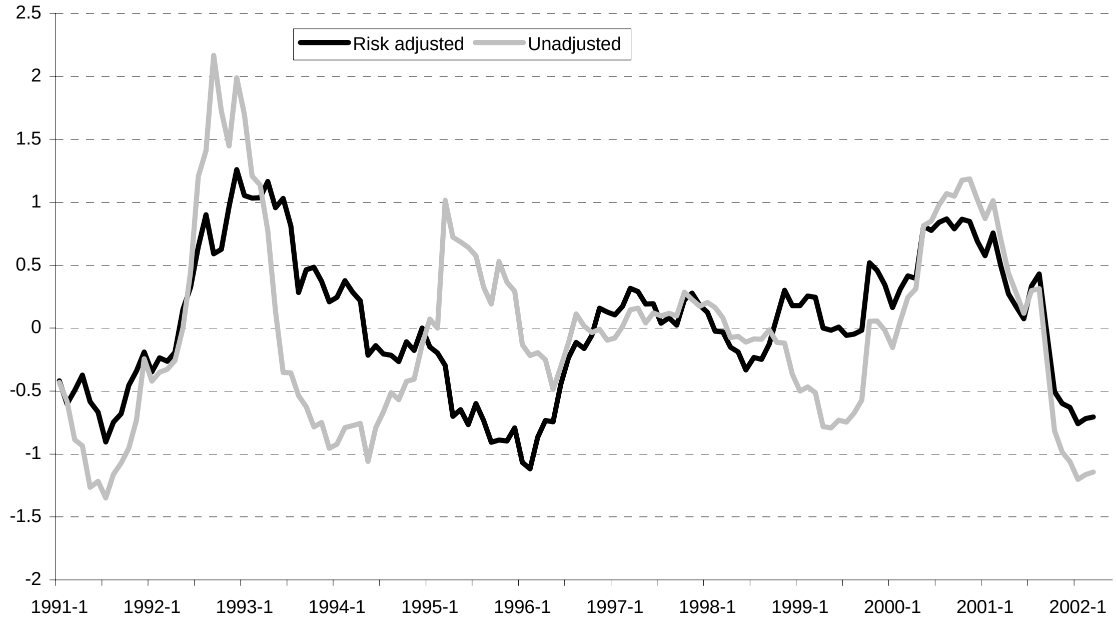
Graph 5

Adjusting for risk premia: interest rate results

Risk-adjusted real interest rate and time-varying natural rate of interest (smoothed estimate)



Real interest rate gap; risk-adjusted and unadjusted



Comparing the risk-adjusted and unadjusted real interest rate gaps (see lower panel of Graph 5) reveals substantial differences in the first half of the 1990s, but also non-negligible differences, particularly in 1999 (up to 80 basis points) and 2000 and 2002 (30-40 basis points each). In several instances (1993-94, 1995-96, 1999), even the sign of the risk-adjusted real interest rate gap estimate is opposite to the unadjusted one. In other words, the risk-adjusted real interest rate gap and the unadjusted one would have yielded opposite monetary policy advice during these periods. Contrary to the unadjusted estimate, euro area monetary policy is now no longer qualified as expansionary in 1999 and is also considered less expansionary in 2002. On the other hand, the adjusted real interest rate gap suggests a lesser degree of restrictiveness during the upswing in 2000-01. More generally, the adjusted estimates suggest smoother and more cautious changes in the Eurosystem's policy stance.

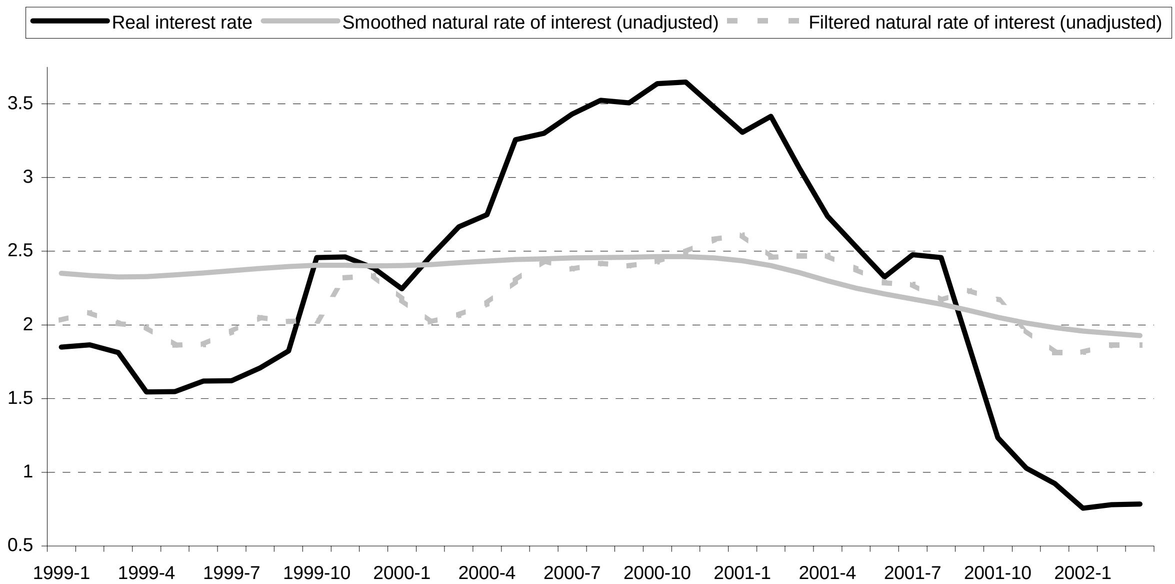
4. Real-time estimates and confidence bands

For practical monetary policy purposes, estimates of the natural rate need to be done "real-time", ie on the basis of data available only up to the point in time where the monetary policy decision is taken. As new data become available, the original estimates are continuously revised reflecting the richer information set available. Graph 6 shows the divergence between real-time estimates ("filtered") and those based on the entire sample ("smoothed") since the start of EMU.[15] The panel below is based on the unadjusted interest rate series; the panel at the top of the following page uses the risk-adjusted money market series as derived in Section 3. The real-time estimation error reaches up to 1/2 percentage point for both series. This is also reflected in the real interest rate gaps derived from these four natural-rate series (Graph 7). Our estimates confirm the finding pointed out in the literature (see, for example, Orphanides (2001), Orphanides and Williams (2002) and Laubach and Williams (2001)) that policy rules based on unobserved macroeconomic variables, such as the natural rates of output, unemployment or interest - or the derived "gaps" - involve a substantial margin of error if applied "real-time" and should thus be used cautiously.

Graph 6

Filtered and smoothed TVNRIs, unadjusted and risk-adjusted data

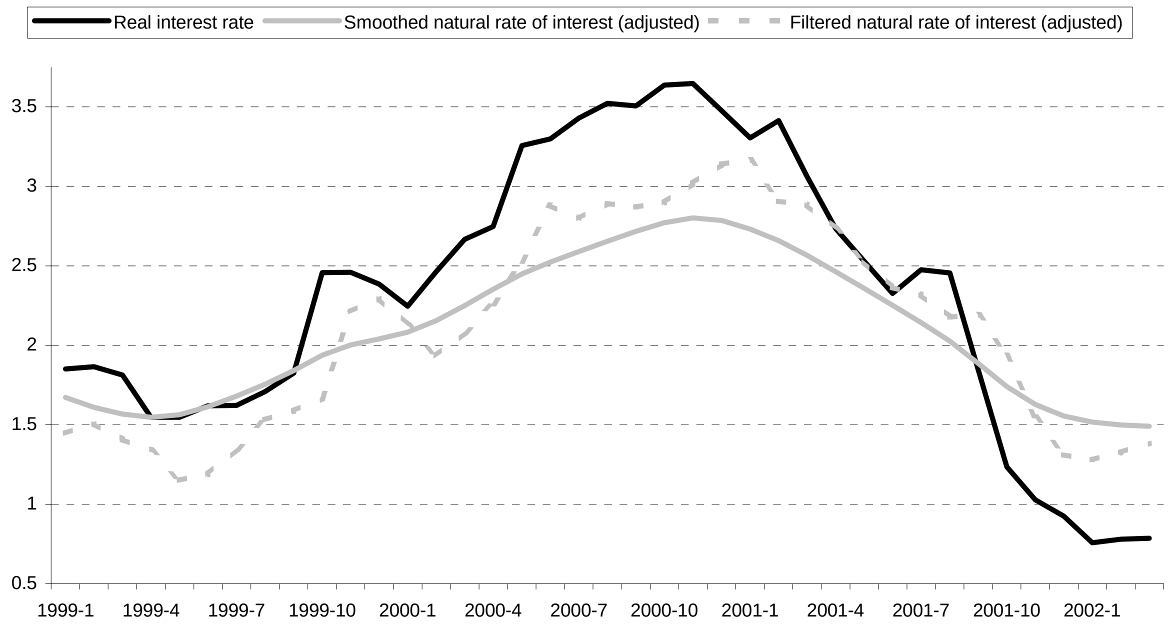
Unadjusted



15 We abstain from showing and interpreting the - even bigger - divergences for the period before 1999 since the number of data points available for these real-time estimates becomes quite small, given our initial choice of investigating only data starting from January 1991.

Graph 6 (cont)

Risk adjusted

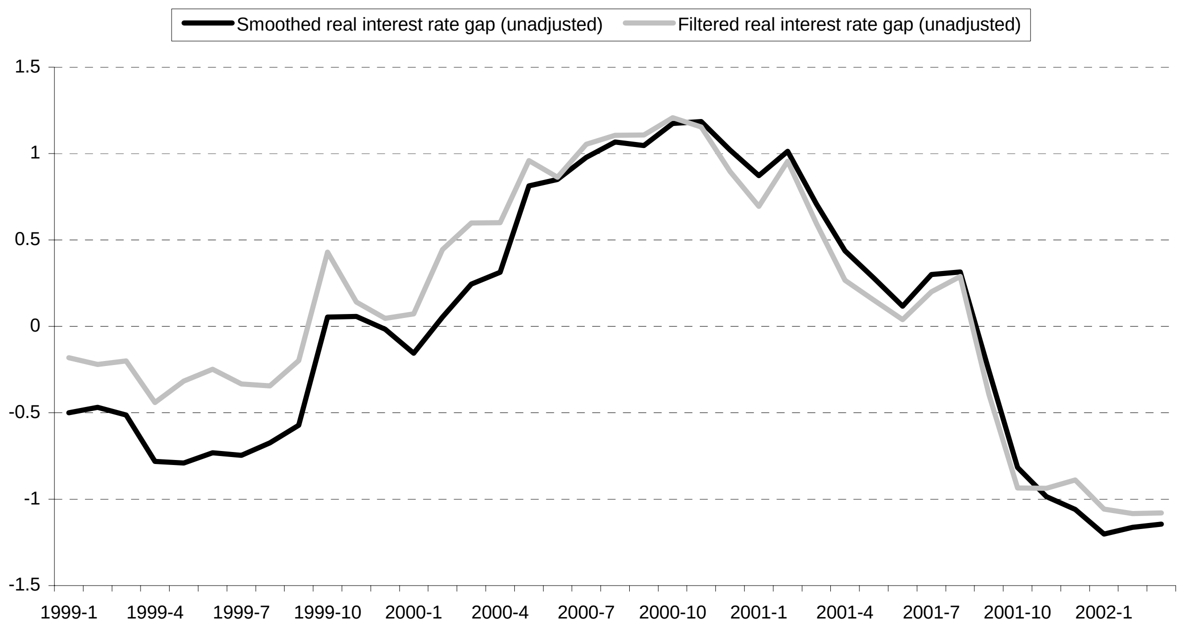


However, even the smoothed series, based on the full-sample estimates, suffer from substantial uncertainty, as shown in Graph 8. Wrapping a 75% confidence band around our estimates of the TVNRI, deviations between the actual and natural real rates of interest are shown to be insignificant during most of the 1990s and up to most recently. In EMU, the estimate based on the unadjusted interest rate series (first panel) signals periods of loose monetary policy in 1999 and from late 2001 onwards and a restrictive stance in 2000. However, after adjusting for risk premia (second panel), the Eurosystem's monetary policy can no longer be qualified as either significantly expansionary or restrictive, except for some months of tightness in the year 2000.

Graph 7

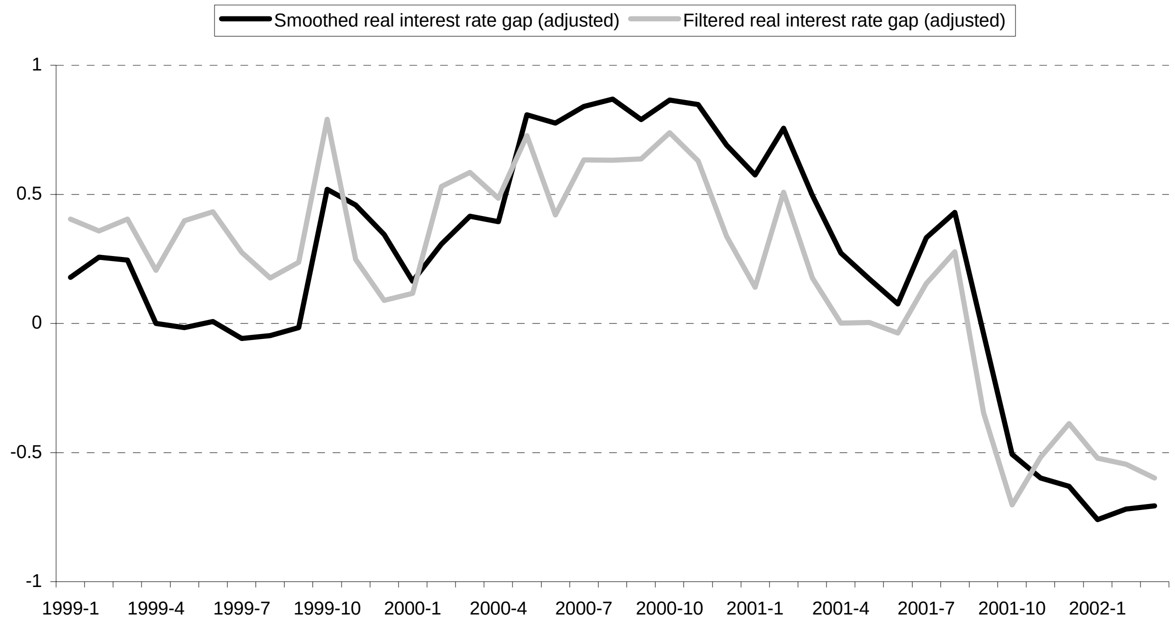
Filtered and smoothed real interest rate gaps, unadjusted and risk-adjusted data

Unadjusted



Graph 7 (cont)

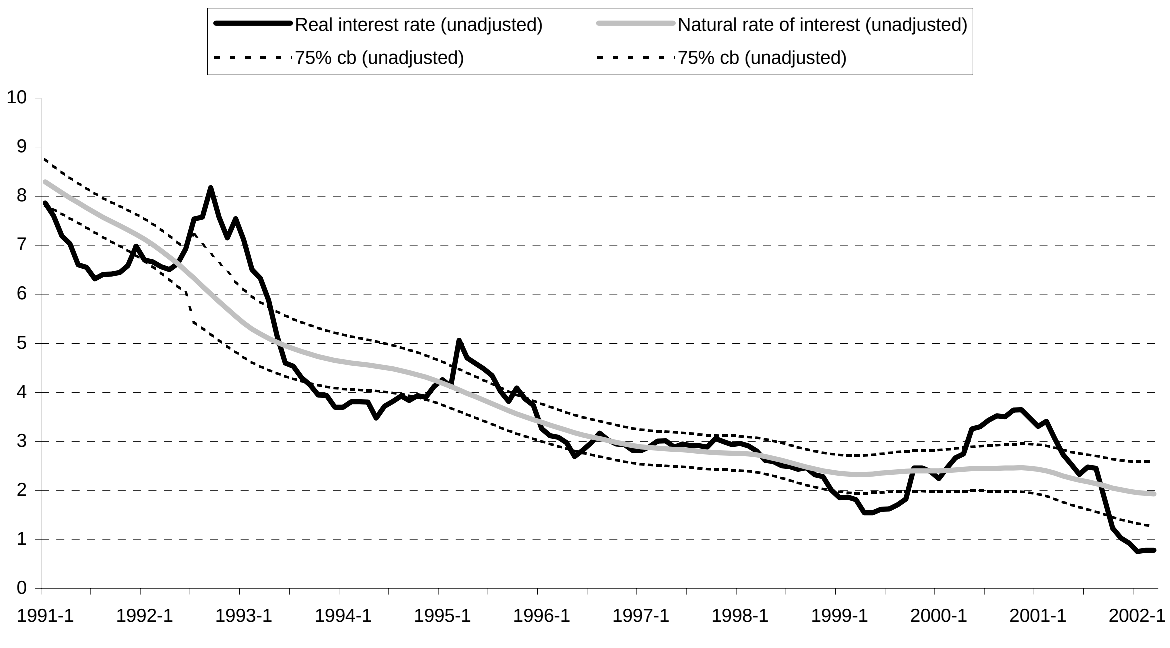
Risk adjusted



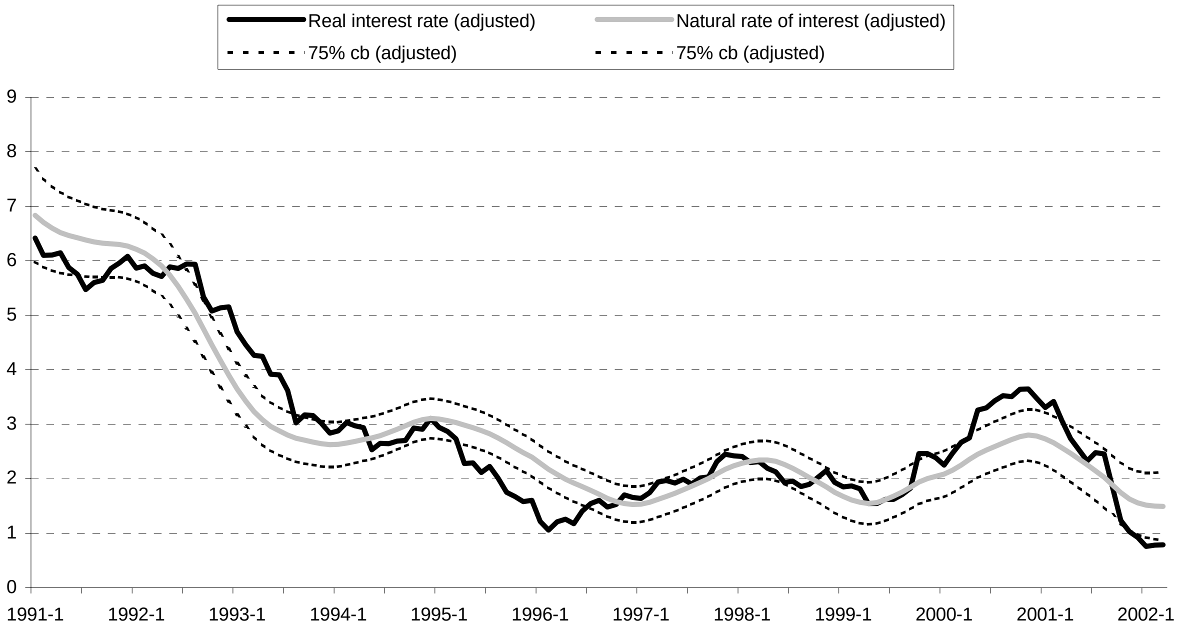
In the final panel of Graph 8 we compare the risk-adjusted natural rate (ie the neutral rate that could have been the guidepost for monetary policy in the absence of risk premia) with the unadjusted real interest rate (ie the real interest rate as it actually prevailed). As expected from Section 3, we find that - seen from this perspective - the aggregate synthetic euro area monetary policy was almost without interruption restrictive (ie the actual rate lay above the 75% confidence band of the natural-rate estimate) between July 1992 and mid-1998.

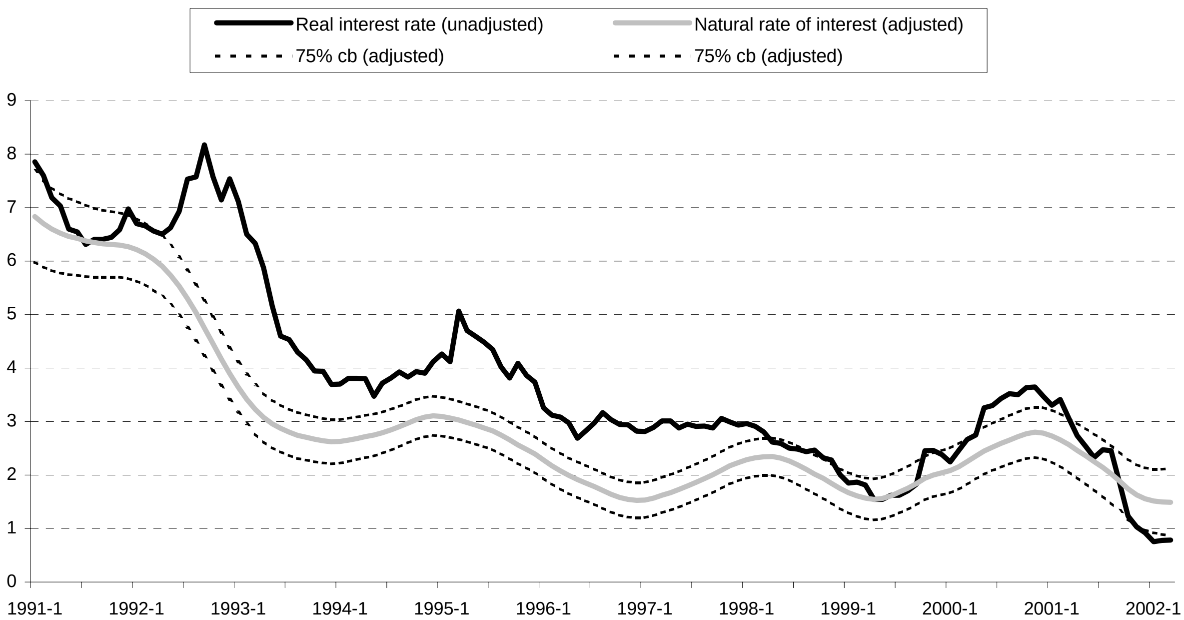
Graph 8

The real interest rate, TVNRIs and confidence bands (cb)



Graph 8 (cont)





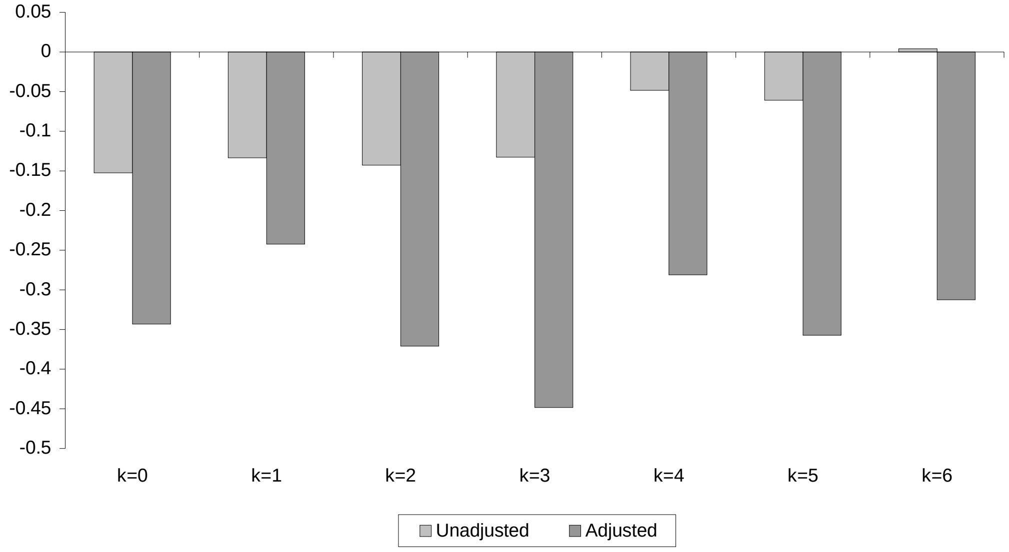
5. Leading indicator properties of the real interest rate gaps for inflation

The real interest rate gap is a widely used measure of the monetary policy stance. However, the analysis carried out so far illustrates clearly that the point estimates of the real interest rate gap may differ substantially depending upon the statistical technique used in identifying the natural rate of interest. Significant differences about the stance of monetary policy arise as well if the euro area interest rate series is adjusted for interest rate premia in the pre-EMU period. On this last point, we are interested in the advantages or disadvantages of using the adjusted series for monetary policy evaluation. This section compares the adjusted and unadjusted series in terms of the properties of the real interest rate gap emerging from both datasets as a leading indicator of inflation in the euro area.

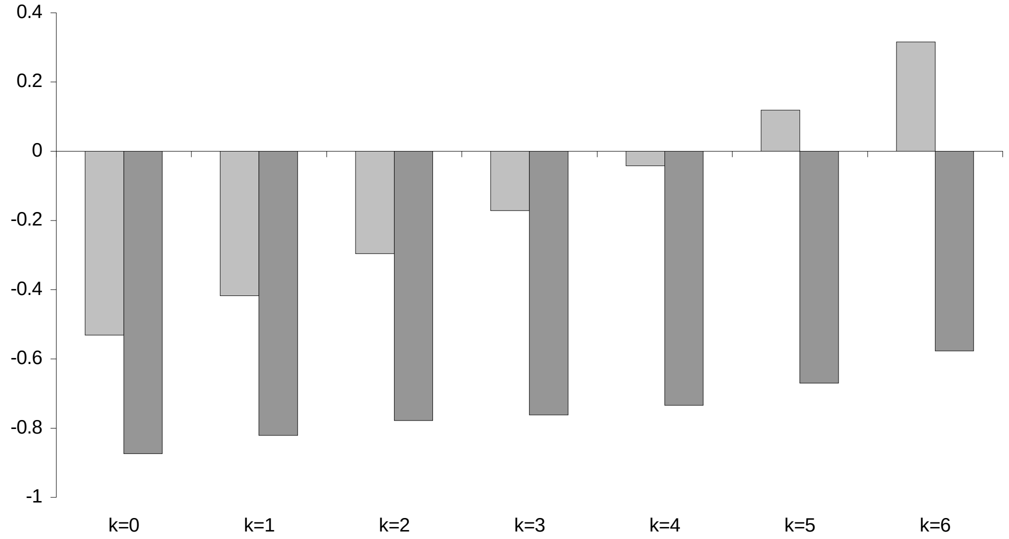
Graph 9

Leading indicator properties: real interest rate gaps

Correlation between *monthly* inflation and the
real interest rate gap at lag *k*



Correlation between *annual* inflation and the
real interest rate gap at lag *k*



Graph 9 shows the correlation between monthly (upper panel) and annual (lower panel) inflation and the real-time (ie filtered) estimates of the ex ante real interest gap[16] at different lags, *k*, ranging from zero to six months. The correlations refer to the period between January 1999 and March 2002.[17] The correlation up to a lag of six months appears always negative for the risk-adjusted real interest rate

16 The filtered estimates of the real interest rate gap were computed using the multivariate unobserved components approach for both series.

17 The complete sample of national interest rates up to December 1998 is required to perform the adjustment, so real-time estimates based on adjusted data prior to 1999 would be misleading as they would not be representative of the information that is available to the monetary policy authority at a given point in time.

gap series, while the correlation between the real interest rate gap emerging from the unadjusted series and inflation turns positive for lags of more than five (monthly inflation rate) or four (annual inflation rate) months. The correlation is higher in absolute terms for the adjusted series at all evaluated lags, giving a clear indication of the superior leading-indicator properties of the adjusted real interest rate gap. The negative correlation between the (adjusted) real interest rate gap and inflation is consistent with economic theory (see, for example, Neiss and Nelson (2001)). This suggests that the real interest rate gap resulting from the adjusted interest rate series may serve better as an indicator of the monetary policy stance than the one calculated from the original series of aggregated EMU short-term interest rates.

6. Risk premium adjustment and euro area feedback rule estimates

In this section we assume that monetary policy in the euro area can be represented by an interest rate feedback rule à la Clarida et al (1998), such that the central bank sets the short-term interest rate ($\tilde{i}_t$) according to the following rule[18]

$$\tilde{i}_t = i_t^* + \delta\left[E(\pi_{t+12} - \pi_{t+12}^* \mid \Omega_t)\right] + \gamma\left[E(g_t \mid \Omega_t)\right] \tag{9}$$

where i_t^* is the time-varying nominal interest rate target. Monetary policy reacts to changes in the deviation of expected inflation from some bliss value (π_t^*) and to changes in the expected output gap, g_t. We further assume interest rate smoothing, so that the actual interest rate is given by

$$i_t = (1-\eta)\tilde{i}_t + \eta i_{t-1} + \zeta_t \tag{10}$$

where $\eta \in [0,1]$ is the smoothing parameter and ζ_t is an iid error. Combining equations (9) and (10), we can write

$$i_t = (1-\eta)r_t^* + (1-\eta)\delta(\pi_{t+12} - \pi_{t+12}^*) + (1-\eta)\gamma g_t + (1-\eta)\pi_{t+12} + \varphi_t \tag{11}$$

where r_t^* is the natural, time-varying, real interest rate (defined as the natural nominal interest rate minus expected inflation), and the error term, φ_t, is a linear combination of the error in equation (10) and the forecast errors in predicting the inflation rate, its “normal rate”, π_t^*, and the output gap. The estimation of equation (11) was carried out using the general method of moments, as suggested in Clarida et al (1998). The instruments used were past values of inflation, the interest rate and the output gap. The output gap is taken to be the smoothed estimate of the cyclical components of output and inflation in the multivariate unobserved components model for the risk-unadjusted interest rate data. The natural rate of interest data correspond to the smoothed estimates of the TVNRI, and the inflation target is taken to be the smoothed estimate of the trend in inflation extracted from the multivariate unobserved components model with the original interest rate data.

Table 1 reports the estimates of the structural parameters in equation (11) using risk-unadjusted and adjusted data (and thus unadjusted and adjusted TVNRIs). The estimated parameters corresponding to reactions of monetary policy to inflation and the output gap are higher for risk-unadjusted interest rate data than for adjusted data, although there is no statistically significant difference for the reaction to inflation deviations from trend. Notice that there is a basic difference in the interpretation of the parameter associated with the reaction to inflation in our specification compared to that of Clarida et al (1998). In the case of targeting a fixed level of inflation (as in Clarida et al (1998)), disinflationary monetary policy corresponds to an estimate of δ significantly greater than one. In contrast, when the targeted level of inflation is assumed variable, as in our case, a δ parameter not significantly different

[18] For the pre-EMU period, this amounts to the assumption that the (weighted) average of euro area central banks’ monetary policies can be represented by means of an aggregate reaction function.

from one (as is the case in the setting with adjusted interest rate data) is still consistent with disinflation, given the decreasing trend of inflation.

Table 1

Estimated monetary policy reaction functions (euro area, 1991:01-2002:03)

Parameter	Risk-unadjusted interest rate data	Risk-adjusted interest rate data
η	0.825*** (0.009)	0.831*** (0.013)
δ	1.515*** (0.272)	1.232*** (0.374)
γ	0.979*** (0.374)	0.386*** (0.118)
Sargan test	16.921 (p-value = 0.963)	16.399 (p-value = 0.971)

* (**) [***] stands for significance at the 10% (5%) [1%] level. Estimation carried out by GMM, using past values of interest rates, inflation and the output gap as instruments.

Substantial differences, however, appear in the estimate of the reaction of aggregate monetary policy in EMU to the output gap. For unadjusted data the results imply that monetary policy reacted in a one-to-one fashion to the output gap, an estimate more than twice greater than the one corresponding to the adjusted interest rate data. The source of these contradictory results appears to lie in the risk premium component of the aggregate interest rate data in the pre-EMU period. The time variation of the interest rate risk premium happens to coincide closely with the cyclical variation in the output gap.[19] Thus, if a reaction function as above is estimated for pre-EMU aggregate euro area monetary policy using non-risk-adjusted nominal interest rates, the dynamics of policy interest rates which are actually driven by risk premia are *erroneously* taken to be reactions of monetary policy to the output gap. This is confirmed by our finding that the correlations between the national interest rate risk premia and the corresponding output gaps are negative or not significantly different from zero in all individual euro area countries, with the exception of Finland.[20] The high response coefficient of monetary policy to the output gap when using risk-unadjusted data seems to be thus a statistical artefact. The coefficients estimated on the basis of risk-adjusted interest rate data are more in line with the estimates reported by, for example, Clarida et al (1998).

7. Summary and conclusions

This paper has pursued five objectives: first, to estimate time-varying natural rates of interest for the euro area, using a structural statistical model; second, to explore the consequences of pre-EMU national interest rate risk premia for TVNRI estimates; third, to evaluate the robustness of such estimates in real-time settings and when bearing in mind the wide confidence bands of such estimates; fourth, to explore the leading indicator properties of our real interest rate gap estimates for euro area inflation; and fifth, to estimate feedback rules for monetary policy in EMU, focusing on the differences implied by the use of raw aggregate interest rate data for the pre-EMU period.

We estimate the TVNRI by means of a multivariate unobserved components approach, with aggregate monthly euro area data (January 1991 to March 2002) on ex ante real interest rates, core inflation and

[19] The correlation between the aggregate risk premium and the output gap is 0.685.

[20] The correlations range between −0.66 for the Netherlands and 0.35 for Finland. The lack of synchronisation across national business cycles explains, thus, the coincidence of expansions and risk premium in the pre-EMU aggregate series and therefore the relatively higher response of monetary policy to the output gap implied by the estimation of feedback rules for the euro area using raw aggregated interest rate data.

industrial production; the (unobserved) trend component in the real interest rate for the euro area is taken to be the natural rate of interest. Our first estimate is based on simple aggregated money market rates for the pre-EMU part of our sample and yields a TVNRI that falls from 8% in early 1991 to around 2% by the start of EMU and has remained there ever since. This contrasts sharply with a fixed estimate based on the sample average of 3.8%.

However, simple aggregate money market interest rate data were, in particular until the mid-1990s, distorted by various risk premia no longer relevant in the new regime of the euro area. We extract those risk premia from national interest rate data and derive a synthetic measure of the aggregate euro area money market interest rate. The risk premium is hypothesised to be the part of each country's (nominal) interest rate spread with Germany unexplained by differentials in inflation expectations and output gap desynchronisation. The estimated risk premium is found to have coincided closely with the bouts of ERM tensions in the early and mid-1990s and converges towards zero by end-1998. On the basis of the regime change adjusted interest rate series, we re-estimate the TVNRI: it now fluctuated between 1 and 3½% between 1994 and spring 2002. The average over the full-sample period is close to 3%.

The real interest rate gaps derived from the unadjusted and adjusted TVNRIs differ substantially in terms of the derived real interest rate gaps, thus yielding different ex post assessments of European monetary policies pre-EMU and in EMU. In several instances (1993-94, 1995-96, 1999), the risk-adjusted and the unadjusted real-rate gap would have yielded opposite monetary policy advice. Contrary to the unadjusted estimate, euro area monetary policy is no longer qualified as expansionary in 1999 and is also considered less expansionary in 2002. On the other hand, the adjusted real interest gap suggests a lesser degree of restrictiveness during the upswing in 2000-01. More generally, the adjusted estimates suggest smoother and more cautious changes in the Eurosystem's policy stance.

For practical monetary policy estimates we also explore to what extent "real-time" estimates deviate from full-sample estimates. We find that the real-time estimation error reaches up to ½ percentage point for both the risk premia unadjusted and adjusted series. This confirms the finding in the literature that policy rules based on unobserved macroeconomic variables, such as the natural rates of output, unemployment or interest rate - or the derived "gaps" - involve a substantial margin of error if applied "real-time" and should thus be used cautiously. The rather wide 75% confidence bands around our TVNRI estimates further add to practical difficulties in applying TVNRI-based monetary stance indicators or feedback rules.

We conclude the paper with two policy applications. First, we find the risk-adjusted real interest gap to perform considerably better as a leading indicator for euro area inflation than the non-adjusted series. Second, using our TVNRI estimates, we estimate monetary policy feedback rules for the euro area, in order to assess ex post the relative weights attached to inflation and output stabilisation by the ECB Governing Council and by its predecessor pre-EMU euro area central banks. We show that, for the pre-EMU period, using risk-unadjusted policy rates leads to periods of high risk premia being erroneously taken as monetary policy replies to the output gap; by contrast, using risk-adjusted policy rates yields an estimate of the reaction of monetary policy to the output gap corresponding approximately to an increase of 40 basis points for a 1% positive deviation of output from potential output. A positive deviation of inflation from its trend of 1% is estimated to have triggered approximately a 1.2% increase in short-term interest rates.

Appendix:
Estimation results for the multivariate unobserved components models

(A) Results using original interest rate data

Hyperparameter	Estimate
ρ	0.969
λ	0.178
Σ_u	$\begin{bmatrix} 0.005 & & \\ -0.001 & 0.0005 & \\ -7.27\times10^{-5} & -7.64\times10^{-5} & 3.23\times10^{-5} \end{bmatrix}$
Σ_ψ	$\begin{bmatrix} 0.0002 & & \\ -0.0003 & 0.0004 & \\ 1.94\times10^{-5} & -2.69\times10^{-5} & 1.90\times10^{-6} \end{bmatrix}$
Σ_ω	$\begin{bmatrix} 0.032 & & \\ -0.004 & 0.005 & \\ 0.0002 & 5.44\times10^{-5} & 1.97\times10^{-6} \end{bmatrix}$

Residual analysis:

	Real interest rate	Inflation	Industrial production
Standard error	0.218	0.094	0.008
Jarque-Bera test statistic	26.85	2.306	1.655
Durbin-Watson statistic	2.019	1.892	1.926

(B) Results using adjusted interest rate data

Hyperparameter	Estimate
ρ	0.961
λ	0.11
Σ_u	$\begin{bmatrix} 0 & & \\ 0 & 0 & \\ 0 & 0 & 3.26\times10^{-5} \end{bmatrix}$
Σ_ψ	$\begin{bmatrix} 0.002 & & \\ -0.0001 & 0.0001 & \\ 6.55\times10^{-5} & -6.48\times10^{-6} & 2.51\times10^{-6} \end{bmatrix}$
Σ_ω	$\begin{bmatrix} 0.027 & & \\ -0.007 & 0.007 & \\ 0.0001 & -8.42\times10^{-5} & 1\times10^{-6} \end{bmatrix}$

Residual analysis:

	Real interest rate	Inflation	Industrial production
Standard error	0.182	0.093	0.008
Jarque-Bera test statistic	3.726	2.666	0.542
Durbin-Watson statistic	1.962	1.917	1.846

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Inflation, relative prices and nominal rigidities[1]

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Abstract

This paper examines the distribution of Belgian consumer prices and its interaction with aggregate inflation over the period June 1976-September 2000. Given the fat-tailed nature of this distribution, both classical and robust measures of location, scale and skewness are presented. We found a positive short-run impact of the skewness of relative prices on aggregate inflation, irrespective of the average inflation rate. The dispersion of relative prices also has a positive impact on aggregate inflation in the short run and this impact is significantly lower in the subsample starting in 1988 than in the pre-1988 subsample, suggesting that the prevailing monetary policy regime has a substantial effect on this coefficient. The chronic right skewness of the distribution, revealed by the robust measures, is positively cointegrated with aggregate inflation, suggesting that it is largely dependent on the inflationary process itself and would disappear at zero inflation. These results have three important implications for monetary policy.

First, as regards the transmission of monetary policy, our results are in line with the predictions of menu cost models and therefore suggest that this type of friction can be an important factor behind the short-run non-neutrality of monetary policy. Second, as regards the design of robust estimators of core inflation, economic arguments based on menu cost models tend to highlight the importance of the absence of bias. We have proposed an unbiased estimator by taking the time-varying degree of chronic right skewness explicitly into account. Third, as regards the optimal rate of inflation, the chronic right skewness found in the data provides no argument against price stability, as it appears as an endogenous response of optimising price setters and would disappear when targeting a zero inflation rate. This conclusion contrasts sharply with the implications of the exogenously assumed downward rigidity of Tobin (1972), which would justify targeting a sufficiently positive inflation rate in order to facilitate the adjustment of relative prices. Our empirical findings contradict the latter type of downward rigidity, which implies a negative correlation between skewness and inflation. Therefore, the cross-sectional properties of Belgian inflation data do not provide strong arguments against a price stability-oriented monetary policy such as the one pursued by the Eurosystem.

1. Introduction

The aim of this paper is to study the cross-sectional properties of Belgian inflation data. The international literature on this issue highlights, broadly speaking, three not mutually exclusive aspects. First, many papers discuss the positive relationship between inflation on the one hand and the dispersion and/or asymmetry of relative prices on the other. Often these relationships have been interpreted as being symptomatic of nominal rigidities of one form or another. Ball and Mankiw's (1995) menu cost model has recently been the focal point of this strand in the literature. Second, in line with the findings of Bryan et al (1997), it is often documented that inflation data are fat-tailed and this motivates the stochastic approach to core inflation in which robust estimators of location are

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proposed. Third, in quite a few countries researchers found not only a considerable degree of frequently switching left and right skewness but, on average, also a tendency towards right skewness.

The latter characteristic of the data, which is for instance discussed in Roger (2000), raises two additional questions. The first question is whether this chronic right skewness results from an exogenous form of downward nominal rigidity in product markets, such as the one put forward in Tobin (1972), or whether it is endogenously generated as menu cost models suggest. These two sources of asymmetry have different, empirically testable implications for the relation between inflation and skewness: the first source implies a negative relation, whereas the second implies a positive relation. Distinguishing between these two sources of skewness is particularly relevant from a monetary policy perspective, as they have different implications for the optimal rate of inflation. In the case of an exogenous form of downward nominal rigidity, low inflation rates are harmful as they complicate the (downward) adjustment of relative prices. In the other event, low inflation is desirable, as it reduces the costs associated with changing prices, as well as the impact of monetary policy on the distribution of relative prices. The second question raised by the chronic right skewness is how to incorporate it in the construction of robust estimators of core inflation.

This type of analysis often uses the classical characteristics of location, scale, skewness and kurtosis. These measures are, however, very sensitive to outlying values. In this paper we will compare them with robust alternatives, not only for location, as is typically done in the core inflation part of this literature, but also for scale, skewness and tail weight. We will address the question of whether robust measures are applicable in this context, because inflation is often strongly influenced by outliers which are both correct and important. Overly strong robustness may downweight outliers too much and thus yield little sensitivity. Extending the use of robust estimators to the scale, skewness and tail weight of the distribution of inflation data is the main statistical contribution of our paper.

From an economic point of view, one may wonder what justifies downweighting outlying values in inflation data. After all, we all buy goods and services for which prices change dramatically. There is often some assumption about price stickiness underlying this treatment of outliers. In the flexible price benchmark, the classical dichotomy holds: inflation is a purely monetary phenomenon, independent of relative prices, which themselves are influenced by real determinants only. In that case it makes no sense to downweight outlying values in order to compute alternative (core) aggregate measures. With prices sticky in the short run, relative prices and inflation are no longer independent and causality goes in both directions. Relative price shocks - large shocks in particular - can affect aggregate inflation in the short run, thus temporarily masking the effect of the factors which are more relevant from a monetary policy perspective, such as the balance of supply and demand in the economy or the impact of inflation expectations. In such a setting, downweighting outliers aims at putting more weight on these factors. This provides the economic rationale for using robust estimators of location as core inflation measures, as Bryan and Cecchetti (1994) do on the basis of the menu cost model of Ball and Mankiw (1995).

In this paper we extend the argument to measures of scale and skewness and find that the robust alternatives are better suited to show the impact of these monetary policy-related factors on the distribution of relative prices. Using this type of measure, we found that aggregate inflation had a substantial impact on the dispersion of relative prices in Belgium. Moreover, they revealed endogenous chronic right skewness in the distribution of observed relative prices, which tends to increase with aggregate inflation and, according to our econometric results, would tend to disappear with zero inflation. This type of asymmetric price adjustment is what the menu cost model of Ball and Mankiw (1994) predicts, and we consider this as our main empirical result.

We obtained these results using readily available inflation data at a relatively high level of aggregation (a 60-item breakdown), whereas it is the standard view that intramarket rather than intermarket data are the appropriate dimension to uncover a causal relation running from the inflationary process to the distribution of relative prices.[2] We owe this to the fact that we have used the data at the highest frequency available, ie one-month price changes, and that the cross-sectional properties were studied on the basis of robust measures of scale and skewness. As regards the corresponding classical measures, they allowed us to illustrate the causality in the other direction, ie from the distribution of relative price shocks to aggregate inflation.

[2] See for instance Ball and Mankiw (1994), Lach and Tsiddon (1992) or Cecchetti and Groshen (2000) on this point.

The remainder of the paper is structured as follows. Section 2 describes the Belgian inflation data and discusses the format in which we will investigate them. In Section 3, robust measures of location, scale and tail weight are proposed and used to detect the presence of outlying values in the data. Section 4 briefly compares the classical and robust measures of location and scale. Section 5 discusses the classical and robust measures of skewness, as well as the chronic right skewness which they reveal. Section 6 presents, for the classical and the robust measures of skewness and scale respectively, their relation with inflation and discusses the empirical findings against the background of menu cost models. Moreover, the results are interpreted in terms of what is known in the literature on the optimal rate of inflation as “grease” and “sand” effects. Section 7 presents a robust unbiased estimator of core inflation. Section 8 sets out the conclusions.

2. Description of the data

This study is based on Belgian monthly consumer price index (CPI) data for the period June 1976[3] to September 2000, yielding a total of 292 months. For each month, we have aggregated price indices of 60 different product categories. The index of product category i ($i = 1,\ldots, 60$) at month t ($t = 0,\ldots, 291$) is denoted by $I_{i,t}$.

We started by transforming these data into percentage one-month price changes $\Pi_{i,t}$ ($t = 1,\ldots, 291$), defined by:

$$\Pi_{i,t} = \frac{I_{i,t}}{I_{i,t-1}} - 1 \tag{2.1}$$

As the aim was to interpret some of the results obtained in terms of sticky versus flexible price behaviour, the obvious approach was to use data at the highest frequency available.

Note that these price changes can also be seen as the first-order approximation of logarithmic price changes:

$$\ln\left(\frac{I_{i,t}}{I_{i,t-1}}\right) \tag{2.2}$$

Both approaches did indeed yield approximately the same results, including those related to the presence of chronic right skewness. This suggests that using percentage price changes instead of log price changes is not an important factor behind the chronic right skewness, as could have been expected on the basis of Roger (2000). The latter paper inspired us also to test the robustness of the results obtained by removing from the data set 10 product categories for which prices were obviously adjusting infrequently. These are categories which are mainly regulated by government or law, eg bread, tobacco and education. Our results - including the endogenous nature of the chronic right skewness - were only slightly influenced by this modification. Therefore, the paper presents the results for all 60 product categories.

Summarising, we can represent our final data set $\Pi_{i,t}$ with a matrix that consists of 291 rows (indicating the different periods) and 60 columns (for the product categories). A cross section contains the price changes of one particular month, and thus corresponds to one row of the data matrix. Additionally, we have taken account of the fact that each product category has a time-varying weight $w_{i,t}$, which is obtained by multiplying for each period t its fixed Laspeyres-type weight w_i by the change in its relative price between the base period and period t. The Laspeyres-type weights w_i of the CPI reflect the importance of each category in total household consumption expenditure in the base period. Evidently, the weights satisfy $\sum_{i=1}^{60} w_{i,t} = 1$ for all t. In so doing, the weighted mean of the 60 product-specific price changes $\Pi_{i,t}$ corresponds to aggregate inflation.

3 It was not possible to start at an earlier point in time, for instance during the low-inflation regime of the 1960s, for data availability reasons.

3. Detection of outliers

In this section we will mainly show that the Belgian price changes contain a substantial amount of outlying values. For this, we will consider the cross sections and compute robust measures of tail weight for each of them. To show the importance of the tails of univariate data (as the cross sections are), we can use the classical measure of kurtosis. In general, kurtosis is said to characterise the fatness of the tails, or equivalently the tail weight, but it also reflects the shape of the density in the centre. Moreover, the classical measure of kurtosis is based on moments of the data set, and thus it is strongly influenced by outliers. Despite the fact that outliers determine the tail weight, we can construct robust measures to compute it. For this purpose, we first need a robust estimator of *location* and *scale* for univariate data. In general, we denote the sample by x_i ($i = 1,\dots, n$) and the corresponding weights by w_i. As usual, the weights sum to 1. Time subscripts are omitted to simplify notations.

3.1 Robust measure of location

A measure of location should estimate a value that characterises the central position of the data. The best known measure of location is the *weighted mean* or average, defined as:

$$\bar{x} = \sum_{i=1}^{n} w_i x_i \tag{3.1}$$

Note that with the data set we analyse, the weighted mean corresponds to observed inflation.

A typical robust measure of location is the *median*. It is defined by first sorting the observations from smallest to largest, and then taking the middle observation (for an even number of observations we take the average of both observations in the middle). Here, we need the weighted variant of the median. In general, all measures based on percentiles can be modified easily to their weighted version by filling in the weighted percentiles. That is the main reason why all robust measures presented in this paper are based on percentiles.[4] For the p% weighted percentile, denoted by Q_p, we first sort the observations from smallest to largest, and then take the first value with a cumulative weight higher than p%. The weighted median equals the 50% weighted percentile, or $Q_{0.50}$.

3.2 Robust measure of scale

Scale characteristics measure how "spread out" the data values are. The classical measure of scale is the *standard deviation*, which is given by:

$$s = \sqrt{\frac{\sum_{i=1}^{n} w_i \left(x_i - \bar{x}\right)^2}{1 - \sum_{i=1}^{n} w_i^2}} \tag{3.2}$$

where $\bar{x}$ stands for the mean.[5] The *interquartile range* or IQR is a robust measure of scale which, like the median, is based on percentiles and is easy to calculate. The (weighted) interquartile range is the distance between the 75% percentile $Q_{0.75}$ and the 25% percentile $Q_{0.25}$, or:

$$IQR = Q_{0.75} - Q_{0.25} \tag{3.3}$$

3.3 Robust measures of tail weight

We propose six alternatives to the classical kurtosis. We will denote them with tail length and tail mass. The tail length measures are based on differences between the outlying observations and the

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4 Initial work on other robust measures based on couples and triples of observations was abandoned precisely because it was not straightforward to construct them in weighted terms. Verbrugge (1999) presents a robust measure of skewness based on triples for *unweighted* inflation data. Brys et al (2002) also discuss some unweighted robust skewness measures based on percentiles, couples and triples.

5 Equation (3.2) is based on the unbiased sample moments of unequally weighted frequency distributions presented in Roger (forthcoming).

median of the data, while the tail mass measures simply count the outliers. To distinguish the outlying values from the regular ones we use the following outlier rules:

- The *percentile rule*, where an observation is declared an outlier when it lies outside the interval:

  $$[Q_p, Q_{1-p}] \tag{3.4}$$

  for any $0 < p < 1$. Here, we consider two particular choices of p, namely $p = 12.5\%$ and $p = 25\%$.

- The *general boxplot rejection rule* defines outliers as points outside the interval:

  $$\left[med - \frac{3}{2} IQR,\ med + \frac{3}{2} IQR \right] \tag{3.5}$$

  where *med* denotes the median. This criterion is based on the definition of the whiskers in the univariate boxplot (see Tukey (1977)).[6]

- The *asymmetric boxplot rule*. This rule is a special case of the bivariate bagplot in Rousseeuw et al (1999), which is a bivariate generalisation of the boxplot. Points are considered outlying when they lie outside the interval:

  $$\left[med - 3\left(Q_{0.50} - Q_{0.25}\right),\ med + 3\left(Q_{0.75} - Q_{0.50}\right) \right] \tag{3.6}$$

Now we can introduce the *tail length* measures. For any of the outlier rules, we define:

$$\text{left tail length} = \sum_{i=1}^{n} w_i \left(\frac{med - \hat{x}_i}{IQR} \right) \tag{3.7}$$

where $\hat{x}_i$ denote the left outliers found by that specific outlier rule. Note that the median and *IQR* are computed on all observations, including the outliers. Using the percentile rule, we so obtain *left tail length*(125) and *left tail length*(250). The general boxplot rule and the asymmetric box plot (abp) rule lead to the tail length measures left tail *length(box)* and left tail *length(abp)*. By replacing the left outliers with the right outliers in equation (3.7), and by using $(\hat{x}_i - med)$ instead of $(med - \hat{x}_i)$ in the numerator, we get *right tail length*(125), *right tail length*(250), *right tail length(box)* and *right tail length(abp)*.

Next, we obtain measures of the (left) *tail mass* as the sum of the weights of the (left) outliers, ie:

$$\textit{left tail mass} = \sum_{i=1}^{n} w_i \theta_i \tag{3.8}$$

where θ_i equals 1 if x_i is a left outlier and 0 if not. This leads to *left tail mass(box)* and *left tail mass(abp)*. Note that it makes no sense to consider *left tail mass*(125) or *left tail mass*(250) since these measures are always equal to 12.5% or 25%, regardless of the data. Considering the right outliers, we obtain *right tail mass(box)* and *right tail mass(abp)*.

3.4 Results for Belgian inflation data

All measures defined above were applied to the cross sections of the Belgian inflation data. In Graphs 1 and 2 the resulting time series are plotted by considering all 291 consecutive cross sections. On the plots, the scatter points of the different measures are depicted, together with a smoother (solid line). We have chosen to use a Lowess smoother, which is a robust scatter plot smoother.[7] Lowess uses robust locally linear fits, by placing a window about each point and weighting the points that are inside the window so that nearby points receive the most weight.

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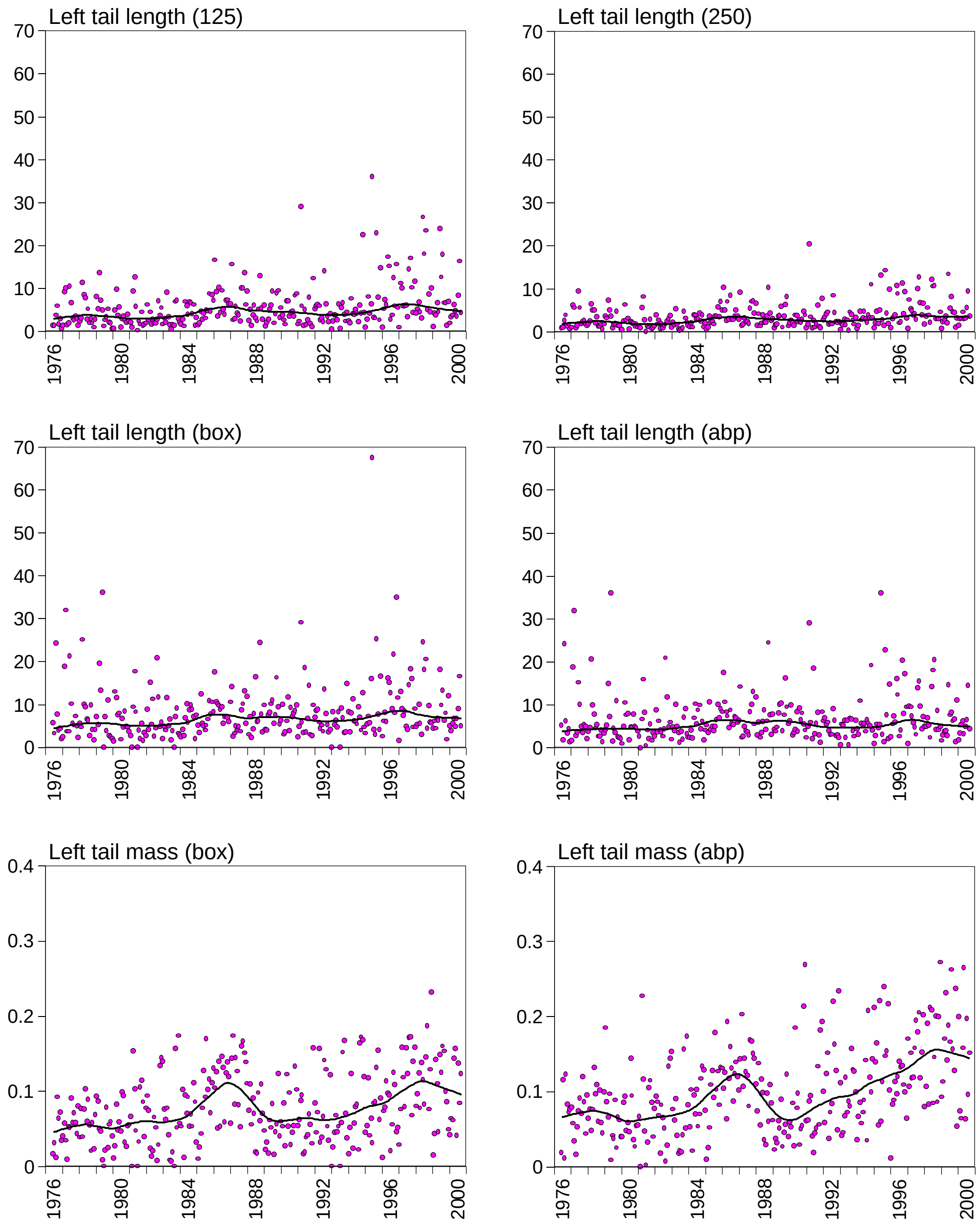
[6] Note that this interval corresponds approximately to $\left[\bar{x} - 2s, \bar{x} + 2s\right]$ in the case of the normal distribution.

[7] See Cleveland (1979).

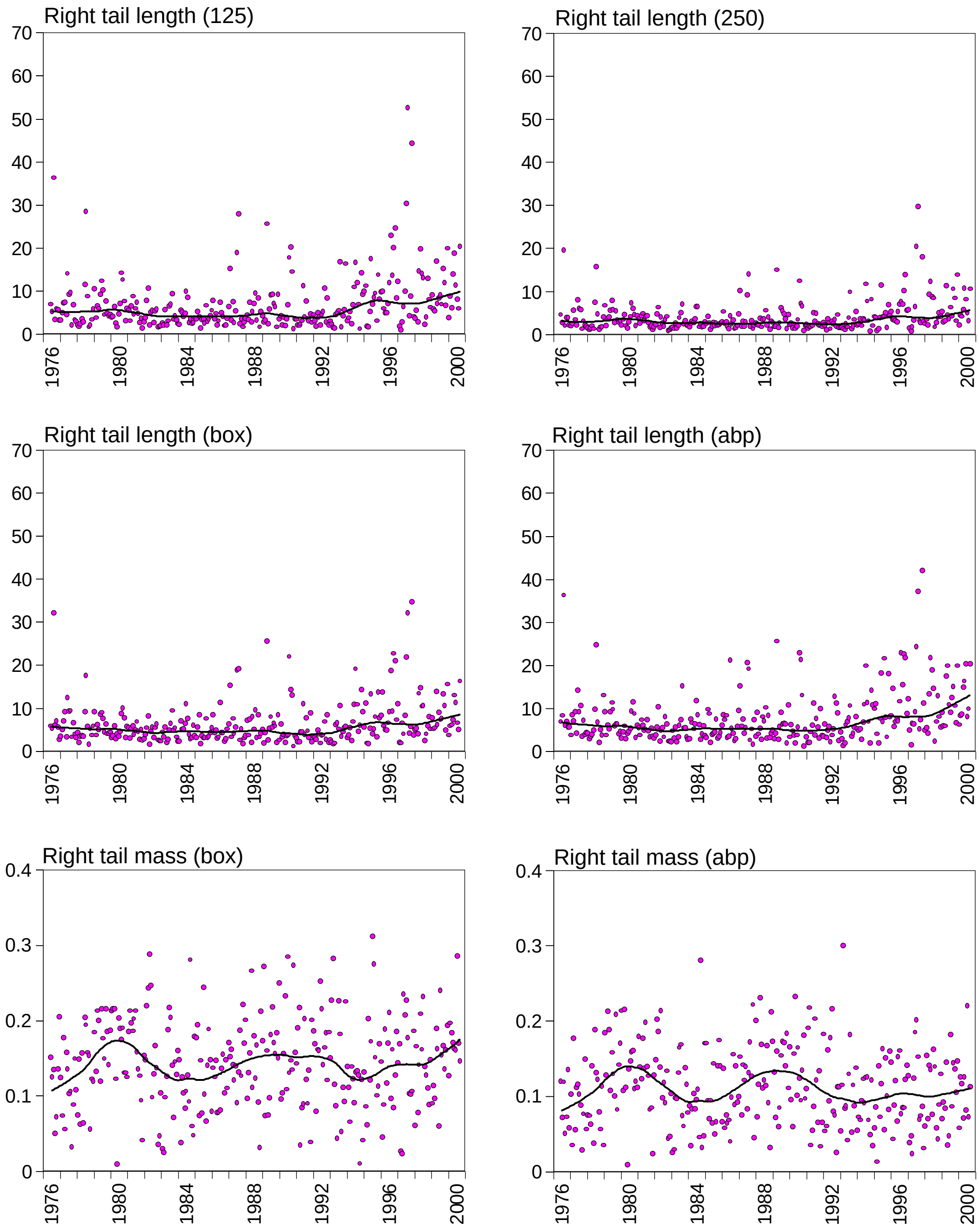
Graph 1

Left tail weight



Graph 2

Right tail weight



The *tail mass(box)* measures show substantial proportions of outliers and these proportions are, moreover, very volatile. This is why we will use robust measures of location, scale and skewness to analyse the data further on. Before doing so, we have a closer look at the tails. On the basis of the smoothed curves, *left tail mass(box)* amounted to roughly 5% at the beginning of the sample and increased to approximately 10% at the end of the sample. *Right tail mass(box)*, in contrast, tends to oscillate around 15% during the whole sample. These observed tail weights are substantially in excess of those for the normal distribution, for which the corresponding *tail mass(box)* measures amount to

2.15% for each tail. This clearly illustrates the fat-tailed nature of Belgian inflation data, a finding which is in line with the results in the international literature on this issue.[8] It should, however, be stressed that most of the international evidence is based on the classical kurtosis, which may for several reasons underestimate the importance of outliers.[9]

We interpret the fact that the smoothed curve indicates an upward tendency for left tail mass as a first piece of evidence against the existence of an exogenous form of downward nominal rigidity in Belgian product markets. Indeed, with aggregate inflation substantially lower in the second half of the period, the probability of having nominal price decreases in the left hand tail increases. If prices are effectively rigid downwards - ie if they cannot decrease in nominal terms for purely exogenous reasons - this should reduce left tail mass at the end of the period, whereas we observe exactly the opposite. The left tail length measures do not show a tendency to decrease over time either, thus confirming the conclusion made above.

The fact that *right tail mass(box)* tends to have larger values than the corresponding left alternative is a first indication of the existence of chronic right skewness, albeit apparently decreasing over time. A possible disadvantage of the general boxplot rejection rule is that it takes the left part of the data into account when defining a right outlier and vice versa. Using the asymmetric boxplot rule overcomes this problem. In so doing, we find that *left tail mass(abp)* increases and *right tail mass(abp)* decreases relative to their symmetrical alternatives, which can be seen as another indication of chronic right skewness. These asymmetrically constructed tail mass measures confirm the tendency for the left-hand tail to increase and the more stationary behaviour of the right-hand tail.

4. Classical and robust measures of location and scale

The classical and robust measures of location and scale are plotted in Graph 3. The robust alternatives were already used in the previous section to construct robust measures of tail weight. In this section we will compare them to their classical counterparts.

4.1 Location

As the use of robust measures of location for inflation data is well developed in the core inflation literature, we only give some brief comments when comparing the mean to the median. The interested reader is referred to other papers in this field for a deeper analysis.[10] As the ADF tests reported in Table 1 fail to reject the null hypothesis of a unit root, both time series contain a stochastic trend. The smoothed curves in Graph 3 seem to confirm this conclusion. The median is substantially less volatile around its trend than the mean, thus confirming that using a robust estimator of location yields a substantial gain in efficiency in the case of a fat-tailed distribution. This could motivate the use of the median as a measure of core inflation statistically. The first robust core inflation measure, proposed by Bryan and Pike (1991), was indeed the median. Subsequently, a wide range of alternative robust estimators of core inflation have been proposed (see footnote 10 for references).

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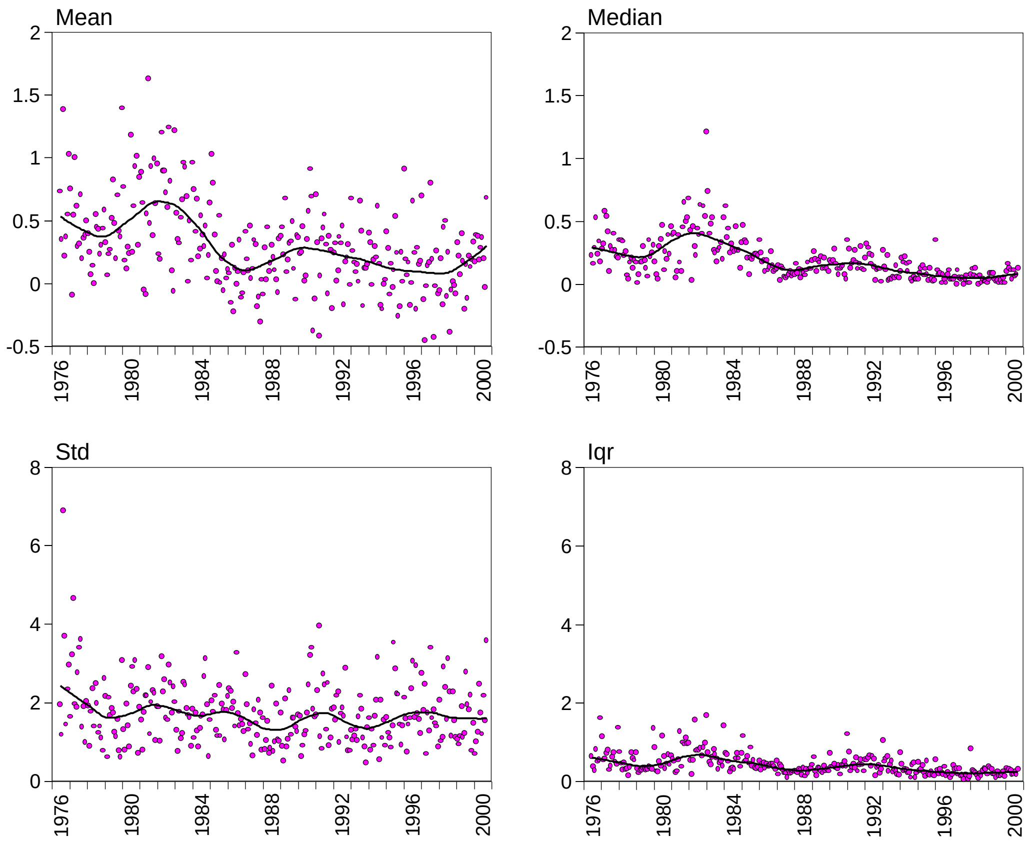
8 See, for instance, Bryan et al (1997), Roger (1997), Kearns (1998), Bakhshi and Yates (1999), Meyler (1999, 2001), Marques and Mota (2000), Aucremanne (2000), Vega and Wynne (2001), Knudsen and Nielsen (2002) and Roger (forthcoming).

9 See for instance Aucremanne (2000) on this so-called masking issue.

10 See for instance Bryan et al (1997), Roger (1997), Kearns (1998), Alvarez and de los Llanos Matea (1999), BIS (1999), Bakhshi and Yates (1999), Le Bihan and Sédillot (1999), Meyler (1999, 2001), Roger (2000), Aucremanne (2000), Landau (2000), Vega and Wynne (2001), Nielsen and Knudsen (2002) and Roger (forthcoming).

Graph 3

Classical and robust measures of location and scale



As can be seen from Table 2, the median is cointegrated with the mean, but with a coefficient (0.5934) that is substantially less than one. In Graph 3 it can indeed be verified that the median tends to be lower than the mean. This is another indication of chronic right skewness in the Belgian inflation data and raises the question of constructing a core inflation measure which incorporates this characteristic of the data (see Section 7). As such, the median violates the first condition put forward in Marques et al (2000) for an ideal core inflation measure. It is said to be a biased estimator. Note also that the constant in the cointegration relation is very close to 0, suggesting that the chronic asymmetry would disappear completely at zero inflation (see also Section 6).

4.2 Scale

Comparing the classical standard deviation with *IQR* indicates that relying on a robust alternative dramatically alters the characteristics of the measure of scale. According to the ADF tests in Table 1, *IQR* contains a unit root whereas the classical measure appears as a stationary variable. Moreover, Graph 3 shows that the variability of *IQR* around its smoothed curve is substantially lower than the variability of the classical standard deviation. We owe this to the fact that the classical measure is dominated by the impact of outliers or, in economic terms, by large relative price shocks. In the absence of outliers, *IQR* would in contrast tend to be larger than the standard deviation (in the case of the normal distribution *IQR* $\cong$ 1.35 std). Evidently, the impact of outliers on the classical measure of scale is magnified by squaring their deviations from the mean, as can be seen from equation (3.2). A more detailed analysis of the measures of scale and their relation with aggregate inflation is presented in Section 6.

Table 1

Unit root tests for classical and robust measures of location, scale and skewness

(augmented Dickey-Fuller test statistic)

	With a constant in the test equation[1]	Significance of the constant - p-value[2]	Lag number[3]
Location			
Mean	−1.74		11
Median	−1.58		11
Scale			
Standard deviation	−3.97	0.00	11
IQR	−1.74		11
Skewness			
skew(class)	−3.82	0.12	11
dskew(class)	−5.80	0.02	11
dskew(125)	−2.55		11
dskew(250)	−3.44	0.00	11
meme	−2.59		11

[1] The 95% critical value for rejection of the null hypothesis of a unit root is −2.87. Inclusion of a trend in the test equations for those variables for which the null of a unit root was not rejected did not change the results. In other words, they were not trend stationary either. [2] Only reported when the null hypothesis of a unit root is rejected. [3] Given the monthly frequency of the data, 11 lags were necessary to produce residuals without autocorrelation.

Table 2

Cointegration of robust measure of location with actual inflation (mean)

	Median
Lag number	11
Cointegration equation (CE)[1]	
Constant	0.0002 (0.01)
Mean	−0.5934 (−10.54)
Trace statistic[2]	
No CE	35.09
At most 1 CE	4.70

[1] Normalised cointegration coefficients, with the coefficient of the variable at the top of the column normalised to 1. [2] The 95% critical value is 19.96 for rejection of the null hypothesis of no cointegration equation and 9.24 for rejection of the null hypothesis of at most 1 cointegration equation. The cointegration rank and the specification of the deterministic components of the model were determined jointly on the basis of the general test procedure discussed in Johansen (1992). However, models having trends in the levels of the variables (constants in the VAR) were not considered.

5. Classical and robust measures of skewness

Skewness reflects the shape of the distribution. A symmetric distribution has zero skewness, a distribution which is asymmetric with the largest tail to the right has a positive skewness, and a distribution with a longer left tail has a negative skewness.

5.1 Classical measures of skewness

Normally the standardised, unitless measures of asymmetry (skewness) are used. The best known measure of skewness is the classical skewness,[11] which is defined as:

$$skew(class) = \frac{\sum_{i=1}^{n} w_i \left(x_i - \overline{x}\right)^3}{\left(1 - 3\sum_{i=1}^{n} w_i^2 + w_i^3\right) s^3} \tag{5.1}$$

However, we will consider destandardised measures of asymmetry as well. In this way skewness becomes dependent on scale, but this correlation does not bother us. Indeed, the economic models we rely on suggest that scale and skewness interact (see also Section 6). Ball and Mankiw (1995) show that scale magnifies the effect of skewness on inflation, while the asymmetric range of inaction in Ball and Mankiw (1994), which is a possible source of right skewness in the data, is also unscaled. All destandardised measures of asymmetry are expressed in some unit, and the robust measures have the same units as the data and the measures of location and scale. The latter will facilitate their use in the construction of an unbiased core inflation estimator in Section 7. The destandardised classical skewness is defined as:

$$dskew(class) = \frac{\sum_{i=1}^{n} w_i \left(x_i - \overline{x}\right)^3}{1 - 3\sum_{i=1}^{n} w_i^2 + 2\sum_{i=1}^{n} w_i^3} \tag{5.2}$$

5.2 Robust measures of skewness

A disadvantage of the classical measures of skewness is that they change dramatically when we introduce an outlier. The impact of outliers is even stronger than in the case of the mean and the standard deviation. On the other hand, skewness is supposed to measure the asymmetry of the observations, so we may not downweight outliers too heavily. The first robust alternative we propose is *dskew*(125), which is given by:

$$dskew(125) = \left(Q_{0.875} - Q_{0.50}\right) - \left(Q_{0.50} - Q_{0.125}\right) \tag{5.3}$$

with Q_p again the *p*% (weighted) percentile. The following measure is very similar, but it is based on other percentiles. We compute *dskew*(250) as:

$$dskew(250) = \left(Q_{0.75} - Q_{0.50}\right) - \left(Q_{0.50} - Q_{0.25}\right) \tag{5.4}$$

Another measure of skewness can be obtained by standardising the data as:

$$z_i = x_i - med \tag{5.5}$$

and then taking the first moment of these standardised observations which corresponds to the mean-median difference, *meme* yielding:

$$meme = \overline{z} = \sum_{i=1}^{n} w_i z_i \tag{5.6}$$

Strictly speaking this measure is not robust, as it uses the mean. However, we consider it here as an alternative measure of skewness as it has, compared to the classical measures, the advantage that the influence of what happens in the tails is far less accentuated.

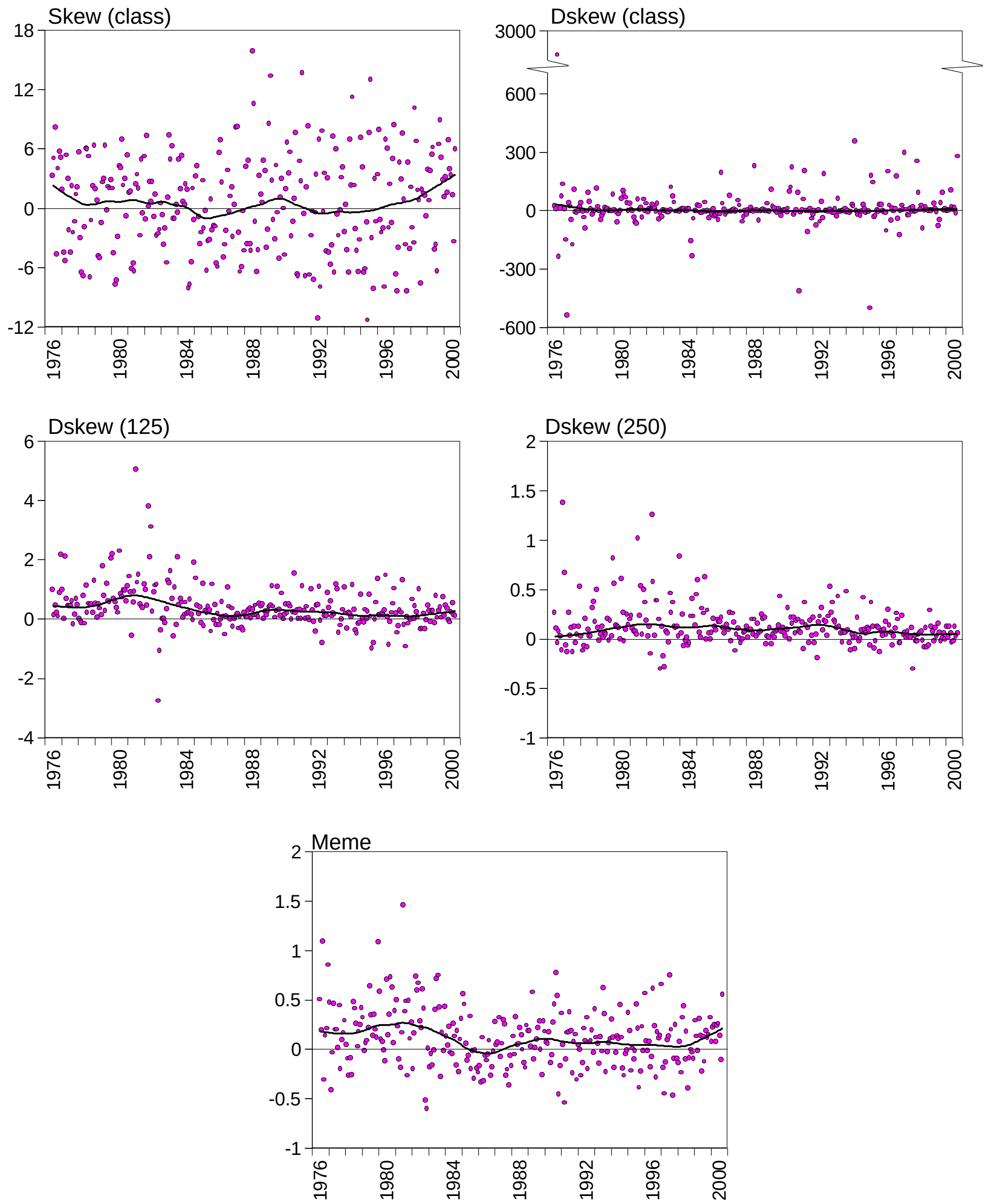
[11] Equations (5.1) and (5.2) are based on the unbiased sample moments of unequally weighted frequency distributions presented in Roger (forthcoming).

5.3 Chronic right skewness

We have applied both types of measures of skewness on the cross sections of the Belgian inflation data. The resulting time series are plotted in Graph 4. The classical measures of skewness show a substantial degree of frequently switching left and right skewness, which is a typical result in the

Graph 4

Classical and robust measures of skewness



literature with regard to the analysis of inflation data.[12] However, they do not show a clear tendency towards positive values. As for scale, the time series properties of the robust measures of skewness are fundamentally different from those of the classical ones. As the ADF tests in Table 1 indicate, the null hypothesis of a unit root in the classical measures was rejected at the 99% significance level. Moreover, the constant term in the test equation was not different from zero at the conventional significance levels for *skew(class)*. For *dskew(class)* the constant was significant at the 95% level, but not at the 99% level. In addition, in this case the estimated value of the constant (11.14) is small relative to the variability observed in the series. Hence, the classical measures hardly reveal any form of chronic right skewness in a significant way, notwithstanding the fact that we provided evidence of a tendency towards right skewness in Sections 3 and 4.

In contrast, the robust measures *dskew*(125) and *dskew*(250) show a more pronounced tendency towards positive values. Hence, they better reveal the chronic right skewness of the data. The mean-median difference *meme* also shows such a tendency, although it takes negative values more frequently than the two other robust measures. We owe the latter to the fact that *meme* is in fact not robust. The null hypothesis of a unit root is rejected for *dskew*(250) at the 95% significance level, suggesting mean reversion around a significant positive constant. In contrast, for *dskew*(125) and *meme*, the null of a unit root is not rejected, suggesting a time-varying degree of chronic right skewness. Particularly in the second half of the sample, the tendency towards right skewness seems less pronounced, thus confirming the findings of Sections 3 and 4. A chronic tendency towards right skewness is also found in several other countries,[13] and some of these studies also mention that this tendency is less pronounced in the most recent period, when inflation is lower.

6. Inflation and relative prices

In this section we report our empirical results regarding the relationship between aggregate inflation and the classical and robust measures of scale and skewness, and interpret them against the background of menu cost models, as these have recently become the focal point in this literature. We start with an intuitive discussion of the main implications of these models.

6.1 Menu cost models

Menu cost models assume that changing prices involves a cost, which is fixed in the sense that it does not depend on the magnitude of the price change. Examples of this type of cost are changes to price lists, catalogues, advertising, etc. Simplifying the economy to one without trend inflation, where only zero mean relative price shocks occur, Ball and Mankiw (1995) show that the menu cost produces a symmetric range of inaction. Firms react only to large relative price shocks - responding equally to positive and negative shocks - for which the advantage of changing prices outweighs the menu cost.

As Graph 5 illustrates,[14] symmetric distributions of relative price shocks do not affect aggregate inflation, as (large) price increases are exactly compensated by (large) price decreases. It is easy to verify that, in this case, increasing the variance of the (symmetric) distribution of relative price shocks has no effect on aggregate inflation either. However, things change when the distribution of relative price shocks is asymmetric. When these shocks are skewed to the right (left), large relative price increases (decreases) will no longer be compensated totally by large relative price changes in the

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[12] This property of the data is documented for several other countries in, for instance, Bryan et al (1997), Roger (1997), Kearns (1998), Alvarez and de los Llanos Matea (1999), Bakhshi and Yates (1999), Le Bihan and Sédillot (1999), Marques and Mota (2000), Aucremanne (2000), Meyler (2001), Vega and Wynne (2001), Knudsen and Nielsen (2002) and Roger (forthcoming).

[13] See, for instance, Chatelain et al (1996) and Le Bihan and Sédillot (1999) for France, Roger (1997) and Roger (forthcoming) for New Zealand, Kearns (1998) for Australia, Marques and Mota (2000) for Portugal, Meyler (1999, 2001) for Ireland, and Vega and Wynne (2001) for the euro area as a whole and for participating countries. In contrast, in the United States the distribution is symmetric (Cecchetti and Groshen (2000)).

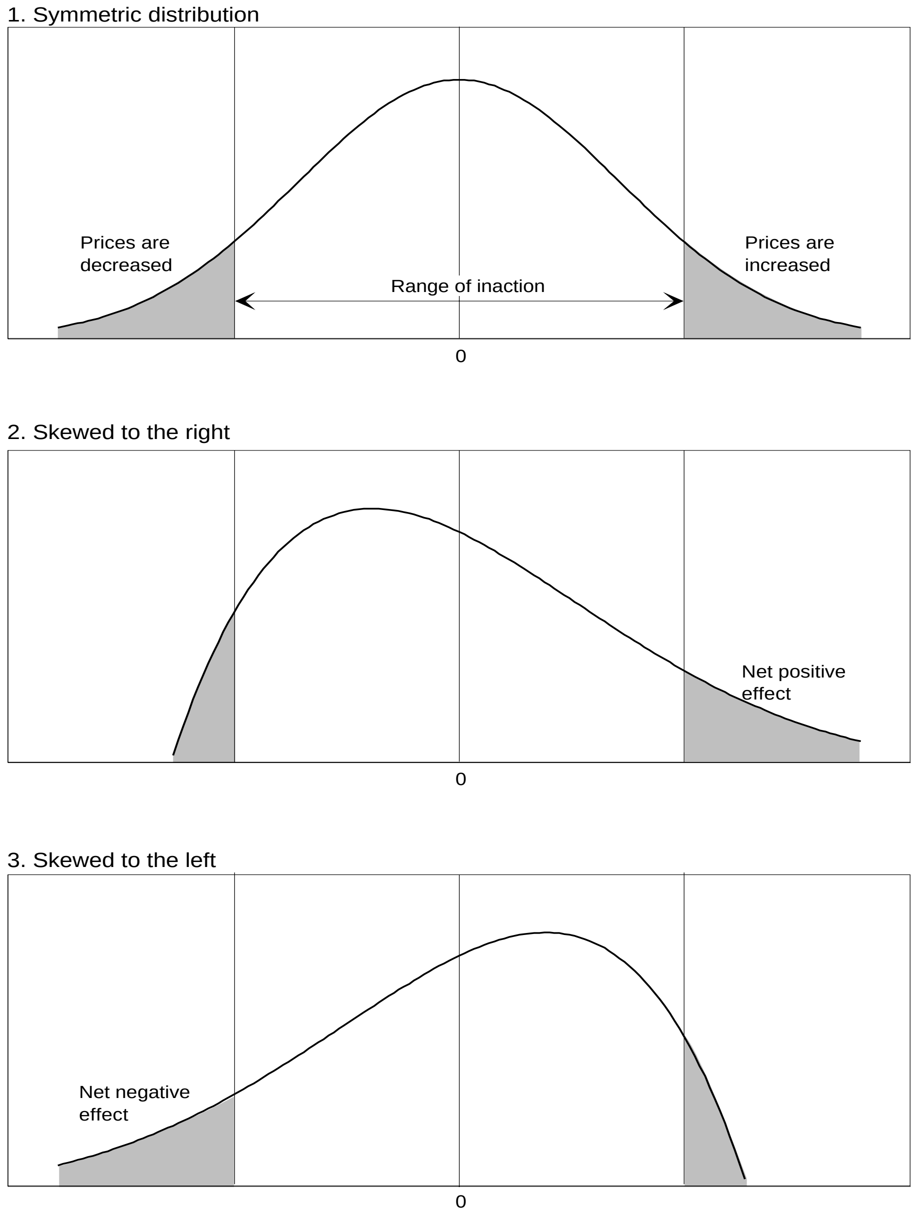
[14] The graph is based on Ball and Mankiw (1995).

opposite direction, and aggregate inflation will increase (decrease) in the short run. In other words, the model predicts that inflation is positively related to the skewness of the relative price shocks in the short run and, by extension, also to the skewness of observed relative price changes. Increasing the variance of the skewed distributions - a phenomenon which can be measured by using destandardised measures of skewness - magnifies the impact of skewed relative price shocks on inflation. Ball and Mankiw have interpreted the positive correlation between inflation and the skewness of the distribution of relative prices as evidence in favour of menu cost models.

Graph 5

The impact of the shape of the distribution of relative price shocks in a menu cost model without trend inflation

Density functions of zero mean relative price shocks

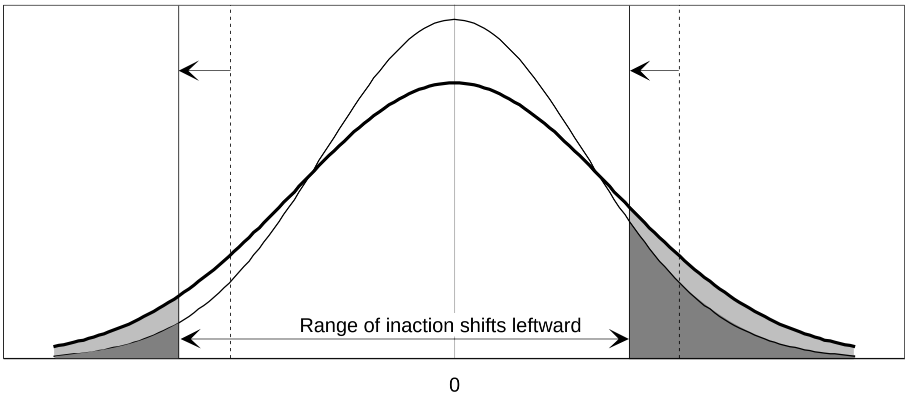


When trend inflation is introduced in an otherwise similar model, the optimising behaviour of price setters leads to an asymmetric range of inaction, as is illustrated in Graph 6. Trend inflation shifts the range of inaction endogenously leftwards: for a given absolute value of a relative price shock, an upward adjustment is more likely than a downward adjustment. The intensity of this shift depends on trend inflation.[15] Intuitively, this asymmetry comes from the fact that trend inflation can lead to the desired relative price decreases even if nominal prices are not changed, whereas it magnifies the incentive to change nominal prices when a relative price increase is desirable.

Graph 6

Introducing trend inflation in a menu cost model

Density functions of zero mean relative price shocks



This has three implications for the relation between inflation and relative prices: (i) as is illustrated in Graph 6, increasing the variance of a symmetric distribution of relative price shocks now has a positive impact on observed inflation in the short run, and this impact increases with the intensity of the leftward shift of the range of inaction or, equivalently, with trend inflation; (ii) the impact of asymmetric price shocks on inflation in the short run is not fundamentally altered by the introduction of trend inflation in the model; and (iii) the model generates a tendency towards right skewness in the distribution of observed price changes, as price adjustment is more likely for positive relative price shocks than for negative shocks and this effect, too, increases with trend inflation. Clearly, for the latter effect, causality runs from trend inflation to the distribution of observed relative prices and this impact would disappear when targeting a zero inflation rate, in which case the range of inaction is again symmetric as in the first model.

Our findings with respect to the time series properties of the classical and the robust measures of scale and skewness respectively are not without consequences for their relation with aggregate inflation. They indicate that it is not appropriate to relate the classical measures of scale and skewness to inflation. Rather, they should be related to the first difference of inflation. This relation will be discussed in Section 6.2. With our data, relating the robust measures of scale and skewness to inflation must, in contrast, be done in a cointegration framework. The latter relations will be discussed in Sections 6.3 and 6.4.

[15] For a formal derivation of this result, we refer to Ball and Mankiw (1994) or to Andersen (2000).

6.2 Using classical measures: relative prices affecting inflation

Table 3 reports our regression results linking the first difference of observed monthly inflation with the classical measures of scale and skewness. Following De Abreu Lourenco and Gruen (1995), the sample was split into two subperiods to illustrate the role of trend inflation. According to the menu cost theory, the prevailing inflationary regime should particularly affect the estimated coefficient for scale. The first subperiod, running from 1976.09 to 1987.12, was characterised by a substantially higher average inflation rate than the second subperiod, running from 1988.01 to 2000.09. For each subperiod a first regression is reported using the contemporaneous standard deviation, as well as two lags of this variable. The next equation adds the classical skewness and two lags as explanatory variables. Adding *dskew(class)* in a similar way did not yield significant coefficients for this variable.[16] Table 3 gives the estimated coefficients, as well as the corresponding t-statistics. As the Durbin Watson statistics of the estimated regressions reveal the presence of autocorrelation, the t-statistics were calculated using the heteroskedasticity and autocorrelation consistent (HAC) covariance matrix estimator of Newey and West (1987).

Table 3

Regression results relating the change in inflation to the classical measures of scale and skewness

	Constant	**Standard deviation**			***skew(class)***			**Adjusted R^2**	**DW**	**Coefficient restrictions[1] p-value**	
		t	*t* – 1	*t* – 2	*t*	*t* – 1	*t* – 2			H_0 C(2) = −C(3), C(4) = 0, C(5) = −C(6), C(7) = 0	H_0: C(2) = 0, C(3) = 0, C(4) = 0
	C(1)	C(2)	C(3)	C(4)	C(5)	C(6)	C(7)				
Period 1976.09-1987.12	−0.073 (−0.98)	0.197 (5.39)	−0.186 (−3.38)	0.026 (0.62)				0.200	2.58	0.58	0.00
Average annual inflation: 5.3%	−0.061 (−1.02)	0.189 (4.88)	−0.164 (−3.77)	0.008 (0.26)	0.039 (4.94)	−0.043 (−4.08)	−0.001 (−0.08)	0.378	2.71	0.89	0.00
Period 1988.01-2000.09	0.109 (1.36)	0.079 (1.53)	−0.088 (−1.99)	−0.056 (−1.39)				0.045	2.60	0.27	0.12
Average annual inflation: 2.8%	0.098 (1.70)	0.044 (1.24)	−0.060 (−1.66)	0.041 (−1.38)	0.024 (6.65)	−0.032 (−7.20)	0.002 (0.53)	0.383	2.70	0.32	0.20

[1] Wald test.

All the estimated coefficients for the contemporaneous standard deviation (C(2)) and contemporaneous *skew(class)* (C(5)) are positive. The estimated coefficients for the first lag of these variables (C(3) and C(6) respectively) have more or less the same magnitude in absolute value as the coefficient of the corresponding contemporaneous variable, but have systematically the opposite sign. All the coefficients for the second lag are statistically non-significant (C(4) and C(7) respectively). The null hypothesis which imposes these features as restrictions on the coefficients was not rejected by the first Wald test presented in Table 3. This clearly illustrates the short-run nature of the estimated equations: while having a clear impact on the change in inflation, the standard deviation and the skewness do not have a permanent effect on inflation. This suggests that these relations illustrate the impact of relative price shocks on inflation, which according to economic theory is short-lived. This would imply that, in the estimated regressions, causality is running from the standard deviation and

[16] Results of this third type of regression are therefore not reported in Table 3.

skew(class) to aggregate inflation. Overall, these results are in line with the predictions of menu cost models, outlined in the previous section. But do they really allow us to discriminate sticky from flexible price behaviour?

Finding a positive coefficient for contemporaneous skewness is not particularly relevant in this respect, as the traditional approach which interprets the classical mean-skewness correlation as evidence in favour of menu costs has recently been criticised on two grounds. In economic terms, Balke and Wynne (2000) showed that a flexible price general equilibrium model can generate this correlation as well. Statistically, Bryan and Cecchetti (1999) have attributed this result to the small-sample bias characterising this correlation in the case of fat-tailed distributions.[17] However, the impact of the inflation regime on the estimated coefficients seems more relevant in this respect. Comparing the regression results for the two subperiods shows that the impact of the prevailing inflation regime is moderate for the coefficients of skewness. The inflation regime matters much more for the impact of scale, as the coefficients for the standard deviation are substantially reduced from the first to the second subsample, to the extent that they are no longer significant. The second Wald test presented in Table 3 clearly rejects the null hypothesis that all the coefficients of the standard deviation are zero in the first subsample, but not in the second subsample. In addition, this result is in line with the predictions of menu cost models and suggests an important role for trend inflation, which in principle is not crucial in flexible price models.

6.3 Using robust measures: inflation affecting relative prices

As shown in Table 4, using the robust measure *dskew*(125) reveals a clear positive cointegration relationship between asymmetry and inflation. Each percentage point of additional (monthly) inflation tends to increase *dskew*(125) by 1.5 percentage points. Moreover, the constant term in the cointegration relation is very small both in statistical and in economic terms, suggesting that the chronic right skewness would disappear at zero inflation.[18] As such, the long-term behaviour of the chronic right skewness measured by *dskew*(125) seems to be an integral part of the inflationary process itself.

Also for *dskew*(250), the Johansen cointegration test reveals the existence of a positive cointegration relation with inflation, notwithstanding the fact that the ADF test reported in Table 1 suggests that *dskew*(250) is stationary.[19] This measure of asymmetry tends to increase by 0.26 percentage points for each percentage point rise in (monthly) inflation. The constant in the cointegration relation for *dskew*(250) suggests the existence of some form of chronic right skewness which is independent of the inflationary process. The impact of this constant is, however, relatively small compared to the impact of inflation. Indeed, each 0.2% of additional monthly inflation (approximately 2.4% on a yearly basis) increases *dskew*(250) by the same amount as that resulting from the constant. This suggests that, relative to what has been observed historically, a substantial part of the chronic asymmetry measured by *dskew*(250) disappears at zero inflation.

Summarising these results, for both robust measures of skewness there exists a positive long-run relation with aggregate inflation. Moreover, all of the asymmetry measured by *dskew*(125) and a substantial part of the asymmetry measured by *dskew*(250) would disappear at zero inflation. These findings confirm the result found for the mean-median relationship documented in Section 4. By uncovering this type of endogenous chronic right skewness, these results tend to provide more

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[17] The idea is that when samples are drawn from a fat-tailed distribution, they will tend to contain outliers (ie observations drawn from the left- or the right-hand tail), which influence both the mean and the classical skewness in the same direction. As a consequence, even for symmetric but fat-tailed distributions it is very likely that skewed samples will be drawn. In that event, the sampling may be an important source of the observed mean-skewness sample correlation, which does not necessarily characterise the distribution. Interesting in this respect is the observation that the coefficient of skewness is, for both periods, no longer significant when the regressions are estimated with the median instead of the mean as the inflation measure. Having no significant impact of *skew(class)* on the change in inflation beyond the first lag also illustrates the simultaneity in the mean-skewness correlation. See also the comments of Ball and Mankiw (1999) on this small-sample bias.

[18] The sign of the constant term even suggests that the distribution would become slightly skewed to the left at zero inflation.

[19] In the case of conflicting results, the Johansen test dominates the ADF test, implying that *dskew*(250) also contains a unit root.

evidence in favour of menu cost models than that found on the basis of the classical measures only. Moreover, these results are qualitatively different from those of the previous subsection on the impact of skewness. Relating robust measures of skewness to aggregate inflation in a cointegration framework overcomes, by the very long-run nature of such a relation, the small-sample bias which typically characterises the contemporaneous correlation between inflation and skewness. The long-run nature of the relationship also suggests that monetary policy-related factors, such as the balance of supply and demand in the economy and inflation expectations, rather than relative price shocks, are the driving force.[20] This also corroborates our presumption, put forward in the introduction, that downweighting outliers gives more weight to these monetary policy-related factors. The finding that causality runs from aggregate inflation to relative prices fits less well in a flexible price scenario.

Table 4

Cointegration of the robust measures of skewness and scale with actual inflation (mean)

	***dskew*(125)**	***dskew*(250)**	***IQR***
Lag number	11	11	11
Cointegration equation (CE)[1]			
Constant	0.0412	–0.0534	–0.1790
	(0.73)	(–2.55)	(–5.39)
Mean	–1.5037	–0.2579	–0.8088
	(–9.42)	(–4.38)	(–8.65)
Trace statistic[2]			
No CE	30.86	24.88	28.21
At most 1 CE	3.41	3.39	4.90

[1] Normalised cointegration coefficients, with the coefficient of the variable at the top of each column normalised to 1. [2] The 95% critical value is 19.96 for rejection of the null hypothesis of no cointegration equation and 9.24 for rejection of the null hypothesis of at most 1 cointegration equation. The cointegration rank and the specification of the deterministic components of the model were determined jointly on the basis of the general test procedure discussed in Johansen (1992). However, models having trends in the levels of the variables (constants in the VAR) were not considered.

It is also important to note that this type of endogenous right skewness only reveals apparent downward nominal rigidity, as it would largely disappear at zero inflation. This differs substantially from the exogenously assumed downward nominal rigidity of Tobin (1972), which implies a negative rather than a positive relation between aggregate inflation and asymmetry, essentially on the basis of the same argument as the one we used in Section 3 to motivate a reduction of the left-hand tail. This difference is essential when the implications of our results for the optimal rate of inflation are examined, as is done in the next subsection.

6.4 Grease and sand effects

Tobin (1972) used the existence of exogenous downward nominal rigidity in labour markets to justify the statement that "higher prices or faster inflation can diminish involuntary, disequilibrium unemployment, even though voluntary, equilibrium labour supply is entirely free of money illusion" (see also Akerlof et al (1996) for a more recent treatment). The idea is that inflation relaxes the constraint that downward rigidity imposes on the adjustment of relative wages. According to this argument, inflation "greases" the wheels of the labour market. Extrapolated to product markets, the "grease" argument essentially states that, due to downward rigidities, there is insufficient relative price

[20] In Sections 6.2 and 6.3 the causal direction was inferred from the short- and long-run nature of the respective relationships. This approach differs from the one followed in Hall and Yates (1998), where the concept of Granger causality was used.

variability at low inflation rates, and that increasing inflation therefore leads to a more flexible economy and hence to a better economic performance. Maintaining the metaphor, inflation does, however, also have sand effects. The sand effect emphasises the fact that higher inflation can lead to unnecessary relative price variability which disrupts the allocative role that relative prices play in a market economy. These sand effects can result either from the staggered nature of price changes in the case of price stickiness or from a Lucas type of imperfect information, whereby higher and more variable inflation complicates the breakdown of observed nominal price changes into an aggregate and a relative component (Lucas (1972, 1973)). Sand effects emphasise the excess of relative price variability at higher inflation rates and provide arguments in favour of a low inflation target.

Against this background, it is clear that the interpretation of the relation between inflation and relative price variability, which will be discussed below, is not straightforward, as a positive effect of inflation on relative price variability can be symptomatic of both grease and sand effects and, depending on which effect is dominant, leads to completely different policy implications as to the optimal rate of inflation. The complex nature of the link between inflation and relative price variability was already put forward in Fischer (1981).

Using the robust measure of scale *IQR*, we do indeed find a strong positive cointegration relation between inflation and the dispersion of relative prices (see Table 4). The estimated impact of aggregate inflation on the dispersion of relative prices is again substantial, as a monthly inflation rate of 0.2% nearly doubles the dispersion that would prevail in the absence of inflation.

The literature on grease and sand effects[21] emphasises the fact that intermarket data, ie the dimension of inflation data we are examining, are particularly relevant for finding grease effects, while sand effects should even occur among prices of identical goods and hence should also be present in intramarket data. As to sand effects, the dimension of the data is also important when trying to distinguish between the two possible sources of sand effects. Intermarket data are the most relevant for imperfect information induced sand effects, while staggering should also affect intramarket data.

Cecchetti and Groshen (2000) also point to the fact that sand effects should be symmetrical, while grease effects may have an asymmetric impact, as they facilitate downward adjustment in particular. With this in mind, our result that the chronic right skewness is largely endogenous, rather than resulting from presumed downward rigidities, considerably reduces the scope for substantial grease effects. Hence, we interpret the inflation-*IQR* relation as sand rather than as grease, and we conclude that the cross-sectional properties of Belgian inflation data do not provide strong arguments against a price stability-oriented monetary policy which targets a low inflation rate. Theoretically, this conclusion is in line with the implications of menu cost models. In Ball and Mankiw (1994), the endogenous asymmetry erases grease effects completely so that these authors find that, in their model, the optimal rate of inflation is zero, as it allows (i) a maximal reduction of sand effects and (ii) a reduction of the resources spent on changing prices. Empirically, our results appear in line with those reported in Yates (1998), where the absence of a negative relation between inflation and skewness is interpreted as evidence against the existence of specific downward rigidities. Suvanto and Hukkinen (forthcoming) found that declining prices were rather frequent in Finland during the period 1995-2001 and conclude from this that the assumption of downward rigidity of nominal prices cannot be generalised to all situations.

7. An unbiased measure of core inflation

In the statistical approach to core inflation, robust estimators of location are proposed on the basis of the fat-tailed nature of the distribution of price changes. Section 3 documented this characteristic of the data for Belgian one-month price changes. On the basis of the results presented in Sections 5 and 6 we found, moreover, that the distribution is not only fat-tailed but also skewed to the right. Given the chronic right skewness, symmetrically constructed robust estimators tend to underestimate aggregate inflation, as has been documented in Section 4 for the median. Several asymmetrically constructed

[21] See, for instance, Cecchetti and Groshen (2000).

robust estimators have been proposed to overcome this problem.[22] They all have in common that the robust estimator is centred around a higher percentile than the 50% percentile and that this central percentile is essentially obtained by averaging over time some indicator of skewness. In so doing, this approach assumes a degree of chronic right skewness which is stable over time. However, by using robust measures we were able to uncover the time-varying and endogenous nature of the chronic right skewness in Belgian one-month price changes. This characteristic of the data presumably explains why some instability in the central percentile was found in Aucremanne (2000), when it was calculated for different periods, each of which was characterised by a different average inflation rate.

The use of robust estimators of location as measures of core inflation has also been motivated in economic terms by Bryan and Cecchetti (1994) on the basis of a variant of the (symmetric) menu cost model of Ball and Mankiw (1995). Since then, the economic rationale of robust estimators has, however, been criticised by several authors, mainly for two reasons.

First, as was emphasised above, the short-run mean-skewness correlation was found not to provide sufficient evidence in favour of menu costs. Second, even if menu costs or some other form of price stickiness do indeed exist, one should be careful in downweighting outliers. In that event, not only relative price shocks but also the inflationary process itself affects the distribution of relative prices. Hence, an outlier can be the result of a pure relative price shock, in which case downweighting this observation seems justified. Alternatively, it can also correspond to a price change induced by aggregate demand fluctuations, which are more relevant from a monetary policy perspective. In a context of infrequent adjustment of prices, this type of price change, too, will typically be large. This point was made in several papers, such as Zeldes (1994), Bakhshi and Yates (1999) and more recently in Aoki (2001) and in Mankikar and Paisley (2001). Finding an endogenous degree of chronic right skewness illustrates that this problem is not a purely theoretical issue, but has a clear practical relevance as well.

Against this background, it is our view that the chronic asymmetry found in the Belgian inflation data provides additional evidence in favour of menu cost models, on top of the evidence obtained on the basis of the classical mean-skewness correlation only. As such, this reinforces the economic rationale for the use of robust estimators of location, but at the same time it complicates their construction as the endogenous nature of the chronic right skewness should be taken into account. These economic arguments tend to put a lot of weight on the absence of bias in the estimator, whereas initially the focus was much more on the efficiency gain. In the case of skewed distributions, there is indeed a trade-off between efficiency and absence of bias. This point is illustrated, for instance, in Le Bihan and Sédillot (1999). We present a robust estimator of location below based on the median as a measure of core inflation, which is by construction unbiased and is nevertheless more efficient than the mean.

Our starting point is the first condition of Marques et al (2000) for an ideal core inflation measure, which provides an operational definition for an unbiased estimator. According to their terminology, a core inflation estimator is considered unbiased if cointegration with a unitary coefficient is found between actual and core inflation. In the previous sections, we provided evidence on two occasions that this was not the case for the median. First, in Section 4 we found a coefficient which is substantially less than one (0.5934, to be precise) in the cointegration equation linking the median and the mean. Second, in Section 5 it was found that the mean-median difference *meme* is a non-stationary variable, even in a test equation incorporating a constant term. The latter finding illustrates clearly that fixing the bias is a more complicated issue than merely correcting for a constant term, as is sometimes suggested.

Our strategy is to link *meme* in a cointegration relation to one of the robust measures of (chronic right) skewness and to exploit this cointegration relation subsequently to construct an unbiased estimator of core inflation. In so doing, we found that *meme* was cointegrated with *dskew*(125) in the following way:

$$meme - 0.3057\ dskew(125) \cong I(0)$$

By construction, this implies that the variable $median + 0.3057\ dskew(125)$ is cointegrated with a unitary coefficient with the mean (or, equivalently, with actual inflation). In consequence, this variable can be considered as an unbiased estimator of core inflation. The rationale of this approach is that, by

22 See, for instance, Chatelain et al (1996), Roger (1997), Kearns (1998), Aucremanne (2000), Marques and Mota (2000) and Meyler (1999, 2001).

incorporating *dskew*(125), the median is corrected upwards in order to take account of the chronic right skewness of the distribution, which is, as emphasised above, time-varying and largely part of the inflationary process itself. Hence, the fraction of the mean-median difference which is attributable to the chronic right skewness is incorporated into the core inflation measure, while the latter ignores only the fraction of the mean-median difference which is influenced by what is happening far down in the tails.

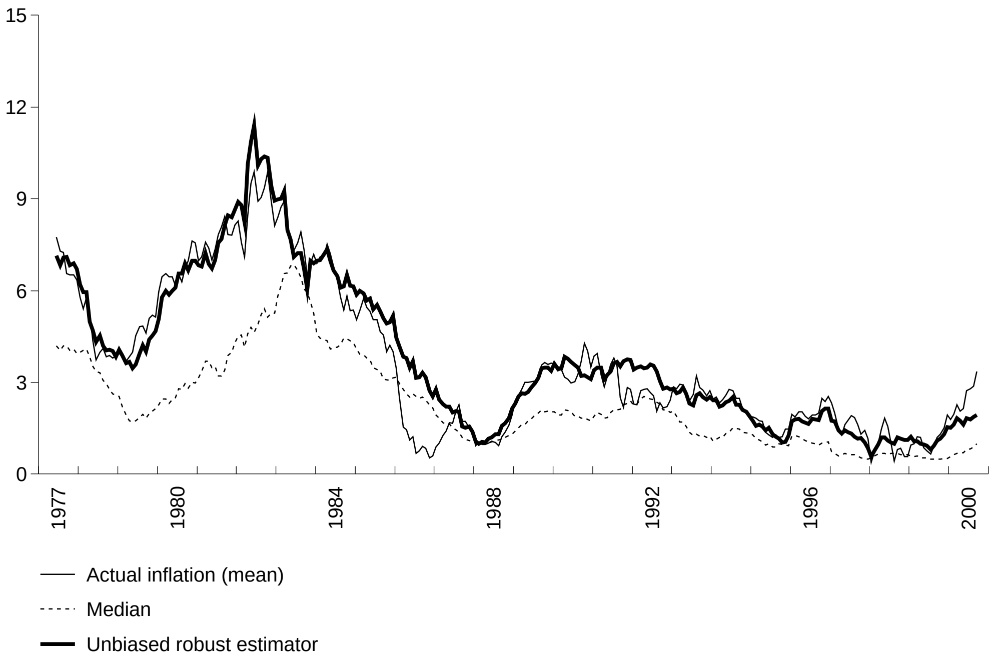
As inflation data are often expressed as year-on-year growth rates, we decided to express the core inflation measure considered as 12-month price changes as well, by simply compounding the original one-month price changes of the last 12 months. A similar approach - robust estimation on the basis of one-month price changes and subsequent smoothing by compounding it over the last 12 months - is applied in the Bank of England (see Mankikar and Paisley (2001)), and was also followed in Aucremanne (2000). All in all, the proposed core inflation measure of period *t*, expressed in terms of 12-month price changes, corresponds to:

$$\Pi_{s=0}^{11}\left[1+\left(median_{t-s}+0.3057\,dskew(125)_{t-s}\right)\right]-1 \qquad (7.1)$$

Graph 7

Unbiased robust estimator of core inflation

Compounded results, percentage changes



In Graph 7 the proposed estimator of core inflation is plotted together with the 12-month inflation rate and the median, which has been compounded in a similar way to obtain 12-month price changes as well. A comparison of the proposed core inflation measure with the median clearly illustrates the upward, but time-varying, correction made to the median, which makes the new estimator unbiased. But it also shows that the proposed core inflation measure is less smooth over time than the median, thus clearly illustrating the trade-off between absence of bias and efficiency. Despite this loss in efficiency relative to the median, the proposed core inflation measure remains smoother than actual inflation.[23] Of course, smoothness is a desirable property of a core inflation measure. However, as the smoothness of the shocks underlying the (core) inflationary process, as well as the smoothness of their transmission into prices, is unknown, it is not clear a priori exactly how smooth the core inflation measure should be. The loss of smoothness compared to the median is therefore not necessarily a drawback. Indeed, it seems that it is compensated for by the fact that the proposed core inflation measure is more deeply embedded in economic theory, by trying to abstract only from relative price changes which are due to pure relative price shocks, but not from those which, in a context of infrequent price adjustment, are the result of the ongoing inflationary process itself. The proposed core inflation measure deviates particularly from observed inflation in 1976, when oil prices dropped sharply, and in 2000, when oil prices increased substantially.

8. Summary and conclusions

In this paper we have studied the properties of the distribution of Belgian consumer prices for the period June 1976-September 2000, by using both classical and robust measures of location, scale, skewness and tail weight. The robust measures of tail weight showed clearly (i) the fat-tailed nature of the distribution, (ii) the short-run volatility of the tail weights, (iii) the tendency for the right-hand tail to dominate the left-hand tail, which points towards chronic right skewness, and (iv) the increase over time of the left-hand tail and the more stationary behaviour of the right-hand tail. The presence of outliers makes the classical measures of location, scale and skewness very volatile relative to the robust alternatives which have been used in the paper. Moreover, in the case of scale and skewness, the influence of the outliers on the classical measures erased any long-run time profile, whereas for their robust alternatives a stochastic trend was discovered, as was the case for the inflationary process itself. Finally, the classical measures of skewness hardly revealed any form of chronic right skewness, whereas the robust measures clearly bring this characteristic of the data, as well as its time-varying nature, into the picture.

In the econometric part of the paper, we discussed the relation between the distribution of relative prices and aggregate inflation. According to models with nominal rigidities - sticky price models in general, or more particularly menu cost models - the causality of this relation can run in two directions and both directions have been discussed in the paper. In particular, we were able (i) to describe the short-run impact of relative price shocks on aggregate inflation by using the classical measures of scale and skewness and (ii) to reveal the impact of the inflationary process on the distribution of observed relative prices by relating robust measures of scale and skewness to aggregate inflation in a cointegration framework.

Our main empirical results in this respect are threefold. First of all, we found a short-run impact of the skewness of observed relative prices on aggregate inflation, in line with Ball and Mankiw (1995). Second, it was found that the short-run impact of the dispersion of observed relative prices on inflation was substantially lower in the subsample starting in 1988 than in the pre-1988 subsample, suggesting that the prevailing monetary policy regime has a substantial effect on this coefficient. This result is in line with the model of asymmetric price adjustment of Ball and Mankiw (1994). Third, our further empirical results highlight the endogeneity of the asymmetry in the distribution of Belgian consumer prices. Indeed, it was found that the chronic right skewness was positively cointegrated with aggregate inflation. Moreover, we found little evidence of chronic right skewness not dependent on the inflationary process, suggesting that the asymmetry would disappear at zero inflation. Overall, these results are in line with the predictions of menu cost models and, importantly, they go beyond the contemporaneous mean skewness correlation. The latter has been criticised recently for not providing sufficient evidence in favour of menu costs on its own. The results presented are symptomatic of nominal rigidities, in the sense that prices are adjusted infrequently. However, they do not point in the direction of specific downward rigidities, other than those endogenously generated by the prevailing inflation rate.

[23] As in Aucremanne (2000), smoothness has been measured here as the standard deviation of the *first difference* of the estimator considered.

These results have three important policy implications.

First, as regards the transmission of monetary policy, they suggest that menu costs can be an important factor behind the short-run non-neutrality of monetary policy and the observed output and inflation dynamics. It should be taken into account that these models generate asymmetric output effects in consequence of the asymmetric nature of price adjustment to which they lead endogenously. As prices tend to adjust more slowly in the case of a negative shock than in the case of a positive shock, output is affected more when monetary policy is tightened than in the opposite event. According to menu cost models, this asymmetry depends on the prevailing inflation rate: it is more pronounced at higher rates of inflation and disappears when inflation is equal to zero. In this respect, it is interesting to remember that Peersman and Smets (2001) found larger monetary policy effects on output in recessions than in booms, not only in the euro area as a whole, but also in Belgium in particular. They did not attempt to distinguish between the various theories explaining this asymmetry. According to our results, menu costs could be a part of the story, at least for Belgium.

Second, as regards the design of core inflation measures, providing evidence in favour of menu cost models reinforces the economic rationale for the use of robust estimators of location, but at the same time it complicates their construction as the endogenous right skewness of the distribution of relative prices should be taken into account. These economic arguments tend to put a lot of weight on the absence of bias in the estimator. We have proposed an estimator which has this property, as it takes the time-varying degree of chronic right skewness explicitly into account.

Third, as regards the optimal rate of inflation, the chronic right skewness found in the data provides no argument against price stability, as it reveals only apparent downward nominal rigidity in product markets, which is an endogenous response of optimising price setters and which would disappear when targeting a zero inflation rate. The policy implication of this result contrasts sharply with the exogenously assumed downward rigidity of Tobin (1972), which would justify targeting a positive inflation rate in order to facilitate the adjustment of relative prices. In the absence of specific downward nominal rigidities, finding that aggregate inflation affects the distribution of relative prices rather provides an argument in favour of price stability, as it allows the impact of monetary policy on relative prices to be minimised. Clearly, this impact disrupts the allocative role prices play in a market economy. In the menu cost model of Ball and Mankiw (1994), the optimal rate of inflation is indeed equal to 0. Evidently the analysis presented here does not take into account other factors which could justify a low but positive inflation target, such as downward nominal rigidities in labour markets, the zero bound for nominal interest rates and the presumably positive bias in aggregate inflation measurement. In any case, the cross-sectional properties of Belgian inflation data do not provide strong arguments against a price stability-oriented monetary policy such as the one pursued by the Eurosystem.

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Inflation targeting in Brazil: lessons and challenges

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1. Introduction

This paper assesses the inflation targeting regime adopted in July 1999 in Brazil, examining the challenges faced in its first three years. The inflation targeting mechanism has proved to be highly important for macroeconomic stabilisation. In spite of different inflationary pressures, the inflation rate has been maintained at a low level in the context of a floating exchange rate regime and inflationary shocks. We stress three important challenges that are also common in other emerging market economies: construction of credibility, change in relative prices, and exchange rate volatility. Moreover, we describe the methodology used to deal with inflationary shocks, and examine some issues involved in the institutional design of inflation targeting, such as the use of core inflation measures, escape clauses, tolerance intervals, establishment of targets, and target horizon.

We show that the inflation expectations of the private sector have not been departing significantly from the targets even in the face of inflationary shocks. Other evidence also supports the view that the established inflation targets have worked as an important coordinator of expectations. The estimated reaction function of the Central Bank shows that monetary policy has been reacting strongly to inflationary pressures. In particular, the Central Bank reacts to inflation expectations, providing evidence that monetary policy is conducted on a forward-looking basis. We also find some evidence of change in inflation rate dynamics, basically the reduction in the degree of persistence in inflation. The volatility of output and inflation has also decreased in the inflation targeting period.

We also stress the significant inflationary pressures stemming from the change in relative prices in the economy ("administered or monitored" versus "market" prices) and from the exchange rate volatility in the last few years. We estimate the pass-through from exchange rate to inflation rate using a vector autoregression (VAR) estimation, showing the higher pass-through for "administered or monitored" prices.

The Central Bank has developed a methodology to estimate the inflationary effects of change in relative prices, exchange rate depreciation and inflation inertia. The corresponding results help the conduct of monetary policy as it quantifies the sources of inflation.

Section 2 presents an overview of the first three years of inflation targeting. Section 3 assesses the different challenges for the inflation targeting regime. Section 4 presents the methodology used to deal with shocks, and Section 5 examines some issues involved in the institutional design of inflation targeting. A final section concludes the paper.

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2. Overview of the first three years of inflation targeting

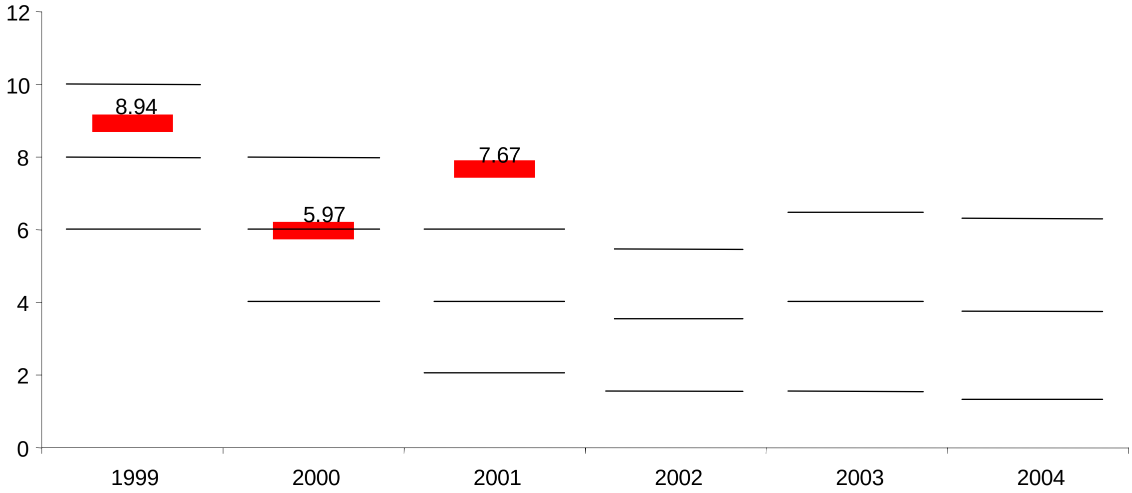
The current inflation targeting regime was adopted in mid-1999, after the floating of the currency in January of the same year. In the first two years, inflation rates were kept on target, having absorbed the initial impact of the exchange rate depreciation in 1999. The successful transition was supported by a considerable fiscal improvement, a shift from the primary surplus of 0.01% of GDP in 1998 to 3.23% in 1999, 3.51% in 2000, 3.68% in 2001 and 3.54% in the last 12 months up to August 2002. The macroeconomic policy has three basic elements: floating exchange rate regime, change in the fiscal regime, and inflation targeting.

The targets are established in June year t for calendar year inflation at $t+2$, except for 1999 and 2000, when both targets were set in June 1999. The inflation rate is measured by a consumer price index, the IPCA, produced by IBGE. Graph 1 shows the targets for 1999-2004, and actual inflation for 1999-2001. Up to 2002, the tolerance intervals were 2 percentage points above and below the central target, and as of 2003 the intervals were enlarged to 2.5 percentage points. The inflation rate was 8.9% and 6.0% for targets of 8% and 6% for 1999 and 2000, respectively.

Graph 1

Inflation: targets and actual

In percentages



However, in 2001 and 2002, several external and domestic shocks hit the Brazilian economy with a significant impact on inflation. The inflation rate reached 7.7% in 2001, 1.7 percentage points above the upper limit of the inflation target,[2] and is expected to be above the upper limit in 2002 as well. The energy crisis, the deceleration of the world economy, the 11 September attacks on the United States, and the Argentine crisis generated strong pressure for the depreciation of the real in 2001. In October, the average exchange rate had increased by 39.6% (a depreciation of domestic currency of 28.3%) when compared to the average of December 2001. Graph 2 shows the exchange rate level since 1998. In 2002, the shocks included increased risk aversion in capital markets, and uncertainties related to Brazil's future macroeconomic policies under the upcoming government, leading to a new wave of depreciation.

The change in relative prices in the economy affected the inflation rate significantly as well. The administered-by-contract or monitored prices - administered prices, for short - rose well above the other prices - market prices, for short. The administered prices are defined as the ones little affected by domestic demand and supply conditions or that are in some way regulated by some public agency.

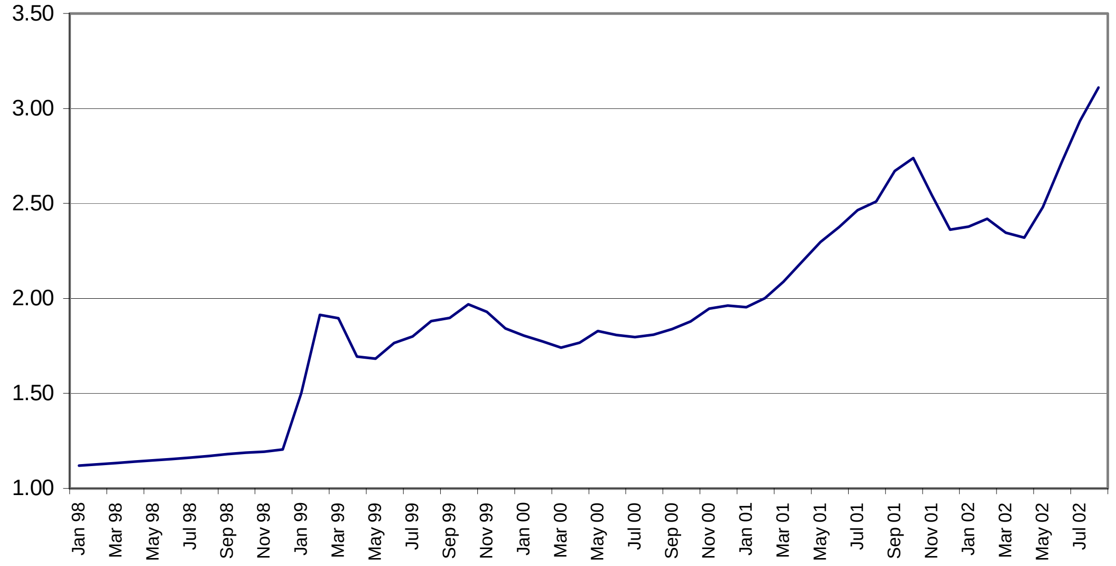
[2] The reasons for the non-fulfilment of the target in 2001 were explained in an open letter from the Governor of the Central Bank of Brazil to the Minister of Finance, available at www.bcb.gov.br.

The group was defined by the Monetary Policy Committee (Copom) in July 2001, and includes oil by-products, fixed telephone, residential electricity, and public transportation. Its weight in the IPCA was 30.8% in June 2002. Furthermore, the energy crisis, from 2001 to the beginning of 2002, and the deregulation of oil by-product markets also led to inflationary pressures.

Graph 2

Real/US dollar exchange rate

Monthly averages

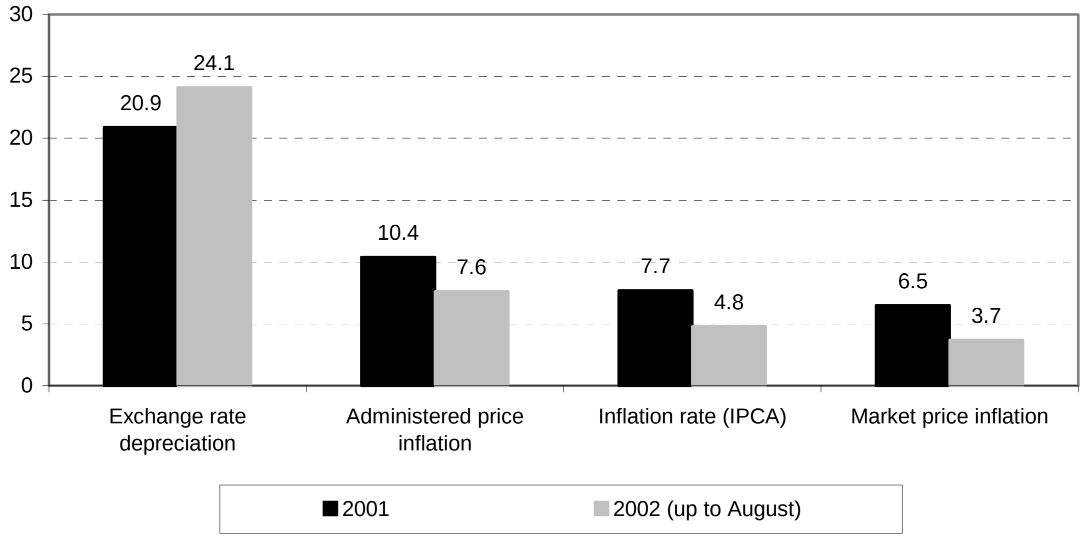


Graph 3 shows the exchange rate depreciation, the increase in administered and market prices, and the inflation rate for 2001 and 2002 (up to August). The administered prices rose 10.4% in 2001 and 7.6% in January-August 2002, whereas market prices increased by 6.5% and 3.7%, respectively (the values for 2002 are not annualised).

Graph 3

Exchange rate depreciation and inflation

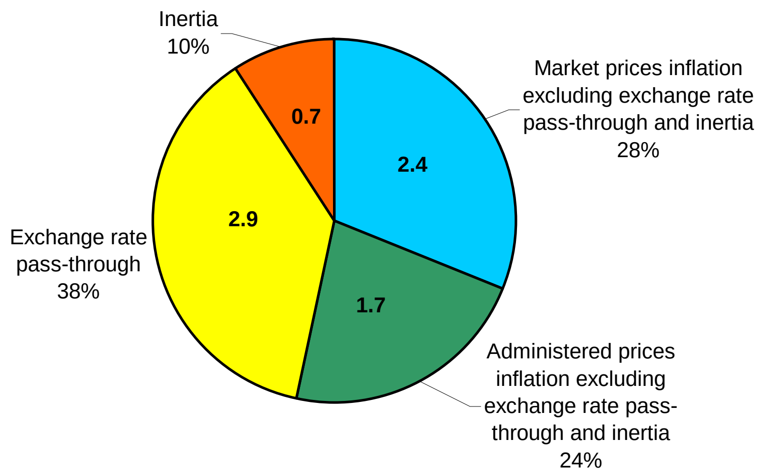
In percentages



Graph 4

Contribution to inflation in 2001

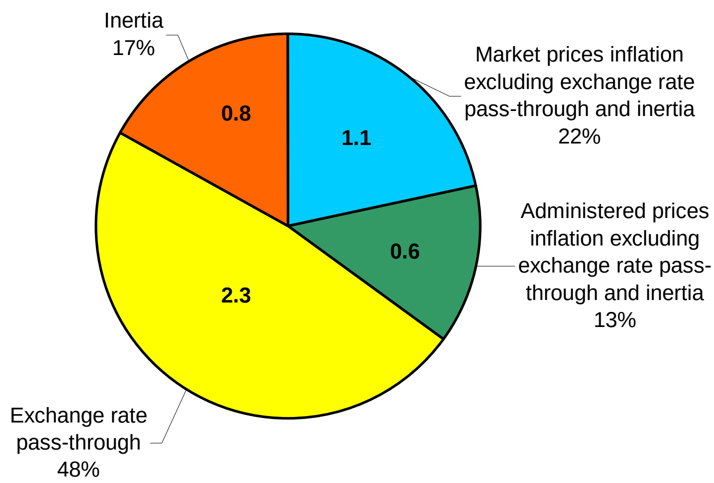
Percentage of the total and percentage variation
(values within the chart) in the period



Graph 5

Contribution to inflation in 2002 (January-August)

Percentage of the total and percentage variation
(values within the chart) in the period



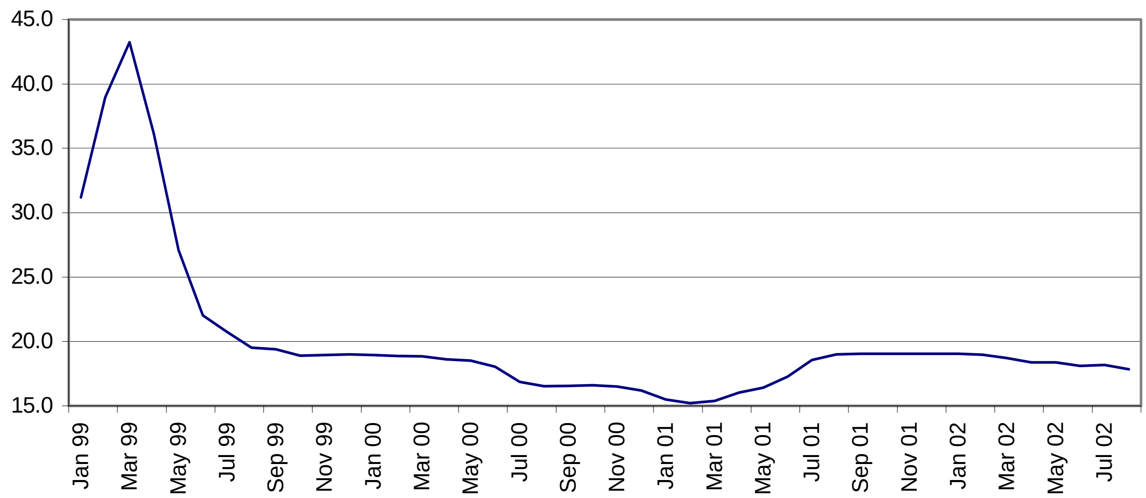
Using the structural model of the Central Bank[3] and information concerning the mechanisms for the adjustment of administered prices, it is possible to estimate the contribution for the inflation rate stemming from exchange rate pass-through, inflation inertia from the previous year, and inflation of administered prices and market prices that is not explained by the exchange rate pass-through and the inertia referred to. Graphs 4 and 5 show the values for 2001 and January-August 2002. The values in the inner part of the charts are the percentage point contributions for the inflation rate, and, in the outer part, the corresponding proportion. In 2001, 38% of the inflation rate can be explained by the exchange rate depreciation, whereas for January-August 2002 the contribution of the exchange rate reaches 48%.

In 2001 and 2002, the Central Bank acted pre-emptively, aiming at minimising the potential inflationary effects of the different shocks, mainly the exchange rate depreciation and the increase in administered prices. The main guideline of monetary policy was to limit the propagation of the shocks to the other prices in the economy. Graph 6 presents the path of the basic interest rate - the Selic rate - controlled by the Central Bank. Between March and July 2001, the Central Bank raised the interest rate significantly (375 basis points), interrupting the downward trend observed previously. Some improvement in the macroeconomic context at the beginning of 2002 allowed some reduction of the interest rate, interrupted by the inflationary pressure coming from the exchange rate depreciation. If the Central Bank had not acted pre-emptively, inflation would have been higher than actually observed, and the adjustment in the real exchange rate would have taken place in an environment of greater uncertainty. In view of the intensity and magnitude of the shocks that hit the Brazilian economy in 2001 and 2002, the cost in terms of output losses of a policy aimed at offsetting completely these shocks and keeping inflation within the tolerance intervals would have been significantly higher.

Graph 6

Base interest rate (Selic)

Monthly averages, in percentages



We can also verify that there has been a gain in terms of variability of the inflation rate, output and interest rate. Table 1 reports the average, standard error and coefficient of variation (ratio of standard error to average). It compares the first three years of inflation targeting with the Real Plan period before the adoption of inflation targeting. For this last period, the table also reports the figures for a

[3] For an overview of the structural model, see Bogdanski et al (2000). Using the aggregate supply curve, which relates the current inflation of market prices to expected and past headline inflation, output gap and exchange rate change, we estimate the contributions of the exchange rate pass-through and of the inertia from the previous year for market prices. For administered prices, the estimation depends on the criteria used for the price adjustment of specific items.

shorter sample, which excludes the first quarters of the Real Plan, characterised by a transition to stabilisation. The inflation rate is measured by the IPCA, output by seasonally adjusted GDP, and the (nominal) interest rate by the Selic rate. We use quarterly data. In the case of GDP, we use the annualised quarter over quarter growth rates. The variability of output, inflation and the inflation rate is smaller in the inflation targeting period. This does not imply necessarily that there have been gains in terms of trade-off between output and inflation because this result also depends on the magnitude and variability of the shocks that hit the economy. In terms of average, the output growth is higher and the interest rate is lower in the inflation targeting period. The inflation rate is smaller if we compare to the whole period before inflation targeting. In the case of the 1996:01-1999:02 period, the smaller average of the inflation rate is to a large extent a consequence of the pegged exchange rate regime, which turned out to be unsustainable in the medium run.

Table 1

Inflation rate, GDP growth and interest rate

Annual average, standard deviation (SD) and coefficient of variation; quarterly data

Period	Inflation rate			GDP growth			Interest rate		
	Avg	**SD**	**Coefficient of variation**	**Avg**	**SD**	**Coefficient of variation**	**Avg**	**SD**	**Coefficient of variation**
Real Plan before inflation targeting:									
1994:04-1999:02	10.3	9.2	0.89	2.0	6.3	3.16	35.4	14.1	0.40
1996:01-1999:02	5.8	4.8	0.84	2.0	5.2	2.55	28.2	6.0	0.021
During inflation targeting:									
1999:03-2002:02	7.1	3.0	0.42	2.4	3.5	1.46	18.0	1.4	0.08

3. Challenges in inflation targeting

We stress three important challenges in the first three years of inflation targeting in Brazil: construction of credibility, change in relative prices, and exchange rate volatility.

3.1 Constructing credibility

Inflation targeting is, to a large extent, a credibility issue. The Central Bank should act and communicate in a way to convince the market that inflation will be under control. This section shows the estimates of different specifications for Central Bank Taylor-type rules and discusses whether the Central Bank has been effective in controlling inflation expectations. We show that the Central Bank has been reacting strongly to deviations of expected inflation from the target, and that, despite the failure to achieve the target in 2001, inflation expectations remain under control. Furthermore, we present some indications of change in inflation rate dynamics. We conclude that the Central Bank of Brazil has gained credibility in the conduct of monetary policy. The credibility, however, is still under construction as it takes time to achieve it. Besides, the absence of central bank independence in the legal framework is an obstacle to achieving higher levels of credibility.

3.1.1 The reaction function of the Central Bank

We estimate a reaction function of the Central Bank of Brazil that relates the interest rate to expected inflation and to the output gap, allowing also for some interest rate smoothing:

$$i_t = \alpha_1 i_{t-1} + (1-\alpha_1)(\alpha_0 + \alpha_2 y_{t-1} + \alpha_3 (E_t \pi_{t+j} - \pi^*_{t+j})) \tag{1}$$

where i_t is the interest rate, y_t is the output gap, $E_t\pi_{t+j}$ is inflation expectations and π^*_{t+j} is the inflation target, both referring to some period in the future, as will be explained below.[4] The sample consists of monthly data between July 1999, when the regime was formally introduced,[5] and June 2002.

We use two different definitions of interest rate. The first one is the base rate (Selic rate) decided by Copom in their meetings. The second definition is the interest rate gap, defined as the difference between the Selic rate and its trend, estimated by an HP filter.[6] The motivation to use the gap is to have some idea of how the Central Bank deviates the interest rate from equilibrium when faced by an increase in inflation expectations. This is particularly important for Brazil because, when inflation targeting was introduced, real interest rates were considerably high.[7] Therefore, a convergence to steady-state equilibrium would require a downward trend for interest rates. As Bogdanski et al (2001) discuss, in the first two years of the inflation targeting regime, several shocks hit the Brazilian economy and, in many cases, the Copom decision was to leave interest rates constant. This would be equivalent to an increase in interest rates if we consider that the equilibrium interest rate was falling.

Monthly industrial production (seasonally adjusted), as measured by IBGE, is the proxy for output. The output gap was obtained by the difference between the actual and the HP-filtered series.[8]

We use two sources for inflation expectations. The first is the inflation forecasts of the Central Bank of Brazil presented in the quarterly *Inflation Report*. The advantage of this source is that Copom should take interest rate decisions based on its own inflation forecasts. The forecasts in the *Inflation Report* are made assuming a constant interest rate equal to the one decided on in the previous Copom meeting. Therefore, they signal whether the Central Bank should change the interest rate. However, public information about Copom's inflation forecasts is available only on a quarterly basis. In order to obtain monthly figures, it was necessary to interpolate the data. The second source is obtained by a daily survey that the Central Bank conducts among financial institutions and consulting firms.[9] The survey asks what firms expect for year-end inflation in the current and in the following years.[10] This expectation, however, is made jointly with an expectation for the interest rate (not necessarily constant).

The Brazilian inflation targeting regime sets year-end inflation targets for the current and the following two years. Since it is necessary to have a single measurement of inflation deviation from the target, it was necessary to create a new variable, weighting the expected deviations from target in different years. The variable chosen was:

$$D_j = \frac{(12-j)}{12}(E_j\pi_t - \pi^*_t) + \frac{j}{12}(E_j\pi_{t+1} - \pi^*_{t+1}) \tag{2}$$

where D_t is the measure of expected deviation of inflation from the target, j indexes the month, and t indexes the year. Therefore, D_t is a weighted average of current-year and following-year expected deviation of inflation from the target, where the weights are inversely proportional to the number of months remaining in the year.[11] Observe that D_t does not contain inflation expectations referring to two

4 Clarida et al (1998, 2000) estimate forward-looking reaction functions for France, Germany, Italy, Japan, the United Kingdom and the United States. Instead of using central bank or survey expectations, they employ a Generalised Method of Moments (GMM) estimation. It is basically a forward-looking version of the backward-looking reaction function proposed by Taylor (1993).

5 Decree 3088 of 21 June 1999 established inflation targeting in Brazil. Therefore, the July Copom meeting of that year was the first one under a formal inflation targeting regime.

6 The Hodrick-Prescott filter was passed over the monthly data series between September 1994 (two months after the introduction of the real) and June 2002.

7 During the pegged exchange rate regime, which ended in January 1999, the Selic rate needed to be at high levels in order to prevent a large outflow of reserves. In the first months following the flotation of the real, the Selic rate needed to be kept at high levels to prevent an inflation-exchange rate depreciation spiral.

8 Estimations using output growth and the output gap obtained by extraction of a linear trend were also performed. The results were similar and are not reported in this paper.

9 This survey is available on the Central Bank of Brazil website (www.bcb.gov.br). In this estimation, we use the inflation expectations collected on the eve of Copom meetings, avoiding possible endogeneity problems.

10 In November 2001 the survey started collecting expectations for the following 12 months as well.

11 It is not necessary to have a single measure of inflation deviation. If there were enough data, it would be possible to use expected inflation for the current and the following years (and possibly more years ahead) in the reaction function. But it

years in advance, despite the existence of a target for such a period. Given the shorter lags in the transmission mechanism of monetary policy estimated for the Brazilian economy and the higher uncertainty associated with the forecasts, it is reasonable to assume that Copom concentrates on current- and following-year forecasts to take interest rate decisions.

Table 2

Estimation of reaction function of Central Bank

Dependent variable: Selic interest rate; monthly averages

Regressors	Coefficients and standard errors			
	With *Inflation Report* inflation expectations		With market inflation expectations	
Constant	17.50*** (0.36)	17.57*** (0.48)	16.49*** (0.63)	16.68*** (0.69)
Interest rate (*t*–1)	0.76*** (0.07)	1.04*** (0.13)	0.72*** (0.08)	1.36*** (0.18)
Interest rate (*t*–2)		–0.20** (0.08)		–0.56*** (0.15)
Deviation of expected inflation rate from target	1.78** (0.84)	1.84 (1.19)	1.74** (0.66)	1.42* (0.72)
Output gap (*t*–1)	–0.44*** (0.11)	–0.47*** (0.16)	–0.25* (0.13)	–0.13 (0.17)
R-squared	0.9287	0.9418	0.9272	0.9539
Adjusted R-squared	0.9220	0.9342	0.9188	0.9465
LM test for autocorrelation of residuals (p-values)				
One lag	0.0357	0.5186	0.0059	0.7408
Four lags	0.2165	0.6766	0.0757	0.5612

Note: Standard error in parentheses; *, ** and *** indicate that the coefficient is significant at the 10%, 5% and 1% level, respectively.

Tables 2 and 3 report the estimations using the Selic interest rate and the gap of the Selic interest rate as dependent variable, respectively. Each table presents the estimations with inflation forecasts of the Central Bank (sample: 1999:06-2002:06) and of the market (sample: 2000:01-2002:06).[12] The estimations using only one lag for the interest rate usually present serial correlation of the residuals, but this problem is solved using two lags.[13] There has been a high degree of interest rate smoothing. The sum of the coefficients on the two lags is 0.8 or above. The coefficient on the output gap is usually not statistically significant when using market expectations or presents the wrong sign when using inflation expectations presented in the *Inflation Reports*. We have also tested for the inclusion of exchange rate change in the reaction function, but this variable is not statistically significant.

would then be necessary to introduce dummy variables for the months since it is reasonable to assume that the weight given for current-year inflation should decrease along the year.

12 The data on IPCA expectations are available only as of January 2000.

13 In this case, the equation is $i_t = \alpha_1 i_{t-1} + \alpha_4 i_{t-2} + (1 - \alpha_1 - \alpha_4)(\alpha_0 + \alpha_2 y_{t-1} + \alpha_3 (E_t \pi_{t+j} - \pi^*_{t+j}))$.

Table 3

Estimation of reaction function of Central Bank

Dependent variable: gap of Selic interest rate; monthly averages

Regressors	Coefficients and standard errors			
	With *Inflation Report* inflation expectations		**With market inflation expectations**	
Constant	–1.51*** (0.36)	–1.28*** (0.36)	–3.28*** (0.54)	–3.53*** (0.65)
Gap of interest rate (*t*–1)	0.81*** (0.06)	1.08*** (0.09)	0.71*** (0.08)	1.34*** (0.19)
Gap of interest rate (*t*–2)		–0.25*** (0.06)		–0.54*** (0.15)
Deviation of expected inflation rate from target	5.01*** (0.92)	4.25*** (0.77)	3.70*** (0.58)	3.63*** (0.68)
Output gap (*t*–1)	–0.38** (0.15)	–0.43*** (0.13)	–0.05 (0.13)	0.08 (0.17)
R-squared	0.9653	0.9768	0.9694	0.9797
Adjusted R-squared	0.9620	0.9738	0.9658	0.9765
LM Test for autocorrelation of residuals (p-values)				
One lag	0.1254	0.4020	0.0080	0.4255
Four lags	0.0796	0.4754	0.0461	0.4356

Note: Standard error in parentheses; *, ** and *** indicate that the coefficient is significant at the 10%, 5% and 1% level, respectively.

Most importantly, the coefficient on inflation expectations is greater than one and significantly different from zero. Employing the *Inflation Report*'s expectations, the coefficient is 1.84[14] and 4.25 using the Selic rate and the gap of Selic, respectively. Therefore, we can conclude that the Central Bank has been reacting strongly to expected inflation. It conducts monetary policy on a forward-looking basis, and responds to inflationary pressures.

It is interesting to note that such coefficients are around 1.4-1.8 when the dependent variable is the Selic rate,[15] and above 3.6 when the dependent variable is the gap of the Selic rate. This result supports the view that, given a downward trend for interest rates, Copom decisions to leave the interest rate constant may be interpreted as a tightening of monetary policy. Moreover, in the case of the gap of the Selic rate, the coefficients are significantly different from one in all specifications.

3.1.2 Inflation expectations and the role of targets

A naive analysis of the inflation targeting regime in Brazil might say that this regime has not been successful in controlling inflation. As Graph 7 shows, since mid-2001, 12-month inflation has been above the upper limit of the tolerance interval.[16] Nevertheless, inflation outcomes are not a sufficient

[14] In this case, the p-value is 0.13, but we have to consider the small size of the sample.

[15] Favero and Giavazzi (2002) also estimated a similar reaction function using market expectations, and obtained similar results (coefficient equal to 1.78). Silva and Portugal (2002) used a different specification, and obtained different results.

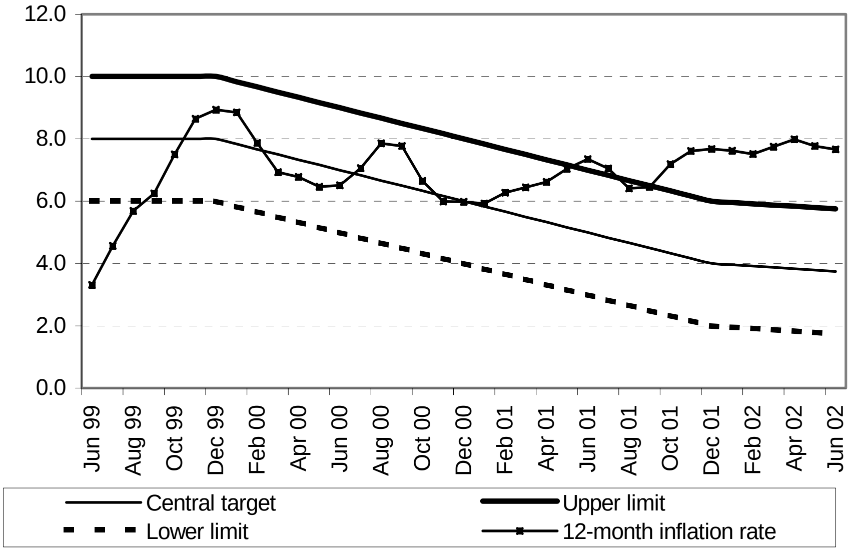
[16] There are established targets only for year-end inflation. Therefore it was necessary to impute a target to the other months of the year, which was done by linear interpolation.

statistic for evaluating the performance of the Central Bank. The evolution of inflation expectations, and the role of the target should be more relevant variables for assessing the credibility of the Central Bank. Furthermore, it is necessary to take into account the shocks that hit the economy.

Graph 7

Inflation: targets and actual

In percentages



Since the introduction of the inflation targeting regime in Brazil, the economy has been hit by inflationary shocks, notably by supply and cost-push shocks. As of 2001, shocks such as the energy crisis, the readjustments of administered prices and the exchange rate depreciation have forced the Central Bank to reassess the trade-off between inflation and output variability. Since then and, in a more systematic way, since January 2002, the conduct of monetary policy has been based on accommodating the first-round effects of supply and cost-push shocks. This means monetary policy will allow relative price movements to affect inflation, but will neutralise the second-round effects.

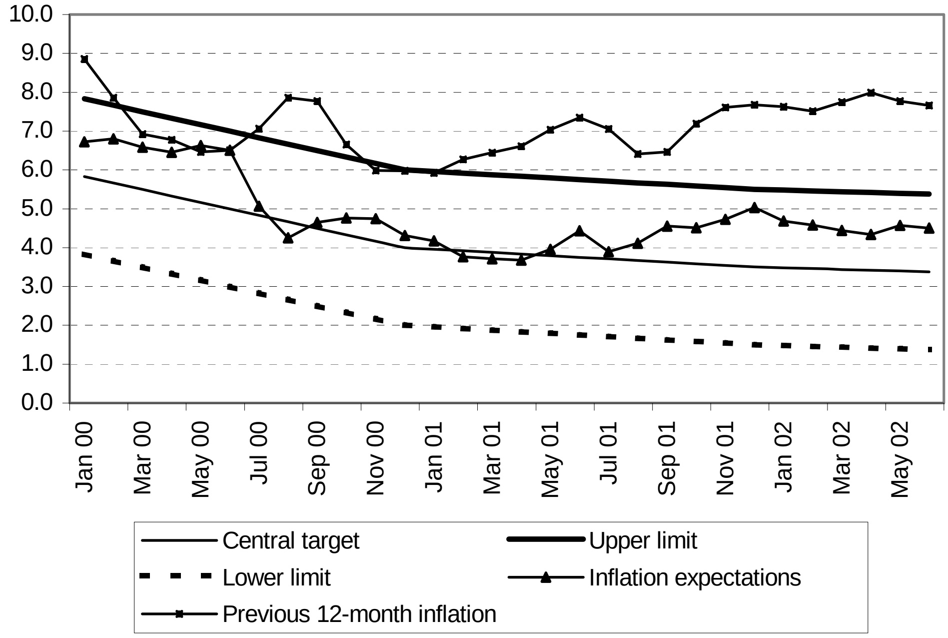
As long as the market understands the objectives of the Central Bank, and its conduct is credible, inflation expectations should be contained and, except for unforeseen new inflationary shocks, inflation should gravitate around the target. Two conditions are necessary to guarantee that inflation expectations will remain controlled. The first one is clear communication with the market. The market needs to understand why actual inflation was above the target and how monetary policy is being conducted in order to make inflation return to the target. The Central Bank of Brazil communicates with the market via informal speeches or formal documents, such as the minutes of the Copom meetings, which are released one week after the meetings, and the *Inflation Report*, which is published on a quarterly basis. The second condition for controlling expectations is that the conduct of monetary policy should be consistent with the main guidelines expressed by Copom. In this sense, the reaction function estimated in the previous subsection shows that the Central Bank has been acting consistently with the inflation targeting framework.

Graph 8 suggests that the two conditions stated above have been met. It shows the 12-month ahead inflation that is expected by the market, the 12-month ahead target, and actual 12-month accumulated inflation. We estimate the 12-month ahead expected inflation rate using the inflation expected up to the end of the current year and, for the remaining months necessary to achieve 12 months, the corresponding proportion of following-year expected inflation. The 12-month ahead target is estimated by interpolation. It is clear that inflation expectations have always been below the upper limit of the tolerance interval. This has been true even since the second half of 2001, when actual inflation surpassed the tolerance interval. The correlation coefficient between the actual and expected inflation series is low (0.12). However, there are subsamples where the correlation coefficient is higher. For example, after February 2001, the correlation between the series is 0.70. Even for such subsamples, where inflation expectations tend to move closer to previous inflation, the movements of expectations tend to be smoother than the movements of actual inflation. As the graph shows, the gap between actual and expected inflation increased after mid-2001, when actual inflation surpassed the upper limit of the tolerance interval. Therefore, especially for this period, the credibility of the Central Bank seemed to be essential to keep inflation expectations under control.

Graph 8

Inflation: 12-month ahead expected inflation, the inflation target and actual inflation

In percentages



Other evidence to suggest the gains in credibility of the Central Bank is to evaluate the role of the target in forming expectations. We have run ordinary least squares (OLS) regressions of 12-month ahead market inflation expectations on its own lags, the 12-month ahead inflation target and the interest rate (sample: 2000:01-2002:06). Table 4 reports the results. Since we find serial correlation of residuals with one lag for expected inflation, we also estimate the model using two lags. All coefficients are statistically significant and have the expected sign. The positive coefficient on the interest rate may be explained by the reaction of interest rates to inflationary pressures. When the Central Bank (and the market) foresees higher inflation, the rate of interest is increased. Most importantly, expected inflation reacts significantly to the inflation targets (coefficient equal to 0.96). Since this result could be a consequence of some correlation between targets and past inflation, we also include the actual 12-month inflation rate in the regression (specifications III and IV). This variable is not statistically significant. Therefore, there are indications that the expectations are forward-looking, and the inflation targets play an important role.

In summary, although the actual inflation rate has been above the upper limit of the tolerance interval in 2001 and 2002, the inflation targeting regime has been successful in anchoring expectations. This is a consequence of the gains of credibility that the Central Bank has achieved since the implementation of the inflation targeting regime.

Table 4

Estimation of reaction function of inflation expectations

Dependent variable: market inflation rate expectations (adjusted)

Regressors	Coefficients and standard errors			
	I	II	III	IV
Constant	–4.23*** (1.30)	–4.75*** (1.31)	–4.22*** (1.32)	–4.92*** (1.35)
Market inflation rate expectations (*t*–1)	0.24 (0.18)	0.48** (0.19)	0.27 (0.18)	0.50** (0.19)
Market inflation rate expectations (*t*–2)		–0.39** (0.15)		–0.40** (0.15)
Interest rate (*t*–1)	0.27*** (0.07)	0.29*** (0.07)	0.25*** (0.08)	0.27*** (0.08)
Inflation rate target (12-month ahead)	0.74*** (0.22)	0.96*** (0.24)	0.70*** (0.23)	0.95*** (0.24)
12-month inflation rate (*t*–1)			0.06 (0.10)	0.08 (0.11)
R-squared	0.8978	0.9030	0.8993	0.9053
Adjusted R-squared	0.8855	0.8861	0.8826	0.8838
LM test for autocorrelation of residuals (p-values)				
One lag	0.0663	0.5196	0.0652	0.7730
Four lags	0.0160	0.1333	0.0149	0.1316

Note: Standard error in parentheses; *, ** and *** indicate that the coefficient is significant at the 10%, 5% and 1% level, respectively.

3.1.3 Change in inflation dynamics

As the inflation targeting regime is supposed to affect the formation of inflation expectations, we can consider the possibility that the backward-looking component in price adjustment has become less important. The share of backward-looking firms could have become smaller and/or firms could give less consideration to past inflation when adjusting prices. This would reduce the degree of persistence in inflation. Following Kuttner and Posen (1999), we estimate a simple aggregate supply curve for the low-inflation period to assess whether the inflation targeting regime was accompanied by some structural change.[17] Using monthly data, we regress the inflation rate (measured by the IPCA) on its own lags, the unemployment rate[18] (lagged one period), and the exchange rate change in 12 months (lagged one period). The regression also includes dummy variables that multiply the regressors referred to for the inflation targeting period. The inflation rate and exchange rate change are measured in monthly terms.

[17] It is important to stress that the Central Bank structural model used for inflation forecasting employs quarterly data, and has a different specification, for example it includes a forward-looking term for inflation, and a term for the output gap instead of the unemployment rate.

[18] We use the seasonally adjusted unemployment rate (criterion: seven days) produced by IBGE. The results are qualitatively similar if we use the raw data or the unemployment rate estimated according to the criterion of 30 days.

Table 5

Estimation of aggregate supply curve

Dependent variable: monthly inflation rate

Regressors	Coefficients and standard errors		
	First specification	**Second specification**	**Third specification**
Constant	0.74** (0.36)	0.81** (0.35)	0.79** (0.32)
Dummy constant[1]	0.38*** (0.14)	0.56*** (0.15)	0.39*** (0.14)
Inflation rate (*t*–1)	0.74*** (0.09)	0.81*** (0.12)	0.61*** (0.13)
Dummy inflation rate (*t*–1)[1]	–0.59*** (0.20)	–0.58*** (0.21)	–0.41** (0.19)
Inflation rate (*t*–2)		–0.12 (0.12)	–0.09 (0.12)
Dummy inflation rate (*t*–2)[1]		–0.30 (0.20)	–0.24 (0.19)
Unemployment (*t*–1)	–0.09* (0.05)	–0.10** (0.05)	–0.10** (0.05)
Exchange rate change (*t*–1) (12-month average)			0.10*** (0.04)
Dummy for 2000:07			1.08*** (0.33)
R-squared	0.6431	0.6766	0.5537
Adjusted R-squared	0.6269	0.6538	0.5055
LM test for autocorrelation of residuals (p-values)			
One lag	0.1857	0.8353	0.5454
Four lags	0.0040	0.1693	0.1081

Note: Standard error in parentheses; *, ** and *** indicate that the coefficient is significant at the 10%, 5% and 1% level, respectively. We exclude data for the inflation rate previous to 1994:09. The sample starts in 1994:10, 1994:11 and 1995:08 (for the exchange rate we excluded data previous to 1994:06), respectively, and ends in 2002:06.

[1] Refers to the inflation targeting period.

Table 5 shows three different specifications. In the first, we include only one lag for inflation and do not include the exchange rate change. From the estimated coefficients on the dummy variables, we can conclude that there is a statistically significant change in the constant and in the coefficient on lagged inflation in the inflation targeting period. The autoregressive coefficient falls from 0.74 to 0.15. The coefficient on lagged unemployment is negative. In all three specifications, there is no statistically significant change in the coefficient on lagged unemployment.[19] However, since the residuals present serial autocorrelation, we use a second specification that adds another lag for the inflation rate. The change in the coefficient of the first lag of the inflation rate is still significant: from 0.81 to 0.23. The

[19] The estimations reported in Table 5 were conducted without including the terms corresponding to the inflation targeting dummies interacting with the unemployment rate and exchange rate change.

sum of the two lags before and after the adoption of inflation targeting is 0.69 and –0.19, respectively. Therefore, we can conclude that there has been a substantial reduction in the degree of inflation persistence after inflation targeting was adopted. This implies a lower output cost to curb inflationary pressures and to reduce average inflation.[20]

The third specification includes the lagged exchange rate change.[21] The coefficient is positive, and we could not reject the null hypothesis of no structural break for the coefficient in the inflation targeting period. For the lagged inflation terms the results are relatively similar to those from the second specification (the first autoregressive component decreases from 0.61 to 0.20, and the sum of the two lags goes from 0.52 to –0.13). The coefficient on the lagged exchange rate is 0.10, which, considering the lagged inflation terms, generates a 12-month pass-through of 21% and 9% for the whole sample and for the inflation targeting period, respectively. The smaller pass-through in the recent period, however, is a consequence of the lower degree of persistence in inflation. In Section 3.3, we present an estimation of the pass-through using a VAR model and the structural model.

The coefficient on lagged unemployment is about –0.10. Therefore, a 1 percentage point increase in the unemployment rate decreases the inflation rate by 1.2 percentage points when measured in annual terms. Considering the indirect effects via inflation inertia, the total effect over a year in inflation reduction is 2.3 percentage points and 1.1 percentage points for the whole sample and for the inflation targeting period, respectively. As before, this result is explained by the different degrees of inflation persistence.

3.2 Change in relative prices

Monetary policy has been facing a significant change in relative prices in the economy that has markedly affected the inflation rate. Since mid-1995, administered prices have increased systematically above market prices.[22] Graph 9 shows the ratio of administered prices to market ones since January 1992. The ratio rose 23.7% in the first three years of inflation targeting (comparing June 2002 to June 1999). The weight of this group in the IPCA grew from a 17% average (from January 1991 to July 1999) to 28% in August 1999 as a result of a new household budget survey. It reached 30.8% in June 2002 because its changes were greater than those of market prices.

The dynamics of administered prices differ from those of market prices in three aspects:

(a) Dependence on international prices in the case of oil by-products.

(b) A greater pass-through from the exchange rate. There are three basic links: (i) the price of oil by-products depends on oil prices denominated in domestic currency; (ii) electricity rates are partly linked to exchange rate variations; and (iii) the price adjustments settled in the contracts that govern electricity and telephone rates are partly indexed to the General Price Index (IGP), which is more affected by the exchange rate than the CPIs.

(c) Stronger backward-looking behaviour. Electricity and telephone rates are generally adjusted annually, and the contractual clauses usually stipulate that adjustments should be based on a weighted average of the past change of IGP and of the exchange rate.

[20] Note that, although the constant in the regression is higher in the inflation targeting period, unconditional expected inflation (up to a constant referring to the natural unemployment rate) is equal to 2.9 and 1.3 for the periods before and after the adoption of inflation targeting using the first specification; and 2.6 and 1.1 employing the second specification.

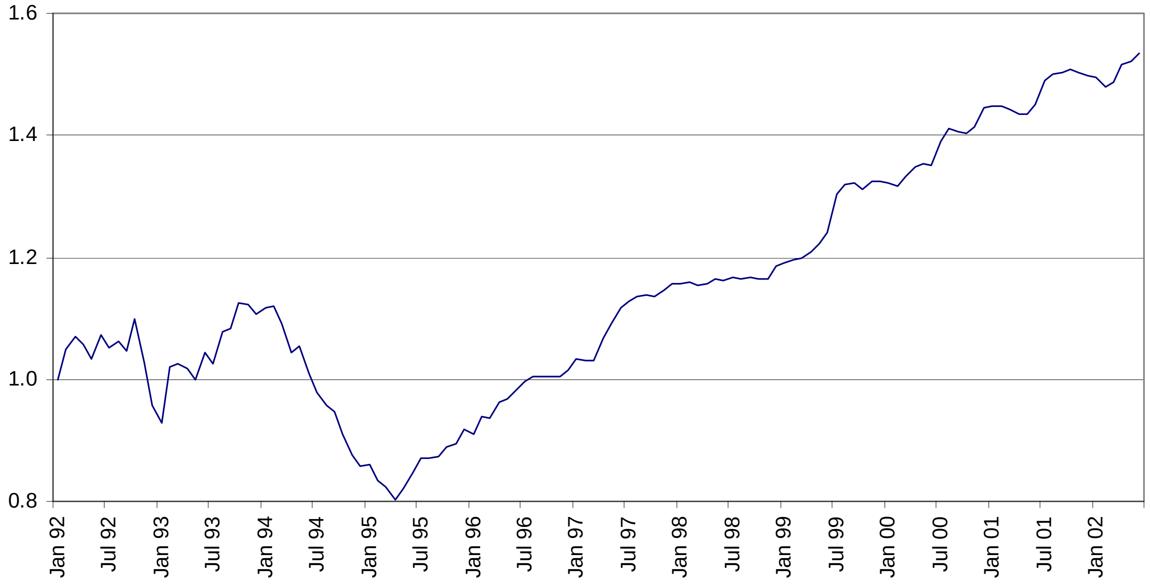
[21] We use the 12-month change; the one-, three- and six-month changes were not significant. To avoid the presence of autocorrelation in the residuals, we include in the third specification a dummy variable for 2000:07. After 0.27% monthly average inflation in the first half of 2000, inflation reached 1.6% in July, markedly above market expectations, because of the off-cropping season and a significant rise in administered prices. Including this dummy in the three specifications has no major effect on the estimated coefficients.

[22] For more details on the behaviour of administered prices, see Figueiredo (2002).

Graph 9

Ratio of administered prices to market prices

January 1992 = 1



Items (a) and (c) are beyond the control of monetary policy, and the exchange rate (item (b)) is only partially affected by monetary policy. In particular, these three factors have exerted strong inflationary pressures during the inflation targeting period. Between June 1999 and June 2002, the oil price rose 53.0% (from USD 15.77 to USD 24.13 a barrel of crude (Europe Brent)). The exchange rate increased by 53.7% in the same period, and by 125.2% if we compare to December 1998 (a depreciation of the domestic currency of 35.0% and 55.6%, respectively). The presence of a strong backward-looking component implies a higher output cost and inflation rate during periods of disinflation. First, the response of inflation to any inflationary shock is more persistent. Second, since the inflation targets for Brazil are decreasing, it is important that the price adjustments converge to the targets to reduce or avoid output costs. In the presence of stronger backward-looking behaviour, however, the adjustment is slower, implying a greater output gap reduction to meet the targets.

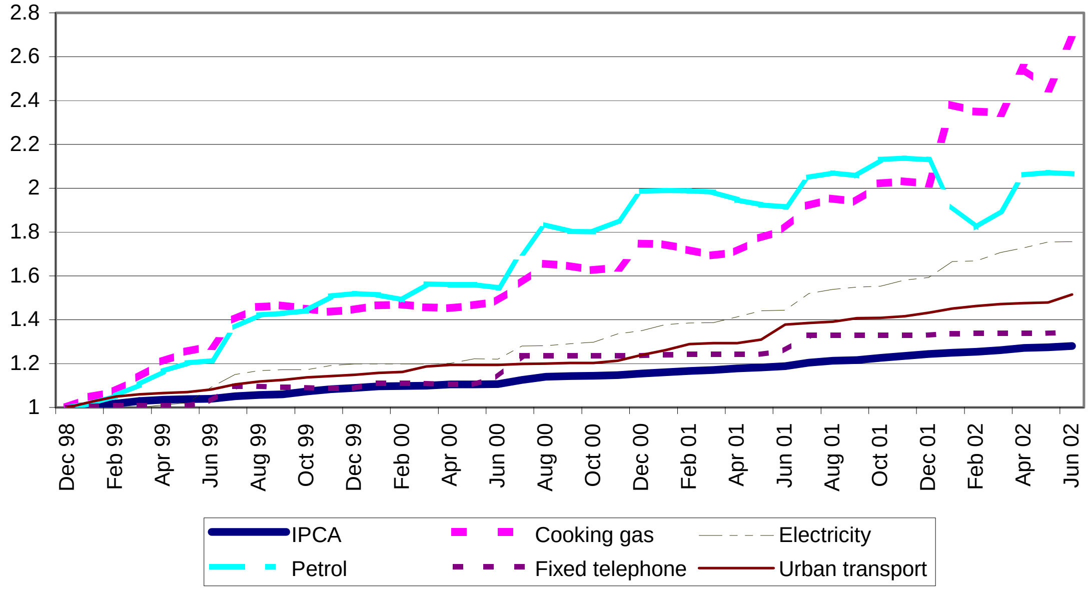
Moreover, the telephone, electricity and oil by-product sectors faced some major structural reforms that had some initial implications for the inflation rate. Fixed telephone rates saw two spikes in 1996 and 1997 because the line acquisition fee experienced a sharp fall (not included in the price index), whereas phone rates increased. The oil by-product sector underwent deregulation at the beginning of 2002 with the end of controls on prices and subsidies on cooking gas (whose prices rose about 18% in January 2002). In the case of electricity, the rationing between 2001 and 2002 led to a rise in electricity rates.

Graph 10 shows the path of the price levels of petrol, cooking gas, telephone use, electricity, urban transport and the headline IPCA level from December 1998 to June 2002. It is clear that these prices have exerted significant pressure on the inflation rate.

Graph 10

Price levels for the IPCA and selected items

December 1998 = 1



The effect of the inflation rate on relative prices is broadly known. In this paper, we stress the effect of change in relative prices on the inflation rate. As a measure of the dispersion of relative prices, we use the standard deviation of the monthly change of the 52 items that comprise the IPCA. We then test for Granger causality between relative prices and the inflation rate.[23] The results are reported in Table 6, which shows the estimation using one and three lags (selected with Schwarz and Akaike information criteria, respectively) for a sample from 1994:12 to 2002:06. We can reject the null hypothesis that relative prices do not Granger cause the inflation rate. Therefore, change in relative prices conveys information about future inflation. We can also reject the null hypothesis that the inflation rate does not Granger cause relative prices.

Table 6

Granger causality test: relative prices and the inflation rate (IPCA)

Sample: 1994:12-2002:06

Null hypothesis	**One lag**		**Three lags**	
	F-statistic	**P-value**	**F-statistic**	**P-value**
Relative prices do not Granger cause the inflation rate	2.89	0.0926	3.15	0.0293
Inflation rate does not Granger cause relative prices	16.71	0.0001	5.35	0.0020

23 We can reject that they are integrated of order one.

3.3 Exchange rate volatility

Dealing with exchange rate volatility has been one of the main challenges faced by inflation targeting regimes in emerging market economies. Compared to industrialised economies, emerging markets seem to be more sensitive to the effects of financial crisis in other countries. Exchange rate market volatility generates frequent revisions of inflation rate expectations and may result in non-fulfilment of inflation targets. As a general rule, the actions of the central bank should not move the exchange rate to artificial or unsustainable levels. However, the central bank may react to exchange rate movements to curb the resulting inflationary pressures and to reduce the financial impact on dollar-denominated assets and liabilities in the balance sheet of firms.

Regarding the financial problems associated with exchange rate volatility, Hausmann et al (2001) argue that all countries that are not able to issue debt in their own currency are more vulnerable to the impact of currency mismatches in their balance sheets. Those mismatches are even more dramatic in a financially integrated world, where rumours of financial problems may lead to capital flight that might produce self-fulfilling crises, generating bad equilibrium. As observed by Schmidt-Hebbel and Werner (2002), the level of reserves works as an insurance against the occurrence of this bad equilibrium. If the entire burden of the adjustment to capital outflows during a financial crisis is borne by exchange rate depreciation, the country might have a backward-bending exchange rate supply curve with no equilibrium being possible. The authors justify foreign exchange rate intervention for the following reasons: (i) facilitating adjustment to sudden reductions in capital inflows; (ii) accumulating reserves; (iii) reducing excessive exchange rate volatility (associated with lower liquidity in foreign exchange markets); and (iv) raising the supply of exchange rate insurance.

Given the problems associated with exchange rate volatility and the pros of intervention, the Central Bank of Brazil, like other emerging market economies, including some that also adopt inflation targeting, has actually been implementing a dirty-floating exchange rate policy.[24] Such interventions are made as transparent as possible in order to avoid the concern expressed by Mishkin (2000) that intervention may hinder the credibility of monetary policy as the public may realise that stabilising the exchange rate takes precedence over promoting price stability as a policy objective.

In Brazil, the volatility of the exchange rate has been considerable. From 1999:07 to 2002:06, the exchange rate (monthly average) increased on average 1.2% per month, with a standard error of 3.6 and a coefficient of variation (ratio of standard error to average) of 3.0. The inflationary pressures resulting from exchange rate depreciation are more related to the magnitude of the depreciation than to the pass-through coefficient.[25] According to the structural model of the Central Bank, the pass-through to market price inflation, as a percentage of the observed depreciation, is 12% after one year of the depreciation. The pass-through to administered prices is estimated to be 25%, resulting in a pass-through of about 16% for the headline IPCA. In line with the estimates, between January 2001 and August 2002, the price of the dollar moved from BRL 1.95 to BRL 3.11, implying an increase of 59.5%. In the same period, the IPCA rose 12.2%. In this sense, Brazil seems to be closer to the lower end of the estimates done by Hausmann et al (2001). They estimated the pass-through accumulated in 12 months for more than 40 countries and found a value below 5% for G7 countries, and, at the other extreme, figures above 50% for countries such as Mexico, Paraguay and Poland.

We can also use a VAR estimation with monthly data to assess the pass-through and the importance of exchange rate shocks to inflation rate variability. We use two specifications. Both include output, spread of EMBI+ (Emerging Markets Bond Index Plus) over Treasury bonds,[26] exchange rate (monthly average), and interest rate (monthly average). Output is measured by industrial production, seasonally adjusted data, produced by IBGE. The inclusion of EMBI+ was necessary because it is a good indicator for financial crises, both foreign (Argentina, Asia, Mexico, Russia) and domestic (beginning of 1999), which have a significant impact on interest rates. The interest rate is the Selic overnight rate, the basic interest rate in the economy, controlled by the Central Bank. In the first specification, we use administered and market prices as variables, whereas in the second we use the consumer price index

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[24] Calvo and Reinhart (2002) discuss the limited empirical evidence of truly free-floating countries.

[25] See Goldfajn and Werlang (2000) for the reasons for the low pass-through in the Brazilian January 1999 devaluation episode.

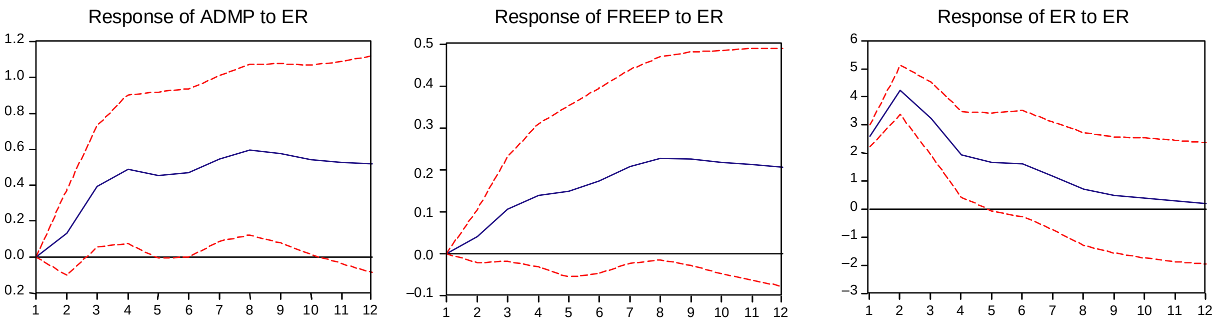
[26] We use EMBI from September 1994 to December 1998, and EMBI+ thereafter.

IPCA instead. We estimate the model in levels, that is, using I(1) and I(0) regressors instead of using the error correction representation.[27] The estimation is consistent and captures possible existing cointegration relationships (Sims et al (1990), Watson (1994)). The variables used are the log levels of output, administered prices, market prices, IPCA and exchange rate, and the levels of EMBI+ spread and interest rate. We use a Cholesky decomposition with the following order in the first specification: output, administered prices, market prices, EMBI+, exchange rate, and interest rate. In the second specification, the CPI substitutes for administered and market prices. Since the financial variables react more rapidly to shocks, we include them after output and price. We also estimate using interest rate before exchange rate. The results, even numerically, are very similar. We use two samples. The first one includes the whole period of the Real Plan, from September 1994 to June 2002.[28] The second sample starts with the implementation of the inflation targeting regime (July 1999) in order to try to capture some specificities of the recent period. However, since the sample is very short, the estimation does not generate statistically significant results.

Graph 11 shows the impulse responses to a one standard deviation of exchange rate shock, using the whole sample. It presents the point estimates and the two-standard-error bands, which were estimated using a Monte Carlo experiment with 1,000 draws. The values shown are percentage points. The lag length of the VAR estimations was chosen according to the Schwarz criterion, but we test for the presence of serial correlation of residuals, and increase the number of lags when necessary to obtain no serial-correlated residuals.[29] The responses of administered and market prices are positive and statistically significant. The increase in administered prices is greater than that of market prices (note that the scales in the graphs are different). The exchange rate increases initially 2.6%, reaching a total of 4.3% in the second month, and starts decreasing after that. The rise of both administered prices and market prices reaches a maximum in the eighth month. The values of the pass-through are presented in Table 7. We estimate the pass-through as the ratio of the price increase in a 12-month horizon to the value of the exchange rate shock. If we consider the value of the exchange rate shock in the first month, the pass-through is 19.7% for administered prices, and 7.8% for market prices. Considering the value of the exchange rate shock in the second month, the pass-through is 12.1% and 4.8%, respectively. The pass-through for administered prices is 2.5 higher than that for market prices. Graph 12 shows the responses in the case of the specification that includes the IPCA instead of administered and market prices.[30] The pass-through to the IPCA was estimated at 14.1% and 8.4%, considering the first and second month shock, respectively.

Graph 11

Impulse responses of administered prices (ADMP), market prices (FREEP) and exchange rate (ER) to an exchange rate shock



[27] According to augmented Dickey-Fuller unit root tests, we can accept the presence of a unit root for the log levels of the IPCA, administered prices, market prices, exchange rate, interest rate, and for the level of EMBI+ spread. We reject the presence of a unit root for the monthly change of those variables, and for the level of interest rate.

[28] July and August 1994 were excluded because the price indices were still "contaminated" by the previous high-inflation period. In this case, the start of the sample is adjusted according to the number of lags used.

[29] We have used four lags for both specifications.

[30] The response of the price level stabilises if we consider a 24-month horizon.

Table 7

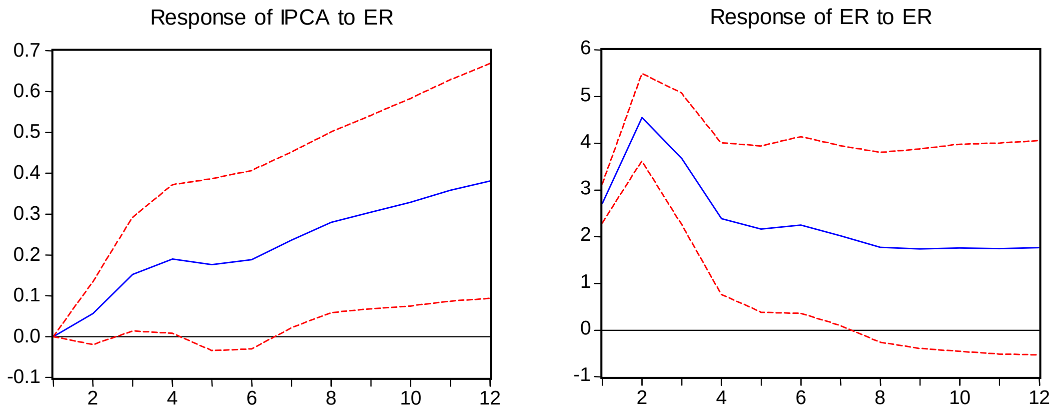
Pass-through considering different specifications: ratio of price change (12-month horizon) to an exchange rate shock

Value of exchange rate shock considered	Sample					
	Real Plan period			Inflation targeting period		
	Administered prices	Market prices	IPCA	Administered prices	Market prices	IPCA
Pass-through using the first-month exchange rate shock	19.7	7.8	14.1	18.8	8.4	12.6
Pass-through using the second-month exchange rate shock	12.1	4.8	8.4	11.6	5.2	7.8
Ratio of pass-through, administered prices versus market prices			2.5			2.2

We also consider a variance decomposition analysis, which gives the percentage of the forecast error variance of a variable that can be attributed to a shock to a specific variable. The influence of exchange rate shocks on administered prices is greater than on market prices. Considering a 12-month horizon, shocks to the exchange rate explain 24.9% of the forecast error variance of administered prices, and 16.3% of that of market prices. Using the specification with the IPCA, the value is 23.0%.

Graph 12

Impulse responses of the price level (IPCA) and exchange rate to an exchange rate shock



Since the inflation targeting regime may have represented a structural change in the relationships, and the exchange rate regime is different from most of the previous period, we estimate a VAR model for the first three years of inflation targeting (1999:07-2002:06). However, the sample size is too short, and the response of administered and market prices is positive, but not statistically significant using a two-standard-error band (they are significant in the first months if we use a one-standard-error band).

To compare with the previous estimation, however, we show the point estimates in Table 7. They are very similar to those found for the whole sample.[31] These results using a VAR model are not in line with those in Muinhos (2001), which shows a structural break in the pass-through coefficient when the exchange rate regime changed. The estimations are conducted using a linear and a non-linear Phillips curve. The pass-through in the same quarter of the exchange rate change fell from more than 50% to less than 10%.

In terms of variance decomposition, exchange rate shocks explain 23.4% and 40.2% of the forecast error variance of administered and market prices, respectively, in a 12-month horizon (the first value is almost statistically significant, and the second is significant). Therefore, in this estimation, the contribution of exchange rate shocks was greater for market prices than for administered. For the case of the IPCA, the exchange rate shocks explain 32.8% of the forecast error variance of prices.

Therefore, exchange rate volatility is an important source of inflation variability. The design of the inflation targeting framework has to take into account this issue to avoid a possible non-fulfilment of inflation targets as a result of exchange rate volatility decreasing the credibility of the Central Bank.

4. Methodology for calculating inflation inertia and the effects of the shock to administered prices

The interest rate should react to inflationary shocks. However, monetary policymakers have to consider several issues concerning the shocks: their nature (demand or supply shocks), degree of persistence (temporary or permanent), size and inflationary impact. In the case of supply shocks, there is a trade-off between output gap and inflation.[32] The optimal response of the interest rate depends on the degree of inflation aversion, on the response of inflation to the output gap, and on the degree of persistence of the shock. Monetary policy should react less, and we can even consider that it may not react, when supply shocks are temporary or have a small size. Likewise, the greater the time horizon of the inflation target, the lower the reaction of the Central Bank.

As discussed in previous sections, change in relative prices has been one of the main challenges faced by the Central Bank of Brazil. Since the implementation of the Real Plan, in July 1994, administered price inflation has been well above market price inflation. As long as there is some downward rigidity in prices, change in relative prices is usually translated into higher inflation. However, monetary policy should be oriented towards eliminating only the secondary effect of supply shocks on the inflation rate while preserving the initial realignment of relative prices. Therefore, the efforts of the Central Bank to quantify the first-order inflationary impact of administered price inflation have become particularly important, since it helps to implement monetary policy in a flexible manner and without losing sight of the larger objective of achieving the inflation targets set by the National Monetary Council (CMN).

The first-order inflationary impact of the shock to administered items is defined as the variation in administered prices exceeding the target for the inflation rate, weighted by the share of administered prices in the IPCA and excluding the effects of the inflation inertia from the previous year and of variations in the exchange rate. The effect of inflation inertia is excluded because inflation propagation mechanisms should be neutralised by monetary policy, which has to consider the appropriate period. As a rule of thumb, the Central Bank considers 18 months an adequate period to offset the inertial effects of higher inflation. The exchange rate variation is excluded because this variable is affected by monetary policy and could reflect demand shocks. Therefore, in defining the shock to administered prices, only the component of relative price change that has no relation to activities of the Central Bank of Brazil is preserved as a first-order supply shock.

This section summarises the methodology currently used to separate the effect, via inertia, of previous-year inflation on current-year inflation, and the inflationary impact brought about by the shock to

[31] We have used two lags in both specifications. With the IPCA and three lags, however, the values are smaller for the pass-through: 9.6% and 4.8%.

[32] See Clarida et al (1999).

administered prices.[33] In this summary, it is assumed that the inertial effects and the pass-through from exchange rate to prices are the same for all goods in the economy.

4.1 Calculating the primary effect of the shock to administered prices

The first-order inflationary impact or primary effect of readjustments in administered prices is calculated by the difference between administered price inflation and the inflation target for the year (weighted by the influence of administered prices on the IPCA), excluding the effects of inflation inertia and of the exchange rate variation on administered prices:

$$ShA = \left(\pi_{adm} - \pi^{*}\right)\omega_{adm} - \left(IA + CaA\right) \quad (3)$$

where ShA is the first-order inflationary impact of administered prices; π_{adm} is administered price inflation; π^* is the inflation target; ω_{adm} is the weight of administered prices in the IPCA; IA is the effect of the inertia in the previous year on the evolution of administered prices; and CaA is the effect of the exchange rate variation on the evolution of administered prices. The following subsection shows the calculation of the IA and CaA components.

4.1.1 Calculating the effect of inflation inertia and exchange rate pass-through on administered prices

The model adopted by the Central Bank of Brazil assumes that the inflation in a given quarter depends on the inflation registered in the previous quarter, which in turn depends on the inflation in the quarter before, and so on. The inertia inherited in a given year results from the inflation registered in the last quarter of the previous year, and its calculation is based on the inflation that exceeded the target. The inertia inherited from the last quarter of the previous year impacts the inflation in each quarter of the current year according to the following formula:

$$I_{j,y_t} = (\pi_{j=4,y_{t-1}} - \pi^{*}_{j=4,y_{t-1}})C^{j}_{inertia}\,\omega_{group} \quad (4)$$

where I_{j,y_t} is the effect of the inflation inertia in the previous year (y_{t-1}) on the inflation of the jth quarter of the current year (y_t); $\pi_{j=4,y_{t-1}}$ is the inflation in the last quarter ($j = 4$) of the previous year (y_{t-1}); $\pi^{*}_{j=4,y_{t-1}}$ is the inflation target in the last quarter of the previous year, approximated by one quarter of the target set for that year; and $C_{inertia}$ is the coefficient that measures the pass-through of the inflation in the previous quarter to the current quarter, according to Central Bank estimates. This coefficient is raised to the jth power; ω_{group} is the weight of the group (market or administered prices) in the IPCA. The total impact of previous-year inflation on current-year inflation via inertia is obtained by adding the effects estimated for each quarter:

$$I_{y_t} = \prod_{j=1}^{4}(1 + I_{j,y_t}) - 1 \quad (5)$$

where Π represents the productory symbol. In this paper, we assume, for simplicity, that $I = IA$, that is, the inertia estimated for administered prices is the same as that for market prices.

The formula below shows how to measure the influence of exchange rate variation on the primary impact of the shock to administered prices:

$$CaC_t = (e_t - e_{t-k})\,\alpha_2\omega \quad (6)$$

where CaC_t is the effect of the exchange rate variation on the price adjustment of utility C in month t; ($e_{t-1} - e_{t-k}$) is the exchange rate variation accumulated from $t - k$ to t (the value of k depends on the specific good one is analysing. There are utilities whose price adjustments depend on the 12-month exchange rate variation, while for other goods, such as petrol, price adjustment is based on the

[33] See Freitas et al (2002) for a more detailed description of the methodology.

evolution of the exchange rate in the previous month. As stated before, for simplicity, we assume all goods follow the same rule); α_2 is the pass-through of the exchange rate variation to prices; and ω is the weight of the specific good in the IPCA, which, in this paper, corresponds to administered prices as a whole.

4.2 An example

Table 8 shows a hypothetical example of how the primary effect of the shock to administered prices and the inertia inherited from the previous year could be useful in a monetary policy decision. This example was built assuming that the target for inflation is 4% and expected inflation 5%.

Table 8

Example of a calculation of the target adjusted for the inertia effect from the previous year and for the primary effect of the shock to administered prices

	Item	%
(a)	Target for year *t*	4.0
(b)	Contribution of year *t*–1 inertia to inflation in year *t*	0.8
(c)	Inertia from year *t*–1 to be accommodated in year *t* (= (b)/2)	0.4
(d)	Administered price inflation forecast for year *t*	8.0
(e)	Contribution of administered price inflation above the target (= ((d) – π^{target})ω_{adm})	1.2
(f)	Inertia effects of year *t*–1 on year *t* administered price inflation	0.2
(g)	Exchange rate impact on administered price inflation	0.5
(h)	Primary effect of the shock to administered prices (= (e) – (f) – (g))	0.5
(i)	Target adjusted for the inertia effect from the previous year and for the primary effect of the shock to administered prices (= (a) + (c) + (h))	4.9
(j)	Inflation forecast for year *t*	5.0

According to this example, inflation is expected to be 1 percentage point above the target for that year. The cookbook recipe would suggest that Copom raise the interest rate.[34] However, Copom should adjust the target, adding the impact of inertia to be tolerated in that year (line c) and the primary effect of the shock to administered prices (line h). Observe that Copom interprets as a shock not the whole increase in administrative prices, but only the increase that is not explained by inertia and the exchange rate change.

The target adjusted by the above-mentioned effects rises to 4.9%, which is close to the inflation forecast of 5%. Hence, in this case, the optimal policy would be to leave interest rates unchanged. There are, however, other points to be taken into consideration. The most important one is the trade-off between credibility and flexibility that arises when the forecast for inflation approaches the upper limit of the tolerance interval, while the forecast excluding the inertia and administered price shocks remains around the target. There is no clear answer for solving this trade-off, but, as a general guideline, the Central Bank should be more flexible the higher its credibility, the better it can communicate with the market, and the stronger the output loss involved if inflation is brought back to target. In this sense, the bands should be considered mainly as checkpoints, with the Central Bank explaining clearly the reasons for the non-fulfilment of the targets.

[34] Even if the projected deviation from the target were caused only by demand shocks, the optimal response of the Central Bank would not necessarily be to raise interest rates. It would depend on the effectiveness of monetary policy in reducing inflation in that year, the inflation forecasts for the following years, the expected duration of the shock, etc.

5. Institutional design of inflation targeting

The inflation targeting framework has to be designed in such way that the conduct of monetary policy is oriented consistently towards the fulfilment of targets, but at the same time takes into account the limits for achieving this. Inflation is not totally under the control of the monetary authority, and output costs have to be considered. There are various reasons for the non-fulfilment of targets. The first relates to the models used by central banks: model misspecification, uncertainty concerning the estimated coefficients, possible structural breaks, existence of variables that are difficult to model, etc. The second is the presence of unexpected shocks in the economy. The third is the presence of lags in the effects of monetary policy.

We stress four issues involved in the institutional design of inflation targeting: (i) the choice of price index (core versus headline inflation); (ii) the inclusion or not of escape clauses; (iii) the size of the tolerance intervals (bands); and (iv) the horizon and criteria used for the targets.[35] Besides these issues, it is important to note the current gap in the Brazilian institutional framework represented by the absence of central bank independence. Central bank independence has been implemented in several countries, and is an important element for consolidating a policy oriented towards price stability.

5.1 "To core or not to core"

The use of some measure of core inflation has been justified on the grounds that a measure of inflation that is less sensitive to temporary price movements and more reflective of the long-term trend is necessary. Monetary policy should not target a variable that is subject to temporary movements. A core inflation measure is also justified based on the argument that a measure of inflation that is less sensitive to supply shocks, such as oil prices shocks, is necessary.

There are different measures of core inflation. The most common are the exclusion method and the trimmed mean method. The first usually excludes some items such as food, oil by-product and other energy prices because these prices present high seasonality and are often subject to supply shocks. The symmetric trimmed mean core excludes the items presenting the highest and the lowest change in the period. The items are ordered according to their change. The items excluded are those whose accumulated weight from the top of the list reaches some threshold, say 20% or 30%, and those following the same criterion from the bottom of the list.[36]

In Brazil, the change in relative prices has motivated the discussion of the adoption of a core inflation measure, in particular a measure that would exclude administered prices. Nowadays, only a few countries target a core inflation measure, for example Canada and Thailand, which use core by exclusion. We do not include in this group countries such as the United Kingdom and South Africa, which use an inflation measure that excludes only mortgage interest rates. In this case, the motivation for the adoption of an exclusion index is different: increases in interest rates, via mortgage rates, positively affect the headline inflation rate. Actually, the international experience has pointed to the use of headline indices: Australia, New Zealand and the Czech Republic abandoned the use of core inflation measures in 1998, 1999 and 2002, respectively. Other countries, such as Colombia, Iceland, Israel, Mexico, Peru, Poland, Sweden and Switzerland also use headline inflation (Ferreira and Petrassi (2002)).

The main argument against the use of core inflation is that it is less representative of the loss of the purchasing power of money. Agents are concerned about the whole basket of consumption. In

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35 For different international experiences in terms of these four items, see Ferreira and Petrassi (2002) and Mishkin and Schmidt-Hebbel (2002).

36 The sample of the variations of the inflation rate components is ordered $\{x_1, \ldots, x_n\}$ with their respective weights $\{w_1, \ldots, w_n\}$. The symmetric trimmed mean is obtained from $\bar{x}_\alpha = \left(1/1 - \frac{2\alpha}{100}\right)\sum_{i \in I_\alpha} w_i x_i$, where α is the threshold, $I_\alpha = \left\{ i \mid \frac{\alpha}{100} < W_i < \left(1 - \frac{\alpha}{100}\right)\right\}$, I_α is the set of the components to be considered in the computation of the trimmed mean with α%, and W_i is the accumulated weight up to ith component (Figueiredo (2001)).

the Brazilian case, exclusion of the administered items would imply leaving out more than 30% of the representative consumption basket. In this sense, private agents may question a monetary policy that is not concerned about the overall consumer price index.

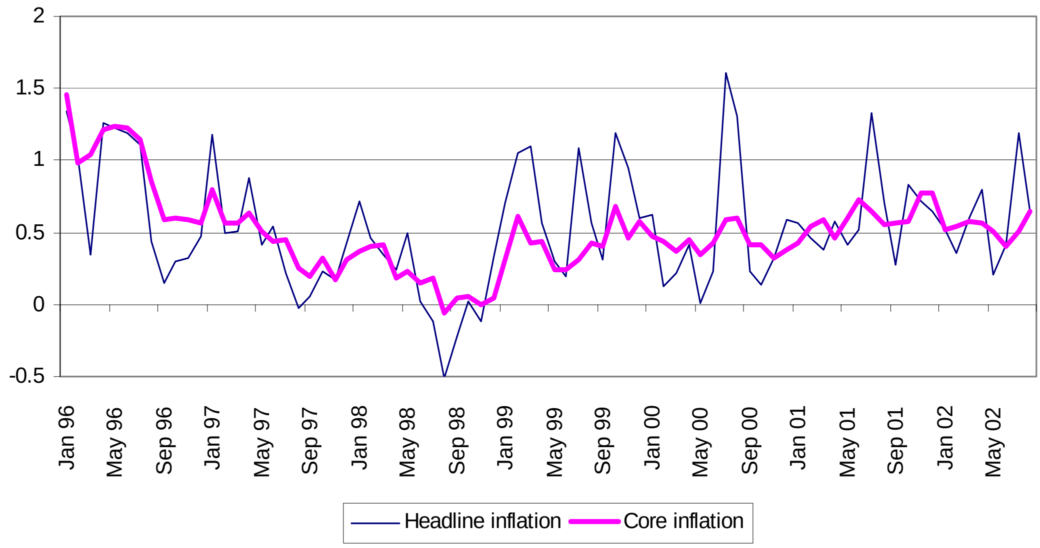
Furthermore, in the Brazilian case, on some occasions during the 1970s and 1980s, the government excluded some items from the headline index on an ad hoc basis in order to reduce the official inflation rate, or even changed the official index. As a result, agents in Brazil tend to be reluctant to accept an index that excludes some items because it reminds them of these changes in the past.

The adoption of a trimmed mean core in turn would imply a great loss in terms of communicability. The basket that comprises the index is not known a priori: it depends on the evolution of prices. Furthermore, the choice of the threshold is not trivial, and is necessary to smooth some prices whose adjustments take place only from time to time.[37] The Central Bank of Brazil uses a 20% symmetric trimmed mean core that includes the smoothing of eight items.[38] Graph 13 presents the monthly headline (IPCA) and core inflation rates. The core measure is considerably less volatile than the headline. The standard deviation of core inflation is 0.28 and that of headline inflation 0.42 (sample: 1996:01-2002:08).

Graph 13

Headline and core inflation

In percentages per month



Nevertheless, the trimmed mean core has been shown to play an important role as predictor of inflation trend. Table 9 shows Granger causality tests between core inflation and headline inflation.[39] We find that core inflation Granger causes headline inflation, that is, core inflation conveys information about future inflation (beyond that contained in past inflation), and headline inflation does not Granger cause core inflation. Therefore, core inflation can be used as a useful source of information about future inflation.

[37] The discontinuous adjustments tend to be larger than the average. Therefore, in the absence of smoothing, these items would be systematically excluded.

[38] See Figueiredo (2001) for an evaluation of different core measures for Brazil.

[39] See also Figueiredo and Staub (2002). Figueiredo (2001) found that the core measure has the “attractor” property as well.

Table 9

Granger causality test: core inflation and headline inflation (IPCA)

Sample: 1996:01-2002:06

Null hypothesis	One lag		Two lags	
	F-statistic	**P-value**	**F-statistic**	**P-value**
Core inflation does not Granger cause headline inflation	4.83	0.0311	7.14	0.0015
Headline inflation does not Granger cause core inflation	0.04	0.8479	0.98	0.3797

5.2 Escape clauses

Since the inflation rate is subject to several factors that are beyond the control of monetary policy, the success of the conduct of monetary policy should not be judged exclusively in terms of the fulfilment or not of the inflation targets. Under some circumstances, such as significant supply shocks, the Central Bank cannot avoid the inflationary impact of the shock because of the presence of lags in the effects of monetary policy or should not avoid it because of the associated output costs.

In the case of escape clauses included in the inflation targeting framework, it is set in advance of the circumstances under which the central bank can justify the non-fulfilment of targets. The inflation target design in New Zealand, South Africa, the Czech Republic and Switzerland includes escape clauses (Ferreira and Petrassi (2002)). In New Zealand, they can be invoked in the case of unpredictable events that can affect the inflation rate, such as natural disasters, and change in commodity prices and indirect tax rates. In South Africa, escape clauses include significant change in terms of trade, natural disasters, and interruption of external capital flows. Besides significant changes in international prices and agricultural production, natural disasters, and change in indirect tax rates, escape clauses in the Czech Republic comprise changes in regulated prices that affect headline inflation by more than 1-1.5 percentage points, and large changes in the exchange rate not related to domestic monetary policy. In Switzerland, escape clauses refer to change in the exchange rate and the prices of some items such as oil and imported goods.

There is clearly a trade-off in the adoption of escape clauses in the framework. Their inclusion allows a better assessment of the conduct of the Central Bank, and may avoid excessive responses from monetary policy that could otherwise occur. However, their adoption may signal that the monetary authority will be lenient towards some inflationary pressures, and their excessive use can affect the credibility of the regime.

In the Brazilian case, since the regime is still relatively new, and its credibility is still under construction, the adoption of escape clauses could negatively affect its credibility. Furthermore, the tolerance intervals should be enough to accommodate most of the shocks that the economy is subject to.

5.3 Tolerance intervals (bands)

The limits of the forecasting models, the possibility of unexpected shocks hitting the economy, and the presence of lags in the effects of monetary policy justify either the use of tolerance intervals for the point targets or the use of range targets in the absence of point targets in most of the inflation targeting countries. The size of the bands varies across countries, going from 1 percentage point in Australia and Israel to 3 percentage points in South Africa, 3.5 in Iceland, and 4 in Brazil for 2002 and 5 for 2003 and 2004.

The size of the bands should be large enough to allow the inflation rate to be within them in most circumstances, but at the same time they are not supposed to be too large to avoid a lenient conduct of monetary policy. The size of the bands has to be established according to the importance of the three factors mentioned above: it depends on the limits of the forecasting models, the frequency and magnitude of the shocks that the economy is subject to, and the lag length of the effects of monetary policy. In the Brazilian economy, it is clear that the first two factors lead to a larger band size. First, other economies can use models estimated using a large sample because they have a much longer history of stability, and in many cases the inflation targeting regime has been adopted over a longer period.[40] As a result, the forecast model can be estimated more precisely. In Brazil, the dynamics of inflation in the high-inflation period are markedly different from those in the low-inflation period. As a consequence, most of the estimations that model inflation have to start after June 1994. Moreover, with just three years of inflation targeting, possible structural breaks in the relationships are not easily found. Second, the Brazilian economy has been hit by frequent and large shocks. Most of them are related to its position as an emerging market economy - high volatility of country risk premium and of the exchange rate - and to some structural transformations that led to a change in relative prices. The volatility of the inflation rate and exchange rate in Brazil is still one of the highest in inflation targeting economies.

As we saw in previous sections, the exchange rate depreciation accounted for 38% and 48% of the inflation rate in 2001 and January-August 2002, respectively. Furthermore, exchange rate shocks explain 24.9% and 32.8% of the 12-month ahead forecast error variance of the inflation rate considering samples for the whole Real Plan period and for the inflation targeting period, respectively. The upper limit of the tolerance interval in 2001 was not enough to accommodate the shocks. Taking into account these factors affecting the band size, the National Monetary Council (CMN) has enlarged the tolerance intervals from 2 to 2.5 percentage points above and below the central targets for 2003 and 2004.

5.4 Establishment of targets and target horizon

The inflation targets have to be set taking into account both the long-term goal of price stability and the conditions for their achievement. If the actual or expected inflation rate is above the long-term goal, the targets have to be set in such a way that the inflation rate converges to it. However, it is necessary to take into consideration the associated output costs, and some country specificities that may lead to a medium-term inflation rate goal above a long-term one.

The length of the target horizon also has implications for the magnitude of the response of monetary policy to shocks. The longer the target horizon, the smaller the effects of current shocks in expected inflation for the target horizon. As a consequence, monetary policy tends to respond less to shocks.

The targets in Brazil are set in June by the CMN for the end of the calendar year two years ahead. The initial targets were established taking into account the domestic currency depreciation of the beginning of 1999, and aiming at reducing the inflation rate to low levels. In June 1999, the targets were established at 8%, 6% and 4% for 1999, 2000 and 2001, respectively, and, in June 2000, at 3.5% for 2002. In principle, inflation targets should not be changed to avoid loss of credibility. Nevertheless, the continuous pursuit of targets that are perceived in advance as having low achievability reduces the credibility of the Central Bank. Taking into account this balance of risks, the CMN decided in June 2002 to revise upwards the target for 2003 from 3.25% to 4%, and set the target at 3.75% for 2004. We consider that private agents in general have positively appraised the revision. Insisting on an unrealistic target would have negatively affected the credibility of monetary policy.

6. Conclusions

The inflation targeting regime in Brazil is relatively new, but has proved to be important in achieving low inflation rate levels even in a context of large shocks. The presence of a central bank committed to achieving preannounced inflation targets has worked as an important coordinator of expectations and generated a more stable inflation scenario. The pursuit of the goal, and the significant increase in the transparency that has marked the conduct of monetary policy - including the release of the minutes of

[40] Since there is a transition period of learning, possible structural changes with the new regime can be found more easily with a larger sample.

Copom meetings seven days after the event and of the quarterly *Inflation Report* - have helped develop awareness of the importance of the price stability commitment.

In this period, the regime has faced many challenges, including the construction of credibility - still under way - a change in relative prices, and exchange rate volatility. Dealing with them has required a large effort on the part of the Central Bank, which itself has also learned substantially and improved the system. The Central Bank has reacted strongly to inflation expectations, consistent with the inflation targeting framework. Market expectations have behaved in a controlled way, even in the presence of inflationary shocks. The estimations also indicate a reduction in the degree of inflation persistence and in the volatility of output and inflation.

The increase in administered prices and the exchange rate depreciation have exerted significant inflationary pressures. The Central Bank has developed a methodology to estimate the different sources of inflation, which has been used in the conduct of monetary policy.

Several issues comprise the institutional design of the inflation targeting framework. The conclusions pointed to the maintenance of headline inflation as the target and to the enlargement of the tolerance intervals (adopted for 2003 and 2004).

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Inflation persistence and costly market share adjustment: a preliminary analysis

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Abstract

In this paper we develop a dynamic general-equilibrium model to explore the role, if any, that market share may play in inducing inflation persistence. We extend a standard sticky-price model by including a form of market share discussed in Rotemberg and Woodford (1995). In particular, a firm that raises its price relative to competing firms will not only sell less to its existing customers but also lose future market share; and as market share is costly to regain, firms attempt to minimise price movements that erode their market share. It is the latter feature that we believe may offer insights on the observed inertial behaviour of inflation.

1. Introduction

The inability of standard macroeconomic models to deliver degrees of inflation persistence found in the data has led many researchers to suggest alternative explanations for the observed inertial behaviour of inflation. Dittmar et al (2001), for instance, argue that it is possible to account for inflation persistence in a flexible-price, general-equilibrium business-cycle model if the monetary authority follows an interest rate rule. The policy rule transforms output persistence induced by a persistent technology shock into inflation persistence. Other authors have focused on different forms of contracting. Fuhrer and Moore (1995) propose relative-wage contracting while Jadresic (2000) proposes a staggered price-setting model with a flexible distribution of price duration to explain inflation persistence. Roberts (1998) and Ball (2000) apply different forms of near-rational expectations in otherwise standard staggered wage setting models to examine the inertial behaviour of inflation. Along a similar margin, Andolfatto and Gomme (2002), Andolfatto et al (2002) and Erceg and Levin (2001) each suggest a model in which households and firms use optimal filtering to disentangle long-lasting and transitory shifts in the monetary policy rule to account for the observed dynamics of inflation. Finally, Mankiw and Reis (2001) argue that inflation persistence is caused by the slow diffusion of information about macroeconomic conditions.

In this paper, we offer an alternative explanation for inflation persistence: costly market share. We are not arguing that costly market share is the only explanation but that it may be an additional factor that helps us to understand inflation dynamics. This paper examines the implications of introducing market share into an otherwise standard sticky-price model. To this end, we construct and analyse a dynamic, general-equilibrium model that incorporates Taylor-style price contracts and a market share concept similar to that discussed in Rotemberg and Woodford (1992). We then examine the implications of the interaction between price contracts and market share for price adjustment. As Ball and Romer (1990) argue, both a real rigidity and nominal price rigidity are required to explain sluggish price adjustment. In the type of market share model we consider, demand has a dynamic pattern; a firm that increases its current price not only sells less to its existing customers but also erodes its market share in the next period. Having a smaller market share decreases future sales for any given future price and, thus,

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lowers the present value of expected future profits. This feature, we believe, will induce firms to slow the rate of introduction of price increases.

The idea that market share may influence pricing decisions is not new. Froot and Klemperer (1989) study exchange rate pass-through when firms' future demand depends on current market shares. Expected future exchange rates in their framework affect the value of current market share and so affect current pricing strategies. They show that this type of intertemporal dependence implies that the magnitude of the pass-through will depend on whether exchange rate movements are thought to be temporary or permanent.

Stiglitz (1979) and Ball and Romer (1990) argue that imperfect information induces existing customers to be more responsive to price increases than prospective new customers to price decreases (making the marginal revenue curve steeper). In particular, Ball and Romer introduce market share into a menu-cost model where sellers base their pricing decisions on maximising the current period profit. In this environment, the presence of market share increases the degree of real rigidity measured by the insensitivity of real price to changes in aggregate demand so that the real output effect of exogenous changes in the money supply becomes more palpable.

Rotemberg and Woodford (1995, 1999) examine the implications of introducing market share, inter alia, into an otherwise standard neoclassical growth model. The type of market share model is based on Phelps and Winter (1970). Under this specification firms incorporate, into their decision-making process, the effect of today's pricing decision on future market share. Rotemberg and Woodford argue that this type of structure can capture the idea that consumers have switching costs (see Beggs and Klemperer (1992)) when changing from one producer to another. These papers demonstrate that market share considerations of this form can introduce real rigidity into the model as well as generate a countercyclical markup. They do not, however, examine the implications for the degree of nominal price rigidity in the model. Finally, Yun (1998) examines the consequences for government budget deficits of introducing market share into a sticky-price model. Yun finds that including market share tends to not only reduce the size but also the sign of output's response to an exogenous increase in the government budget deficit.

On the empirical side, if one believes that the importance of market share is inversely related to the degree of competition, then there is much empirical evidence supporting a negative relationship between market share and the frequency of price changes. In addition, models of price adjustment predict greater frequency of price changes in markets with more competition because firms face more elastic demand (eg Barro (1972)). In the empirical literature the firm concentration ratio is often used as an inverse measure of market competition, with a higher value expected to be correlated with less elastic demand. Several papers find an inverse relationship between the concentration ratio and the frequency of price changes for US data (Carlton (1986) and Caucutt et al (1999)). Encaoua and Geroski (1986) use data for five Organisation for Economic Co-operation and Development countries to estimate the relationship between price, cost and concentration. They find, in general, that higher degrees of concentration are associated with slower price adjustments to cost changes. Bils and Klenow (2002) examine the frequency of price changes for 350 categories of goods and services using unpublished data from the BLS from 1995 to 1997. They also find evidence of a positive empirical relationship between market competitiveness and price flexibility.

As Rotemberg and Woodford (1995) argue, one reason for the importance of market share may be switching costs. Switching costs also appear empirically important for pricing decisions. Carlton (1979) and Hubbard and Weiner (1992) find systematic differences between prices when buyers and sellers meet randomly and when buyers and sellers establish an ongoing relationship. During booms, prices associated with random meetings increase substantially relative to prices determined by an ongoing relationship, even for what appear to be homogeneous goods.

The remainder of this paper is organised as follows. Section 2 describes the structure of the economic model and Section 3 details its calibration. In Section 4 we discuss our findings, while concluding remarks are contained in Section 5.

2. The model

Much of the model structure and calibration comes from Dib (2001), who in turn borrows from Rotemberg and Woodford (1995, 1997) and others. The economy consists of households, final-good-producing firms, intermediate-good-producing firms, and a central bank. The intermediate-good-producing firm combines labour and capital in the production of a differentiated good that it sells in a monopolistically competitive market to the final-good producer. This final-good producer combines the continuum of intermediate goods into a single final good that it sells in a perfectly competitive market to households for consumption and investment.

As in Taylor (1980), we assume that intermediate firms hold their prices fixed for two periods. The firms are evenly distributed across the two periods so that half the firms can reset their price in odd-numbered periods and half in even-numbered periods. Calvo-style pricing is used more commonly in recent literature but, for the purposes of this paper, Taylor contracting provides a simpler base case upon which to build. The main innovation of the paper will be the addition of market share considerations to the problem of the intermediate-good producer. In particular, if an intermediate producer increases its price relative to the general price level, then it will not only decrease the demand for its product this period but will also lose market share in the following period.

2.1 The household

The representative household derives utility from consumption of the final good, c_t, from holding real money balances, M_t/P_t, and from leisure, $(1-h_t)$. Household preferences are described by the following expected utility function:

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, \frac{M_t}{P_t}, h_t\right) \tag{1}$$

where $\beta \in (0,1)$ is the discount rate.

The period utility function, u, is given by:

$$u(\bullet) = \frac{\gamma}{\gamma-1}\log\left[c_t^{\frac{\gamma-1}{\gamma}} + b^{\frac{1}{\gamma}}\left(\frac{M_t}{P_t}\right)^{\frac{\gamma-1}{\gamma}}\right] + \eta\log(1-h_t) \tag{2}$$

where b, γ and η are positive parameters.

Investment, i_t, is done by the household and increases the capital stock according to the standard equation:

$$k_{t+1} = (1-\delta)k_t + i_t \tag{3}$$

where δ represents a constant depreciation rate.

The household's budget constraint is given by the following equation:

$$c_t + i_t + \frac{M_t}{P_t} \le r_t k_t + w_t h_t + \frac{M_{t-1} + T_t + D_t}{P_t} \tag{4}$$

Let r_t and w_t denote the real capital rental rate and real wage rate, respectively. Households receive a monetary transfer, T_t, directly from the central bank and a dividend payment, D_t, from the intermediate-good producers.

The household's maximisation problem is to choose $\{c_t, M_t, h_t, k_{t+1}\}$ in order to maximise its expected utility function in equation (1). The Bellman equation for this dynamic programming problem can be written as follows:

$$V(k_t, M_{t-1}, \Omega_t) = \max_{\{c_t, M_t, h_t, k_{t+1}, i_t\}}\left[u\left(c_t, \frac{M_t}{P_t}, h_t\right) + \beta E_t V(k_{t+1}, M_t, \Omega_{t+1})\right] \tag{5}$$

subject to the constraints in equations (3) and (4). The variable Ω_t represents the information set available to households at time t upon which their decisions are based. The first-order conditions for this problem are given by:

$$\frac{c_t^{-\frac{1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b^{\frac{1}{\gamma}}\left(\frac{M_t}{P_t}\right)^{\frac{\gamma-1}{\gamma}}} - \lambda_t = 0 \tag{6}$$

$$\frac{b^{\frac{1}{\gamma}}\left(\frac{M_t}{P_t}\right)^{-\frac{1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b^{\frac{1}{\gamma}}\left(\frac{M_t}{P_t}\right)^{\frac{\gamma-1}{\gamma}}} - \lambda_t + \beta E_t\left(\frac{P_t\lambda_{t+1}}{P_{t+1}}\right) = 0 \tag{7}$$

$$\frac{\eta}{1-h_t} - \lambda_t w_t = 0 \tag{8}$$

$$\beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left(r_{t+1} + (1-\delta)\right)\right] - 1 = 0 \tag{9}$$

$$k_{t+1} - (1-\delta)k_t - i_t = 0 \tag{10}$$

2.2 The final-good-producing firm

The consumption and investment good purchased by households is produced by a Dixit and Stiglitz (1977) aggregator. This final good, y_t, is produced from a continuum of imperfectly substitutable intermediate goods, y_{jt}, according to the following CES production function:

$$y_t \leq \left(\int_0^1 s_{jt}^{\frac{1}{\theta}} y_{jt}^{\frac{\theta}{\theta-1}} dj\right)^{\frac{\theta}{\theta-1}}, \qquad \theta > 1 \tag{11}$$

The parameter θ represents the degree of substitutability between intermediate inputs and the degree of monopoly power of the firms producing these inputs. The variable s_{jt} represents the market share of firm j that is assumed to evolve according to the following expression:

$$s_{jt} = \left(\frac{P_{jt-1}}{P_{t-1}}\right)^{-\chi} s_{jt-1}, \qquad \chi > 0 \tag{12}$$

Market share follows a random walk process such that a firm's share at time t depends on its share at $t-1$ as well as its price relative to the aggregate price level at $t-1$. When a firm's price increases relative to the market price at t, its market share at $t-1$ will decrease. As long as this price differential persists, firm j's market share will continue to fall. Firm j will need to undercut the market price in order to rebuild its market share back up to its original level. As discussed above, the introduction of market share can be motivated by the customer market model of Phelps and Winter (1970). The firm that lowers its price today not only expands the demand for its product in the current period but also increases its customer base in subsequent periods.

The final good is sold at price P_t in a perfectly competitive market while input y_{jt} is purchased at price P_{jt} from a monopolistically competitive supplier. The final-good producer maximises its profits given in the following expression:

$$\max_{y_{jt}}\left[P_t\left(\int_0^1 s_t^{\frac{1}{\theta}}\, y_{jt}^{\frac{\theta-1}{\theta}} dj\right)^{\frac{\theta}{\theta-1}} - \int_0^1 P_{jt} y_{jt} dj\right] \tag{13}$$

The resulting first-order condition for input y_{jt} yields the following demand function for intermediate goods:

$$y_{jt} = y_t \left(\frac{P_{jt}}{P_t} \right)^{-\theta} s_t \tag{14}$$

Similar input demand functions have also been used in Rotemberg and Woodford (1995) and Yun (1998). The underlying motivation for this specification is that consumers face costs of switching from one product to another. As such, there is inertia in their buying patterns and hence the market share of the firms. See Klemperer (1995) and Beggs and Klemperer (1992) for examples of switching cost models.

The demand for input y_{jt} increases with aggregate output, y_t, and price, P_t, but decreases with input price P_{jt}. Since the final-good producer sells its output in a perfectly competitive market, it earns zero profits in each period. The resulting zero profit condition yields a definition for the aggregate price level given in equation (15):

$$P_t = \left(\int_0^1 s_{jt} P_{jt}^{1-\theta} dj \right)^{\frac{1}{1-\theta}} \tag{15}$$

2.3 The intermediate-good-producing firm

The intermediate good is produced using capital, k_{jt}, and labour, h_{jt}, according to the following decreasing returns to scale production function:

$$y_{jt} \le A_t k_{jt}^{\alpha_1} h_{jt}^{\alpha_2}, \qquad \alpha_1, \alpha_2 \in (0,1), \ \alpha_1 + \alpha_2 < 1 \tag{16}$$

Decreasing returns to scale are assumed since, under the standard constant returns to scale assumption, firms do not care about the scale of their operations. With decreasing returns there is an optimal size for the firm and producers will try to offset the effects of shocks that reduce their market share and keep them away from their preferred scale of production. The producers' desire to maintain a desired level of production will ensure that the random walk specification of market share in (12) will actually have a steady state.

A standard technology shock, A_t, affects all firms symmetrically and evolves according to the following AR(1) equation:

$$A_t = (1 - \rho_A) A + \rho_A A_{t-1} + \varepsilon_{At} \tag{17}$$

where $\rho_A \in (-1,1)$ and ε_{At} is a normally distributed iid shock.

The intermediate-good producer is assumed to be only able to change its price once every two periods. In other words, prices evolve according to two-period staggered Taylor contracting. Half the firms will change their prices in even-numbered periods while the remainder of the firms will change their prices only in odd-numbered periods. In support of assuming two-period contracting, Christiano et al (2001) find that prices are fixed for approximately two quarters in their estimated model. The firm selects capital, labour, and the price of its output to maximise the discounted stream of future profits given by:

$$\max_{\{k_{jt}, h_{jt}, p_{jt}\}} E_0 \left[\lambda_t \frac{D_{1jt}}{P_t} + \beta \lambda_{t+1} \frac{D_{2jt+1}}{P_{t+1}} + \beta^2 \lambda_{t+2} \frac{D_{1jt+2}}{P_{t+2}} + \beta^3 \lambda_{t+3} \frac{D_{2jt+3}}{P_{t+3}} + \cdots \right] \tag{18}$$

where

$$D_{1jt} = P_{jt} y_{jt} - P_t r_t k_{jt} - P_t w_t h_{jt} \tag{19}$$

and

$$D_{2jt+1} = P_{jt} y_{jt+1} - P_{t+1} r_{t+1} k_{jt+1} - P_{t+1} w_{t+1} h_{jt+1} \tag{20}$$

The intermediate firm's problem is to maximise discounted profits in (18) subject to:

$$A_t k_{jt}^{\alpha_1} h_{jt}^{\alpha_2} \ge y_t \left(\frac{P_{jt}}{P_t} \right)^{-\theta} s_t \tag{21}$$

The first-order conditions are given by:

$$\alpha_1 \frac{y_{jt}}{k_{jt}} \frac{\xi_t}{\lambda_t} - r_t = 0 \tag{22}$$

$$\alpha_2 \frac{y_{jt}}{h_{jt}} \frac{\xi_t}{\lambda_t} - w_t \tag{23}$$

$$\begin{aligned} & y_{jt} + \theta y_t \left(\frac{P_{jt}}{P_t}\right)^{-\theta-1} s_{jt}\left(\frac{\xi_t}{\lambda_t} - \frac{P_{jt}}{P_t}\right) + \beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\frac{P_t}{P_{t+1}} y_{jt+1}\right] \\ & \quad + \beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left(\frac{\xi_{t+1}}{\lambda_{t+1}} - \frac{P_{jt}}{P_{t+1}}\right)\left(\frac{P_t}{P_{t+1}} y_{t+1}\theta\left(\frac{P_{jt}}{P_{t+1}}\right)^{-\theta-1} s_{jt+1} + \chi y_{t+1}\left(\frac{P_{jt}}{P_{t+1}}\right)^{-\theta}\left(\frac{P_{jt}}{P_t}\right)^{-\chi-1} s_{jt+1}\right)\right] \\ & \quad + \beta^2 E_t\left[\frac{\lambda_{t+2}}{\lambda_t}\chi y_{t+2}\left(\frac{P_{jt+2}}{P_{t+2}}\right)^{-\theta}\left(\frac{P_{jt}}{P_{t+1}}\right)^{-\chi-1} s_{jt+2}\left(\frac{\xi_{t+2}}{\lambda_{t+2}} - \frac{P_{jt+2}}{P_{t+2}}\right)\right] = 0 \end{aligned} \tag{24}$$

$$A_t k_{jt}^{\alpha_1} h_{jt}^{\alpha_2} - y_t\left(\frac{P_{jt}}{P_t}\right)^{-\theta} s_{jt} = 0 \tag{25}$$

The Lagrangian multiplier for equation (21) is given by ξ_t. Equation (22) equates the marginal rate of substitution for capital to the real interest rate and equation (23) that for labour to the real wage. These equations imply that the price markup over costs is given by $q_t = \lambda_t/\xi_t$. Equation (24) governs the price setting behaviour of the monopolistically competitive intermediate-good producer.[2]

2.4 The monetary authority

The monetary authority adjusts the money supply each period by making equal lump sum transfers to all households. Therefore, we have $M_t - M_{t-1} = T_t$. Assume that the monetary authority follows the policy rule for the money growth rate given by:

$$\mu_t = (1-\rho_\mu)\mu + \rho_\mu \mu_{t-1} + \varepsilon_{\mu t} \tag{26}$$

where μ_t denotes the growth rate of money in period t ($M_t / M_{t-1} = \mu_t$) and $\rho_\mu \in (-1,1)$ is its persistence parameter. The money supply growth rate shock is an iid random variable given by $\varepsilon_{\mu t}$. The steady state money growth rate and inflation rate is given by μ.

2.5 Market clearing conditions

The market clearing conditions for this economy are given by:

labour: $h_t = h_{1t} + h_{2t}$ (27)

capital: $k_t = k_{1t} + k_{2t}$ (28)

final goods: $y_t = c_t + i_t$ (29)

2.6 Symmetric equilibrium and solution

In a symmetric equilibrium, all intermediate-good-producing firms setting their price in a given period are identical. As such, all firms that can set their price in odd-numbered periods are identical. The same is true for firms setting their price in even periods. Let y_{1t} and y_{2t} represent the output of firms

[2] We are investigating the feasibility of introducing a full oligopoly-pricing problem into this general equilibrium framework but have yet to work out the details.

setting their price in odd-numbered and even-numbered periods, respectively. All other intermediate-good-producers' variables are similarly labelled.

There is no real growth in the model but there can be nominal growth. Therefore, real variables do not need to be rescaled but all nominal variables need to be deflated by the money stock in order to be able to solve for a symmetric stationary equilibrium. The following normalisations are necessary:

$$m_t = \frac{M_t}{P_t} \quad \text{or} \quad p_t = \frac{P_t}{M_t}, \quad p_{jt} = \frac{P_{jt}}{M_t} \quad \forall j \tag{30}$$

A symmetric equilibrium is composed of an allocation set, $\{y_t, y_{1t}, y_{2t}, c_t, m_t, h_t, h_{1t}, h_{2t}, k_t, k_{1t}, k_{2t}, i_t\}$, and a sequence of prices and costate variables, $\{p_t, p_{1t}, p_{2t}, w_t, r_t, q_{1t}, q_{2t}, \lambda_t\}$, that satisfy the household's first-order conditions in equations (6)-(10), the intermediate-good-producer's first-order conditions in equations (22)-(25), the production function in equation (11), the demand functions in equation (14), the aggregate price definition in equation (15) and the market clearing conditions in equations (27)-(29). This represents a system of 20 equations with 20 unknowns.

The solution technique used to solve this model was a stacked-time method described in Armstrong et al (1998).

3. Calibration

The calibration of the model follows closely the results in Dib (2001). In that study, roughly one third of the structural parameters were fixed whereas the remainder were estimated on Canadian data using the approach described in Hansen and Sargent (1998). The parameters are reported in Table 1.

Table 1

Calibrated parameters

Parameters	β	η	α_1	α_2	δ	θ	b	μ	ρ_μ	γ	A	ρ_A
Values	0.992	1.42	0.33	0.6	0.025	10.0	0.535	1.0	0.0	0.4366	220.67	0.9471

The major exception to following Dib is the parameter θ, which represents the elasticity of substitution between different inputs and the degree of monopoly power. We calibrated θ to equal 10 since this represents a middle ground between the value calibrated in Dib ($\theta = 6$) and that estimated by Kim (2000) ($\theta = 12.4$), albeit with US data. Sensitivity analysis with different values of θ showed that the results pertaining to the importance of market share did not substantially change. In the experiments below we consider two values of χ, 5 and 15, to examine their implications for inflation persistence. Capital's share in production, α_1, is set at 0.33 while labour's share, α_2, is assumed to be 0.6. This introduces a relatively minor degree of decreasing returns to scale.

Other minor deviations from the estimated parameters in Dib (2001) include assuming that monetary policy shocks are not persistent ($\rho_\mu = 0$) and that the steady state inflation rate is zero ($\mu = 1.0$). These modifications helped to simplify the solution of the model and should not have significantly affected the results.

4. Results

In this section we compare the predictions of the standard sticky-price model to the model augmented by market share. We focus the analysis on inflation for two reasons: (i) we conjecture that the presence of market share will help induce inflation persistence; and (ii) there is a large empirical literature demonstrating that the response of inflation to a shock should be gradual and hump-shaped (see, for example, Christiano et al (1999)).

Graphs 1 and 3 present the response of inflation to a technology and a money supply shock, respectively.[3] Graphs 2 and 4 contain the responses of output to the same two shocks. The solid line represents the response of inflation (or output) in the standard sticky-price model whereas the dashed and dotted lines are inflation responses from the models with greater degrees of market share. To be precise, $\chi = 5$ for the dashed line and $\chi = 15$ for the dotted line. For both types of shocks, the standard sticky-price model admits an inflation response that peaks in the first period and then decays very quickly to steady state. This result offers prima facie evidence supporting the conclusions in Christiano et al (2001) that the critical nominal friction in their model is staggered wage contracts, not price contracts.

Looking across the two figures for inflation, it is readily apparent that, for the chosen calibration, the presence of market share in our model does not significantly prolong the reaction of inflation to either shock. The presence of market share, however, can substantially diminish the first-period response of inflation, with greater values of χ leading to greater dampening of the inflation response. Given the current calibration of the model, $\chi = 15$ was the largest market share parameter that could be assumed. Above that level, the model exhibited evidence of instability that we do not yet fully understand.

One possible reason for the lack of a significant increase in inflation persistence may be that wages, which are completely flexible, are moving in a manner to unwind any effect arising from market share concerns. In preliminary work, we investigated a version of the model that also included wage contracts but found that their interaction with market share did little to change the response of inflation. Even in the extreme case of virtually no wage response to the shock, the effect of market share was about the same.

The main reason we believe market share is not playing a large role is that the intermediate-good producers are not playing an oligopoly pricing game. So far, each intermediate producer has assumed that the price and output levels of his competitors do not respond to changes in his price. If a more sophisticated pricing game was being played in which the reaction of the competitors was taken into account, then it is possible that market share would become a more significant variable in the decision-making process.

Another factor that may be playing a role is that entry and exit are not permitted in this version of the model. As such, even when a firm earns negative profits because it moved its price too much or too little, it will not be forced out of the industry. This could also be described as there being no punishment for earning losses. It could therefore be interesting to investigate market share in a financial accelerator model (see Bernanke et al (1999)) in which the net worth of the firm was an important determinate of the equilibrium outcome. Firms may then be more interested in protecting their market share if it also implies they are protecting their net worth and future borrowing ability.

We also tried different methods of incorporating market share into the model but the effects on the inflation response were not substantially changed.[4] In one model, however, which assumed that deviations of a firm's price from the market price imposed a direct real cost on the firm, inflation responses to shocks were small and very persistent. This version of the model was unsatisfactory and ad hoc. But it does indicate that market share could be important for inflation persistence.

A sensitivity analysis revealed some interesting results. First, the degree of persistence of inflation is not particularly sensitive to the level of steady state inflation. Inflation was marginally less persistent at lower rates of average inflation but the difference was too small to be of note. Somewhat more interesting, however, is the fact that the model exhibits an asymmetry between the effects of a positive and a negative shock.[5] The inflation response is larger for a positive money growth rate shock than for a negative shock of equal magnitude (see Graph 5). There is a very small asymmetry apparent in the base case model without market share but it is strongly accentuated by the presence of market share effects. The demand function in equation (14) naturally implies greater increases in demand for a price decline than decreases following a price increase. The presence of market share in equation (14) strongly

[3] We also considered impulse responses for money demand and labour supply shocks. However, these results were quite similar to the technology shock shown.

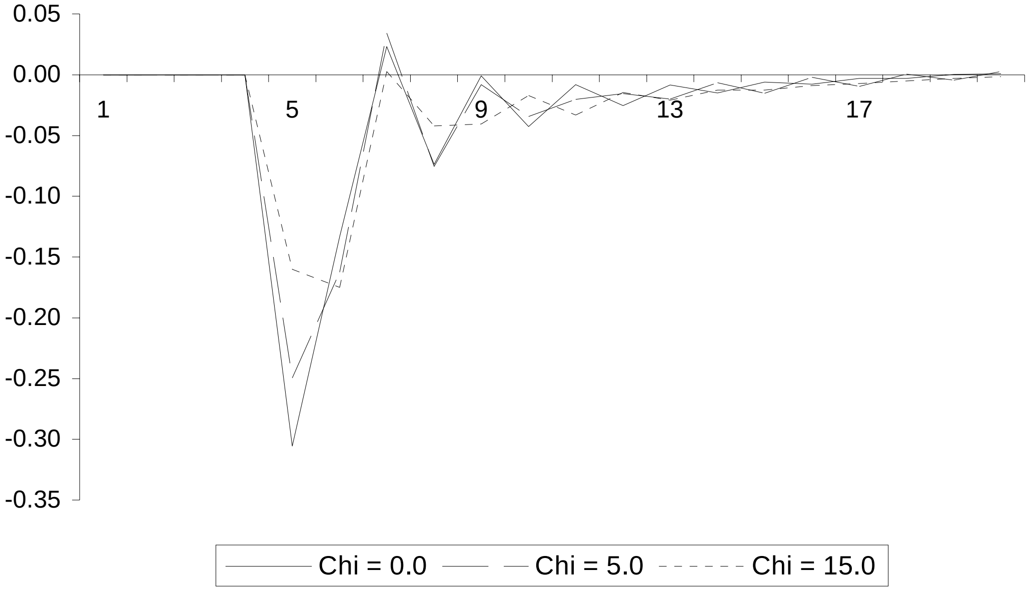
[4] We also examined the implications of three-period contracts but found that the results were quite similar.

[5] The stacked-time solution technique used in this paper yields a non-linear solution to the model.

Graph 1

Inflation response to a technology shock

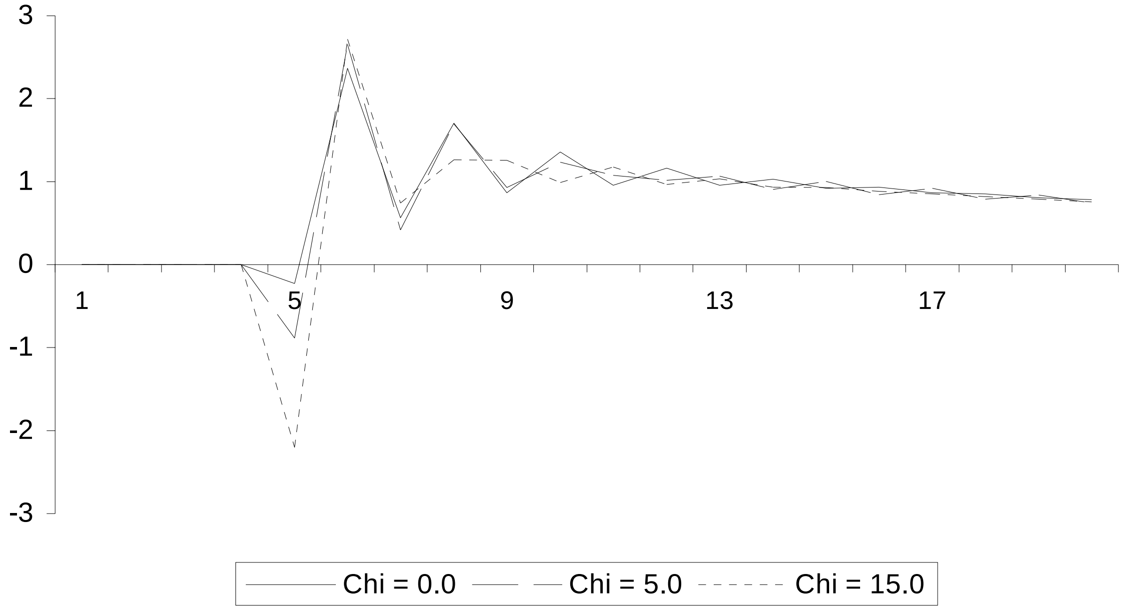
Percentage point deviation



Graph 2

Output response to a technology shock

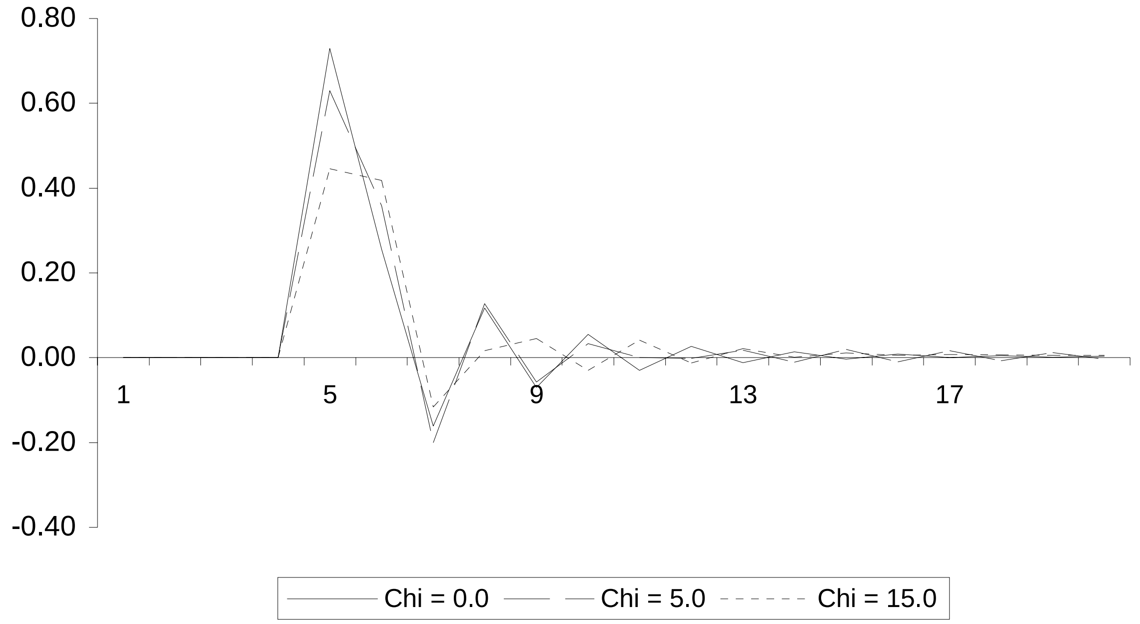
Percentage deviation



Graph 3

Inflation response to a money supply shock

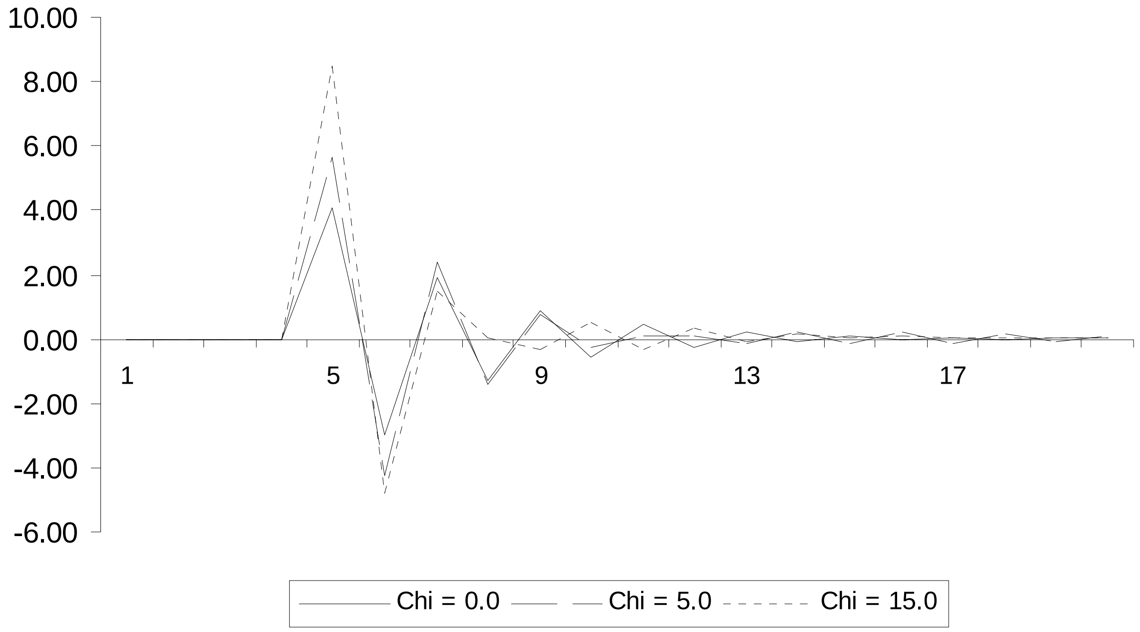
Percentage point deviation



Graph 4

Output response to a money supply shock

Percentage deviation

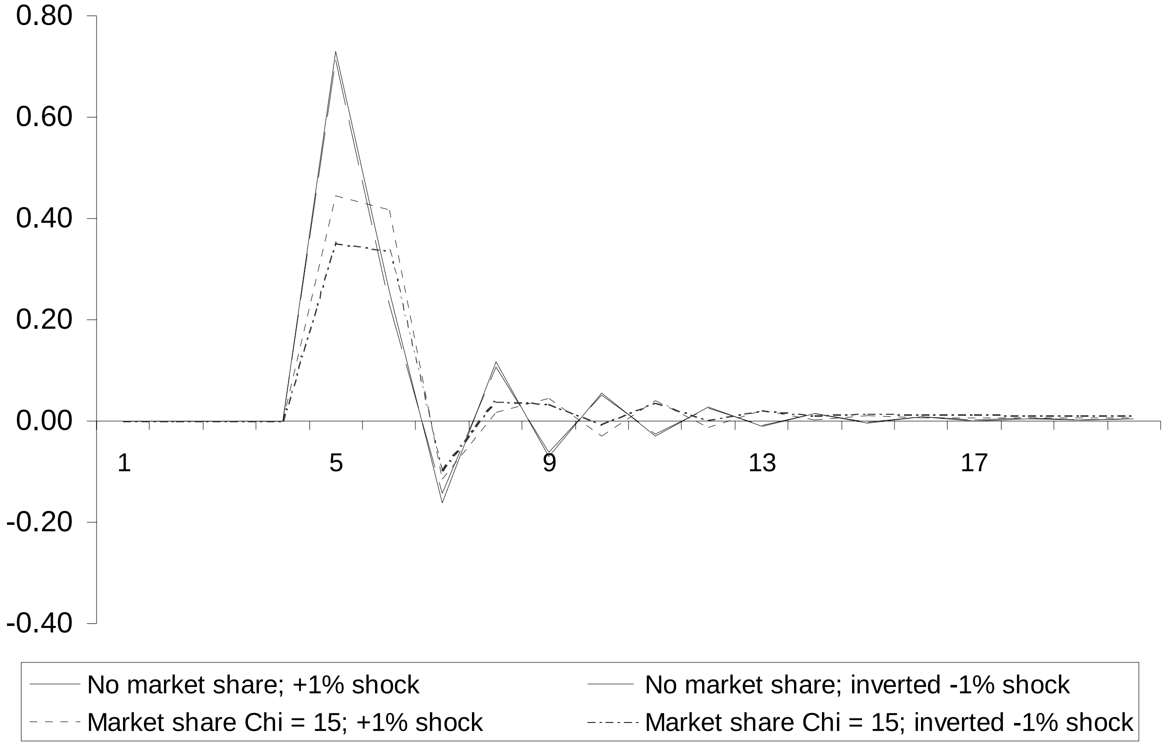


enhances this natural asymmetry. In addition, some of the asymmetry seems to be coming from the inflation tax on money holdings. Unfortunately, one would have expected that, following a negative money shock, the initial price mover would decrease his price by even more (than for a positive money shock) given that this would persistently improve his market share. The initial price mover does not take advantage of this opportunity to steal market share from his competitors. This is another indication that the firms in this model are not playing a pricing game that is as sophisticated as occurs in reality.

Graph 5

Inflation response to a money supply shock

Percentage point deviation



Turning to the output responses in Graphs 2 and 4, we see that market share increased the size of the response following both technology and money shocks. This is unsurprising given that the inflation responses were dampened. However, it is interesting that, despite significant and persistent deviations of the market shares and outputs of the two types of firms, there is no increased persistence of the deviation of aggregate output. The movements of market share of each firm type are offsetting, implying that the shape of the aggregate output response is basically as in the base case without market share. Longer Taylor contracts or Calvo-style pricing would probably yield more persistent output movements since market share changes would not cancel out as easily upon aggregation.

5. Conclusions

In this paper, we examine whether market share is able to improve our understanding of inflation persistence. To this end, we develop a dynamic, general-equilibrium model that features sticky prices and market share, and study the implications of their interaction using a series of standard shocks. Sticky prices are incorporated via Taylor-style contracts and concern over market share is added using a form of the "customer market" model described in Phelps and Winter (1970). Unfortunately, the form of market share considered in this paper did little to prolong the response of inflation to a shock, although it did reduce the first-period response.

However, the analysis has revealed a number of interesting alternative specifications of the model that should be fruitful to pursue. Further research is, therefore, key to determining the true role of market share in the persistence of inflation. In particular, empirical estimation of this or similar models is necessary to better determine the empirical importance of market share considerations as a contributor to inflation persistence.

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Assessing future inflation in inflation targeting: forecasts or simulations?

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Abstract

A key element of inflation targeting is some kind of assessment of future inflation. We distinguish two basic types of such an assessment, forecast and simulation, which differ in the way they treat the central bank's future behaviour. A forecast is a likely picture of the future including a likely future behaviour of the central bank, while a simulation is a likely picture of the future if the central bank behaves in a predetermined way. When deciding which of these two ways to go, the central bank has to deal with some non-trivial dilemmas on three distinct levels: construction of the assessment, decision-making based on it and its communication. We discuss the pros and cons of both the options on these three levels.

1. Introduction and basic terms

Over the last decade, one of the novel features of the environment in which central banks operate has been an increasing pressure on them to become more transparent and accountable and to communicate more intensively with the public. More than ever before, central banks seek to share their opinion on the state and prospects of the economy and to prove the appropriateness of their monetary policy measures. Hand in hand with this development, we have witnessed a growing popularity of inflation targeting, which is generally considered to be the most transparent existing monetary policy regime. A key element of this regime is an assessment of the future course of inflation (and perhaps other economic variables) that is compared to the inflation target to determine whether the current policy stance is appropriate, too expansionary, or too restrictive. Despite the fact that inflation targeting relies heavily on an assessment of the future path of inflation, little discussion has been devoted to the numerous non-trivial questions that arise in connection with an assessment of future inflation on three distinct levels: construction of such an assessment, its use in monetary policy decision-making and its communication to the public. The present paper aims to fill in this gap.

Of the many aspects of an assessment of the future, we focus on the treatment of the behaviour of the central bank, because this is the aspect that is most intimately connected to the actual monetary policy decision-making. Before we discuss the pros and cons of the alternative treatments, we need to say a few words on terminology. Usually, when assessing the future, one tries to draw its likely picture - ie using a likely scenario of each exogenous variable, at each time period selecting a likely reaction of each economic agent represented in the model, taking a likely value of each coefficient, etc. A likely picture of the future is often called a forecast, but we encounter other labels too, such as a prediction, outlook and projection. In central banking circles, this way of looking into the future is often referred to as an "unconditional forecast" to distinguish it from a "conditional forecast", which is a purposeful attempt to draw not simply a likely picture of the future, but a likely picture of the future if the central bank does not change the level of its interest rate throughout the forecasted period of time. An

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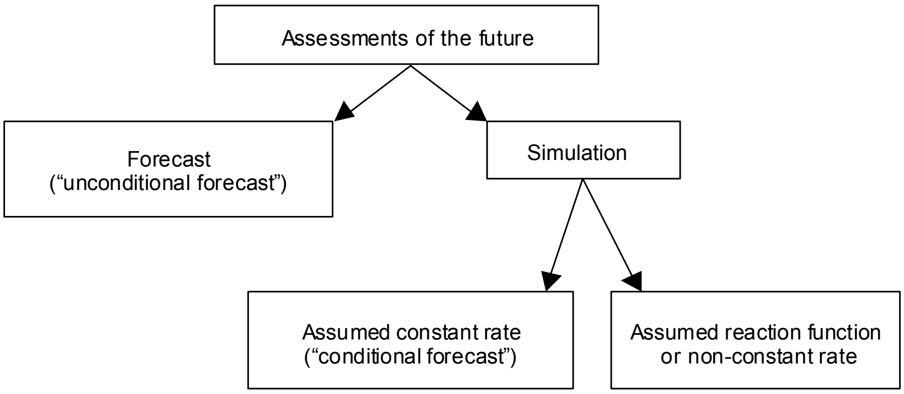
assessment of the future in which a given agent is “forced” to behave in a specific (not necessarily a likely) way is often called a simulation or a (policy) experiment. This terminology is illustrated in Figure 1.

Figure 1

Basic types of assessments of the future



The labels “conditional” and “unconditional” are potentially misleading because in reality every assessment of the future is conditional on some assumptions, while the above use of the terms restricts the terminology just to one special type of conditionality. That is why we believe that the intuitive terminology “forecasts versus simulations” is preferable.

In practice, when building a model on which to base a forecast, the reactions of the central bank are usually generated by a reaction function. This is a specific equation in which the value of the decision variable (typically the central bank’s interest rate) is determined by past, current or expected values of various variables in a way that - at least in the opinion of the model builders - approximates the decision-making criteria of the actual central bank decision-makers (from now on simply “the board”). The approximation, of course, has to be chosen with regard to tractability of the resulting model. In simulations, the trajectory of the board’s decisions may be determined directly by the model builder without any modelling or it may be generated by inserting various (not necessarily likely) reaction functions into the predictive model.[2]

Clearly enough, except in cases like multiple equilibria, there is usually just one forecast at each point in time because just one picture of the future is usually the best guess (once we decide whether we need the mode, the mean or the median). On the other hand, there can be as many simulations as we can devise trajectories of the central bank’s future decisions.

At first sight, it may seem straightforward that obtaining and using a standard forecast, ie a likely picture of the future, is preferable and that it makes little sense to weaken the predictive value of the forecast by making it a simulation, ie by assuming that one of the agents will behave in a way that is not necessarily a likely one (so that the overall result may not be a likely assessment of the future). Central bankers, however, do find simulations useful, which is documented by Table 1. The primary reason seems to be the fact that simulations make it possible to “evaluate” - as Lucas (1976) puts it - alternative policies.

The goal of the present paper is to identify advantages and disadvantages of the use of forecasts and simulations in the areas of their construction, their use in monetary policy decision-making and their communication. The rest of the paper is organised accordingly: Sections 2 to 4 compare the two ways of looking into the future at these three levels and Section 5 concludes.

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[2] With regard to exchange rate, note that we consider the short-term interest rate to be the only central bank instrument, think of the exchange rate as being determined within the model and abstract from possible FX interventions. If interventions were to be considered as a standard policy instrument, we would have to enrich the discussion of simulations accordingly.

Table 1

How the future is assessed at some inflation-targeting central banks

<table>
<tr><th rowspan="2">Type of assessment</th><th rowspan="2">Simulation assumes</th><th rowspan="2">Examples of countries</th><th colspan="2">Published trajectory of</th></tr>
<tr><th>IR</th><th>ER</th></tr>
<tr><td rowspan="4">Simulation</td><td>Constant IR and ER</td><td>Australia, Hungary, Norway</td><td colspan="2">Constant as assumed</td></tr>
<tr><td rowspan="3">Constant IR</td><td>Chile</td><td>Constant as assumed</td><td>EER index at end of forecast period</td></tr>
<tr><td>Sweden</td><td>Constant as assumed</td><td>Yearly averages of EER</td></tr>
<tr><td>United Kingdom</td><td>Constant as assumed</td><td>Quarterly average of EER at end of forecast period</td></tr>
<tr><td rowspan="3">Forecast</td><td rowspan="3">Not applicable</td><td>Canada</td><td>None</td><td>None</td></tr>
<tr><td>Czech Republic</td><td>Basic shape verbally</td><td>Basic shape verbally</td></tr>
<tr><td>New Zealand</td><td>Quarterly averages of three-month IR</td><td>Half-year averages of EER rounded to integers</td></tr>
</table>

Note: IR = interest rate, ER = exchange rate, EER = effective ER. The table is based on websites or publications of the respective banks available in spring 2002.

2. Construction of simulations and forecasts

To avoid any misunderstanding, we emphasise that since the most common difference between forecasts and simulations as used in central banking practice is their treatment of the central bank, the comparison in this and in the following sections will be based on this difference alone. Problems that are common to both forecasts and simulations will be suppressed. In this section we want to compare simulations and forecasts in terms of their construction.

2.1 Simulations and the Lucas critique

In reality, all agents quite naturally expect that all other agents will in the future behave in a likely way. If one of the agents, namely the central bank, then in fact behaves (as the simulation generally assumes) in a way that was not judged as likely, this will surprise the other agents and falsify to some extent their expectations. As a result, individual agents may change to some extent their perception of the central bank’s behaviour and, consequently, they may change their own behaviour.

The simulation, in order to be a likely picture of the future, given that the central bank behaves in the assumed way, has to predict all these changes and their implications for the behaviour of all agents. The simulation will be able to predict the changes the better, the closer the underlying predictive model will be to the ideal of a fully micro-founded, disaggregated, structural model of the economy.

In practice, it is almost impossible to build the ideal, fully structural, micro-models where the decision-making of each agent is explicitly modelled. Instead, actual predictive models are of a more or less reduced aggregated form and the structure of and coefficient values in many of their relationships are based on regularities observed in the past when all agents including the central bank behaved in a likely, expected way.

While unexpected behaviour on the part of the central bank would not necessitate a change in the structure and values of the fully structural models, it may imply the need to change structure and/or values in the reduced-form relationships. This is one interpretation of the Lucas (1976) critique: the assumption that the central bank behaves in an unexpected way may imply a need to change the structure and/or coefficient values in the rest of the predictive model. And here lies the key problem of simulations: it is very difficult to guess exactly how the structure and/or coefficient values should change. Indeed, it is so difficult that model builders often do not take these changes into account. The decision not to incorporate these changes, however, may cause the results of the simulation to deviate from what they should be, namely a likely picture of the future given that the central bank behaves in the assumed way. The simulation thus may contain an error. We will call such an erroneous simulation "degenerated".

To take a simple example, suppose that the IS curve in a given model is articulated as the following relationship:

$$y_t = b_0 - b_1\,(R_t - E_t\,\pi_{t+1})$$

where y_t is the output gap, b_0 and b_1 are coefficients, $b_1 \geq 0$, R_t is the current nominal interest rate and $E_t\,\pi_{t+1}$ is expected future inflation, so that $(R_t - E_t\,\pi_{t+1})$ is the current real rate of interest. In reality, the relationship between the output gap and the real interest rate may not be linear, but normally, when agents in the economy expect the central bank to act so as to achieve the inflation target, the linear approximation may imply only negligible discrepancies vis-à-vis reality. If, however, the bank starts to behave in a way (as possibly assumed in a simulation) which suggests that it no longer aims to fulfil the target, agents will conclude that the actual target is different - let us say, it seems to be much higher than the official target. In that case, $E_t\,\pi_{t+1}$ may be much higher than it would have been otherwise. This change in expectations may still be captured correctly in the model - so far, so good. But the agents may think that higher inflation means higher volatility of prices, higher uncertainty, etc and the boost in their spending (due to a lower real interest rate) may be less than proportionate, causing the gap to shrink less than it would have shrunk if the linear relationship still held. Therefore, once we steer away from the "normal" behaviour of the central bank on which the specification of the model is based and for which it works fairly well, the picture of the future drawn by the model is incorrect, unless the model is modified appropriately (in this case, b_1 needs to be lowered).

Of course, if the central bank trajectory assumed in the simulation is not far from the bank's likely trajectory (so that the simulation is close to a standard forecast), then the implied changes that should be made in the rest of the model may be negligible and also the error of the simulation may be negligible (see Leeper and Zha (2002)). An example may be a simulation where we want to see what would happen if a needed rate cut is postponed by the central bank by three months. Given all sorts of uncertainties in the practice of monetary policy, this delay may not surprise agents in the economy very much, so that the existing forecasting model may remain roughly valid and the simulation may be close to a forecast.

The less realistic the assumed central bank trajectory is, the more significant will be the implied changes and the larger will be the error, that is, the more degenerated the simulation will be. To return to the above example, consider a period of a growing domestic demand when a rate hike is in order. In such a situation, a simple simulation with constant interest rates for the next several quarters may - if the coefficient b_1 is not decreased - show a much narrower negative or much wider positive output gap than it would actually be if nominal interest rates stayed constant. On the basis of this degenerated simulation, the central bank may increase the interest rate more than is necessary.

To sum up, on the level of construction, the main problem with simulations is that they may be more or less degenerated and therefore provide a more or less misleading set of information. On the other hand, by constructing simulations, we avoid a problem that has to be dealt with when constructing a forecast: the difficulty of identifying a likely reaction function of the central bank. In simulations, either no reaction function of the central bank is identified and simply various trajectories of its future behaviour are assumed, or various reaction functions are inserted into the predictive model without trying to earmark a likely one.

2.2 Forecasts and the specification of the central bank's reaction function

The construction of a forecast, on the other hand, is impossible without identifying a likely reaction function.[3] As with any economic agent's reaction function, this is not an easy task. Some authors (eg Vickers (1998)) think it is simply not feasible, while we are not a priori so sceptical. There are several approaches that come to mind, each of them assuming that there are data and methods reliable enough to produce the reaction function's specification that will be more reliable than a direct guess (however educated). One approach, which we will call the "loss function" approach, is based on determining the loss function of the board and then transforming it through model optimisation into the "true", or likely reaction function. A second approach, which we will call the "shock response" approach, rests in presenting the board members with simulations showing model responses to different shocks under various reaction functions. Another approach, which may be called the "estimation" approach, aims at extracting the reaction function from the board's past decisions. We will now discuss these three approaches in more detail.

In the first step of the "loss function approach", the board members are shown a table with a few key variables and they fill in relative weights they assign to (the stabilisation of) the given variables in comparison with the others. If only two variables (such as inflation and output) come into question, the board members can indicate their preferences graphically - by picking a specific point on a curve linking various combinations of variability in these two variables. In the second step, the model builder constructs a loss function based on the answers. The last step is to transform the loss function through model optimisation into a likely reaction function. This approach combines a very crude questionnaire part in the first two steps with a rigorous model optimisation in the last step.

Although this way of identifying the central bank's reaction function may seem attractive at first sight, the problem is that it depends heavily on the assumption that the board members are able (with the help of the model builder in the second step) to formalise their preferences and able to do it in a non-biased way. The aggregation of responses of individual members of the board is not an easy task either: should the model builders weigh the responses equally or should they try to construct weights based on how strong the positions of individual members within the board appear to be? Another problem, voiced by Goodhart (2001), is the complexity of the optimal control approach; it may lead the board members "to regard the whole exercise as a mysterious 'black box'" (p 173), limiting significantly their ability to explain to the public the forecast and their decisions based on it. Also, the optimal reaction function that comes out of this approach is often too complex to be useful as a guide for policy discussions. Sometimes, the signs of some of the variables in the reaction function may even be counter-intuitive. For example, in the model of the Czech economy presented in Hlédik (2002), the optimum reaction function has the following form, in which the coefficient on the German GDP deflator (α_{13}) comes out - counter-intuitively - negative (the general message is clear even without explaining the individual symbols' meanings):

$$i_t = \alpha_1 i_{t-1} + \alpha_2 y_t + \alpha_3 y_{t-1} + \alpha_4 \pi^{net}_{t-1} + \alpha_5 \pi^{net}_{t-2} + \alpha_6 \, defl_{t-1} + \alpha_7 \, defl_{t-2} + \alpha_8 \, defl_{t-3} + \alpha_9 \pi^{adm}_t + \alpha_{10} \Delta ner_t$$
$$+ \alpha_{11} \pi^{imp}_t + \alpha_{12} \pi^{imp}_{t-1} + \alpha_{13} \, defl^{Ger}_t + \alpha_{14} i^{Ger}_t + \alpha_{15} \, risk_t + \alpha_{16} y^{Ger}_t + \alpha_{17} \, rer_{t-1} + \alpha_{18} r_{t-1}$$

The "shock response" approach is similar to the loss function approach but it combines, in a sense, all three steps into one. To begin, the model builder designs a few realistic reaction functions, runs the model with these reaction functions under various shocks (demand, supply, risk premium and other shocks) and then presents the board members with the responses of the key variables to the shocks under the various reaction functions.[4]

If the board members feel comfortable with the response paths of the variables under one of the suggested reaction functions, the reaction function is chosen as a likely one. If they are not satisfied,

3 The concept of forecast as a likely way things will unfold in the future implies that we do want a likely reaction function, even if it "cannot be directly related to a reasonable optimality condition" and/or "in practical simulations on different macro models, its performance is inferior and nonrobust". Svensson (2001, p 45) sees these properties of the reaction function used in the New Zealand predictive model as reasons to consider a different reaction function.

4 Goodhart (2001) and Svensson (2001) consider an exercise of this nature, but they view it as a way for the board to find an appropriate response to actual individual shocks, ie they suggest to do this for each coming shock anew rather than to do this once for various hypothetical shocks as a way to determine a reaction function to be used for constructing forecasts for some time into the future.

the assumed reaction functions are changed, and responses to the same shocks under the new reaction functions are presented to the board and assessed. This iterative process may go on until the board accepts the reactions, which means that a likely reaction function has been found. Unfortunately, this is a rather demanding and time-consuming process. Moreover, since the individual iterations are simulations, they are subject to the "degeneration" problem described above, unless the model builder, having changed the central bank's reaction function, is able to adjust the rest of the model so that it captures the changes in the behaviour of the other agents corresponding to the change in the central bank's reaction function.

The "estimation approach" builds on past data on monetary policy decisions and other variables. If we believe the central bank responds in a forward-looking manner to fluctuations in future inflation and future real economic activity, it may seem natural at first sight to try to estimate the relationship between the central bank's interest rate at a moment in time and later actual figures on inflation, real economic activity, etc. But in practice interest rates react in a forward-looking manner to shocks that would otherwise push inflation away from the target. This means that, if policy is successful, past data will show that interest rates have fluctuated, while inflation has stayed more or less at the target level.[5] To sum up: if policy reacts to anticipated shocks successfully, their later impact on prices will be unobservable from actual data and the estimation of the central bank's reaction function from past data is impossible.

A more promising alternative is to realise that the board's decisions are based on forecasts, not actual future data, and that the forecasts are always based on past and actual data. Reacting to forecasts then basically means reacting to a combination of past and actual data. One may therefore try to obtain the reaction function by constructing and estimating a VAR-type relationship between interest rates and several other variables, eg inflation, domestic and foreign output gap, exchange rate. Some central banks may even have a long time series of simulations of future development (usually based on the constant interest rate assumption) at their disposal. In that case, acknowledging that it is based on a simplistic picture of the monetary policy decision-making in the inflation targeting regime, we can directly estimate the relationship between the divergence of the simulated path of inflation from the target as an independent variable and (lagged) interest rates as a dependent variable.

The difficulties central banks have when trying to come up with a likely reaction function may seem paradoxical, given that it is their own reaction function. In fact, however, the central bank's model builders face similar difficulties when modelling the behaviour of the other agents in the economy. The model behaviour of the central bank is special only in the sense that the actual central bank has a choice: either to ask its model builders to treat the bank in the model in the same way they treat other agents, that is, to model the bank's likely reaction function (arriving at a forecast), or to ask the model builders to construct simulations instead of a forecast. If the first option is chosen, then one (or preferably a combination) of the above-mentioned or other approaches must be attempted, bearing in mind the limitations.

Even though forecasts and simulations seem conceptually quite different ways to assess the future, some central banks in fact take a middle path. Aware of problems related to simulations (degeneration and possible model explosion due to absence of stabilising reactions from the central bank[6]), they combine a simulation and a forecast. More specifically, such a hybrid assessment of future inflation assumes that the central bank's interest rate is constant for the first s quarters and that, from the quarter $s + 1$, the central bank "wakes up" and tries to bring future inflation back to target with a given reaction function. Of course, the reaction function should be likely for this case and thus it may differ from the reaction function that would be likely for the case where the bank is reacting all the time. The value of s is usually selected to represent the end of what the central bank considers the horizon of the most effective monetary policy transmission. Therefore, it may seem that, up until and including the quarter s, we obtain a standard constant-interest-rate simulation that is afterwards saved from possible explosion by "switching on" the central bank's reaction function. In fact, however, forward-

5 In this paper, when talking of fulfilling the central bank's inflation target, we implicitly mean a balanced fulfilment of the inflation target and any other targets the central bank may have (minimising the output gap, etc).

6 Model explosion may in fact be viewed as an example of degeneration: the simulation gives results that are very unlikely in reality and it does so because it is built on the wrong implicit assumption that even though the central bank is now (in the simulation) reacting in unexpected ways, the economy will work along the same lines as previously, when the central bank behaved roughly as expected.

looking agents in the forecast (if there are any) anticipate the switching-on of the reaction function. The anticipation may already influence their behaviour in the simulatory phase, in which case the simulation ceases to be a standard constant-interest-rate simulation. At times, this departure from the standard form of a constant-interest-rate simulation may have an influence on the forecasted paths of inflation and/or other variables and that is why it should be noted both in monetary policy decision-making and communication.

3. Use of simulations and forecasts in monetary policy decision-making

As in the previous section, we will start with simulations and we will - unless noted otherwise - assume that they are constructed without any degeneration. The reason for the attractiveness of simulations in the area of decision-making is clear - they enable the central bank to do what Lucas (1976) calls "policy evaluation". That is, they show what the results would be (in terms of inflation, output, etc) if the central bank follows alternative future interest rate trajectories. Specifically in inflation targeting, once we compare the simulated future development of inflation with the inflation target, we may obtain an idea of the direction in which the central bank interest rate trajectory assumed in the simulation needs to be adjusted, in order to bring inflation closer to the target at the policy horizon.

Unfortunately, the policy advice a simulation gives is incomplete: it is qualitative (direction) but not quantitative (extent). The information about how much to adjust the trajectory has to be obtained elsewhere. For example, we can analyse the monetary policy transmission mechanism in order to obtain an idea of the sensitivity of inflation in various future horizons to a unitary change in the central bank's current interest rate. Another possible way to supply the quantitative advice is to construct and present to the board members a fan of simulations, showing the future development of the economy assuming several alternative trajectories of the central bank's interest rate. The board members then simply select the simulation whose results they like most, ask for values of the interest rate trajectory upon which the selected simulation is based and set the actual interest rate in accord with the starting value of that trajectory. The process can even be iterative - the board selects a simulation out of a fan of simulations, the staff prepare and present a fan composed of a few variations of the selected simulation, the board selects again, etc. Note a link to a forecast: after a sufficiently high number of iterations, the simulation selected at the end should be very close to a forecast. Understandably, the problem with the "fan approach" is that it is a rather time-consuming process.

Contrary to Martijn and Samiei (1999), we think that using a simulation as a basis for decision-making is compatible with the empirically observed interest rate smoothing. For example, if the simulation and additional quantitative analysis suggest that the interest rate should be increased by 1 percentage point to bring future inflation back to the target, the bank board may decide to realise this increase in several steps. It is true, however, that in the meantime the simulation will indicate missing of the target, suggesting that each of the decisions in the series was "incorrect". It is up to the bank's communication to explain the concept of interest rate smoothing or, in other words, to explain that the decisions have to be judged as a series rather than each one separately.

The last issue we want to discuss in connection with the use of simulations in monetary policy decision-making is the assumption of an unchanged central bank interest rate. Theoretically, simulations can assume various trajectories of the central bank interest rate, from completely flat trajectories (unchanged central bank interest rate) to very complex shapes. In practice, however, central banks (eg the Bank of England, Sveriges Riksbank, the National Bank of Hungary) tend to prefer the flat extreme, that is, trajectories which assume no change in the interest rate.

Board members at these central banks apparently see advantages of the central bank's constant interest rate assumption over other, more complex assumptions. Maybe they think that such a simulation is easiest to grasp and work with because a constant nominal interest rate keeps the impact of monetary policy on the economy constant (which is not true if inflation expectations change and if it is the real interest rate that matters). Or maybe the board members think that such an assumption is just a naturally obvious choice for a simulation. Or they appreciate the extreme simplicity of the trajectory as showing most blatantly to the public that it is a mere simulation, not an actual forecast of the central bank's future interest rate trajectory. Another reason, stressed by Kohn (2001) and Goodhart (2001), is that given the often very heated debates on what the current monetary policy stance should be, the board members may often not be able to arrive at any more "reasonable" future path of the central bank's interest rate than the constant one. Goodhart also appreciates the fact that the constant-interest-rate simulation induces the board to take a pre-emptive decision now, while giving thought to simulations assuming other trajectories may lead the board members to always prefer trajectories in which any action occurs at a later time (when more information will be available to judge the appropriateness of the action).

On the other hand, the constant interest rate assumption has some serious disadvantages. One is implied by the finding of Sargent and Wallace (1975) that constant interest rates may imply a non-unique price level in the long run. Another disadvantage, already alluded to in Section 2, has been assumed away in this section so far. The more unrealistic (vis-à-vis current and anticipated economic circumstances) the no-change trajectory is that the staff are required to assume in the simulations, the higher is the risk of degeneration of the simulation. Less degeneration might be achieved by taking more complex and more realistic trajectories.

Quite apart from the danger of degeneration, we have to be aware of the fact that, in the near future, the board's decision-making will be focused on a later segment of the target and the board may decide then to change interest rates, violating the constant interest rate assumption made today for the purposes of today's decision-making. Therefore, if simulations assume for the interest rate a constant rather than a more realistic path beyond the current period, and if the target horizon is longer than the shortest lag at which the interest rate affects inflation (the inflation control lag), the simulations have a time inconsistency element built into them (Leitemo (forthcoming)).

Let us now briefly discuss monetary policy decision-making based on forecasts. An integral part of the forecast is a trajectory of future central bank interest rates. The board is thus presented with an interest rate trajectory that is consistent with both the assessment of the future and with fulfilling the inflation target in accord with the reaction function specified in the forecasting model. This trajectory can then be viewed as a policy suggestion. It could also be arrived at through a series of simulations; the construction of a forecast seems to be a more straightforward way. The high "fixed costs" connected with arriving at a likely reaction function are compensated by very low "variable costs" which in the case of simulations may prove to be quite high (see Section 2).

On the one hand, the suggestion regarding the trajectory of interest rates may be viewed as an advantage. It can be compared to what the board members a priori thought an appropriate trajectory might look like and, if there are significant differences, they may be discussed in order to identify their sources and perhaps to modify the various assumptions underlying the forecast (Hampton (2002)). On the other hand, the board members may feel obliged to accept the suggested trajectory of the central bank interest rate; they may feel "locked up in it". In reality, however, they do not have to agree with the suggestion. For example, they may attach various additional risks to the basic forecast being presented. If the forecast is then published as "the Bank's forecast" rather than "the Bank staff's forecast", however, the board members' disagreement with the forecast may be a problem. This brings us to communication issues discussed in the next section.

4. Use of simulations and forecasts in the central bank's communication

Today, many central banks strive for a high degree of transparency. Many central bankers would also agree that publishing an assessment of future inflation is a key characteristic of transparency. Nevertheless, specific reasons for publishing one (apart from the fact that other central banks do so too) may not always be entirely clear.

4.1 Reasons for publishing an assessment of future inflation

Since the form in which an assessment of future inflation is published must reflect its goals, let us start by discussing the reasons for publishing it. We see two basic reasons. The first is that it can anchor expectations in times when the central bank expects to temporarily miss its inflation target so that the target in itself ceases to serve as the usual expectation anchor. There are situations (mainly supply shocks) when it may be economically legitimate and substantiated for the central bank not to react (or to react only partially) to an expectation that its inflation target will be missed. These situations arise more frequently in small open economies that are more exposed to external shocks.[7] In such situations the public may ask what they should expect, given that inflation will diverge from the target; the central bank can answer by publishing the anticipated future course of inflation (assuming that it does show a return to the target corridor). In the other case, ie when the assessment of future inflation signals that the inflation target will be fulfilled, the publication of the assessment will not bring much added value in terms of anchoring expectations, but it will not do any harm in this area either.

Obviously, the only type of assessment of future inflation suitable for this purpose is the currently valid forecast, where by “currently valid” we mean a forecast which also incorporates the board’s latest decision. This implies that if the board makes its decision on the basis of a forecast but the decision is not as forecasted, then a new forecast has to be constructed to incorporate the actual decision (which may take some time). A simulation - or even a forecast that does not incorporate the board’s last decision - is not a suitable expectation anchor as it is not the central bank’s best guess about the future.

The other reason for the central bank to publish its view on future inflation is that the view can serve as an explanation of the decision that the board has just taken. This explanation can have two forms, either negative or positive. The negative form of explanation shows what unwelcome results would probably ensue if the decision were not taken. A simulation as well as a forecast not including the decision being explained will serve well. However, only the appropriate direction, not the appropriate extent of the decision to be taken is shown. This form thus allows only a qualitative assessment of the appropriateness of the decision actually taken. A central bank that publishes a simulation also runs the risk that the simulation will be incorrectly understood by the public to be a forecast (Martijn and Samiei (1999), Bofinger (2000)), which - in some situations - can have rather detrimental consequences. For example, the experience of the Czech National Bank when it was publishing simulations showed that the media had a tendency to present constant-interest-rate simulations produced by the central bank and forecasts produced by other institutions side by side and to compare them, when in fact they were conceptually incomparable.

The positive form of explanation shows what welcome results will probably ensue thanks to the decision having been taken. This form of explanation is informationally richer as it shows that the decision actually taken was the appropriate one both qualitatively and quantitatively, that is, in terms of both direction and extent. For this form, only the currently valid forecast can be used.

4.2 Publishing the trajectory of the interest rate and other variables consistent with the forecast

The above analysis of the motivation for communicating the central bank’s view of the future seems to imply that, overall, a forecast may be preferable to a simulation. Several arguments can, however, be put forward against publishing a forecast. We will mention two, calling them the “commitment argument” and the “destabilisation argument”.

The “commitment argument” (Goodhart (2001)) runs as follows. If the inflation forecast is to be credible, the agents need to know its key properties and assumptions. If the central bank is an important player in the economy, then the path of the central bank’s interest rate is an important component of the forecast and it should be made public. The problem is that agents in the economy may view the interest rate trajectory as a commitment of the central bank to follow it in its future monetary policy decisions. Of course, there are reasons why the trajectory should not be viewed in this way. First, the board members may have other decision inputs beside the forecast; they may - as mentioned in Section 3 - attach various additional risks to the forecast, etc.[8]

Moreover, the trajectory, just as the whole forecast, is based on today’s information, so that any new piece of information obtained later may potentially modify the forecast and thus the future part of the

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7 The central banks concerned sometimes even explicitly state that their inflation target may not be fulfilled under specific types of shocks. This arrangement is then referred to as “escape clauses”.

8 In other words, publishing a forecast with the interest rate trajectory does not necessarily mean a “policy bias” in the sense of, for example, the Fed’s “bias announcements” published between May 1999 and January 2000.

central bank's interest rate trajectory. These reasons may seem difficult to communicate to the general public and therefore the perception of commitment may seem hard to eradicate. Nevertheless, the only existing long-term experience, that of the Reserve Bank of New Zealand, which has been using and publishing forecasts since 1997, does not support the commitment argument: "our observers - namely the public and financial markets - also accept the conditionality of the projections and do not see them as being a constraint on official cash rate (OCR) settings" (Hampton (2002), p 8). Even if the bank succeeds in explaining that it is not and cannot be obliged to follow the published trajectory, some authors (eg Bofinger (2000)) fear that frequent changes to this forecasted trajectory due to newly arriving data may undermine the reputation of the central bank.

The second argument against publishing a forecast, the "destabilisation argument", is more economic in nature. The argument is that if the central bank is perceived to produce high-quality forecasts and if it publishes a forecasted trajectory of certain financial variables, namely the short-term market interest rates and the exchange rate, this may have a highly destabilising effect on the respective markets. More specifically, if the central bank publishes a forecast showing an exchange rate appreciation, this forecast may concentrate market expectations at the forecasted level of appreciation as well as decrease future uncertainty. This concentration of expectations and reduction in uncertainty may then cause the appreciation to occur much faster. An easy pragmatic solution to this problem is to publish the forecasted trajectory of the exchange rate with some fuzziness added, eg by publishing the forecasted trajectory of an effective exchange rate (see Table 1).

While we think that the destabilisation argument may be true for the exchange rate, we believe the same argument does not hold in the case of short-term market interest rates. The reason is that the central bank is usually able to control current short-term market interest rates at the forecasted level and the market is aware of this ability of the central bank. This has a useful implication: the published forecast of the central bank's interest rate trajectory may help concentrate market expectations of future short-term market interest rates at the level suggested by the central bank's forecast, thus concentrating, through the term structure, today's long-term interest rates at a level consistent with the forecast.

There are therefore arguments both for and against publishing the interest rate trajectory consistent with the given forecast. Fortunately, a compromise solution similar to the exchange rate case may be found. Namely, the central bank may choose how explicit it is while communicating the future interest rate trajectory. The Reserve Bank of New Zealand, for instance, publishes both a chart and a table of future quarterly averages of the 90-day interest rate. As an example of a less explicit publication, the Czech National Bank describes in simple words the direction in which interest rates consistent with the presented forecast will move in the future.[9]

5. Conclusion

Given its focus on difficult operational dilemmas, this paper can hardly have a clear-cut conclusion in the form of specific recommendations for inflation targeting central banks in general. As we have seen, the choice between simulations and forecasts has several dimensions, in each of which various arguments can be put forward on both sides. Before opting for one of the two approaches or switching between them, specific circumstances at the given central bank have to be considered - the sophistication of the modelling apparatus available, the length and quality of the data series that can be used, the degree of risk of the public misunderstanding the communicated message, etc. Of course, the ultimate choice will to a large extent depend on which of the two options will seem more "user-friendly" to the board members.

9 This may reflect the fact that in the case of the RBNZ there is a single decision-maker, the governor of the RBNZ, whose reaction function is mapped onto the forecast, whereas in the case of the CNB there are seven decision-makers whose "average" reaction function enters the forecast.

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The role of money in monetary policymaking[1]

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Abstract

In this paper, the conceptual and empirical bases for the role of monetary aggregates in monetary policy making are reviewed. It is argued that money can act as a useful information variable in a world in which a number of indicators are imperfectly observed. In this context, the paper discusses the role of a reference value or benchmark for money growth in episodes of heightened financial uncertainty. A reference value for money growth can also act as an anchor for expectations and policy decisions to prevent divergent dynamics, such as the spiralling of the economy into a liquidity trap, which can occur under simple interest rate rules for policy conduct. The paper concludes that using information included in monetary aggregates in monetary policy decisions can provide an important safeguard against major policy mistakes in the presence of model uncertainty.

1. Introduction

Inflation is a monetary phenomenon. Monetary growth in excess of increases in the public's demand for money balances will eventually decrease the purchasing power of money or, equivalently, raise the general price level. The long-term relationship between money and prices has been a cornerstone of monetary economics for several centuries (eg Hume (1752)) and has been documented for many countries and many eras (eg McCandless and Weber (1995)).

While recognition of this empirical regularity is almost ubiquitous within the economics profession, substantial controversy persists about the usefulness of the relationship between money and prices in understanding, predicting and controlling inflation, and thus about its relevance for the design and implementation of monetary policy. Such controversy continues to be reflected in the ongoing debate about the appropriate design of monetary policy strategies.

Following the unacceptably high rates of inflation observed during the 1970s, many leading central banks adopted intermediate targets for monetary growth as the centrepiece of their monetary policy strategies. However, in the more benign inflationary environment of the 1990s, the role played by monetary aggregates in the policy framework of many central banks diminished. By the end of the century, Laurence Meyer (2001), a member of the Federal Reserve System's Board of Governors, was able to assert "… *money plays no role in today's consensus macro model, and it plays virtually no role in the conduct of monetary policy, at least in the United States*." Nonetheless, other central banks give monetary analysis a much more important role in their formulation of monetary policy. Notably, the European Central Bank (ECB) has accorded "*a prominent role to money*" within its monetary policy strategy (ECB (1999a,b), Issing et al (2001)).

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[1] An earlier version of this paper was presented at the AEA meetings in Atlanta, 4-6 January 2002. We are grateful to C Brand, D Gerdesmeier, V Gaspar, M Goodfriend, H-J Klöckers, G Korteweg, R Motto, P Moutot and C Willeke for very helpful comments. The views expressed in this paper are those of the authors and do not necessarily reflect those of either the European Central Bank or the Eurosystem.

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To the casual observer, the suggestion that monetary developments are not an important component of monetary policymaking sounds odd. As reflected in ECB (2000), Selody (2001) and King (2002), central banks generally adopt the view that monetary developments should not be ignored since - at a minimum - they offer an additional source of information which can help improve the robustness of monetary policy decisions (see Pill (2001)). This notwithstanding, much - although not all - recent academic discussion of monetary policy has neglected or ignored monetary aggregates.[4] This contrasts with the seminal work of monetarist economists such as Milton Friedman, who saw monetary dynamics as central to understanding the inflation process (eg Friedman and Schwartz (1963)). In the light of the contrast between these two branches of the literature, the prominent role of money in the ECB's monetary policy strategy[5] has been the subject of an ongoing debate in both academic and policy circles.

Against the background of a more general discussion of the role of money and monetary analysis in monetary policymaking, this paper discusses conceptual and empirical aspects of the role of money in the conduct of monetary policy. Three related aspects - which are not mutually inconsistent - of the role of money in monetary policymaking can be distinguished.

First, monetary aggregates might be useful to proxy for variables that are unobservable or observable only with time lags. Thereby money can contribute information for assessing the appropriate stance of monetary policy, which is not included in simple interest rate rules. A simple comparison between the short term rate manoeuvred by the central bank and some conventional interest rate benchmark, say based on a Taylor rule, may often be a very inaccurate measure of the prevailing monetary conditions as perceived by market participants. There are at least two dimensions to this signalling and proxying role of money. One such dimension is related to the fact that the construction of summary indicators for economic slack or overheating is subject to considerable dispute. Therefore, policymakers' knowledge of the output gap may not at all be superior to their knowledge of money velocity behaviour, and so they may find it useful to consult money growth data as an early indicator of the prevailing economic conditions. Another aspect of money as an incremental gauge of the posture of policy becomes apparent in times of financial turbulence.

Second, and related to the above discussion, money may play an important structural role in the transmission mechanism of monetary policy to the price level. The importance of such transmission channels is essentially an empirical question, and may vary over time or even prove to be episodic. As discussed by King (2002), money and credit would play an important role if *imperfections in the financial sector* (ie borrowing and liquidity constraints) permit changes in the structure of balance sheets to influence yields and spreads in a manner that is relevant for intertemporal economic behaviour, such as pricing, consumption, saving and investment decisions.[6] Should such effects prove important, neglecting monetary dynamics in the formulation of monetary policy decisions will come at a potentially large cost. Some commentators cite the recent prolonged Japanese recession as an example of such costs, on the basis that asset market dynamics in Japan were driven or accommodated by a monetary policy that neglected monetary and financial developments.

Finally, money can provide *a nominal anchor for the economy*. A monetary policy that responds to monetary developments - in addition to the fundamental shocks which hit the economy from time to time - can help to rule out destabilising explosive paths for inflation expectations that could be triggered and sustained by self-fulfilling expectations.

Of course, experience in the conduct of monetary policy over many decades has demonstrated that reliable guideposts come and go, sometimes requiring policymakers to review and adjust their

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4 Analyses conducted in the context of strategies based on inflation targeting or Taylor rules are illustrative of this approach.

5 The reference value and monetary analysis more generally form the money pillar of the ECB's strategy (ECB (1999a, 2000)). The ECB points out that monetary analysis and the respective models have always to be seen in conjunction with the second pillar of the ECB's monetary policy strategy, which uses the analysis of other economic and financial indicators and models for the support of monetary policy decisions. Much of the academic criticism of the ECB's assignment of a prominent role has arisen in the context of the so-called "new neoclassical synthesis" view of the macroeconomy (Goodfriend and King (1997)). In this context, monetary aggregates are not seen as playing an active role in the transmission mechanism of monetary policy and, as such, should not play an important role - still less a "prominent role" - in the formulation of monetary policy decisions.

6 Note that that situation constitutes a violation of the Modigliani/Miller theorem, which states that the financial structure of a firm or household should not affect its value and thus its economic decisions and behaviour.

theories, procedures and operating methods. This notwithstanding, there are many reasons why the role of money in monetary policymaking has proved durable. The remainder of the paper, in reviewing these reasons, is organised as follows.

Section 2 surveys the empirical properties of money, focusing on results for the euro area. While much of the evidence relates to the indicator properties of monetary dynamics for inflation (rather than investigating structural models of the transmission mechanism), this section nevertheless offers broad empirical support for the incorporation of monetary analysis into the monetary policymaking process.

Section 3 reviews a number of conceptual arguments in favour of assigning a prominent role to money in the formulation of monetary policy. In large part, these arguments follow from the view that money provides a nominal anchor to the economy, which helps avoid instability in the economy by ruling out indeterminacy or ambiguity in the determination of the price level.

Section 4 discusses how monetary analysis can be combined with analysis of demand and supply interactions and cost pressures to arrive at a single policy decision regarding the level of short-term interest rates. This discussion takes as its starting point uncertainty about the role of money in the transmission mechanism of monetary policy. A well designed monetary policy should acknowledge this uncertainty, but nevertheless ensure that monetary developments are not ignored or neglected in the design of policy decisions.

While this paper cannot (and does not attempt to) resolve all issues related to the role of monetary developments in formulating monetary policy, it does provide empirical, conceptual and practical support for assigning money an important role in monetary policy decisions in the euro area. These are summarised briefly in Section 5, which offers some brief concluding remarks.

2. Empirical foundations

Since the ECB and the single monetary policy have been assigned the primary objective of maintaining price stability in the euro area, monetary developments should only influence monetary policy decisions insofar as they provide information that furthers the achievement of that objective. In other words, monetary developments are important for monetary policy decisions to the extent that they cause, help to predict or are otherwise associated with price developments such that they should play a role in monetary policy decisions.

Ideally, the relationship between monetary and price developments would be explored in the context of a structural model with well developed micro-foundations. Unfortunately, notwithstanding ensuing discussion, structural models of monetary and financial interactions that are both sufficiently empirically relevant and conceptually appealing to be used as a guide to monetary policy decisions have yet to be developed. While considerable progress is being made in the field of monetary dynamic general equilibrium (DGE) models, their practical relevance for policymaking awaits further tests.

Consequently, in practice, empirical assessments of the relationship between money and prices are based on semi-structural or reduced-form models such as money demand equations, VARs or reduced-form indicator relationships. The remainder of this section reviews the application of such approaches to euro area data.

(a) Stability of the relationship between money and prices

The stability of the relationship between the money stock and the price level is typically evaluated in the context of a money demand equation, which relates money to prices and other key macroeconomic variables (such as real income and interest rates). Stability is assessed using cointegration techniques (Engle and Granger (1987), Johansen and Juselius (1990)), which test whether a stable long-run relationship among the levels of the variables exists.

A number of such studies have been undertaken on euro area data. Since cointegration techniques require long data samples, these investigations rely largely on data for the euro area prior to monetary union constructed from pre-existing national monetary series. In addition to the usual concerns regarding the stability of economic relationships in the face of a regime change such as the introduction of the single monetary policy, the empirical analysis thus faces additional, though unavoidable, uncertainties regarding the quality of the data and the appropriate aggregation technique.[7]

Table 1

Summary of studies of the long-run money demand equations for euro area M3

	Sample	**Aggregation method**	**Income elasticity**	**Interest rate (semi) elasticity**	**Other variables in long-run money demand equation**	**Weak exogeneity**
Coenen and Vega (1999)	1980:4-1997:2	Sum logs of national components	1.14	−0.820 (on the spread between the long- and short-term interest rate)	Inflation, with a coefficient of −1.462 (interpreted as a measure of opportunity cost)	Output, inflation, short-term interest rate, long-term interest rate
Brand and Cassola (2000)	1980:1-1999:3	Sum national components at irrevocable fixed exchange rates	1.33	−1.608 (on the long-term interest rate)	None (estimated as a system with the yield curve and Fischer parity conditions)	None
Calza et al (2001)	1980:1-1999:4	Sum national components at irrevocable fixed exchange rates	1.34	−0.86 (on the spread between the short-term market interest rate and the own rate on M3)	None	Output

Sources: Coenen and Vega (1999); Brand and Cassola (2000); Calza et al (2001).

Three major studies of the demand for the broad monetary aggregate M3 in the euro area have been prepared and published by ECB staff (Coenen and Vega (1999), Brand and Cassola (2000), Calza et al (2001)).[8] The main results of these papers are summarised in Table 1. While the approaches vary in detail,[9] all three studies find a stable long-run demand for euro area M3, ie a cointegrating relationship involving money, the price level, national income and some opportunity cost variables is obtained.[10] The intuition behind this finding is powerfully illustrated in Graph 1, which shows the income velocity of circulation for euro area M3 in the period 1980-2001. The steady and smooth decline in M3 velocity over this period reflects the stability of the estimated money demand equations.

[7] However, these concerns apply to all data series for the euro area in the period prior to the introduction of the euro. In practice, the quality of the monetary data is thought to be at least as high as that of other series.

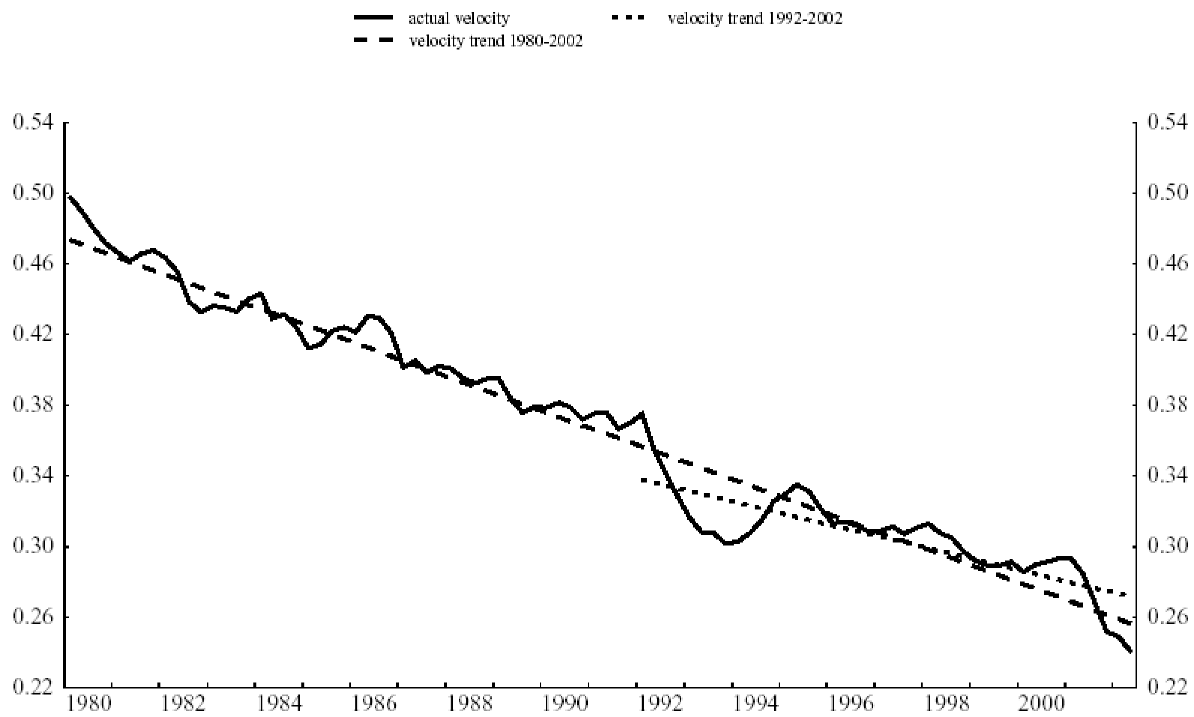
[8] Euro area M3 is defined as the following liabilities of euro area monetary financial institutions (MFIs) held by euro area residents: currency in circulation; overnight deposits; deposits with agreed maturity up to three years; deposits redeemable at notice up to three months; repurchase agreements; money market fund shares/units and money market paper; and debt securities with maturity up to two years.

[9] Such as in the choice of interest rates used to measure the opportunity cost of holding money, in the aggregation technique used to construct the euro area back data, in the sample period investigated or in the specification of the equation.

[10] More recent stability tests have confirmed the long-run stability conditions of the demand for M3 in the euro area. See, among others, Brand et al (2002) and Bruggeman et al (2003).

Graph 1

M3 velocity trends for the euro area (log levels)



Note: Velocity is measured as the ratio of nominal GDP to M3. The underlying quarterly series are seasonally adjusted and constructed by aggregating national data converted into euros at the irrevocable exchange rates applied as from 1 January 1999 and as from 1 January 2001 in the case of Greece. The M3 series is based on the headline index of adjusted stocks (for further details, see the technical notes in the "Euro area statistics" section of the *ECB Monthly Bulletin*). M3 quarterly data are averages of end-month observations.

Source: ECB (M3) and ECB calculations based on Eurostat data (GDP).

Therefore, in contrast to some results obtained in other G7 economies (such as the United Kingdom and the United States), the evidence in favour of a simple and stable long-run relationship between broad money and the price level in the euro area over the last two decades appears robust.[11]

Stracca (2001) has also investigated the properties of a Divisia monetary aggregate for the euro area. Divisia aggregates weight the different components of monetary aggregates according to their "moneyness", with the weights being related to the opportunity cost associated with holding the monetary asset rather than a non-monetary asset bearing a market return. Stracca finds a stable demand for a euro area Divisia monetary aggregate, thereby demonstrating the robustness of the results outlined above to different aggregation techniques.

All in all, the stability of euro area money demand relationships suggests that a path for the evolution of the money stock can be derived which, conditional on developments in other macroeconomic variables, is consistent with the maintenance of price stability over the medium term.

[11] These results support the a priori intuition that the demand for broader monetary aggregates is more likely to be stable than that for narrow monetary aggregates, since the former internalise the substitution between different categories of monetary asset that may create instabilities in the latter. This notwithstanding, money demand equations for euro area M1 also show surprising stability, albeit with less conventional specifications. Stracca (2000) investigates various specifications for the opportunity cost term and finds that a stable demand for M1 can be estimated if the interest rate semi-elasticity is allowed to vary with the level of interest rates.

(b) Leading indicator properties of money for price developments and macroeconomic outcomes

Given the lags in monetary transmission, a monetary policy aimed at the maintenance of price stability must be forward-looking. Leading information on future price developments is therefore crucial. Current monetary developments may contain information about future price developments, ie money may be a leading indicator of inflationary or deflationary pressures. It is important that such forward-looking information is incorporated into the monetary policymaking process.

Money may also contain leading information on other macroeconomic variables that - although not constituting the ultimate objective of monetary policy - will influence the future course of the economy and, eventually, price developments. Such information is also central to monetary policy decisions, since it will influence the magnitude and timing of policy actions.

Several studies by the staff of the ECB have investigated the leading indicator properties of monetary developments in the euro area. For example, in the context of the money demand studies reported above, Brand and Cassola (2000) find that neither inflation nor aggregate demand are weakly exogenous to their money demand system, suggesting that monetary developments will help to predict these variables. Trecroci and Vega (2000) extend the Coenen-Vega money demand framework and also find that money helps predict future inflation.[12] Broadly speaking, these results are consistent with those reported by Gerlach and Svensson (2002) for euro area M3. In the context of a P* model (Hallman et al (1991)), Gerlach and Svensson show that the so-called real money gap - a measure of the monetary disequilibrium relative to a stable long-run money demand equation - helps to predict future price developments.

A comprehensive assessment of the leading indicator properties of money in the euro area is offered by Nicoletti-Altimari (2001). Following the approach proposed by Stock and Watson (1999) for forecasting inflation in the United States, this study focuses on the out-of-sample forecasting performance of potential indicator variables.

A brief summary of the main results from this paper is presented in Table 2. The numbers in the table show the ratio of the forecast errors of a specific indicator model relative to those of a benchmark model, which captures inflation as a pure autoregressive process. A number greater than one therefore indicates a poor model, while a number less than one is associated with a model that performs better than the benchmark.

Using Table 2 (and, more generally, Nicoletti-Altimari's (2001) results), a number of conclusions can be drawn. First, there is considerable evidence that including monetary indicators improves the out-of-sample forecasting performance of a pure autoregressive model of price developments. Second, the performance of money-based indicators relative to other indicators (such as estimates of the output gap or cost pressures) improves as the horizon of the forecast lengthens. Third, it is noteworthy that (nominal) M3 growth offers the best relative forecast performance at the longest (three-year-ahead) horizon. Finally, various other monetary indicators - including measures of monetary growth, estimates of monetary disequilibrium (like the P* indicator) and indicators based on the components (eg M1, M2) and counterparts (notably loans to the private sector) of the broad monetary aggregate M3 - also appear to exhibit leading indicator properties for price developments. As a result, a composite monetary indicator which combines information from all these measures could be constructed which would outperform any individual measure.[13]

These results point to monetary developments being an important indicator of medium-term trends in price dynamics in the euro area. Given the necessarily medium-term orientation of monetary policy,[14] they suggest that monetary indicators should be given an important role. On the basis of the indicator results, one can construct money-based forecasts of future price developments. Although, as with any single forecast, these money-based projections do not provide a sufficient basis for monetary policy

12 For a review of the monetary tools used at the ECB, see ECB (2001a) and Masuch et al (2001).

13 Very favourable leading indicator properties of broad monetary aggregates for inflation developments at medium-term horizons in the euro area are also found by Gottschalk et al (1999) and Cristadoro et al (2001).

14 Implied by Friedman's famous "long and variable lags" in the transmission mechanism of monetary policy actions to the price level.

decisions,[15] such information can be an important input to the monetary policy process, eg for cross-checking results obtained on the basis of structural macroeconometric models.

Table 2

Leading indicator of properties of monetary variables for HICP inflation in the euro area[1]

The sample period is 1992:1-2000:3

Variable		Transformation	Horizon in quarters			
			1	4	8	12
Univariate model, for reference (% RMSE)			0.50	0.62	0.70	1.02
M1		DLN	0.98	1.04	1.05	0.95
M2		DLN	0.98	0.92	0.89	0.90
M3		DLN	0.90	1.29	0.98	0.43
Credit		DLN	0.93	0.90	0.74	0.58
Money gap	BC	LN	1.05	1.02	0.87	0.64
	CV	LN	1.11	1.05	1.31	1.46
P*	BC	DLN	0.86	0.76	0.60	0.80
	CV	DLN	1.08	0.98	0.97	1.08
Output gap		LN	1.14	1.01	0.96	0.78
Unemployment		L	0.90	0.82	1.36	0.88
Unit labour costs		DLN	1.09	0.94	0.87	1.20
Effective exchange rate		DLN	1.20	1.14	1.03	1.04
Oil prices		DLN	1.37	1.05	0.99	1.81

Note: Transformations: D = first difference; LN = logarithm; L = level. BC is the Brand and Cassola (2000) model; CV is the Coenen and Vega (1999) model.

[1] This table reports the ratio of the MSE of the out-of-sample forecasts for the model including the indicator variable to the MSE of the simple univariate time series model of inflation.

Source: Nicoletti-Altimari (2001), Table 1a, p 39.

Other studies (reported briefly in Masuch et al (2001)) also point to money have leading indicator properties for other key macroeconomic variables. In particular, annual growth rates of M1 have been found to help predict future developments in real activity about one year ahead.[16]

[15] In particular, since the money-based projections are not derived from a structural model of the economy, they do not offer a basis for calibrating the magnitude of the appropriate interest rate response to counter emerging inflationary or deflationary pressures.

[16] In addition to the formal econometric studies discussed above, central banks' staff normally undertake a regular detailed analysis of monetary data. This analysis extracts the information from monetary developments that is relevant for monetary policy decisions, and thus tries to identify special factors or portfolio shifts which distort the relation between money and prices. A detailed discussion of the framework used for this analysis in the case of the ECB - including the judgmental and institutional analysis that complements econometric techniques - is provided in Masuch et al (2001). It is noteworthy that central bank staff who closely monitor developments in financial and banking markets are often in a position to interpret and correct "headline" monetary developments using "off-model" information that is not incorporated into econometric studies.

This discussion therefore suggests that - at least on the basis of euro area monetary aggregates - empirical support exists for the following assertions: first, a stable long-run relationship between money, prices and a small number of other key macroeconomic variables exists; and second, monetary developments are leading indicators of future price developments, especially at longer horizons.

(c) Money as a proxy for unobserved variables: the output gap

Research on Taylor rules has emphasised the importance of "real-time" data uncertainty for monetary policy decisions. In particular, a number of studies of the United States have found that uncertainty arising from revisions to output gap and inflation estimates may lead to a significant deterioration in the performance of Taylor-like monetary policy rules (Orphanides (2000)). Less energy has been devoted to investigating money's potential role as an information variable in this context. However, if measures of money are subject to fewer revisions - and on average of lesser magnitude than estimates of real output - then monetary aggregates may play a significant role in providing timely and "steady hand" information about the current state of the economy.

In a recent paper, Coenen et al (2001) pursue this avenue of research. In a model with rational expectations, nominal inertia and an apparently totally passive status of money - along the lines of the New Keynesian benchmark model discussed in Section 3 below - monetary developments are shown to be of great help to the policymaker, since money balances react to the "true" level of income, whereas the central bank is assumed to receive only a noisy measure of output. To be sure, the extent to which monetary data enhance the available information set depends crucially on the effort that monetary authorities exert in collecting monetary statistics and undertaking monetary analysis.

(d) Money as a proxy for unobserved variables: monetary and financial conditions

The money stock can serve as a proxying index also along a different dimension. In a recent paper, Nelson (2002) emphasises the effects of monetary policy upon a whole "spectrum of rates" - over and above that manoeuvred by the central bank - as the driving force within the transmission mechanism. However, a large part of the complete set of yields that matter for aggregate demand is unobservable to monetary authorities. Hence, if the demand for money can be thought of as a function of a broad set of yields besides those observed in securities markets, then movements in money aggregates would convey information that the central bank would not otherwise be able to extract from alternative indicators.

In fact, the historical association between protracted episodes of money growth in excess of some sustainable reference rate and the build-up of financial imbalances and asset price bubbles can probably be interpreted in this light. In periods of financial turbulence the implicit rate at which market participants discount future expected earnings from asset portfolios may vary in ways that are both unpredictable and unobservable to monetary authorities. In these circumstances, a simple comparison between the short-term rate manoeuvred by the central bank and some interest rate benchmark, based say on a Taylor rule, may not be an accurate measure of the prevailing monetary conditions as perceived by market participants. By contrast, monetary quantities - primarily due to their link to credit - have a powerful (incremental) role to play as indicators of the actual stance.

Issing (2002) brings some suggestive evidence to this effect. He analyses three past episodes which, in hindsight, are regarded as having involved large, if unintentional, monetary policy mistakes. In all three cases he investigates whether a policy taking the quantity theoretic equation seriously, and using a money stock indicator as a gauge for the prevailing conditions, could have been instrumental in yielding a better macroeconomic outcome.

Graph 2, which we borrow from that contribution, depicts the evolution of some key indicators in the 1920s and early 1930s in the United States in the face of a major build-up and subsequent collapse of equity prices. The excess money measure used in the graph is defined as the difference between the

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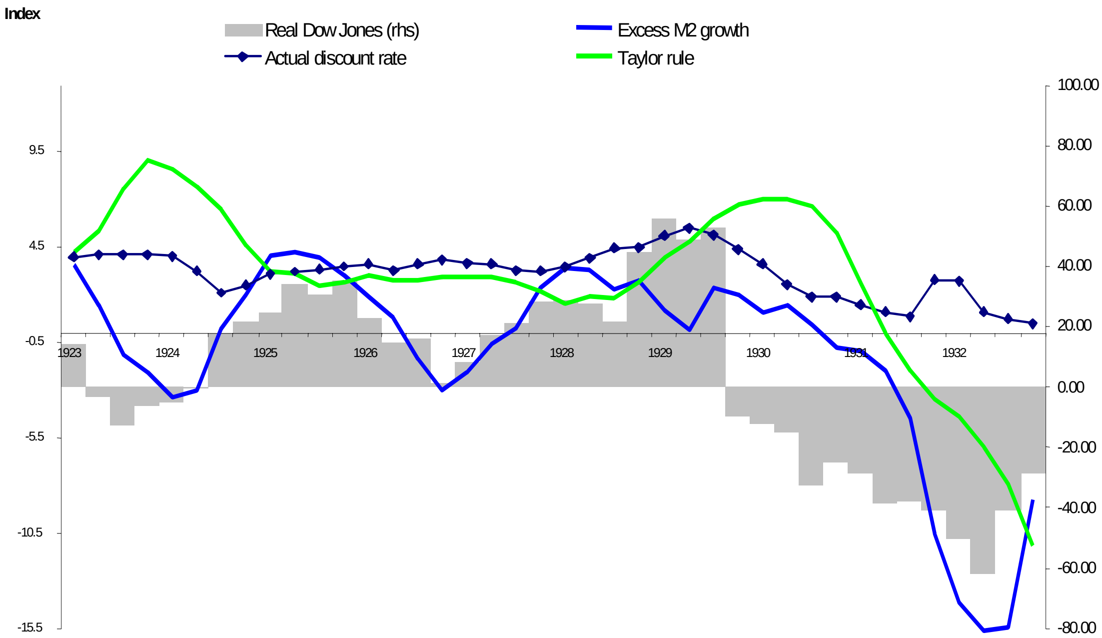
Such analysis therefore often adds to the policy-relevant information in monetary developments, extending their relevance beyond what would be suggested by the econometric studies reported above alone.

actual growth rate of nominal broad money and the rate that would be implicit in the quantity relation with real income growing at its potential rate, inflation at the central bank's implicit objective, and velocity at its long-term trend.[17]

Graph 2

The United States in the 1920s:
excess money growth, real asset price growth and monetary policy

Annual percentage changes



Note: Excess money growth is defined as $\Delta_4 e = \Delta_4 m - [\Delta_4 p^* + \Delta_4 y^*] + \Delta_4 v^*$, where Δ_4 denotes the four-quarter difference operator and m, p^*, y^* and v^* stand for (logs of) the actual stock of M2, the price objective, real potential GDP, and the long-term velocity of circulation, respectively. The price objective is normalised to 1, potential output is obtained applying an HP-filter to actual real GDP, trend velocity for 1923-30 is constructed by interpolating a linear trend to realised velocity over 1921-29, and by imposing a structural break afterwards to reflect the sharp contraction in nominal GDP, primarily led by a fall in producer prices. The Taylor rule has been calibrated to an equilibrium real interest rate equal to the average real discount rate observed in the first two quarters of 1923, and imposing an inflation coefficient of 1.5 and an output gap coefficient of 0.5.

Source: Issing (2002).

Notwithstanding its purely descriptive nature, this exercise is instructive. It suggests that a quantity measure would have conveyed information which was not forthcoming from a pure analysis of the interest rate used by the Fed in its operations. It shows that, had the Fed looked at a measure of excess money growth, had it not rejected the then novel normative framework offered by the quantity theory of the business cycle, it would have probably realised that monetary policy was too lax, not too tight, for much of the 1920s.[18] Intriguingly, the measure of excess money growth appears to move in sympathy with the profile of the histograms which represent the growth rates of real stock prices in New York. It becomes positive - and significantly so - in those years in which the market is most buoyant. And it turns negative when the market pauses or falls. Perhaps, one can conclude, money was growing too fast in the years immediately preceding the crash, compared to the long-term necessities of an inflation-free economy operating at potential. Perhaps, that excess of monetary injection was spilling over into the purchase of financial assets. However, looking at the discount rate

[17] See the note to Graph 2.

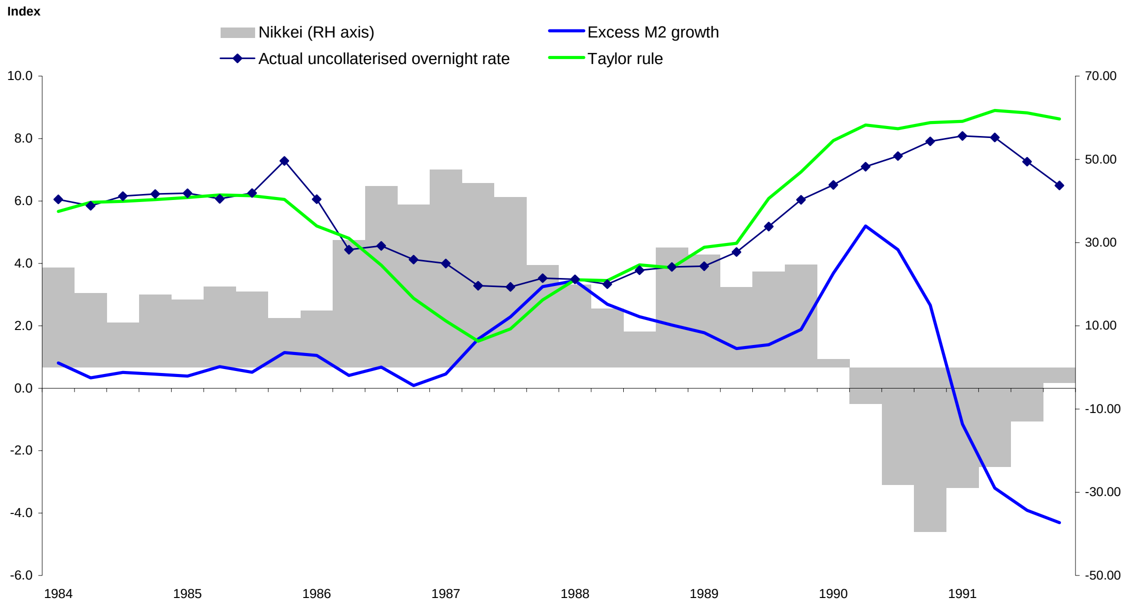
[18] That the stance of policy may have been too lax in the later phase of the asset price build-up of the 1920s, besides being a long-standing contention of some prominent representatives of the Austrian School at the time, has been recently remarked by Bordo and Jeanne (2002).

only, to the exclusion of the monetary indicator, and measuring the historical path of the discount rate against the benchmark provided by the Taylor rule, one would draw the opposite indication. The extent of the abrupt policy reversal in the first half of 1929, which many contemporary observers quote as a primary cause of the disorderly fall in the market, is also more apparent from the quantitative than the interest rate indicator.

Graph 3

Japan in the 1980s:
excess money growth, real asset price growth and monetary policy

Annual percentage changes



Note: Excess money growth is defined as $\Delta_4\ e = \Delta_4\ m - [\Delta_4\ p^* + \Delta_4\ y^*] + \Delta_4\ v^*$, where Δ_4 denotes the four-quarter difference operator and m, p^*, y^* and v^* stand for (logs of) the actual stock of M2+CDs, the price objective, real potential GDP, and the long-term velocity of circulation, respectively. The Bank of Japan's implicit inflation objective has been set equal to a yearly rate of 1.7% (the average of the Japanese CPI inflation between 1984 and 1991), potential output is obtained applying an HP-filter to actual real GDP, and trend velocity is constructed by interpolating a linear trend to realised velocity over a 20-year period starting in 1980. The Taylor rule has been calibrated to an equilibrium real interest rate equal to the average real uncollateralised overnight rate observed in the first two quarters of 1984, and imposing an inflation coefficient of 1.5 and an output gap coefficient of 0.5.

Sources: Bank of Japan; ECB staff calculations.

A similar picture emerges from the Japanese data (Graph 3). While a Taylor rule would have signalled an appropriate-to-tight stance of policy until well into 1989, excess money was building up in the second half of the 1980s, finally at an accelerating pace.[19] Apparently, the Bank of Japan had expressed early concerns that rapid money growth might predispose the "dry wood" needed to set the asset market on fire. But probably no tightening - in excess of that already apparent in the data - could have been justified to the public on the back of persistently subdued inflation and growing measures of productivity. Again, it seems that a monetary policy gauge focused on inflation and a measure of slack only - to the neglect of money - would have failed to sound the alarm. Furthermore, alternative

[19] McCallum (2000) confirms the good fit of a Taylor rule to the actual policy orientation of the Bank of Japan in the 1980s. He also finds that a rule involving a target for base money growth would have provided important insights to the policymakers in those difficult circumstances.

indicators, such as private credit, may at times outperform broad money in signalling that observed swings in asset prices are abnormal and may prelude financial distress.[20]

Of course, at times shocks to money demand may obscure the message that money indicators convey. Therefore, it is crucial that central banks are able to filter crude monetary data in order to extract the underlying signal of future risks to prices.

3. Conceptual considerations

The basic theoretical justification for assigning a prominent role to money in a monetary policy strategy lies in the following fact: it is simply impossible to observe high and sustained inflation without systematic monetary accommodation. Similarly, a prolonged and substantial deflation requires monetary contraction.

What is meant by “monetary accommodation”? In the past, this concept has often been identified with a central bank’s adoption of an interest rate rule. In other words, rather than pursuing a quantitative target for money, the central bank sets an operational target for a nominal short-term interest rate. In a famous article, Sargent and Wallace (1975) challenged this practice on the basis that such a regime leaves the price level indeterminate and would thus tolerate (or even trigger) prolonged periods of high inflation.

However, following McCallum (1981), it was recognised that “monetary accommodation” was not synonymous with an interest rate rule *as such*. In particular, McCallum showed that an interest rate feedback rule would not lead to nominal indeterminacy if the rule was defined so as to have an impact on, say, the price level in the upcoming period. McCallum showed that monetary authorities could set monetary policy in terms of an interest rate, provided that the way in which the policy interest rate was manoeuvred reflected a concern about the future evolution of some nominal magnitude.[21]

However, this line of analysis suggested that the “nominal magnitude” did not necessarily need to be money. It led to the conclusion that central banks could adopt a policy rule whereby the policy interest rate fed back from a set of endogenous variable indicators, but *not including money*. Such a moneyless framework still provided the economy with the anchor that it needed for nominal values to be pinned down.[22]

Formulated in this manner, McCallum’s result had far-reaching consequences for the theory and practice of monetary policy. It gave rise to the flourishing literature on interest rate rules for monetary policy, which constitute one building block of what Goodfriend and King (1997) have named “the new neoclassical synthesis” in macroeconomics. This framework maintains that it is, in general, possible to develop guidelines for monetary policy aimed at price stability without having to specify policy in terms of a monetary aggregate.

To be sure, the guiding principles stemming from this framework exhibit recognisable “monetarist” features: they are wedded to neoclassical reasoning; they are built on the presumption that inflation is ultimately a monetary phenomenon, which can ultimately be governed by the central bank given that the latter has the power to supply base money and thus to set the overnight interest rate; and they recommend making low and stable inflation the primary objective of monetary policy. Nevertheless, this approach departs decisively from the heart of monetarism by rejecting the monetarists’ practice of organising monetary analysis largely in terms of the interplay between the supply of money and the demand for real balances.

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[20] Alternative indicators, such as private credit, may at times outperform broad money in signalling that observed swings in asset prices are abnormal and may prelude financial distress. The close correlation between domestic credit growth and the change in (a composite indicator of various) real asset prices is stressed in a recent contribution by Borio and Lowe (2002).

[21] This insight was subsequently refined by Woodford (2002, Chapter 2), who argued that, in order to pin down prices, the central bank need not adjust its interest rate instrument in response to *nominal* quantities. All that is needed is a reaction function linking the policy interest rate to *endogenous* variables. More on this below.

[22] Woodford (2002, Chapter 2), in particular, raises this point with force.

Therefore, while recognising the validity and robustness of the long-run link between monetary growth and inflation, prominent contributors to this branch of literature argue that money should not be assigned a special status in the monetary policymaking process. Monetary policy should not pay special attention to developments in monetary aggregates because the observed long-run relationship between money and prices says nothing about the direction of causality running between them (Galí (2001)). In this context they argue that paying excessive attention to monetary developments simply exposes monetary policy decisions unnecessarily to the vagaries of money demand.

Against this background, the scope of the remainder of Section 3 is rather limited. Working *within* the new neoclassical synthesis framework briefly outlined above, the section evaluates whether the strong policy conclusions drawn above are justified. This discussion is organised in two parts. First, we outline the basic new neoclassical synthesis model. Second, we show that within this environment a class of popular rules that do not include money can give rise to self-fulfilling fluctuations.

(a) A non-monetarist model

An extremely simplified version of the new neoclassical synthesis model can be reduced to these three summary conditions:[23]

$$y_t = \gamma_0 - \gamma_1 \left(i_t - E_t \pi_{t+1} \right) + E_t y_{t+1} + e_t \tag{1}$$

$$\pi_t = \delta_0 \, E_t \, \pi_{t+1} + \delta_1 \left(y_t - y^* \right) + u_t \tag{2}$$

$$\left(m_t - p_t \right) = \eta_0 + \eta_1 y_t - \eta_2 i_t + z_t \tag{3}$$

where, other than the short-term nominal interest rate under the control of the central bank, i_t, and the inflation rate, π_t, all variables are expressed in logarithms: y_t is output, p_t is the price level, m_t is (base) money, and e_t, u_t and z_t are stochastic error terms. $E_{t-1}x_t$ represents the expectation of x_t at time $t - 1$, where t is (discrete) time.[24]

Equation (1) (with γ_0 and γ_1 both positive) is a dynamic stochastic IS curve which can be derived from the Euler condition associated with the representative household's savings decision by imposing standard market clearing conditions. It states that output y_t is related (negatively) to the contemporaneous real interest rate and (positively) to expectations of future output conditions.

Equation (2) (with $\delta_1 > 0$ and $0 < \delta_0 < 1$) is a forward-looking Phillips curve, which can be derived from optimal pricing decisions of monopolistically competitive firms facing constraints on the frequency of future price changes. The current rate of inflation responds to expectations of future inflation and the current level of resource utilisation, as proxied by the output gap. Equation (3) is a money demand relation, which is obtained from the optimal marginal conditions on consumption and money holdings, assuming money provides liquidity services that are valued by the agent along with consumption goods. It states that real money balances vary positively with income and negatively with the nominal interest rate.

Equations (1) and (2) are central to the new neoclassical synthesis view of macroeconomics. Assuming a household utility function that is additively separable between consumption and real money balances, these two equations describe the dynamics of inflation and output as a function of the short-term nominal interest rate *only*. Except for the nominal interest rate term appearing in equation (1), the system is block-recursive: the transmission mechanism of monetary policy operates solely via prices (the cost of borrowing), and not via quantities (eg the availability of credit or money holdings).

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[23] Seminal examples of this line of thought can be found in Woodford (1997, 2002, Chapter 4), Goodfriend and King (1997), Clarida et al (1999, 2000), McCallum (2001) and the rightly celebrated book by Taylor (1999).

[24] The contemporaneous inflation rate is defined as $\pi_t = p_t - p_{t-1}$.

In principle, the first two equations could be made entirely autonomous, provided the interest rate manoeuvred by the central bank is itself made insensitive to any magnitude which does not appear in either equation (1) or equation (2). A very general formulation of such a rule is provided below:

$$i_t = \Phi\left(y_t, E_t y_{t+1}, \pi_t, E_t \pi_{t+1}, e_t, u_t\right) \tag{4}$$

where, notably, the set of indicators deemed relevant for policy does not include $(m - p)_t$.

Assuming this policy rule performs well - in a sense to be made explicit shortly - "the monetary sector [becomes] basically an afterthought to monetary policy analysis. The familiar LM curve only serves the purpose of determining the quantity of money given the price level, real income, and the nominal interest rate" (Kerr and King (1996)). In this context, equation (3) would appear superfluous. It only serves to specify the quantity of money needed to clear the money market at the interest rate dictated by the policy rule. Monetary dynamics are thus irrelevant to the determination of price developments and should not concern a central bank aiming at price stability.

Taking these results at face value, the autonomous (or moneyless) policy rule (equation (4)) is both analytically convenient and capable of simplifying the task confronted by a central bank. However, this prima facie view is insufficient.

(b) Is money useful as nominal anchor?

Technically, it is not sufficient to demonstrate that a moneyless rule exists which is *consistent* with a particular desired equilibrium. One has also to demonstrate that the desired outcome is the *unique* equilibrium associated with that rule. In other words, one has to demonstrate that the posited policy rule avoids situations in which the central bank, quite unintentionally, permits economic fluctuations (and, in particular, deviations from price stability) which arise solely from self-fulfilling expectations. If a policy rule were to tolerate these situations, not only would the response of the economy to exogenous (fundamental) shocks be indeterminate, but endogenous variables might also start reacting to random variables unrelated to the structure of the model (leading to "sunspot equilibria" where outcomes are determined solely by self-fulfilling private expectations).

Such a situation would clearly pose a severe problem for central banks: apparently well designed rules would not ensure price stability, at least under a sufficiently wide range of conceivable circumstances. This observation is what motivates the quest for uniqueness of equilibria in monetary models and gives justification to the role money can play as a nominal anchor in monetary economies.

(c) Two moneyless rules

The literature has pursued two different specifications of the autonomous or moneyless policy rules discussed above.

(c.i) Target rules in a linear-quadratic policy problem

According to the target rule approach, the interest rate rule for monetary policy is defined implicitly as the solution to an optimisation problem facing the central bank. In the literature it is often assumed that the central bank selects its interest rate policy by minimising a loss function expressed in terms of the deviations of inflation and output from mandated objectives (π^* and y^*), taking the structure of the economy as given:

$$L = \tfrac{1}{2} E_t \left\{ \sum_{j=0,\infty} \beta^j \left[(\pi_{t+j} - \pi^*)^2 + \lambda (y_{t+j} - y^*)^2 \right] \right\} \tag{5}$$

In most applications, the central bank finds the interest rate path which minimises a quadratic loss function expressed in terms of deviations of objective variables from target (equation (5)), subject to the linear constraints (equations (1) and (2)) of the new neoclassical synthesis model (hence "linear-quadratic").[25]

λ is the relative weight attached to output stabilisation in the central bank's policy preferences.[26] Can this linear-quadratic policy regime inoculate the economy against the risks of chronic instability which have been briefly described at the beginning of Section 3(b)?

The answer is: not always, at least under rational expectations. Under this regime, equation (4) takes the following form:

$$i_t = \chi_0 + \chi_1 e_t + \chi_2 u_t \tag{4a}$$

for an appropriate specification of the constant term χ_0 and the reaction coefficients χ_1 and χ_2. However, as proved by Woodford (1999) and Svensson and Woodford (2003), the model defined by equations (1), (2) and (4a) admits a large multiplicity of bounded solutions, in the hypothesis that private expectations fully internalise the authorities' reaction function (4a) as part of the policy regime which they face. These include both solutions implying different equilibrium responses to fundamental shocks (e_t and u_t), and solutions involving responses by the central bank to non-fundamental states of the economy, such as sunspots in private expectations.

At root, this multiplicity result stems from: first, the rational expectations definition of an equilibrium, which, by itself, makes the economy particularly sensitive to revisions in expectations; and second, the possibility that a policy of elastic currency leads the private sector to actually *act* on those expectations by drawing more or less money from the central bank at the fixed policy rate. In such an environment, a policy rule like equation (4a) - which specifies each period's nominal interest rate as a function solely of exogenous states or shocks - does not provide the economy with a defence against off-equilibrium revisions in expectations.[27, 28]

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[25] Formulating the problem using this linear-quadratic specification has presentational and computational advantages. In particular, it yields linear policy rules which are invariant to (additive) uncertainty, ie they exhibit so-called certainty equivalence. However, it is not certain whether such a loss function is a good approximation for central banks in practice. This is particularly relevant for central banks which have a price stability objective or a clear inflation target and no or only a subordinated mandate to simultaneously contribute to output smoothing.

[26] The linear-quadratic (or "target rule") approach to monetary policy has been strongly advocated by Svensson (1999a, 1999b).

[27] Two issues related to the characterisation of target rules given above need to be kept distinct. One issue is whether a reaction formula such as (4a), which results from the solution to the linear-quadratic dynamic programming problem represented by (1), (2) and (5), *can* be consistent with an optimal equilibrium in which inflation remains solidly anchored around the target value π^* and inflation and output evolve solely as a function of the fundamental shocks identified in the structural representation of the model. A distinct issue is whether such situation is the *unique* possible non-explosive solution to the equilibrium conditions which can be supported by a reaction rule such as (4a). Or there may exist other possible equilibria which are equally consistent with (4a) but imply (undesirable) dynamics of the model state variables, whereby these variables fluctuate in unpredictable ways in response to the fundamental shocks (and, in addition, may also respond to non-fundamental shocks which have no analytical representation in the equations describing the structural dynamics of the model). In this respect, one should bear in mind that many numerical experiments available in the literature on the performance of target rules of the sort described in Section *c.i.* are either conducted on the basis of backward-looking models, or – in case they use a purely forward-looking structure as in the text above – do not explicitly tackle the issue of uniqueness or, similarly, assume that private expectations do not internalise (4a) when forming expectations of policy action. An example of the first approach is Rudebusch and Svensson (1999), which will be further discussed in Section 4 below. An example of the second approach is Clarida et al (1999) and Jensen (2002a). These two papers are briefly discussed in footnote 31. It should also be borne in mind that the failure of a rule like equation (4a) to induce determinacy is not confined to the case of rational expectations. Evans and Honkapohja (2001) discuss the case in which private agents revise expectations according to an adaptive learning mechanism while the central bank solves its model under a rational expectations assumption. They show that in this case private expectational errors - due to learning - do not receive an adequate response by the central bank, which only reacts to the fundamental shocks, ut, and et. Hence, expectational errors of the past tend to become ingrained and lead to a process of cumulative divergence of the economy from the rational expectations equilibrium.

[28] Woodford (2000b) discusses analytical ways to circumvent indeterminacy problems in purely forward-looking inflation targeting environments of the type expounded in this Section. These solutions generally involve recourse to optimal delegation schemes whereby the loss function assigned to the central bank is modified relative to the one which reflects the 'true' preferences of society – a function of quadratic deviations of output from potential and inflation from target, such as in (5) – by inclusion of additional lagged values of target variables. The purpose of these additions is to induce an implied reaction rule which makes the nominal interest rate a function of lagged endogenous variables in addition to the terms figuring in (4a). Dependence of the reaction function on such variables is a necessary – though not sufficient – condition for determinacy. Examples of such delegation schemes include the options of charging the central bank with stabilisation of the

To conclude this subsection, rules derived within the target rule framework (whereby the monetary authority reacts to the fundamental shocks hitting the economy) do not appear to pass the test of uniqueness. Rather, in extreme circumstances, they could lead to bursts of inflation deriving from self-fulfilling changes in expectations.[29]

(c.ii) Moneyless instrument rules: the Taylor principle

A second family of policy rules which can “close” the model without reference to equation (3) are those in which the policy interest rate is made a direct function of endogenous variables, such as inflation and output (eg Taylor (1993)).

Recent variants of this approach typically use expected (instead of realised) inflation, as in the following specification:

$$i_t = r^* + \pi^* + \alpha\,(E_t\,\pi_{t+k} - \pi^*) + \beta\,(y_t - y^*) \qquad (6)$$

where r^* is a parameter of the system (the equilibrium real interest rate) and k is some forecasting horizon deemed relevant for monetary policy.

Clarida et al (1999, 2000) provide a thorough investigation of the properties of a system in which the central bank behaves according to equation (6). They conclude that a sufficient condition for the rational expectations equilibrium to be unique in a macroeconomic model similar to equations (1) to (3) is that the interest rate instrument be made to increase more than one for one in response to increases in forecast inflation, ie $\alpha > 1$.[30, 31] The numerical constraint that $\alpha > 1$ has come to be known

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price level – rather than inflation rate – as in Vestin (1999), and the proposals to include a nominal output growth term (Jensen, 2002b) or an interest rate smoothing term (Woodford, 1999) in the central bank’s assigned loss function. Svensson and Woodford (2003) take a step further by exploring history-dependent variants of inflation targeting which are inherently robust to multiplicity problems. They conclude that robustness of this kind can be achieved within an inflation forecast targeting universe only at the cost of contaminating the dynamic optimisation analytics of a pure targeting procedure with elements of commitment to an instrument rule of the type that is discussed in the text under Section *c.ii*. In particular, they show that a way to achieve determinacy is to amend the general targeting procedure described in the text with a commitment to a particular direct interest rate response, whereby the central bank reacts to deviations of private expectations of inflation and output gap from the central bank’s forecasts. The relative intricacy of this solution, however, seems at odds with the simplicity and transparency of inflation targeting in its pure original incarnation described, say, in Svensson (1997, 1999a).

29 A distinct issue is whether a target rule such as the one described in this section - and involving a monetary policy reaction function of the type represented in equation (4a) - is welfare-optimising or can be found to be dominated by an alternative rule obtained under precommitment. As shown in Woodford (1999), discretionary policymaking in a model incorporating forward-looking behaviour is indeed typically characterised by a stabilisation bias, ie it may lead to a suboptimal degree of proactivism in the central bank response to shocks (via equation (4a)). Therefore, when agents’ decisions depend on their expectations of the future state of the economy - as in the model sketched in equations (1) to (3) - there are gains to be had from a more inertial pattern of response. Woodford (1999) and Svensson and Woodford (2003) investigate various mechanisms which can induce inertia in discretionary monetary policymaking, among which they propose a number of optimal delegation schemes whereby the central bank is assigned an appropriately modified loss function. More recently, Söderström (2001) has investigated whether assigning the central bank a loss function which includes a term in money growth can indeed induce the type of inertial behaviour which can be expected to enhance welfare. Since money is demand-determined in his model, its rate of growth is related to the change in the nominal interest rate and the growth rate of output. Therefore, he concludes: “a suitably designed target for money growth may introduce inertia in to the discretionary policy rule, leading to improved outcomes”. He also notes that “this mechanism is entirely due to money being related to other variables in the economy, and not due to any indicator role for money”.

30 Bernanke and Woodford (1997) come to broadly the same conclusions using a model similar to equations (1) and (2) but with a slightly modified timing of price revision by firms.

31 Strictly speaking, Clarida et al (1999, 2000) find that □ > 1 is a sufficient condition for determinacy only when □ = 0 and the stabilising threshold of □ dips below unity as □ increases. They also establish an upper bound for □ beyond which determinacy conditions are violated. This upper bound is well above the numerical value for □ which was conjectured by Taylor (1993) to be stabilising. However, the result of Clarida et al and the similar result of Jensen (2002a) - within an inflation forecast targeting environment similar to the one expounded in Section *c.i.* - that determinacy can be achieved in a forward-looking model by postulating that the central bank is committed to a rule that makes the policy interest rate a sharply increasing function of expected future inflation has been questioned by Svensson and Woodford (2003). They contend that such a monetary policy reaction function may not be “a fully operational specification of the monetary policy rule […] as the central bank’s instrument is expressed as a function of endogenous variables (conditional expectations of future inflation and output) that themselves depend upon current monetary policy. In practice, the bank would have to forecast the paths of the endogenous variables, given its contemplated action. This forecast should depend only upon information about the exogenous disturbances, and the bank’s contemplated policy; thus, an operational version of the

in the most recent debate as the *Taylor principle*, as it was first conjectured in the seminal Taylor (1993) article.

The issue in this subsection is thus whether this policy prescription - which suggests that it is sufficient for central banks to ignore money and set interest rates solely on the basis of non-monetary indicators - is robust across a sufficiently broad array of variations to the basic model sketched above. The answer developed here is once more: no, at least under rational expectations. In what remains of this subsection we shall therefore review the cases in which *the Taylor principle - by itself - fails to deliver a unique and determinate solution to the policy problem* of keeping macroeconomic magnitudes safely anchored to the stated objectives of policy.

(ii.1) The Taylor principle with a non-Ricardian government

The macroeconomic model described by equations (1) and (2) and the policy rule (equation (6)) is not only moneyless; it also lacks any form of interest-yielding public liability. This is difficult to justify since, in general, the nominal interest rate set by the central bank will affect the terms at which the public debt is rolled over.

Only if the fiscal authority always stands ready to adjust its primary surplus in response to any past development which caused a deviation between the actual stock of public debt and some specified long-term target can the relationship between interest rate and public finances be ignored. For this to be the case, any interest rate increases implemented by the central bank in pursuit of price stability would have to be accompanied by an appropriate fiscal response to offset the consequences of higher real borrowing costs for the rate at which public debt is accumulated (eg in the case of higher real interest rates, the primary surplus would have to increase). Leeper (1991), in a seminal contribution, defined such fiscal arrangements as “passive”. More recently, Woodford (2000a) refers to such accommodating fiscal regimes as of a “Ricardian” type.

In a less than Ricardian fiscal regime, the macroeconomic system (equations (1) to (3)) is *incomplete*. One needs to augment it with the government flow budget constraint to check the determinacy conditions. However, the conditions turn out *not* to be satisfied if the inflation coefficient in equation (6) is above unity.[32]

Moreover, Woodford (2000a) has shown that even the existence of a debt limit that *eventually* constrains the growth of public debt is not sufficient for the fiscal regime to qualify as “Ricardian” in Woodford’s sense. If the fiscal authority is ultimately committed to modify its course once some extreme debt limit is breached, but is nonetheless less than forthcoming in reacting to changes in monetary policy *before* that limit is approached, then a monetary policy rule embodying the Taylor principle (like equation (6)) would *not* - by itself - guarantee price stability. As shown by Woodford, in these circumstances, the equilibrium would be characterised by an inflationary spiral, in which progressively higher rates of inflation lead to higher real interest rates, hence higher rates of growth of nominal government liabilities, which in turn lead to higher rates of inflation.[33]

These findings suggest that a monetary policy regime which blindly responded to inflation forecasts and the output gap while respecting the Taylor principle would wind up accommodating inflationary developments. Asset *stocks*, eg money, by contrast, may be a useful source of information for monetary policymakers which helps to stabilise the economy.

policy rule, in which the central bank’s procedure is completely specified as an algorithm, is equivalent to a rule that sets the nominal interest rate as a function of the exogenous disturbances, and leads to indeterminacy”.

32 Technically, the system would then have four equations: (1) to (3) and the flow budget constraint of the government. It can then be shown that, with a less than Ricardian fiscal authority, one needs □ < 1 in order to obtain two stable and two unstable eigenvalues. The latter are needed because the set of endogenous variables include two predetermined and two “jump” variables.

33 The irony in this is that a monetary policy rule that would conventionally be thought to be anti-inflationary may instead lead to an inflationary spiral when combined with an unsuitable fiscal policy. A monetary policy episode which could confirm these perverse dynamics was studied by Loyo (1999).

(ii.2) The Taylor principle with liquidity constraints

As we argued above, equations (1) to (3) constitute a reduced-form representation of an underlying money-in-the-utility structural model with a zero cross partial derivative between consumption and real balances. A key issue, which we have left in the background so far, is what measure of money appears in the utility function.

In the conventional specification discussed above, the implicit assumption is that the liquidity services which are valued by the representative agent are associated with the real money balances the agent holds at the end of the period *after* all market transactions have been concluded. This seemingly innocuous timing assumption has a very important implication: goods can be exchanged for other goods and for bonds without the intermediation of money.

However, money is typically seen as distinct precisely because it acts as a medium of exchange. In other words, the conventional new neoclassical synthesis model - in the version above - does not seem adequately to capture the fundamental rationale which underlies the demand for a non-remunerated asset like money, ie while inflicting a cost in terms of forsaken interest, money helps to facilitate a number of transactions which would not otherwise be possible. Holding currency *before* commencing trading may be what provides agents with the utility services which motivate a monetary economy in the first place.

Carlstrom and Fuerst (2001a) amend the model to allow for a genuine transactions role of money. They assume real money balances enter the utility function at the *beginning* of the period, before trade in goods takes place. The Taylor principle does not survive this amendment for a model calibration similar to that used by Clarida et al (2000). The same result - that real determinacy requires an inflation coefficient in equation (6) below unity - is derived by Christiano and Rostagno (2001a,b) and Benhabib et al (2001c). The first two papers use a suite of cash-in-advance and limited participation models with flexible prices and an elastic labour supply. The third paper uses a money-in-the-production-function framework. All papers uncover indeterminacy and/or equilibrium cycles under a rule embodying the Taylor principle.

Here, again, a minor (timing) modification to the underlying framework suffices to overturn the basic policy message. A monetary policy blindly following the Taylor principle and ignoring monetary developments is associated with an indeterminate equilibrium, where the economy is left without an anchor and fluctuates unpredictably around the "virtuous" equilibrium.

(ii.3) The Taylor principle from a global perspective

It should be emphasised that equations (1) to (3) are derived by linearising a set of non-linear optimal conditions around a non-stochastic steady state. However, any analysis based on linearisation must be interpreted as being local in a neighbourhood of the steady state and only valid under sufficiently small perturbations of the system. How small must the perturbations be to justify such a local analysis?

An emerging strand of literature has started to investigate the properties of Taylor rules such as equation (6) from a global perspective, ie removing the assumption that perturbations are necessarily small. Benhabib et al (2001a), for example, convincingly argue that the standard practice of studying monetary models in a small neighbourhood of the steady state can generate a misleading impression about the set of possible equilibrium outcomes. In particular, even in cases in which rules embodying the Taylor principle guarantee uniqueness of the rational expectations equilibrium *locally*, they may fail to do so *globally*. They construct a money-in-the-utility model which closely resembles the one underlying equations (1) to (3) and impose a monetary policy reaction function which explicitly acknowledges the zero lower bound on nominal interest rates.[34] They find that the mechanical implementation of a Taylor-like monetary policy rule founded on the Taylor principle per se can trap the economy in perverse dynamics. Along these trajectories, explosive inflation expectations - even if divorced from underlying economic fundamentals - end up being systematically validated by the

[34] The "lower bound problem" arises from the fact that in a monetary economy the central bank cannot engineer negative nominal interest rates as long as its counterparts retain the option to hold zero interest currency.

central bank.[35] In other words, they uncover an uncountable number of equilibrium trajectories - invisible from the point of view of the conventional local analysis - which originate in a vicinity of the "virtuous" steady state, and finally converge to a situation in which the nominal interest rate is zero and the monetary policy becomes ineffective.

All that is needed for the economy to start the slide towards the lower bound is that agents - for some reason - come to expect the economy to enter a deflationary phase. In these circumstances, interest rates are constantly being lowered in response to the observed fall in price inflation, and in an attempt to reverse the persistent decline in inflation. However, these efforts are to no avail, because expected future inflation may fall - along a possible equilibrium trajectory - at the same time and ex ante real interest rates are not reduced and continue to be high enough to restrain demand despite falling prices.[36]

(c.iii) Caveats

Are the sort of multiplicity and stability problems associated with moneyless policy rules something which real world central banks should worry about? Or are they to be confined to the realm of analytical curiosa? In particular, is it likely that some sort of horse race dynamics between an always proactive central bank and constantly overpessimistic private sector expectations may finally ensue which can lead the economy to spiral down to the lower bound? The judgment is still pending and different leading authors hold quite diverging views on this issue of policy relevance. McCallum (2001) maintains that conclusions based on bubbles and indeterminacy arguments are of dubious merit and many of these vanish under a minimum-state-variable criterion for equilibrium selection. Woodford (2002, Chapter 2), on the opposite side, takes these problems seriously. For example, while conceding that "the economy can only move to one of [the downward-spiralling] alternative paths if expectations about the future change significantly, something that one may suppose should not easily occur", he acknowledges that "one must worry that a large shock could nonetheless perturb the economy enough that expectations settle upon another equilibrium".[37]

At the very least, a central bank should note that perverse inflation dynamics have been encountered in simulation exercises of calibrated models used widely in the literature. For example, Rudebusch and Svensson (1999) acknowledge that their experiments with simple versions of Taylor rules such as equation (6) imply that "nominal interest rates would be negative a non-negligible portion of the time". They go on to say that "intuitively, with an estimated equilibrium real funds rate of 2.5%, if inflation ever falls to, say, –3%, then, with a zero nominal funds rate, the real funds rate is still restrictive, so the output gap decreases and inflation falls even further".

Christiano and Gust (1999) show that the set of policy elasticities to inflation and the output gap under which a Taylor-like rule becomes a source of instability within a limited participation model - with a cash-in-advance timing - is much broader than for conventional specifications of sticky-price and money-in-the-utility models.[38] Experiments conducted on the basis of an "eclectic" macro-model

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[35] In other words, an "expectational bubble" can emerge in the price level if the central bank pursues a Taylor-like rule with an inflation coefficient greater than unity.

[36] Is this scenario, in which monetary authorities and the private sector in a sense "chase each other" along a sliding path to zero interest and negative inflation rates, a reasonable description of what could happen? Some scholars argue that it is, at least in the case in which the "way to go" between the target stationary equilibrium and the "liquidity trap" stationary equilibrium is sufficiently short and the Taylor coefficient on inflation in the monetary authorities' reaction function is sufficiently large. Benhabib et al (2001a) describe the current situation in Japan as possibly the outcome of such perverse dynamics.

[37] The emerging strand of literature on adaptive learning is also split. Bullard and Mitra (2000) find that, under a forward-looking Taylor rule such as equation (6), the equilibrium with adaptive learning is determinate. By contrast, Carlstrom and Fuerst (2001b) demonstrate the existence of learnable sunspot equilibria in a cash-in-advance model when both the central bank and the private agents learn adaptively. They also prove that, when the central bank is subject to a learning process, while private sector expectations are always rational, sunspot equilibria are always learnable, and thus are indeed a cause for concern.

[38] The limited participation model introduces a friction into the workings of the financial markets to the extent that, due to rigidities in portfolio adjustments, a monetary injection at time t is disproportionately absorbed by financial intermediaries and thus channelled to finance investment rather than consumption. This assumption is what allows the model to generate an impulse-response pattern whereby a surprise monetary injection is followed by a fall in the equilibrium nominal rate of interest (liquidity effect) and a rise in output. By contrast, these features are not easily reproduced by competing new

proposed by Christiano et al (2001) - conflating different sources of nominal frictions, liquidity effects and consumption and investment inertia in a rich stochastic general equilibrium context - confirm that forward-looking proactive Taylor rules produce excess volatility. The same indeterminacy problems are encountered by Levin et al (2001) for forecast-based Taylor rules at horizons exceeding one year ahead across a number of competing models incorporating rational expectations, short-run nominal inertia and long-run monetary neutrality.

This evidence, of course, releases a warning signal in a central bank profoundly concerned about the robustness of its policy course. At the very least, the theoretical and simulation results surveyed in this subsection suggest that decision-makers should broaden - rather than narrow - the set of indicators which they routinely look at to inform decisions. Identifying moneyless policy rules - in the sense defined above - for the sake of parsimony may not be a useful exercise. Moreover, the consequences of adopting a rule narrowly focused on a handful of indicators to the exclusion of others may turn out to be unpleasant. Whether money could help in this quest for a broader perspective, even within seemingly moneyless models, is the subject of the next section.

(c.iv) Addressing the pathologies associated with moneyless rules

Monitoring monetary developments can protect the economy against some of the pathologies associated with moneyless monetary policy rules described in Section 3(c) above. Although there are parameterisations and timing assumptions in variants of the new neoclassical synthesis model under which conventional Taylor rules lead to good macroeconomic outcomes, other plausible parameterisations and timing hypotheses exist in which these moneyless policy rules may lead to bouts of inflation or deflation. At root, this is because moneyless interest rate policy rules can - under the latter assumptions - be supported by various rates of monetary growth. Each of these money growth rates is associated with a different real outcome for the economy. A central bank concerned with robustness should adopt a monetary policy strategy that would *also* be effective with regard to its objectives if the economy were better described by the latter set of model assumptions than the former. Such an approach would thus seem to rule out the adoption of moneyless Taylor-like rules.

In circumstances where conventional moneyless rules fail, a policy of money growth monitoring can, in effect, provide the economy with an anchor. Christiano and Rostagno (2001a, 2001b), for example, postulate a policy framework in which a Taylor rule based strategy is followed as long as money growth falls within a specified target range. If that target is ever violated, however, the Taylor rule is abandoned in favour of a Friedman-like constant money growth rule.[39] They show that the latter escape clause can provide the plain Taylor reaction function with the "servomechanism" needed to remove the undesired trajectories - to which the Taylor rule may lead - from the space of possible events.[40]

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neoclassical models, which postulate various sorts of price rigidities. A description of models of this type is provided by Christiano et al (1997).

[39] This policy is shown to be benign and non-interfering with the operation of the Taylor rule in the case of a model à la Clarida et al (1999, 2000). On the other hand, it would improve economic performance substantially, by eliminating undesired equilibria, if the economy were to be better represented by a cash-in-advance model.

[40] It is open to debate whether the switch from a Taylor rule to a Friedman rule would involve a change in the operating procedures used by the central bank, ie whether the central bank would have to renounce its practice of setting a target for a short term interest rate (in a way consistent with the Taylor-rule prescriptions) and begin announcing short-run targets for money growth. In the latter case, it would appear to be of relevance to ensure that the aggregate for which a target is announced is controllable by the monetary authorities with a sufficient degree of precision. Historical experience is indeed consistent with the notion that a switching rule of the type discussed in Christiano and Rostagno (2001) may be implemented both by a continuation of the interest-rate-centred operating procedure and by a change in the operating procedures in favour of one centred on money quantities. Mayer (2001), for example, explains that when the Federal Reserve started setting short-term targets for M1 in January 1970 - reflecting disappointment with recent macroeconomic performance - it established them in the form of the two-month (in 1975 extended to annual) target growth rates. The federal funds rate was then calibrated to a level estimated to be consistent with hitting the broad money growth target. Conversely, when in October 1979 - out of fears that inflation may have gotten out of control - the Fed embarked on a decisive policy of monetary contraction, it seemed natural to mark the policy change with a discontinuation of the practice to set a target for the funds rate. However, the need to express the money target in terms of a broad aggregate did not seem to pose a problem of controllability of the new target. Mayer states that: "Policy was implemented during this period by estimating the total reserve growth [ie the intermediate target for the narrow monetary aggregate under authorities' control] necessary to meet the money growth target [for the broader official target aggregate] and by holding to the associated path for non-

The more extreme pathologies associated with non-linearities can also be cured by a suitable transition to a different operating scheme centred upon the targeting/control of monetary aggregates. Benhabib et al (2001b) study the virtues of such a switching regime in the context of providing insurance against the liquidity trap. Svensson (2001) also appeals to the standing possibility for a central bank, at any time, to abandon a Taylor rule and start expanding the money stock by means of purchases of foreign exchange.[41] Interestingly, apart from the general doubts on the usefulness of Taylor rules for actual policymaking, even among proponents a consensus is emerging on the need to scrap any Taylor-like strategy, should the threat of a deflationary trap materialise. However, this implies that a fully credible commitment to the Taylor rule alone would not be possible in the first place.

The key message contained in these contributions is that the announcement of a definition of price stability - or, alternatively, an inflation or price level target - while a major constituent element of a monetary framework founded on price stability, does *not* in itself constitute a sufficient guarantee that such an objective will be attained, unless the announcement is supported by a stabilising “rule” which specifies the central bank moves conditional on protracted deviations from equilibrium. This rule is the second major element needed to anchor expectations. Underlying this logic is a sharp distinction between an *equilibrium condition*, an *objective of policy*, and a fully operational specification of the *monetary policy rule*. A target for inflation or for a price level may be an equilibrium condition (ie a state of affairs that one observes ex post). It may be announced as the objective of policy (ie a central bank may choose to announce, say, an inflation or price level target as the medium-term aim of its policy). But it will never constitute an operational version of a strategy, ie a complete description of the bank’s decision procedure as an algorithm for action. The latter can only be described in terms of how the bank intends to steer its *instruments of policy* (ie either a short-term interest rate or some measure of the stock of outside money in circulation) in the face of the various contingencies, as the situation may dictate. And, notably, it is the expectation of a systematic response of such instruments to off-equilibrium states which is key in sustaining a virtuous equilibrium. Ultimately, it is the off-equilibrium prescriptions of a policy framework - of any type - which make the framework credible.

The fact that such off-equilibrium prescriptions may involve a distinctive role for monetary aggregates, as information variables and triggers of action, as well as possibly as an instrument of policy alternative to the short-term interest rate, is no accident. Take the example of the liquidity trap. In Krugman’s (1998) words: “A liquidity trap involves a type of credibility problem. A monetary expansion that the market expected to be sustained (that is, matched by equiproportional expansions in all future periods) would always work [in lifting the economy off the trap]. If monetary expansion does not work, if there is a liquidity trap, it must be because the public does not expect it to be sustained.” The threat to abandon a “moneyless” interest-based policy rule and to switch to a monetary policy rule involving the implementation of a constant rate of growth for the money base - as in Christiano and Rostagno (2001a) - serves precisely this purpose. To make that monetary expansion credible, the central bank needs to provide a detailed operational specification, ie a complete description of the way the central bank will manage its instrument of policy from the time in which the zero lower bound is hit onwards. This operational specification has to make clear that the money supply will have to be increased by enough to render that equilibrium untenable, so that expectations will have to coordinate on a different equilibrium, namely the one dictated by the central bank’s objective.[42]

borrowed reserves. In the process, the federal funds rate was free to move to whatever level would be consistent with the money growth objective over time.” Mayer’s rationale for the switch of focus in policy which occurred in 1979 seems to be consistent with the story told in Christiano and Rostagno (2001). He argues that “monetary policy was focused on steadily reducing inflation, and policymakers were less certain about what increase in nominal and real interest rates would be required to achieve the objective of reducing inflation than they were about the money-inflation relationship.” (page 8). This is a rather vivid manner to describe the role of money in ‘emergency’ situations in which policymakers find alternative money-less rules a less reliable guide for policy adjustment.

41 Other papers rely on the argument that other policies (eg fiscal policy) could be used to stimulate the economy in a deflationary situation.

42 The above notwithstanding, there are other solutions to the instability or indeterminacy problems associated with conventional money-less policy rules, which do not require explicit reliance on monetary aggregates. Money-less rules providing off-equilibrium responses to non-fundamental shocks to expectations are proposed in Svensson and Woodford (2003) within the context of inflation targeting procedures. We refer the reader to footnote 28 for a brief discussion of these rules.

4. Robustness and the role of monetary developments in monetary policy rules

(i) Models of monetary policy transmission and their implications for monetary policy rules

The preceding section has demonstrated that apparently small deviations from the benchmark New Keynesian macroeconomic model may have profound implications for the design and conduct of monetary policy. At the theoretical level, when conventional monetary policy rules are employed, such deviations from the benchmark model permit indeterminacy and multiplicity of equilibria. In practical terms, this suggests that the mechanical pursuit of Taylor-like rules for monetary policy exposes an economy to the risk of significant instability and substantial deviations from price stability.

The pathologies associated with indeterminacy and multiplicity are not the only implications of varying the assumptions underlying the standard model. Variations to the benchmark New Keynesian model also have implications for the transmission mechanism of monetary policy and thus for the performance of any given monetary policy rule against the loss function described by equation (5). For example, if the assumption that money balances and consumption are weakly separable in the utility function (implicit in the standard New Keynesian model) is relaxed, money balances will enter both the dynamic IS and Phillips curve equations (equations (1) and (2), respectively). Similarly, adopting the Carlstrom and Fuerst (2001a) cash-in-advance timing assumption will result in a role for monetary dynamics in the transmission process. In either case, the performance of monetary policy rules which are designed to preserve price stability around the steady state defined by the linearised relationships analogous to equations (1) to (3) will be affected by how the central bank chooses to vary the short-term interest rate in response to monetary dynamics.[43]

At this stage, one does not need to stake out a definitive position regarding these underlying and rather technical assumptions about how money balances enter the representative agent's utility function in a dynamic general equilibrium model. Such assumptions are anyway hard to distinguish or verify empirically. One can simply argue that, in pursuing their objective of price stability, monetary policymakers would be ill advised to rely *solely* on the results of the benchmark New Keynesian model, which appear rather fragile in the face of small (and difficult to reject) variations to the underlying economic structure. In other words, central banks should not ignore completely the insights provided by variations to the benchmark model - especially those which give some role to money - given the long and influential pedigree of money-based analysis in monetary policy design and implementation.

All models are necessarily an abstraction from, and thus a simplification of, reality. Each model emphasises some aspects of the monetary policy transmission process while obscuring others. In some circumstances, the simplifications implied by the benchmark New Keynesian model may provide a better insight into the challenges facing monetary policy. Other circumstances may favour analyses conducted using variants of that benchmark model, which give a more important role to monetary and financial dynamics in the transmission process. Relying on one model to the exclusion of all others appears misguided.

Policymakers therefore need to integrate analysis conducted using a variety of macroeconomic models into a single process for taking monetary policy decisions. This has led to broad acceptance of the view that central banks should base their policy decisions on a suite of models and tools, rather than relying on a single model for policy advice (eg Bank of England (1999), Pill (2001), Selody (2001)).

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[43] Comparing these variants with the benchmark New Keynesian model, one might argue that two distinct characterisations of monetary policy transmission exist (Engert and Selody (1998)). One tradition (embodied in the work of monetarists, such as Milton Friedman and reflected in the variant models discussed in the main text) views money as central to the determination of the price level. Monetary dynamics therefore play an *active* role in the transmission mechanism. The other tradition (reflected, for example, in the benchmark model) characterises price dynamics as an outcome of interactions between supply and demand and cost pressures. Within this paradigm, monetary developments do not play an active role in monetary policy transmission, but rather reflect the evolution of the arguments of money demand. Money therefore plays a *passive* role in price level determination. However, in the latter framework money may be a good indicator of future prices to the extent that it reflects underlying trends in nominal GDP.

At the very least, the number of variants to the benchmark New Keynesian model used for the analysis of monetary policy reflects substantial continued uncertainty surrounding the monetary policy transmission mechanism. A well designed monetary policy rule or strategy has to confront and overcome this uncertainty.

A substantial literature has considered the conduct of monetary policy in the face of uncertainty (eg ECB-CFS (2000)). With regard to uncertainties about the structure of the economy (typically labelled model or paradigm uncertainty), McCallum (1988) has suggested the following approach. In his view, a well designed monetary policy rule should "perform well" across a set of plausible competing reference models that spans a broad spectrum of model uncertainty. Levin et al (2001) have implemented this approach for New Keynesian models of the US economy. The models investigated by Levin et al are estimated using different data and with somewhat different specifications, but that are all essentially of the benchmark type.[44]

However, following Selody (2001), it is natural to extend McCallum's robustness criterion to encompass analysis under a broader set of variants of the benchmark New Keynesian framework, rather than focusing solely on that benchmark to the exclusion of other models. Therefore, effective monetary policy should perform well in a variety of models of the transmission mechanism, spanning those where money has a structural role in dynamic IS and/or Phillips curve equations and those where it does not (ECB (2000)).[45]

Drawing on the work of Gerdesmeier et al (2002), the remainder of this section investigates these issues. To illustrate our analysis, we use two very simple analytical models, which are described in the Appendix. The benchmark model embodies output gap and Phillips curve equations; the other is a simple P* framework (Hallman et al (1991)).[46]

As described in Section 2, the available empirical evidence for the euro area suggests that the money stock has a stable relationship with the price level (conditional on developments in other macroeconomic variables) and exhibits leading indicator properties for inflation. In the context of the analysis presented here, it is particularly noteworthy that the P* model has empirical support in both the euro area (eg Gerlach and Svensson (2002)) and also - albeit more controversially - in the United States (eg Orphanides and Porter (2001)). While certainly not conclusive, such evidence offers some loose empirical support for the plausibility of variants to the benchmark New Keynesian model that give some role to monetary variables in the transmission process.

In the manner of Rudebusch and Svensson (1999), both the benchmark and P* models are kept extremely simple for expositional purposes.[47] In particular, we choose to use backward-looking specifications, thereby avoiding many of the problems of determinacy and instability discussed in Section 2. Moreover, by using linearised models around a carefully selected steady state, we limit ourselves to discussion of small perturbations from an equilibrium associated with price stability. We thus focus on how monetary policy should respond to economic shocks (including monetary shocks) in the vicinity of this desired steady state, given uncertainty about the transmission mechanism.

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44 More recently, Levin and Williams (2002) have extended their approach to an analysis of forward- and backward-looking Phillips curve models of US monetary policy.

45 One might argue that this approach involves giving preference to monetary policy rules or strategies that avoid bad outcomes (ie instability or indeterminacy of the price level) even in adverse circumstances. This follows Brunner and Meltzer (1968), who - anticipating by some 30 years Hansen and Sargent's (2000) application of robust control theory to monetary policy - advocate monetary targeting on the basis that it provides the least harmful policy framework given the uncertainty surrounding the structure of the transmission mechanism.

46 The specification of the passive money model is a simplified version of the model estimated by Rudebusch and Svensson (1999) (and subsequently employed by Levin and Williams (2002)). The specification of the active money P* model is that suggested by Svensson (2000).

47 Rudebusch and Svensson (1999) argue that using simple, backward-looking linear models of the transmission mechanism is preferable for expositional purposes because well known optimal control techniques (Sargent (1987)) can be applied straightforwardly, increasing the transparency of the results.

Following much of the recent academic literature, we characterise monetary policy within our simple analytical framework as a contingent policy rule for short-term nominal interest rates.[48] Our analysis then proceeds in two steps. First, we discuss the role of monetary developments in optimal interest rate policy rules within the P* model, which here is seen as representing a variant of the benchmark model where money enters the Phillips curve equation and thus has an active role in the transmission mechanism. The resulting policy rule is compared with the optimal rule derived from the benchmark approach. Second, we discuss how monetary developments should affect interest rate decisions when policymakers entertain both the benchmark model and variants to it, as McCallum's robustness criterion requires.

(ii) Optimal policy rules in the two models - the role of monetary developments

Adopting the quadratic central bank loss function that has become standard in the academic literature (equation (5)), conventional techniques can be used to derive optimal monetary policy rules for the two models considered here. Given the simplicity of the models, these rules can be expressed as linear functions of the four state variables: inflation, the output gap, and current and lagged values of the real money gap.[49] These rules are shown in the Appendix. In the main text we summarise some of the simple but important results that follow from this exercise.

Once money enters the structural equations of the transmission mechanism, monetary developments are an argument of the optimal policy rule. Svensson (1997) has shown that optimal monetary policy should respond to the determinants of inflation, not inflation itself. Within the variant to the benchmark model where money enters the Phillips curve, monetary developments are a determinant of price dynamics and thus should influence interest rate decisions that aim to maintain price stability. By the same token, monetary developments do not affect price dynamics in the benchmark model (as already noted in Section 3). Optimal monetary policy for that model will thus be independent of monetary dynamics.

However, even within the variant to the benchmark model where money plays a role in the Phillips curve, the optimal monetary policy cannot be characterised *solely* as a response to monetary developments. The influence of monetary developments on interest rate decisions should be *conditional* on developments in other macroeconomic variables. In other words, variables such as the output gap and inflation also enter the optimal monetary policy rule in variants to the benchmark model (when represented by the P* model). This result has a number of practical implications.

First, as shown by Svensson (2000), even the simple P* framework adopted here does not necessarily provide support for naïve characterisations of monetary targeting. (Intuition would anyway not suggest favouring monetary targeting within the benchmark New Keynesian framework.)

In other words (and adopting the terminology suggested by Svensson (1999a)), even in the context of a simple P* model, the optimal monetary policy rule is neither a simple money-based instrument rule of the form:

$$i_t = \varphi\,[(\ln \mathbf{M}_t - \ln \mathbf{M}_{t-1}) - k\,] \tag{7}$$

nor an intermediate monetary targeting rule defined (implicitly) as the solution to the following problem:

$$\textit{minimise} \quad E_0 \sum [(\ln \mathbf{M}_t - \ln \mathbf{M}_{t-1}) - k\,]^2 \tag{8}$$

subject to the constraints implied by the structure of the underlying economic model.[50]

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48 Of course, as a practical matter, we would not advocate mechanical pursuit of such a policy rule by central banks, since the exercise of informed judgment is a crucial component of any policy regime. Nonetheless, analytical exercises involving monetary policy rules constitute a useful reference point for policy analysis, giving the basis for a systematic (if not rule-bound) policymaking process (see ECB (2001c)).

49 As in Gerlach and Svensson (2002), the real money gap is defined as the difference between the observed real money stock and the real money stock consistent with real output at potential and income velocity at its long-run equilibrium level.

50 *k* is a benchmark rate of monetary growth, for example that consistent with the maintenance of price stability over the medium term.

Indeed, as shown in the Appendix, even in the simple models considered here, the performance of pure money-based rules such as equations (7) and (8) appears quite poor.[51] Pure money-based rules do not come close to mimicking the optimal policy rule in *either* the benchmark model *or* variants to it.

Second, the bivariate relationship between monetary dynamics (in particular, monetary growth) and optimal monetary policy (captured by the level of short-term nominal interest rates) is complicated by developments in other variables, and is therefore likely to be complex. On this basis, one should not anticipate a simple linear unconditional relationship between interest rates and monetary growth. Table 4 (in the Appendix) shows the bivariate correlations between inflation, monetary growth and interest rate in stochastic simulations of the two models, assuming the central bank follows the associated optimal policy rule. The bivariate correlations between monetary growth and interest rates are quite low, reflecting the complex and conditional nature of this relationship.[52]

Finally, the analysis in the Appendix demonstrates that the relationship between optimal interest rate decisions and monetary developments is shock-specific. In both simple models of monetary transmission entertained here, the bivariate relationship between monetary growth and interest rates depends on whether there is a demand shock, a supply shock or a monetary shock. In response to some shocks, the optimal monetary policy response in the face of rapid monetary growth may be a large immediate rise in interest rates. In response to other shocks, the optimal monetary policy response in the face of rapid monetary growth may be smaller and more gradual. Indeed, in some contexts, faster monetary growth may point to no interest rate change or even an interest rate cut.[53] Again, this suggests that interest rate changes should not be mechanically linked to monetary growth and that the bivariate relationship between interest rate changes and monetary dynamics may be complex if the optimal policy rule is being followed.

Another implication of the shock-specific behaviour of money is that monetary developments can help identify the nature of shocks and thus prompt an appropriate interest rate response. This is a necessary component of optimal policy in the P* model, where monetary shocks have an impact on price dynamics. However, even in the benchmark New Keynesian model where money plays no role in the transmission process, cross correlations in the dynamic responses of money and other macroeconomic variables imply that monetary dynamics can help to identify the nature of the shocks. They can thus provide information useful to policymakers who would optimally respond in a shock-specific manner. Money may therefore prove to be a useful indicator even in the benchmark New Keynesian framework. This is the essence of the Coenen et al (2001) result reported in Section 2.

(iii) Formulating rules that perform well in both paradigms

Gerdesmeier et al (2002) consider the design of monetary policy rules where, because of uncertainty about which model or variant is most realistic or relevant, policymakers entertain a variety of models of monetary policy transmission. As one would expect, they show that monetary developments should influence monetary policy decisions when money plays an active role in the monetary transmission mechanism within at least one of the models being considered.

This conclusion is intuitive. However, Gerdesmeier et al (2002) obtain a number of other, less obvious results. Within their framework, they show that monetary developments play an important role in interest rate decisions (in the sense that the coefficient on the real money gap in the favoured monetary policy rule is large) even when the weight accorded to the variant of the benchmark model (captured by the P* specification) is relatively low. The intuition behind this result is as follows. Gerdesmeier et al (2002) minimise a weighted average of the losses in the two models. Ignoring monetary developments in the P* model may be costly, because a crucial determinant of price dynamics is being ignored. At the same time, allowing a role for monetary dynamics in the benchmark

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51 Given the trivial nature of the models, it is hard to assign an economic meaning to the values of the loss function in terms of some more fundamental welfare measure. In other words, their ad hoc nature means that micro-founded welfare criteria are not available.

52 Interestingly, this correlation is even lower in the active money P* model than in the passive money framework.

53 This is, of course, simply an implication of the need to condition the interest rate decision on other variables in addition to money.

model may be relatively benign. Even in the benchmark model, monetary dynamics are associated with developments in the output gap, inflation and interest rates, which are themselves determinants of inflation within that model. Monetary developments may therefore capture information in other, policy-relevant variables.[54] As a result, the costs of ignoring money in the P* variant to the benchmark model may rise more rapidly than the benefits of ignoring money in the benchmark framework. This leads to a relatively prominent role for money in a policy rule that addresses model uncertainty across the P* and benchmark specifications.

Gerdesmeier et al (2002) also show that their favoured monetary policy rule implies larger responses to all state variables (including the real money gap, the monetary argument in their policy rule) than would be implied by alternative approaches, such as averaging the optimal rules from the two models (ie analysing the benchmark and variant models without reference to one another) or deriving an optimal rule from a hybrid framework that averages the two models (ie obscuring the distinction between the benchmark and its variant).[55]

Although the conditional response of interest rates to monetary developments may be large, this does not imply that the unconditional volatility of interest rates under the policy rules analysed by Gerdesmeier et al (2002) will be higher than for other policy regimes. As discussed above, interest rates also respond to variables other than money. In practice, developments in money may therefore be offset by developments in other arguments of the policy rule, such as inflation and/or the output gap, resulting in modest unconditional interest rate volatility.

The Gerdesmeier et al (2002) paper thus leads to three conclusions. First, once variants to the benchmark New Keynesian model are entertained, monetary developments may influence monetary policy decisions. Second, the role accorded to monetary dynamics in formulating interest rate decisions may be relatively large, even if the weight accorded to the variant model that emphasises the role of money is modest. Third, on occasion arguments of the monetary policy rule will point in different directions. The output gap may suggest a rate increase, while monetary dynamics suggest a rate cut. This should not be seen as a shortcoming of the approach. Indeed, the role of the monetary policy rule is precisely to provide a framework for reconciling and combining the information in various indicators into a single robust interest rate decision.

5. Concluding remarks

Much recent academic literature on monetary policy has suggested that monetary aggregates should not play a large role in monetary policy decisions. Within the so-called new neoclassical synthesis, monetary developments are not seen as playing an active role in the transmission mechanism of monetary policy. Monetary policy rules advocated by adherents of these models are often moneyless - they suggest that central banks can neglect or even ignore monetary developments when taking interest rate decisions. Moreover, many prominent empirical studies, in particular for the United States, have concluded that the demand for money is unstable in both long and short runs and that monetary developments largely constitute “noise” which policymakers would do well to ignore.

This paper has challenged these very strong - and, in our view, erroneous - conclusions.

[54] For example, the real money gap is positively related to the output gap. If interest rates rise in response to a positive money gap (as the P* model would require), they will implicitly rise in response to an output gap (as the passive money framework would require). The loss associated with responding to the money gap in the passive money paradigm therefore may be modest.

[55] This result runs counter to the conclusions of Brainard (1967) inter alia, which suggest that uncertainty about the structure of the transmission mechanism should lead to attenuated monetary policy responses. Gerdesmeier et al (2002) offer the following intuition. The Brainard result follows from the possibility that structural uncertainty renders inflation uncontrollable using an interest rate instrument. In such circumstances, changing interest rates would simply destabilise other variables such as the output gap without helping to maintain price stability. If such a scenario is possible, monetary policy responses will be attenuated to avoid the destabilising impact of such a policy. However, in the Gerdesmeier et al (2002) framework, controllability is possible in both the benchmark model and its variant. The issue is not whether the system is controllable, but rather the channels through which control is exercised. In this environment, monetary policy responses are stronger than in the Brainard framework.

On empirical grounds, we survey a large literature which supports the view that money both has a stable relationship with prices in the euro area and exhibits leading indicator properties for future price developments, at least in the euro area.

On conceptual grounds, we note that monetary policy regimes which neglect monetary developments are prone to expectational instability - a practical, as well as theoretical, problem, which may lead to the maintenance of price stability being threatened. Broadly speaking, these results follow from the observation that monetary policy regimes which ignore money may lack a nominal anchor.

On empirical and practical grounds, we suggest that monetary developments contain information about the state of the economy which - regardless of whether money plays an active role in the transmission mechanism of monetary policy - should be integrated into the policymaking process. Of course, in models where money does play an "active" role, monetary dynamics necessarily enter optimal policy rules.

Appendix:
Model uncertainty and monetary policy rules

(a) The output gap model

In its simplest form, the "output gap model" (OGM) (representative of the benchmark view of monetary policy transmission) can be presented as:

$$y_t = \lambda y_{t-1} - \delta(i_{t-1} - E_{t-1}\pi_t) + \varepsilon_{s,t} \tag{9}$$

$$\pi_t = \pi_{t-1} - \beta(y_{t-1} - y^*_{t-1}) + \varepsilon_{s,t} \tag{10}$$

where y is the output gap, i is the short-term nominal interest rate under the control of the central bank, π is inflation and ε_d and ε_s are demand and supply shocks, respectively. For notational simplicity, the variables are de-meaned and de-trended, such that potential output is zero (see Rudebusch and Svensson (1999)).

To facilitate comparisons with the P* model discussed below, a money demand equation is appended to the basic OGM. The money demand equation is "appended" in the sense that price and output dynamics are fully determined by equations (9) and (10): this is why the OGM represents the benchmark view of monetary transmission. This money demand equation has a standard error correction specification, namely:

$$\Delta(m-p)_t = \phi\Delta(m-p)_{t-1} - \vartheta((m-p)_{t-1} - y_{t-1} + \gamma i_{t-1}) + \varepsilon_{md,t} \tag{11}$$

(b) The P* model

The P* model (representative of variants to the benchmark view of monetary policy transmission) can be summarised by the following system of equations (where the notation is the same as above, with i* the nominal short-term interest rate holding in steady state equilibrium with price stability, normalised to zero) (see Hallman et al (1991), Svensson (2000)):

$$y_t = \lambda y_{t-1} - \delta(i_{t-1} - E_{t-1}\pi_t) + \varepsilon_{s,t} \tag{12}$$

$$\Delta(m-p)_t = \phi\Delta(m-p)_{t-1} - \vartheta((m-p)_{t-1} - y_{t-1} + \gamma\, i_{t-1}) + \varepsilon_{md,t} \tag{13}$$

$$\pi_t = (1-\omega)\pi_{t-1} + \omega\Delta p^*_{t-1} - \mu(p_{t-1} - p^*_{t-1}) + \varepsilon_{s,t} \tag{14}$$

$$p^*_t = m_t - y^*_t - \lambda i^* = m_t \tag{15}$$

(c) Central bank preferences

Consistent with the academic literature, the objectives of the central bank are summarised by the loss function (equation (5)), which is used here for illustrative purposes. Note that this loss function assumes a steady state rate of inflation of zero, which - in the context of this framework - corresponds to the central bank's definition of price stability.

(d) Analysis

Using conventional techniques (as discussed, for example, in Rudebusch and Svensson (1999)), each model can be solved to find the "optimal monetary policy rule" which minimises the loss function (equation (5)). As discussed in the main text, this rule (and the results it obtains) can then be compared with simple money-based rules, such as those defined by equations (7) and (8).[56] This exercise is presented in Table 3.

Table 3

Performance of optimal and money-based rules in the two models

		Output gap model	P* model
Optimal rule			
Coefficient on:	y_t	10.051	7.358
	Δp_t	10.512	8.472
	$(m-p)_t$	0	15.386
	$(m-p)_{t-1}$	0	−12.118
Loss with optimal rule		**6.309**	**8.836**
Simple money-based instrument rule			
Response parameter φ		2.135	1.906
Loss with simple money-based instrument rule		**15.589**	**24.959**
Simple intermediate monetary targeting rule			
Loss with simple intermediate monetary targeting rule		**23.909**	**24.652**

Note: Because of the de-meaning and de-trending of all variables, all steady states have been normalised to zero.

Table 4

Bivariate correlations in simulations of the two models under optimal rules

	Inflation	Monetary growth	Interest rates
(a) Output gap model			
Inflation	1		
Monetary growth	0.77	1	
Interest rates	0.40	0.35	1
(b) P model*			
Inflation	1		
Monetary growth	0.86	1	
Interest rates	0.16	0.22	1

56 For the simple money-based instrument rule (equation (1)), the response parameter φ is chosen so as to minimise the central bank's loss function described by equation (5).

Table 4 shows the bivariate correlations between short-term nominal interest rates, inflation and monetary growth in the two simple models, under the assumption that the optimal rule described in Table 3 is followed. These results are discussed in the main text. Note that, counter to intuition, the contemporaneous correlation between optimal interest rate changes and money growth is higher in the benchmark model (rather than the variant P* model where money enters the Phillips curve and thus plays an active role in monetary transmission).

Table 5 describes the policy rule that minimises the average central bank loss over the two models presented above and permits comparison with the optimal rule for each of the two underlying models. This rule is one variant of the monetary policy rules analysed in Gerdesmeier et al (2002) that attempt to address the problem of model uncertainty, ie the need to arrive at a *single* interest rate decision on the basis of analysis in *both* the benchmark model and in the variant of it. As noted in the main text, the response of interest rates to monetary developments (ie the response coefficients on the money gap in the policy rule) is large. Moreover, these coefficients are greater than the average of the two corresponding coefficients in the individual underlying models. The intuition behind these results is discussed in the main text.

Table 5

Coefficients and performance of rule that minimises average central bank loss over the two paradigms

	Bayesian rule weighting loss functions ($q = 0.5$)	**OGM optimal rule**	**P* optimal rule**
Coefficient in weighted rule on:			
$(y - y^*)_t$	9.572	10.051	7.358
Δp_t	9.481	10.512	8.472
$(m - p)_t$	9.525	0	15.386
$(m - p)_{t-1}$	–8.190	0	–12.118
Loss in OGM	7.096	6.309	9.210
Loss in P* model	9.456	12.673	8.836
Mean loss	8.276	9.491	9.023
Maximum loss	9.456	12.673	9.210

Note: The rule described above minimises the average central bank loss over the two paradigms (summarised by the two models), ie min $L = 0.5 \times L_{OG} + 0.5 \times L_{P^*}$.

The parameter calibrations used to undertake the exercises reported in this Appendix are shown in Table 6.

In synthesis, in both of the models introduced in this Appendix, the adoption of a monetary policy rule that preserves price stability ensures that monetary growth will fluctuate around its steady state rate (ie M3 growth oscillates around the reference value). This is a direct implication of the observation that the optimal policy rule in both models will render the economic system stable if it is to preserve price stability. Yet if the underlying monetary policy rule adopted by the central bank does not preserve price stability,[57] then monetary growth diverges from the steady state (ie the reference value) in both models.

Table 6

Calibrated values for the model parameters

Parameter	Calibrated value	Economic interpretation
λ	0.9	Output persistence.
δ	0.1	Real interest rate elasticity of aggregate demand.
β	0.1	Sensitivity of inflation to the output gap.
ϕ	0.6	Persistence of real monetary growth.
υ	0.1	Error correction coefficient in money demand equation.
γ	0.25	Long-run interest rate elasticity of money demand.
ω	0.5	Weight on lagged inflation in P* inflation equation.
μ	0.2	Error correction coefficient in P* inflation equation.
$\sum_{OG} = \sum_{P*}$	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$	Covariance matrix of the structural economic (demand, supply and money) shocks. (For simplicity, a diagonal matrix with unit variances is assumed for both models.)
ψ	0.5	Relative weight on inflation variance in the central bank's loss function.

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[57] In the output gap model, it is sufficient to choose a monetary policy rule with a coefficient less than unity on inflation, such that the real interest rate does not rise in response to an inflationary shock (see Clarida et al (1999)). In other words, violating the Taylor principle is sufficient to induce instability. This condition is not sufficient in the P* model: a rule that preserves price stability may have a coefficient less than unity on inflation in this context.

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The role of money in monetary policymaking[1]

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Abstract

In this paper, the conceptual and empirical bases for the role of monetary aggregates in monetary policy making are reviewed. It is argued that money can act as a useful information variable in a world in which a number of indicators are imperfectly observed. In this context, the paper discusses the role of a reference value or benchmark for money growth in episodes of heightened financial uncertainty. A reference value for money growth can also act as an anchor for expectations and policy decisions to prevent divergent dynamics, such as the spiralling of the economy into a liquidity trap, which can occur under simple interest rate rules for policy conduct. The paper concludes that using information included in monetary aggregates in monetary policy decisions can provide an important safeguard against major policy mistakes in the presence of model uncertainty.

1. Introduction

Inflation is a monetary phenomenon. Monetary growth in excess of increases in the public's demand for money balances will eventually decrease the purchasing power of money or, equivalently, raise the general price level. The long-term relationship between money and prices has been a cornerstone of monetary economics for several centuries (eg Hume (1752)) and has been documented for many countries and many eras (eg McCandless and Weber (1995)).

While recognition of this empirical regularity is almost ubiquitous within the economics profession, substantial controversy persists about the usefulness of the relationship between money and prices in understanding, predicting and controlling inflation, and thus about its relevance for the design and implementation of monetary policy. Such controversy continues to be reflected in the ongoing debate about the appropriate design of monetary policy strategies.

Following the unacceptably high rates of inflation observed during the 1970s, many leading central banks adopted intermediate targets for monetary growth as the centrepiece of their monetary policy strategies. However, in the more benign inflationary environment of the 1990s, the role played by monetary aggregates in the policy framework of many central banks diminished. By the end of the century, Laurence Meyer (2001), a member of the Federal Reserve System's Board of Governors, was able to assert "… *money plays no role in today's consensus macro model, and it plays virtually no role in the conduct of monetary policy, at least in the United States*." Nonetheless, other central banks give monetary analysis a much more important role in their formulation of monetary policy. Notably, the European Central Bank (ECB) has accorded "*a prominent role to money*" within its monetary policy strategy (ECB (1999a,b), Issing et al (2001)).

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1 An earlier version of this paper was presented at the AEA meetings in Atlanta, 4-6 January 2002. We are grateful to C Brand, D Gerdesmeier, V Gaspar, M Goodfriend, H-J Klöckers, G Korteweg, R Motto, P Moutot and C Willeke for very helpful comments. The views expressed in this paper are those of the authors and do not necessarily reflect those of either the European Central Bank or the Eurosystem.

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To the casual observer, the suggestion that monetary developments are not an important component of monetary policymaking sounds odd. As reflected in ECB (2000), Selody (2001) and King (2002), central banks generally adopt the view that monetary developments should not be ignored since - at a minimum - they offer an additional source of information which can help improve the robustness of monetary policy decisions (see Pill (2001)). This notwithstanding, much - although not all - recent academic discussion of monetary policy has neglected or ignored monetary aggregates.[4] This contrasts with the seminal work of monetarist economists such as Milton Friedman, who saw monetary dynamics as central to understanding the inflation process (eg Friedman and Schwartz (1963)). In the light of the contrast between these two branches of the literature, the prominent role of money in the ECB's monetary policy strategy[5] has been the subject of an ongoing debate in both academic and policy circles.

Against the background of a more general discussion of the role of money and monetary analysis in monetary policymaking, this paper discusses conceptual and empirical aspects of the role of money in the conduct of monetary policy. Three related aspects - which are not mutually inconsistent - of the role of money in monetary policymaking can be distinguished.

First, monetary aggregates might be useful to proxy for variables that are unobservable or observable only with time lags. Thereby money can contribute information for assessing the appropriate stance of monetary policy, which is not included in simple interest rate rules. A simple comparison between the short term rate manoeuvred by the central bank and some conventional interest rate benchmark, say based on a Taylor rule, may often be a very inaccurate measure of the prevailing monetary conditions as perceived by market participants. There are at least two dimensions to this signalling and proxying role of money. One such dimension is related to the fact that the construction of summary indicators for economic slack or overheating is subject to considerable dispute. Therefore, policymakers' knowledge of the output gap may not at all be superior to their knowledge of money velocity behaviour, and so they may find it useful to consult money growth data as an early indicator of the prevailing economic conditions. Another aspect of money as an incremental gauge of the posture of policy becomes apparent in times of financial turbulence.

Second, and related to the above discussion, money may play an important structural role in the transmission mechanism of monetary policy to the price level. The importance of such transmission channels is essentially an empirical question, and may vary over time or even prove to be episodic. As discussed by King (2002), money and credit would play an important role if *imperfections in the financial sector* (ie borrowing and liquidity constraints) permit changes in the structure of balance sheets to influence yields and spreads in a manner that is relevant for intertemporal economic behaviour, such as pricing, consumption, saving and investment decisions.[6] Should such effects prove important, neglecting monetary dynamics in the formulation of monetary policy decisions will come at a potentially large cost. Some commentators cite the recent prolonged Japanese recession as an example of such costs, on the basis that asset market dynamics in Japan were driven or accommodated by a monetary policy that neglected monetary and financial developments.

Finally, money can provide *a nominal anchor for the economy*. A monetary policy that responds to monetary developments - in addition to the fundamental shocks which hit the economy from time to time - can help to rule out destabilising explosive paths for inflation expectations that could be triggered and sustained by self-fulfilling expectations.

Of course, experience in the conduct of monetary policy over many decades has demonstrated that reliable guideposts come and go, sometimes requiring policymakers to review and adjust their

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4 Analyses conducted in the context of strategies based on inflation targeting or Taylor rules are illustrative of this approach.

5 The reference value and monetary analysis more generally form the money pillar of the ECB's strategy (ECB (1999a, 2000)). The ECB points out that monetary analysis and the respective models have always to be seen in conjunction with the second pillar of the ECB's monetary policy strategy, which uses the analysis of other economic and financial indicators and models for the support of monetary policy decisions. Much of the academic criticism of the ECB's assignment of a prominent role has arisen in the context of the so-called "new neoclassical synthesis" view of the macroeconomy (Goodfriend and King (1997)). In this context, monetary aggregates are not seen as playing an active role in the transmission mechanism of monetary policy and, as such, should not play an important role - still less a "prominent role" - in the formulation of monetary policy decisions.

6 Note that that situation constitutes a violation of the Modigliani/Miller theorem, which states that the financial structure of a firm or household should not affect its value and thus its economic decisions and behaviour.

theories, procedures and operating methods. This notwithstanding, there are many reasons why the role of money in monetary policymaking has proved durable. The remainder of the paper, in reviewing these reasons, is organised as follows.

Section 2 surveys the empirical properties of money, focusing on results for the euro area. While much of the evidence relates to the indicator properties of monetary dynamics for inflation (rather than investigating structural models of the transmission mechanism), this section nevertheless offers broad empirical support for the incorporation of monetary analysis into the monetary policymaking process.

Section 3 reviews a number of conceptual arguments in favour of assigning a prominent role to money in the formulation of monetary policy. In large part, these arguments follow from the view that money provides a nominal anchor to the economy, which helps avoid instability in the economy by ruling out indeterminacy or ambiguity in the determination of the price level.

Section 4 discusses how monetary analysis can be combined with analysis of demand and supply interactions and cost pressures to arrive at a single policy decision regarding the level of short-term interest rates. This discussion takes as its starting point uncertainty about the role of money in the transmission mechanism of monetary policy. A well designed monetary policy should acknowledge this uncertainty, but nevertheless ensure that monetary developments are not ignored or neglected in the design of policy decisions.

While this paper cannot (and does not attempt to) resolve all issues related to the role of monetary developments in formulating monetary policy, it does provide empirical, conceptual and practical support for assigning money an important role in monetary policy decisions in the euro area. These are summarised briefly in Section 5, which offers some brief concluding remarks.

2. Empirical foundations

Since the ECB and the single monetary policy have been assigned the primary objective of maintaining price stability in the euro area, monetary developments should only influence monetary policy decisions insofar as they provide information that furthers the achievement of that objective. In other words, monetary developments are important for monetary policy decisions to the extent that they cause, help to predict or are otherwise associated with price developments such that they should play a role in monetary policy decisions.

Ideally, the relationship between monetary and price developments would be explored in the context of a structural model with well developed micro-foundations. Unfortunately, notwithstanding ensuing discussion, structural models of monetary and financial interactions that are both sufficiently empirically relevant and conceptually appealing to be used as a guide to monetary policy decisions have yet to be developed. While considerable progress is being made in the field of monetary dynamic general equilibrium (DGE) models, their practical relevance for policymaking awaits further tests.

Consequently, in practice, empirical assessments of the relationship between money and prices are based on semi-structural or reduced-form models such as money demand equations, VARs or reduced-form indicator relationships. The remainder of this section reviews the application of such approaches to euro area data.

(a) Stability of the relationship between money and prices

The stability of the relationship between the money stock and the price level is typically evaluated in the context of a money demand equation, which relates money to prices and other key macroeconomic variables (such as real income and interest rates). Stability is assessed using cointegration techniques (Engle and Granger (1987), Johansen and Juselius (1990)), which test whether a stable long-run relationship among the levels of the variables exists.

A number of such studies have been undertaken on euro area data. Since cointegration techniques require long data samples, these investigations rely largely on data for the euro area prior to monetary union constructed from pre-existing national monetary series. In addition to the usual concerns regarding the stability of economic relationships in the face of a regime change such as the introduction of the single monetary policy, the empirical analysis thus faces additional, though unavoidable, uncertainties regarding the quality of the data and the appropriate aggregation technique.[7]

Table 1

Summary of studies of the long-run money demand equations for euro area M3

	Sample	**Aggregation method**	**Income elasticity**	**Interest rate (semi) elasticity**	**Other variables in long-run money demand equation**	**Weak exogeneity**
Coenen and Vega (1999)	1980:4-1997:2	Sum logs of national components	1.14	–0.820 (on the spread between the long- and short-term interest rate)	Inflation, with a coefficient of –1.462 (interpreted as a measure of opportunity cost)	Output, inflation, short-term interest rate, long-term interest rate
Brand and Cassola (2000)	1980:1-1999:3	Sum national components at irrevocable fixed exchange rates	1.33	–1.608 (on the long-term interest rate)	None (estimated as a system with the yield curve and Fischer parity conditions)	None
Calza et al (2001)	1980:1-1999:4	Sum national components at irrevocable fixed exchange rates	1.34	–0.86 (on the spread between the short-term market interest rate and the own rate on M3)	None	Output

Sources: Coenen and Vega (1999); Brand and Cassola (2000); Calza et al (2001).

Three major studies of the demand for the broad monetary aggregate M3 in the euro area have been prepared and published by ECB staff (Coenen and Vega (1999), Brand and Cassola (2000), Calza et al (2001)).[8] The main results of these papers are summarised in Table 1. While the approaches vary in detail,[9] all three studies find a stable long-run demand for euro area M3, ie a cointegrating relationship involving money, the price level, national income and some opportunity cost variables is obtained.[10] The intuition behind this finding is powerfully illustrated in Graph 1, which shows the income velocity of circulation for euro area M3 in the period 1980-2001. The steady and smooth decline in M3 velocity over this period reflects the stability of the estimated money demand equations.

7 However, these concerns apply to all data series for the euro area in the period prior to the introduction of the euro. In practice, the quality of the monetary data is thought to be at least as high as that of other series.

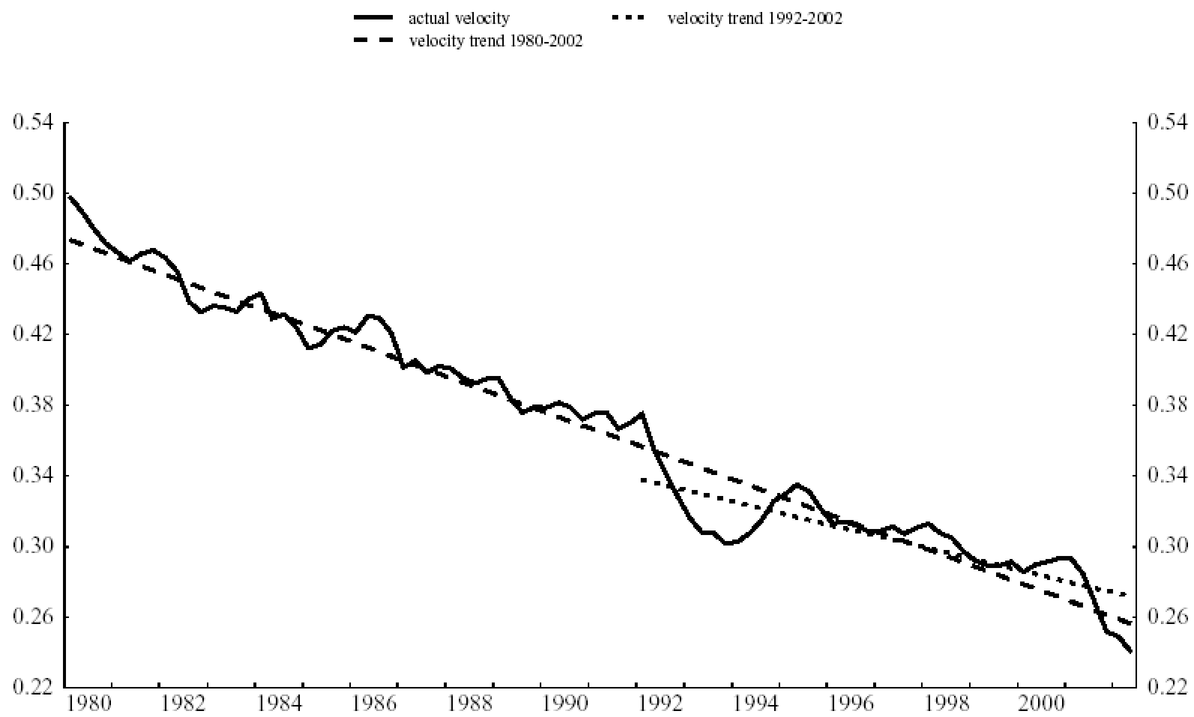
8 Euro area M3 is defined as the following liabilities of euro area monetary financial institutions (MFIs) held by euro area residents: currency in circulation; overnight deposits; deposits with agreed maturity up to three years; deposits redeemable at notice up to three months; repurchase agreements; money market fund shares/units and money market paper; and debt securities with maturity up to two years.

9 Such as in the choice of interest rates used to measure the opportunity cost of holding money, in the aggregation technique used to construct the euro area back data, in the sample period investigated or in the specification of the equation.

10 More recent stability tests have confirmed the long-run stability conditions of the demand for M3 in the euro area. See, among others, Brand et al (2002) and Bruggeman et al (2003).

Graph 1

M3 velocity trends for the euro area (log levels)



Note: Velocity is measured as the ratio of nominal GDP to M3. The underlying quarterly series are seasonally adjusted and constructed by aggregating national data converted into euros at the irrevocable exchange rates applied as from 1 January 1999 and as from 1 January 2001 in the case of Greece. The M3 series is based on the headline index of adjusted stocks (for further details, see the technical notes in the "Euro area statistics" section of the *ECB Monthly Bulletin*). M3 quarterly data are averages of end-month observations.

Source: ECB (M3) and ECB calculations based on Eurostat data (GDP).

Therefore, in contrast to some results obtained in other G7 economies (such as the United Kingdom and the United States), the evidence in favour of a simple and stable long-run relationship between broad money and the price level in the euro area over the last two decades appears robust.[11]

Stracca (2001) has also investigated the properties of a Divisia monetary aggregate for the euro area. Divisia aggregates weight the different components of monetary aggregates according to their "moneyness", with the weights being related to the opportunity cost associated with holding the monetary asset rather than a non-monetary asset bearing a market return. Stracca finds a stable demand for a euro area Divisia monetary aggregate, thereby demonstrating the robustness of the results outlined above to different aggregation techniques.

All in all, the stability of euro area money demand relationships suggests that a path for the evolution of the money stock can be derived which, conditional on developments in other macroeconomic variables, is consistent with the maintenance of price stability over the medium term.

[11] These results support the a priori intuition that the demand for broader monetary aggregates is more likely to be stable than that for narrow monetary aggregates, since the former internalise the substitution between different categories of monetary asset that may create instabilities in the latter. This notwithstanding, money demand equations for euro area M1 also show surprising stability, albeit with less conventional specifications. Stracca (2000) investigates various specifications for the opportunity cost term and finds that a stable demand for M1 can be estimated if the interest rate semi-elasticity is allowed to vary with the level of interest rates.

(b) Leading indicator properties of money for price developments and macroeconomic outcomes

Given the lags in monetary transmission, a monetary policy aimed at the maintenance of price stability must be forward-looking. Leading information on future price developments is therefore crucial. Current monetary developments may contain information about future price developments, ie money may be a leading indicator of inflationary or deflationary pressures. It is important that such forward-looking information is incorporated into the monetary policymaking process.

Money may also contain leading information on other macroeconomic variables that - although not constituting the ultimate objective of monetary policy - will influence the future course of the economy and, eventually, price developments. Such information is also central to monetary policy decisions, since it will influence the magnitude and timing of policy actions.

Several studies by the staff of the ECB have investigated the leading indicator properties of monetary developments in the euro area. For example, in the context of the money demand studies reported above, Brand and Cassola (2000) find that neither inflation nor aggregate demand are weakly exogenous to their money demand system, suggesting that monetary developments will help to predict these variables. Trecroci and Vega (2000) extend the Coenen-Vega money demand framework and also find that money helps predict future inflation.[12] Broadly speaking, these results are consistent with those reported by Gerlach and Svensson (2002) for euro area M3. In the context of a P* model (Hallman et al (1991)), Gerlach and Svensson show that the so-called real money gap - a measure of the monetary disequilibrium relative to a stable long-run money demand equation - helps to predict future price developments.

A comprehensive assessment of the leading indicator properties of money in the euro area is offered by Nicoletti-Altimari (2001). Following the approach proposed by Stock and Watson (1999) for forecasting inflation in the United States, this study focuses on the out-of-sample forecasting performance of potential indicator variables.

A brief summary of the main results from this paper is presented in Table 2. The numbers in the table show the ratio of the forecast errors of a specific indicator model relative to those of a benchmark model, which captures inflation as a pure autoregressive process. A number greater than one therefore indicates a poor model, while a number less than one is associated with a model that performs better than the benchmark.

Using Table 2 (and, more generally, Nicoletti-Altimari's (2001) results), a number of conclusions can be drawn. First, there is considerable evidence that including monetary indicators improves the out-of-sample forecasting performance of a pure autoregressive model of price developments. Second, the performance of money-based indicators relative to other indicators (such as estimates of the output gap or cost pressures) improves as the horizon of the forecast lengthens. Third, it is noteworthy that (nominal) M3 growth offers the best relative forecast performance at the longest (three-year-ahead) horizon. Finally, various other monetary indicators - including measures of monetary growth, estimates of monetary disequilibrium (like the P* indicator) and indicators based on the components (eg M1, M2) and counterparts (notably loans to the private sector) of the broad monetary aggregate M3 - also appear to exhibit leading indicator properties for price developments. As a result, a composite monetary indicator which combines information from all these measures could be constructed which would outperform any individual measure.[13]

These results point to monetary developments being an important indicator of medium-term trends in price dynamics in the euro area. Given the necessarily medium-term orientation of monetary policy,[14] they suggest that monetary indicators should be given an important role. On the basis of the indicator results, one can construct money-based forecasts of future price developments. Although, as with any single forecast, these money-based projections do not provide a sufficient basis for monetary policy

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[12] For a review of the monetary tools used at the ECB, see ECB (2001a) and Masuch et al (2001).

[13] Very favourable leading indicator properties of broad monetary aggregates for inflation developments at medium-term horizons in the euro area are also found by Gottschalk et al (1999) and Cristadoro et al (2001).

[14] Implied by Friedman's famous "long and variable lags" in the transmission mechanism of monetary policy actions to the price level.

decisions,[15] such information can be an important input to the monetary policy process, eg for cross-checking results obtained on the basis of structural macroeconometric models.

Table 2

Leading indicator of properties of monetary variables for HICP inflation in the euro area[1]

The sample period is 1992:1-2000:3

Variable		Transformation	Horizon in quarters			
			1	**4**	**8**	**12**
Univariate model, for reference (% RMSE)			0.50	0.62	0.70	1.02
M1		DLN	0.98	1.04	1.05	0.95
M2		DLN	0.98	0.92	0.89	0.90
M3		DLN	0.90	1.29	0.98	0.43
Credit		DLN	0.93	0.90	0.74	0.58
Money gap	BC	LN	1.05	1.02	0.87	0.64
	CV	LN	1.11	1.05	1.31	1.46
P*	BC	DLN	0.86	0.76	0.60	0.80
	CV	DLN	1.08	0.98	0.97	1.08
Output gap		LN	1.14	1.01	0.96	0.78
Unemployment		L	0.90	0.82	1.36	0.88
Unit labour costs		DLN	1.09	0.94	0.87	1.20
Effective exchange rate		DLN	1.20	1.14	1.03	1.04
Oil prices		DLN	1.37	1.05	0.99	1.81

Note: Transformations: D = first difference; LN = logarithm; L = level. BC is the Brand and Cassola (2000) model; CV is the Coenen and Vega (1999) model.

[1] This table reports the ratio of the MSE of the out-of-sample forecasts for the model including the indicator variable to the MSE of the simple univariate time series model of inflation.

Source: Nicoletti-Altimari (2001), Table 1a, p 39.

Other studies (reported briefly in Masuch et al (2001)) also point to money have leading indicator properties for other key macroeconomic variables. In particular, annual growth rates of M1 have been found to help predict future developments in real activity about one year ahead.[16]

[15] In particular, since the money-based projections are not derived from a structural model of the economy, they do not offer a basis for calibrating the magnitude of the appropriate interest rate response to counter emerging inflationary or deflationary pressures.

[16] In addition to the formal econometric studies discussed above, central banks' staff normally undertake a regular detailed analysis of monetary data. This analysis extracts the information from monetary developments that is relevant for monetary policy decisions, and thus tries to identify special factors or portfolio shifts which distort the relation between money and prices. A detailed discussion of the framework used for this analysis in the case of the ECB - including the judgmental and institutional analysis that complements econometric techniques - is provided in Masuch et al (2001). It is noteworthy that central bank staff who closely monitor developments in financial and banking markets are often in a position to interpret and correct "headline" monetary developments using "off-model" information that is not incorporated into econometric studies.

This discussion therefore suggests that - at least on the basis of euro area monetary aggregates - empirical support exists for the following assertions: first, a stable long-run relationship between money, prices and a small number of other key macroeconomic variables exists; and second, monetary developments are leading indicators of future price developments, especially at longer horizons.

(c) Money as a proxy for unobserved variables: the output gap

Research on Taylor rules has emphasised the importance of “real-time” data uncertainty for monetary policy decisions. In particular, a number of studies of the United States have found that uncertainty arising from revisions to output gap and inflation estimates may lead to a significant deterioration in the performance of Taylor-like monetary policy rules (Orphanides (2000)). Less energy has been devoted to investigating money’s potential role as an information variable in this context. However, if measures of money are subject to fewer revisions - and on average of lesser magnitude than estimates of real output - then monetary aggregates may play a significant role in providing timely and “steady hand” information about the current state of the economy.

In a recent paper, Coenen et al (2001) pursue this avenue of research. In a model with rational expectations, nominal inertia and an apparently totally passive status of money - along the lines of the New Keynesian benchmark model discussed in Section 3 below - monetary developments are shown to be of great help to the policymaker, since money balances react to the “true” level of income, whereas the central bank is assumed to receive only a noisy measure of output. To be sure, the extent to which monetary data enhance the available information set depends crucially on the effort that monetary authorities exert in collecting monetary statistics and undertaking monetary analysis.

(d) Money as a proxy for unobserved variables: monetary and financial conditions

The money stock can serve as a proxying index also along a different dimension. In a recent paper, Nelson (2002) emphasises the effects of monetary policy upon a whole “spectrum of rates” - over and above that manoeuvred by the central bank - as the driving force within the transmission mechanism. However, a large part of the complete set of yields that matter for aggregate demand is unobservable to monetary authorities. Hence, if the demand for money can be thought of as a function of a broad set of yields besides those observed in securities markets, then movements in money aggregates would convey information that the central bank would not otherwise be able to extract from alternative indicators.

In fact, the historical association between protracted episodes of money growth in excess of some sustainable reference rate and the build-up of financial imbalances and asset price bubbles can probably be interpreted in this light. In periods of financial turbulence the implicit rate at which market participants discount future expected earnings from asset portfolios may vary in ways that are both unpredictable and unobservable to monetary authorities. In these circumstances, a simple comparison between the short-term rate manoeuvred by the central bank and some interest rate benchmark, based say on a Taylor rule, may not be an accurate measure of the prevailing monetary conditions as perceived by market participants. By contrast, monetary quantities - primarily due to their link to credit - have a powerful (incremental) role to play as indicators of the actual stance.

Issing (2002) brings some suggestive evidence to this effect. He analyses three past episodes which, in hindsight, are regarded as having involved large, if unintentional, monetary policy mistakes. In all three cases he investigates whether a policy taking the quantity theoretic equation seriously, and using a money stock indicator as a gauge for the prevailing conditions, could have been instrumental in yielding a better macroeconomic outcome.

Graph 2, which we borrow from that contribution, depicts the evolution of some key indicators in the 1920s and early 1930s in the United States in the face of a major build-up and subsequent collapse of equity prices. The excess money measure used in the graph is defined as the difference between the

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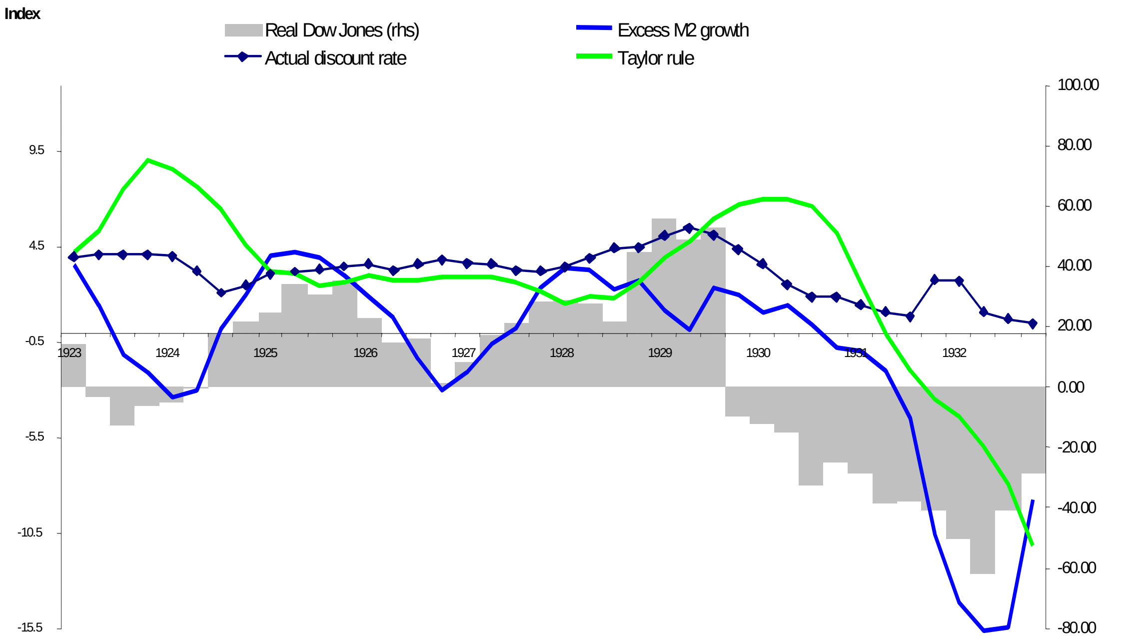
Such analysis therefore often adds to the policy-relevant information in monetary developments, extending their relevance beyond what would be suggested by the econometric studies reported above alone.

actual growth rate of nominal broad money and the rate that would be implicit in the quantity relation with real income growing at its potential rate, inflation at the central bank's implicit objective, and velocity at its long-term trend.[17]

Graph 2

The United States in the 1920s: excess money growth, real asset price growth and monetary policy

Annual percentage changes



Note: Excess money growth is defined as $\Delta_4 e = \Delta_4 m - [\Delta_4 p^* + \Delta_4 y^*] + \Delta_4 v^*$, where Δ_4 denotes the four-quarter difference operator and m, p^*, y^* and v^* stand for (logs of) the actual stock of M2, the price objective, real potential GDP, and the long-term velocity of circulation, respectively. The price objective is normalised to 1, potential output is obtained applying an HP-filter to actual real GDP, trend velocity for 1923-30 is constructed by interpolating a linear trend to realised velocity over 1921-29, and by imposing a structural break afterwards to reflect the sharp contraction in nominal GDP, primarily led by a fall in producer prices. The Taylor rule has been calibrated to an equilibrium real interest rate equal to the average real discount rate observed in the first two quarters of 1923, and imposing an inflation coefficient of 1.5 and an output gap coefficient of 0.5.

Source: Issing (2002).

Notwithstanding its purely descriptive nature, this exercise is instructive. It suggests that a quantity measure would have conveyed information which was not forthcoming from a pure analysis of the interest rate used by the Fed in its operations. It shows that, had the Fed looked at a measure of excess money growth, had it not rejected the then novel normative framework offered by the quantity theory of the business cycle, it would have probably realised that monetary policy was too lax, not too tight, for much of the 1920s.[18] Intriguingly, the measure of excess money growth appears to move in sympathy with the profile of the histograms which represent the growth rates of real stock prices in New York. It becomes positive - and significantly so - in those years in which the market is most buoyant. And it turns negative when the market pauses or falls. Perhaps, one can conclude, money was growing too fast in the years immediately preceding the crash, compared to the long-term necessities of an inflation-free economy operating at potential. Perhaps, that excess of monetary injection was spilling over into the purchase of financial assets. However, looking at the discount rate

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[17] See the note to Graph 2.

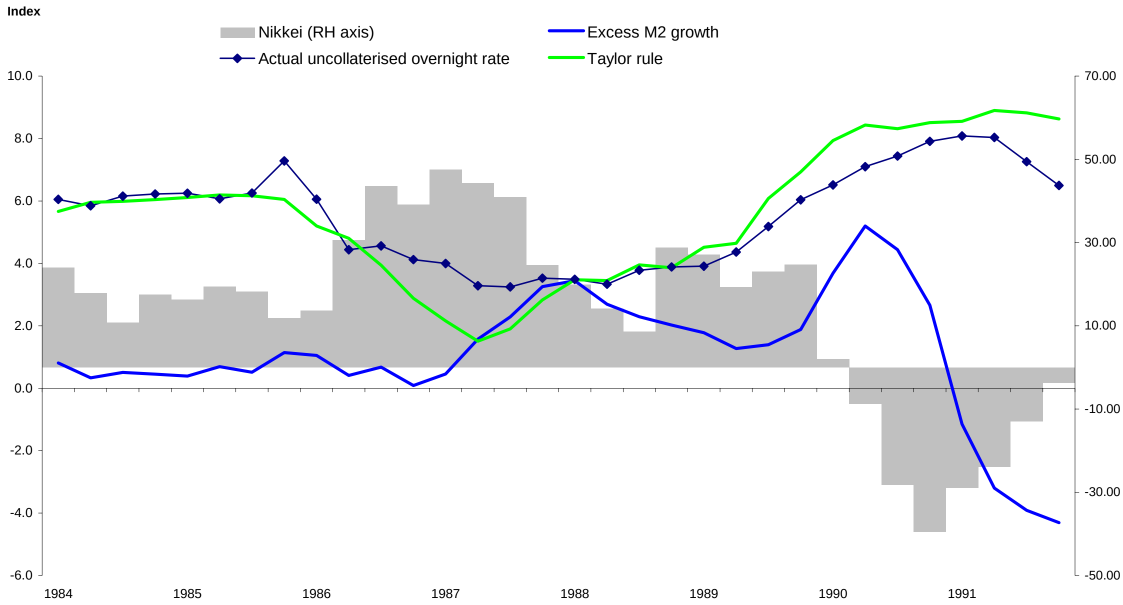
[18] That the stance of policy may have been too lax in the later phase of the asset price build-up of the 1920s, besides being a long-standing contention of some prominent representatives of the Austrian School at the time, has been recently remarked by Bordo and Jeanne (2002).

only, to the exclusion of the monetary indicator, and measuring the historical path of the discount rate against the benchmark provided by the Taylor rule, one would draw the opposite indication. The extent of the abrupt policy reversal in the first half of 1929, which many contemporary observers quote as a primary cause of the disorderly fall in the market, is also more apparent from the quantitative than the interest rate indicator.

Graph 3

Japan in the 1980s: excess money growth, real asset price growth and monetary policy

Annual percentage changes



Note: Excess money growth is defined as $\Delta_4\, e = \Delta_4\, m - [\Delta_4\, p^* + \Delta_4\, y^*] + \Delta_4\, v^*$, where Δ_4 denotes the four-quarter difference operator and *m*, *p**, *y** and *v** stand for (logs of) the actual stock of M2+CDs, the price objective, real potential GDP, and the long-term velocity of circulation, respectively. The Bank of Japan's implicit inflation objective has been set equal to a yearly rate of 1.7% (the average of the Japanese CPI inflation between 1984 and 1991), potential output is obtained applying an HP-filter to actual real GDP, and trend velocity is constructed by interpolating a linear trend to realised velocity over a 20-year period starting in 1980. The Taylor rule has been calibrated to an equilibrium real interest rate equal to the average real uncollateralised overnight rate observed in the first two quarters of 1984, and imposing an inflation coefficient of 1.5 and an output gap coefficient of 0.5.

Sources: Bank of Japan; ECB staff calculations.

A similar picture emerges from the Japanese data (Graph 3). While a Taylor rule would have signalled an appropriate-to-tight stance of policy until well into 1989, excess money was building up in the second half of the 1980s, finally at an accelerating pace.[19] Apparently, the Bank of Japan had expressed early concerns that rapid money growth might predispose the "dry wood" needed to set the asset market on fire. But probably no tightening - in excess of that already apparent in the data - could have been justified to the public on the back of persistently subdued inflation and growing measures of productivity. Again, it seems that a monetary policy gauge focused on inflation and a measure of slack only - to the neglect of money - would have failed to sound the alarm. Furthermore, alternative

[19] McCallum (2000) confirms the good fit of a Taylor rule to the actual policy orientation of the Bank of Japan in the 1980s. He also finds that a rule involving a target for base money growth would have provided important insights to the policymakers in those difficult circumstances.

indicators, such as private credit, may at times outperform broad money in signalling that observed swings in asset prices are abnormal and may prelude financial distress.[20]

Of course, at times shocks to money demand may obscure the message that money indicators convey. Therefore, it is crucial that central banks are able to filter crude monetary data in order to extract the underlying signal of future risks to prices.

3. Conceptual considerations

The basic theoretical justification for assigning a prominent role to money in a monetary policy strategy lies in the following fact: it is simply impossible to observe high and sustained inflation without systematic monetary accommodation. Similarly, a prolonged and substantial deflation requires monetary contraction.

What is meant by “monetary accommodation”? In the past, this concept has often been identified with a central bank’s adoption of an interest rate rule. In other words, rather than pursuing a quantitative target for money, the central bank sets an operational target for a nominal short-term interest rate. In a famous article, Sargent and Wallace (1975) challenged this practice on the basis that such a regime leaves the price level indeterminate and would thus tolerate (or even trigger) prolonged periods of high inflation.

However, following McCallum (1981), it was recognised that “monetary accommodation” was not synonymous with an interest rate rule *as such*. In particular, McCallum showed that an interest rate feedback rule would not lead to nominal indeterminacy if the rule was defined so as to have an impact on, say, the price level in the upcoming period. McCallum showed that monetary authorities could set monetary policy in terms of an interest rate, provided that the way in which the policy interest rate was manoeuvred reflected a concern about the future evolution of some nominal magnitude.[21]

However, this line of analysis suggested that the “nominal magnitude” did not necessarily need to be money. It led to the conclusion that central banks could adopt a policy rule whereby the policy interest rate fed back from a set of endogenous variable indicators, but *not including money*. Such a moneyless framework still provided the economy with the anchor that it needed for nominal values to be pinned down.[22]

Formulated in this manner, McCallum’s result had far-reaching consequences for the theory and practice of monetary policy. It gave rise to the flourishing literature on interest rate rules for monetary policy, which constitute one building block of what Goodfriend and King (1997) have named “the new neoclassical synthesis” in macroeconomics. This framework maintains that it is, in general, possible to develop guidelines for monetary policy aimed at price stability without having to specify policy in terms of a monetary aggregate.

To be sure, the guiding principles stemming from this framework exhibit recognisable “monetarist” features: they are wedded to neoclassical reasoning; they are built on the presumption that inflation is ultimately a monetary phenomenon, which can ultimately be governed by the central bank given that the latter has the power to supply base money and thus to set the overnight interest rate; and they recommend making low and stable inflation the primary objective of monetary policy. Nevertheless, this approach departs decisively from the heart of monetarism by rejecting the monetarists’ practice of organising monetary analysis largely in terms of the interplay between the supply of money and the demand for real balances.

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[20] Alternative indicators, such as private credit, may at times outperform broad money in signalling that observed swings in asset prices are abnormal and may prelude financial distress. The close correlation between domestic credit growth and the change in (a composite indicator of various) real asset prices is stressed in a recent contribution by Borio and Lowe (2002).

[21] This insight was subsequently refined by Woodford (2002, Chapter 2), who argued that, in order to pin down prices, the central bank need not adjust its interest rate instrument in response to *nominal* quantities. All that is needed is a reaction function linking the policy interest rate to *endogenous* variables. More on this below.

[22] Woodford (2002, Chapter 2), in particular, raises this point with force.

Therefore, while recognising the validity and robustness of the long-run link between monetary growth and inflation, prominent contributors to this branch of literature argue that money should not be assigned a special status in the monetary policymaking process. Monetary policy should not pay special attention to developments in monetary aggregates because the observed long-run relationship between money and prices says nothing about the direction of causality running between them (Galí (2001)). In this context they argue that paying excessive attention to monetary developments simply exposes monetary policy decisions unnecessarily to the vagaries of money demand.

Against this background, the scope of the remainder of Section 3 is rather limited. Working *within* the new neoclassical synthesis framework briefly outlined above, the section evaluates whether the strong policy conclusions drawn above are justified. This discussion is organised in two parts. First, we outline the basic new neoclassical synthesis model. Second, we show that within this environment a class of popular rules that do not include money can give rise to self-fulfilling fluctuations.

(a) A non-monetarist model

An extremely simplified version of the new neoclassical synthesis model can be reduced to these three summary conditions:[23]

$$y_t = \gamma_0 - \gamma_1\left(i_t - E_t\pi_{t+1}\right) + E_t y_{t+1} + e_t \tag{1}$$

$$\pi_t = \delta_0\ E_t\ \pi_{t+1} + \delta_1\left(y_t - y^*\right) + u_t \tag{2}$$

$$\left(m_t - p_t\right) = \eta_0 + \eta_1 y_t - \eta_2 i_t + z_t \tag{3}$$

where, other than the short-term nominal interest rate under the control of the central bank, i_t, and the inflation rate, π_t, all variables are expressed in logarithms: y_t is output, p_t is the price level, m_t is (base) money, and e_t, u_t and z_t are stochastic error terms. $E_{t-1}x_t$ represents the expectation of x_t at time $t-1$, where t is (discrete) time.[24]

Equation (1) (with γ_0 and γ_1 both positive) is a dynamic stochastic IS curve which can be derived from the Euler condition associated with the representative household's savings decision by imposing standard market clearing conditions. It states that output y_t is related (negatively) to the contemporaneous real interest rate and (positively) to expectations of future output conditions.

Equation (2) (with $\delta_1 > 0$ and $0 < \delta_0 < 1$) is a forward-looking Phillips curve, which can be derived from optimal pricing decisions of monopolistically competitive firms facing constraints on the frequency of future price changes. The current rate of inflation responds to expectations of future inflation and the current level of resource utilisation, as proxied by the output gap. Equation (3) is a money demand relation, which is obtained from the optimal marginal conditions on consumption and money holdings, assuming money provides liquidity services that are valued by the agent along with consumption goods. It states that real money balances vary positively with income and negatively with the nominal interest rate.

Equations (1) and (2) are central to the new neoclassical synthesis view of macroeconomics. Assuming a household utility function that is additively separable between consumption and real money balances, these two equations describe the dynamics of inflation and output as a function of the short-term nominal interest rate *only*. Except for the nominal interest rate term appearing in equation (1), the system is block-recursive: the transmission mechanism of monetary policy operates solely via prices (the cost of borrowing), and not via quantities (eg the availability of credit or money holdings).

[23] Seminal examples of this line of thought can be found in Woodford (1997, 2002, Chapter 4), Goodfriend and King (1997), Clarida et al (1999, 2000), McCallum (2001) and the rightly celebrated book by Taylor (1999).

[24] The contemporaneous inflation rate is defined as $\pi_t = p_t - p_{t-1}$.

In principle, the first two equations could be made entirely autonomous, provided the interest rate manoeuvred by the central bank is itself made insensitive to any magnitude which does not appear in either equation (1) or equation (2). A very general formulation of such a rule is provided below:

$$i_t = \Phi\left(y_t, E_t y_{t+1}, \pi_t, E_t \pi_{t+1}, e_t, u_t\right) \tag{4}$$

where, notably, the set of indicators deemed relevant for policy does not include $(m - p)_t$.

Assuming this policy rule performs well - in a sense to be made explicit shortly - “the monetary sector [becomes] basically an afterthought to monetary policy analysis. The familiar LM curve only serves the purpose of determining the quantity of money given the price level, real income, and the nominal interest rate” (Kerr and King (1996)). In this context, equation (3) would appear superfluous. It only serves to specify the quantity of money needed to clear the money market at the interest rate dictated by the policy rule. Monetary dynamics are thus irrelevant to the determination of price developments and should not concern a central bank aiming at price stability.

Taking these results at face value, the autonomous (or moneyless) policy rule (equation (4)) is both analytically convenient and capable of simplifying the task confronted by a central bank. However, this prima facie view is insufficient.

(b) Is money useful as nominal anchor?

Technically, it is not sufficient to demonstrate that a moneyless rule exists which is *consistent* with a particular desired equilibrium. One has also to demonstrate that the desired outcome is the *unique* equilibrium associated with that rule. In other words, one has to demonstrate that the posited policy rule avoids situations in which the central bank, quite unintentionally, permits economic fluctuations (and, in particular, deviations from price stability) which arise solely from self-fulfilling expectations. If a policy rule were to tolerate these situations, not only would the response of the economy to exogenous (fundamental) shocks be indeterminate, but endogenous variables might also start reacting to random variables unrelated to the structure of the model (leading to “sunspot equilibria” where outcomes are determined solely by self-fulfilling private expectations).

Such a situation would clearly pose a severe problem for central banks: apparently well designed rules would not ensure price stability, at least under a sufficiently wide range of conceivable circumstances. This observation is what motivates the quest for uniqueness of equilibria in monetary models and gives justification to the role money can play as a nominal anchor in monetary economies.

(c) Two moneyless rules

The literature has pursued two different specifications of the autonomous or moneyless policy rules discussed above.

(c.i) Target rules in a linear-quadratic policy problem

According to the target rule approach, the interest rate rule for monetary policy is defined implicitly as the solution to an optimisation problem facing the central bank. In the literature it is often assumed that the central bank selects its interest rate policy by minimising a loss function expressed in terms of the deviations of inflation and output from mandated objectives (π^* and y^*), taking the structure of the economy as given:

$$L = \tfrac{1}{2} E_t \left\{ \sum_{j=0,\infty} \beta^j \left[(\pi_{t+j} - \pi^*)^2 + \lambda (y_{t+j} - y^*)^2 \right] \right\} \tag{5}$$

In most applications, the central bank finds the interest rate path which minimises a quadratic loss function expressed in terms of deviations of objective variables from target (equation (5)), subject to the linear constraints (equations (1) and (2)) of the new neoclassical synthesis model (hence "linear-quadratic").[25]

λ is the relative weight attached to output stabilisation in the central bank's policy preferences.[26] Can this linear-quadratic policy regime inoculate the economy against the risks of chronic instability which have been briefly described at the beginning of Section 3(b)?

The answer is: not always, at least under rational expectations. Under this regime, equation (4) takes the following form:

$$i_t = \chi_0 + \chi_1 e_t + \chi_2 u_t \tag{4a}$$

for an appropriate specification of the constant term χ_0 and the reaction coefficients χ_1 and χ_2. However, as proved by Woodford (1999) and Svensson and Woodford (2003), the model defined by equations (1), (2) and (4a) admits a large multiplicity of bounded solutions, in the hypothesis that private expectations fully internalise the authorities' reaction function (4a) as part of the policy regime which they face. These include both solutions implying different equilibrium responses to fundamental shocks (e_t and u_t), and solutions involving responses by the central bank to non-fundamental states of the economy, such as sunspots in private expectations.

At root, this multiplicity result stems from: first, the rational expectations definition of an equilibrium, which, by itself, makes the economy particularly sensitive to revisions in expectations; and second, the possibility that a policy of elastic currency leads the private sector to actually *act* on those expectations by drawing more or less money from the central bank at the fixed policy rate. In such an environment, a policy rule like equation (4a) - which specifies each period's nominal interest rate as a function solely of exogenous states or shocks - does not provide the economy with a defence against off-equilibrium revisions in expectations.[27, 28]

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[25] Formulating the problem using this linear-quadratic specification has presentational and computational advantages. In particular, it yields linear policy rules which are invariant to (additive) uncertainty, ie they exhibit so-called certainty equivalence. However, it is not certain whether such a loss function is a good approximation for central banks in practice. This is particularly relevant for central banks which have a price stability objective or a clear inflation target and no or only a subordinated mandate to simultaneously contribute to output smoothing.

[26] The linear-quadratic (or "target rule") approach to monetary policy has been strongly advocated by Svensson (1999a, 1999b).

[27] Two issues related to the characterisation of target rules given above need to be kept distinct. One issue is whether a reaction formula such as (4a), which results from the solution to the linear-quadratic dynamic programming problem represented by (1), (2) and (5), *can* be consistent with an optimal equilibrium in which inflation remains solidly anchored around the target value π* and inflation and output evolve solely as a function of the fundamental shocks identified in the structural representation of the model. A distinct issue is whether such situation is the *unique* possible non-explosive solution to the equilibrium conditions which can be supported by a reaction rule such as (4a). Or there may exist other possible equilibria which are equally consistent with (4a) but imply (undesirable) dynamics of the model state variables, whereby these variables fluctuate in unpredictable ways in response to the fundamental shocks (and, in addition, may also respond to non-fundamental shocks which have no analytical representation in the equations describing the structural dynamics of the model). In this respect, one should bear in mind that many numerical experiments available in the literature on the performance of target rules of the sort described in Section *c.i.* are either conducted on the basis of backward-looking models, or – in case they use a purely forward-looking structure as in the text above – do not explicitly tackle the issue of uniqueness or, similarly, assume that private expectations do not internalise (4a) when forming expectations of policy action. An example of the first approach is Rudebusch and Svensson (1999), which will be further discussed in Section 4 below. An example of the second approach is Clarida et al (1999) and Jensen (2002a). These two papers are briefly discussed in footnote 31. It should also be borne in mind that the failure of a rule like equation (4a) to induce determinacy is not confined to the case of rational expectations. Evans and Honkapohja (2001) discuss the case in which private agents revise expectations according to an adaptive learning mechanism while the central bank solves its model under a rational expectations assumption. They show that in this case private expectational errors - due to learning - do not receive an adequate response by the central bank, which only reacts to the fundamental shocks, ut, and et. Hence, expectational errors of the past tend to become ingrained and lead to a process of cumulative divergence of the economy from the rational expectations equilibrium.

[28] Woodford (2000b) discusses analytical ways to circumvent indeterminacy problems in purely forward-looking inflation targeting environments of the type expounded in this Section. These solutions generally involve recourse to optimal delegation schemes whereby the loss function assigned to the central bank is modified relative to the one which reflects the 'true' preferences of society – a function of quadratic deviations of output from potential and inflation from target, such as in (5) – by inclusion of additional lagged values of target variables. The purpose of these additions is to induce an implied reaction rule which makes the nominal interest rate a function of lagged endogenous variables in addition to the terms figuring in (4a). Dependence of the reaction function on such variables is a necessary – though not sufficient – condition for determinacy. Examples of such delegation schemes include the options of charging the central bank with stabilisation of the

To conclude this subsection, rules derived within the target rule framework (whereby the monetary authority reacts to the fundamental shocks hitting the economy) do not appear to pass the test of uniqueness. Rather, in extreme circumstances, they could lead to bursts of inflation deriving from self-fulfilling changes in expectations.[29]

(c.ii) Moneyless instrument rules: the Taylor principle

A second family of policy rules which can "close" the model without reference to equation (3) are those in which the policy interest rate is made a direct function of endogenous variables, such as inflation and output (eg Taylor (1993)).

Recent variants of this approach typically use expected (instead of realised) inflation, as in the following specification:

$$i_t = r^* + \pi^* + \alpha\,(E_t\,\pi_{t+k} - \pi^*) + \beta\,(y_t - y^*) \qquad (6)$$

where r^* is a parameter of the system (the equilibrium real interest rate) and k is some forecasting horizon deemed relevant for monetary policy.

Clarida et al (1999, 2000) provide a thorough investigation of the properties of a system in which the central bank behaves according to equation (6). They conclude that a sufficient condition for the rational expectations equilibrium to be unique in a macroeconomic model similar to equations (1) to (3) is that the interest rate instrument be made to increase more than one for one in response to increases in forecast inflation, ie $\alpha > 1$.[30, 31] The numerical constraint that $\alpha > 1$ has come to be known

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price level – rather than inflation rate – as in Vestin (1999), and the proposals to include a nominal output growth term (Jensen, 2002b) or an interest rate smoothing term (Woodford, 1999) in the central bank's assigned loss function. Svensson and Woodford (2003) take a step further by exploring history-dependent variants of inflation targeting which are inherently robust to multiplicity problems. They conclude that robustness of this kind can be achieved within an inflation forecast targeting universe only at the cost of contaminating the dynamic optimisation analytics of a pure targeting procedure with elements of commitment to an instrument rule of the type that is discussed in the text under Section *c.ii*. In particular, they show that a way to achieve determinacy is to amend the general targeting procedure described in the text with a commitment to a particular direct interest rate response, whereby the central bank reacts to deviations of private expectations of inflation and output gap from the central bank's forecasts. The relative intricacy of this solution, however, seems at odds with the simplicity and transparency of inflation targeting in its pure original incarnation described, say, in Svensson (1997, 1999a).

29 A distinct issue is whether a target rule such as the one described in this section - and involving a monetary policy reaction function of the type represented in equation (4a) - is welfare-optimising or can be found to be dominated by an alternative rule obtained under precommitment. As shown in Woodford (1999), discretionary policymaking in a model incorporating forward-looking behaviour is indeed typically characterised by a stabilisation bias, ie it may lead to a suboptimal degree of proactivism in the central bank response to shocks (via equation (4a)). Therefore, when agents' decisions depend on their expectations of the future state of the economy - as in the model sketched in equations (1) to (3) - there are gains to be had from a more inertial pattern of response. Woodford (1999) and Svensson and Woodford (2003) investigate various mechanisms which can induce inertia in discretionary monetary policymaking, among which they propose a number of optimal delegation schemes whereby the central bank is assigned an appropriately modified loss function. More recently, Söderström (2001) has investigated whether assigning the central bank a loss function which includes a term in money growth can indeed induce the type of inertial behaviour which can be expected to enhance welfare. Since money is demand-determined in his model, its rate of growth is related to the change in the nominal interest rate and the growth rate of output. Therefore, he concludes: "a suitably designed target for money growth may introduce inertia in to the discretionary policy rule, leading to improved outcomes". He also notes that "this mechanism is entirely due to money being related to other variables in the economy, and not due to any indicator role for money".

30 Bernanke and Woodford (1997) come to broadly the same conclusions using a model similar to equations (1) and (2) but with a slightly modified timing of price revision by firms.

31 Strictly speaking, Clarida et al (1999, 2000) find that □ > 1 is a sufficient condition for determinacy only when □ = 0 and the stabilising threshold of □ dips below unity as □ increases. They also establish an upper bound for □ beyond which determinacy conditions are violated. This upper bound is well above the numerical value for □ which was conjectured by Taylor (1993) to be stabilising. However, the result of Clarida et al and the similar result of Jensen (2002a) - within an inflation forecast targeting environment similar to the one expounded in Section *c.i.* - that determinacy can be achieved in a forward-looking model by postulating that the central bank is committed to a rule that makes the policy interest rate a sharply increasing function of expected future inflation has been questioned by Svensson and Woodford (2003). They contend that such a monetary policy reaction function may not be "a fully operational specification of the monetary policy rule […] as the central bank's instrument is expressed as a function of endogenous variables (conditional expectations of future inflation and output) that themselves depend upon current monetary policy. In practice, the bank would have to forecast the paths of the endogenous variables, given its contemplated action. This forecast should depend only upon information about the exogenous disturbances, and the bank's contemplated policy; thus, an operational version of the

in the most recent debate as the *Taylor principle*, as it was first conjectured in the seminal Taylor (1993) article.

The issue in this subsection is thus whether this policy prescription - which suggests that it is sufficient for central banks to ignore money and set interest rates solely on the basis of non-monetary indicators - is robust across a sufficiently broad array of variations to the basic model sketched above. The answer developed here is once more: no, at least under rational expectations. In what remains of this subsection we shall therefore review the cases in which *the Taylor principle - by itself - fails to deliver a unique and determinate solution to the policy problem* of keeping macroeconomic magnitudes safely anchored to the stated objectives of policy.

(ii.1) The Taylor principle with a non-Ricardian government

The macroeconomic model described by equations (1) and (2) and the policy rule (equation (6)) is not only moneyless; it also lacks any form of interest-yielding public liability. This is difficult to justify since, in general, the nominal interest rate set by the central bank will affect the terms at which the public debt is rolled over.

Only if the fiscal authority always stands ready to adjust its primary surplus in response to any past development which caused a deviation between the actual stock of public debt and some specified long-term target can the relationship between interest rate and public finances be ignored. For this to be the case, any interest rate increases implemented by the central bank in pursuit of price stability would have to be accompanied by an appropriate fiscal response to offset the consequences of higher real borrowing costs for the rate at which public debt is accumulated (eg in the case of higher real interest rates, the primary surplus would have to increase). Leeper (1991), in a seminal contribution, defined such fiscal arrangements as “passive”. More recently, Woodford (2000a) refers to such accommodating fiscal regimes as of a “Ricardian” type.

In a less than Ricardian fiscal regime, the macroeconomic system (equations (1) to (3)) is *incomplete*. One needs to augment it with the government flow budget constraint to check the determinacy conditions. However, the conditions turn out *not* to be satisfied if the inflation coefficient in equation (6) is above unity.[32]

Moreover, Woodford (2000a) has shown that even the existence of a debt limit that *eventually* constrains the growth of public debt is not sufficient for the fiscal regime to qualify as “Ricardian” in Woodford’s sense. If the fiscal authority is ultimately committed to modify its course once some extreme debt limit is breached, but is nonetheless less than forthcoming in reacting to changes in monetary policy *before* that limit is approached, then a monetary policy rule embodying the Taylor principle (like equation (6)) would *not* - by itself - guarantee price stability. As shown by Woodford, in these circumstances, the equilibrium would be characterised by an inflationary spiral, in which progressively higher rates of inflation lead to higher real interest rates, hence higher rates of growth of nominal government liabilities, which in turn lead to higher rates of inflation.[33]

These findings suggest that a monetary policy regime which blindly responded to inflation forecasts and the output gap while respecting the Taylor principle would wind up accommodating inflationary developments. Asset *stocks*, eg money, by contrast, may be a useful source of information for monetary policymakers which helps to stabilise the economy.

policy rule, in which the central bank’s procedure is completely specified as an algorithm, is equivalent to a rule that sets the nominal interest rate as a function of the exogenous disturbances, and leads to indeterminacy”.

32 Technically, the system would then have four equations: (1) to (3) and the flow budget constraint of the government. It can then be shown that, with a less than Ricardian fiscal authority, one needs $\square < 1$ in order to obtain two stable and two unstable eigenvalues. The latter are needed because the set of endogenous variables include two predetermined and two “jump” variables.

33 The irony in this is that a monetary policy rule that would conventionally be thought to be anti-inflationary may instead lead to an inflationary spiral when combined with an unsuitable fiscal policy. A monetary policy episode which could confirm these perverse dynamics was studied by Loyo (1999).

(ii.2) The Taylor principle with liquidity constraints

As we argued above, equations (1) to (3) constitute a reduced-form representation of an underlying money-in-the-utility structural model with a zero cross partial derivative between consumption and real balances. A key issue, which we have left in the background so far, is what measure of money appears in the utility function.

In the conventional specification discussed above, the implicit assumption is that the liquidity services which are valued by the representative agent are associated with the real money balances the agent holds at the end of the period *after* all market transactions have been concluded. This seemingly innocuous timing assumption has a very important implication: goods can be exchanged for other goods and for bonds without the intermediation of money.

However, money is typically seen as distinct precisely because it acts as a medium of exchange. In other words, the conventional new neoclassical synthesis model - in the version above - does not seem adequately to capture the fundamental rationale which underlies the demand for a non-remunerated asset like money, ie while inflicting a cost in terms of forsaken interest, money helps to facilitate a number of transactions which would not otherwise be possible. Holding currency *before* commencing trading may be what provides agents with the utility services which motivate a monetary economy in the first place.

Carlstrom and Fuerst (2001a) amend the model to allow for a genuine transactions role of money. They assume real money balances enter the utility function at the *beginning* of the period, before trade in goods takes place. The Taylor principle does not survive this amendment for a model calibration similar to that used by Clarida et al (2000). The same result - that real determinacy requires an inflation coefficient in equation (6) below unity - is derived by Christiano and Rostagno (2001a,b) and Benhabib et al (2001c). The first two papers use a suite of cash-in-advance and limited participation models with flexible prices and an elastic labour supply. The third paper uses a money-in-the-production-function framework. All papers uncover indeterminacy and/or equilibrium cycles under a rule embodying the Taylor principle.

Here, again, a minor (timing) modification to the underlying framework suffices to overturn the basic policy message. A monetary policy blindly following the Taylor principle and ignoring monetary developments is associated with an indeterminate equilibrium, where the economy is left without an anchor and fluctuates unpredictably around the “virtuous” equilibrium.

(ii.3) The Taylor principle from a global perspective

It should be emphasised that equations (1) to (3) are derived by linearising a set of non-linear optimal conditions around a non-stochastic steady state. However, any analysis based on linearisation must be interpreted as being local in a neighbourhood of the steady state and only valid under sufficiently small perturbations of the system. How small must the perturbations be to justify such a local analysis?

An emerging strand of literature has started to investigate the properties of Taylor rules such as equation (6) from a global perspective, ie removing the assumption that perturbations are necessarily small. Benhabib et al (2001a), for example, convincingly argue that the standard practice of studying monetary models in a small neighbourhood of the steady state can generate a misleading impression about the set of possible equilibrium outcomes. In particular, even in cases in which rules embodying the Taylor principle guarantee uniqueness of the rational expectations equilibrium *locally*, they may fail to do so *globally*. They construct a money-in-the-utility model which closely resembles the one underlying equations (1) to (3) and impose a monetary policy reaction function which explicitly acknowledges the zero lower bound on nominal interest rates.[34] They find that the mechanical implementation of a Taylor-like monetary policy rule founded on the Taylor principle per se can trap the economy in perverse dynamics. Along these trajectories, explosive inflation expectations - even if divorced from underlying economic fundamentals - end up being systematically validated by the

[34] The “lower bound problem” arises from the fact that in a monetary economy the central bank cannot engineer negative nominal interest rates as long as its counterparts retain the option to hold zero interest currency.

central bank.[35] In other words, they uncover an uncountable number of equilibrium trajectories - invisible from the point of view of the conventional local analysis - which originate in a vicinity of the "virtuous" steady state, and finally converge to a situation in which the nominal interest rate is zero and the monetary policy becomes ineffective.

All that is needed for the economy to start the slide towards the lower bound is that agents - for some reason - come to expect the economy to enter a deflationary phase. In these circumstances, interest rates are constantly being lowered in response to the observed fall in price inflation, and in an attempt to reverse the persistent decline in inflation. However, these efforts are to no avail, because expected future inflation may fall - along a possible equilibrium trajectory - at the same time and ex ante real interest rates are not reduced and continue to be high enough to restrain demand despite falling prices.[36]

(c.iii) Caveats

Are the sort of multiplicity and stability problems associated with moneyless policy rules something which real world central banks should worry about? Or are they to be confined to the realm of analytical curiosa? In particular, is it likely that some sort of horse race dynamics between an always proactive central bank and constantly overpessimistic private sector expectations may finally ensue which can lead the economy to spiral down to the lower bound? The judgment is still pending and different leading authors hold quite diverging views on this issue of policy relevance. McCallum (2001) maintains that conclusions based on bubbles and indeterminacy arguments are of dubious merit and many of these vanish under a minimum-state-variable criterion for equilibrium selection. Woodford (2002, Chapter 2), on the opposite side, takes these problems seriously. For example, while conceding that "the economy can only move to one of [the downward-spiralling] alternative paths if expectations about the future change significantly, something that one may suppose should not easily occur", he acknowledges that "one must worry that a large shock could nonetheless perturb the economy enough that expectations settle upon another equilibrium".[37]

At the very least, a central bank should note that perverse inflation dynamics have been encountered in simulation exercises of calibrated models used widely in the literature. For example, Rudebusch and Svensson (1999) acknowledge that their experiments with simple versions of Taylor rules such as equation (6) imply that "nominal interest rates would be negative a non-negligible portion of the time". They go on to say that "intuitively, with an estimated equilibrium real funds rate of 2.5%, if inflation ever falls to, say, –3%, then, with a zero nominal funds rate, the real funds rate is still restrictive, so the output gap decreases and inflation falls even further".

Christiano and Gust (1999) show that the set of policy elasticities to inflation and the output gap under which a Taylor-like rule becomes a source of instability within a limited participation model - with a cash-in-advance timing - is much broader than for conventional specifications of sticky-price and money-in-the-utility models.[38] Experiments conducted on the basis of an "eclectic" macro-model

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[35] In other words, an "expectational bubble" can emerge in the price level if the central bank pursues a Taylor-like rule with an inflation coefficient greater than unity.

[36] Is this scenario, in which monetary authorities and the private sector in a sense "chase each other" along a sliding path to zero interest and negative inflation rates, a reasonable description of what could happen? Some scholars argue that it is, at least in the case in which the "way to go" between the target stationary equilibrium and the "liquidity trap" stationary equilibrium is sufficiently short and the Taylor coefficient on inflation in the monetary authorities' reaction function is sufficiently large. Benhabib et al (2001a) describe the current situation in Japan as possibly the outcome of such perverse dynamics.

[37] The emerging strand of literature on adaptive learning is also split. Bullard and Mitra (2000) find that, under a forward-looking Taylor rule such as equation (6), the equilibrium with adaptive learning is determinate. By contrast, Carlstrom and Fuerst (2001b) demonstrate the existence of learnable sunspot equilibria in a cash-in-advance model when both the central bank and the private agents learn adaptively. They also prove that, when the central bank is subject to a learning process, while private sector expectations are always rational, sunspot equilibria are always learnable, and thus are indeed a cause for concern.

[38] The limited participation model introduces a friction into the workings of the financial markets to the extent that, due to rigidities in portfolio adjustments, a monetary injection at time t is disproportionately absorbed by financial intermediaries and thus channelled to finance investment rather than consumption. This assumption is what allows the model to generate an impulse-response pattern whereby a surprise monetary injection is followed by a fall in the equilibrium nominal rate of interest (liquidity effect) and a rise in output. By contrast, these features are not easily reproduced by competing new

proposed by Christiano et al (2001) - conflating different sources of nominal frictions, liquidity effects and consumption and investment inertia in a rich stochastic general equilibrium context - confirm that forward-looking proactive Taylor rules produce excess volatility. The same indeterminacy problems are encountered by Levin et al (2001) for forecast-based Taylor rules at horizons exceeding one year ahead across a number of competing models incorporating rational expectations, short-run nominal inertia and long-run monetary neutrality.

This evidence, of course, releases a warning signal in a central bank profoundly concerned about the robustness of its policy course. At the very least, the theoretical and simulation results surveyed in this subsection suggest that decision-makers should broaden - rather than narrow - the set of indicators which they routinely look at to inform decisions. Identifying moneyless policy rules - in the sense defined above - for the sake of parsimony may not be a useful exercise. Moreover, the consequences of adopting a rule narrowly focused on a handful of indicators to the exclusion of others may turn out to be unpleasant. Whether money could help in this quest for a broader perspective, even within seemingly moneyless models, is the subject of the next section.

(c.iv) Addressing the pathologies associated with moneyless rules

Monitoring monetary developments can protect the economy against some of the pathologies associated with moneyless monetary policy rules described in Section 3(c) above. Although there are parameterisations and timing assumptions in variants of the new neoclassical synthesis model under which conventional Taylor rules lead to good macroeconomic outcomes, other plausible parameterisations and timing hypotheses exist in which these moneyless policy rules may lead to bouts of inflation or deflation. At root, this is because moneyless interest rate policy rules can - under the latter assumptions - be supported by various rates of monetary growth. Each of these money growth rates is associated with a different real outcome for the economy. A central bank concerned with robustness should adopt a monetary policy strategy that would *also* be effective with regard to its objectives if the economy were better described by the latter set of model assumptions than the former. Such an approach would thus seem to rule out the adoption of moneyless Taylor-like rules.

In circumstances where conventional moneyless rules fail, a policy of money growth monitoring can, in effect, provide the economy with an anchor. Christiano and Rostagno (2001a, 2001b), for example, postulate a policy framework in which a Taylor rule based strategy is followed as long as money growth falls within a specified target range. If that target is ever violated, however, the Taylor rule is abandoned in favour of a Friedman-like constant money growth rule.[39] They show that the latter escape clause can provide the plain Taylor reaction function with the “servomechanism” needed to remove the undesired trajectories - to which the Taylor rule may lead - from the space of possible events.[40]

neoclassical models, which postulate various sorts of price rigidities. A description of models of this type is provided by Christiano et al (1997).

39 This policy is shown to be benign and non-interfering with the operation of the Taylor rule in the case of a model à la Clarida et al (1999, 2000). On the other hand, it would improve economic performance substantially, by eliminating undesired equilibria, if the economy were to be better represented by a cash-in-advance model.

40 It is open to debate whether the switch from a Taylor rule to a Friedman rule would involve a change in the operating procedures used by the central bank, ie whether the central bank would have to renounce its practice of setting a target for a short term interest rate (in a way consistent with the Taylor-rule prescriptions) and begin announcing short-run targets for money growth. In the latter case, it would appear to be of relevance to ensure that the aggregate for which a target is announced is controllable by the monetary authorities with a sufficient degree of precision. Historical experience is indeed consistent with the notion that a switching rule of the type discussed in Christiano and Rostagno (2001) may be implemented both by a continuation of the interest-rate-centred operating procedure and by a change in the operating procedures in favour of one centred on money quantities. Mayer (2001), for example, explains that when the Federal Reserve started setting short-term targets for M1 in January 1970 - reflecting disappointment with recent macroeconomic performance - it established them in the form of the two-month (in 1975 extended to annual) target growth rates. The federal funds rate was then calibrated to a level estimated to be consistent with hitting the broad money growth target. Conversely, when in October 1979 - out of fears that inflation may have gotten out of control - the Fed embarked on a decisive policy of monetary contraction, it seemed natural to mark the policy change with a discontinuation of the practice to set a target for the funds rate. However, the need to express the money target in terms of a broad aggregate did not seem to pose a problem of controllability of the new target. Mayer states that: “Policy was implemented during this period by estimating the total reserve growth [ie the intermediate target for the narrow monetary aggregate under authorities’ control] necessary to meet the money growth target [for the broader official target aggregate] and by holding to the associated path for non-

The more extreme pathologies associated with non-linearities can also be cured by a suitable transition to a different operating scheme centred upon the targeting/control of monetary aggregates. Benhabib et al (2001b) study the virtues of such a switching regime in the context of providing insurance against the liquidity trap. Svensson (2001) also appeals to the standing possibility for a central bank, at any time, to abandon a Taylor rule and start expanding the money stock by means of purchases of foreign exchange.[41] Interestingly, apart from the general doubts on the usefulness of Taylor rules for actual policymaking, even among proponents a consensus is emerging on the need to scrap any Taylor-like strategy, should the threat of a deflationary trap materialise. However, this implies that a fully credible commitment to the Taylor rule alone would not be possible in the first place.

The key message contained in these contributions is that the announcement of a definition of price stability - or, alternatively, an inflation or price level target - while a major constituent element of a monetary framework founded on price stability, does *not* in itself constitute a sufficient guarantee that such an objective will be attained, unless the announcement is supported by a stabilising "rule" which specifies the central bank moves conditional on protracted deviations from equilibrium. This rule is the second major element needed to anchor expectations. Underlying this logic is a sharp distinction between an *equilibrium condition*, an *objective of policy*, and a fully operational specification of the *monetary policy rule*. A target for inflation or for a price level may be an equilibrium condition (ie a state of affairs that one observes ex post). It may be announced as the objective of policy (ie a central bank may choose to announce, say, an inflation or price level target as the medium-term aim of its policy). But it will never constitute an operational version of a strategy, ie a complete description of the bank's decision procedure as an algorithm for action. The latter can only be described in terms of how the bank intends to steer its *instruments of policy* (ie either a short-term interest rate or some measure of the stock of outside money in circulation) in the face of the various contingencies, as the situation may dictate. And, notably, it is the expectation of a systematic response of such instruments to off-equilibrium states which is key in sustaining a virtuous equilibrium. Ultimately, it is the off-equilibrium prescriptions of a policy framework - of any type - which make the framework credible.

The fact that such off-equilibrium prescriptions may involve a distinctive role for monetary aggregates, as information variables and triggers of action, as well as possibly as an instrument of policy alternative to the short-term interest rate, is no accident. Take the example of the liquidity trap. In Krugman's (1998) words: "A liquidity trap involves a type of credibility problem. A monetary expansion that the market expected to be sustained (that is, matched by equiproportional expansions in all future periods) would always work [in lifting the economy off the trap]. If monetary expansion does not work, if there is a liquidity trap, it must be because the public does not expect it to be sustained." The threat to abandon a "moneyless" interest-based policy rule and to switch to a monetary policy rule involving the implementation of a constant rate of growth for the money base - as in Christiano and Rostagno (2001a) - serves precisely this purpose. To make that monetary expansion credible, the central bank needs to provide a detailed operational specification, ie a complete description of the way the central bank will manage its instrument of policy from the time in which the zero lower bound is hit onwards. This operational specification has to make clear that the money supply will have to be increased by enough to render that equilibrium untenable, so that expectations will have to coordinate on a different equilibrium, namely the one dictated by the central bank's objective.[42]

borrowed reserves. In the process, the federal funds rate was free to move to whatever level would be consistent with the money growth objective over time." Mayer's rationale for the switch of focus in policy which occurred in 1979 seems to be consistent with the story told in Christiano and Rostagno (2001). He argues that "monetary policy was focused on steadily reducing inflation, and policymakers were less certain about what increase in nominal and real interest rates would be required to achieve the objective of reducing inflation than they were about the money-inflation relationship." (page 8). This is a rather vivid manner to describe the role of money in 'emergency' situations in which policymakers find alternative money-less rules a less reliable guide for policy adjustment.

41 Other papers rely on the argument that other policies (eg fiscal policy) could be used to stimulate the economy in a deflationary situation.

42 The above notwithstanding, there are other solutions to the instability or indeterminacy problems associated with conventional money-less policy rules, which do not require explicit reliance on monetary aggregates. Money-less rules providing off-equilibrium responses to non-fundamental shocks to expectations are proposed in Svensson and Woodford (2003) within the context of inflation targeting procedures. We refer the reader to footnote 28 for a brief discussion of these rules.

4. Robustness and the role of monetary developments in monetary policy rules

(i) Models of monetary policy transmission and their implications for monetary policy rules

The preceding section has demonstrated that apparently small deviations from the benchmark New Keynesian macroeconomic model may have profound implications for the design and conduct of monetary policy. At the theoretical level, when conventional monetary policy rules are employed, such deviations from the benchmark model permit indeterminacy and multiplicity of equilibria. In practical terms, this suggests that the mechanical pursuit of Taylor-like rules for monetary policy exposes an economy to the risk of significant instability and substantial deviations from price stability.

The pathologies associated with indeterminacy and multiplicity are not the only implications of varying the assumptions underlying the standard model. Variations to the benchmark New Keynesian model also have implications for the transmission mechanism of monetary policy and thus for the performance of any given monetary policy rule against the loss function described by equation (5). For example, if the assumption that money balances and consumption are weakly separable in the utility function (implicit in the standard New Keynesian model) is relaxed, money balances will enter both the dynamic IS and Phillips curve equations (equations (1) and (2), respectively). Similarly, adopting the Carlstrom and Fuerst (2001a) cash-in-advance timing assumption will result in a role for monetary dynamics in the transmission process. In either case, the performance of monetary policy rules which are designed to preserve price stability around the steady state defined by the linearised relationships analogous to equations (1) to (3) will be affected by how the central bank chooses to vary the short-term interest rate in response to monetary dynamics.[43]

At this stage, one does not need to stake out a definitive position regarding these underlying and rather technical assumptions about how money balances enter the representative agent's utility function in a dynamic general equilibrium model. Such assumptions are anyway hard to distinguish or verify empirically. One can simply argue that, in pursuing their objective of price stability, monetary policymakers would be ill advised to rely *solely* on the results of the benchmark New Keynesian model, which appear rather fragile in the face of small (and difficult to reject) variations to the underlying economic structure. In other words, central banks should not ignore completely the insights provided by variations to the benchmark model - especially those which give some role to money - given the long and influential pedigree of money-based analysis in monetary policy design and implementation.

All models are necessarily an abstraction from, and thus a simplification of, reality. Each model emphasises some aspects of the monetary policy transmission process while obscuring others. In some circumstances, the simplifications implied by the benchmark New Keynesian model may provide a better insight into the challenges facing monetary policy. Other circumstances may favour analyses conducted using variants of that benchmark model, which give a more important role to monetary and financial dynamics in the transmission process. Relying on one model to the exclusion of all others appears misguided.

Policymakers therefore need to integrate analysis conducted using a variety of macroeconomic models into a single process for taking monetary policy decisions. This has led to broad acceptance of the view that central banks should base their policy decisions on a suite of models and tools, rather than relying on a single model for policy advice (eg Bank of England (1999), Pill (2001), Selody (2001)).

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[43] Comparing these variants with the benchmark New Keynesian model, one might argue that two distinct characterisations of monetary policy transmission exist (Engert and Selody (1998)). One tradition (embodied in the work of monetarists, such as Milton Friedman and reflected in the variant models discussed in the main text) views money as central to the determination of the price level. Monetary dynamics therefore play an *active* role in the transmission mechanism. The other tradition (reflected, for example, in the benchmark model) characterises price dynamics as an outcome of interactions between supply and demand and cost pressures. Within this paradigm, monetary developments do not play an active role in monetary policy transmission, but rather reflect the evolution of the arguments of money demand. Money therefore plays a *passive* role in price level determination. However, in the latter framework money may be a good indicator of future prices to the extent that it reflects underlying trends in nominal GDP.

At the very least, the number of variants to the benchmark New Keynesian model used for the analysis of monetary policy reflects substantial continued uncertainty surrounding the monetary policy transmission mechanism. A well designed monetary policy rule or strategy has to confront and overcome this uncertainty.

A substantial literature has considered the conduct of monetary policy in the face of uncertainty (eg ECB-CFS (2000)). With regard to uncertainties about the structure of the economy (typically labelled model or paradigm uncertainty), McCallum (1988) has suggested the following approach. In his view, a well designed monetary policy rule should "perform well" across a set of plausible competing reference models that spans a broad spectrum of model uncertainty. Levin et al (2001) have implemented this approach for New Keynesian models of the US economy. The models investigated by Levin et al are estimated using different data and with somewhat different specifications, but that are all essentially of the benchmark type.[44]

However, following Selody (2001), it is natural to extend McCallum's robustness criterion to encompass analysis under a broader set of variants of the benchmark New Keynesian framework, rather than focusing solely on that benchmark to the exclusion of other models. Therefore, effective monetary policy should perform well in a variety of models of the transmission mechanism, spanning those where money has a structural role in dynamic IS and/or Phillips curve equations and those where it does not (ECB (2000)).[45]

Drawing on the work of Gerdesmeier et al (2002), the remainder of this section investigates these issues. To illustrate our analysis, we use two very simple analytical models, which are described in the Appendix. The benchmark model embodies output gap and Phillips curve equations; the other is a simple P* framework (Hallman et al (1991)).[46]

As described in Section 2, the available empirical evidence for the euro area suggests that the money stock has a stable relationship with the price level (conditional on developments in other macroeconomic variables) and exhibits leading indicator properties for inflation. In the context of the analysis presented here, it is particularly noteworthy that the P* model has empirical support in both the euro area (eg Gerlach and Svensson (2002)) and also - albeit more controversially - in the United States (eg Orphanides and Porter (2001)). While certainly not conclusive, such evidence offers some loose empirical support for the plausibility of variants to the benchmark New Keynesian model that give some role to monetary variables in the transmission process.

In the manner of Rudebusch and Svensson (1999), both the benchmark and P* models are kept extremely simple for expositional purposes.[47] In particular, we choose to use backward-looking specifications, thereby avoiding many of the problems of determinacy and instability discussed in Section 2. Moreover, by using linearised models around a carefully selected steady state, we limit ourselves to discussion of small perturbations from an equilibrium associated with price stability. We thus focus on how monetary policy should respond to economic shocks (including monetary shocks) in the vicinity of this desired steady state, given uncertainty about the transmission mechanism.

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[44] More recently, Levin and Williams (2002) have extended their approach to an analysis of forward- and backward-looking Phillips curve models of US monetary policy.

[45] One might argue that this approach involves giving preference to monetary policy rules or strategies that avoid bad outcomes (ie instability or indeterminacy of the price level) even in adverse circumstances. This follows Brunner and Meltzer (1968), who - anticipating by some 30 years Hansen and Sargent's (2000) application of robust control theory to monetary policy - advocate monetary targeting on the basis that it provides the least harmful policy framework given the uncertainty surrounding the structure of the transmission mechanism.

[46] The specification of the passive money model is a simplified version of the model estimated by Rudebusch and Svensson (1999) (and subsequently employed by Levin and Williams (2002)). The specification of the active money P* model is that suggested by Svensson (2000).

[47] Rudebusch and Svensson (1999) argue that using simple, backward-looking linear models of the transmission mechanism is preferable for expositional purposes because well known optimal control techniques (Sargent (1987)) can be applied straightforwardly, increasing the transparency of the results.

Following much of the recent academic literature, we characterise monetary policy within our simple analytical framework as a contingent policy rule for short-term nominal interest rates.[48] Our analysis then proceeds in two steps. First, we discuss the role of monetary developments in optimal interest rate policy rules within the P* model, which here is seen as representing a variant of the benchmark model where money enters the Phillips curve equation and thus has an active role in the transmission mechanism. The resulting policy rule is compared with the optimal rule derived from the benchmark approach. Second, we discuss how monetary developments should affect interest rate decisions when policymakers entertain both the benchmark model and variants to it, as McCallum's robustness criterion requires.

(ii) Optimal policy rules in the two models - the role of monetary developments

Adopting the quadratic central bank loss function that has become standard in the academic literature (equation (5)), conventional techniques can be used to derive optimal monetary policy rules for the two models considered here. Given the simplicity of the models, these rules can be expressed as linear functions of the four state variables: inflation, the output gap, and current and lagged values of the real money gap.[49] These rules are shown in the Appendix. In the main text we summarise some of the simple but important results that follow from this exercise.

Once money enters the structural equations of the transmission mechanism, monetary developments are an argument of the optimal policy rule. Svensson (1997) has shown that optimal monetary policy should respond to the determinants of inflation, not inflation itself. Within the variant to the benchmark model where money enters the Phillips curve, monetary developments are a determinant of price dynamics and thus should influence interest rate decisions that aim to maintain price stability. By the same token, monetary developments do not affect price dynamics in the benchmark model (as already noted in Section 3). Optimal monetary policy for that model will thus be independent of monetary dynamics.

However, even within the variant to the benchmark model where money plays a role in the Phillips curve, the optimal monetary policy cannot be characterised *solely* as a response to monetary developments. The influence of monetary developments on interest rate decisions should be *conditional* on developments in other macroeconomic variables. In other words, variables such as the output gap and inflation also enter the optimal monetary policy rule in variants to the benchmark model (when represented by the P* model). This result has a number of practical implications.

First, as shown by Svensson (2000), even the simple P* framework adopted here does not necessarily provide support for naïve characterisations of monetary targeting. (Intuition would anyway not suggest favouring monetary targeting within the benchmark New Keynesian framework.)

In other words (and adopting the terminology suggested by Svensson (1999a)), even in the context of a simple P* model, the optimal monetary policy rule is neither a simple money-based instrument rule of the form:

$$i_t = \varphi\,[(\ln \mathbf{M}_t - \ln \mathbf{M}_{t-1}) - k\,] \qquad (7)$$

nor an intermediate monetary targeting rule defined (implicitly) as the solution to the following problem:

$$\textit{minimise} \quad E_0 \sum\,[(\ln \mathbf{M}_t - \ln \mathbf{M}_{t-1}) - k\,]^2 \qquad (8)$$

subject to the constraints implied by the structure of the underlying economic model.[50]

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[48] Of course, as a practical matter, we would not advocate mechanical pursuit of such a policy rule by central banks, since the exercise of informed judgment is a crucial component of any policy regime. Nonetheless, analytical exercises involving monetary policy rules constitute a useful reference point for policy analysis, giving the basis for a systematic (if not rule-bound) policymaking process (see ECB (2001c)).

[49] As in Gerlach and Svensson (2002), the real money gap is defined as the difference between the observed real money stock and the real money stock consistent with real output at potential and income velocity at its long-run equilibrium level.

[50] k is a benchmark rate of monetary growth, for example that consistent with the maintenance of price stability over the medium term.

Indeed, as shown in the Appendix, even in the simple models considered here, the performance of pure money-based rules such as equations (7) and (8) appears quite poor.[51] Pure money-based rules do not come close to mimicking the optimal policy rule in *either* the benchmark model *or* variants to it.

Second, the bivariate relationship between monetary dynamics (in particular, monetary growth) and optimal monetary policy (captured by the level of short-term nominal interest rates) is complicated by developments in other variables, and is therefore likely to be complex. On this basis, one should not anticipate a simple linear unconditional relationship between interest rates and monetary growth. Table 4 (in the Appendix) shows the bivariate correlations between inflation, monetary growth and interest rate in stochastic simulations of the two models, assuming the central bank follows the associated optimal policy rule. The bivariate correlations between monetary growth and interest rates are quite low, reflecting the complex and conditional nature of this relationship.[52]

Finally, the analysis in the Appendix demonstrates that the relationship between optimal interest rate decisions and monetary developments is shock-specific. In both simple models of monetary transmission entertained here, the bivariate relationship between monetary growth and interest rates depends on whether there is a demand shock, a supply shock or a monetary shock. In response to some shocks, the optimal monetary policy response in the face of rapid monetary growth may be a large immediate rise in interest rates. In response to other shocks, the optimal monetary policy response in the face of rapid monetary growth may be smaller and more gradual. Indeed, in some contexts, faster monetary growth may point to no interest rate change or even an interest rate cut.[53] Again, this suggests that interest rate changes should not be mechanically linked to monetary growth and that the bivariate relationship between interest rate changes and monetary dynamics may be complex if the optimal policy rule is being followed.

Another implication of the shock-specific behaviour of money is that monetary developments can help identify the nature of shocks and thus prompt an appropriate interest rate response. This is a necessary component of optimal policy in the P* model, where monetary shocks have an impact on price dynamics. However, even in the benchmark New Keynesian model where money plays no role in the transmission process, cross correlations in the dynamic responses of money and other macroeconomic variables imply that monetary dynamics can help to identify the nature of the shocks. They can thus provide information useful to policymakers who would optimally respond in a shock-specific manner. Money may therefore prove to be a useful indicator even in the benchmark New Keynesian framework. This is the essence of the Coenen et al (2001) result reported in Section 2.

(iii) Formulating rules that perform well in both paradigms

Gerdesmeier et al (2002) consider the design of monetary policy rules where, because of uncertainty about which model or variant is most realistic or relevant, policymakers entertain a variety of models of monetary policy transmission. As one would expect, they show that monetary developments should influence monetary policy decisions when money plays an active role in the monetary transmission mechanism within at least one of the models being considered.

This conclusion is intuitive. However, Gerdesmeier et al (2002) obtain a number of other, less obvious results. Within their framework, they show that monetary developments play an important role in interest rate decisions (in the sense that the coefficient on the real money gap in the favoured monetary policy rule is large) even when the weight accorded to the variant of the benchmark model (captured by the P* specification) is relatively low. The intuition behind this result is as follows. Gerdesmeier et al (2002) minimise a weighted average of the losses in the two models. Ignoring monetary developments in the P* model may be costly, because a crucial determinant of price dynamics is being ignored. At the same time, allowing a role for monetary dynamics in the benchmark

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51 Given the trivial nature of the models, it is hard to assign an economic meaning to the values of the loss function in terms of some more fundamental welfare measure. In other words, their ad hoc nature means that micro-founded welfare criteria are not available.

52 Interestingly, this correlation is even lower in the active money P* model than in the passive money framework.

53 This is, of course, simply an implication of the need to condition the interest rate decision on other variables in addition to money.

model may be relatively benign. Even in the benchmark model, monetary dynamics are associated with developments in the output gap, inflation and interest rates, which are themselves determinants of inflation within that model. Monetary developments may therefore capture information in other, policy-relevant variables.[54] As a result, the costs of ignoring money in the P* variant to the benchmark model may rise more rapidly than the benefits of ignoring money in the benchmark framework. This leads to a relatively prominent role for money in a policy rule that addresses model uncertainty across the P* and benchmark specifications.

Gerdesmeier et al (2002) also show that their favoured monetary policy rule implies larger responses to all state variables (including the real money gap, the monetary argument in their policy rule) than would be implied by alternative approaches, such as averaging the optimal rules from the two models (ie analysing the benchmark and variant models without reference to one another) or deriving an optimal rule from a hybrid framework that averages the two models (ie obscuring the distinction between the benchmark and its variant).[55]

Although the conditional response of interest rates to monetary developments may be large, this does not imply that the unconditional volatility of interest rates under the policy rules analysed by Gerdesmeier et al (2002) will be higher than for other policy regimes. As discussed above, interest rates also respond to variables other than money. In practice, developments in money may therefore be offset by developments in other arguments of the policy rule, such as inflation and/or the output gap, resulting in modest unconditional interest rate volatility.

The Gerdesmeier et al (2002) paper thus leads to three conclusions. First, once variants to the benchmark New Keynesian model are entertained, monetary developments may influence monetary policy decisions. Second, the role accorded to monetary dynamics in formulating interest rate decisions may be relatively large, even if the weight accorded to the variant model that emphasises the role of money is modest. Third, on occasion arguments of the monetary policy rule will point in different directions. The output gap may suggest a rate increase, while monetary dynamics suggest a rate cut. This should not be seen as a shortcoming of the approach. Indeed, the role of the monetary policy rule is precisely to provide a framework for reconciling and combining the information in various indicators into a single robust interest rate decision.

5. Concluding remarks

Much recent academic literature on monetary policy has suggested that monetary aggregates should not play a large role in monetary policy decisions. Within the so-called new neoclassical synthesis, monetary developments are not seen as playing an active role in the transmission mechanism of monetary policy. Monetary policy rules advocated by adherents of these models are often moneyless - they suggest that central banks can neglect or even ignore monetary developments when taking interest rate decisions. Moreover, many prominent empirical studies, in particular for the United States, have concluded that the demand for money is unstable in both long and short runs and that monetary developments largely constitute “noise” which policymakers would do well to ignore.

This paper has challenged these very strong - and, in our view, erroneous - conclusions.

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[54] For example, the real money gap is positively related to the output gap. If interest rates rise in response to a positive money gap (as the P* model would require), they will implicitly rise in response to an output gap (as the passive money framework would require). The loss associated with responding to the money gap in the passive money paradigm therefore may be modest.

[55] This result runs counter to the conclusions of Brainard (1967) inter alia, which suggest that uncertainty about the structure of the transmission mechanism should lead to attenuated monetary policy responses. Gerdesmeier et al (2002) offer the following intuition. The Brainard result follows from the possibility that structural uncertainty renders inflation uncontrollable using an interest rate instrument. In such circumstances, changing interest rates would simply destabilise other variables such as the output gap without helping to maintain price stability. If such a scenario is possible, monetary policy responses will be attenuated to avoid the destabilising impact of such a policy. However, in the Gerdesmeier et al (2002) framework, controllability is possible in both the benchmark model and its variant. The issue is not whether the system is controllable, but rather the channels through which control is exercised. In this environment, monetary policy responses are stronger than in the Brainard framework.

On empirical grounds, we survey a large literature which supports the view that money both has a stable relationship with prices in the euro area and exhibits leading indicator properties for future price developments, at least in the euro area.

On conceptual grounds, we note that monetary policy regimes which neglect monetary developments are prone to expectational instability - a practical, as well as theoretical, problem, which may lead to the maintenance of price stability being threatened. Broadly speaking, these results follow from the observation that monetary policy regimes which ignore money may lack a nominal anchor.

On empirical and practical grounds, we suggest that monetary developments contain information about the state of the economy which - regardless of whether money plays an active role in the transmission mechanism of monetary policy - should be integrated into the policymaking process. Of course, in models where money does play an "active" role, monetary dynamics necessarily enter optimal policy rules.

Appendix:
Model uncertainty and monetary policy rules

(a) The output gap model

In its simplest form, the "output gap model" (OGM) (representative of the benchmark view of monetary policy transmission) can be presented as:

$$y_t = \lambda y_{t-1} - \delta(i_{t-1} - E_{t-1}\pi_t) + \varepsilon_{s,t} \tag{9}$$

$$\pi_t = \pi_{t-1} - \beta(y_{t-1} - y^*_{t-1}) + \varepsilon_{s,t} \tag{10}$$

where y is the output gap, i is the short-term nominal interest rate under the control of the central bank, π is inflation and ε_d and ε_s are demand and supply shocks, respectively. For notational simplicity, the variables are de-meaned and de-trended, such that potential output is zero (see Rudebusch and Svensson (1999)).

To facilitate comparisons with the P* model discussed below, a money demand equation is appended to the basic OGM. The money demand equation is "appended" in the sense that price and output dynamics are fully determined by equations (9) and (10): this is why the OGM represents the benchmark view of monetary transmission. This money demand equation has a standard error correction specification, namely:

$$\Delta(m-p)_t = \phi\Delta(m-p)_{t-1} - \vartheta((m-p)_{t-1} - y_{t-1} + \gamma i_{t-1}) + \varepsilon_{md,t} \tag{11}$$

(b) The P* model

The P* model (representative of variants to the benchmark view of monetary policy transmission) can be summarised by the following system of equations (where the notation is the same as above, with i^* the nominal short-term interest rate holding in steady state equilibrium with price stability, normalised to zero) (see Hallman et al (1991), Svensson (2000)):

$$y_t = \lambda y_{t-1} - \delta(i_{t-1} - E_{t-1}\pi_t) + \varepsilon_{s,t} \tag{12}$$

$$\Delta(m-p)_t = \phi\Delta(m-p)_{t-1} - \vartheta((m-p)_{t-1} - y_{t-1} + \gamma\, i_{t-1}) + \varepsilon_{md,t} \tag{13}$$

$$\pi_t = (1-\omega)\pi_{t-1} + \omega\Delta p^*_{t-1} - \mu(p_{t-1} - p^*_{t-1}) + \varepsilon_{s,t} \tag{14}$$

$$p^*_t = m_t - y^*_t - \lambda i^* = m_t \tag{15}$$

(c) Central bank preferences

Consistent with the academic literature, the objectives of the central bank are summarised by the loss function (equation (5)), which is used here for illustrative purposes. Note that this loss function assumes a steady state rate of inflation of zero, which - in the context of this framework - corresponds to the central bank's definition of price stability.

(d) Analysis

Using conventional techniques (as discussed, for example, in Rudebusch and Svensson (1999)), each model can be solved to find the "optimal monetary policy rule" which minimises the loss function (equation (5)). As discussed in the main text, this rule (and the results it obtains) can then be compared with simple money-based rules, such as those defined by equations (7) and (8).[56] This exercise is presented in Table 3.

Table 3

Performance of optimal and money-based rules in the two models

		Output gap model	P* model
Optimal rule			
Coefficient on:	y_t	10.051	7.358
	Δp_t	10.512	8.472
	$(m - p)_t$	0	15.386
	$(m - p)_{t-1}$	0	−12.118
Loss with optimal rule		**6.309**	**8.836**
Simple money-based instrument rule			
Response parameter φ		2.135	1.906
Loss with simple money-based instrument rule		**15.589**	**24.959**
Simple intermediate monetary targeting rule			
Loss with simple intermediate monetary targeting rule		**23.909**	**24.652**

Note: Because of the de-meaning and de-trending of all variables, all steady states have been normalised to zero.

Table 4

Bivariate correlations in simulations of the two models under optimal rules

	Inflation	Monetary growth	Interest rates
(a) Output gap model			
Inflation	1		
Monetary growth	0.77	1	
Interest rates	0.40	0.35	1
(b) P model*			
Inflation	1		
Monetary growth	0.86	1	
Interest rates	0.16	0.22	1

[56] For the simple money-based instrument rule (equation (1)), the response parameter φ is chosen so as to minimise the central bank's loss function described by equation (5).

Table 4 shows the bivariate correlations between short-term nominal interest rates, inflation and monetary growth in the two simple models, under the assumption that the optimal rule described in Table 3 is followed. These results are discussed in the main text. Note that, counter to intuition, the contemporaneous correlation between optimal interest rate changes and money growth is higher in the benchmark model (rather than the variant P* model where money enters the Phillips curve and thus plays an active role in monetary transmission).

Table 5 describes the policy rule that minimises the average central bank loss over the two models presented above and permits comparison with the optimal rule for each of the two underlying models. This rule is one variant of the monetary policy rules analysed in Gerdesmeier et al (2002) that attempt to address the problem of model uncertainty, ie the need to arrive at a *single* interest rate decision on the basis of analysis in *both* the benchmark model and in the variant of it. As noted in the main text, the response of interest rates to monetary developments (ie the response coefficients on the money gap in the policy rule) is large. Moreover, these coefficients are greater than the average of the two corresponding coefficients in the individual underlying models. The intuition behind these results is discussed in the main text.

Table 5

Coefficients and performance of rule that minimises average central bank loss over the two paradigms

	Bayesian rule weighting loss functions ($q = 0.5$)	**OGM optimal rule**	**P* optimal rule**
Coefficient in weighted rule on:			
$(y - y^*)_t$	9.572	10.051	7.358
Δp_t	9.481	10.512	8.472
$(m - p)_t$	9.525	0	15.386
$(m - p)_{t-1}$	–8.190	0	–12.118
Loss in OGM	7.096	6.309	9.210
Loss in P* model	9.456	12.673	8.836
Mean loss	8.276	9.491	9.023
Maximum loss	9.456	12.673	9.210

Note: The rule described above minimises the average central bank loss over the two paradigms (summarised by the two models), ie min $L = 0.5 \times L_{OG} + 0.5 \times L_{P*}$.

The parameter calibrations used to undertake the exercises reported in this Appendix are shown in Table 6.

In synthesis, in both of the models introduced in this Appendix, the adoption of a monetary policy rule that preserves price stability ensures that monetary growth will fluctuate around its steady state rate (ie M3 growth oscillates around the reference value). This is a direct implication of the observation that the optimal policy rule in both models will render the economic system stable if it is to preserve price stability. Yet if the underlying monetary policy rule adopted by the central bank does not preserve price stability,[57] then monetary growth diverges from the steady state (ie the reference value) in both models.

Table 6

Calibrated values for the model parameters

Parameter	Calibrated value	Economic interpretation
λ	0.9	Output persistence.
δ	0.1	Real interest rate elasticity of aggregate demand.
β	0.1	Sensitivity of inflation to the output gap.
ϕ	0.6	Persistence of real monetary growth.
υ	0.1	Error correction coefficient in money demand equation.
γ	0.25	Long-run interest rate elasticity of money demand.
ω	0.5	Weight on lagged inflation in P* inflation equation.
μ	0.2	Error correction coefficient in P* inflation equation.
$\sum_{OG} = \sum_{P*}$	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$	Covariance matrix of the structural economic (demand, supply and money) shocks. (For simplicity, a diagonal matrix with unit variances is assumed for both models.)
ψ	0.5	Relative weight on inflation variance in the central bank's loss function.

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[57] In the output gap model, it is sufficient to choose a monetary policy rule with a coefficient less than unity on inflation, such that the real interest rate does not rise in response to an inflationary shock (see Clarida et al (1999)). In other words, violating the Taylor principle is sufficient to induce instability. This condition is not sufficient in the P* model: a rule that preserves price stability may have a coefficient less than unity on inflation in this context.

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The role of financial factors in the transmission of monetary policy[1]

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1. Introduction

The last two decades have been marked by far-reaching changes in financial markets. The combined effects of financial deregulation and innovation against the backdrop of globalisation and the development of new information and communication technologies may have contributed to strengthening the role of financial factors in the economic cycle and, hence, to an alteration of the channels used for transmitting monetary policy. In addition, the implementation of the single European monetary policy has accelerated the financial integration process in the euro area, in particular on the bond market. Finally, the privatisations, the increasing share of equities in households' assets and the rise in asset prices in the late 1990s should have contributed to strengthening the role of the wealth effect in the transmission mechanism.

The purpose of this paper is to identify the ways in which financial factors may alter the transmission mechanism. In the first part, an example drawn from the "US miracle" in the 1990s highlights these financial factors and the way in which they were able to operate in the United States and contributed to amplifying the business cycle and also, possibly, macro-financial imbalances. In the second part, we focus on the euro area. On the one hand, during the last 20 years, this area has undergone changes in its financial structures that have made it more similar to English-speaking countries. However, wealth effects remain difficult to spot in the euro area. On the other hand, and again in contrast with English-speaking countries, financial intermediation is stronger there. Credit market flaws are also probably more important, enabling a priori the broad credit channel to play a more prominent role in the euro area to the detriment of typical bank lending or interest rate channels. In this case, however, empirical results are mixed. Overall, financial factors thus seem to have more affected the monetary policy transmission mechanism in the United States or even more generally in English-speaking countries than in the euro area. The conclusion of this paper focuses on the role of financial factors, in particular asset prices in the conduct of monetary policy.

2. Transmission channels - role of financial factors

2.1 Identification of the main financial factors

We may group the main financial factors at play in the transmission mechanism of monetary policy into two categories:

- the first includes asset prices (shares, property);[2]
- the second is derived from the existence of an external funding premium and credit constraints; this category is at the origin of the credit cycle.[3]

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[1] The views expressed in this paper are those of the authors and do not necessarily reflect the opinion of the Bank of France.

[2] Mishkin (2001).

[3] Clerc (2001). It is worth noting that this restrictive definition is used in the ECB's works on the transmission mechanism in the euro area in order to interpret the expression "financial factors" (see, for example, Angeloni et al (2002)).

There is furthermore a tight link between these two categories, because of the guarantees required prior to the granting of loans. This issue is dealt with below in the second category.

2.1.1 Asset prices

In the long term, monetary policy is capable of influencing asset prices. More specifically, a credible monetary policy contributes to reducing uncertainty and therefore risk premiums and eventually increases the growth potential and therefore asset prices.[4] Nevertheless, when studying transmission mechanisms, it is necessary to focus on the short-term effects of monetary policy on changes in asset prices. These effects are two-pronged: any change in interest rates, especially if it is unanticipated, influences growth expectations and the rates used to discount future income derived from the holding of assets (shares and property). The resulting change in asset prices influences corporates' and households' spending behaviour.

Any change in share prices may have an impact on enterprises' capital through the "Tobin q" factor and on household consumption through the wealth effect. As far as "Tobin's q"[5] is concerned, any increase in share prices following a decrease in interest rates leads to an increase in the value of capital installed compared to new capital (thus increasing the "Tobin q" factor) and stimulates capital expenditure by enterprises. Turning to the wealth effect, and according to the life cycle theory,[6] households smooth out their consumption level according to their current income, but also according to their wealth level. An increase in share prices increases households' wealth and thus prompts them to spend more.[7]

Just as an increase in share prices stimulates corporate capital investment, an increase in property prices supports construction expenditures, because it becomes more profitable to build a new housing unit than to buy an existing one. In addition, rising property prices boost households' net assets and therefore also trigger a wealth effect.

2.1.2 External financing premium and credit constraints

Despite the considerable advances made during the last two decades, in particular concerning the availability of accounting and financial information, financial markets still suffer from information imperfections and asymmetries. The recent and growing concern about corporate earnings disclosure and accounting standards is a striking case in point. It illustrates how difficult it is for creditors to assess not only businesses' financial statements but also the real value of their assets as well as the nature and degree of the risk associated with their capital projects.

The existence of such imperfections accounts for certain patterns documented in a very large number of empirical works, in particular: (i) external funding is more expensive than self-financing, especially when it is not secured; (ii) the gap between the cost of external and internal financing (defined as the external financing premium) decreases with the borrower's net wealth and increases with the amount of funds borrowed; (iii) an adverse shock impacting the borrower's net wealth increases the cost of external financing, restricts the borrower's access to finance, and may lead the borrower to reduce his capital expenditure and payroll expenses as well as the level of his output. When businesses face an overall shock affecting their net wealth or balance sheet (in which case, reference is made to the balance sheet channel), then the financial accelerator mechanism is triggered and amplifies the initial shock.[8]

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4 ECB (2002).

5 Tobin (1969).

6 Modigliani (1971).

7 It should, however, be noted that according to Lettau and Ludvigson (2001), despite the importance and persistence of shocks to households' net wealth (such shocks being incidentally attributable to share price fluctuations), the consumption of households only depends on the components of their wealth and income. Under these conditions, there would be no room for a wealth effect in the monetary policy transmission mechanism.

8 Hubbard (1994).

2.1.2.1 *External financing premium*

The external financing premium stems from several factors. First, a company that seeks external funding instead of relying on self-financing incurs not only transaction costs but also the implicit cost of finding and drafting a loan agreement. Second, debt agreements permit creditors to exert control over the borrowing company. The problem of verification costs addressed by Townsend (1979), where the lender has to pay a fixed audit fee to assess the rate of return generated by the borrower, is one of the reasons why unsecured external financing can prove more expensive than internal financing.

The cost of external financing depends, inter alia, on monetary policy. The impacts of monetary policy are both direct - the financing premium is the sum of a riskless interest rate, ie the policy rate, and a company-specific risk factor - and indirect, insofar as a rate hike reduces the value of a company's collateral or its net wealth. In particular, an unexpected tightening of policy lowers the company's future revenue flows and raises the discount rate used to compute the present value of those flows. Further, higher interest rates exacerbate the financial constraints on the weakest companies, and hence their likelihood of default, which pushes up the financing premium.

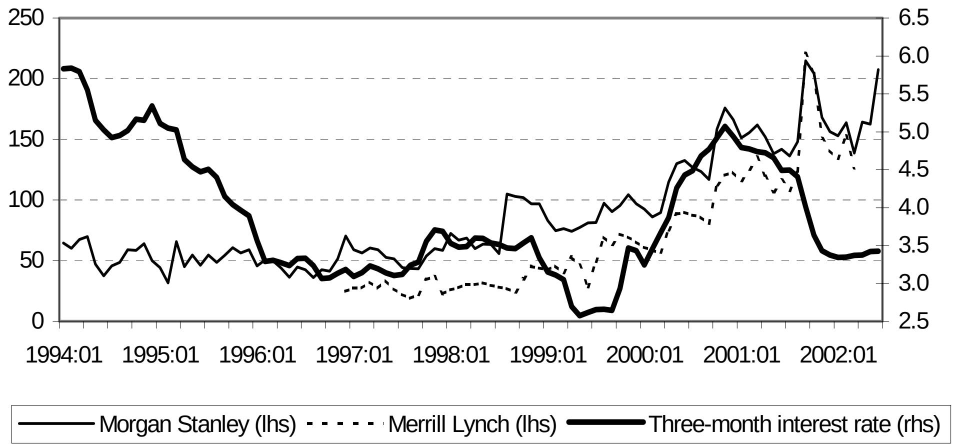
The financing premium can be gauged by observing the difference between the high-yield bond rate - ie corporate bonds with below investment grade rating (BBB-rated) - and the corresponding rate for the highest-quality firms (AAA-rated). That difference is referred to here as the "credit spread".

Graph 1 shows the relationship between the interest rate and the external financing premium, as proxied by credit spreads, in the euro area. The interest rate used here is the three-month interbank rate (the German rate as representative of the euro area until 1999 and Euribor thereafter).

Graph 1

Credit spreads and the interest rate

In basis points and percentages



During the period under review, interest rates seem to be closely correlated with credit spreads. However, that correlation weakens towards the end of the period, because the trend towards tighter spreads, which seems to coincide with monetary easing in early 2001, went into reverse in the aftermath of 11 September 2001. Financing conditions then improved before deteriorating once again on the uncertainties caused by stock market turmoil in early 2002.

2.1.2.2 *Financing constraints*

Financing constraints arise because lenders cannot force borrowers to repay their debt since such debt is not secured. Lenders reduce accordingly the amount of the funds they intend to provide, thus creating a form of credit squeeze.

In addition, if an enterprise's human capital cannot be separated from the physical capital,[9] then the value of a capital expenditure project may exceed its recovery value in the event of default. In such an event, management may threaten to terminate the agreement by withdrawing the human capital. The lenders, who are thus aware that contracts may be renegotiated ex post, will limit their loans to the discounted values of collateral. This mechanism is central to the recent models of the credit cycle's general balance.[10] This mechanism also introduces a specific interaction between asset prices and credit constraints, because the borrower's credit caps are determined by the price of the assets used as collateral and more generally by the borrower's general wealth. However, at the same time, as shown by Kiyotaki and Moore (1997), asset prices are also influenced by the level of credit constraints. This interaction constitutes a powerful transmission mechanism through which shock effects persist and are amplified and propagated.

2.2 Illustration based on an interpretation of the "US miracle"

The phase of strong and protracted growth observed in the United States during the second half of the 1990s may provide a particularly impressive example of the main theoretical mechanisms introduced above. While this episode stems from technological advances and the resulting productivity gains, it is likely that financial factors have largely contributed to the unusual scope and duration of this activity cycle.

2.2.1 Financial factors have probably contributed to amplifying the productivity shock and making it more persistent

Progress made in the new ITC sector and its swift spread to most industries led to a sharp acceleration in the US economy's productivity gains from the mid-1990s (Table 1).

The subsequent improvement in the US economic outlook and the possible increase of its growth potential then contributed to a sharp rise in the price of financial assets, first in the new technology sectors and thereafter in nearly all industries.

Table 1

US real wages, productivity and wage costs

Annual averages, in percentages

	Hourly wages	Productivity	Unit wage costs
1983-92	4.1	3.0	1.0
1993-2002	3.7	3.7	0.1
1993	2.8	1.9	0.8
1994	2.8	3.0	–0.2
1995	2.1	3.9	–1.7
1996	1.3	3.5	–2.1
1997	1.9	4.2	–2.2
1998	5.4	5.4	0.0
1999	4.0	4.6	–0.5
2000	6.5	6.7	–0.2
2001	6.9	1.6	5.3
2002[1]	3.6	2.0	1.6

[1] Forecasts.

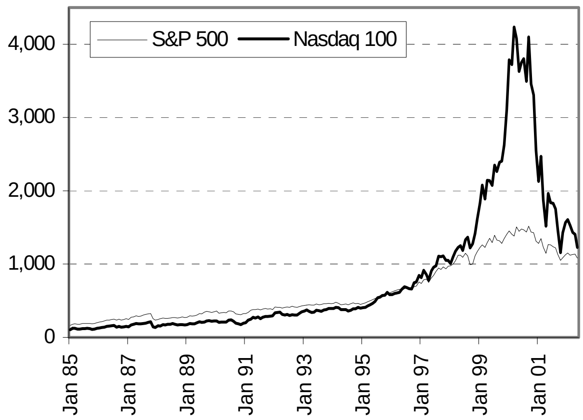
Source: IMF.

[9] Hart and Moore (1994).

[10] Kiyotaki and Moore (1997); Bernanke et al (1999).

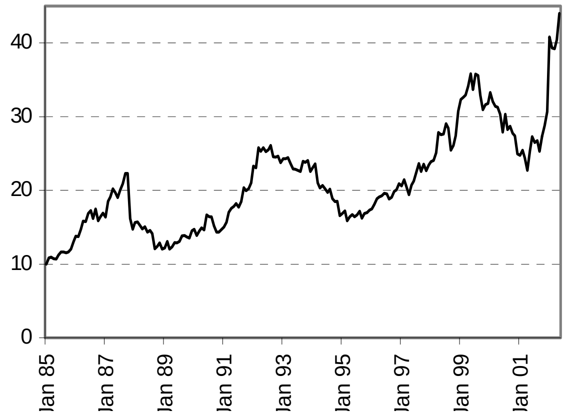
Graph 2

US stock market indices



Graph 3

S&P 500's p/e ratio



Source: Datastream.

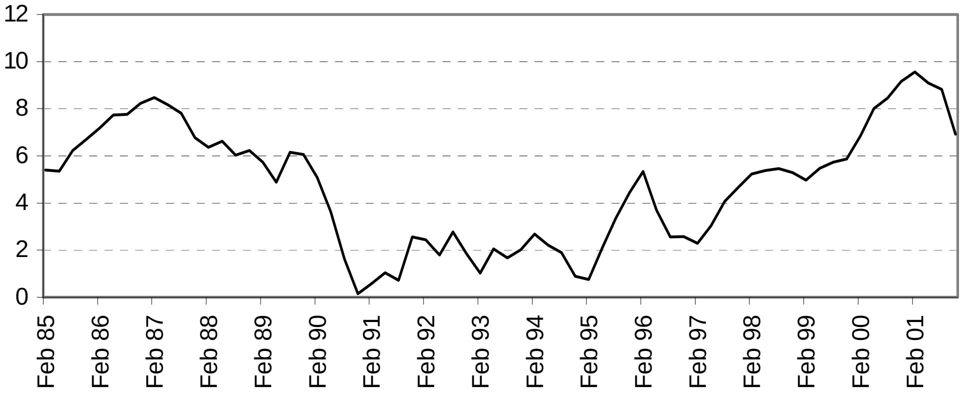
As a case in point, the Nasdaq index rose sharply from the beginning of 1995. The value of this index has increased almost tenfold within five years. Other industries benefited from this rally, in particular with an annual increase of nearly 25% for the S&P 500 index between 1995 and 2000. The S&P 500's p/e ratio also gained from the euphoria prevailing on financial markets and more than doubled over the same period (Graphs 2 and 3).

This increase in the price of financial assets went along with spontaneous and self-sustained growth in household expenditure and corporate capital expenditure, as well as an increase in household housing investment, contributing to a rise in property prices (Graph 4).

Graph 4

US residential property prices

Changes over four quarters, in percentages



Source: Datastream.

These rising asset prices may have activated the balance sheet channel through a rise in the value of collateral. Economic agents were thus able to increase their indebtedness, in particular with banks, and accordingly to increase their spending or buy new assets if they expected a sufficiently high return in view of the risk incurred and the financing cost.

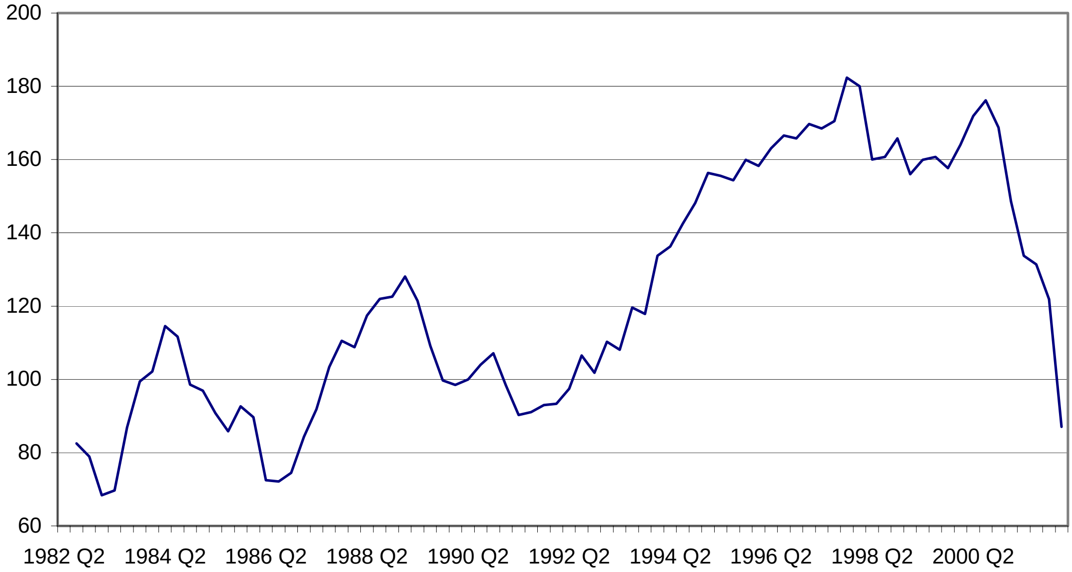
From this point of view, the extraordinary resilience shown in 2001 by US household expenditure may be reconciled with the surge in activity on the mortgage refinancing market and the strong increase in residential property prices. Indeed, the leverage resulting from the increase in the value of the mortgaged collateral and property prices is deemed to have contributed significantly to the rise in household consumption expenditures (ranging from 10 to 25%[11]).

Furthermore, wages have been adjusted gradually to the productivity gains, probably because of the time lag necessary for economic agents to become aware of a productivity shock, but also because of the very sharp increase in non-wage income, in particular income from stock market investments, as well as the development of new forms of compensation (stock options). The relative increase in wages in the sectors benefiting from productivity gains also limited traditional contagion phenomena to other sectors (Balassa-Samuelson effects). In sum, enterprises have been able to overall maintain, or even increase, their margins and invest more without deteriorating their financial structure (Graph 5).

Graph 5

Real pre-tax profits of non-financial enterprises

1990 = 100



Source: Datastream.

2.2.2 Financial factors may also have generated major macro-financial imbalances

These changes may have led to major macro-financial imbalances. More specifically, the financial amplification phenomena may have prevented the proper working of the typical activity stabilisation mechanisms. Indeed, contrary to the previous cycles, household indebtedness grew continuously (Graph 6). Neither the increase in interest rate charges, because of a volume effect, nor the monetary tightening, because of a price effect, seems to have significantly dented this trend. The rise in property prices also enabled households to access bank loans more easily. This specific context made households (and more generally the US economy) more dependent on changes in asset prices. The same holds true for the banking sector, which seems, at the end of this period of strong growth, more exposed to property risk. Finally, because the outlook for return on capital seemed higher in the United States, the rest of the world contributed to the financing of the US economy without any material increase in long-term interest rates. The current deficit grew rapidly

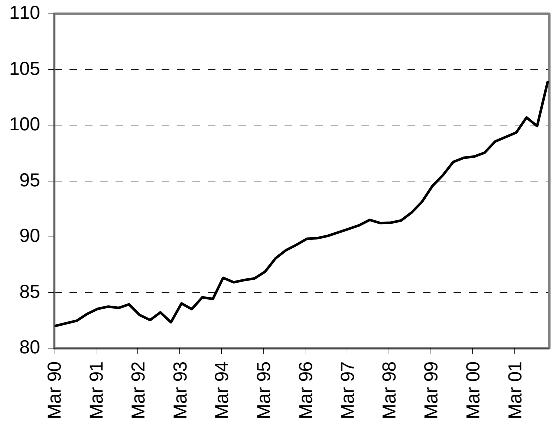
[11] BIS (2002).

and even reached 5% of gross domestic product (GDP), ie a level that seems hard to sustain in the medium term (Graph 7).

Graph 6

Household debt

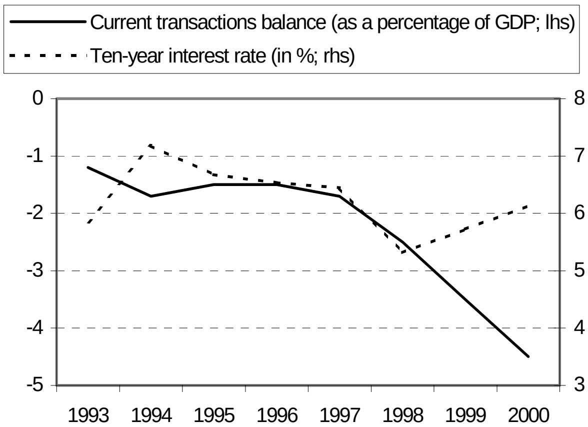
As a percentage of gross disposable income



Source: Datastream.

Graph 7

Current transactions balance and long-term interest rates



Source: OECD.

In terms of monetary policy, such changes raise the issue of the factoring-in of asset prices. On the one hand, the role played by financial factors in the US economy's recent dynamics seems to show that the main expenditure items (consumption and investment) largely depend on wealth effects. In 2002, an increase in the saving rate following a reduction in the household debt level or a decrease in asset prices would most certainly weigh on the recovery process. On the other hand, households' high indebtedness does not seem to be lastingly sustainable, except if the outlook for return on capital remains favourable, which is not likely.

In terms of financial stability, the major role played by property loans has probably heightened the banking sector's vulnerability to property risk. The same holds true for the large refinancing agencies such as Fannie Mae and Freddie Mac, which are major players on the US secondary mortgage market. While there are multiple risk-hedging opportunities, the information provided by these two agencies in March 2002 concerning their counterparties on the derivatives market has shown that the risk diversification level is finally small: only eight counterparties represent nearly 80% of their transactions on the derivatives market.[12] Following the phase of strong growth at the end of the 1990s, the macroeconomic and financial balance therefore seems to be highly dependent on changes in property prices.

Furthermore, the increase in US current imbalances creates a risk for the global economy. While we have noted in the past that such imbalances may be brought down nearly spontaneously, most past corrections involved a very substantial depreciation of foreign exchange rates.

[12] BIS (2002).

3. What about the euro area?

3.1 Asset prices and wealth effects

Several factors have made the financial structures of the euro area more similar to those of the United States, or more generally those of the G7 English-speaking countries (United States, Canada, United Kingdom): financial liberalisation, households' share ownership, the new economy and changes specific to the financial sector. However, empirical studies do not always clearly show wealth effects in the euro area, for reasons that shall be discussed when reviewing each of these factors.

3.1.1 Financial liberalisation

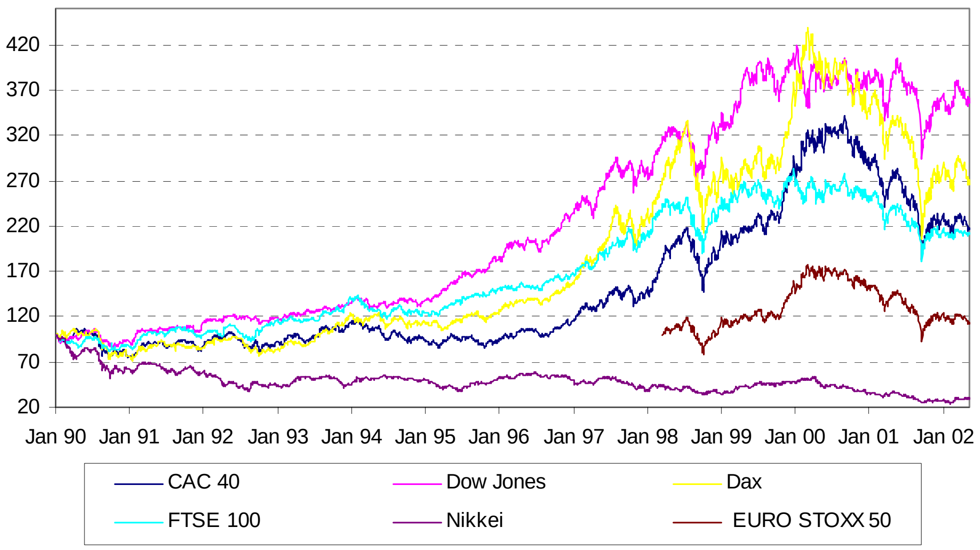
One of the expected effects of the financial liberalisation implemented in OECD countries since the end of the 1970s has been to facilitate access to home ownership and credit by facilitating use of assets held, such assets being themselves valued at a higher price. Wealth effects may thus spread easily. However, a recent OECD study[13] covering the G7 countries other than Germany did not show that financial liberalisation in continental Europe (France, Italy) had any effect before the beginning of the 1990s. In addition, the strongest impact on the relationship between consumption and households' wealth (taken as a whole or by component: financial, property or otherwise) relates to the long term, while no marked effect is observed on dynamic relationships.

Accordingly, this impact would have consisted in a weakening of the liquidity constraints, leading to an increase in the consumption level, but not in an effect on consumers' short-term behaviour reflecting a wealth effect. As shown by the authors, such results may, however, stem from the fact that, in France and in Italy, financial liberalisation occurred later and more gradually than in English-speaking countries.

Graph 8

Main stock market indices

January 1990 = 100[1]



[1] Except for EURO STOXX 50, where April 1998 = 100.

Source: Bank of France.

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[13] Boone et al (2001).

3.1.2 *Holding of shares*

The general rise in share prices and a more widespread share ownership through financial liberalisation and privatisations of public enterprises led to an increase in the holding of financial assets by households in the euro area during the 1990s.

Table 2

Households' shareholding

	Percentage of financial assets held directly in the form of shares by households and non-profit institutions serving households		**Percentage of shareholders**	
	1991	**1999**	**1995**	**2000**
Germany	10.9	20.5	6.2[1]	9.8
France	44.5	46.7	12.0[1]	12.7
Italy	20.6	43.3	5.0	7.8[2]
United Kingdom	17.7	22.8	22.8[3]	23.3[4]
United States	16.9	32.9	15.2	19.2[2]

[1] 1997. [2] 1998. [3] 1993. [4] 1996.

Source: Norman et al (2002).

Nevertheless, marginal propensity to consume financial wealth remains lower in Germany, France and Italy than in the United States. This may reflect the fact that the amount of financial assets held by households is smaller in Europe but may also show that a larger proportion of the shares is held by persons with high incomes or belonging to older age groups.[14] In addition, we may wonder whether the wealth effect is not more linked to the holding of property than to share ownership, particularly because shares are generally more volatile than property prices, and property is less concentrated among persons with a high income. In fact, a recent study covering a sample of 14 countries during the last 25 years, as well as a sample of states of the United States shows, for all the regions studied, major wealth effects linked to net wealth invested in property, while such an effect is not as clear for investment in shares.[15] Such conclusions are confirmed by the IMF in the last edition of the *World Economic Outlook* showing also that the wealth effect is clearer in economies where "market financing" plays a prominent role (United States, United Kingdom, Australia, Canada, Ireland, Netherlands, Sweden) rather than in countries relying mainly on "bank financing" (Belgium, Denmark, Spain, Finland, France, Germany, Italy, Norway, Japan), but that this effect is gaining in importance everywhere.[16]

3.1.3 *New economy*

The development of the new economy may have contributed to heightening the similarity between financial structures and behaviours in the United States and in the euro area for two types of reasons:

- in the ITC sector, behaviours in terms of investment and financing are comparable among G7 countries, while we note an actual link between investment and changes in share prices

[14] Norman et al (2002).

[15] Case et al (2001).

[16] IMF (2002).

in the other sectors (showing a “Tobin q” factor is at work) existing in English-speaking countries but not in continental European countries;[17]

- the impact of changes in the prices of the ITC shares in terms of wealth effect is comparable in continental Europe and in English-speaking countries, while, for securities from other sectors, this impact is weaker in continental Europe.[18]

However, it seems difficult to draw conclusions from these observations because of the features of “new economy” firms, in particular the fact that return on investment is highly unpredictable, inducing specific financial behaviour,[19] and because the stock market capitalisations of ITC securities are highly different from across countries (in March 2001, 8% of GDP in Germany, 18% in the Netherlands and 24% in France, versus 33% in the United States and 35% in the United Kingdom, according to Edison and Sløk (2001a)).

3.1.4 Financial sector

Finally, the euro area’s financial sector has in recent years undergone a number of structural changes that have brought it closer to its US counterpart. The most obvious of these changes is the introduction of the single currency, which blurred the distinctions between national markets and even unified the money market altogether. Other material changes are related to the development of competition, linked to the changeover to the single currency but also to the creation of the single market, and to the use of securitisation, which is increasing albeit at a slow pace. Finally, through information and communication technologies, which are broadly used by the financial sector, the new economy also impacted the operation of the financial sector in the euro area as well as in other major industrial countries. However, it is likely that most of these changes tended to strengthen the interest rate channel through swifter and broader propagation of changes in interest rates, rather than increase the role of financial factors in the mechanism serving to transmit monetary policy.

3.2 Information asymmetries, liquidity constraints and external financing premium

The need to assess the transmission mechanism of the single monetary policy according to a harmonised methodology led to a major research project steered by the Eurosystem as part of a network (called Eurosystem Monetary Transmission Network or MTN). The first results were published in the form of ECB papers. These results are used as a benchmark in order to characterise the role of financial factors in Europe. Before analysing this project, we would like to show how the recent changes and facts summarised in the first part may in theory modify the way in which major macroeconomic data react to a monetary policy shock.

3.2.1 A theoretical illustration based on a financial accelerator model

Two of the main features of the last economic cycle observed in most developed countries are: first, its degree of persistence, because the sole growth phase, which started in the middle of the 1990s, has been generally close to that of a “normal” activity cycle; and second, the amplitude of this cycle, with recorded growth rates that lastingly exceeded these economies’ potential growth rates. While an explanation based on technological factors has been submitted in the case of the United States, it is difficult to document a material impact of new technologies on economic activity in other economies, in particular the euro area, which suggests that other factors are at play.

At the same time, it is interesting to note that most of the work focusing on the monetary policy transmission mechanism runs into two major difficulties: first, the weak elasticity of productive investment and household consumption in response to interest rate changes, as shown by econometric estimates; and second, the relative inability of theoretical approaches to take into account the degree of shock amplification and persistence, in particular monetary policy. In fact, a recent trend

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[17] Edison and Sløk (2001b).

[18] Edison and Sløk (2001a).

[19] Direction Générale des Études et des Relations Internationales (2002).

in economic literature consists in integrating the credit market flaws into "real cycle" models and manages to a certain extent to overcome these difficulties. We are therefore tempted to regard financial factors as the possible sources of amplification and persistence phenomena relating to the multiple shocks that may have affected the recent dynamics of developed economies.

Bernanke, Gertler and Gilchrist's work (1999) is in line with this school of thought. The main assumption used by the authors is that imperfections do exist on credit markets, in the form of information asymmetries and problems linked to contract performance. Such imperfections may lead to agency costs that are liable to create a gap between the cost of self-financing and that of external financing (external financing premium).

From a theoretical point of view, this model integrates certain features that are essential to the way in which a monetary policy stimulus is transmitted to the economy. This model includes a reference to monopolistic competition, in which prices are determined in accordance with the terms first suggested by Calvo (1983) and serving to integrate nominal rigidities. In addition, we are using this model in a version including real rigidities in the form of an adjustment cost to the capital stock and a lag between the decision to invest and the actual commissioning of productive investment.

Within this model, it is possible to distinguish two channels for the transmission of monetary policy:

- The interest rate channel. This channel affects those components of demand that are sensitive to the real interest rate: the first includes household consumption through substitution effects between different time periods; then productive investment, because a change in central banks' interest rates affects the cost of capital. In addition, a change in interest rates also generates wealth effects, in particular by changing the discount rate used by economic agents in order to assess their current wealth. A cut in official interest rates increases for instance the discounted value of collateral, thus reducing the external financing premium and enabling economic agents to fund additional consumption or investment. Finally, official interest rates directly affect the cost of capital, thus weighing on enterprises' investment decisions.
- The broad credit channel relies on the existence of an external financing premium in response to present flaws on the credit market. This channel also includes elements linked to the wealth effect. Any factor contributing to a change in economic agents' net wealth alters this external financing premium and leads to a change in the spending level. In the absence of aggregated data on the euro area, the leverage effect is calibrated on the basis of French data (see Chatelain and Teurlai (2000)). Taking into account the model's structure, this effect only influences corporate capital expenditure and entrepreneurs' consumption. As regards entrepreneurs' consumption, the model is calibrated so that one additional euro in economic agents' net wealth only increases consumption up to €0.024.[20]

It is, however, necessary to mention that the model used is subject to two significant limitations:

- The interest rate channel does not trigger any income effect for households. Taking into effect the fact that this effect has a perverse impact in the euro area, because households are net creditors, the interest rate channel is probably overvalued in the model.
- In addition, the model relates to a closed economy. This assumption is not negligible, because, despite a low degree of openness comparable to that of the United States, the euro area has nevertheless seemed to be sensitive to outside changes. Therefore, the transmission mechanism as modelled here does not include the potentially powerful foreign exchange channel.

Such a model provides the following responses to an unanticipated monetary policy shock.[21]

The existence of real and nominal rigidities leads to a one- or two-period lag between the occurrence of the monetary policy shock and the time when production and prices are affected respectively. However, for these two variables, the maximum impact is reached as early as the second period,

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[20] Such an effect is significantly lower than that shown in econometric estimates made in the United States, where the wealth effect generally ranges between 3 and 5½%.

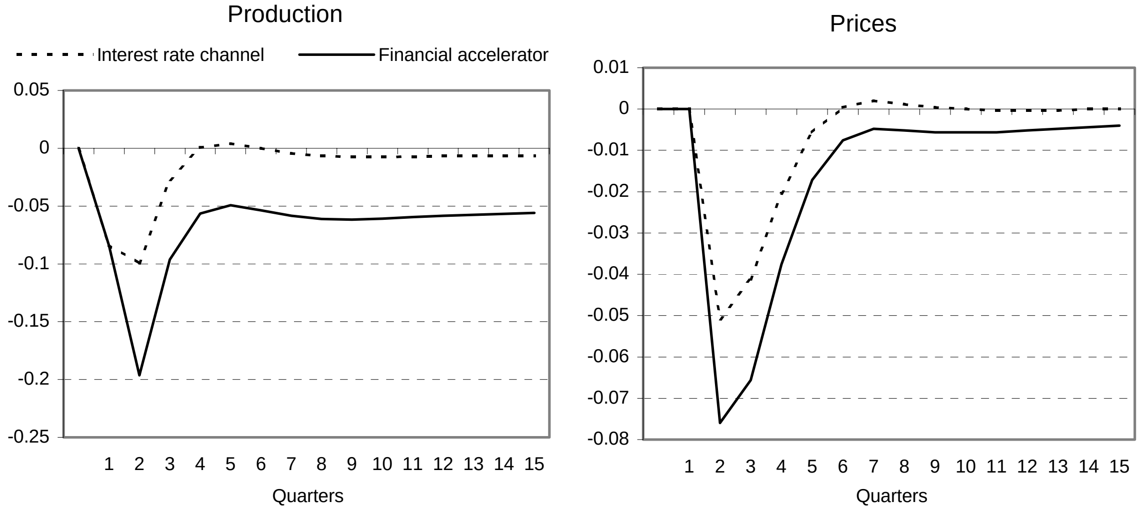
[21] This shock is equal to one standard deviation, which corresponds to an interest rate shock equal to 20 basis points.

which seems very fast, especially as concerns prices. This effect then dwindles while variables return to their long-term equilibrium level, thus reflecting monetary policy's neutral nature.

The financial accelerator mechanism has two essential implications. The first implication is the amplification of monetary policy's impact on production and prices, if we compare these two variables' response in an environment where only the interest rate channel is effective (Graph 9). Also, if we use solely the interest rate channel, the second implication is that this shock is made more persistent, especially as regards production.

Graph 9

Production and price effects of a non-anticipated monetary policy shock



3.2.2 While there is a role for financial factors, it is more difficult to quantify

We are seeking to assess the role of financial factors by comparing three approaches: the use of vector autoregression (VAR) models, the relationship between credit spreads and economic activity, and lessons drawn from the MTN project.

3.2.2.1 What VAR models teach us

Since the seminal works conducted by Sims,[22] most of the research focusing on monetary policy transmission mechanisms has relied on a VAR methodology. We use the same type of approach here by considering the responses obtained on the basis of two VAR representations of the euro area.

The first representation relies on the contribution of Garcia and Verdelhan (2001). This is a structural VAR model based on abridged quarterly data relating to the euro area. The endogenous variable vector (*Y*) includes the annual growth of GDP in the euro area and the series showing primary differences in terms of annual inflation, three-month interest rates and budget balance. In this model, structural shocks are identified by using the methodology developed by Galí (1992) making it possible to distinguish between short- and long-term constraints. The assumptions used are as follows: only the supply side shock has a long-term impact on the GDP level; a monetary shock has no instantaneous effect on GDP; and the budgetary shock does not instantaneously affect inflation or interest rates. Despite the limitations inherent in such an exercise, such as the presence of structural disruptions, this model is estimated over the 1970-2000 period. Confidence intervals are built by bootstrapping. The results are shown in the left-hand panels of Graph 10.

The second VAR presentation makes use of the results obtained by Peersman and Smets (2001), on which the MTN project incidentally relies. The endogenous variable vector is significantly different,

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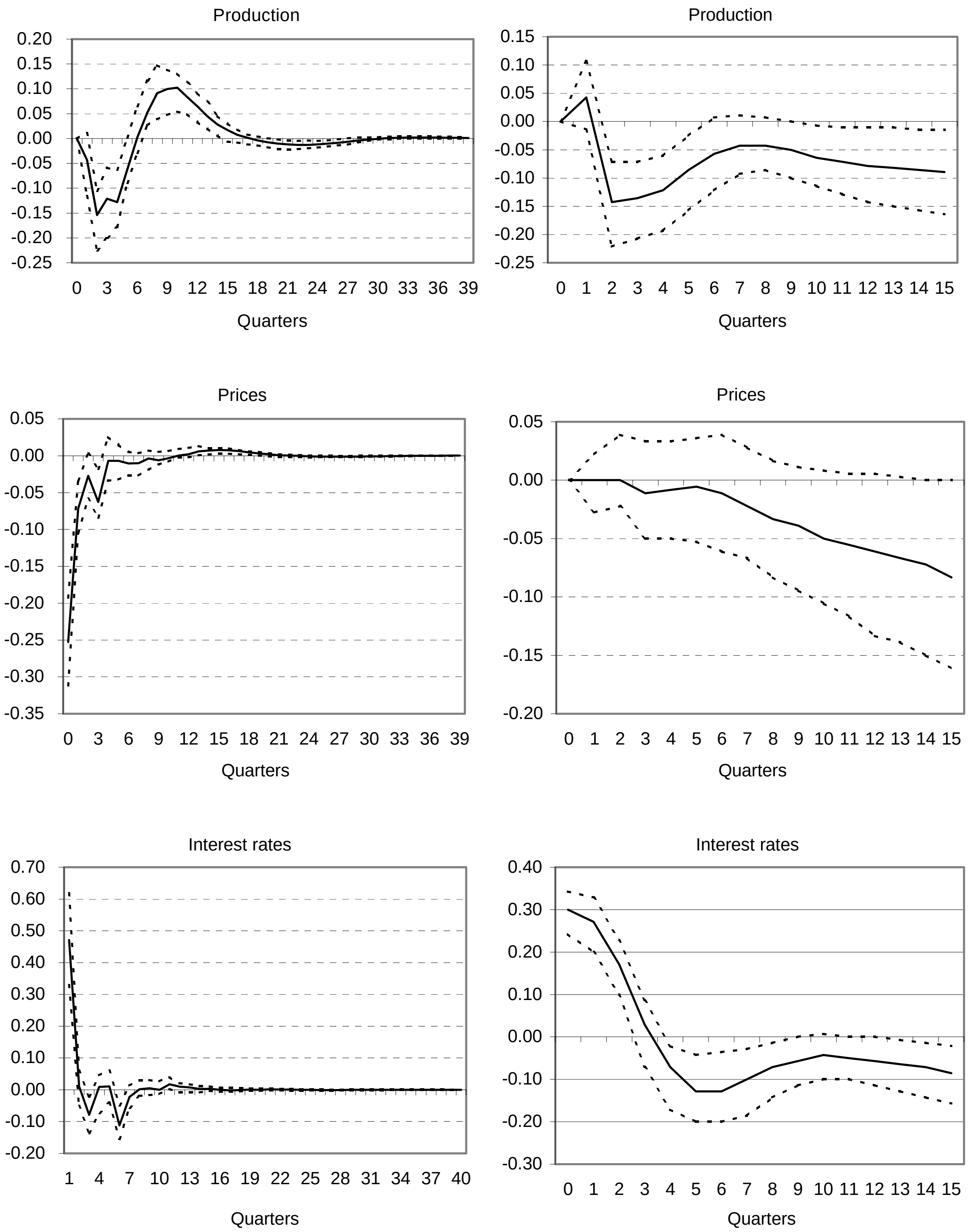
22 Sims (1972, 1980).

because it includes, in addition to real GDP, the consumer price index, the standard short-term interest rate and the real effective foreign exchange rate.

Graph 10

Responses to a one-off unanticipated monetary policy shock in the euro area's VAR models



Sources: Left-hand panels, Bank of France, based on Garcia and Verdelhan (2001); right-hand panels, Peersman and Smets (2001).

Structural shocks are analysed through a Choleski decomposition, the variables being ordered as specified above. As an implied identification constraint, this leads to the conclusion that a monetary policy shock does not have any instantaneous impact on activity or on prices, but may affect the real effective foreign exchange rate. This model is estimated on the basis of quarterly data for the 1980-98 period. Here also, the only supply side shock is supposed to have a real impact on the GDP level, reflecting the assumption that monetary policy is neutral. The results of the simulations are shown in the right-hand panels of Graph 10.

Differences in specifications, samples and specification constraints prevent a direct comparison of simulations. It is, however, possible to analyse the way in which production and prices respond to an unanticipated monetary policy shock and to compare such a response to that provided by the theoretical model (see Graph 9).

We first note that, in the two simulations, production responds in the same way to an unanticipated monetary policy shock. The shock's impact seems to be greatest after two quarters, the GDP returning thereafter to its equilibrium level. Subsequently, the response of the first VAR induces a specific GDP adjustment based on the constraint of monetary policy vis-à-vis long-term activity. In terms of profile, this response recalls that of the sole interest rate channel identified by the theoretical model. Moreover, the second VAR shows the monetary shock's long-term impact on activity and, in fact, the profile of the activity response is totally comparable to the pattern suggesting the presence of financial effects within the euro area.

In terms of prices, the response provided by these alternative approaches is very different: while the theoretical model, with or without financial accelerator, suggests, like the first VAR, that prices return to their equilibrium level, the second VAR shows a remnant effect of monetary policy on prices. It is difficult to come to a final conclusion concerning the information provided by these various results as to the monetary policy transmission mechanisms at work in the euro area. Indeed, responses given by the theoretical model, as well as by the first VAR, suggest that prices respond very quickly. However, we would a priori expect a more gradual impact of the monetary policy impulse, the maximum impact being generally reached after four to five years in macroeconomic models.[23] In addition, most of research work shows that prices gradually return to their equilibrium level. Because simulations are shown for 15 quarters only, the results shown by Peersman and Smets do not make it possible to judge whether the situation subsequently returns to normal.

In sum, the forecasts made in respect of the theoretical model do not seem atypical, in particular because such a model includes the financial factors. We may therefore not totally dismiss the presence of financial effects in the euro area, however, without proving it finally.

3.2.2.2 Analysis of the relationship between credit spreads and economic activity

Credit spreads provide an approximate measure of the external financing premia paid by corporates. Experience has shown that when monetary policy is tightened, the cost of external financing increases more than proportionally to the rise in interest rates. This reflects, inter alia, the greater likelihood of default. Accordingly, there may be a mechanism - materialised by a chain of causation between wider credit spreads and future levels of activity and inflation - that amplifies the business cycle. To verify this assumption, we adopted two approaches in succession: computing cross correlations and performing Granger causality tests. We then observed the results obtained with small VAR models.

Cross-correlation calculations

We computed cross correlations between credit spreads, lagged by several periods, and economic growth indicators. For the indicators, we used the year-on-year change in industrial production (based on monthly data) and aggregate GDP growth in the euro area (quarterly data). The results are shown in Graphs 11 and 12.

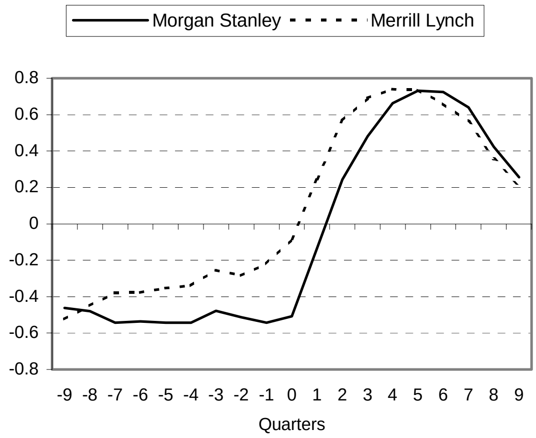
[23] Van Els et al (2001).

Graph 11

Graph 12

Cross correlations

Between credit spreads (BBB-AAA) and GDP growth



Between credit spreads and industrial production growth

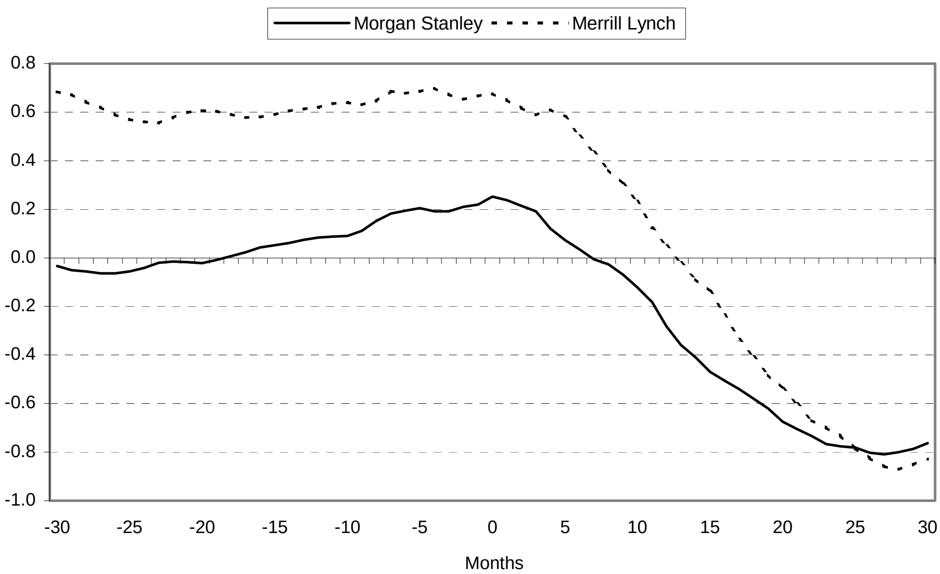
In both cases, the spreads act as leading indicators of economic activity. The correlation is negative for lagged periods: a widening spread appears to indicate a future slowdown in activity; conversely, a narrowing spread indicates a pickup in future growth. The maximum correlation, almost –0.6, occurs for spreads lagged by between 15 and 20 months. One possible interpretation would be that investors demand lower risk premia when their expectations for growth or activity improve.

If we also consider that the spread series with which we are working follow an identical pattern, Graph 12 seems to indicate a decline in the information content of spreads as regards industrial production for the longest horizons. The correlations obtained from the series supplied by Merrill Lynch for the period in question (1999-2002) seem to be non-existent for lags in excess of 20 months whereas they are significant in the data supplied by Morgan Stanley (correlations computed for the period 1994-2002). By contrast, outcomes are comparable for a one-year horizon.

Making the same calculations using the year-on-year change in the harmonised index of consumer prices (HICP) for the euro area, back-dated for the period 1994-2002, we obtain the correlations shown in Graph 13.

Graph 13

Cross correlations between credit spreads and inflation



Here, the correlations are positive for lagged periods (Merrill Lynch spreads) and negative for leading periods beyond a horizon of approximately one year (Morgan Stanley and Merrill Lynch). In addition, the correlations seem to strengthen over the recent period. The correlation coefficient is near zero if we look at the spread derived from Morgan Stanley data but is significantly positive (0.6) for correlations computed over a more recent period (Merrill Lynch spread). This means that credit spreads are also leading indicators of inflation. One explanation for these correlations is as follows: in periods of accelerating inflation, or when an inflationary surge is expected, economic agents demand higher risk premia for investing in corporate bonds.

Granger causality tests

Tables 3 and 4 show the results of Granger causality tests[24] between credit spreads and several indicative variables of economic activity (year-on-year changes and output gaps for industrial production (IPI) and euro area GDP), as well as inflation. The number of lags has been chosen on the basis of different information criteria (AIC, Schwartz and Hannan-Quinn) or likelihood ratio tests. Where the results of these tests differ, we generally choose the most parsimonious model because of the small number of data.

We have also presented the results obtained for very small lags (two and four quarters for GDP, two and four months for the IPI and the HICP). A low probability, ie less than 1%, 5% or 10%, indicates that we reject the assumption that variable *x* does not cause variable *y* at thresholds of 1%, 5% or 10%. In other words, we accept the causality of *x* for *y*.

Table 3

Granger causality tests on credit spreads (Morgan Stanley)

Lags	***x* does not cause the credit spread**	**Prob**	**Lags**	**The credit spread does not cause *x***	**Prob**
2 quarters	YoY GDP growth	0.01***	2 quarters	YoY GDP growth	0.73
2 quarters	Output gap (GDP)	0.02**	2 quarters	Output gap (GDP)	0.52
4 quarters	Output gap (GDP)	0.02**	4 quarters	Output gap (GDP)	0.83
10 months	Output gap (IPI)	0.07*	10 months	Output gap (IPI)	0.99
10 months	YoY change in IPI	0.01***	10 months	YoY change in IPI	0.51
2 months	YoY change in HICP	0.01***	2 months	YoY change in HICP	0.56
4 months	YoY change in HICP	0.03**	4 months	YoY change in HICP	0.22
10 months	YoY change in HICP	0.01***	10 months	YoY change in HICP	0.02**

Note: *** Causality of *x* for *y* is accepted at the threshold of 99%; ** 95%; * 90%. YoY = Year-on-year.

These tests confirm our earlier results, although the picture is less clear-cut. First, we note substantial differences depending on which spread is used. This is mainly due to the fact that the tests were conducted over a different period, owing to the availability of data (1994-2002 for the Morgan Stanley series, 1999-2002 for Merrill Lynch).

Second, we observe that the results are highly sensitive to the number of lags, which reflects the weakness of the causality, in the sense of Granger, highlighted by the tests. In particular, Table 3 seems to establish that a spread is primarily a reflection of current or past economic conditions rather than a leading indicator of activity. However, since the two series of spreads follow comparable patterns from 1999 onwards, Table 4 shows that the causal direction tends to reverse sharply over the recent period and that the information content of the spreads has tended to increase since that date as

[24] A variable *x* Granger-causes a variable *y* if, when used to explain the dynamic of *y*, it makes *y* easier to forecast or, in other words, if the coefficients of the past values of *x* are statistically significant in explaining *y*.

regards both inflation and, to a lesser degree, activity. Although these results are not robust, they are nonetheless consistent with the financial accelerator hypothesis and seem to confirm that a broad credit channel does exist in the euro area.

Table 4

Granger causality tests on credit spreads (Merrill Lynch)

Lags	*x* does not cause the credit spread	Prob	Lags	The credit spread does not cause *x*	Prob
2 quarters	YoY GDP growth	0.45	2 quarters	YoY GDP growth	0.93
2 quarters	Output gap (GDP)	0.11	2 quarters	Output gap (GDP)	0.24
4 quarters	Output gap (GDP)	0.34	4 quarters	Output gap (GDP)	0.42
4 quarters	YoY GDP growth	0.96	4 quarters	YoY GDP growth	0.54
10 months	Output gap (IPI)	0.09*	10 months	Output gap (IPI)	0.77
12 months	YoY change in IPI	0.62	12 months	YoY change in IPI	0.04**
4 months	YoY change in HICP	0.84	4 months	YoY change in HICP	0.09*
10 months	YoY change in HICP	0.05**	10 months	YoY change in HICP	0.06*

Note: *** Causality of *x* for *y* is accepted at the threshold of 99%; ** 95%; * 90%. YoY = Year-on-year.

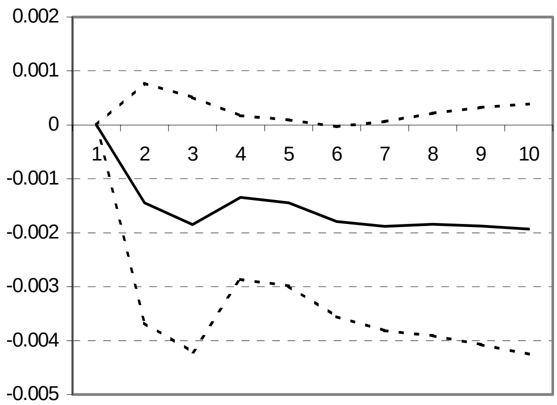
Significance of a financial accelerator effect - results of a VAR model

To determine whether changes in spreads have a meaningful quantitative impact on economic activity, we followed the example of Gertler and Lown (2000) and estimated simple bivariate VAR models containing the output gap, measured on the basis of the IPI or GDP, and the credit spread supplied by Merrill Lynch, which helps to place emphasis on the recent period. In these VAR models, the credit spread comes last, implying that changes in the output gap have an immediate impact on the credit spread but that the reverse is not true. The number of lags used, in view of the information criteria (AIC, Schwarz and Hannan-Quinn), is three for each variable and in each of the models estimated. The responses of the output gap to an unexpected shock to the credit spread of one standard deviation are shown in Graphs 14 and 15.

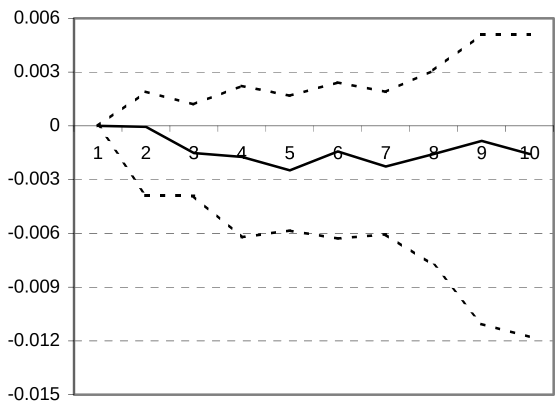
Graph 14 Graph 15

Output gap responses to a shock of one standard deviation to the spread

Output gap based on industrial production



Output gap based on GDP



A financial shock, reflected by a widening of credit spreads, would indeed have a recessionary impact on activity, consistent with occurrences of financial acceleration. In the case of the euro area, the impact would be long-lasting but only very weakly significant (Graph 14) or insignificant (Graph 15).

In sum, it would seem that credit spreads provide a good approximation of external financing premia in the euro area. They can also act as leading indicators of activity, consistent with the presence of a broad credit channel. However, the results are precarious, because only a small number of observations is available and because the data do not cover a full business cycle. Further, the period under review is characterised by bouts of financial instability, which lead to a rise in market risk premia and a greater likelihood of business failures. This may explain why spreads have tended to widen continually in the EMU area since the late 1990s.

3.2.2.3 Other empirical results on the transmission mechanism in the euro area

The results of the major research work conducted under the aegis of the Eurosystem as part of the MTN project lead to a similar conclusion after relying on a very broad range of alternative approaches: simulations of macroeconomic models, VAR models, work on individual data relating to enterprises and credit institutions.

This work shows that the interest rate channel is important in most countries of the euro area and that it practically represents the sole monetary transmission mechanism in many countries of the euro area. However, financial factors, even though they are difficult to characterise, seem to play a non-negligible role in most economies of the area, such as Germany, Italy or even France.

Table 5

Monetary policy transmission channels in the euro area

Results obtained on individual data concerning banks	Data insufficient to conclude that financial factors play a role	Dismissal of the assumption that the interest rate channel is predominant		Non-dismissal of the assumption that the interest rate channel is predominant	
		Financial factors' role in consumption and investment	Financial factors' role in consumption but not in investment	Financial factors' role in investment but not in consumption	No role for financial factors
Supply of credit sensitive to official interest rates	Netherlands Portugal	Greece France?	Germany	Italy France?	
Inelastic credit supply				Austria	Finland Spain
Non-conclusive results	Ireland	Belgium			Luxembourg

Source: Angeloni et al (2002).

It is of course too early to know specifically the monetary transmission mechanism in the euro area. The results shown above also seem to prove that banks play a smaller than expected role in the transmission mechanism.

4. Conclusion

The fact that financial factors tend to play a growing role in the configuration and amplitude of economic cycles has many implications for central banks.

In terms of monetary policy, this first raises the issue of the possible factoring-in of asset prices in the definition and conduct of monetary policy. However, such factoring-in must be made bearing in mind the primary objective of central banks, which is to ensure the stability of the price of flows. Insofar as financial factors influence activity cycles, and therefore the prices of flows, their trends must be carefully analysed, and full use must be made of leading inflation indicators. This does not require a change in central bank behaviour.

The same is probably not true as far as financial stability is concerned. Indeed, recent macroeconomic changes show that the growing weight of financial factors in the economy's dynamics may also have a destabilising effect. If final demand overly depends on changes in asset prices or the granting of financings, the central bank may be tempted to focus excessively on financial factors when conducting its monetary policy. However, this type of behaviour would lead to a possibly dangerous asymmetrical reaction from the central bank, because it would create a moral hazard for economic agents.[25] In addition, the use of a single instrument - the interest rate - in order to pursue two objectives might lead to a conflict between these objectives. The current situation (contained inflation) shows how difficult it would be for central banks to justify, for instance, a significant interest rate increase in order to ensure financial stability in the absence of price pressures. In addition, a second difficulty may arise from the fact that financial stability considerations may be rooted in the very near term, while price stability is defined as a medium-term objective. Accordingly, we may envisage resorting to a second instrument specifically focused on the financial stability objective.

Many avenues may be explored in this respect. If we restrict ourselves to the changes in monetary policy transmission channels highlighted in this article, a particularly significant amplification factor seems to be linked to the highly procyclical nature of bank credit. This element is in particular due to cyclical changes in the value of collateralised assets, which are, where applicable, strengthened by the procyclical nature of certain prudential ratios. Accordingly, we might envisage creating instruments more specifically intended to correct this bias. One of the approaches currently explored and already applied in certain European countries, such as Spain, consists in setting up proactive provisions, where banks set aside during a growth phase the provisions that are to be used during a downturn. By evening out bank earnings throughout the cycle, this mechanism reduces cyclical fluctuations associated with changes in the balance sheet of financial intermediaries and the sometimes destabilising effects due to too sharp an increase in loans granted to the economy.[26]

More generally, some issues are still pending concerning the adequate measurement of risk and the way to hedge against such risk and prevent information imperfections and asymmetries on financial markets. These reflections therefore clearly depend on those studies conducted on economic information and market transparency.

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The challenges of the "new economy" for monetary policy[1]

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Abstract

The advent and spread of information and communication technologies (ICTs) increase potential output growth. It is uncertain to what extent and for how long they do so. We use the term "new economy" (NE) to describe the acceleration in potential output growth and the attendant and partly temporary slowdown in inflation. Assessing the NE is, however, a complicated and delicate task. The impact of the NE on the conduct of monetary policy may differ depending on the timescale. In a long-run perspective, the central bank could capitalise on the NE to set lower inflation targets. In the short to medium term, central banks should be cautious when identifying changing patterns in potential output growth, as temporary errors in appreciation may have an asymmetrical impact on economic stability: the production instability that could result from central banks mistakenly perceiving the advent of an NE would be greater than that generated by the failure to recognise a genuine rise in potential output growth.

The advent and spread of information and communication technologies (ICTs) is an ongoing technological revolution driven by steady and galloping improvement in the performance of ICTs. A case in point: price indices for computer hardware, and more specifically microprocessors, which are supposed to take account of improvements in the performance of these goods using hedonic techniques, have shed an annual average of roughly 20% (for computer hardware) and 40% (for microprocessors) in some three decades. The impact of this revolution is twofold: it has boosted the potential output growth rate durably and dampened inflation, at least temporarily. The term "new economy" (NE) is used in this paper to depict this twofold effect.

Our aim here is to describe the impact of the NE on the conduct of monetary policy. We focus first on the impact of the NE on the variables that are crucial to monetary policy, namely output growth and inflation. We then go on to analyse the consequences for monetary policy, ie the setting by the central bank of a short-term interest rate that serves the dual objective of stabilising inflation and output.

1. ICTs, potential output growth and measuring potential output and inflation

Performance gains in production yielded by ICTs may impact significantly on the potential output growth rate. Various other questions and accounting uncertainties may influence assessment of the effects of the widespread use of ICTs on potential output growth or the measurement of price and wage developments.

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[1] This study is a revised version of a paper presented at the 50th Annual Congress of the *Association Française de Science Économique* - AFSE (French Association of Economics), held in Paris on 20 and 21 September 2001 (Cette and Pfister (2002)). The views expressed herein are those of the authors and do not reflect those of the Bank of France or the Eurosystem. We thank our colleagues Pascal Jacquinot and Ferhat Mihoubi for their help and Antoine Magnier for his comments at the AFSE conference. All errors remain the sole responsibility of the authors.

1.1 The effects of the spread of ICTs on potential output growth[2]

ICTs may have a dual impact on potential output growth: a sustained impact in the medium to long term via capital deepening effects and gains in total factor productivity (TFP), and a more transient impact in the short to medium term resulting from the lagged adjustment of average wages to productivity.

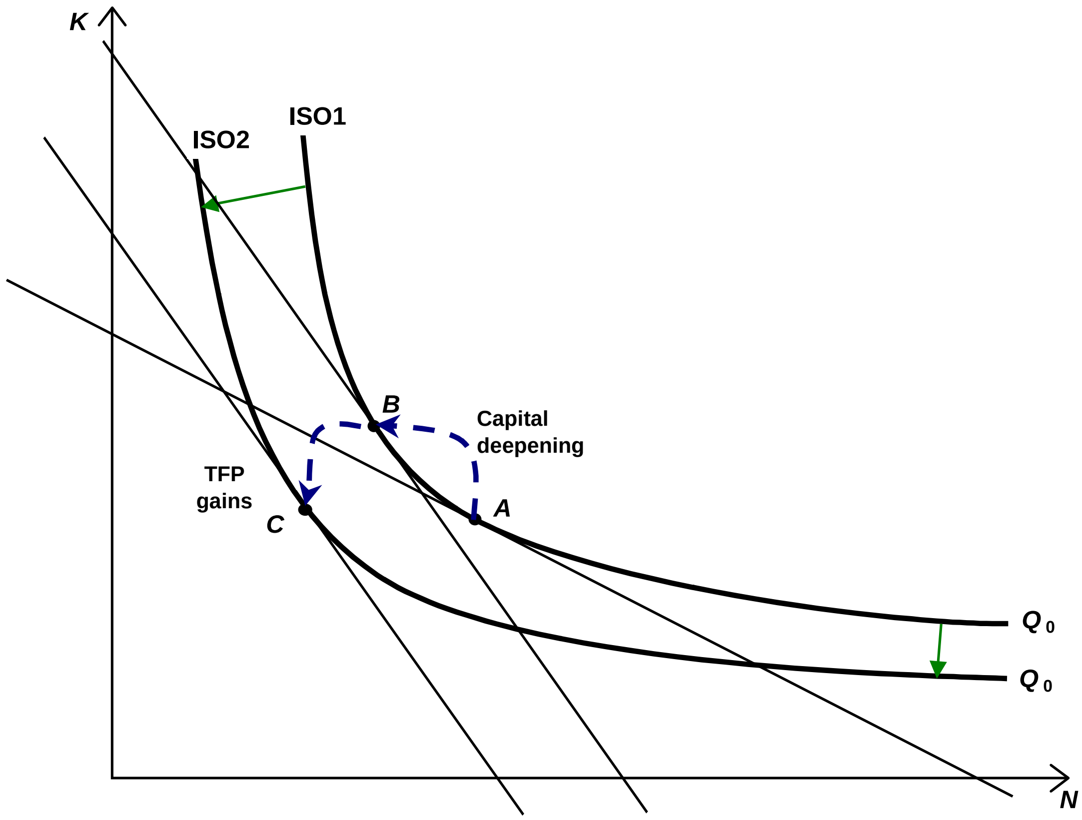
1.1.1 Medium- to long-term effects

The adoption and diffusion of ICTs may have a medium-term effect on potential output growth. This effect is the sum of two elements: changes in TFP gains and capital deepening brought on by differing trends in the price of investment.

Figure 1 below depicts the twofold ICT-induced effect on potential output. The figure assumes an output of Q_0. *A* represents the starting point, where the factor costs line is tangent to the initial isoquant ISO1. Changes in real factor prices brought about by the spread of ICTs - whose prices, due to gains in productive performance, tend to be lower than those for non-ICT investment - alter the slope of the costs line and shift the tangency with the isoquant ISO1 from *A* to *B*. The shift from *A* to *B* corresponds to the capital deepening effect referred to above. In addition, possible gains in TFP make it possible to achieve the same level of output (Q_0) with a smaller input. This corresponds to the shift from isoquant ISO1 to isoquant ISO2. The factor costs line is tangent to this new isoquant at *C*, which indicates the input combination minimising the costs of production following the spread of ICTs.

Figure 1

Uptake of ICTs: an illustration of the impact on the input combination



Q: Output; *K*: Fixed productive capital; *N*: Labour.

[2] What follows builds largely on the insights of Cette et al (2002b). Appendix 1 reprises the formalisation, taken from this study, of the effects of the spread of ICTs on potential output growth.

The rise in the potential output growth rate is a gradual one. The gradual improvement corresponds to the time needed for ICTs to become pervasive. Once they are in widespread use, the new potential output growth rate is maintained thanks to the constant upgrading of ICTs. Two aspects must be stressed:

- The roles attributed respectively to TFP and substitution among factors of production in the modification of potential output growth depend primarily on the accounting treatment applied to the volume-price breakdown of investment series in nominal terms. This observation, which is often stressed - see Gordon (2000b)[3] or Stiroh (2001)[4], for instance - forces us to put the economic significance of possible changes in the estimated TFP rate into perspective. Two opposing cases are possible. If the volume-price breakdown is based entirely on a “factor costs” approach, the spread of ICTs has no effect on price inflation - potential output gains stem exclusively from gains in TFP.[5] Conversely, if the volume-price breakdown is based uniquely on a “services produced” approach, TFP gains amount to zero and gains in potential output growth result solely from capital deepening effects. The accounting treatment currently applied to the volume-price breakdown of ICT investment is based on two approaches.[6] The “services produced” approach is usually based on hedonic and matched model methods.[7] Computer hardware is mostly recognised under a “services produced” approach in France as well as in the United States. Accounting for computer software is based solely on “factor costs” in France. In the United States, some software is also recorded using a “services produced” approach, specifically prepackaged software and some custom software, ie a total of 50% of software expenditure. The volume-price breakdown of own-account and other custom software is based on a “factor costs” approach. Lastly, for telecommunications equipment, the volume-price breakdown is based on a “services produced” approach solely for digital telephone switching equipment in the United States, and otherwise on a “factor costs” approach. To conclude, let us point out that these approaches will no doubt evolve significantly in the coming years for computer software and telecommunications equipment, with hedonic methods being extended to these two types of ICT (Parker and Grimm (2000), Grimm et al (2002)). A number of economists, eg Jorgenson(2001)[8] and Gordon (2000b),[9] have called for such change.
- In an ICT-producing economy, if the volume-price breakdown is at least partially based on a “services produced” approach, the advent of ICTs may keep the lid on growth in output prices. In an exclusively ICT-using economy, trends in output prices will not necessarily be modified by the emergence of ICTs. The United States is close to falling within the first group, while France is close to falling within the second. In fact, if we consider the three components of ICT to be computer hardware, computer software and telecommunications equipment, it appears that, currently,[10] it is mainly prices of computer hardware - and not

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3 “Indeed, the faster the assumed decline in prices for software and communication equipment, the slower is TFP growth in the aggregate economy…” Gordon (2000b).

4 “Note that the neoclassical framework predicts no TFP growth from IT use since all output contributions are due to capital accumulation. Computers increase measured TFP only if there are nontraditional effects like increasing returns, production spillovers, or network externalities, or if input are measured incorrectly.” Stiroh (2001).

5 These aspects are discussed in greater detail in Cette et al (2000, 2002a).

6 For a more detailed presentation of the methods used, see Jorgenson (2001) for the United States and Cette et al (2000), which compares the methods used in France and the United States.

7 Taking into account ICT performance gains using a “services produced” approach does not only involve using hedonic methods, it may also be carried out using matched model methods. Consequently, with regard to the US economy, several studies by Landefeld and Grimm (2000) show that these two methods arrive at price developments in IT equipment that are very similar.

8 “Unfortunately, software prices are another statistical blind spot with only prices of prepackaged software adequately represented in the official system of price statistics. The daunting challenge that lies ahead is to construct constant quality price indexes for custom and own-account software”, Jorgenson (2001, p 12).

9 “The government deflators for software and telecommunication equipment exhibit implausibly low rates of price decline”, Gordon (2000b, p 51).

10 Probably partly due to reasons linked to product-specific differences in the methodologies used in the national accounts to break down the capital expenditure into volume and price.

those of computer software or telecommunications equipment - that are diverging from those of other capital goods. As it happens, France and the euro area in general produce relatively small amounts of computer hardware.

It is difficult to assess the impact of the spread of ICTs on potential output growth. If the price of investment was perfectly measured under a “services produced” approach, the impact would be equivalent to the capital deepening effect resulting from the price differential between ICT investment and other capital expenditure. However, given that “services produced” are taken very partially into account in national accounts price estimates, part of the impact of ICTs on potential output growth is attributed in the accounts to TFP gains.

Cette et al (2002b) estimate that, overall, the spread of ICTs should contribute approximately 1.5 to 2 percentage points to the US potential output growth rate. This estimate is based on several conventional assumptions. The capital deepening effect on potential output growth should slightly exceed 1 percentage point annually and the more uncertain TFP effect should run at 1/4 of a percentage point to 1 percentage point. Though the latter figure may appear high, it may be attributed to the fact that quality changes are currently taken into account only for a limited fraction of ICT expenditure, as a factor costs approach is used to measure most of this expenditure (see above). Carried out for France, the same assessment finds an impact that is half as significant, given that the spread of ICTs is also half as extensive.

All in all, the spread of ICTs may appear to have a very substantial impact on potential output growth. However, the measurements compare a real situation in which ICTs exist to an extreme and theoretical situation characterised by the complete absence of ICTs. Moreover, the measurements assume that the differential between output price and investment price developments arises entirely from the spread of ICTs. This means that the impact of ICTs on potential output growth is magnified but also makes it possible to indirectly recognise ICT components that are embedded in capital goods and that are, as such, not recorded as ICT investment. Lastly, it should be pointed out that the hitherto very limited inclusion of quality effects in measurements of computer software and telecommunications equipment prices considerably reduces the capital deepening component.

1.1.2 Short- to medium-term effects

The lagged adjustment of average wages, more specifically average labour costs, to the productivity level reduces inflationary pressure during the ICT rollout period or, in other words, during the productivity boom, and subsequently during the period in which average wages progressively adjust to the new productivity path.

Let us assume that, prior to and following the spread of ICTs, labour productivity grows at a constant rate, and that productivity accelerates constantly as ICTs become widespread. Let us also assume a lag in the adjustment of average wages, more specifically average labour costs, to the productivity level, based for instance on the first-order error correction model proposed by Blanchard and Katz (1997). During the ICT diffusion period, the increase in average wages is smaller than the rise in productivity. Consequently, the gap between average wages and their equilibrium level increases as a percentage of this equilibrium level. Once ICTs have become widespread, growth in average wages outpaces that of productivity. The gap between average wages and their equilibrium level therefore gradually fades. Once adjustment is complete, barring other shocks, growth in average wages matches that of productivity.

During the entire transition period covering the spread of ICTs and the adjustment of levels in which average wages are below their equilibrium level, the NAIRU falls and consequently the level of potential gross domestic product (GDP) increases in comparison with a situation in which average wages immediately adjust to their equilibrium level. This process is described in several papers, for instance Meyer (2000b), Blinder (2000), Ball and Moffit (2001) and Ball and Mankiw (2002). Given identical trends in labour productivity, the size of this transition effect depends on the speed at which average wages adjust to productivity, which is very difficult to assess. For the United States, assuming a very gradual adjustment, Ball and Moffit (2001, pp 24 and 25) estimate the temporary drop in the NAIRU, following a productivity surge, at roughly 1 percentage point at the end of the previous decade. Assuming a more rapid adjustment - over three years - Cette et al (2002b) arrive at a temporary fall in the NAIRU of about 0.2 percentage points. In France, and the euro area as a whole, given the slower spread of ICTs and broad-based policies aimed at tempering the rise in productivity, productivity did not escalate and might in fact have flagged in the second half of the previous decade.

The temporary drop in the NAIRU observed in the United States is therefore not likely to have taken place.

1.2 Other accounting issues or uncertainties[11]

The magnitude and duration of ICT-induced gains in potential output growth are uncertain. There are, moreover, a large number of accounting issues pertaining to this constantly and rapidly evolving area.

1.2.1 The magnitude and duration of gains in potential output growth are uncertain

A great deal has recently been written on the uncertainties surrounding the extent and duration of TFP gains and of capital deepening effects stemming from the spread of ICTs. These uncertainties have already been dealt with in Cette et al (2002a,b,c) and shall therefore only be reviewed rapidly here.

Four types of uncertainty pertaining to the size of the impact of ICTs may be broadly distinguished:

- The observed speed-up in TFP gains in the US economy as a whole is very recent. It dates back to the mid-1990s. Consequently, some economists, Gordon (2000a,b) for instance, believe that a substantial part of this speed-up is likely to be cyclical and an outgrowth of US economic expansion in the 1990s. This is not a view that is shared by most other analytic studies such as Jorgenson and Stiroh (2000), Jorgenson (2001), Jorgenson et al (2001), Oliner and Sichel (2000, 2002) or Council of Economic Advisers (2001, 2002).
- Strong uncertainty also surrounds the sectoral allocation of TFP gains traceable to the spread of ICTs, and the spillover of gains from ICT-producing to ICT-using sectors. However, TFP gains are allocated essentially according to the rules applied to the volume-price breakdown used for ICTs. This difficulty, described by Cette et al (2000) and Brynjolfsson and Hitt (2000), requires us to be cautious in discussing the allocation of TFP gains to ICT-producing or ICT-using sectors.
- Another uncertainty is highlighted in the numerous studies based on individual data that focus on the conditions determining whether the spread of ICTs leads to productivity gains (see Greenan and Mairesse (2000) or Brynjolfsson and Hitt (2000) for a detailed examination of such studies). The spread of ICTs does not necessarily lead to gains in productive efficiency. The existence and extent of these gains is in fact largely determined by other aspects, which also hinge on human resources management.
- One last major issue concerns industrialised European countries' capacity to derive real benefits from the development of ICTs in respect of real and potential output growth and surges in productivity. Gust and Marquez (2000) conclude that the beneficial effects the new economy and ICTs have on labour productivity and TFP will eventually materialise in all industrialised countries. The magnitude of these effects and the duration of the time lag with the United States nevertheless remain uncertain. Uncertainty about the magnitude of the effects stems mainly from our patchy knowledge of the positive interaction, occurring via spillover effects, between ICT-producing and ICT-using industries. If this interaction is substantial, Europe will enjoy more limited ICT-induced gains than the United States given its smaller ICT-producing industry.[12]

There is also strong uncertainty about the duration of ICT-related performance gains. The main efficiency gains result from microprocessors, whose processing power has constantly kept pace with "Moore's Law", which predicts the doubling of processing power every 18 to 24 months. Jorgenson (2001) stresses that it would be rash to extrapolate this trend ad infinitum. Whether or not Moore's Law will continue to hold in ICT-producing industries is not the only vexed issue concerning

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[11] What follows is based to a large extent on Cette et al (2002a,b,c).

[12] Pilat and Lee (2001, pp 21-2) offer several reasons why a sizeable ICT-producing sector is not a prerequisite for deriving full benefits in terms of growth: proximity to producers of computer software could be more relevant than proximity to producers of computer hardware. Besides, several countries, for example Australia, appear to benefit significantly from using ICTs without necessarily boasting a large ICT-producing industry. The contribution of ICTs to economic growth in European countries could therefore expand substantially in Europe, and more specifically in France, in the coming years.

performance gains. Gordon (2000b) also raises doubts about human ability to fully exploit increasing computer capability.

1.2.2 Lingering accounting uncertainties

Methods used in the national accounts to refine estimations of new economy-related variables have improved significantly in recent years. These improvements aim for instance to take better account of quality effects and in particular the performance gains arising from business investment in ICT. This has led Gordon (2000b, 2002) to posit that the impact of the introduction and spread of ICTs on output and productivity growth is not necessarily more profound than that of previous technological "revolutions" such as the invention of the steam engine in the 19th century or of electricity at the start of the 20th. In fact, such a comparison is undermined by the fact that estimates of inputs and especially outputs have been extensively refined in recent decades. Via a drop in prices and an accompanying increase in volumes, these estimates now take better account of qualitative improvements that were overlooked in previous statistics, such as increasingly comfortable rail transport and housing. However, in an assessment of the US economy over a very long period, Crafts (2002) estimated that, since 1974 and especially 1995, the contribution made by ICTs to annual output and productivity growth has vastly surpassed that made by the steam engine in 1830-60, the period in which it was most widely used, and exceeded that made by electricity in 1899-1929 and even 1919-29. Fraumeni (2001) and Litan and Rivlin (2001) also underline that a raft of varying ICT-induced improvements in the quality of certain services, such as commercial and health services, are not recognised in national accounting statistics. Output growth would therefore appear to be currently understated.

Notwithstanding these improvements in national accounting methods, supply and use balances are still established according to conventions that have an impact on the assessment of GDP level and growth. Lequiller (2000) expounds on this. He shows that the breakdown of ICT resources between final use and intermediate use is based on different methodologies in the United States and in France, and more generally Europe. This apparently results in a larger share being attributed to final use, and therefore to higher GDP growth, in the United States than in Europe. Given that, on average, ICT-related activities tend to develop faster than other activities, this methodological difference should have a significant impact not only on the level of GDP but also its growth rate. Lequiller's analysis clearly illustrates some uncertainties in the assessment of growth that inevitably result from ICTs. It also highlights the uncertainties in the GDP estimate that may result from the complicated breakdown - based on accounting rules that are in themselves questionable - of the use of certain ICT-related goods and services, such as mobile telephony goods and services, between households and businesses.

In this constantly evolving area, accounting methods are changing in all countries and may differ from one country to another. The US consumer price index is a case in point: the Boskin report (1996) led to a host of methodological changes that were aimed at improving assessments of consumer price inflation. Volume-price breakdown methods applied to ICTs in particular have also evolved considerably in a number of countries. The changes aim to take better account of quality effects (Cette et al (2000)). When these accounting changes are not applied to the entire historical period available, they can lead to discontinuities that make it difficult to analyse developments in the prices and volumes of the variables concerned.

The consequences of methodological changes are more complex than they appear to be (Lequiller (2000)). Hence, a change in the volume-price breakdown that increases the volume for certain ICT goods and services may increase real GDP for the reasons referred to above, but this increase is tempered by the intermediate use that resident agents make of imports of these goods and services. Landefeld and Grimm's (2000) analysis of US Bureau of Economic Analysis methodology shows, on the basis of a large number of studies, that using hedonic techniques to carry out the volume-price breakdown of ICTs does not appear to significantly affect the measurement of real GDP and the GDP deflator. However, the authors propose a comparison with matched model methods, which take quality effects largely into account. A broader comparison with factor cost approaches, which are closer to those used to measure countless other goods and services, would be more appropriate here.

Another source of uncertainty lies in the fact that the share of ICTs in the output and expenditure of economic agents has expanded considerably in recent decades (Mairesse et al (2000)). Consequently, where a volume-price breakdown methodology has been established for each type of good, the methodology structure has evolved to increasingly include methods that take better account of changes in quality, for instance hedonic indices. This change in structure could therefore affect the "average methodology" of the volume-price breakdown, leading to a shift in emphasis from price to volume to an extent that is unknown.

Lastly, in the future, measurement methods shall continue to evolve to better capture quality changes in certain ICT goods and services. The example of computer software and telecommunications equipment discussed above is probably one of the most significant, as in France and the United States, these goods and services account for over 1.5% and 2.5% of GDP respectively. These methodological changes are bound to have a significant impact on the measurement of GDP prices and volumes. The same is true for other ICT goods and services that are on the rise, such as mobile telephony (Lequiller (2000)). Uncertainties about the measurement of ICTs and the volume-price breakdown methods that are applied to them are therefore relevant not only to the past but also to the future.

2. Taking the "new economy" into account in the conduct of monetary policy

Taking the "new economy" (NE) into account in the conduct of monetary policy is done here in the framework of a Taylor rule.[13] This raises two difficulties:

- In the long term, it is acknowledged that inflation, control of which is the primary objective of monetary policy, is a monetary phenomenon. Yet, growth in money supply is not taken into account in the simple Taylor rule. However, this rule does incorporate two factors that make it possible to determine whether monetary growth is inflationary: the inflation target and potential output or, more specifically, deviations in the trends observed in relation to these variables.
- The simple Taylor rule is generally not optimal, in the sense that it would make it possible to minimise a priori a quadratic loss function for the central bank. However, it does have advantages in terms of ease of use and communication. Furthermore, it is possible to modify some of its parameters in order to reduce the deviations of inflation and output from their target. We shall focus here on this approach.

Using simulations, we will examine how the NE can be taken into account in the conduct of monetary policy from a long-term and a short- to medium-term perspective.

2.1 What are the implications for the conduct of monetary policy in the long term?

In the long term, within a Fisherian approach, the nominal interest rate is the sum of real interest rate and expected inflation. Now, by raising the economy's potential output growth rate, the NE should result in a rise in the long-term equilibrium real interest rate: the productivity boom increases the profitability of investment, pushing up the real interest rate, which allows saving and investment to balance in line with full employment. Although monetary policy only controls the short-term nominal interest rate, it may take into account rises in the equilibrium real interest rate by reducing the gap between the "natural" and "market" rates, as defined by Wicksell.[14] However, as this form of passive adjustment of monetary policy to the NE is inevitable in the long term, it is not simulated in this paper. Furthermore, to the extent that monetary policy is credible, inflation expectations should correspond to the central bank's inflation target. Central banks then have two choices. They can either take advantage of the sustainable positive supply shock, arising from the NE, to lower their targets - to be credible, the target decrease must be a permanent one. Or they can choose to leave the inflation target unchanged and focus on stabilising inflation rather than stabilising output. For simplicity, these

13 Taylor (1993).

14 Meyer (2000a).

choices are simulated in a polar fashion: the simple Taylor rule is compared with a form of inflation targeting in which, in a Taylor rule, the inflation stabilisation coefficient is equal to one and the output stabilisation coefficient is zero. In reality, however, both choices can be combined, and this is made even easier if the NE spontaneously results in the economy becoming less cyclical, thanks to, for example, better management of durable goods inventories.[15]

We therefore compare two monetary policy variants affecting the parameters of the Taylor rule: lowering the inflation target, and stabilising inflation. The latter is sometimes recommended in the event of a permanent acceleration in productivity.[16] The simulations were carried out using a highly simplified model of a closed economy described in Appendix 2, and the MARCOS model developed at the Bank of France.[17] In the reference scenario, the NE is simulated by an exogenous increase in the growth rate of potential output (1% in the first model), or in productivity (0.2% in MARCOS). Where the inflation target is lowered, it is reduced by 1 percentage point. These simulations cannot claim to be a faithful representation of the economic reality, but are simply for illustrative purposes: the model is highly simplified, and the calculations made under the MARCOS model incorporate a technology shock in a single economy similar to the French economy. The results are summarised in Table 1 and show, for each variant, the corresponding loss (discounted quadratic sum of the deviations in inflation and output).[18]

Table 1

Monetary policy variants

Monetary policy rule	**Taylor rule**		**Stabilising inflation**	
Changing the inflation target	**Yes**	**No**	**Yes**	**No**
Simplified model				
Loss on deviation in inflation	0.013	0.020	0.012	0.019
Loss on output gap	0.078	0.117	0.077	0.114
Total loss	0.091	0.137	0.090	0.133
MARCOS				
Loss on deviation in inflation	5.22	2.20	13.69	10.19
Loss on output gap	35.18	40.18	37.71	45.98
Total loss	40.40	42.38	52.40	56.18

These variants provide the following information:

- Overall, the comparison of monetary policy rules comes out somewhat in favour of the Taylor rule. Indeed, the simplified model shows that there is a marginal advantage in stabilising inflation, but the substantial advantage of the Taylor rule in MARCOS is more consistent with a scenario in which taking the output gap into account results in a lower inflation rate.

15 McConnell and Perez-Quiros (2000).

16 Cechetti (2002).

17 MARCOS (Modèle à Anticipations Rationnelles de la Conjoncture Simulée) is a calibrated rational expectations model of the French economy. It is chiefly designed for carrying out medium- to long-term simulations. It was built under the assumption of a small country with monopolistic competition in product and labour markets, in which wages are negotiated in accordance with a right-to-manage model of the labour market, and the consumption of households, which do not face liquidity constraints, is led by intertemporal optimisation behaviour under the life cycle hypothesis. See Jacquinot and Mihoubi (2000).

18 The discount rate is 3.5% in the simplified model and equal to the short-term real interest rate of the reference scenario in MARCOS.

- The reduction of the inflation target is always favourable, as the NE is spontaneously disinflationary. Furthermore, it only has a moderate impact on output, particularly in MARCOS.

It should, however, be noted that the effects of lowering the inflation target are analysed here in a highly simplified form, without considering the optimal non-zero inflation rate.[19] Much has been written about the economic costs of inflation, such as menu costs, “inflationary tax”, greater price fluctuations leading to a higher degree of uncertainty of expectations, etc. Similarly, in the presence of downward nominal rigidities of wages and other prices, the “optimal” relative price adjustment could require a minimal level of inflation. Therefore, an inflation-unemployment trade-off would appear in the low inflation range, and lowering an already low inflation target could result in a cost in terms of output growth. While this representation is theoretically relevant, the empirical measurement of nominal rigidities, and thus of “optimal” inflation, is nevertheless difficult (INSEE (1997)). In addition, nominal rigidities are probably related to past inflation, which contributes to shaping expectations: for the same level of current inflation, these rigidities would be greater in the aftermath of periods of high inflation, and weaker following a prolonged period of low inflation, such as that experienced by industrialised countries since the mid-1980s. Lastly, these rigidities are not present across the board: ICT prices fall.

2.2 Managing the transition towards the “new economy” in the short to medium term

In the short to medium term, the new economy raises the issue of transition management - the same problem crops up, in opposing terms, once the NE has petered out. Specifically, the spread of the NE spawns new factors of uncertainty in the conduct of monetary policy. Uncertainties are pervasive in the measurement of output and prices, the duration of the trend that is placed under the NE banner (and hence its actual existence, as it must be sustainable in order to be qualified as such) and in changes in behaviour, and therefore in the accompanying monetary policy transmission channel.

2.2.1 Short- to medium-term dynamics

The spread of the NE has two opposing impacts on prices:

- A so-called “direct” disinflationary effect resulting from a lagged indexation of real wages to productivity that leads to a temporary drop in the NAIRU;[20] and
- A demand effect in the form of a double boom in corporate investment and household consumption. The boom in investment is triggered by the profit opportunities attendant on the uptake of new technologies, the drop in relative prices of high-tech equipment and the decrease in the cost of financing ICT investment due to the surge in the prices of equities issued by ICT-related companies. The boom in consumer spending is spurred by the wealth effect fed by soaring equity prices and the promising outlook for labour income.

In such an environment, the central bank is in a position to choose between two favourable scenarios: turning to advantage the speed-up in productivity growth to allow a further increase in output at an unchanged rate of inflation, or combining a reduction in inflation with a more gradual pickup in output. This alternative was presented by a governor of the Federal Reserve Board, who believes that the productivity surge was mainly used in the United States to boost output temporarily and, to a lesser extent, to lower inflation.[21]

This view could be taken even further:

- The “direct” disinflationary effect is a temporary companion to the more permanent effect resulting from the increase in TFP. It is this more sustained effect that may enable the

[19] Akerlof et al (1996), Wyplosz (2000).

[20] Meyer (2000a,b), Ball and Mankiw (2002), Ball and Moffit (2001), Cette et al (2002b).

[21] Meyer (2000b). Gordon (2000a) also points out the following: “... by helping to hold down inflationary pressures in the last few years, the New Economy allowed the Federal Reserve to postpone the tightening of monetary policy for several years in the face of a steadily declining unemployment rate”.

lowering of the inflation target, while the "direct" disinflationary effect permits an "opportunistic" slowdown of inflation.

- The "direct" disinflationary effect and the demand effect are to some extent mutually exclusive. Notably, the "direct" disinflationary effect can only occur if the spurt in productivity is unforeseen or deemed short-lived, but in such cases, the increase in corporate equity prices and expectations of a rise in labour income are not as robust. This is a point worth making in view of the potential spread of the NE worldwide and particularly in Europe. The precedent set in the United States could in fact lead private economic agents to adjust their demand to the rise in their permanent income, and to factor the pickup in productivity into wage negotiations more quickly than they did in the United States. The "direct" disinflationary effect would therefore be less pronounced.
- As concerns actions taken by the Federal Reserve (Fed), a study of the minutes of meetings of the Federal Open Market Committee (FOMC) shows that, contrary to what is suggested by Ball and Tchaidze (2002), FOMC members, while being aware as in 1996 of a possible acceleration in trend productivity growth, did not explicitly attach great importance to the drop in the NAIRU. In the second half of the 1990s, the FOMC appeared to be striving rather to stabilise one specific indicator of inflation, the core PCE deflator.[22] In any case, the Fed's policy has drawn mixed reactions. On the one hand it has been criticised for leaving a limited legacy by favouring "covert inflation targeting" over explicit rules.[23] On the other hand, the Fed under the chairmanships of Volcker and Greenspan has been applauded for taking better account of technology shocks than had been done previously.[24] On the latter point, it must nonetheless be noted that the NE emerged a long time after Paul Volcker had taken office (see below), and that it is easier for monetary policy to take account of supply shocks when these shocks are positive, as in the case of the NE, than when they are negative, eg rising oil prices.

2.2.2 Taking uncertainties into account

Economic policymakers are generally faced with three types of uncertainty:[25] uncertainty about the state of the economy or economic data, known as "additive" uncertainty (referred to here as type 1 uncertainty), uncertainty about the parameters of the model underlying the economy, termed "multiplicative" uncertainty (type 2) and uncertainty about the model itself (type 3).

Among the forms of uncertainty fed by the advent of the NE, type 1 uncertainty is probably the greatest in Europe. It is linked to the extent and timing of a new economy, and therefore to its measurement (see ECB (2001)). This type of uncertainty calls for an attenuated response to data that might be subject to measurement error - in this case output and inflation.[26] This approach, which appears to correspond to central bank behaviour,[27] presses the case for taking the NE cautiously and progressively into account in the conduct of monetary policy.

Uncertainty about the duration of the NE, and the behavioural changes that may go along with it, ranks as type 2 or even type 3 uncertainty. Studies conducted to date do not, however, arrive at an unequivocal conclusion on the impact of the NE on monetary policy transmission channels. Ehrmann and Ellison (2001), for instance, show that since 1984 US industrial response to monetary policy has been increasingly sluggish. The authors attribute this to the fact that new technologies enable companies to keep a closer eye on inventories and more easily adjust production levels. They therefore now prefer to wait for demand to change before adjusting production, whereas before they would have anticipated changes in demand. This study nevertheless raises at least two problems. The

[22] Wynne (2002).

[23] Mankiw (2001).

[24] Galí et al (2002).

[25] Le Bihan and Sahuc (2002).

[26] Orphanides (1998), Svensson and Woodford (2000).

[27] Orphanides (1998), Rudebusch (2000).

first is a dating problem. The authors reprise research by McConnell and Perez-Quiros (2000), who show that there was a structural break in the volatility of output in the United States in the first quarter of 1984. However, in monetary policy terms, the break is usually situated in 1979, at the time Paul Volcker took up his post,[28] while in NE terms, the pickup in labour productivity in the United States was observed only in the second half of the 1990s. Ehrmann and Ellison then develop a model for output trends based on the capacity utilisation rate, even though ICTs might have led to a break in the "optimal" level of this variable precisely because inventories were managed more efficiently. Conversely, referring to the expectations hypothesis of the interest rate structure and to the fact that the NE has been accompanied by a reduction in the service life of capital, von Kalckreuth and Schröder (2002) maintain that the NE must have increased the efficiency of the transmission channel by cutting the time to maturity of the interest rate that enters into investment decisions. However, they do not verify their postulate. In any case, long-standing research shows that type 2 uncertainty, like type 1, calls for gradualism.[29] Admittedly, it has been proven more recently that an aggressive monetary policy may be justified in cases where inflation is very persistent.[30] However, if monetary policy is credible, there is little chance of this assumption being verified.[31] As far as type 3 uncertainty is concerned, it may, in a first instance, call for an aggressive strategy when the central bank, faced with radical uncertainty, wishes to ensure a minimum outcome[32] - in the case under consideration, it would allow real interest rates to drop sharply if it wished to ensure that the NE took off at all costs. In a second approach, robustness is achieved by ensuring that the monetary policy decision delivers similar results irrespective of the model used.[33] This is a stance typical of central banks, which often have several models or representations of the economy. It is the approach used here.

The NE and the faster productivity growth that comes in its wake create uncertainties for monetary policy. These uncertainties are simulated by two International Monetary Fund (IMF) economists using the MULTIMOD model. Three scenarios are analysed.[34] In the first scenario, the central bank and the private sector correctly perceive the productivity shock when it occurs. In the second, the central bank and the private sector mistakenly perceive a productivity shock of the same size and revise their mistaken perception after five years. In the third scenario, the central bank's error, one it makes alone, is that it only perceives the productivity shock five years after it has occurred. Compared with the baseline scenario, in which there is no shock, it appears that the central bank's error in being slow to perceive the emergence of the NE entails costs in terms of the stability of production and inflation. However, the highest costs result from the two sectors mistakenly perceiving the development of an NE. In this case, the inflation speed-up would need to be tamped down by a tough monetary policy stance - all the more so because potential output growth has fallen short of expectations.

The simplified model laid out in Appendix 2 finds these two results. The model simulates two types of technology shock that increase the potential output growth rate by 1 percentage point: a one-off shock that occurs in the first year, and a permanent shock. Like in Bayoumi and Hunt's (2000) simulation, the central bank is faced with a situation of uncertainty. In both cases, it may believe that a permanent technology shock has occurred and accordingly adjust its assessment of potential output. This affects the output gap used in the Taylor rule. If the central bank believes that a technology shock has occurred, it may revise its assessment of potential output and also lower its inflation target by 1 percentage point. The results are summarised in Table 2, which indicates total loss on inflation and output.

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28 See, for instance, Clarida et al (2000).

29 Brainard (1967).

30 Söderström (2000).

31 Cecchetti (2000).

32 Hansen and Sargent (2000).

33 McCallum (1999).

34 Bayoumi and Hunt (2000), IMF (2000). The first paper includes a fourth scenario in which the central bank, unlike the private sector, does not believe in the emergence of an NE and is proven right. This results in output and inflation lower than that in the first scenario. The authors also show that a nominal GDP rule leads to a loss that is smaller than with inflation targeting, particularly in the third scenario.

Table 2

Uncertainty about the NE and monetary policy stance

Monetary policy rule	Taylor rule			Stabilising inflation		
Changing the assessment of potential output	**Yes**		**No**	**Yes**		**No**
Changing the inflation target	**Yes**	**No**	**No**	**Yes**	**No**	**No**
Loss in the event of a trend shock	0.091	0.137	0.175	0.090	0.133	0.162
Loss in the event of a one-off shock	0.198	0.200	0.181	0.193	0.196	0.156

The lessons from the simplified variants are as follows:

- Loss is exacerbated if the central bank is mistaken in its analysis, irrespective of whether the shock is a trend or a temporary shock. Error therefore entails a cost, which seems logical.
- Losses are greater when the central bank mistakenly perceives a trend shock than when it fails to recognise a true shock. This asymmetry, which stems primarily from loss on the stability of economic activity, may be "intuitively" explained as follows. If the central bank mistakenly perceives a trend shock, it spurs a speed-up in the output growth rate beyond the unchanged potential rate. Becoming aware of its mistake, the bank then strives to put a brake on output growth, to bring it below its potential rate until the inflationary pressures have dissipated, so as to finally allow output growth to match its potential rate. If the central bank fails to recognise a true rise in potential output growth, it strives to keep output growth at its previous potential rate. Once it perceives its error, it endeavours to propel output growth beyond its potential rate until the disinflationary pressures have dissipated to finally allow output growth to match its new potential rate. In other words, if, for the sake of simplicity, it is assumed that monetary policy is immediately and totally effective, the output growth rate would change three times in the first case and only twice in the second. This asymmetry requires the central bank to be cautious in identifying the possible development of an NE.
- If an NE is proven to have emerged, the losses are alleviated by the lowering of the inflation target. This is simply attributable to the fact that the lowering of the target goes along with the temporary disinflationary shock arising from the development of the NE. Conversely, if the central bank wrongly perceives a trend shock and lowers its inflation target, losses are higher. Central banks must therefore be especially prudent when lowering inflation targets.

In addition to uncertainty about the development of an NE, uncertainty about the measurement of inflation and GDP that ensues from this new situation could make a Taylor rule and inflation targeting temporarily less effective. In its conduct of monetary policy, it could therefore be in the central bank's interest to take account of other indicators that could help shore up its cyclical analysis. Potential indicators include:

- Money supply: the financial innovations brought on by the NE, such as the issuance of electronic money, financial disintermediation or the increased substitutability between financial assets that results from the fall in transaction costs, could nevertheless give impetus to the velocity of money, ie in the case of the euro area, they could curb the fall in the velocity of M3. This rise in velocity, which is difficult to assess, would counter the impact that the increase in potential output growth has on money supply. It is therefore quite difficult to speculate on how the long-term relationship between money and prices could evolve with the development of an NE.
- Nominal GDP: as the development of the NE could lead to an inflation measurement error that more or less offsets the GDP measurement error, the case could be made for paying closer attention to trends in nominal income when defining interest rate policy. However, the shortcomings inherent in targeting nominal income, rather than prices, remain patent,

particularly the fact that such a strategy implies potentially infinite inflation and output variances.[35] Consequently, this strategy would appear to be ill equipped to adequately protect the economy from shocks other than NE-related uncertainty, notably that arising from measurement error.

- Survey data or information provided by financial markets: given that they are partially subjective, these sources of information - more so than data resulting partly from accounting conventions - could take account of changes in behaviour that may occur with the advent of the NE. It is true that they could also reflect errors in perception made by the private sector, but at the end of the day, they would make it possible to cross-check the information supplied by the national accounts, increasing the soundness of the cyclical analysis.

3. Conclusion

The adjustment of monetary policy to the new NE-engendered environment has been analysed entirely from the perspective of interest rate policy. The role played by other economic policies, as well as the international environment or the difficulties that the NE could raise for the implementation of monetary policy have been overlooked. It is nevertheless worth touching on the findings of a number of studies carried out on these aspects. We shall do so by way of conclusion.

- Structural policies can pave the way for an NE to emerge and develop. They could do so notably by giving free rein to the different competitive forces in order to reduce nominal rigidities in the transition phase, and in the longer term by creating an environment that nurtures technical progress with a view to boosting potential supply and passing on the fall in production costs. Fiscal policy can also limit the rise in the real equilibrium interest rate by improving the government budget balance.[36]
- By acting as a driver of internal demand and improving corporate profitability, an NE worsens the current account balance and triggers capital inflows into the country in which it has developed, leading, in the short to medium term, to a rise in the exchange rate.[37]
- Various authors[38] have highlighted two ways in which monetary policy could lose its effectiveness and the central bank its financial independence as a result of the NE-related technology upheaval. The first way would be via the dwindling use of central bank money in transactions due to the spread of electronic money, held as a claim on securities, and the complete securitisation of the financing of the economy. The second way would be through an erosion in the demand for central bank reserves, with the same factors leading to the establishment of clearing systems outside the purview of the central bank, and possibly limiting demand for banknotes to the financing of underground activities. The only way to avoid what Friedman (2000) calls a “decoupling at the margin” that would render monetary policy ineffective and the level of prices indeterminate, would then be to impose legal constraints - for example, by making it mandatory for taxpayers to pay their taxes in liabilities drawn against the central bank, as suggested by Goodhart (2000). The risk of decoupling is, however, probably very slight. Above all, like Woodford (2000), we may question financial markets’ ability to generate an equilibrium interest rate that would allow intertemporal arbitrage while maintaining purchasing power. Financial markets would therefore continue to be in need of an institution that is not in competition with them, that entails no credit risk and whose balance sheet items provide a reference for the setting of short-term interest rates; namely, a central bank. Legal constraints would therefore be unwarranted.

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[35] Ball (1997), Rudebusch (2000).

[36] Meyer (2000a).

[37] Bailey et al (2001), Tille et al (2001).

[38] Cechetti (2002), Costa and De Grauwe (2001), Freedman (2000), Friedman (2000), Goodhart (2000), King (1999), Mésonnier (2001) and Woodford (2000).

Appendix 1:
Formalising the spread of ICTs and potential output growth

This formalisation is taken from Cette et al (2002b).

As indicated in the study, medium- to long-term effects are distinguished from short- to medium-term effects.

Medium- to long-term effects

Assume a Cobb-Douglas production function with unit returns to scale and autonomous Hicks-neutral technological progress (the effects of this technological progress therefore match TFP gains):

$$Q = A\, e^{\gamma t}\, K^{\alpha}\, N^{1-\alpha} \qquad \text{and} \qquad \text{output growth rate: } \overset{o}{Q} = \gamma + \alpha \overset{o}{K} + (1-\alpha)\overset{o}{N} \tag{1}$$

In the long term, at the potential level of the variables, the capital output ratio remains constant:

$$\overset{o}{P}_Q + \overset{o}{Q}{}^* = \overset{o}{P}_K + \overset{o}{K}{}^* \qquad \text{and} \qquad \overset{o}{K}{}^* = \overset{o}{Q}{}^* + (\overset{o}{P}_Q - \overset{o}{P}_K) \tag{2}$$

The following expression for potential output growth is derived from the previous equations:

$$\overset{o}{Q}{}^* = \frac{\gamma}{1-\alpha} + \frac{\alpha}{1-\alpha}(\overset{o}{P}_Q - \overset{o}{P}_K) + \overset{o}{N}{}^* \tag{3}$$

In the absence of a differential between output price and investment price developments $(\overset{o}{P}_Q = \overset{o}{P}_K)$, we find the customary expression for potential output growth:

$$\overset{o}{Q}{}^* = \frac{\gamma}{1-\alpha} + \overset{o}{N}{}^*$$

The advent and spread of ICTs may have a twofold impact: an increase in TFP gains and a slowdown in the real price of investment. It is also assumed that in the medium to long term, the spread of ICTs does not change the potential employment level ($N^{*\prime} = N^*$), which means that in the medium to long term it impacts neither on the level of the NAIRU ($U^{*\prime} = U^*$) nor on the potential labour supply ($POP^{*\prime} = POP^*$). Therefore:

$$\overset{o}{Q}{}^{*\prime} = \frac{\gamma'}{1-\alpha} + \frac{\alpha}{1-\alpha}(\overset{o}{P}{}'_Q - \overset{o}{P}{}'_K) + \overset{o}{L}{}^* \qquad \text{with: } \gamma' \geq \gamma \text{ and } \overset{o}{P}{}'_K \leq \overset{o}{P}_K; \quad \overset{o}{P}{}'_Q \leq \overset{o}{P}_Q \tag{4}$$

The gains in potential output growth resulting from the spread of ICTs are given as the difference between equations (4) and (3):

$$\Delta \overset{o}{Q}{}^* = \overset{o}{Q}{}'^* - \overset{o}{Q}{}^* = \frac{\gamma'-\gamma}{1-\alpha} + \frac{\alpha}{1-\alpha}\left[(\overset{o}{P}{}'_Q - \overset{o}{P}_Q) - (\overset{o}{P}{}'_K - \overset{o}{P}_K)\right] \tag{5}$$

The change in the potential output growth rate caused by the spread of ICTs is the sum of the two elements. The first $(\frac{\gamma'-\gamma}{1-\alpha})$ corresponds to the effect of the change in TFP gains, the second $(\frac{\alpha}{1-\alpha}[(\overset{o}{P}{}'_Q - \overset{o}{P}_Q) - (\overset{o}{P}{}'_K - \overset{o}{P}_K)])$ to the capital deepening effect caused by the difference between the change in output price and the change in the price of investment.

Short- to medium-term effects

For simplicity, we assume that labour productivity grows at a constant rate, before and after the spread of ICTs, and that productivity accelerates at a constant rate during the rollout period. The ICT rollout period spans from date t_1 to date t_2. Labour productivity can be written in a simplified form using the following logarithms:

$$(q-n) = \lambda_1 t + \lambda_3 \text{ before the rollout period, when } t < t_1 \tag{6.1}$$

$$(q-n) = \lambda_1 t + \lambda_2 (t - t_2) + \lambda_3 \text{ after the rollout period, when } t > t_2 \tag{6.2}$$

$$(q-n) = \lambda_1 \; t + \lambda_2 \; \frac{t-t_1}{t_2-t_1} \; t + \lambda_3 \text{ during the rollout period, when } t_1 \le t \le t_2 \tag{6.3}$$

Labour productivity therefore rises at an annual level λ_1 before the ICT rollout period, $\lambda_1 + \lambda_2$ after this period, and $\lambda_1 + \lambda_2 \; \frac{t-t_1}{t_2-t_1}$ during this period.

For labour costs (more specifically per capita labour costs), we assume, as do Meyer (2000b), Blinder (2000), Ball and Moffit (2001) and Ball and Mankiw (2002), that growth in labour costs smoothly adjusts to the rise in productivity. This lagged adjustment is given by the simplified equation:

$$\overset{o}{W} \; = \; \beta_1 + \overset{o}{P}_{c-1} - \phi(L)(\overset{o}{Q/N}) - \beta_3 \, U_{t-1}, \quad \text{with } \phi(1) = 1 \tag{7}$$

Before the spread of ICTs (ie before t_1) or once ICTs have become totally widespread (after t_2) and once growth in labour costs has adjusted completely to productivity, the "long-term" NAIRU is easily deducted from equation (7): $U^* = \; \beta_1 / \beta_3$

In the shorter term, during the ICT rollout period, due to the lagged adjustment of growth in labour costs to that of productivity, we have $\phi(L)(\overset{o}{Q/N}) \prec (\overset{o}{Q/N})$. The NAIRU is therefore temporarily lower than its long-term level, as shown by Meyer (2000b):

$$U^*_{CT} = \; U^* - \frac{1}{\beta_3} \; (1-\; \phi(L)) \; \overset{o}{Q/N}) \tag{8}$$

The fact that the NAIRU is temporarily lower than its long-term level enables a temporary gain in potential GDP. Potential employment N^* is defined by the equation:

$N^* = (1 - U^*)POP^*$

where POP^* denotes the potential labour supply whose level is unchanged by the spread of ICTs ($POP^* = POP$).

From the logarithmic equation (1) and equation (9), we therefore derive the temporary gain in the potential GDP level:

$$\Delta \, q^*_{CT} \;\; = (1-\alpha) \;\; \Delta_{CT} n^* \approx (1-\alpha) \;\; (U^* - U^*_{CT}) = \frac{(1-\alpha)}{\beta_3} \; (1-\phi(L)) \; \overset{o}{Q/N} \tag{9}$$

This temporary gain in the potential GDP level corresponds to a similarly temporary gain in the economy's potential output growth.

Notations

Q	Volume of output
K	Volume of fixed productive capital
N	Volume of labour
POP	Labour supply
P_Q	Price of output
P_K	Price of investment in fixed productive capital
P_c	Price of household consumption
W	Per capita labour costs
U	Unemployment rate, with $N = (1 - U)POP$ and $L^* = (1 - U^*)POP^*$, U^* denoting the NAIRU
α	Elasticity of output as a ratio to capital
β_1, β_2, β_3	Coefficients in equation (7) denoting labour cost formation

λ_1, λ_2, λ_3	Coefficients in equation (6) denoting trends in labour productivity
γ	Autonomous technological progress, ie gains in TFP
t	Time variable
t_1 and t_2	Start and end of the ICT rollout period
L	Time lag operator
$\phi(L)$	Polynomial of the time lag operator in the labour cost equation (7), with $\phi(1) = 1$
"$_{CT}$"	as a subscript of a variable indicates that it is the short- to medium-term value of this variable
"^{o}"	above a variable denotes its growth rate
"*"	as an exponent of a variable denotes its potential level
"$'$"	as an exponent of a variable denotes its level during the ICT rollout period
"Δ"	in front of a variable denotes the differential between the two situations before and after the spread of ICTs

Variables in lower case correspond to their logarithms

"$_{-1}$"	as a subscript denotes a lagged variable

Appendix 2:
Technology shock and monetary policy: a highly simplified model

A highly simplified model illustrates the impact transitory and protracted technology shocks have on GDP growth and inflation, assuming different monetary policy responses. It corresponds to a closed economy or to the global economy.

We define ex ante potential output (*QEA*) as the level of potential output excluding the effects of fluctuations in the real interest rate. In the absence of a technology shock, ex ante potential output (*QEASC*) is assumed to grow at a constant rate. A technology shock alters the ex ante potential output growth rate, which is then denoted as *QEAAC*. There are two possible types of technology shock. The first, which is transitory, is characterised by a 1 percentage point pickup in the growth rate of ex ante potential output over one period. The second and protracted shock is typified by a steady 1 percentage point increase in the growth rate of ex ante potential output.

Variations in the real interest rate are prompted by supply shocks that gradually impact on the level of potential output. This effect is denoted by equation (1) assuming that the supply shock (as a percentage) is proportional to the smoothed and lagged gap between the real interest rate and real output growth. The gap is smoothed by averaging gap values over four periods:

$$etir = a \quad (TIRHC - \Delta TARGET - \overset{o}{Q})_{1,-1} \tag{1}$$

The volume of ex post potential output, ie including the supply shocks corresponding to fluctuations in the real interest rate, is therefore written:

$$qep = qeaac + etir \tag{2}$$

The adjustment of the volume of actual output (*Q*) to the volume of ex post potential output (*QEP*) is represented using a second-order error correction model. The advantage of this model is that it leads in the long term to a perfect adjustment, and in the short to medium term to cyclical differences that are supposed to correspond to the dynamic accelerator-multiplier equation and to the effects of economic agents' mistaken expectations about the nature and size of the technology shock. Therefore:

$$q = \phi(L)\ [qep], \qquad \text{with: } \phi(L) = \frac{b_0 + b_1 L + b_2 L^2}{1 + (-2 + 2\,b_0 + b_1)\,L + (1 - b_0 + b_2)\,L^2} \text{ where } \phi(1) = 1 \text{ is verified} \tag{3}$$

The ex ante (*eqea*) and ex post output gap is the (logarithmic) difference between the volume of actual output (*q*) and the volume of potential output, ex ante in the absence of a shock (*qeasc*) and ex post (*qep*) respectively:

$$eqea = q - qeasc \qquad \text{and} \qquad eqep = q - qep \tag{4}$$

Compared to a situation without a shock where the output gap is assumed to be zero, an inflation differential is created by the non-nullity of the smoothed ex post output gap (the gap is smoothed by averaging gap values over two periods):

$$\Delta \overset{o}{P} = c \quad eqep_1 \tag{5}$$

Lastly, monetary policy corresponds to the application of a Taylor rule. When applying this rule, the parameter for weighting the inflation differential and the output gap may, however, be modified, as the rule may be transformed into a simple inflation target (if $\alpha = 1$). We also use Bayoumi and Hunt's (2000) two opposing assumptions in which the central bank may fail to recognise a technology shock and therefore fail to modify its assessment of potential output, or on the contrary, take it into account. In the following notations, the central bank correctly perceives a shock where $d = 1$ and fails to do so where $d = 0$.

$$TIR = \alpha \;\; \Delta \overset{o}{P} + (1-\alpha)(d \;\; eqep + (1-d)\, eqea) + d \quad QE\overset{o}{A}AC + (1-d)\, QE\overset{o}{A}SC \tag{6}$$

Output (PQ) and inflation (PP) losses are calculated as the discounted quadratic sum over 100 years for output gaps and inflation differentials respectively:

$$PQ = \sum_{i=1}^{100} \frac{1}{(1+r)^i}\, eqep_i^2 \qquad \text{and} \qquad PP = \sum_{i=1}^{100} \frac{1}{(1+r)^i}\,(\Delta \overset{o}{P}_i - \Delta TARGET)^2 \tag{7}$$

Standard values are used for the various parameters of this simplified model: $a = -0.75$; $b_0 = 0.70$; $b_1 = 0.1$; $b_2 = 0.1$; $c = 0.5$; $d = 1$ if the central bank perceives an NE, and 0 if it does not; $0 \leq \alpha \leq 1$, $\alpha = 0.5$ if there is a Taylor rule and 1 if there is inflation targeting; $e = 0$ or 1; $r = 3.5\%$.

Notations

Q	Volume of actual output, denoted by equation (3)
QEASC	Volume of ex ante potential output in the absence of a shock, given by assumption
QEAAC	Volume of ex ante potential output in the presence of a shock, given by assumption
QEP	Volume of ex post potential output, denoted by equation (2)
eqea	Ex ante output gap (relative), denoted by equation (4)
eqep	Ex post output gap (relative), denoted by equation (4)
etir	Impact (as a relative gap) of real interest rate fluctuations on potential GDP volume, denoted by equation (1)
$\overset{o}{P}$	Inflation
TIR	Real interest rate, denoted by equation (6)
TIRHC	Level of real interest rate excluding variations in the central bank's inflation target
TARGET	Central bank's inflation target
r	Discount rate
PQ	Loss on output, denoted by equation (7)
PP	Loss on inflation, denoted by equation (7)
a	Parameter in equation (1) that reflects the impact of fluctuations in the real interest rate on output
b_0, b_1 and b_2	Parameters in equation (3) that reflect the adjustment of output to its potential level
c	Parameter in equation (5) that reflects the impact of the output gap on inflation
d	Parameter in equation (6) that reflects whether or not the central bank has identified a technology shock
α	Parameter in the Taylor rule, equation (6)
$\phi(L)$	Polynomial of the time lag operator *L*

A variable in lower case indicates that it is expressed logarithmically or as a relative gap for output gaps.

"o"	above a variable indicates the growth rate of this variable over time.
"Δ"	in front of a variable indicates the differential in this variable compared with a situation in which there is no technology shock.
"*l*"	as a subscript indicates that this is a smoothed variable, with equal weighting. Smoothing is carried out over four periods in equation (1) and over two periods in equation (5).
"−1"	as a subscript indicates that the variable has a time lag of one period.

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Real long-term interest rates and monetary policy: a cross-country perspective

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1. Introduction

The real rate of interest is a central concept in economics. It represents the price of the intertemporal allocation of goods and thereby determines saving, investment and, ultimately, economic growth. Despite the importance of the real rate for our understanding of intertemporal choice, operationalising the concept turns out to be difficult. First of all, in a world of nominal contracts, real rates usually cannot be observed directly. This problem is particularly important in the case of long-term real rates in which long-term inflationary expectations come into play. Second, it is not clear to which extent monetary policy can affect real interest rates. Although the central bank sets *nominal* interest rates, by doing so it will also affect short-term *real* rates as long as rigidities prevent prices from adjusting immediately. It is much less clear whether monetary policy has much of an effect on medium- to long-term real interest rates. Third, even if we did have information on the level of real interest rates and if the central bank could affect it, we still need a benchmark in order to assess the current level of the real rate, for example to determine the stance of monetary policy. The quest for such benchmarks actually predates the definition of the real rate by Fisher (1930) and goes back to the work on the natural rate of interest by Wicksell (1898).[2] More recent contributions are Woodford (2002) and Neiss and Nelson (2001).

This paper does not tackle the benchmark issue explicitly, but rather concentrates on the first two questions, the answers to which can be seen as a prerequisite for an adequate analysis of the "monetary policy/natural rate" issue. Given these two problems, it comes as little surprise that policy-oriented research on real interest rates has mostly concentrated on the short end of the term structure. An example is the literature on interest rate feedback rules, most prominently associated with the work of John Taylor. In a Taylor rule, the (nominal) policy rate is set equal to a sort of "natural" real rate of interest plus target inflation as well as two terms proportional to the deviations from target of output and inflation, respectively. Another example is the literature on inflation forecasts, where deviations of the real rate of interest from a benchmark are used to forecast future price developments. Such real interest gaps have been analysed, for example, in Neiss and Nelson (2001).

This concentration on the short end of the term structure is at odds with the fact that both saving and investment decisions tend to be inherently medium- to long-term. It seems unlikely that policy-induced fluctuations in short-term real interest rates will have much impact on the real economy unless they also affect long-term real rates. It is this link between short-term real rates as a proxy for monetary policy and long-term real interest rates that is the focus of our paper. In particular, we ask whether such a relation exists, and - if so - whether it has been stable over time. The latter question is motivated by the fact that there may have been changes due to European monetary union (EMU) and/or financial globalisation.

Before proceeding to the estimation part of the paper, we dwell on the measurement problem related to the unobservability of real interest rates or inflation expectations. We argue that this issue can be

1 We are grateful to Christian Dembiermont of Data Bank Services at the BIS for tracing otherwise unavailable interest rate series. Part of the work on this paper was undertaken when the first author visited the Federal Reserve Bank of Kansas City, whose hospitality is gratefully acknowledged. The opinions expressed are those of the authors and do not necessarily reflect the views of the Deutsche Bundesbank.

2 Wicksell's concept does not clearly distinguish between nominal and real rates. His "natural" rate of interest represents the return on fixed assets in an environment with no inflation. Any divergence of the "actual" rate of interest (which roughly corresponds to a nominal market rate) from the "natural" rate will result in an adjustment of the price level. The realisation that there could be various "natural" interest rates for different growth paths and employment levels caused Keynes (1936) to develop the concept of the "neutral" interest rate, which presupposes full employment.

addressed by using survey data on inflation expectations. We construct series of five- and 10-year ex ante real interest rates for 10 industrialised countries based on price expectations published by Consensus Economics. Although survey data have important drawbacks, the available evidence makes us believe that the Consensus is not a bad measure for inflation expectations, especially when considering the alternatives.

We then estimate the effect of monetary and fiscal policy on long-term real interest rates. Monetary policy is proxied by the short-term real rate, and fiscal policy by government net borrowing and public debt. The panel econometric techniques applied exploit both the time dimension and the cross-country variation of our data set. Specifically, this strategy allows us to perfectly control for “world factors”, which in this setting can be interpreted as a pure time effect. This, in turn, enables us to analyse whether a change in a country’s monetary or fiscal policy relative to the rest of the world influences the deviation of its long-term real interest rate from the world level.

We find that country-specific monetary policy is an important factor determining real rates, although the evidence suggests that it has become less important since the late 1990s. This is not purely related to EMU but applies equally to the non-EMU countries of our sample. Instead, it seems that monetary policy has generally become more synchronised across countries, leaving less room for differences in national long-term real rates.

The second important determinant of long-term real interest rates is fiscal policy. In general, high debt or government borrowing tend to be associated with high long-term real interest rates, although the recent Japanese experience of low real rates and very high debt provides a counter-example. In contrast to the case of monetary policy, we do not find evidence that country-specific fiscal policy has become less effective over time.

Our work extends the existing literature especially in two dimensions: one is the use of inflation forecasts to construct ex ante medium- and long-term real rates. The other is the use of panel data methods that allow us to concentrate on cross-country differences while perfectly controlling for “world factors”. Nevertheless, our methodology is not without its own problems. The small size of our sample (at most 10 countries and 25 semiannual observations) makes it impossible to use sophisticated econometric methods that permit us to better identify causality. As a consequence, reverse causation cannot be ruled out, although we argue that the problem is unlikely to be so large as to render our results useless. Moreover, the small size of our data set prevents the estimation of richer econometric models, such as dynamic panel models. As so often in empirical work, the alternative is to live with the shortcomings or not to use the data at all. Our work should therefore rather be interpreted as a complement to the existing literature, not as a substitute for it.

The paper is structured as follows. Section 2 discusses the impact of monetary and fiscal policy on long-term real interest rates and reviews the relevant literature. Section 3 addresses measurement issues, followed by a descriptive section on developments in long-term ex ante real rates since the early 1990s. The estimations that form the core of the paper are presented in Section 5. A final section summarises our key results and concludes.

2. Macroeconomic policy and long-term real interest rates

2.1 Monetary policy

Most recent work in macroeconomics has been based on the understanding that prices are sticky in the short run but adjust over longer time horizons. While there may be disagreement on how long it takes for prices to adjust, it is probably safe to say that they tend to be rather sticky for periods as short as a quarter but fairly flexible for horizons of several years. In such a world, a change in short-term *nominal* interest rates induced by monetary policy will have a large effect on short-term *real* rates. The impact on longer-term real rates is likely to be much smaller.

Take the simple example of an economy in which prices are set in advance for one period but fully adjust afterwards. In equilibrium, the real rate of interest is $\bar{r}$, which is assumed to be constant. Now suppose that in period *t* the central bank wants to stimulate the economy by cutting the one-period nominal rate by Δ. Since prices cannot adjust within the same period, the change in the nominal rate brings about a decline in the one-period real rate by an equal amount to $r_t^1 = \bar{r} - \Delta$ (the superscript indicates time to maturity). In $t+1$, prices will adjust and completely offset the monetary stimulus. As a consequence, the expected one-period real rate is $Er_{t+1}^{1}=\bar{r}$. According to the expectations hypothesis of the term structure of interest rates, long-term rates should be equal to the expected average short rates over the same maturity. This should hold for both real and nominal interest rates due to a no-arbitrage condition.[3] For example, the N-period real rate at t, r_t^N, is related to the sequence of one-period rates by:

$$\left(1+r_t^N\right)^N=E\left(1+r_t^1\right)\left(1+r_{t+1}^1\right)\ldots\left(1+r_{t+N-1}^1\right)$$

Taking logarithms and rearranging yields:

$$r_t^N=\frac{1}{N}E\sum_{j=0}^{N-1}r_{t+j}^1=\frac{1}{N}\left(N\bar{r}-\Delta\right)=\bar{r}-\frac{\Delta}{N}$$

Thus the effect of monetary policy on longer-term real rates declines with the maturity for which the rates apply.[4]

In more realistic models, the decline may not be linear. In general terms:

$$r_t^l=f\left(r_t^s,\bar{r}_t\right) \tag{1}$$

The long-term real rate r_t^l is a function of the short-term real rate r_t^s and some natural real rate $\bar{r}_t$, which may vary over time. Since $\bar{r}_t$ cannot be observed, we rewrite equation (1) as:

$$r_t^l=f^*\left(r_t^s,X_t\right) \tag{1$'$}$$

where X_t is a vector containing the determinants of $\bar{r}$. We can isolate the effect of monetary policy by decomposing the short real rate into the natural rate and a term indicating the tightness of monetary policy $r_t^{gap}=r_t^s-\bar{r}_t$, which corresponds to the real interest gap of Neiss and Nelson (2001). More formally:

$$r_t^l=f^{**}\left(r_t^{gap},X_t^*\right) \tag{1$''$}$$

Unfortunately, r_t^{gap} cannot be observed but requires an estimate of $\bar{r}_t$. Moreover, the output gap and the parameters of f^{**} would have to be estimated simultaneously in order to avoid inconsistencies. This can only be achieved within a well structured model of real interest rates. Economic theory does not provide much guidance in this respect, as the various theoretical models tend to give conflicting results.[5] As a consequence, empirical models of real interest rates have essentially been ad hoc. They tend to include a number of possible factors that shift the supply of and the demand for loanable funds and hence the equilibrium real interest rate. We therefore prefer to estimate equation (1′) rather than (1″).

2.2 Fiscal policy

Public saving and dissaving typically account for a substantial proportion of total saving in developed economies. It thus seems that the scope for fiscal policy to affect long-term real interest rates can be much larger than that for monetary policy. For example, the rise in real interest rates in the early 1980s

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3 Costs of arbitrage would introduce term premia, which may vary over time. This should not affect the validity of the argument unless the term premium covaries with the level of interest rates.

4 The result that the long rates move in the same direction as the short rate, only by a smaller amount, does not necessarily extend to nominal rates. In that case, long and short rates may even move in different directions if the policy action that drives the short rate affects inflation expectations by a sufficiently large amount. See Romer and Romer (2000) and Ellingsen and Söderström (2001).

5 For a review the reader is referred to Bliss (1999). See also the appendix in Deutsche Bundesbank (2001).

has been attributed to the rise in government deficits in that period.[6] This argument, of course, hinges on the assumption that Ricardian equivalence does not hold. If, on the contrary, agents believe that they will have to pay for today's high deficit through higher taxes in the future, they may cut current consumption and thus offset any fiscal stimulus. In that case, fiscal policy would have no effect on real interest rates.

2.3 Country-specific and global variables

A large number of papers, including Blanchard and Summers (1984), argue that interest rates are substantially determined worldwide, rather than domestically, because a large pool of capital flows towards nations with high real rates tends to equalise rates around the world. They stress that this seems to be true not only for small open economies, but also for large economies like the United States. This corresponds to the results presented in Barro and Sala-i-Martin (1990), who find for 10 OECD countries that their respective expected real interest rate depends primarily on world factors, rather than on own country factors. This is in line with the more recent findings of Al Awad and Goodwin (1998) who - on the basis of cointegration and Granger causality techniques - find a high degree of integration of international asset markets, which implies a strong cointegration among G10 ex ante real interest rates. Nevertheless, they also find an important role for transaction costs, which prevent real interest rate equalisation across countries. Wu (1999) - by applying cointegration techniques to German and Japanese real interest rate and exchange rate data - finds evidence in favour of a long-run relationship between real exchange rate and expected real interest differentials only if the current accounts are explicitly considered. The hypothesis of strong cross-country linkages is also confirmed by Pain and Thomas (1997). Applying cointegration techniques to data from several industrial countries, they find evidence for a "European" short-term real interest rate, with Germany being the dominant player. But this result does not seem to be robust with respect to the inclusion of US rates, indicating that US rates determine the trend in European rates. Interestingly, they also find evidence that the degree of integration has increased over time. This is in line with the results presented in Fountas and Wu (1999), who find evidence in favour of bilateral real interest rate convergence between Germany and several other countries for long-term real interest rates. They attach this to the growing degree of integration in the world financial markets. In a more recent paper they apply a comparable cointegration technique to test for bilateral real interest rate convergence in the G7 against the United States (Fountas and Wu (2000)). They find strong evidence for bilateral real short-term interest rate convergence to a long-run relationship between US rates and rates in Canada, France, Germany and the United Kingdom. Moreover, they find evidence in favour of a bilateral real *long-term* interest rate convergence to a long-run relationship between US rates and rates in France and Germany. This means that for France and Germany, *long-term* real interest rate changes are influenced by the US monetary policy stance.

Given the strong results pointing at a close interrelationship between national real rates, some papers estimate a world interest rate rather than looking at national interest rates. Kraemer (1996) aggregates national data of the G7 countries and estimates a single-equation error correction model. He finds that the resulting aggregate long-term real interest rate is mainly determined by the real short-term interest rate, capacity utilisation and structural public borrowing. Orr et al (1995) pool data from 17 countries to estimate an error correction model. They find that the low-frequency component of the real interest rate is mainly determined by profitability, a risk measure, the current account, the government deficit and a measure for surprise inflation. The high-frequency component is influenced principally by monetary and fiscal policy. They interpret the low-frequency factors as the fundamentals that influence savings and investment trends, whereas the high-frequency factors change the expectations about the fundamental factors. On the basis of the idea of a world real interest rate, Ford and Laxton (1999) analyse the role of global fiscal developments. They find that the increase in OECD-wide government debt since the late 1970s was a major factor in the rise in real interest rates.

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6 Refer to Blanchard and Summers (1984) for a critique of this argument and a discussion on the effects of fiscal policy. They argue that the aggregate inflation-adjusted structural deficit for the major nations of the OECD did not change significantly between 1978 and 1984. Instead, they claim, expected profitability has risen, as indicated by an increase in stock prices. This drove up the demand for loanable funds and thereby the real rate of interest.

Contrasting these studies, Breedon et al (1999) find that it is hard to argue that national real interest rates converge to a single world rate, although international factors are important. They also find that the large and persistent differences in real interest rates across countries cannot be explained in terms of real exchange rate expectations. Transaction costs and country-specific factors, for example country-specific risk and the portfolio home bias, still seem to play a significant role.

We, instead, are interested in these world factors only in so far as we want to assess which country-specific factors determine a country's real interest rate. In contrast to the previous literature that concentrated on time series methods, we use panel econometric techniques because they allow us to control for all possible world factors. By introducing a complete set of time dummies in a fixed-effects regression, all factors that do not vary across countries (but over time) are filtered out as long as they influence the countries' real rates in a similar manner. Basically, this amounts to explaining differences in movements of real rates across countries by cross-country differences in movements of the right-hand variables. World factors, which by definition do not differ across countries, are completely captured by these time dummies. If the country-specific factors turn out to be insignificant, then a country's real rate is purely determined by such world factors. If, on the contrary, country-specific factors turn out to be significant, then domestic variables play a role for domestic real rates - which is important especially in the case of monetary and fiscal policy. It would then be of interest to find out whether the strength of these influences has changed over time.

3. Measuring real interest rates and data

Measuring real interest rates is far from trivial. Ideally, one would like to derive them from market prices, for example from inflation-indexed bonds or loan contracts. Such instruments have been fairly common in environments with high inflation and have recently been introduced in a number of low-inflation countries. However, among the industrialised countries only the United Kingdom provides series that span more than a few years.[7]

In the absence of inflation-indexed securities, real interest rates can be computed by deflating a nominal rate of interest by a measure of expected inflation using the Fisher parity:

$$r = i - \pi^e \qquad (2)$$

Here, r stands for the real interest rate and i for the nominal interest rate with the same maturity; π^e represents the expected inflation rate for the period in question.[8] One has to bear in mind, though, that this simple Fisher parity is based on a number of restrictive assumptions. For instance, tax aspects are omitted although, in practice, their role is not negligible. In addition, it assumes that investors are indifferent as to whether their investment is nominal or real, as long as the yield differential is in line with expected inflation. This is in contrast with recent work in finance which suggests that an economically significant inflation risk premium exists and varies over time.[9] Unfortunately, such risk premia are unobservable, and can therefore not be eliminated when computing real rates. As a consequence, any measure of real interest rates computed from nominal rates and expected inflation will necessarily be polluted.

Unfortunately, deflating nominal interest rates by expected inflation only transfers the data problem to another level as expectations are inherently unobservable. One possibility is to ask market participants directly. Such survey data are available from Consensus Economics, who ask a number of professional forecasters based in a variety of countries about their expectations of a wide range of economic variables. More specifically, we use their long-term forecasts, which have been published biannually in April and October since the autumn of 1989. They contain forecasts for - inter alia - real

7 See Deacon and Derry (1998).

8 Strictly speaking, the formula above only provides an approximation. The exact form of the Fisher parity is $(1+i)=(1+r)\ (1+\pi^e)$. We use this correct formula for our computations.

9 Buraschi and Jiltsov (2002) find that the inflation risk premium contained in the yield of 10-year US treasuries is highly time-varying, fluctuating between 0.2 and 1.6 %.

GDP growth and inflation in the current and each subsequent calendar year up to 10 years in the future.

As is always the case with surveys, one may doubt (i) whether the surveyed institutions or individuals accurately state their views, (ii) whether they put enough effort into their answers to make them meaningful, and (iii) whether these views reflect the inflation expectations of economic decision-makers. Let us deal with these three arguments in turn.

(i) We can think of two distinct motives for respondents to deviate from their true beliefs. Firstly, they may not want to reveal their information in order to secure trading profits. This motive seems particularly relevant for predictions over the very short term on which trading profits can be made. It appears less pertinent for the longer-term forecasts, which have a much bigger weight in our estimations. In addition, the time lag with which the Consensus is published (about one week) is relatively long by financial market standards, giving panelists ample time to trade on their predictions. Another reason for misstating one's beliefs may be the generation of publicity. In the model of Laster et al (1999), for example, forecasters' wages depend both on the accuracy of the forecast and on the publicity they generate for their employer. Since publicity tends to be "good publicity" or "no publicity" (good performance is made public while negative performance usually is not), forecasters have incentives to bias their forecasts in order to "stand out of the crowd" if their predictions turn out to be true. Such incentives are particularly strong for independent forecasters serving occasional users of forecasts, but less so for those working directly for regular users such as banks or industrial corporations. This is borne out by the data. Laster et al find that independent forecasters deviate from the Consensus by a far greater extent than their peers at banks or in industry. Security firms come somewhere in between. This sort of behaviour does not affect the mean forecast, although it drives up the variance. Misstatement cancels out over time (for each individual forecaster) or across firms. We thus conclude that the Consensus Forecast does appear to give a fairly accurate picture of the average view of the respondents.

(ii) We have argued that it is unlikely that the panelists of the Consensus misstate their views in order to obtain trading profits. But what if there are no profits to be made from trading on their forecasts in the first place, simply because they are little more than informed guesses? This point seems particularly pertinent for long-term predictions, which are less easily exploited by trading. Unfortunately, we cannot rule out this possibility. Nevertheless, the fact that the Consensus seems to be superior to most other forecasts, including those from international public institutions where forecasting over the longer term is a main part of their business, suggests that it is not so bad after all and gives reason for muted optimism.

(iii) Let us turn to the third question of whether the Consensus correctly reflects the view of market participants. Unfortunately, there is little we can say about this save that many of the analysts surveyed are employed by more or less prestigious institutions, and that their forecasts receive a lot of press coverage. They should therefore be known to decision-makers. Whether or not these agree with their content is difficult to assess.

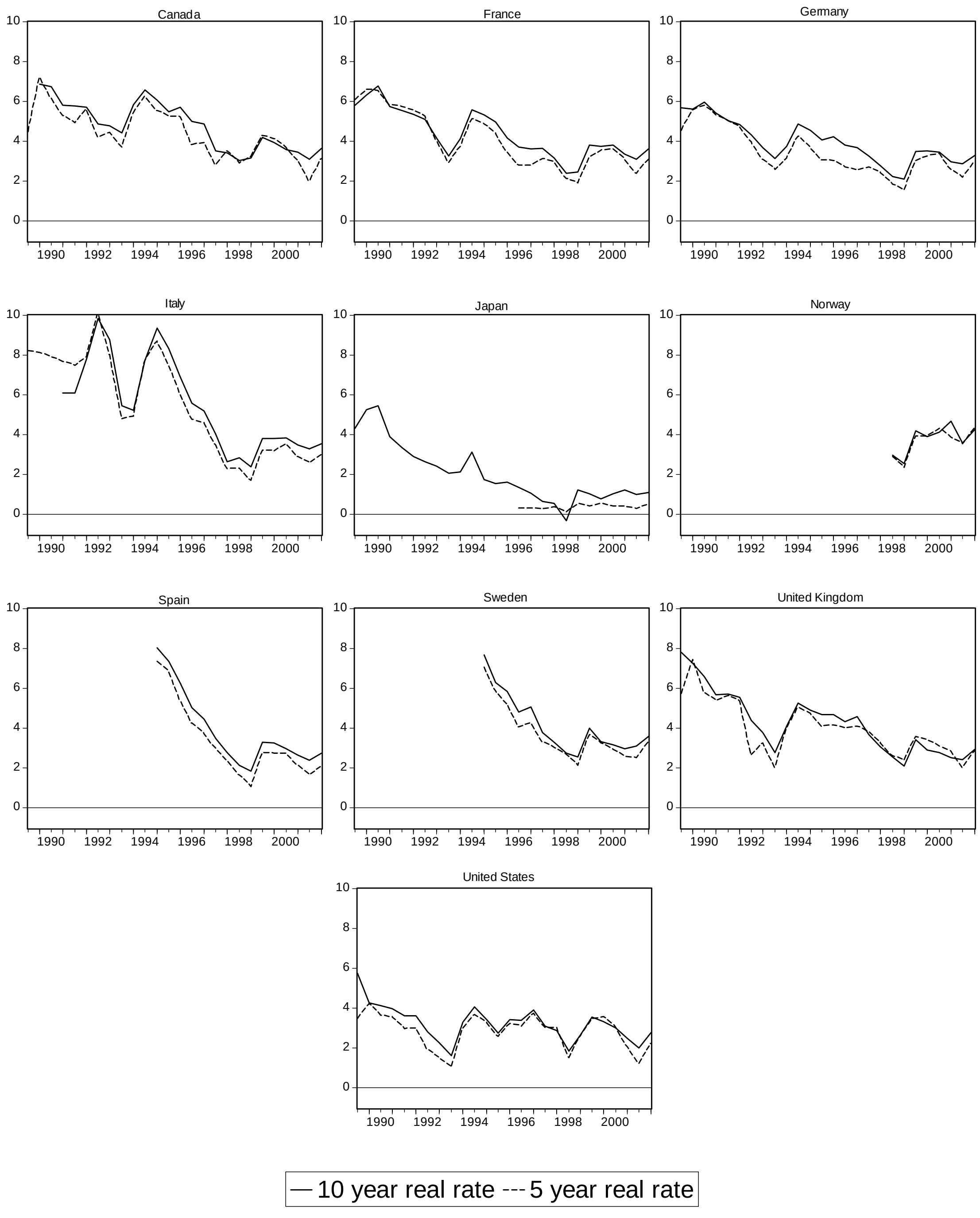
Summing up, the available evidence makes us believe that the Consensus is not a bad measure for inflation expectations, especially when considering the alternatives. Model-based estimates can be criticised on the basis that it is even less clear whether they have anything at all to do with actual expectations. Deutsche Bundesbank (2001), for example, shows that ARMA forecasts for inflation can differ considerably from the Consensus, especially during periods of strong inflation or disinflation. Furthermore, although time series models may have a good forecasting power a few quarters ahead, the longer-term predictions tend to correspond to the unconditional mean of the sample over which they are estimated. This may not be very plausible if the mean has been driven by exceptional factors one does not expect to be repeated. Examples for this are German reunification or oil price changes.

Irrespective of whether inflation expectations are derived from surveys or whether they are estimated, the maturity and type of the underlying nominal interest rate as well as the choice of the price index are relevant issues. Analyses of real interest rates are only useful if the time horizon for such rates covers the whole investment period. In the case of capital investments this is usually several years, for savings decisions it might even amount to decades (eg for retirement saving). Real interest rates for shorter maturities are not very informative in this respect, unless assumptions are made about price and interest rate movements in subsequent periods. For our purpose, the yields of nominal government bonds with a residual maturity of five and 10 years appear suitable. Such securities have been available in most developed economies since the 1970s or 1980s. Since government bonds tend to be the least risky asset, their yields should roughly correspond to the opportunity costs of investment, even if most private agents would have to pay higher rates if they took up debt.

As well as the maturity, the choice of the price index depends on the issue being analysed precisely. Moreover, data availability is crucial. We use the consumer price index (CPI), which is available for all the considered countries and provides a fair approximation of the overall price level.

Graph 1

Ex ante real interest rates



4. Long-term ex ante real interest rates since the 1990s

Graph 1 shows five-year and 10-year ex ante real rates for 10 industrialised countries. The sample period begins in 1989, when Consensus Forecasts for CPI inflation are first available for Canada, France, Germany, Italy, Japan, the United Kingdom and the United States. In 1995, Spain and Sweden are added to the list, and in 1998 Norway. A second data constraint is the availability of nominal interest rates of the desired maturity. This is particularly relevant in the case of Japan, which did not introduce five-year bonds before the late 1990s.

As can be seen from Graph 1, ex ante real interest rates in industrialised countries declined during most of the 1990s and have remained in a relatively narrow corridor ranging from just under 2% to just over 4%. The mean five-year ex ante real rate halved from 6.5% in early 1990 to 3.2% in late 1999, and the development of 10-year real rates has been similar. The decline in real interest rates was briefly interrupted during 1993/94, but they soon reverted to their downward trend, which continued until 1998. They increased somewhat during the following years, but eased again in 2001.

The only, although important, exception to this overall picture is the United States. US real rates were much lower than those in other countries during the first half of the 1990s, although they too were declining. Between 1994 and 1997, however, US rates remained relatively constant between 3 and 4%, and declined only in 1998 in line with those of the other countries of our sample.

The 1990s also saw a remarkable convergence of the real interest rates in all countries bar Japan. The difference between the minimum and the maximum rate at a single point in time declined from 4-5 percentage points in the early 1990s to 1-2 percentage points towards the end of the decade. The main factor behind this convergence was the sharp decline in the real interest rates of Italy, Spain and Sweden. During the early 1990s, Italy had by far the highest rates in our sample.[10] In 1992, five-year ex ante real interest rates were 4 percentage points higher than those in France and 5 percentage points higher than the corresponding German rates. In 1999, the difference declined to a few basis points. Ex ante rates for Spain and Sweden are available only as from 1995, so we cannot say much about the first half of the 1990s. But we see real interest rate convergence even during the sample that is available. In early 1995, Spanish real interest rates stood at 7.3%, compared to 3.7% in Germany. Four years later in 1999, Spanish ex ante rates were half a percentage point lower than German rates. What is interesting is that Swedish rates showed a similar decline, although Sweden is not, and at that time was not expected to be, a member of EMU. This suggests that although monetary union may have been a factor in explaining real rate convergence, it was not the only one.

5. Empirical results

5.1 Explanatory variables and estimation methodology

As we have mentioned in Section 2, economic theory provides little guidance as to what a model for real interest rates should look like. Our approach is therefore rather ad hoc. It relates the level of five- and 10-year ex ante real rates (*r*05*cf* and *r*10*cf*, respectively) to a monetary policy variable, fiscal variables and a set of controls. A complete list of the variables and their sources is given in Table A1 of the Appendix.

Our monetary policy variable is the three-month money market rate, deflated by inflation over the previous 12 months (*r*3*mre*). Since inflation is relatively persistent in the short run, *r*3*mre* should be a good proxy for the ex ante real rate. Twelve-month inflation is preferable to three-month inflation for several reasons. Firstly, year-on-year inflation is the headline measure of inflation and should therefore correspond more closely to the expectations of agents than price increases over a shorter time span. Secondly, inflation over short periods may be distorted by temporary factors. This is

[10] Italian nominal and real rates declined sharply in the aftermath of its ejection from the EMS in September 1992, but shot up again about a year later.

reflected by the fact that longer-term inflation tends to have better forecasting power for future price developments than short-term price rises. Thirdly, using price increases for periods of under a year forces us to seasonally adjust the data, thus adding to potential mismeasurement.

We measure fiscal policy by gross government debt (*ggdgs*) and current net borrowing (*nbg*) or, alternatively, cyclically adjusted net borrowing (*nbgca*).

Data availability is a big issue when it comes to controlling for shifts in the supply of, or the demand for, funds that are not related to either monetary or fiscal policy.[11] Let us begin with the supply of funds, ie saving. Public saving is already captured by our fiscal variable. We proxy private saving by both current and expected GDP growth. According to the permanent income and life cycle hypotheses, household saving should depend on future expected or life income, which we proxy by the Consensus Forecast for GDP growth over the five- and 10-year horizon, respectively (*gdp_e*5 and *gdp_e*10). In addition, many studies have found that current income does seem to have an important effect on consumption and saving.[12] We therefore include current GDP growth (*gdp*) as a further explanatory variable for saving.

On the demand side, the main driving force of investment is probably expected profitability. We proxy future profitability by the price/earnings ratio (*peratio*) of the relevant MSCI country index and a competiveness index based on relative price levels (*comix*). The latter is closely related to the concept of the real exchange rate.[13] Both expected and current GDP are also likely to be important driving forces for investment. We control for the possibility that the economy is below its production frontier by including the output gap (*y_gap*) and unemployment (*unrte*).

As mentioned before, our measure for the real interest rate may be polluted by an inflation risk premium. We address this issue by including the 12-month inflation rate (*pi*) as a proxy for inflation risk. This is based on the assumption that a positive relationship exists between the level of the inflation rate and its (expected) variation. Moreover, including the inflation rate as such allows us to say something about the effect of *nominal* shocks.

In order to avoid any problems arising from having an unbalanced sample, we first present estimates for the countries for which data are available for the whole sample period. We then corroborate the results using the full (unbalanced) sample of countries. The data for the estimations with a balanced panel are biannual (April and October) and end in the first half of 2002. In the case of the five-year rate, they start in April 1990, in the case of the 10-year rate in the first half of 1991, leaving us with a maximum of 25 periods and 23 periods for a given country, respectively. In the case of the five-year rate, this maximum number of observations is reached by Canada, the United States, the United Kingdom, France, Italy and Germany, in the case of the 10-year rate by the same group of countries and also by Japan.

Unfortunately, the comparatively small cross-sectional dimension of our dataset restricts the range of possible panel estimation methods. This is especially true for dynamic panel estimations like GMM à la Arellano and Bond (1991), which need a certain minimum number of cross-sectional units. Therefore, due to the low degree of freedom we restrict ourselves to estimating a simple fixed-effects model of the following type:

$$r_{i,t} = \alpha_i + \beta \boldsymbol{X}_{i,t} + d_t + \varepsilon_t \tag{3}$$

Here, $r_{i,t}$ is the respective real rate for country *i* at time *t*, α_i is a country-specific constant (the "fixed effect"), $\boldsymbol{X}_{i,t}$ is a matrix of explanatory variables that vary across time and country, d_t captures the pure time effect and ε_t is an error term which is assumed to be independent and identically distributed. For the estimation, the individual means are subtracted from equation (3) (within estimator). This fixed-effects regression amounts to testing whether movements in differences of the longer-term real rates

11 For a list of possible factors determining the supply of and demand for funds, see, for example, Blanchard and Summers (1984) or Chadha and Dimsdale (1999).

12 Current income will play a direct role if consumers are credit constrained or if income shocks are permanent.

13 If uncovered real interest rate parity holds, then the deviation of a country's real interest rate from world rates should be equal to the expected change in the real exchange rate over the maturity of the investment. The expected change in the real exchange rate should be related to the current level if one assumes that PPP holds in the long run, ie over five or 10 years, respectively.

across countries can be attributed to movements in differences of the explanatory variables across countries.

We estimate equation (3) in levels. Although the evidence on whether or not real interest rates are stationary is inconclusive, there is little reason to believe that the deviation of national real rates from the world rate has a unit root. Unfortunately, the small number of observations does not allow us to apply standard unit root tests.

One shortcoming of static regressions such as (3) is that it is difficult to rule out reverse causality from $r_{i,t}$ to the variables contained in $\boldsymbol{X}_{i,t}$. We address this problem by repeating the estimation using lagged values of *r*3*mre*. This reduces the problem of reverse causality but does not eliminate it, since real interest rates, both short-term and long-term, are fairly persistent. Unfortunately, due to the low number of observations we cannot instrument variables.

5.2 Estimation results

The results of our basic estimations with a balanced panel are presented in Table 1. Let us first turn to the estimation for the five-year real rate that includes all the right-hand variables listed above (regression 1). The coefficient of the short-term real rate *r*3*mre* is positive and highly significant. Of the fiscal variables, government debt (*ggdgs*) and cyclically adjusted net borrowing (*nbgca*) are significant at the 5% level. Substituting the latter by non-adjusted net borrowing (*nbg*) does not change the results qualitatively. Of the control variables, expected GDP (*gdp_e*5), the unemployment rate (*unrte*), the output gap (*y_gap*), and the rate of inflation (*pi)* are statistically significant. The positive coefficient on expected GDP growth suggests that economic growth matters primarily through its impact on the demand for funds (investment) rather than the supply (saving). The negative coefficients on unemployment and the output gap indicate that the real interest rate is lower if the economy operates below potential. Finally, the positive relationship between real interest rates and inflation points towards the existence of an inflation risk premium.

In order to obtain a more parsimonious model, we sequentially reject the least significant variable until only significant variables remain. The results are given in the second column of Table 1 (regression 2). Only variables that were significant in the general model remain so in the smaller regression. In the process of reducing the number of coefficients, the output gap also drops out. The other previously significant variables remain significant and keep their signs. Moreover, both the coefficient estimates and their standard errors are of comparable size.

Let us now turn to the results for the 10-year rate given in columns 4 and 5 of Table 1. Note that the sample now also includes Japan, for which five-year rates were not available for the whole estimation period. In order to ensure comparability, we repeat the regression excluding Japan (columns 7-9). We find that the coefficient of the three-month rate (*r*3*mre*) is highly significant but slightly smaller relative to what we found in the previous regressions. The results concerning the fiscal variables depend on whether or not the sample includes Japan. If Japan is included (column 4), then the fiscal variables turn out to be insignificant if both net borrowing (*nbg* or *nbgca*, respectively) and government debt (*ggdgs*) are included. However, government debt becomes significant if we drop net borrowing (see regression 5) and vice versa. If we exclude Japan (regression 7), government debt *ggdgs* is significant at the 5% level. Among the control variables, only the price/earnings ratio (*perat*) and the rate of inflation (*pi*) are significant at the 1% level. The remaining variables are always insignificant at the conventional confidence levels.

Table 1

Results from fixed-effects estimation of basic specification

Explanatory variables	***r*05*cf***				***r*10*cf* (including Japan)**				***r*10*cf* (excluding Japan)**			
	Full sample period		Sample split (98:01)		Full sample period		Sample split (98:01)		Full sample period		Sample split (98:01)	
	1	2	3		4	5	6		7	8	9	
r3mre	0.5171** (0.0438)	0.4883** (0.0422)	0.4652** (0.0445)	–0.0012 (0.1298)	0.4467** (0.0405)	0.3960** (0.0341)	0.4038** (0.0343)	0.0814 (0.0928)	0.4735** (0.0459)	0.4183** (0.0367)	0.4557** (0.0412)	–0.0284 (0.1061)
nbgca	0.0869* (0.0363)	0.0746* (0.0316)	0.0646* (0.0313)	0.0433 (0.0860)	0.0274 (0.0347)				0.0241 (0.0417)			
ggdgs	0.0262* (0.0120)	0.0343** (0.0105)	0.0636** (0.0119)	0.0688** (0.0148)	0.0121 (0.0092)	0.0213** (0.0050)	0.0251** (0.0069)	0.0137 (0.0077)	0.0283* (0.0127)	0.0393** (0.0089)	0.0474** (0.0104)	0.0422** (0.0129)
gdp	0.0115 (0.0348)				0.0246 (0.0343)				0.0557 (0.0358)			
*gdp_e*5/10	0.6157** (0.2177)	0.4724* (0.1872)	0.3487 (0.1969)	0.4979 (0.3417)	0.1156 (0.1955)				–0.0731 (0.3047)			
unrte	–0.1915** (0.0675)	–0.1092* (0.0496)	–0.1857** (0.0549)	–0.3758** (0.1025)	0.0842 (0.0700)				0.1379 (0.0784)			
y_gap	–0.1377* (0.0659)				–0.0468 (0.0687)				–0.0293 (0.0716)			
comix	–0.0075 (0.0066)				–0.0086 (0.0062)				0.0003 (0.0072)			
perat	0.0163 (0.0191)				0.0362** (0.0108)	0.0320** (0.0097)	0.0332** (0.0102)	–0.0023 (0.0220)	0.0547** (0.0203)	0.0527** (0.0194)	0.0583** (0.0210)	0.0216 (0.0396)
pi	0.3932** (0.0562)	0.3569** (0.0511)	0.3095** (0.0525)	0.1304 (0.1279)	0.4354** (0.0658)	0.3702** (0.0514)	0.3445** (0.0525)	0.2619* (0.1061)	0.4429** (0.0695)	0.3453** (0.0561)	0.3371** (0.0578)	0.2518* (0.1220)

Table 1 (cont)

Results from fixed-effects estimation of basic specification

Explanatory variables	***r*05*cf***			***r*10*cf* (including Japan)**			***r*10*cf* (excluding Japan)**		
	Full sample period		Sample split (98:01)	Full sample period		Sample split (98:01)	Full sample period		Sample split (98:01)
	1	2	3	4	5	6	7	8	9
Sample period	90:01-02:01	90:01-02:01	90:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01
No of periods	25	25	25	23	23	23	23	23	23
Countries	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US	7: DE, FR, IT, CA, UK, US, JP	7: DE, FR, IT, CA, UK, US, JP	7: DE, FR, IT, CA, UK, US, JP	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US
No of obs	150	150	150	161	161	161	138	138	138
R^2(w); R^2(b)	0.92; 0.74	0.92; 0.76	0.93; 0.55	0.87; 0.86	0.86; 0.62	0.88; 0.59	0.89; 0.96	0.88; 0.85	0.90; 0.82
F-test (p-val)	0.015	0.001	0.000	0.002	0.000	0.000	0.066	0.000	0.000
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes

Note: Standard deviations in brackets; */** = significant at the 1% and 5% levels.

How stable are these results over time? In particular, did EMU affect the determination of long-term real interest rates? We try to shed more light on these questions by splitting the sample in early 1998.[14] Although EMU did not take place until a year later, by that time markets already anticipated with reasonable certainty which countries would participate and which would remain outside. The output of the split-sample regressions for the five-year rate are given in column 3 of Table 1 and those for the 10-year rate in columns 6 and 9. In all three cases, the coefficient of the short-term real rate becomes insignificant in the second subperiod, indicating that the effect of monetary policy on long-term real rates lost strength after the beginning of 1998. The results concerning fiscal policy are less clear. The coefficients on debt are highly significant and positive in both subperiods as long as Japan is excluded from the sample. If we include Japan, it ceases to be significant after 1998.

To sum up, the short-term real rate is significant in all regressions in the first period but not in the second. In contrast to the short-term interest rate, there is no general evidence that fiscal policy has lost its importance in the late 1990s. Only in the case of 10-year real rates for the sample including Japan do we find that government debt is significant before 1998, but not afterwards (Table 1, regression 6). This suggests that the high level of Japanese debt combined with low real interest rates since the late 1990s drove the results for the full sample. Japan should therefore be viewed as an exception. In all other cases, we cannot statistically reject equality of coefficients for the two subsamples.

5.3 Robustness

In order to check the robustness of the results with respect to changes in the specification, we rerun the estimations (a) with an alternative estimation method, (b) with dummy variables that control for EMU countries, (c) with a lagged short-term interest rate and (d) for the whole (ie unbalanced) sample.

(a): given that we cannot assume that there is no cross-country correlation in the included variables and that there is no autocorrelation within the variables of a given country, we reestimate the models with Feasible GLS. This allows for heteroskedastic panels, cross-country correlation and country-specific AR1 coefficients. Given the small size of our sample, however, it is unlikely that FGLS is efficient. The results given in Table A2 in the Appendix should therefore merely be used as a robustness check of the results of the basic fixed-effect regressions. As it turns out, the results obtained over the full sample period, namely that the short-term real interest rate and fiscal policy that significantly determine long-term real rates, are confirmed. But we no longer find that the effect of short-term real rates weakens over time.

(b): an obvious candidate explanation for the structural break found in regressions 3-9 of Table 1 is, of course, EMU, which constrains nominal rates in the member countries to be essentially identical.[15] As a consequence, differences in real interest rates are mainly due to different inflation expectations. A country with an overheated economy will therefore have lower real rates than a country where the economy operates below potential - just the opposite of what one would normally expect. In order to test for possible EMU effects, we define a dummy variable which is equal to one for EMU countries (DE, FR, IT) on and after 1998:1, but zero otherwise. We interact this dummy with the monetary and fiscal variables, as well as the controls that showed significant coefficients in the previous regressions, and estimate this augmented model. The results of this exercise are reproduced in Table A3 (see Appendix). The EMU variables turn out to be insignificant in all cases, suggesting that the break we found in Table 1 cannot merely be attributed to EMU but is a more general phenomenon.

(c): we try to reduce the problem of reverse causality between *r*3*mre* on the one hand, and *r*5*cf* and *r*10*cf* on the other, by substituting the current short rate with its value lagged by one period (Table A4 in the Appendix). We generally find that monetary policy and fiscal policy are significant determinants of long-term real rates (regressions 2, 5 and 8), although for some reason cyclically adjusted

[14] The results are virtually identical if the split date is 1997:2 or 1998:2.

[15] Assuming that premia for default and liquidity risk are of minor importance.

government borrowing seems to perform better that debt. In addition, the result that monetary policy seems to have lost strength is confirmed (regressions 3, 6 and 9), whereas the evidence concerning fiscal policy is more mixed. In the case of the 10-year rate, estimates for the sample excluding Japan show a highly significant coefficient for cyclically adjusted net borrowing in the first subperiod, but an insignificant coefficient for the second subperiod. In the regressions without Japan, government borrowing is either always insignificant (five-year rates) or always significant (10-year rates).[16]

(d): we repeat the estimates using the unbalanced panel of 10 countries for which at least some observations are available. The results are collected in Table A5 of the Appendix. Apart from some differences concerning the control variables, they largely confirm previous estimates as long as we only look at the entire sample period. If we split the sample in 1998, important differences to previous results appear. In particular, the evidence that monetary policy has lost its impact after 1998 cannot be corrobated. With one exception (regression 9), the coefficient on the short-term real rate remains significant, although the point estimates become somewhat smaller. Fiscal policy appears to be equally effective throughout the 1990s and early 2000s, at least outside Japan.

5.4 Discussion

Our estimates indicate that the short-term real interest rate is one of the main factors driving long-term real interest rates. In all our regressions over the full sample ranging from the early 1990s to spring 2002, lower short-term real rates are ceteris paribus associated with lower long-term real rates. This result is robust to changes in the estimation method or in the composition of the sample. However, we find some evidence that the effect of short-term real rates on long-term rates has on average become less strong in recent years. In most of our regressions, the coefficient for the short-term real interest rate turns out to be insignificant in estimations covering only the later part of our sample. This is not simply the result of EMU but applies also to the countries outside the euro area. In part, this may be due to the fact that both short-term and long-term real interest rates have become more synchronised across countries, leaving less variation for our model to exploit. This is compatible with the hypothesis that the relative importance of world factors, or at least international factors, for national long-term real rates has increased over time. This result is in line with the findings of the empirical literature on real rates, for example Pain and Thomas (1997) and Fountas and Wu (1999, 2000). Since our estimation methodology is based on the differences *between* countries, it is not surprising that we do not obtain significant coefficient estimates.

If it is true that monetary policy can control short-term real rates, then our results - if taken at face value - suggest that monetary policy provides a powerful tool to influence long-term real interest rates. However, can we safely take them at face value? One reason for scepticism is potential reverse causation from long-term real rates to the stance of monetary policy. For example, if long-term real interest rates are high because the economy is expected to grow rapidly over the next few years, inflationary fears may force the central bank to raise short-term interest rates. Nevertheless, the fact that our results basically hold even if we use lagged short real rates suggests that reverse causation is not the whole story.

Our results concerning fiscal variables are less clear than those for the short-term real rate, although this seems to be driven mainly by the Japanese experience of the late 1990s and afterwards. If one drops Japan, then gross government debt turns out to be an important driving force for real interest rates, suggesting that Ricardian equivalence does not hold. The results concerning cyclically adjusted government borrowing are less robust.

Our results are by and large in line with the existing empirical literature, which has up to now concentrated on time series econometrics and not on panel methods. Blanchard and Summers (1984) find that the high real interest rates of the late 1970s and the early 1980s were probably due to the fiscal-monetary policy mix. Fiscal factors are also stressed by Barro and Sala-i-Martin (1990) and by Ford and Laxton (1999). Breedon et al (1999) also stress the importance of domestic factors in determining long-term real interest rates, among them the government debt-to-GDP ratio and real

[16] These results hold if we use government debt instead of net borrowing.

short-term rates. The role of monetary policy is stressed by Allsopp and Glyn (1999), who conclude their paper with the statement that their analysis leads them "... to conclude that it would be wrong to think of the real interest rate as determined ... independent of monetary policy" (p 15).

As in the case of real interest rates, our results concerning fiscal policy represent correlations that do not necessarily indicate causality. Reverse causality may be a problem in particular for net lending. In the long run, high real interest rates add to debt servicing costs and therefore to the government's financing requirements. Nevertheless, interest payments on the public debt tend to be relatively sticky due to the prevalence of long-term nominal interest rates in most countries of our sample and persistent inflation. This should reduce the problem of reverse causality, especially since we are estimating at a half-yearly frequency.

6. Conclusions

The aim of the paper was to shift the focus of the debate on real interest rates more towards long-term rates. We argue that the analysis of real interest rates is only useful if the time horizon for such rates covers the whole investment period. In the case of capital investment, this can be several years, in the case of saving even decades. Given the importance of long-term real interest rates, it is natural to ask to what extent they can be influenced by macroeconomic policy. In the case of monetary policy, this is the stage where short-term real interest rates become important. In the presence of nominal rigidities, short-term real rates are under the control of monetary policy. Although their direct impact on real variables may be limited, they may have a much greater indirect effect through their influence on long-term rates. This link between monetary policy, proxied by the short-term real interest rate, on the one hand, and long-term real rates on the other, is at the heart of the paper. We also consider the effect of fiscal policy, as proxied by government net borrowing and government debt. In contrast to monetary policy, fiscal policy affects the long end of the term structure directly by changing the demand for loanable funds.

Empirical work on ex ante real interest rates comes with serious measurement problems. One of the reasons why relatively little work has been done in this field is scarcity of data. In the absence of inflation-indexed bonds, real rates cannot be observed directly. We believe that survey evidence on inflation expectations can help us to overcome this problem. These price forecasts can be used to deflate nominal interest rates to yield estimates of ex ante real rates. We discuss the problems associated with survey data in depth, but come to the conclusion that they seem to provide a fairly good approximation to the "true" beliefs of market participants.

Our estimation results suggest that both monetary and fiscal policy generally play an important role in the determination of long-term real interest rates. Nevertheless, the importance of monetary policy for long real rates appears to have diminished since the late 1990s. An obvious candidate explanation for this is EMU, in particular since about half of the countries in our sample belong to the euro area. This is not borne out by the data, however. We find that monetary policy has also lost its impact among the non-EMU countries. This is consistent with evidence that monetary policy has become more synchronised across countries, leaving less room for national real interest rates to diverge. Unfortunately, we cannot say whether this implies that monetary policy has indeed become less effective or whether the countries have simply not tried to steer long-term real interest rates away from the group of countries we consider.

In contrast to monetary policy, there is no evidence outside Japan that a country-specific fiscal policy has become less important over time. Only in Japan have low real interest rates coincided with high debt and government borrowing, thus producing insignificant estimates for the coefficients on the fiscal variables.

Data appendix

Table A1

Variables

	Description	Source
A. Monetary variables		
*r*3*mre*	Three-month real interest rate (nominal rate minus annual inflation over last 12 months)	BIS
B. Fiscal variables		
nbg	Net borrowing by general government, % of GDP (corresponds to net lending in OECD database, multiplied by −1)	OECD
nbgca	Net lending by general government, cyclically adjusted, % of GDP	OECD
ggdgs	General government gross debt, % of GDP	OECD
C. Control variables		
*gdp_e*5/10	Real GDP growth expected over the next 5/10 years	Consensus Forecast
gdp	Growth rate of current GDP, 1995 prices	OECD
y_gap	Output gap, % of GDP	OECD
unrte	Unemployment rate	OECD
pi	Inflation over the previous 12 months	OECD
perat	Price earnings ratio based on analysts' forecasts for profits of firms contained in MSCI country index in 12 months' time	I/B/E/S
comix	Competitiveness index, based on relative consumer prices	OECD

Table A2

Results from FGLS estimation (heteroskedastic panels with cross-country correlation, country-specific AR1)

Explanatory variables	***r*05*cf***				***r*10*cf* (including Japan)**				***r*10*cf* (excluding Japan)**			
	Full sample period		Sample split (98:01)		Full sample period		Sample split (98:01)		Full sample period		Sample split (98:01)	
	1	2	3		4	5	6		7	8	9	
r3mre	0.4128**	0.4383**	0.4530**	0.3393**	0.3547**	0.3045**	0.3128**	0.2209**	0.3502**	0.2788**	0.3469**	0.0943
	(0.0399)	(0.0367)	(0.0379)	(0.0924)	(0.0305)	(0.0295)	(0.0308)	(0.0605)	(0.0363)	(0.0330)	(0.0295)	(0.0663)
nbgca	0.0530				0.0010				0.0146			
	(0.0310)				(0.0221)				(0.0316)			
ggdgs	0.0360**	0.0370**	0.0352**	0.0349**	0.0035	0.0056	0.0078	0.0012	0.0285*	0.0322**	0.0370**	0.0345**
	(0.0110)	(0.0098)	(0.0101)	(0.0112)	(0.0076)	(0.0047)	(0.0048)	(0.0058)	(0.0121)	(0.0121)	(0.0096)	(0.0108)
gdp	–0.0275				0.0217				0.0209			
	(0.0234)				(0.0191)				(0.0204)			
*gdp_e*5/10	0.5049**	0.5011**	0.5189**	0.3042	–0.1640				0.0716			
	(0.1776)	(0.1526)	(0.1686)	(0.3313)	(0.1228)				(0.1949)			
unrte	–0.1144				0.0795				0.1444*			
	(0.0648)				(0.0496)				(0.0581)			
y_gap	–0.0155				0.0342				0.0506			
	(0.0445)				(0.0339)				(0.0374)			
comix	–0.0024				–0.0072*				–0.0018			
	(0.0049)				(0.0036)				(0.0042)			
perat	–0.0225				0.0141				0.0035			
	(0.0183)				(0.0083)				(0.0155)			
pi	0.2897**	0.3070**	0.3056**	0.2849**	0.3469**	0.2533**	0.2188**	0.1968**	0.3131**	0.2224**	0.2633**	0.1654**
	(0.0453)	(0.0420)	(0.0416)	(0.0903)	(0.0371)	(0.0361)	(0.0412)	(0.0637)	(0.0456)	(0.0413)	(0.0407)	(0.0579)

Table A2 (cont)

Results from FGLS estimation (heteroskedastic panels with cross-country correlation, country-specific AR1)

Explanatory variables	***r*05*cf***			***r*10*cf* (including Japan)**			***r*10*cf* (excluding Japan)**		
	Full sample period		Sample split (98:01)	Full sample period		Sample split (98:01)	Full sample period		Sample split (98:01)
	1	2	3	4	5	6	7	8	9
Sample period	90:01-02:01	90:01-02:01	90:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01
No of periods	25	25	25	23	23	23	23	23	23
Countries	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US	7: DE, FR, IT, CA, UK, US, JP	7: DE, FR, IT, CA, UK, US, JP	7: DE, FR, IT, CA, UK, US, JP	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US
No of obs	150	150	150	161	161	161	138	138	138
Cross-country correlation	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-specific AR1	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes

Note: Standard deviations in brackets; */** = significant at the 1% and 5% levels.

Table A3

Results from fixed-effects estimation: testing for the effects of EMU

Explanatory variables	***r*05*cf***		***r*10*cf***			
			Including Japan		**Excluding Japan**	
	1		2		3	
		EMU		EMU		EMU
r3mre	0.4863** (0.0484)	–0.1828 (0.2176)	0.3836** (0.0409)	–0.0581 (0.1940)	0.4102** (0.0470)	–0.1259 (0.2073)
nbgca	0.0791* (0.0342)	–0.1224 (0.1214)				
ggdgs	0.0434** (0.0136)	–0.0043 (0.0120)	0.0160** (0.0056)	–0.0120 (0.0068)	0.0355** (0.0137)	–0.0037 (0.0086)
*gdp_e*5/10	0.4267* (0.1915)	–0.1288 (0.4990)				
unrte	–0.0681 (0.0523)	0.0943 (0.1383)				
perat			0.0231* (0.0104)	0.0555 (0.0290)	0.0467* (0.0209)	0.0351 (0.0326)
pi	0.35113** (0.0564)	–0.0753 (0.2838)	0.3421** (0.0584)	–0.0045 (0.1973)	0.3372** (0.0649)	–0.1150 (0.2311)
Sample period	90:01-02:01		91:01-02:01		91:01-02:01	
No of periods	25		23		23	
Countries	6: DE, FR, IT, CA, UK, US		7: DE, FR, IT, CA, UK, US, JP		6: DE, FR, IT, CA, UK, US	
No of obs	150		161		138	
R^2(w); R^2(b)	0.92; 0.74		0.87; 0.80		0.88; 0.86	
F-test (p-val)	0.004		0.000		0.025	
Time dummies	yes		yes		yes	

Note: Standard deviations in brackets; */** = significant at the 1% and 5% levels.

Table A4

Results from fixed-effects estimation: including lagged short-term interest rate

Explanatory variables	***r*05*cf***				***r*10*cf* (including Japan)**				***r*10*cf* (excluding Japan)**			
	Full sample period		Sample split (98:01)		Full sample period		Sample split (98:01)		Full sample period		Sample split (98:01)	
	1	2	3		4	5	6		7	8	9	
r3mre (–1)	0.2483**	0.2199**	0.1820**	–0.1102	0.2258**	0.2398**	0.2608**	0.1097	0.2196**	0.2282**	0.2527**	0.0804
	(0.0544)	(0.0476)	(0.0525)	(0.1531)	(0.0450)	(0.0422)	(0.0446)	(0.1214)	(0.0544)	(0.0455)	(0.0493)	(0.1459)
nbgca	0.1726**	0.1958**	0.1494**	0.2446*	0.0466	0.0644**	0.0368	–0.0338	0.0987	0.1375**	0.1080**	0.0129
	(0.0520)	(0.0358)	(0.0406)	(0.0989)	(0.0446)	(0.0231)	(0.0321)	(0.0682)	(0.0588)	(0.0378)	(0.0407)	(0.0824)
ggdgs	0.0158				0.0227				0.0214			
	(0.0173)				(0.0117)				(0.0191)			
gdp	–0.0377				–0.0153				0.0052			
	(0.0476)				(0.0438)				(0.0475)			
*gdp_e*5/10	0.3028				0.0726				–0.2161			
	(0.3008)				(0.2515)				(0.4084)			
unrte	–0.3565**	–0.3574**	–0.4025**	–0.6155**	–0.0653				–0.0409			
	(0.0912)	(0.0568)	(0.0663)	(0.1002)	(0.0881)				(0.0974)			
y_gap	0.0034				0.0562				0.0661			
	(0.0889)				(0.0873)				(0.0943)			
comix	–0.0051				–0.0062				0.0005			
	(0.0092)				(0.0080)				(0.0096)			
perat	–0.0117				0.0312*				0.0293			
	(0.0267)				(0.0139)				(0.0269)			
pi	0.1143				0.2088**	0.2359**	0.2498**	0.0535	0.1956*	0.2321**	0.2532**	0.0429
	(0.0693)				(0.0803)	(0.0646)	(0.0727)	(0.1563)	(0.0878)	(0.0739)	(0.0820)	(0.1839)

Table A4 (cont)

Results from fixed-effects estimation: including lagged short-term interest rate

Explanatory variables	***r*05*cf***			***r*10*cf* (including Japan)**			***r*10*cf* (excluding Japan)**		
	Full sample period		Sample split (98:01)	Full sample period		Sample split (98:01)	Full sample period		Sample split (98:01)
	1	2	3	4	5	6	7	8	9
Sample period	90:01-02:01	90:01-02:01	90:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01	91:01-02:01
No of periods	25	25	25	23	23	23	23	23	23
Countries	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US	7: DE, FR, IT, CA, UK, US, JP	7: DE, FR, IT, CA, UK, US, JP	7: DE, FR, IT, CA, UK, US, JP	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US	6: DE, FR, IT, CA, UK, US
No of obs	149	149	146	161	161	154	138	138	132
R^2(w); R^2(b)	0.85; 0.09	0.84; 0.18	0.86; 0.48	0.79; 0.09	0.77; 0.87	0.78; 0.91	0.80; 0.81	0.79; 0.74	0.80; 0.82
F-test (p-val)	0.000	0.000	0.000	0.000	0.000	0.000	0.066	0.020	0.000
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes

Note: Standard deviations in brackets; */** = significant at the 1% and 5% levels.

Table A5

Results from fixed-effects estimation: unbalanced sample

Explanatory variables	***r05cf* (excluding Japan)**				***r10cf* (including Japan)**				***r10cf* (excluding Japan)**			
	Full sample period		Sample split (98:01)		Full sample period		Sample split (98:01)		Full sample period		Sample split (98:01)	
	1	2	3		4	5	6		7	8	9	
r3mre	0.5787** (0.0362)	0.5752** (0.0341)	0.5776** (0.0392)	0.4372** (0.0891)	0.4564** (0.0327)	0.4403** (0.0319)	0.4342** (0.0329)	0.2718** (0.0735)	0.4529** (0.0360)	0.4392** (0.0339)	0.4554** (0.0372)	0.1564 (0.0843)
nbgca	0.0479 (0.0320)				0.0123 (0.0303)				0.0099 (0.0352)			
ggdgs	0.0245* (0.0107)	0.0379** (0.0081)	0.0391** (0.0089)	0.0369** (0.0107)	0.0135 (0.0081)	0.0059 (0.0045)	0.0084 (0.0058)	–0.0034 (0.0061)	0.0287* (0.0112)	0.0315** (0.0082)	0.0343** (0.0086)	0.0298** (0.0104)
gdp	0.0505** (0.0318)				0.0449 (0.0300)	0.0904** (0.0266)	0.1024** (0.0270)	0.1597* (0.0705)	0.0531 (0.0310)			
*gdp_e*5/10	0.7146** (0.1915)	0.7937** (0.1713)	0.8150** (0.1898)	0.5977* (0.2892)	0.2837 (0.1588)				0.2510 (0.2361)			
unrte	–0.0791 (0.0498)				0.0939 (0.0477)				0.1081* (0.0497)			
y_gap	–0.2005** (0.0607)	–0.0865* (0.0381)	–0.1111** (0.0413)	0.0590 (0.0775)	–0.0853 (0.0568)	–0.1755** (0.0432)	–0.2108** (0.0451)	–0.1016 (0.0719)	–0.0696 (0.0619)	–0.0886* (0.0372)	–0.1205** (0.0390)	0.0792 (0.0730)
comix	–0.0055 (0.0060)				–0.0094 (0.0055)				–0.0024 (0.0061)			
perat	0.0033 (0.0164)				0.0256** (0.0098)				0.0317 (0.0163)			
pi	0.4867** (0.0495)	0.4643** (0.0465)	0.4522** (0.0490)	0.3563** (0.1054)	0.4480** (0.0463)	0.4524** (0.0467)	0.4397** (0.0465)	0.3292** (0.0872)	0.4433** (0.0488)	0.3858** (0.0432)	0.3761** (0.0434)	0.1493 (0.0978)

Table A5 (cont)

Results from fixed-effects estimation: unbalanced sample

Explanatory variables	***r*05*cf* (excluding Japan)**			***r*10*cf* (including Japan)**			***r*10*cf* (excluding Japan)**		
	Full sample period		Sample split (98:01)	Full sample period		Sample split (98:01)	Full sample period		Sample split (98:01)
	1	2	3	4	5	6	7	8	9
Sample period	89:02-02:01	89:02-02:01	89:02-02:01	89:02-02:01	89:02-02:01	89:02-02:01	89:02-02:01	89:02-02:01	89:02-02:01
Max no of periods	26	26	26	26	26	26	26	26	26
Countries	9: DE, FR, IT, CA, UK, US, ES, NO, SE	9: DE, FR, IT, CA, UK, US, ES, NO, SE	9: DE, FR, IT, CA, UK, US, ES, NO, SE	10: DE, FR, IT, CA, UK, US, JP, ES, NO, SE	10: DE, FR, IT CA, UK, US, JP, ES, NO, SE	10: DE, FR, IT, CA, UK, US, JP, ES, NO, SE	9: DE, FR IT, CA, UK, US, ES, NO, SE	9: DE, FR, IT, CA, UK, US, ES, NO, SE	9: DE, FR, IT, CA, UK, US, ES, NO, SE
No of obs	192	192	192	214	214	214	188	188	188
R^2(w); R^2(b)	0.91; 0.78	0.91; 0.67	0.91; 0.67	0.90; 0.70	0.89; 0.85	0.90; 0.84	0.91; 0.71	0.90; 0.76	0.91; 0.71
F-test (p-val)	0.019	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes

Note: Standard deviations in brackets; */** = significant at the 1% and 5% levels.

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Monetary policy with unobserved potential output

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Abstract

This paper studies some effects of real-time information on the implementation of monetary policy. We consider an economy in which several sources of uncertainty, such as measurement errors and imperfectly observable states, do not allow the policymaker to identify the true state of the economy. Optimal policy thus requires the policymaker to jointly solve a filtering and an optimisation problem. We focus in particular on the case of a non-observable measure of potential output and analyse the consequences of this assumption for the macroeconomy (policy, output and inflation). The paper provides a benchmark model to assess the claim that conditioning policy on a potential output measure using real-time data may be at the root of a biased policy stance, as recently suggested by Orphanides. More generally, it offers a rigorous framework to analyse the effects of imperfect information and to assess the role of macroeconomic indicators in alleviating information problems.

1. Introduction and main findings

This note discusses recent results concerning monetary policy with real-time information.[2] The theme of this paper is that the implementation of monetary policy is often faced with the difficult task of taking decisions in the presence of high uncertainty. Policy decisions require knowledge of a structural economic model and of the state of the economy (the realisation of the different shocks impinging on it). Such information is rarely available to the policymaker. Taking decisions in real time, when the latest data on some target variables (eg inflation, employment and output) may not be available, or may be subject to substantial measurement errors, requires an efficient filtering of the available information to ensure the best possible inference on the state of the economy is formed.

An example illustrates the nature of this basic problem faced by central banks. A stabilising role for monetary policy crucially hinges on some notion of "potential output", a non-observable economic variable representing the desirable (or target) level at which actual output should be. The conduct of monetary policy requires, therefore, that the central bank estimates, and continually updates, its potential output forecast. Orphanides (2000a,b, 2001) provides persuasive support for the view that a significant overestimation of potential output during the oil shocks of the 1970s aggravated inflation at that time by leading to a monetary policy stance which turned out to be, with the benefit of hindsight, excessively loose ex post. Somewhat symmetrically, the strong productivity gains recorded in the United States during the second half of the 1990s raised the possibility, again with the benefit of hindsight, that the subsequently greater than expected increases in potential output could have allowed for a less restrictive monetary policy stance than that initially suggested by real-time estimates of inflation and the output gap.

The work of Orphanides sheds interesting new light on monetary policy during the 1970s and raises an important question about whether such retrospective policy mistakes can be avoided in the future. If they were due to poor but correctable forecasting procedures or to an inefficient specification of the "policy rule", a likely answer to this question is yes. Assessing the extent to which such mistakes were

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2 These results draw on the findings of Cukierman and Lippi (2002) and Gerali and Lippi (2002), where several of the technical details are discussed.

due to “bad policies” rather than to “bad luck” requires a model which identifies optimal monetary policy under imperfect information. Once this benchmark is defined, and its properties are established, one can proceed to evaluate the extent to which (retrospective) policy errors were avoidable.

This paper contributes to the debate on the effects of imperfect information by proposing such a benchmark model and analysing its properties. It is shown that, given the structure of information, some policy decisions which are judged ex post to be mistakes may be unavoidable even if the central bank utilises the most efficient forecasting procedures. Moreover, such retrospective mistakes are small during periods in which changes in potential output are small, and large during periods characterised by substantial changes in the long-run trend of output. During the latter episodes, policy mistakes in a given direction are likely to persist for some time.

The evidence in Orphanides (2001) supports the view that monetary policy during the 1970s was excessively loose since a permanent reduction in potential output was interpreted for some time as a negative output gap. The analytical framework of this paper provides an “optimising” analytical foundation for this mechanism and identifies the conditions under which it operates.[3] Interestingly, a large permanent decrease in potential output does not lead to an excessively loose policy stance under all circumstances. Whether it does or not depends on the relative persistence of demand and of cost shocks, and on other parameters like the degree of conservativeness of the central bank.

While the theoretical analysis suggests that imperfect information may lie at the root of a “biased” policy stance (judged with the benefit of hindsight), a preliminary quantitative assessment of the effects of imperfect information indicates that the effects of such biases on the main macroeconomic variables are not very large. While preliminary, this finding seems to suggest that it is difficult to “explain” the high inflation of the 1970s as a consequence of imperfect information alone.

These results are first presented by means of a simple model by Cukierman and Lippi (2002), which captures the conception of many central banks about the transmission process of monetary policy. The advantage of this simple formulation lies in the tractability of the analytical framework. That model identifies conditions under which the presence of imperfect information leads monetary policy to be *systematically* tighter than under perfect information in periods of permanent increases in potential output and to be too loose relative to this benchmark in periods of permanent reductions in potential output. The reason is that, even when they filter available information in an optimal manner, policymakers as well as the public at large detect permanent changes in potential output only *gradually*. When, as was the case in the 1970s, there is a permanent decrease in potential output, policymakers interpret part of this reduction as a negative output gap and loosen monetary policy too much in comparison to the no permanent-temporary confusion (PTC) benchmark. Thus, in periods of large permanent decreases in productivity, inflation accelerates because of the relatively expansionary monetary policy stance. Conversely, when - as might have been the case in the United States during the 1990s - a “new economy” permanently raises the potential level of output, inflation goes down since, as policymakers interpret part of the permanent increase in potential output as a positive output gap, policy is tighter than under perfect information. A main novel result of the paper is that, even when the information available to policymakers in real time is used efficiently and monetary policy chosen optimally, errors of forecast in real-time estimates of potential output and of the output gap are serially correlated retrospectively. In general, this serial correlation is induced by shocks to potential output, as well as to the cyclical components of output.

We subsequently show how similar results can be produced by a more up-to-date forward-looking model of the “new synthesis” variety developed by Woodford (1999) and Clarida et al (1999).

2. The background analytical framework

The problems analysed in the following can be framed within the setup and notation used by Svensson and Woodford (2000) to model a linear-quadratic economy with two agents, a government

[3] Related work on the effects of imperfect information for monetary policy appears in Ehrmann and Smets (2001), who develop a quantitative assessment of the effects of imperfect information using a numerical analysis based on a calibrated model for the euro area.

and an aggregate private sector, which are assumed to have the same imperfect information on the state of the economy. We use the algorithms developed by Gerali and Lippi (2002) to solve this problems numerically using MATLAB.

The economy is described by:

$$\begin{bmatrix} X_{t+1} \\ x_{t+1|t} \end{bmatrix} = A^1 \begin{bmatrix} X_t \\ x_t \end{bmatrix} + A^2 \begin{bmatrix} X_{t|t} \\ x_{t|t} \end{bmatrix} + Bi_t + \begin{bmatrix} u_{t+1} \\ 0 \end{bmatrix} \tag{2.1}$$

where X_{t+1} is a vector of n_X predetermined variables in period t (natural state variables), x_t is a vector of n_x forward-looking variables, i is a vector of n_i policy instruments, u_t is a vector of n_X iid shocks with mean zero and covariance Σ_u^2, and A^1, A^2 and B are matrices of appropriate dimension. For any variable z_t, the notation $z_{t|\tau}$ denotes the expectation, $E[z_t|I_\tau]$, ie the rational expectation of z_t with respect to the information I_τ available in period τ.

Let Y_t represent the vector of target variables that enter the government criterion function,

$$Y_t = C^1 \begin{bmatrix} X_t \\ x_t \end{bmatrix} + C^2 \begin{bmatrix} X_{t|t} \\ x_{t|t} \end{bmatrix} + C_i i_t \tag{2.2}$$

where C^1, C^2 and C_i are matrices of appropriate dimension. Let the quadratic form describing the period loss function be given by:

$$L_t \equiv Y_t' W Y_t \tag{2.3}$$

where W is a positive semi-definite matrix of weights. The government actions are aimed at minimising the intertemporal loss function

$$\Lambda_t = E\left[\sum_{\tau=0}^{\infty} \delta^\tau L_{t+\tau} \middle| I_t \right] \tag{2.4}$$

where $\delta \in (0, 1)$ is the intertemporal discount factor.

Finally, let the vector of observable variables Z_t be given by:

$$Z_t = D^1 \begin{bmatrix} X_t \\ x_t \end{bmatrix} + D^2 \begin{bmatrix} X_{t|t} \\ x_{t|t} \end{bmatrix} + v_t \tag{2.5}$$

where the "noise" vector v_t is assumed to be iid with covariance matrix Σ_v^2. Information I_t in period t is:

$$I_t \equiv \left\{ Z_\tau,\ \tau \le t;\ A^1, A^2, B, C^1, C^2, C_i, D^1, D^2, W, \delta, \Sigma_u^2, \Sigma_v^2 \right\}$$

3. Application 1 (from Cukierman and Lippi (2002))

This section presents a simplified version of the backward-looking sticky price model presented in Svensson (1997). Although the model is not rooted in explicit microfoundations, it is likely to reflect the views of several central banks about the transmission process of monetary policy. Its main advantage is that it allows the basic consequences of imperfect information to be illustrated analytically in a relatively simple manner. We therefore maintain the assumption that this reduced form model captures the actual behaviour of the economy. A richer economic structure, incorporating transmission lags or forward-looking variables, does not eliminate the effects described in the paper (eg Ehrmann and Smets (2001)) but may introduce new ones. Although such models may be preferable for theoretical and empirical reasons, they would prevent us from illustrating our main points analytically.

3.1 The economy

In this framework (the logarithm of) output (y_t) and inflation (π_t) are determined, respectively, as follows:

$$y_t = z_t - \varphi r_t + g_t \tag{3.1}$$

$$\pi_t = \lambda(y_t - z_t) + u_t \tag{3.2}$$

Here z_t denotes (the log of) potential output at period t, r_t is a *real* short-term interest rate, g_t is a demand shock and u_t a cost push shock. This framework postulates that potential output z is a fundamental long-run determinant of actual output. But, in addition, actual output is also affected by a demand shock and by the real rate of interest, which for given inflationary expectations is determined in turn by the (nominal) interest rate policy of the central bank.

In line with conventional macroeconomic wisdom, we postulate that the demand and cost shocks are less persistent than changes in potential output, which are affected by long-run factors like technology and the accumulation of physical and human capital. The permanence of shocks to potential output is modelled by assuming that z_t is a random walk.[4] More specifically, we postulate the following stochastic processes for the shocks:

$$g_t = \mu g_{t-1} + \hat{g}_t \quad 0 < \mu < 1; \quad \hat{g}_t \sim N(0, \sigma_g^2) \tag{3.3}$$

$$u_t = \rho u_{t-1} + \hat{u}_t \quad 0 < \rho < 1; \quad \hat{u}_t \sim N(0, \sigma_u^2) \tag{3.4}$$

$$z_t = z_{t-1} + \hat{z}_t \qquad \hat{z}_t \sim N(0, \sigma_z^2) \tag{3.5}$$

To reiterate, the main purpose of this simple model is to characterise the macroeconomic consequences of optimally chosen monetary policy (ie a sequence for r_t) when policymakers cannot identify with certainty (not even retrospectively) the sources of output changes.

3.2 Monetary policy

The policy instrument is the nominal interest rate. But since prices are temporarily sticky, the policymaker can bring about the real rate he desires by setting the nominal rate. For convenience and without loss of generality, we can therefore consider the policymaker as setting the real interest rate r_t. This policy instrument is set at the *beginning* of period t before output, inflation (y_t and π_t) and period t shocks are realised. The policy objective is to minimise the objective function:

$$L_t \equiv \tfrac{1}{2} E\left\{ \sum_{j=0}^{\infty} \beta^j \left[\alpha (x_{t+j})^2 + (\pi_{t+j})^2 \right] \Big| \, J_{t-1} \right\} \quad \alpha > 0 \tag{3.6}$$

where $x_t \equiv y_t - z_t$ denotes the output gap (defined as the difference between (the logarithms of) actual and potential output) and J_{t-1} is the information set available at the beginning of period t, when r_t is chosen. The first-order condition for the discretionary (time-consistent) monetary policy $(\min_{r_t} L_t)$ implies:

$$x_{t|t-1} = -\frac{\lambda}{\alpha} \pi_{t|t-1} \tag{3.7}$$

Here $\pi_{t|t-1}$ and $x_{t|t-1}$ are the expected values of inflation and of the output gap conditional on the information available at the beginning of period t, J_{t-1}. At this stage we note that J_{t-1} contains, inter alia, observations on actual inflation and output up to and including period $t-1$. A full specification of J_{t-1} appears below. Since the values of inflation and of the output gap at period t are not known with

[4] Nothing in our results would change if we added a (more realistic) deterministic trend growth to the potential output process.

certainty at the beginning of period t, those variables (which are indirectly controlled by policy) appear in equation (3.7) in expected terms.

The equilibrium outcomes for the interest rate, output and inflation obey:

$$r_t = \frac{1}{\varphi}\left[g_{t|t-1} + \frac{\lambda}{\alpha + \lambda^2} u_{t|t-1} \right] \tag{3.8}$$

$$y_t = z_t + (g_t - g_{t|t-1}) - \frac{\lambda}{\alpha + \lambda^2} u_{t|t-1} \tag{3.9}$$

$$\pi_t = \frac{\alpha}{\alpha + \lambda^2} u_t + \lambda (g_t - g_{t|t-1}) + \frac{\lambda^2}{\alpha + \lambda^2} (u_t - u_{t|t-1}) \tag{3.10}$$

3.3 The structure of information and optimal policy

The interest rate rule in equation (3.8) implies that the optimal real interest rate policy for period $t + 1$, r_{t+1}, requires the policymaker to form expectations about the values of the demand shock and the cost push shocks, g_{t+1} and u_{t+1}. Although he does not observe those shocks directly, the policymaker possesses information about economic variables from which noisy, but optimal, forecasts of the shocks can be derived. In particular, we assume that policymakers know the true structure of the economy: $\Omega \equiv \left\{ \varphi, \lambda, \rho, \mu, \sigma_u^2, \sigma_g^2, \sigma_z^2 \right\}$ but do not know the precise stochastic sources of fluctuations in output and inflation.

Thus, when the interest rate r_{t+1} is chosen, at the beginning of period $t + 1$, the policymaker forms expectations about g_{t+1} and u_{t+1} using historical data. The latter consists of observations on output and inflation up to and including period t. The information available at the beginning of period $t + 1$ is summarised by the information set:

$$J_t = \{\Omega, y_{t-i}, \pi_{t-i} \,|\, i = 0, 1, 2, \ldots\} \tag{3.11}$$

which is used to form the conditional expectations: $g_{t+1|t}$ and $u_{t+1|t}$. Past observations on output and inflation are equivalent to past observations on the two signals, $s_{1,t}$ and $s_{2,t}$ (obtained by rearranging equations (3.9) and (3.10)):

$$s_{1,t} \equiv y_t + g_{t|t-1} + \frac{\lambda}{\alpha + \lambda^2} u_{t|t-1} = z_t + g_t \tag{3.12}$$

$$s_{2,t} \equiv \pi_t + \lambda g_{t|t-1} + \frac{\lambda^2}{\alpha + \lambda^2} u_{t|t-1} = \lambda g_t + u_t \tag{3.13}$$

where variables to the left of the equality sign are observed separately while those to the right are not. Clearly, $s_{1,t}$ and $s_{2,t}$ contain (noisy) information on g_t and u_t which can be used to make inferences on g_{t+1} and u_{t+1}, using the fact that $g_{t+1|t} = \mu g_{t|t}$ and $u_{t+1|t} = \rho u_{t|t}$.

Notice how the optimal estimates of g_t and u_t conditional on J_t, $g_{t|t}$ and $u_{t|t}$ respectively, follow immediately from the two signal equations (3.12) and (3.13), once the optimal estimate of potential output, $z_{t|t}$, is known. Therefore, the signal extraction (or filtering) problem solved by the policymaker reduces to an inference problem concerning the level of potential output.

3.4 Mismeasurement of potential output and policymakers' views about the state of the economy

Let policymakers' forecast errors concerning the variables z_t, g_t and u_t conditional on the information set J_t be:

$$\tilde{u}_{t|t} \equiv u_t - u_{t|t} \tag{3.14}$$

$$\tilde{g}_{t|t} \equiv g_t - g_{t|t} \tag{3.15}$$

$$\tilde{z}_{t|t} \equiv z_t - z_{t|t} \tag{3.16}$$

Using equations (3.12) and (3.13) the following useful relationship between these errors can be derived:

$$\lambda\tilde{z}_{t|t} = -\lambda\tilde{g}_{t|t} = \tilde{u}_{t|t} \tag{3.17}$$

The last equation shows that overestimation of potential output ($\tilde{z}_{t|t} < 0$) simultaneously *implies* an overestimation of the cost push shock and an underestimation of the demand shock. This is summarised in the following remark.

Remark 1. *Potential output overestimation ($\tilde{z}_{t|t} \equiv z_t - z_{t|t} < 0$) implies:*

(i) *demand shock underestimation ($\tilde{g}_{t|t} \equiv g_t - g_{t|t} > 0$)*

(ii) *cost push shock overestimation ($\tilde{u}_{t|t} \equiv u_t - u_{t|t} < 0$)*

Inequalities with opposite signs hold when $\tilde{z}_{t|t} > 0$.

The intuition underlying this result can be understood by reference to equations (3.12) and (3.13). The first equation implies that an increase in $s_{1,t}$ is always and **optimally** interpreted as being due partly to an increase in z_t and partly to an increase in g_t. Similarly, an increase in $s_{2,t}$ is interpreted as partly due to an increase in g_t and partly to an increase in u_t. Thus, when only z_t increases, part of this increase is interpreted as an increase in potential output, but the remainder is interpreted as an increase in g_t. As a consequence the error in forecasting z_t is positive and the error in forecasting g_t is negative, producing a **negative** correlation between the forecast errors in those two variables. Since $s_{2,t}$ does not change the (erroneously) perceived increase in g_t is interpreted as a decrease in u_t, producing a positive forecast error for this variable and, therefore, a **positive** correlation between the forecast errors in u_t and in z_t.

3.5 Consequences of forecast errors in potential output for monetary policy, inflation and the output gap

Remark 1 shows how mismeasurement of potential output distorts policymakers' perceptions about cyclical conditions (cost push and demand shocks). The purpose of this subsection is to answer the following question: how do such noisy perceptions about the phase of the cycle affect monetary policy, inflation and the output gap? We do this by comparing the values of those variables in the presence of the PTC with their values in the benchmark case in which there is no such confusion. In the benchmark case, policymakers possess in each period *direct information* about the realisations of the shocks up to and including the previous period. Formally, in the absence of the PTC policymakers possess, at the beginning of period $t+1$, the information set J_t^* that is defined by:

$$J_t^* = \{J_t, g_{t-i}, u_{t-i} \mid i = 0,1,2,\ldots\} \tag{3.18}$$

3.5.1 Consequences for monetary policy

We begin by studying the determinants of the difference between the settings of monetary policy in the presence and in the absence of the PTC. Using equations (3.8), (3.14), (3.15) and (3.17), the *deviation* of the optimal interest rate in the presence of the PTC from its optimal value in the absence of this confusion $\left(\text{ie } r_{t+1}^* = \frac{1}{\varphi}\left[\mu g_t + \frac{\lambda}{\alpha+\lambda^2}\rho u_t\right]\right)$ can be written as:

$$\Delta r_{t+1} \equiv r_{t+1} - r_{t+1}^* = -\frac{1}{\varphi}\left[\mu\tilde{g}_{t|t} + \frac{\lambda\rho}{\alpha+\lambda^2}\tilde{u}_{t|t}\right] \tag{3.19}$$

$$= \frac{\left(\mu - \frac{\rho\lambda^2}{\alpha+\lambda^2}\right)}{\varphi}\tilde{z}_{t|t} \tag{3.20}$$

It follows immediately from equation (3.19) that if demand shocks are sufficiently persistent in comparison to cost shocks (ie $\mu > \frac{\rho\lambda^2}{\alpha+\lambda^2}$), the deviation of the real interest rate from its full information counterpart moves in the same direction as the forecast error in potential output ($\tilde{z}_{t|t}$). Although one cannot rule out the possibility that, when the persistence in cost shocks is sufficiently larger than that of demand shocks, the opposite occurs, it appears that the first case seems more likely a priori. The reason is that the persistence parameter of the cost shocks is multiplied by a fraction implying that Δr_{t+1} and $\tilde{z}_{t|t}$ are positively related even if ρ is larger than μ, but not by too much. Note that the smaller the (Rogoff (1985) type) conservativeness of the central bank (the higher α), the more likely it is that Δr_{t+1} and $\tilde{z}_{t|t}$ are positively related even when ρ is larger than μ. Hence, for central banks which are (using Svensson's (1997) terminology) relatively flexible inflation targeters, the case in which Δr_{t+1} and $\tilde{z}_{t|t}$ are positively related is definitely the more likely one for most or all values of ρ and μ in the range between zero and one. The various possible effects of imperfect information are summarised in the following proposition:

Proposition 1. *(i) When the persistence of demand shocks is sufficiently high* $\left(\mu > \frac{\rho\lambda^2}{\alpha+\lambda^2}\right)$ *monetary policy is driven mainly by "demand shocks" considerations. This implies that potential output over/underestimation (causing the demand shock to be under/overestimated) leads to real rates which are lower/higher than the rate which is optimal in the absence of the PTC*.

(ii) When the persistence of demand shocks is sufficiently low $\left(\mu < \frac{\rho\lambda^2}{\alpha+\lambda^2}\right)$ *monetary policy is driven mainly by "cost push shocks" considerations. This implies that potential output over/underestimation (causing the cost push shock to be over/underestimated) leads to a real rate which is higher/lower than the rate that is optimal in the absence of the PTC*.

To understand the intuition underlying the proposition, it is useful to consider the case in which there is, in period *t*, a negative shock to potential output and no changes in the cyclical shocks, *g* and *u*. This leads, as of the beginning of period $t+1$, to overestimation of potential output in period *t* ($\tilde{z}_{t|t} < 0$). Remark 1 implies that this overestimation is associated with an overestimation of the cost shock and an underestimation of the demand shock of period *t*.

The policy chosen at the beginning of period $t+1$ aims to offset the (presumed) deflationary impact of the demand shock on the output gap and the (presumed) inflationary impact of the cost shock on inflation. In comparison to the no PTC benchmark, the first objective pushes policy towards expansionism while the second pushes it towards restrictiveness. If demand shocks are relatively persistent, the first effect dominates since policymakers believe that most of what they perceive to be a negative demand shock in period *t* is going to persist into period $t+1$ while what they perceive to be a positive cost shock in period *t* is not going to persist into period $t+1$. Hence, in this case monetary policy is more expansionary than in the no PTC benchmark and Δr_{t+1} and $\tilde{z}_{t|t}$ are positively related (case (i) in the proposition). But if the reverse is true (cost shocks are relatively more persistent), beliefs about the cost shock in period $t+1$ dominate policy, pushing it towards tightening. As a consequence, monetary policy is more restrictive than in the no PTC benchmark and Δr_{t+1} and $\tilde{z}_{t|t}$ are negatively related and case (ii) of the proposition obtains.

3.5.2 Consequences for the output gap and inflation

We turn next to the consequences of mismeasurement of potential output for the output gap and inflation. The objective is, as in the previous subsection, to analyse the deviations of the outcomes obtained in the presence of the PTC from those that arise in its absence. Using equations (3.9) and (3.10), the logical next step is to relate these deviations to the interest rate deviations studied above. This yields:

$$\Delta x_{t+1} \equiv x_{t+1} - x^*_{t+1} = -\varphi \Delta r_{t+1} \tag{3.21}$$

$$\Delta\pi_{t+1} \equiv \pi_{t+1} - \pi^*_{t+1} = -\varphi\lambda\Delta r_{t+1} \tag{3.22}$$

where x^*_{t+1} and π^*_{t+1} are the values of the output gap and inflation under optimal monetary policy in the absence of the PTC. These equations show that when the interest rate is below (above) its value in the absence of the PTC both inflation and the output gap are above (below) their no PTC values.

The case of overexpansionary monetary policy (case (i) of proposition 1) is consistent with the empirical results in Orphanides (2000a,b, 2001), according to which, during the 1970s, US monetary policy was overly expansionary due to an overestimation of potential output and an associated underestimation of the output gap. Obviously, this underestimation could have been due to inefficient forecasting procedures on the part of the Fed. A main message of this paper is that this effect is present even if monetary policy is ex ante optimal and forecasting procedures are as efficient as possible. In normal times, during which the change in potential output is not too far from its mean, this effect is likely to be small and short-lived. But when large permanent shocks to potential output occur, this effect is likely to be large and more persistent. This point is discussed in detail in the next section.

3.6 Optimal potential output forecasts

This section describes the solution to the signal extraction problem faced by policymakers. To convey the intuition of the basic mechanisms at work, we focus in the text on the particular (but simpler) case in which demand and cost push shocks are equally persistent ($\mu = \rho$), which yields a tractable closed form solution without affecting the key properties of the predictor.[5]

The conditional expectation of z_t based on J_t, $z_{t|t}$, is given by (see Cukierman and Lippi (2002)):

$$z_{t|t} = aS_t + (1-a)(1-\kappa)\sum_{i=0}^{\infty}\kappa^i S_{t-1-i} \tag{3.23}$$

where:

$$\kappa \equiv \frac{2}{\phi + \sqrt{\phi^2 - 4}} \in (0,1) \qquad \phi \equiv \frac{2 + T(1+\mu^2)}{1+\mu T} \geq 2\,; \qquad T \equiv \left(\frac{\sigma_z^2}{\sigma_g^2} + \frac{\lambda^2\sigma_z^2}{\sigma_u^2}\right)$$

$$a \equiv \frac{[(1-\mu) + (1-\kappa) + T(1-\mu\kappa)]T}{[T(1-\mu-\mu\kappa) + (1-\mu-\kappa)](1+T) + (T+\mu)(1+\mu T)} \in (0,1) \tag{3.24}$$

$$S_{t-i} \equiv s_{1,t-i} - \frac{\lambda\sigma_g^2}{\sigma_u^2 + \lambda^2\sigma_g^2}s_{2,t-i} = z_{t-i} + \frac{\sigma_u^2 g_{t-i} - \lambda\sigma_g^2 u_{t-i}}{\sigma_u^2 + \lambda^2\sigma_g^2} \tag{3.25}$$

S_{t-i} is a combined signal that summarises all the relevant information from a period's $t-i$ data. Note that it is positively related to that period's potential output and demand shock, and negatively related to that period's cost shock. As a consequence, the optimal predictor generally responds positively to current as well as to all past shocks to demand and potential output, and responds negatively to current as well as to all past, cost shocks.

The conditional forecast equation (3.23) possesses several key properties. First, since a and κ are both bounded between zero and one, the current optimal predictor is positively related to the current as well as to all past signals. Second, the weight given to a past signal is smaller the further in the past that signal is. Third, since $a < 1$, when a positive (negative) innovation to current potential output (z_t) occurs, the potential output *estimate* increases (decreases) *by less* than actual potential output. Fourth, the sum of the coefficients in the optimal predictor in equation (3.23) is equal to one. Finally, note that although the true value of potential output is contained only in the signals $s_{1,t-i}$, the optimal predictor assigns positive weights **also** to the signals $s_{2,t-i}$. The intuitive reason is that, by allowing a

[5] The solution when the degrees of persistence differ ($\rho \neq \mu$), based on the Kalman filter, appears in Cukierman and Lippi (2002).

more precise evaluation of the demand shock, g_t, the utilisation of $s_{2,t-i}$ facilitates the separation of g_t from z_t in the signals $s_{1,t-i}$.

3.6.1 Serial correlation in forecast errors of potential output

The form of the optimal predictor in equation (3.23), in conjunction with the fact that all coefficients are positive and sum to one, implies that when a single shock to potential output occurs (say) in period t and persists forever without any further shocks to potential output, policymakers do not recognise its full impact immediately. Although their forecasting is optimal, policymakers learn about the permanent change in potential output gradually. Initially (in period $t+1$) they adjust their perception of potential output by the fraction a. In period $t+2$ they internalise the larger fraction $a+(1-a)(1-\kappa)$, in period $t+3$ they internalise the even larger fraction $a+(1-a)(1-\kappa)+(1-a)(1-\kappa)\kappa$, and so on. After a large number of periods this fraction tends to 1, implying that after a sufficiently large number of periods the full size of the shock is ultimately learned. Thus, equation (3.23) implies that there is gradual learning about potential output and that forecast errors are, therefore, on the same side of zero during this process.

Conversely, when a single relatively large shock to one of the cyclical components of demand occurs it is partially interpreted for some time as a change in potential output. This too creates ex post serial correlation in errors of forecast in the output gap and in potential output. In general, two kinds of errors can be made. A change in potential output may be partly misinterpreted as a cyclical change, or a cyclical change may be partly misinterpreted as a change in potential output. Both types of errors tend to create ex post serial correlation in errors of forecast. But this serial correlation cannot be utilised in real time to improve policy because, contrary to errors of forecasts of variables which become known with certainty one period after their realisation, the potential output of period t is not known with certainty even after that period. As a consequence the forecast error committed in period t cannot be used to "correct" future forecasts of potential output in the same manner that errors of forecast of a variable that is revealed one period after the formation of that forecast are normally used to update future forecasts.[6]

As a matter of fact, it can be shown that forecast errors of potential output and of the output gap are generally serially correlated even in the population. The remainder of this subsection establishes this fact more precisely and identifies conditions under which this serial correlation is dominated by the variability of innovations to potential output. Note first, from equation (3.17), that the error in forecasting the output gap is equal to minus the error of forecast in potential output. Hence, if errors of forecast of potential output are serially correlated, so are errors of forecast of the output gap. It is shown in Appendix C in Cukierman and Lippi (2002) that the covariance between two adjacent forecast errors is:

$$E[\tilde{z}_{t|t}\tilde{z}_{t-1|t-1}] > 0$$

This leads to the following:

Proposition 2. *Errors in forecasting potential output and the output gap generally display a positive serial correlation*.

Interestingly, this proposition is consistent with recent empirical findings in Orphanides (2000a). Orphanides utilises real-time data on the perceptions of policymakers about potential output during the 1970s and compares those perceptions with current estimates of the historical data. Taking the "current" rendition of estimates of potential output as a proxy for the true values of potential output during the 1970s, he finds highly persistent deviations between the current and the real-time estimates of the output gap (see his Graph 3 in particular).

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6 When the true value of the variable that is being forecasted is revealed with certainty with a lag of one period, as is often assumed, the general principle that forecast errors are serially uncorrelated in the population applies. This feature has been used extensively to test for the efficiency of financial markets. However, when, as is the case here, the true value of the variable that is being forecasted is not revealed afterwards, forecast errors are in general serially correlated.

3.7 A quantitative illustration

As a practical illustration of the effects described above, we present an impulse response analysis of the effects of a potential output shock under imperfect information. The numerical implementation of this exercise relies on the algorithms discussed in Gerali and Lippi (2002). We parametrise our model economy using the settings reported in Table 1 (corresponding to the long-run elasticities reported in the model of Rudebusch and Svensson (1999)).

Table 1

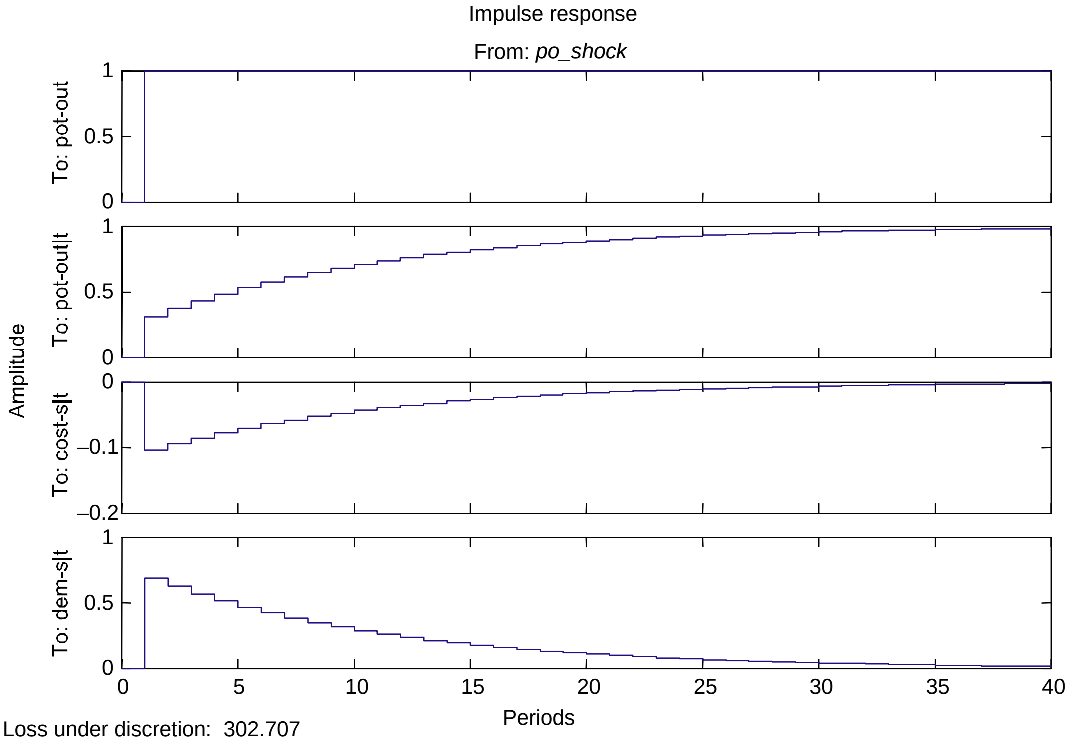
Baseline parameter values for CL model

Parameters						Innovations (std)		
β	α	λ	ρ	μ	φ	σ_z	σ_u	σ_g
0.99	1	0.14	0.7	0.7	1	0.5	1.5	1.5

The example below illustrates the impulse response of the main variables in the system to a unit shock in potential output. Graph 1 illustrates how, with imperfect information, the signal extraction problem faced by the policymaker creates confusion about the sources of the business cycle fluctuations.

Graph 1

Perceived state of the economy in response to a potential output shock



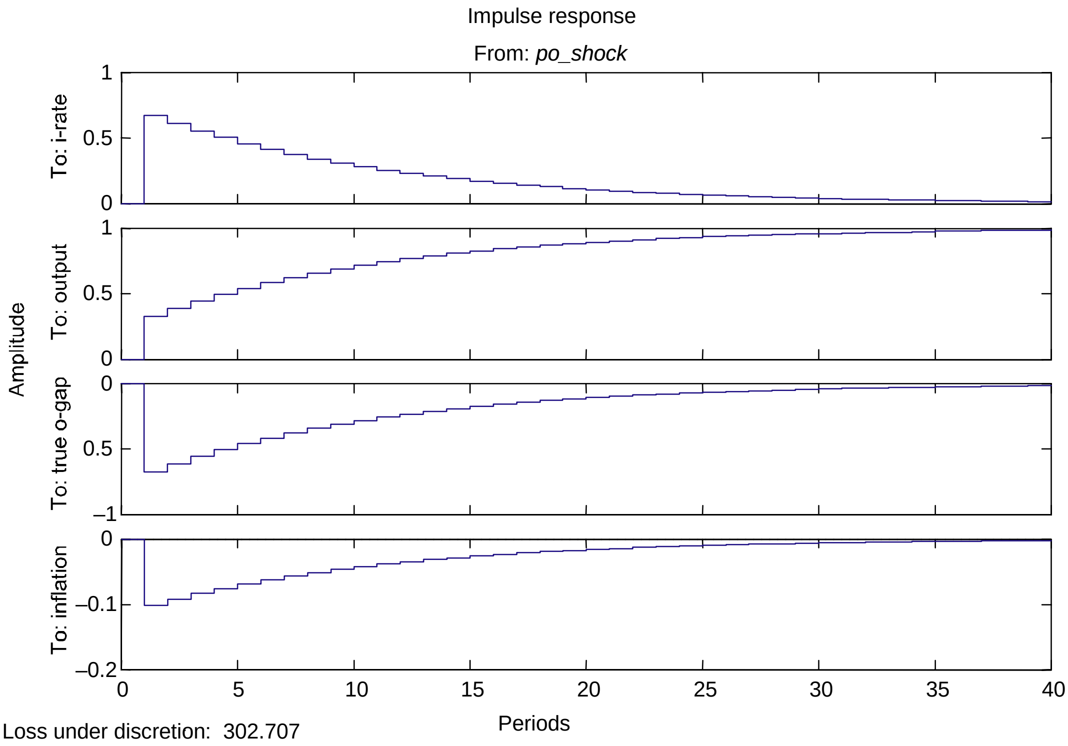
The upper panel displays the true pattern followed by the (unit root) potential output shock. The estimated pattern for this shock (computed with a Kalman filter) is traced out in the second panel. As the theory showed, the learning process is gradual and the forecast errors display a positive serial correlation. The two remaining panels illustrate how misperceptions about potential output cause misperceptions about the cost push and demand shocks, the true value of which is identically zero in this experiment (these relationships obey equation (3.17)). It is evident that an underestimated potential output level implies an overestimated demand shock (to “explain” the currently high output level observed) and an underestimated cost shock (consistent with the relatively low realised inflation).

Quantitatively, of the true 1% increase in potential output only 0.3 is estimated initially, while about 0.7 percentage points of the output rise are attributed to the demand shock.

The policy consequences of these misperceptions are depicted in Graph 2. The parameters chosen are such that the inequality $\left(\mu > \frac{\rho\lambda^2}{\alpha + \lambda^2}\right)$ is satisfied, implying that monetary policy is driven mainly by "demand shocks" considerations (see Proposition 1). Recall that, under the complete information benchmark, there should be no policy response following this shock, ie the optimal interest rate path should be identically zero. The graph shows how, under imperfect information, a positive innovation in potential output causes interest rates to rise above their optimal level in the absence of PTC. This causes the true output gap to fall (even though the policymaker perceives a positive output gap!) and inflation to be lower than under the no PTC benchmark. This is how the model rationalises a situation like the 1990s, when high output growth is associated with low inflation.

Graph 2

Macro effects of a potential output shock with imperfect information

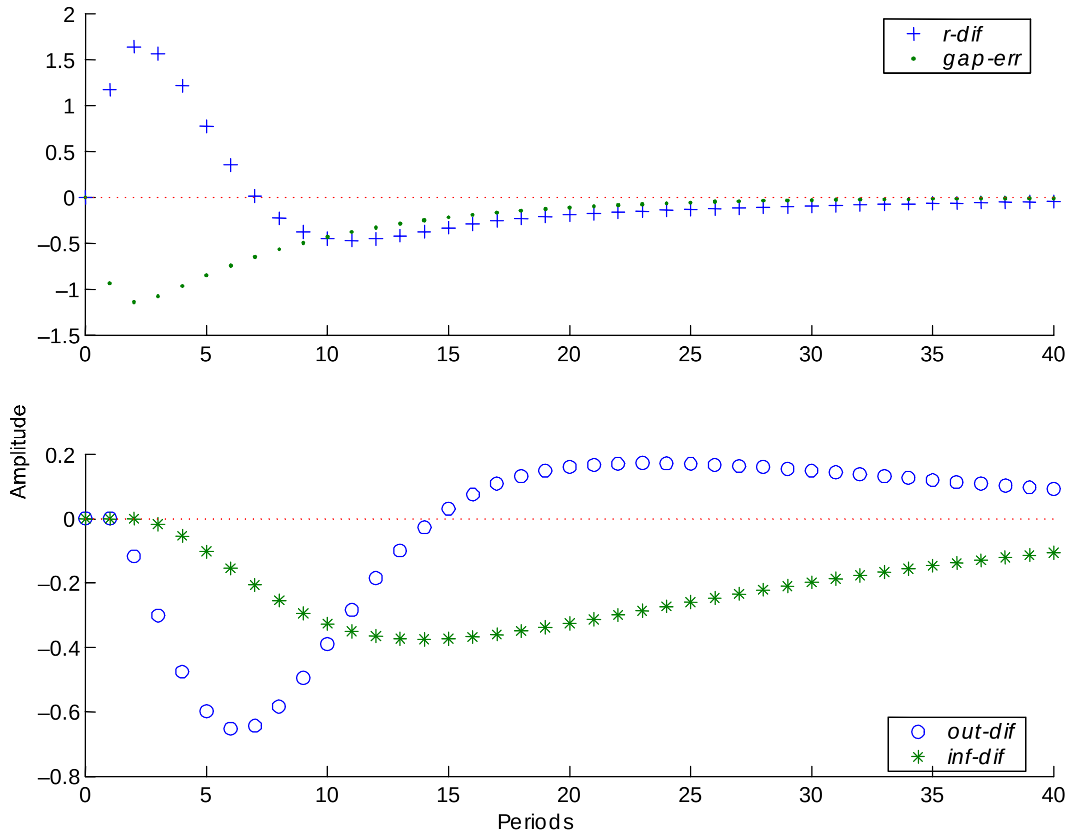


For a more realistic assessment of the quantitative effect of imperfect information, we repeated the exercise developed above using the model of the US economy of Rudebusch and Svensson (1999). Graph 3 reports the values of a given variable under imperfect information in deviation from the values recorded under the full information benchmark (ie potential output is known) after a 1% increase of the output gap. The upper panel shows that, following the shock in potential output, the policymaker's forecast error for the output gap is very large (almost none of the shock is predicted initially) and highly persistent (it takes about two years to learn half of the shock). The interest rate is higher than under full information, as almost all of the output expansion is interpreted as a cyclical shock. As a consequence, both output and inflation are below their full information counterpart (lower panel).

A back-of-the-envelope calculation can be used to compare the magnitudes predicted by our model with the events of the 1970s. If we take Orphanides' measures of the forecast errors in the output gap for the 1970s, hovering about 5 percentage points, we have to scale all the effects in Graph 3 by a factor of –5 (so that the measured forecast error in the output gap is matched in size and sign). This implies that the interest rate under incomplete information is more than 5 percentage points below the full information counterpart during the year following the shock. Moreover, the exercise indicates that inflation and the output gap record a maximum deviation from the full information benchmark of about 2 and 3.5 percentage points, respectively. While those numbers are not too small, indicating that imperfect information might contribute to explain the higher than average inflation recorded in the mid-1970s, they admittedly only go part of the way, leaving a significant part of that inflationary burst unexplained.

Graph 3

Effects of imperfect information (potential output shock)



4. Application 2: a "new synthesis" model (from Gerali and Lippi (2002))

In this section, we use the toolkit derived in Gerali and Lippi (2002) to analyse the real-time information problem of monetary policy within a version of the sticky price framework developed by, among others, Woodford (1999) and Clarida et al (1999). In that framework, output (y_t) and inflation (π_t) are determined, respectively, by a dynamic IS curve and a Phillips curve, according to:[7]

$$y_t = y_{t+1|t} - \sigma[i_t - \pi_{t+1|t}] + g_t \tag{4.1}$$

$$\pi_t = \delta\pi_{t+1|t} + \kappa(y_t - \bar{y}_t) + u_t \tag{4.2}$$

[7] These conditions are derived from the optimising behaviour of consumers (ie an intertemporal Euler equation) and price-setting monopoly firms facing a randomly staggered price adjustment mechanism as in Calvo (1983).

where $\bar{y}_t$ denotes potential output as of period t (ie the output level that would obtain under flexible prices), i_t the nominal interest rate, g_t a demand shock and u_t a cost push shock. The output gap is defined as the difference between actual and potential output, $y_t - \bar{y}_t$.

Following Clarida et al (1999, henceforth referred to as the CGG model), we assume the economy is subject to three types of shocks: demand (g_t), cost push (u_t) and potential output ($\hat{y}_t$). They obey the following processes:

$$\bar{y}_t = \gamma \bar{y}_{t-1} + \hat{y}_t \quad 0 < \gamma < 1; \qquad \hat{y}_t \sim N(0, \sigma^2_{\hat{y}}) \tag{4.3a}$$

$$g_t = \mu g_{t-1} + \hat{g}_t \quad 0 < \mu < 1; \qquad \hat{g}_t \sim N(0, \sigma^2_g) \tag{4.3b}$$

$$u_t = \rho u_{t-1} + \hat{u}_t \quad 0 < \rho < 1; \qquad \hat{u}_t \sim N(0, \sigma^2_u) \tag{4.3c}$$

where the innovations $\hat{y}_{t+1}$, $\hat{u}_{t+1}$ and $\hat{g}_{t+1}$ are iid. Let us assume the measurable variables are given by:

$$\bar{y}^o_t = \bar{y}_t + \theta_{\bar{y}t} \tag{4.4a}$$

$$y^o_t = y_t + \theta_{yt} \tag{4.4b}$$

$$\pi^o_t = \pi_t + \theta_{\pi t} \tag{4.4c}$$

where the measurement errors θ_{jt} are iid. Finally, let the central bank period loss function be:

$$L_t \equiv \tfrac{1}{2}\left[(\pi_t - \pi^*)^2 + \lambda_y (y_t - \bar{y}_t - x^*)^2\right] \tag{4.5}$$

which allows us to encompass some special cases of interest, as done theoretically by Clarida et al (1999).[8]

We introduce imperfect information by adding noise to the measurement block (equation (4.4)). This amounts to assuming that potential output, actual output and inflation are subject to the measurement errors reported in Table 2. With imperfect information, the policymaker uses the available information to form an estimate about the true state of the economy (ie $X_{t|t}$).

Table 2

Baseline parameter values for CGG model (from Gerali and Lippi (2002))

Parameters

δ	γ	ρ	μ	κ	σ	λ_y	x^*	π^*
0.99	0.7	0.4	0.3	0.05	2.0	0.25	0.0	0.0

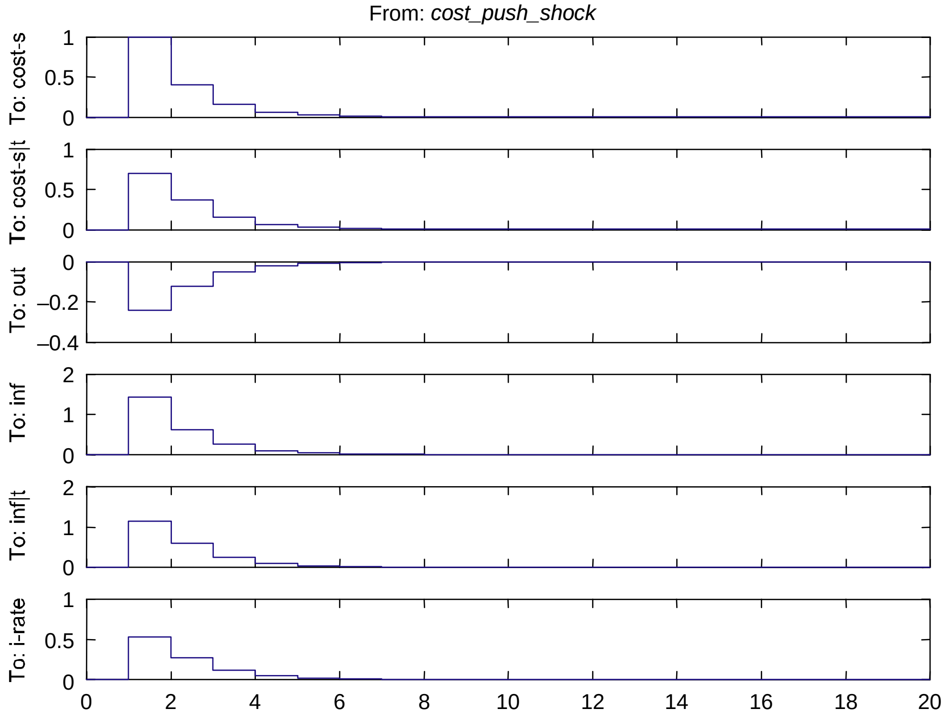
Innovations (std)			**Measurement errors (std)**		
$\sigma_{\bar{y}}$	σ_u	σ_g	$\sigma_{\theta\bar{y}}$	$\sigma_{\theta y}$	$\sigma_{\theta\pi}$
0.001	0.004	0.004	0.004	10^{-8}	10^{-8}

Graph 4 illustrates the effect of a cost push shock under discretion. The first obvious difference with respect to the complete information case is that the true pattern of the shock now differs from the one estimated by the policymaker, as shown in the two upper panels.

8 Among these is the presence of a systematic inflation bias, $x^* > 0$.

Graph 4

Cost push shock with discretion and imperfect information



The signal extraction problem solved with the Kalman filter leads the policymaker to learn only gradually about the realisation of the cost push shock: in the current setup, after a unitary cost push shock ($u_t = 1$) occurs, the contemporaneous estimate of the shock by the policymaker is $u_{t|t} = 0.70$. Naturally, the magnitude of the forecast errors induced by imperfect information depends on the assumptions about the properties of the fundamental processes (eg the persistence of the various structural shocks *g*, *u* and *y* and the signal to noise ratios encoded in Σ_u^2 and Σ_v^2). For instance, if we double the amount of noise in the inflation equation (ie raise $\sigma_{\theta\pi}$), the estimated value of the shock is much smaller ($u_{t|t} = 0.38$), as one would expect in the presence of more noise in the cost push shock indicator, π_t^o.[9]

Through its effect on the expectations about the state of the economy (eg $X_{t|t}$), imperfect information affects the dynamics of the forward-looking variables. First, the policy response of i_t is less strong than in the full information case, as the perceived size of the cost push shock is smaller.[10] The response of output and of inflation is also muted in comparison to the complete information case: output falls by 0.24 (versus 0.32) while inflation increases by 1.4 (versus 1.6). This is due both to the policy response and to the fact that the future expected values of the cost push shock are smaller under incomplete information than under complete information, thus inducing the private economy to expect a different pattern of future shocks and policy.

9 Several key objects produced by the filtering problem are computed by our MATLAB code, such as the matrices *P* and *Po* corresponding, respectively, to the one-step-ahead and contemporaneous forecast errors in X_t.

10 Due to the certainty equivalence feature of our problem, policy differences stemming from imperfect information arise entirely from the estmates of the states as the coefficient *F* in the optimal control function ($I_t = FX_{t|t}$) does *not* depend on the uncertainty.

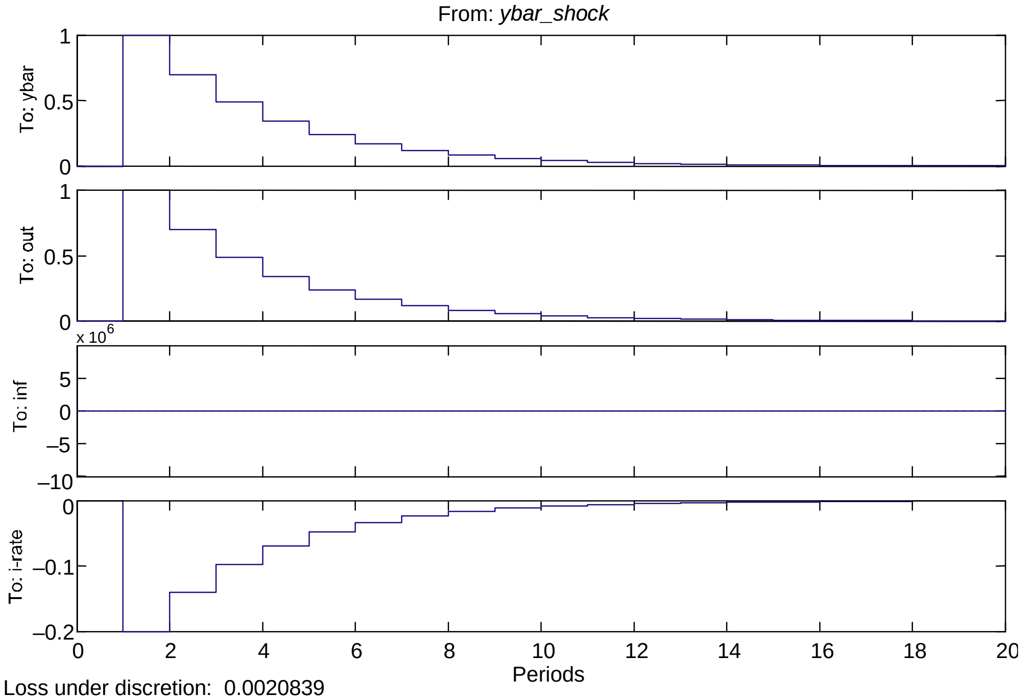
4.1 The macroeconomic consequences of unobservable potential output in the CGG model

We next explore the effects of imperfect information about potential output in the CGG model (under discretionary policy). Several contributions of Orphanides show that potential output estimates are very imprecise in real time. It is argued that basing policy on the estimates of such an unobservable (and noisy) variable may be at the root of important differences between policy based on real-time information and the optimal policy under complete information. To formalise this argument within the CGG model, we compute the effects of a potential output shock in the presence of, respectively, full and incomplete information. The difference in the dynamics of the endogenous variables between these two settings measures the effect of imperfect information.

Graph 5 shows the effect of a potential output shock with full information. The interest rate adjusts in such a way that the dynamics of actual output optimally replicate those of potential output (compare the upper two panels in the graph), eg the “output gap” is nil. This policy poses no trade-off between the objectives of the policymaker, and therefore inflation remains constant at its steady state level.

Graph 5

Potential output shock with full information

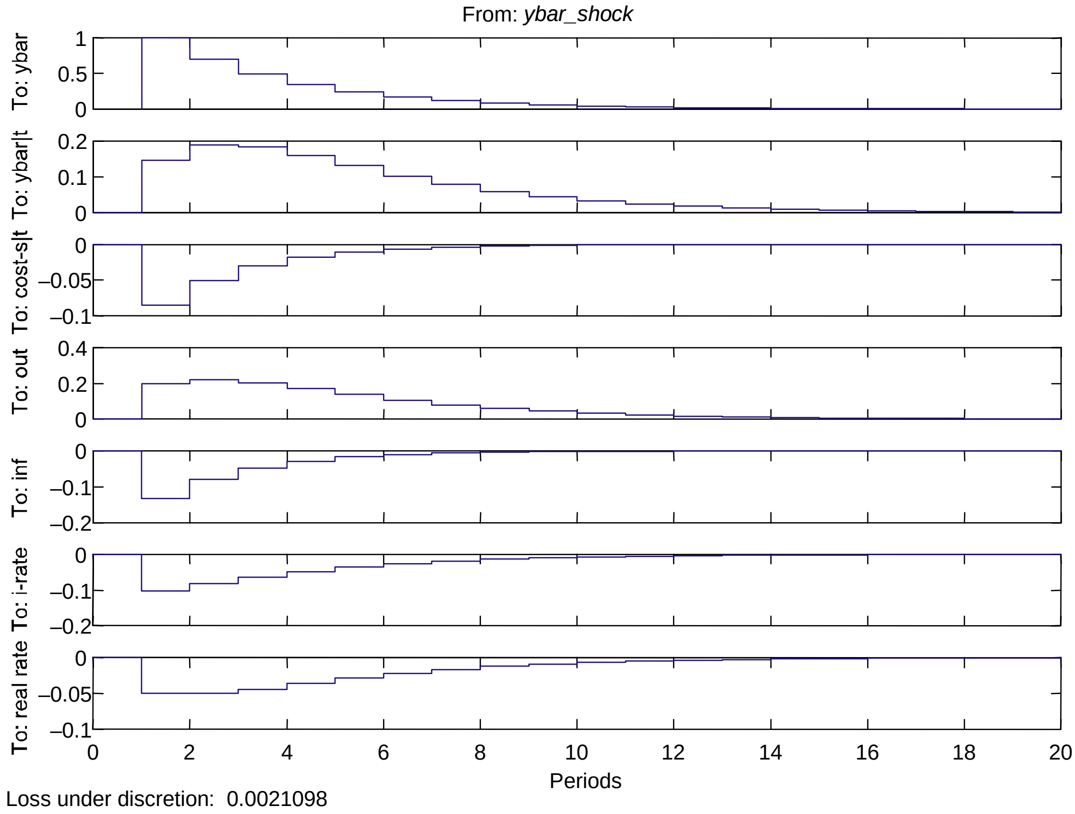


The same potential output shock leads to different consequences under imperfect information, as shown in Graph 6. The upper two panels reveal that the true shock is only partially identified by the policymaker in real time, and that a cost push shock (third panel) is perceived by the policymaker while no such a shock has occurred in reality.

Graph 7, which compares the dynamic response of interest rates, output and inflation under incomplete versus complete information, shows that the interest rate (both nominal and real) is relatively loose (ie is reduced by a smaller amount) under incomplete information. This occurs because, as potential output is underestimated (with incomplete information), the policymaker’s perception of how much the interest rate needs to be lowered is smaller than under complete information (recall that the interest rate is proportional to the expected output growth - see equation (4.1)). Therefore, the interest rate under complete information is loose in comparison to the full information benchmark.[11] As a consequence of different policy and expectations, the dynamics of inflation and the output gap under imperfect information differ from their complete information benchmark. The lower panel shows that, following a positive potential output shock, both inflation and the output gap are lower than their full information counterpart.

Graph 6

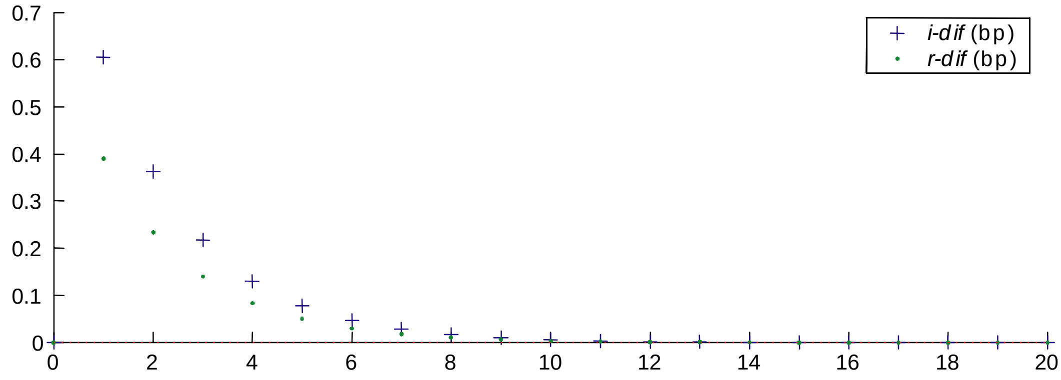
Potential output shock with imperfect information

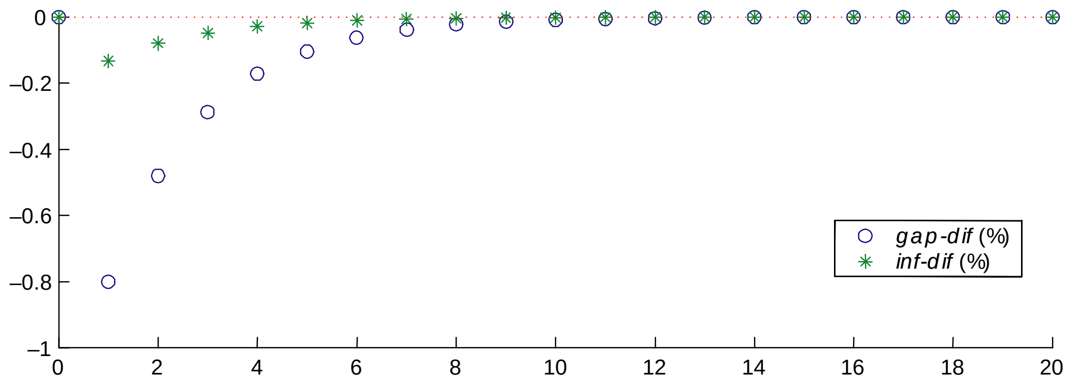


[11] There is a second effect which goes in the opposite direction but is dominated under most plausible parameter values. It arises because the perceived negative cost push (under incomplete information) leads the policymaker to lower the interest rate (no effect under full information since there is no cost push shock).

Graph 7

Effects of imperfect information





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The effect of the increase in the monetary base on Japan's economy at zero interest rates: an empirical analysis[1]

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Abstract

In this paper, we quantify the effect of the so-called "quantitative monetary easing" which the Bank of Japan adopted in March 2001. Now that short-term interest rates are almost zero and monetary base growth is over 20% year on year, active debate continues with respect to the effectiveness of monetary policy at zero interest rates. Taking into account the regime change in monetary policy and the possible non-linearity of money demand at low (or near zero) interest rates, we use a Bayesian vector autoregression (VAR), a VAR with time-varying coefficients, to extract the effect of the increase in the monetary base at zero interest rates. The result of a Bayesian VAR indicates that while an increase in the monetary base previously had a positive impact on prices, it does not now at zero interest rates. In order to investigate the possible reason for this result, we then estimate a money demand function, and test whether a satiation level in demand for the monetary base exists at zero interest rates. The key finding here is that the null hypothesis of the non-existence of the satiation level can be statistically rejected. This means that there may remain room for an increase in the monetary base to stimulate the economy at zero interest rates. Despite the existence of the satiation level of money demand, why does the Bayesian VAR result suggest that an increase in the monetary base does not have a positive impact on economic activity at zero interest rates? One consistent interpretation of these two results is that the effect, if any, of the increase in the monetary base is highly uncertain and very small. We confirm this view by estimating models that include both aggregate demand and aggregate supply functions and testing whether the monetary base enters these equations significantly. Finally, we discuss reasons why the expansion of the monetary base at zero interest rates has such a limited and uncertain effect on the economy.

1. Introduction

On 19 March 2001, the Bank of Japan introduced new procedures for money market operations under which the outstanding balance of current accounts held at the Bank, instead of the overnight call rate, is used as the main operating target. The change in the operating target was closely related to the fact that the overnight call rate had almost reached a zero bound and the Bank still needed to ease monetary policy to combat persistent deflationary pressure. The target level of the outstanding balance of current accounts held at the Bank exceeded the actual amount of February 2001. At the same time, the Bank decided that the new procedures for money market operations should remain in place until the consumer price index (CPI) (excluding perishables; nationwide) registered stably at zero per cent or an increase year on year. The Bank also decided to increase the outright purchase of long-term government bonds if it considered this necessary to smoothly provide liquidity. Furthermore, the Bank

[1] We are grateful for helpful discussions and comments from Stefan Gerlach, Kenneth Kuttner, Edward Nelson, Carl Walsh and Michael Woodford, as well as participants at the Autumn 2002 Central Bank Economists' Meeting held by the Bank for International Settlements. We would also like to thank many staff members of the Bank of Japan for their comments on an earlier draft and Saori Sato for her excellent research assistance. Any remaining errors are our own. The views expressed herein are those of the authors alone and not necessarily those of the Bank of Japan.

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established a so-called “lombard-type” lending facility that enables financial institutions, under certain conditions, to borrow funds from the Bank at the official discount rate as long as they have eligible collateral. This entire policy regime is often referred to as “quantitative monetary easing” measures.

The new policy regime was introduced to explore the possibility of further monetary easing even after short-term interest rates had fallen to zero. The Bank of Japan pursued this policy, while concurrently examining the following effects theoretically assumed on Japan’s economy.

First, lower interest rates would still have a stimulative impact on the economy. In this regard, the announcement that the new policy regime should be maintained until CPI inflation becomes zero or more was intended to induce maximum effects from a rather limited call rate cut on longer-term rates. Second, the abundant provision of liquidity would make money market participants feel more secure about the availability of funds, thereby preserving financial market stability. Third, an increase in reserves might invite liquidity satiation and, consequently, somehow induce portfolio shifts in financial assets, resulting in, for example, a rise in stock prices, depreciation of the yen, or credit expansion. Fourth, decisive monetary policy messages supported by an increase in reserves might have some positive effects on expectations held by corporations and households with respect to the future course of the economy and prices.

One and a half years have passed since the Bank introduced this new policy regime. Based on experiences and related data so far, we analyse the effects of “quantitative monetary easing” measures at zero interest rates and try to make a tentative evaluation. The rest of the paper proceeds as follows. We begin in Section 2 by surveying recent developments in monetary policy and the observed reactions of financial indicators. In Section 3 we survey the transmission mechanism of monetary policy at zero interest rates from a theoretical viewpoint. In Section 4, taking into account the regime change in monetary policy and the possible non-linearity of money demand at low (or near zero) interest rates, we use a Bayesian VAR, a VAR with time-varying coefficients, to extract the effects of the increase in the monetary base. In Section 5, we investigate whether a satiation level of money demand exists at zero interest rates by estimating a money demand function. In Section 6, we then estimate models that include both aggregate demand and aggregate supply functions and examine whether the monetary base enters these equations significantly. In Section 7, we discuss reasons why the expansion of the monetary base at zero interest rates has a limited and uncertain effect on the economy. Section 8 presents concluding remarks.

2. Recent developments in monetary policy in Japan and the reaction of financial indicators

The collapse of asset prices in the early 1990s was the beginning of a long economic slump in Japan, which is characterised as several deep cyclical downturns with some modest short-lived economic recovery. There is a consensus among policymakers and economists that one of the basic structural problems Japan’s economy has faced is the non-performing loan (henceforth NPL) problem of the banking sector. The impaired balance sheet of the banking sector has prevented the transmission mechanism of monetary policy from working smoothly, thereby dampening the financial and economic responses to monetary policy easing.

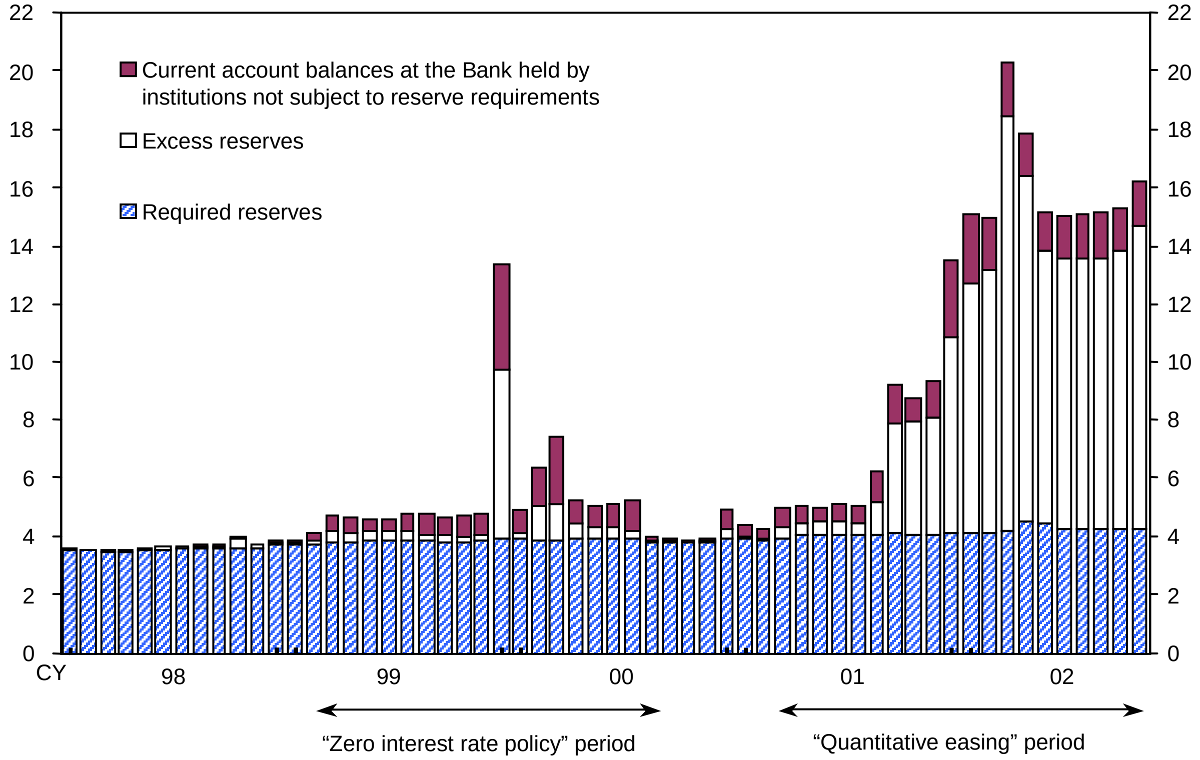
As early as 1995, the Bank of Japan had little room for further reducing interest rates. The Bank maintained the uncollateralised overnight call rate as low as around 0.5% despite the fact that Japan’s economy recovered at a more than 3% growth rate of GDP from 1995 to 1996. In autumn 1997, Japan’s economy started to deteriorate, largely under the influence of financial system disturbance reflecting the failure of large financial institutions. The Bank successively lowered the overnight call rate to 0.02% in February 1999. The period between 1999 and 2000 is often called the “zero interest rate” period. In August 2000, the Bank lifted its “zero interest rate” policy and raised the overnight call rate to 0.25%, since the economy was showing clear signs of continued recovery. However, in late 2000, the economy started to deteriorate again, reflecting adjustment of global IT and related exports, and concern over deflation intensified. The Bank lowered the policy interest rate one last time to 0.15% and then adopted quantitative monetary easing in March 2001. In sum, while the NPL problem of the banking sector has been a serious factor weakening the effects of accommodative monetary policy, the zero bound of interest rates has become an ever more intractable issue from the viewpoint of monetary policy formulation.

That was the background leading to the Bank of Japan's decision to finally discard the orthodox operating framework and adopt a new framework under which it set the outstanding balance of current accounts at the Bank, instead of the uncollateralised overnight call rate, as the main operating target. When the Bank adopted this new regime, it raised the target level of the current account balance to around JPY 5 trillion (March 2001), about JPY 1 trillion larger than that immediately prevailing before the change (Graph 1). After that, it raised the target level to around JPY 6 trillion (August 2001), more than JPY 6 trillion (September), and JPY 10 to 15 trillion (December). Also, on 28 February 2002, to secure financial market stability towards the fiscal year-end, the Bank decided to provide more liquidity to meet a surge in demand irrespective of the target of current account balances, around JPY 10 to 15 trillion. Just before the year-end, the Bank provided a maximum JPY 27 trillion, and, following this year-end requirement, the current account balance has been running around JPY 15 trillion.

Graph 1

Current account balances at the Bank of Japan

In trillions of yen



Note: Each month indicates a reserve maintenance period (from the 16th of one month to the 15th of the following month).
Source: Bank of Japan, *Financial and Economic Statistics Monthly*.

Meanwhile, in order to smoothly provide liquidity, the Bank increased its outright purchases of long-term government bonds from JPY 400 billion to JPY 600 billion per month in August 2001, and thereafter to JPY 800 billion in December, and further to JPY 1 trillion in February 2002.[3]

After adopting quantitative easing, the growth rate of the monetary base started to markedly rise from the second half of 2001, reaching some 30% year on year in March-April 2002, the highest rise since the first oil shock in the 1970s (Graph 2). This has reflected the Bank's ample provision of reserves

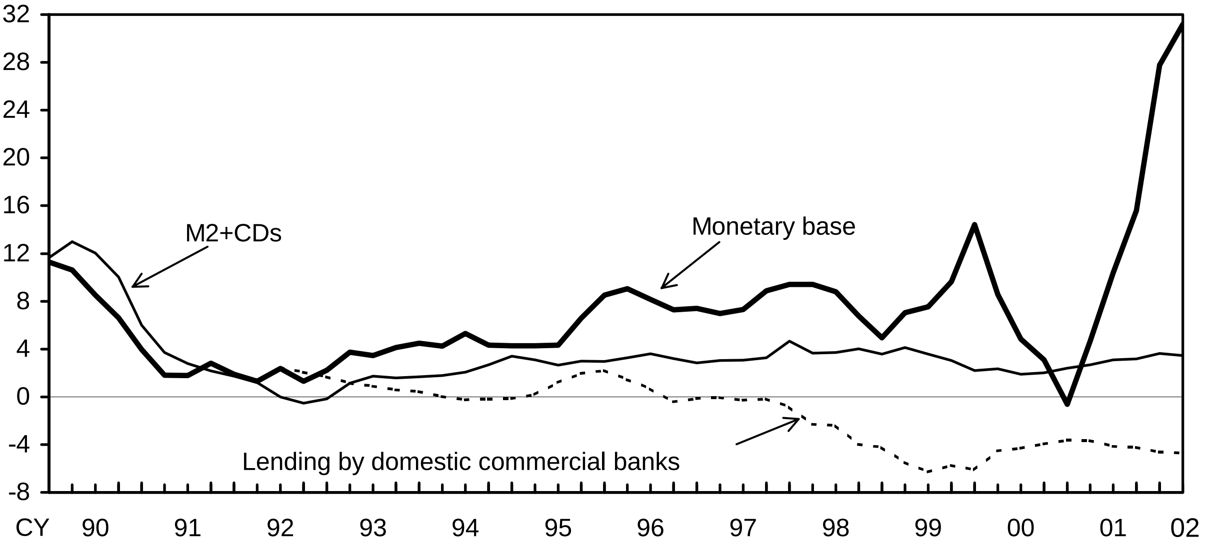
3 In October 2002, the Bank of Japan decided to aim at an outstanding balance of current accounts held at the Bank of around JPY 15 to 20 trillion, and to increase its outright purchases of long-term government bonds from JPY 1 trillion to JPY 1.2 trillion per month.

Graph 2

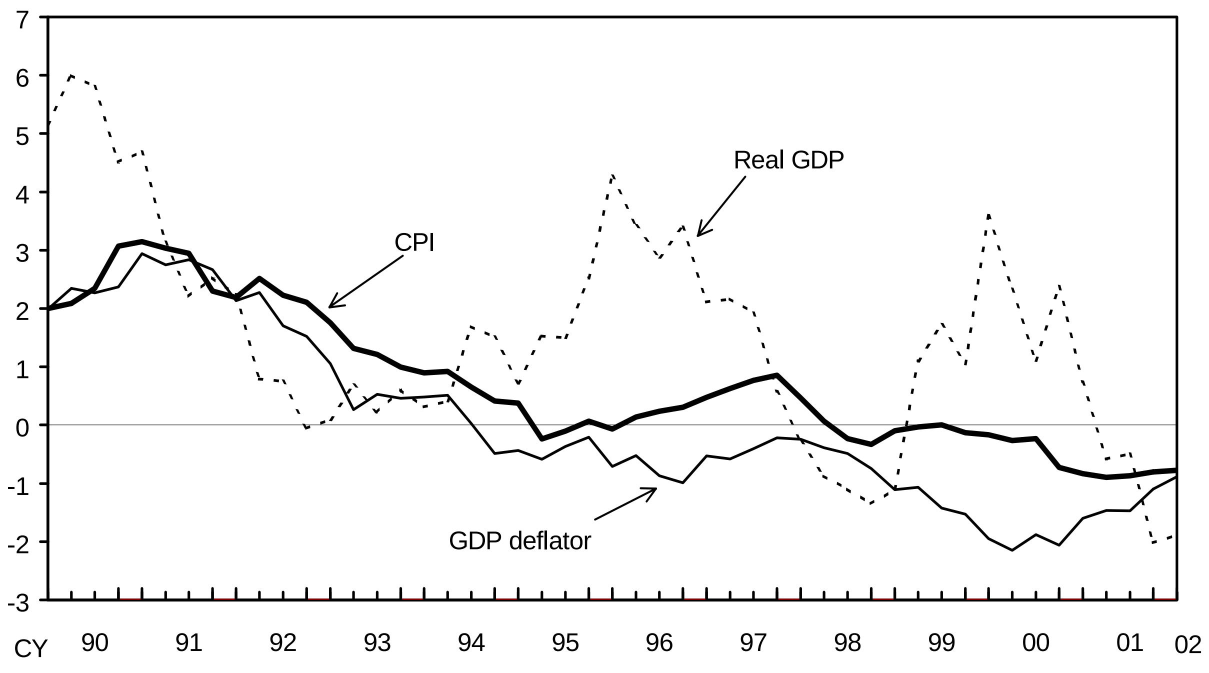
Money, prices and output

Annual percentage changes

(1) Monetary base, M2+CDs, lending



(2) CPI, GDP deflator, real GDP



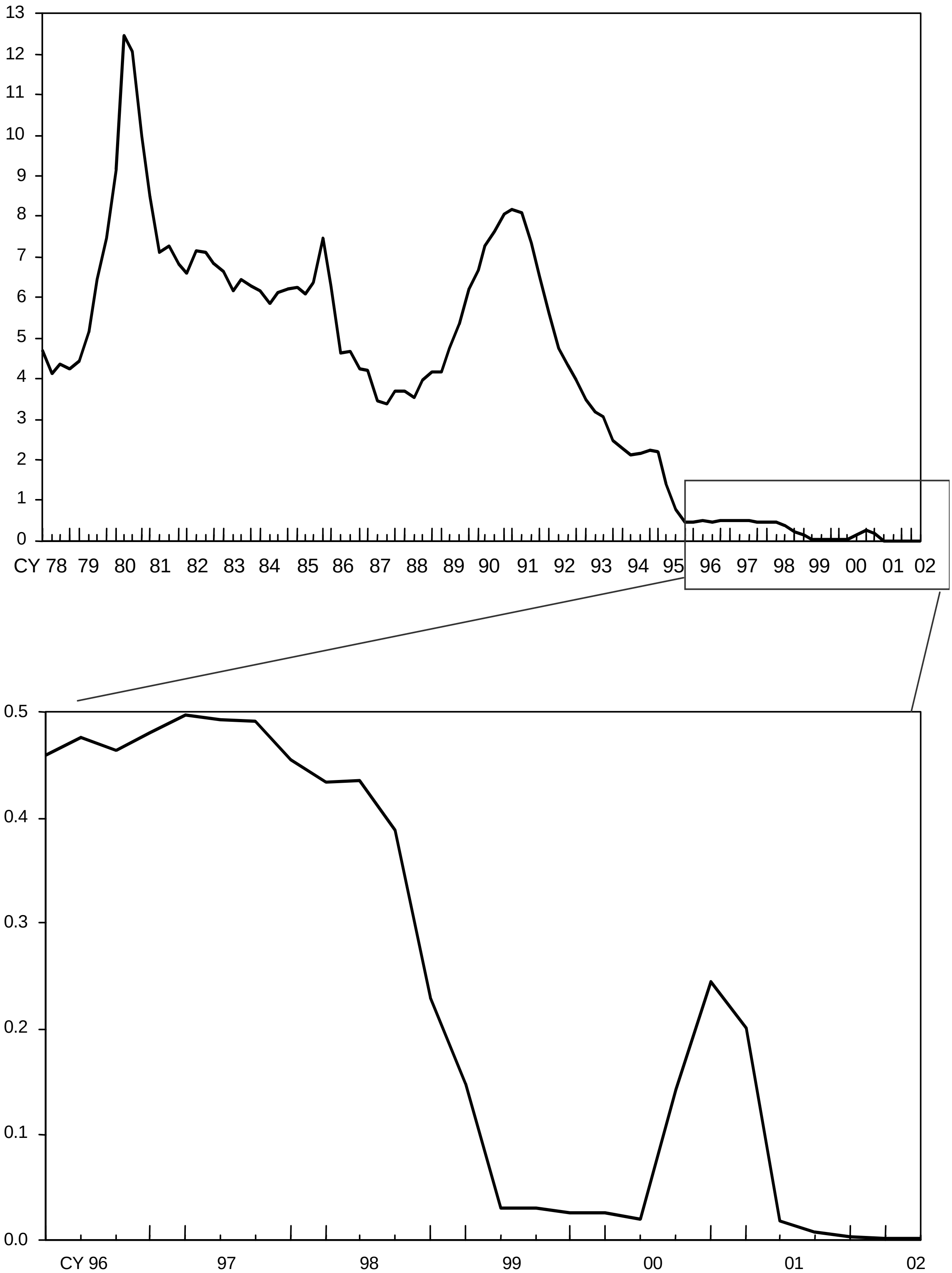
Note: CPI, GDP deflator and real GDP are adjusted to exclude the effects of the consumption tax hike in April 1997.

Sources: Bank of Japan, *Financial and economic statistics monthly*, *Principal figures of financial institutions*; Ministry of Public Management, Home Affairs, Posts and Telecommunications, *Consumer price index*; Cabinet Office, *National accounts*.

Graph 3

Call rates (overnight)

In percentages

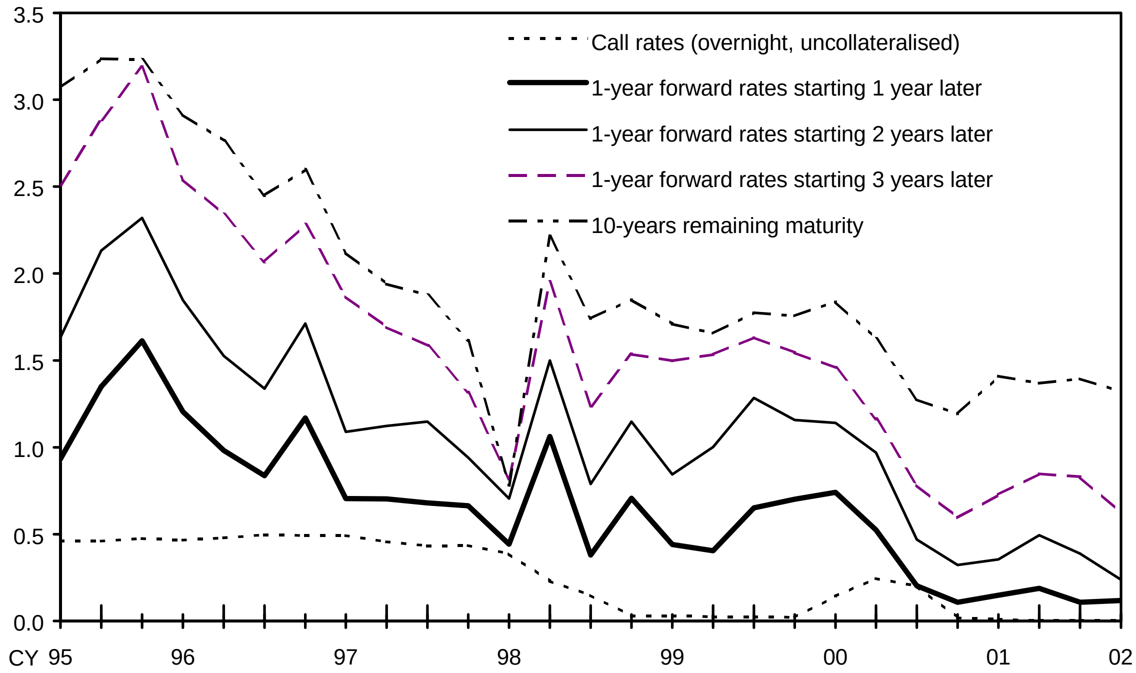


Source: Bank of Japan, *Financial and economic statistics monthly*.

Graph 4

Forward rates of government bond yields

In percentages



Source: Bank of Japan, *Financial and economic statistics monthly*.

and the increase in demand for cash caused by the decline in the opportunity cost of holding money. As a result, the ratio of the monetary base to nominal GDP has increased to 17%, the highest figure since the Second World War period.

While the monetary base has posted double digit percentage growth year on year, what has been the reaction of financial markets since quantitative easing was adopted?[4]

First of all, amid the unprecedented abundant supply of liquidity, not surprisingly the uncollateralised overnight call rate was further lowered to 0.001 or 0.002%, literally almost zero (Graph 3). Another element of the new policy regime is a commitment to continue it until underlying CPI inflation turns positive. Currently in Japan, given economic weakness and persistent downward pressure on prices, most market participants do not see CPI inflation turning positive any time soon. Reflecting such an expectation, the decisive easing stance of the Bank of Japan exerted some downward effect on medium-term forward interest rates (Graph 4).

Second, as the partial removal of blanket deposit insurance (for time and savings deposits, etc) approached, shifts from time and savings deposits to liquid deposits, and deposit shifts among financial institutions were widely seen until the end of fiscal 2001 (Graph 5). However, the substantial provision of reserves by the Bank succeeded in dispelling the liquidity concerns of financial institutions at the end of the fiscal year. Graph 6 shows the premium on the implied forward euroyen rate stepping over the end of the fiscal year, providing evidence of this situation.

Third, a current account balance increase does not seem to have a strong effect on the corporate financing environment in capital markets such as the corporate bond and commercial paper (CP)

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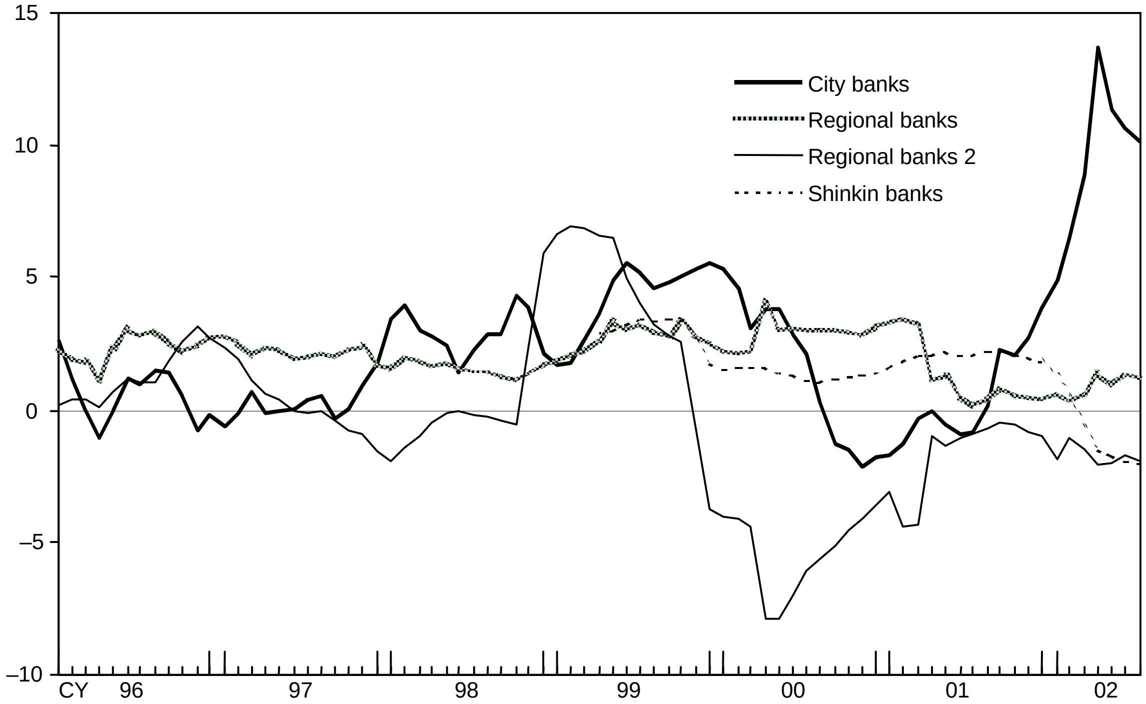
4 See Shirakawa (2002) for details.

Graph 5

Deposits of domestically licensed banks

Annual percentage changes

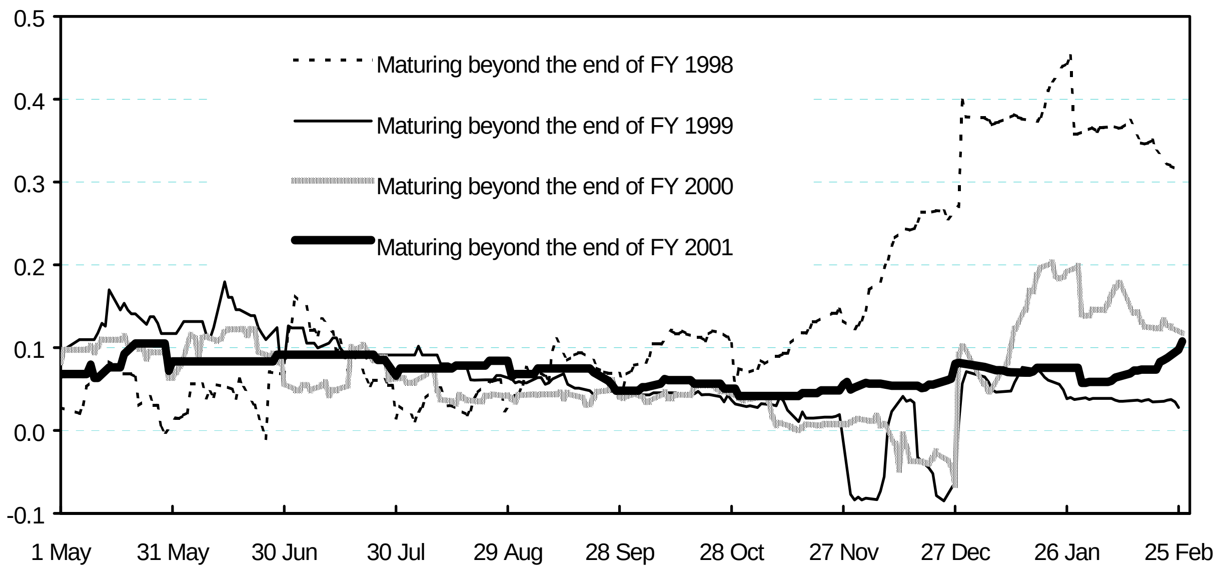


Source: Bank of Japan, *Economic and financial data on CD-ROM*.

Graph 6

Premium of euroyen rates maturing beyond the end of the fiscal year

In percentage points



Note: Premium here is the rate increase in funding liquidity when the maturity steps over the end of the fiscal year.
Premium = (implied forward rates from March to April) – (one month implied forward rates whose contracts expire within the same fiscal year : average of those from February to March and those from April to May).

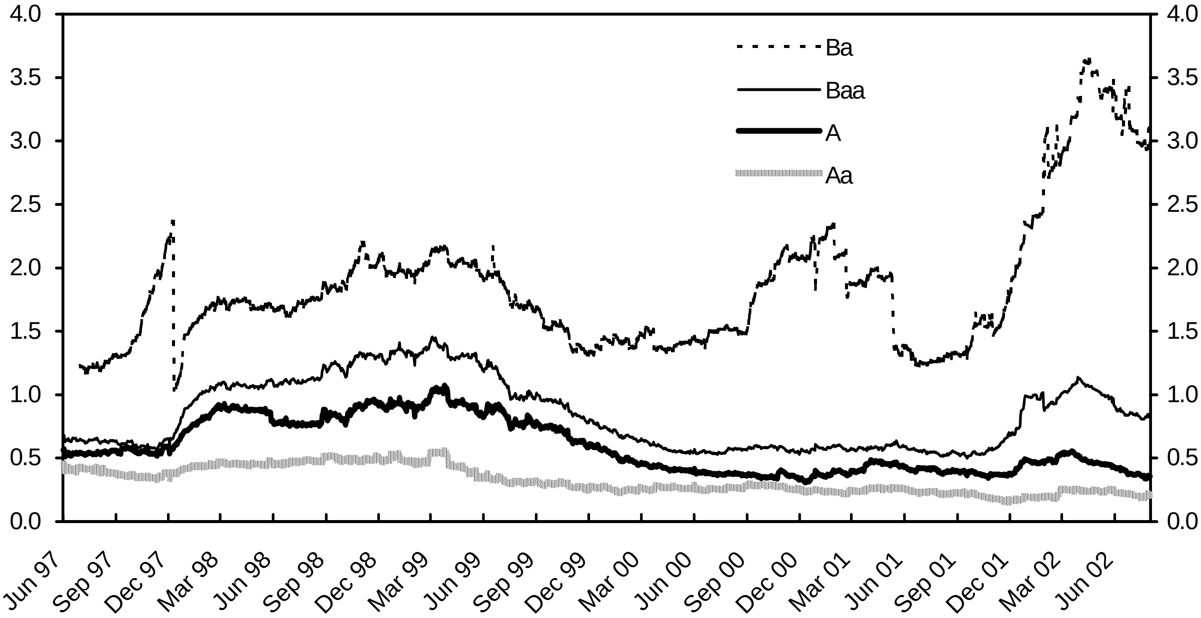
Source: Japanese Bankers Association.

Graph 7

Yield spreads of corporate and public bonds

In percentage points

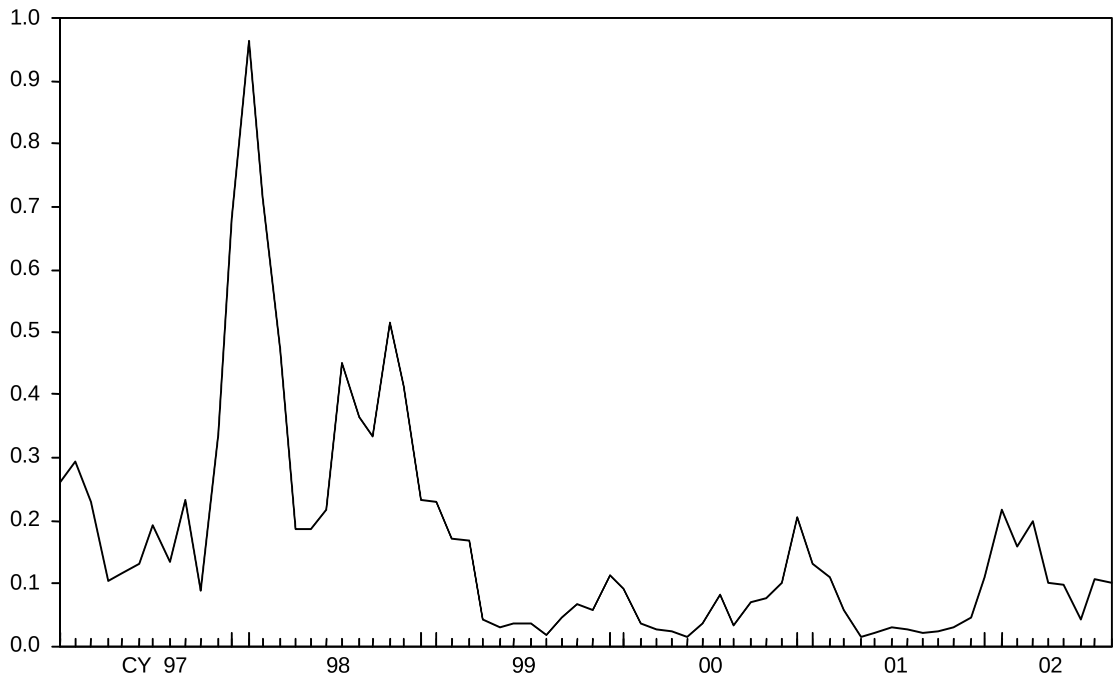
(1) Yields on corporate bond less yields on government security



Note: Yields on bonds with five-year maturity. The indicated ratings are Moody's.

Source: Japan Securities Dealers Association, *Over-the-counter standard bond quotations*, *Reference price (yields) table for OTC bond transactions*.

(2) Yields on CP less yields on financing bills



Note: Yields on FB until March 1999 are replaced with yields on TB.

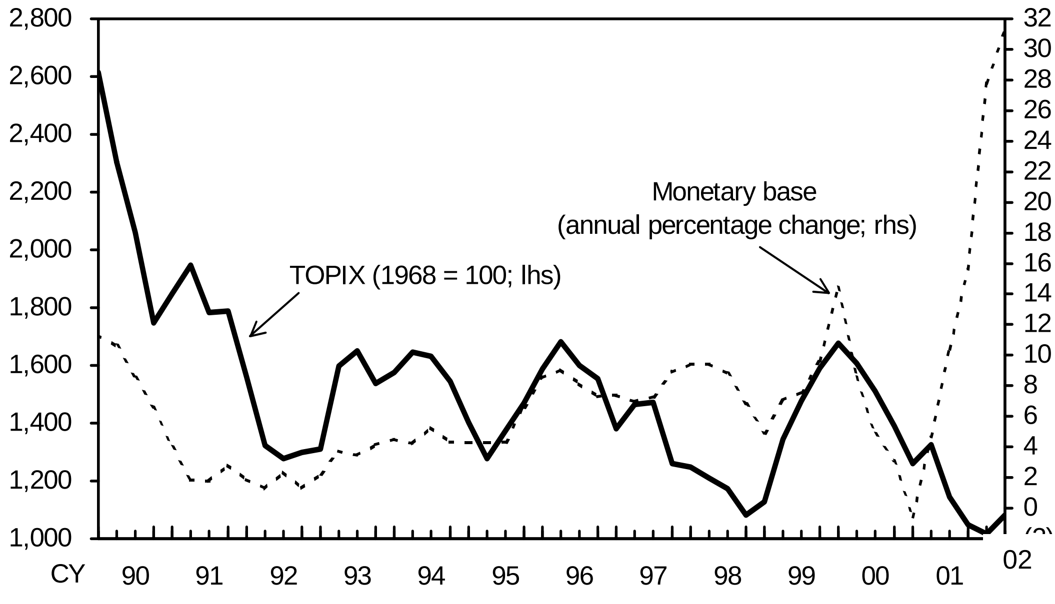
Source: Bank of Japan, *Financial and economic statistics monthly*.

markets. Facing the weakening role of banks as financial intermediaries, enhancing the function of capital markets could be an important route for monetary easing. In this regard, the corporate financing environment has partly improved. The differential (credit spread) between interest rates on corporate bonds and CP and yields on risk-free government bonds declined marginally after March 2001. It should be noted, however, that firms which reap the benefits of monetary easing effects are limited to those with high credit ratings. The effects have not fully permeated through to firms with low credit ratings and those unable to access capital markets. Credit spreads on low-grade corporate bonds have been rising since October 2001, because investors have become more conscious of credit risk.

Fourth, the prices of other financial assets do not seem to be responding to quantitative easing. From March 2001, equity prices temporarily rose until around May because of the anticipated favourable impact of structural reform, but declined thereafter due to a deterioration in the economic outlook (Graph 8). After a short recovery from March 2002, equity prices gradually declined again, mainly reflecting the plunge in US equity prices. While equity price fluctuations reflect various factors, the most important factor seems to be prospects for economic fundamentals, not an increase in the monetary base. As for foreign exchange rates, the yen rate against the dollar mostly moved in the lower 120s but temporarily rose to 116 in September 2001 (Graph 9). The yen depreciated rapidly from November 2001 until February 2002. This seems to be attributable not to monetary easing but rather to a change in the economic outlook, as typically reflected in Japan’s equity prices; while expectations for recovery of the US economy strengthened, uncertainty over prospects for Japan’s economy intensified, including financial system stability. Thereafter, reflecting the plunge in US equity prices, the yen appreciated again to the 115 level in July 2002, and has recently seen little change around 120. So far, it is not clear whether the exchange rate and monetary base appear to move in a same way.

Graph 8

Equity prices and the monetary base



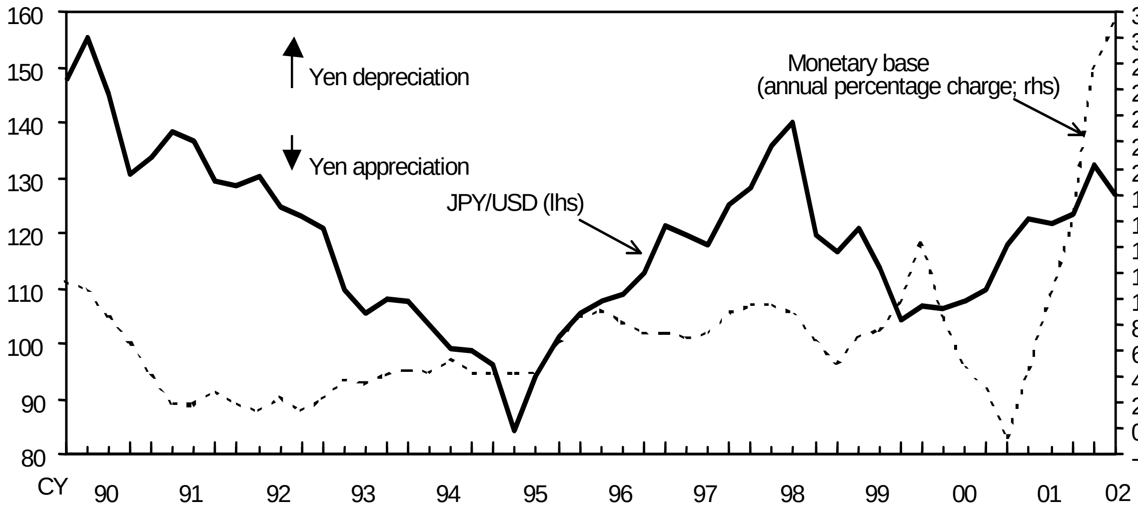
Sources: Tokyo Stock Exchange, *Monthly statistics report*; Bank of Japan, *Financial and economic statistics monthly*.

Finally, as for credit and broad money indicators, bank lending has kept decreasing, while the growth rate of M2+CDs has been stable at around 3% (Graph 2). The decline in bank lending and moderate growth in deposits should result in an increase in some other investments. So far, banks have increased investment in government bonds and Bank of Japan current accounts, both of which are free of credit risks.

In sum, at first sight monetary and financial indicators provide no clear evidence that quantitative easing has produced discernible effects with some exceptions at zero short-term interest rates. However, in order to judge carefully the full effects of quantitative easing, we need to evaluate them quantitatively by conducting empirical analyses based on economic theory.

Graph 9

Exchange rate and the monetary base



Source: Bank of Japan, *Financial and economic statistics monthly*.

3. Monetary policy transmission at zero interest rates

3.1 Monetary base channel

The interest rate channel is the primary mechanism in conventional Keynesian macroeconomic models, which works through the change in the short-term interest rate. If this were the only channel, the economy would be under a liquidity trap when the short-term interest rate is zero.[5] However, monetarists criticise such a Keynesian view saying that conventional macroeconomic models significantly oversimplify the structure of the economy. In the traditional monetarist account, for a full liquidity trap to be effective, the composite asset - money plus bills - must be a perfect substitute for all other assets (Meltzer (1999a)). In practice, however, money is an imperfect substitute for a wide range of financial and real assets, including long-term bonds, corporate bonds, equities, foreign financial assets, physical capital, and durable goods.[6] A change in monetary policy induces a rebalancing of portfolios in general, affecting nominal demand both through wealth and substitution effects on real assets, and through adjustments in a wide range of financial yields relevant to expenditure decisions.

From a theoretical viewpoint, even at zero interest rates the change in the monetary base is expected to cause this rebalancing effect through the following channels.

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5 A “liquidity trap” was suggested by Keynes in the General Theory and revived recently by Krugman (1998, 1999).

6 Some representative quotes of monetarists’ views:

Meltzer (1999b): “Monetary policy works by changing relative prices. There are many, many such prices. Some economists erroneously believe […] monetary policy works only by changing a single short-term interest rate.”

Friedman and Schwartz (1982, pp 57-8): “Keynesians regard a change in the quantity of money as affecting in the first instance ‘the’ interest rate, interpreted as a market rate on a fairly narrow class of financial liabilities […]. We insist that a far wider range of marketable assets and interest rates must be taken into account […]. [We] interpret the transmission mechanism in terms of relative price adjustment over a broad area rather than in terms of narrowly defined interest rates.”

The first channel is a relative asset supply effect. An open market operation by a central bank causes an opposite change in the stocks of the monetary base and securities held by banks, firms or households. Since the monetary base is not a perfect substitute for various other assets, changes in the outstanding balance of the monetary base due to monetary policy may lead to changes in the relative prices of assets. This relative asset supply effect can be realised by changes in the risk premium of asset prices. For example, Meltzer (2001) and McCallum (2000) argue that monetary authorities can use the monetary base to engineer exchange rate depreciation even when short-term nominal interest rates are zero. Implicitly, they view the risk premium in the uncovered interest parity relationship as subject to monetary policy manipulation in the short run.[7]

The risk premium can also be reduced by the second channel, which would work through the reduction of transaction costs by providing ample money.[8] The frictions which money helps to overcome in financial markets are related to its role in providing liquidity services. When economic agents anticipate a liquidity shortage regarding their future revenues, they will boost demand for liquid assets to avoid borrowing due to cash flow constraints. Such asset demand in preparation for a liquidity shortage leads to the higher evaluation of liquid assets. That is, liquidity demand might substantially raise the rates of illiquid assets relative to those of liquid assets due to a liquidity premium.[9] In such circumstances, the increase in money will reduce the probability of liquidity shortage, and consequently affect the liquidity premium and relative asset returns. The relief from concern over the liquidity of financial institutions, mentioned above under the second point of the reaction of financial markets (p 6), can be understood as such an example (Graph 6). From a different perspective, it might be expected that investors take risks more because of a decrease in the liquidity risk premium. Financial institutions might be candidates for such investors, and if they changed their attitude to lending, it would have a positive impact on aggregate demand. In this way, recognising the role of money in reducing financial frictions may provide a more significant role for money in the transmission mechanism.

The expectation effect is another channel. A central bank can lower longer-term interest rates even when short-term rates are zero. Because longer-term rates are formed as averages of expected short-term rates plus some risk premium over their maturity, committing to maintaining the zero interest rate policy longer will lower expected future short-term interest rates. As the strength of this channel relies on the expectation of firms and households with respect to future monetary operations of the central bank, current changes in market operation, realised as an increase in the monetary base, may be expected to enhance the credibility of the central bank.[10] If this contributed to diminishing uncertainty over future short-term interest rates, the term premium would be reduced and hence longer-term rates would be lowered further. The above-mentioned decline in medium-term forward rates in Japan can be regarded as a typical example (Graph 4). It should be noted, however, that this expectation effect can also be classified as part of interest rate channels with longer-term maturities.

As a variety of logic argues a variety of channels, it is difficult to crystallise all into a simple channel. Hereafter, this paper tentatively calls them the “monetary base channel”. As mentioned above, the monetary base channel depends on various changes in yields (or relative prices), rather than money per se.[11] Meltzer (1995, 1999a) argues that a measure of monetary conditions based on real money

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7 However, empirical studies seem to have concluded in general that changes in the relative supply of dollar and foreign currency bonds have little or no lasting impact on exchange rates. In addition, although many useful studies have attempted to measure the degree of substitutability between dollar and foreign currency bonds, there are still no generally accepted estimates of these crucial parameters. These findings suggest that portfolio rebalancing effects on the exchange rate are probably negligible for small to medium-sized changes in the relative quantities of dollar and foreign currency bonds. Of course, they do not preclude the possibility that the Bank of Japan could cause a depreciation of the yen even at the zero bound. However, very large purchases of foreign currency bonds would be required to achieve a significant result.

8 See, for example, King (1999, 2002).

9 Saito and Shiratsuka (2001) point out that Japan’s financial institutions faced severe liquidity constraints during the financial crises that occurred in 1997 and 1998, and that the serious liquidity constraint prevailing in the banking sector resulted in depressed loan activities, limited arbitraging, and poor dealing among financial markets.

10 See, for example, Meyer (2001).

11 There is another view that focuses on money per se: the real balance effect (Pigou (1943)). However, the monetary base, namely “outside” money, accounts for only a very small fraction of financial wealth in developed countries. So the quantitative impact of the real balance effect is inevitably small.

stock can be regarded as a better summary of the various changes in yields than a measure based on a specific real interest rate. One reason he offers for this is that money demand might, like aggregate demand, be a function of many interest rates, as in Friedman (1956).

3.2 Review of the literature on empirical analyses

When the monetary base channel works and the real money stock serves as a better summary of the various changes in yields relevant for economic activities, the monetary base enters the aggregate demand equation for a given short-term interest rate. That is, money could play a role in structural equations for aggregate demand, or in VARs, as a proxy for channels which are not summarised by the real interest rate on short-term securities.

Koenig (1990) and Meltzer (1999a) show that real money growth is a significant determinant of consumption growth in the United States, controlling for the short-term real interest rate. Nelson (2000) also shows that the same property of base money holds for total output (relative to trend or potential) in both the United States and the United Kingdom. However, do these analyses indicate that the monetary base channel works at zero interest rates? While econometric models that are estimated using data from normal periods when the economy operates safely away from the zero bound can provide useful estimates of monetary transmission through the interest rate channel, they are unlikely to capture the effects of the monetary base channel that may remain operative when nominal interest rates are constrained at zero with considerable precision. Taking this point into account, we cannot necessarily regard the empirical analyses of Koenig (1990), Meltzer (1999a) and Nelson (2000) as evidence of the existence of the monetary base channel at zero interest rates, since their analyses do not include any samples from the zero interest rate period.

As for Japan's case, Baig (2002), using the VAR based on the data from 1980 to 2001, shows that expansion of the monetary base has positive effects on both price and output even with the interest rate included in the VAR as a separate variable. Then, Baig (2002) argues that Japan's data support the existence of the monetary base channel even at zero interest rates. However, we have to examine whether his analysis really indicates the effectiveness of the monetary base channel at zero interest rates in Japan. Although Baig (2002) uses Japan's data including the sample period of zero interest rates, his analysis is based on a VAR model which does not allow for time-varying parameters. In other words, his empirical results do not reflect the effect of the monetary base channel at zero interest rates, but the average effect of that channel during the whole sample period. This is a problem which arises from using a long sample which includes different policy regimes. Therefore, we cannot necessarily recognise that the analysis of Baig (2002) suggests the effectiveness of the monetary base channel at zero interest rates in Japan.

Indeed, the results of Baig (2002) do not seem to be consistent with Japan's recent economic performance. Although the growth rate of the monetary base has remained very high for several years, deflation persists in the economy, albeit at low rates (Graph 2). If his results were right, deflation would have stopped. Needless to say, money affects the economy with long and variable lags. We may have to wait just a bit longer. However, the usual range for the lag in the effects of monetary policy on the economy lies somewhere between half a year and approximately two years. Consequently, we seem to be witnessing something very unusual in the relationship between money and the economy.

4. Empirical analyses based on a time-varying VAR

In the previous section, we pointed out the problem regarding the empirical method of investigating the effect of the monetary base channel at zero interest rates. We should not extract the average effect of the monetary base channel during a long sample period, but that reflecting the sample period of zero interest rates only. A Bayesian VAR, a VAR with time-varying coefficients, is one way to solve this problem.[12] Using a time-varying VAR, we allow for possible changes in the interest rate elasticity of money demand and changes in the transmission mechanism at (near) zero interest rates. Since the

[12] See Doan et al (1984) for details of a Bayesian VAR.

Bank of Japan has faced the zero interest rate bound, its policy reaction function has clearly changed. The regime change in monetary policy, from interest rate targeting to quantitative easing, will bring shifts in the responsiveness of economic activity to the increase in the monetary base. A time-varying VAR can capture these changes in economic structure and leads to impulse response functions that vary over time.

4.1 VAR

Before estimating a time-varying VAR, we begin by estimating a VAR as a benchmark, using Japan's quarterly data over the sample period 1980:Q1-2002:Q1. The sample period is chosen to be the same as that in Baig (2002). The specific VAR that we consider contains four variables: inflation rate, output gap, monetary base (growth rate) and overnight call rate.[13, 14] Clearly, this VAR provides a very simple or simplistic description of the economy, but it contains at least the minimum set of variables that are crucial for any discussion of monetary policy.[15] We include four lags in the VAR according to AIC. The VAR is identified by using the Cholesky decomposition, with the order being inflation, output gap, interest rate and monetary base. The choice of ordering is made, according to Baig (2002), on the basis of the speed with which the variables respond to shocks, ie inflation is assumed to respond last, and the monetary base to be the most responsive.

Graph 10 displays impulse response functions based on the estimated VAR. The basic results are the same as those of Baig. That is, both inflation and the output gap respond positively to innovations in the monetary base. Although these responses are not statistically significant, using a longer sample period, 1971:Q2-2002:Q1, results in a significant response (Graph 11).[16] As noted earlier, however, this result does not reflect the effect of the monetary base channel at zero interest rates, but the average effect of the channel during the whole sample period. It can be guessed that the experiences of the 1970s contributed to this result. Therefore, it is not necessarily appropriate to regard the results based on the VAR as evidence of the existence of the monetary base channel at zero interest rates.

4.2 Time-varying VAR

Now, we estimate a time-varying VAR to properly analyse the effects of the monetary base channel at zero interest rates. Write the jth equation in a VAR as:

$$x_{t,j} = X'_{t-1}\beta_{t,j} + u_{t,j} \tag{1}$$

where $x_{t,j}$ is a jth endogenous variable, X_{t-1} is a vector of lagged variables, and $u_{t,j}$ is an error term. $\beta_{t,j}$ is a vector of time-dependent parameters and is assumed to follow a random walk process. $\beta_{t,j}$ is updated according to a Kalman filter algorithm, based on a prior distribution on the initial value of a parameter vector $\beta_{0,j}$.[17] Since $\beta_{t,j}$ is time-dependent, the impulse response functions vary over time.

We focus on the impulse response functions at 1985:Q2 and those at 2002:Q1. The former functions are based on the parameter $\beta_{1985:Q2}$, while the latter are based on the parameter $\beta_{2002:Q1}$. These parameters are estimated by a Kalman filter over sample periods 1971:Q2-1985:Q2 and 1985:Q3-2002:Q1, respectively. The parameter $\beta_{1985:Q2}$ reflects the propagation mechanism of the period just

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13 See the data appendix for a detailed description of the data.

14 To check the robustness of our results, we have re-estimated the VAR by replacing output gap with output growth. While we report only the results obtained from the VAR with output gap, the VAR with output growth yields very similar results.

15 To limit the extent of a "price puzzle" (see Sims (1992), Chari et al (1995) and Bernanke and Mihov (1998)), we re-estimate the VAR including commodity price inflation (or the wholesale price index), but the main results do not change.

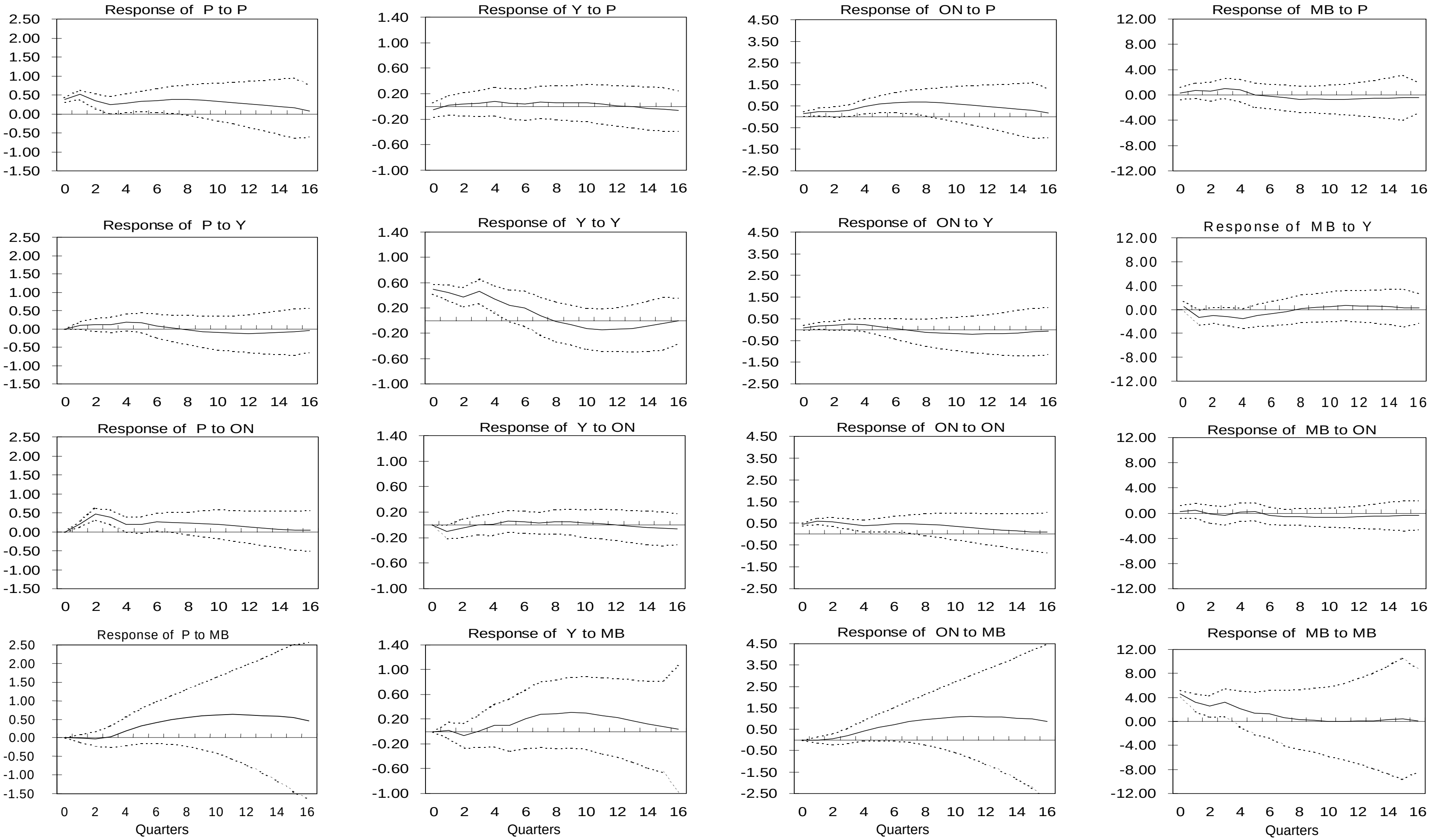
16 The original available data set runs from 1970:Q1 to 2002:Q1. Because of data transformation (first differences and lags), the analysis is performed on the 1971:Q2-2002:Q1 period.

17 We set the hyperparameters of prior distribution at the values which Doan et al (1984) recommend for a typical economic time series. To check the robustness of our results, we re-estimated the time-varying VAR based on the optimised hyperparameters. While we report only the results obtained from the time-varying VAR with the hyperparameters which Doan et al (1984) recommend, the time-varying VAR with the optimised hyperparameters yields very similar results.

Graph 10

Impulse response functions based on VAR (sample period: 1980:Q1-2002:Q1)

Y: output gap ON: uncollateralised overnight call rate (level) P: inflation rate MB: monetary base (growth rate)

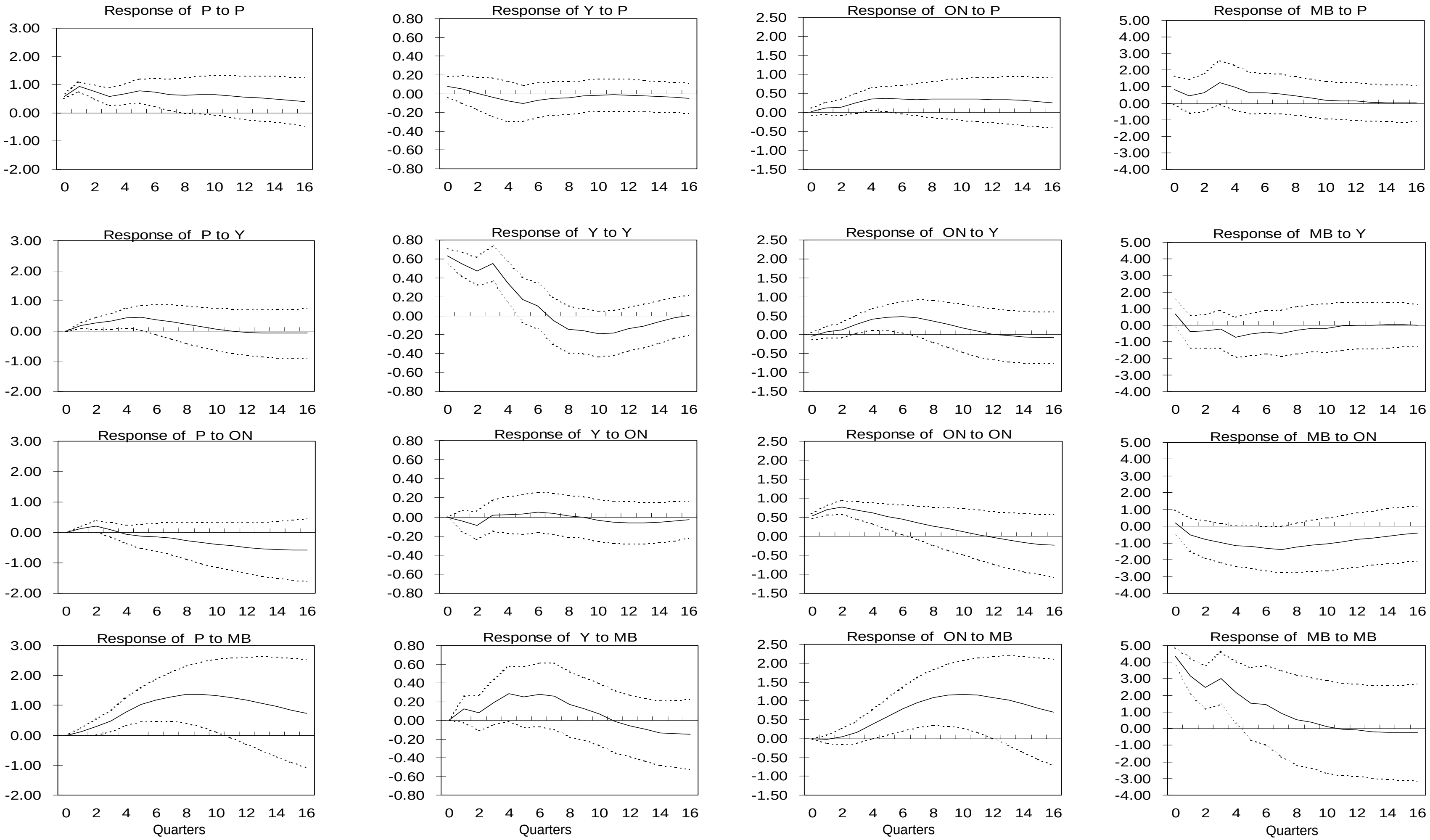


Note: The graph shows a 16-quarter response of variables to a one standard deviation innovation. The dashed lines represent ± 2 standard deviation bands.

Graph 11

Impulse response functions based on VAR (sample period: 1971:Q2-2002:Q1)

Y: output gap ON: uncollateralised overnight call rate (level) P: inflation rate MB: monetary base (growth rate)



Note: The graph shows a 16-quarter response of variables to a one standard deviation innovation. The dashed lines represent ± 2 standard deviation bands.

before the Plaza Accord, while $\beta_{2002:Q1}$ reflects that after the adoption of quantitative easing. The reason why we compare the impulse response functions at 1985:Q2 with those at 2002:Q1 is that 1985:Q2 is near the midpoint of the whole sample period 1971:Q2-2002:Q1. In order to examine whether the propagation mechanism differs between 1985:Q2 and 2002:Q1, we calculate the impulse responses to the common innovations whose covariance matrix is estimated over the whole sample 1971:Q2-2002:Q1.[18] That is, since the covariance matrix of innovations is kept constant, the difference of the impulse response functions provides a measure of a change in the propagation mechanism in the face of unchanged disturbances.

The result, which is shown in Graph 12, is clearly different from that of the VAR. This graph indicates that the increase in the monetary base has a positive effect on inflation at 1985:Q2, but not at 2002:Q1. This finding implies that, beyond the interest rate channel, the monetary transmission process took place through the monetary base channel in the 1980s, but such transmission does not work now at zero interest rates. This seems to reflect the recent observation that the high growth rate of the monetary base does not lead to an indication of inflation (Graph 2).

4.3 Implicit assumption of the monetary base channel

Why does the underlying mechanism of the monetary base channel not work well as theoretically assumed? Here, it should be noted that the monetary base channel at zero interest rates is based on the implicit assumption that money demand is satiated at a finite level. That is, when interest rates are zero, households and firms become satiated with money balances, and any increase in the monetary base beyond that level leads to changes in their portfolios with consequent changes in relative yields on different financial and real assets, and direct and indirect effects on spending.[19] In contrast with such a view, there is another view. When interest rates are zero, households and firms have an infinitely elastic demand for money balances. An increase in the monetary base is absorbed passively in higher balances, and there are no implications for broader measures of money or demand and output. Monetary policy is impotent; there is a liquidity trap.

Which view is consistent with the result of our analysis? As background to the result of the time-varying VAR, we can set two hypotheses:

Hypothesis I: As the interest rate tends to zero, demand for money balances tends to infinity. Therefore, monetary policy has no effect on economic activity at zero interest rates, because any additional money created is simply absorbed passively in money holdings.

Hypothesis II: Money demand exhibits satiation such that the demand is finite at zero interest rates. Therefore, the monetary base channel works even at zero interest rates, but its effect is very small or negligible.

In order to test which hypothesis is accepted, we must estimate the money demand function and examine whether there is a satiation level of money demand at zero interest rates.[20] The next section deals with this issue.

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[18] The shock is calculated as follows. We first calculate the residuals from the coefficients in each period, then the covariance matrix and make the orthogonal shock using the Cholesky decomposition. The ordering is chosen to be the same as that of the VAR: inflation, output gap, interest rate and monetary base.

The lag length is also chosen to be the same as that of the VAR, that is, four lags are included in the time-varying VAR.

[19] We must note that if there are only two financial assets, money and bonds, in the economy, the existence of a finite satiation level of real balances does not mean the existence of a monetary base channel at zero interest rates. Money demand is infinitely elastic at a satiation level in the sense that no further interest rate declines are needed to make people willing to hold larger real balances, even if the elasticity of money demand is bounded at all interest rates greater than zero. For an example of a simple model in which the monetary base channel is ineffective at a zero interest rate, and in which there is satiation in real balances at a finite level, see the discussion of “real balance effects” in Woodford (2002).

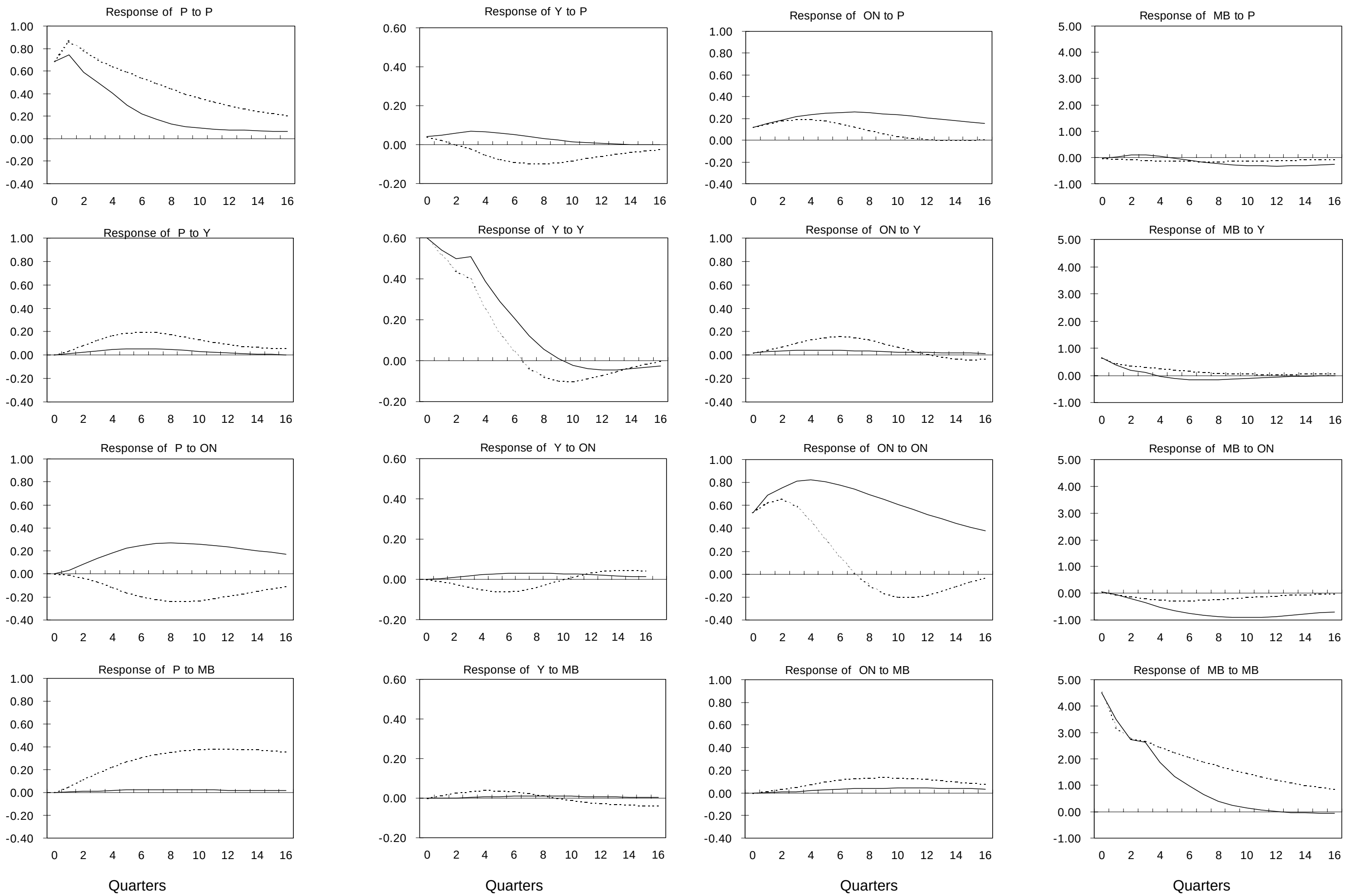
[20] Baig (2002) uses the monetary base (expressed as a ratio of potential output) and the level of interest rate in the VAR with a fixed parameter, which implicitly assumes that there is a satiation level of money demand at zero interest rates. Instead of the level of interest rates, if a logarithmic specification for interest rates is used as a variable of the VAR, it implicitly assumes that money demand tends to infinity as the interest rate tends to zero, that is, there is not a satiation level of money demand at zero interest rates. However, a constraint about whether there is a satiation level of money demand at zero interest rates should not be imposed on the money demand function a priori, but be tested statistically.

Graph 12

Impulse response functions based on time-varying VAR

———2002:Q1 ----1985:Q2

Y: output gap ON: uncollateralised overnight call rate (level) P: inflation rate MB: monetary base (growth rate)



Note: The solid line shows a 16-quarter response of variables at 2002:Q1. The dashed line shows a 16-quarter response of variables at 1985:Q2.

5. Satiation level of money demand

5.1 General money demand function

As in Friedman (1956), the demand for real balances depends not on a single interest rate but on many different interest rates, or, more generally, on the prices of assets relative to the prices of new production of the same assets. These relative prices settle down as the economy adjusts to an equilibrium at which all assets sell at replacement cost. In a full, general equilibrium, prices of bonds and real capital, of domestic and foreign assets, of new and used houses and automobiles, and many other relative prices, can be usefully summarised by a single interest rate. In transition, however, this does not hold true, and the demand for real balances differs from long-run desired real balances. Based on such logic, Meltzer (1999b) argues that the difference between actual and long-run desired money balances is a measure of the excess supply of money, the amount by which prices and other nominal variables must change to restore equilibrium in markets for assets and output.[21]

Here, we assume that long-run desired real balances can be modelled as follows:

$$\frac{M_t}{P_t} = e^{\gamma} Y_t^{\alpha} \left(\frac{i_t}{1+i_t} + \delta \right)^{-\beta} \qquad \alpha > 0,\ \beta > 0,\ \delta \geq 0 \tag{2}$$

where M_t, P_t, Y_t and i_t are the monetary base, price level, real income and call rate, respectively. α, β, γ and δ are parameters. In equation (2), it is assumed that the relative prices of various assets can be usefully summarised by the call rate i_t in the long run.

Equation (2) is consistent with a transactions-time approach and inventory-theoretic approach to money demand. The inventory-theoretic approach says that managing an inventory always requires time, and a larger real balance of money can reduce transaction time. A variation of the transactions-time approach is that consumption requires shopping time, which can be decreased by holding a larger real balance. In order for the transactions-time approach to be consistent with satiation, it must be such that, at some positive real balance amounts, further increases in that ratio would not decrease transactions-time.[22] It should also be noted that equation (2) nests two familiar money demand functions as special cases: the log-log function and semi-log function. Consider the case when the call rate i_t is low enough for the approximation $i_t\ /(1 + i_t) = i_t$ to be reasonable. Taking logs of equation (2) when $\delta = 0$, we obtain the log-log function:

$$m_t - p_t = \alpha y_t - \beta \log(i_t) + \gamma \tag{3}$$

where all lower-case letters, excluding the interest rate i_t, refer to logarithms of the variables in upper-case letters. The elasticity of money demand with respect to interest rates is a full elasticity, which shows the percentage change in money demand in response to a 1% change in interest rates. On the other hand, taking logs of equation (2) when $\delta > 0$ and $\delta >> i_t$, we obtain the semi-log function:[23]

$$\begin{aligned} m_t - p_t &= \alpha y_t - \beta \log(i_t + \delta) + \gamma \\ &= \alpha y_t - \beta \log\left(1 + \frac{i_t}{\delta}\right) - \beta \log \delta + \gamma \\ &\approx \alpha y_t - \frac{\beta}{\delta} i_t + (\gamma - \beta \log \delta) \qquad (\because\ \log(1+x) \approx x \quad \text{for small } x) \end{aligned} \tag{4}$$

The response of money demand to interest rate changes is a semi-elasticity, which indicates the percentage change in cash holdings as a result of a 1 percentage point change in interest rates.

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21 An alternative view is that the economy adjusts to reduce this gap by spending to reduce the real balance of money, when real balances are larger than desired, or to increase the gap by reducing spending when real balances are less than desired. This so-called “real balance effect” is generally considered small, since real balances are a small part of real wealth in developed countries.

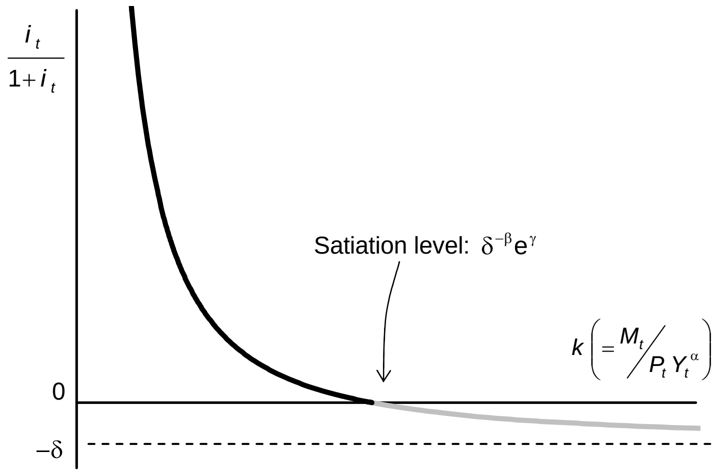
22 See Bakhshi et al (2002) and Wolman (1997).

23 When condition $\delta >> i_t$ is not satisfied, this approximation does not hold true even if $\delta > 0$.

In equation (2), the satiation level of money balances (expressed as *quasi*-Cambridge *k*) at zero nominal interest rates is:

$$k = \left. \frac{M}{PY^{\alpha}} \right|_{i=0} = \delta^{-\beta} e^{\gamma} \tag{5}$$

which is finite if $\delta > 0$.[24] In contrast, if $\delta = 0$, this ratio *k* is infinite, which implies that there is no satiation level of money demand. Regarding log-log and semi-log money demand functions, the former does not have a satiation, whereas the latter does. The figure below illustrates the money demand curve and the location of the satiation level.



Whether δ is zero or strictly positive gives a rather different policy implication. In the case of $\delta = 0$, monetary policy would have no effect on real demand and output, because any additional money created would simply be absorbed passively in money holdings. In contrast, in the case of $\delta > 0$, the monetary base channel works even at zero interest rates, because the creation of money beyond the satiation level would be translated into demand for other assets and, ultimately, via effects on relative yields, into nominal spending.

5.2 Estimation result

Now, we estimate a money demand function and examine whether there is a satiation level of money demand.

Before estimating equation (2) and testing the hypothesis that there is no satiation level ($\delta = 0$) in equation (2), we first attempt to examine whether either of the functions, the log-log function (3) or the semi-log function (4), is appropriate for the long-run desired real balance. If equation (3) or (4) is appropriate for the long-run demand function, we will find a cointegrating relationship among real money ($m_t - p_t$), income (y_t) and interest rate (i_t or $\log(i_t)$). Using Johansen's (1988) maximum likelihood estimation procedure, we conduct a cointegrating test over the sample period 1978:Q1-2002:Q1. The sample period is chosen to avoid the high-inflation period of the first-round increases in oil prices, since the behaviour of holding cash balances in the private sector may have changed after transition to a moderate- or low-inflation period. In addition, the policy stance of the Bank of Japan might also have changed after the first oil shock. Indeed, in 1978, the Bank began announcing quarterly forecasts of money supply.

[24] Here, we call $M/(PY^{\alpha})$ "*quasi*-Cambridge *k*" because α is not necessarily unity, while α is set at unity for original Cambridge *k*.

Table 1 shows the results of the maximum eigenvalue and trace test statistics of the Johansen test for log-log and semi-log functions. Both tests suggest that, for both specifications, there is no cointegrating vector among real money ($m_t - p_t$), income (y_t) and interest rate (i_t or $\log(i_t)$). This implies that neither the semi-log nor the log-log function is appropriate for the long-run money demand function. A more general money demand function is desirable; therefore estimating equation (2) is the next step.

Table 1

Johansen's cointegration test

(1) Series: $m_t - p_t$, y_t, i_t

Null hypothesis: rank = *r*	**Maximum eigenvalue statistic**	**Trace statistic**
$r = 0$	12.9 (21.0)	22.7 (29.7)
$r \leq 1$	8.8 (14.1)	9.8 (15.4)
$r \leq 2$	1.0 (3.8)	1.0 (3.8)

(2) Series: $m_t - p_t$, y_t, log (i_t)

Null hypothesis: rank = *r*	**Maximum eigenvalue statistic**	**Trace statistic**
$r = 0$	14.4 (21.0)	25.7 (29.7)
$r \leq 1$	8.3 (14.1)	11.3 (15.4)
$r \leq 2$	3.0 (3.8)	3.0 (3.8)

Notes: 1. The sample period is 1978:Q1 to 2002:Q1. 2. Numbers in parentheses are critical values at the 5% significance level. 3. The lag length of the VECM is set to 4, obtained from the likelihood ratio test.

For estimation purposes, we rearrange equation (2) as follows:[25]

$$\frac{\dfrac{M_t}{P_t} - e^{\gamma} Y_t^{\alpha} \left(\dfrac{i_t}{1+i_t} + \delta \right)^{-\beta}}{e^{\gamma} Y_t^{\alpha} \left(\dfrac{i_t}{1+i_t} + \delta \right)^{-\beta}} = \frac{k_t}{e^{\gamma} \left(ii_t + \delta \right)^{-\beta}} - 1 = \varepsilon_t \qquad (6)$$

where $k_t = \dfrac{M_t}{P_t Y_t^{\alpha}}$ and $ii_t = \dfrac{i_t}{1+i_t}$

25 When $\delta > 0$, we cannot use Johansen's (1988) maximum likelihood estimation procedure to estimate the parameter δ in equation (2), since taking logs of equation (2) does not lead to a linear system.

ε_t is the percentage deviation of actual money balances from long-run desired money balances. We can assume that the mean of ε_t is zero and that two composite variables, k_t and ii_t, follow stationary processes. Regarding ε_t as an error term, we estimate equation (6) with instrumental variables using the generalised method of moments (GMM). The reason why we use GMM is that ε_t can be considered highly autocorrelated and that the regressors, k_t and ii_t, in equation (6), are themselves endogenous. Due to difficulty in calculation convergence, the estimation of parameter α is carried out by a grid search method. The search is carried out over the range $0.5 \leq \alpha \leq 1.5$ at intervals of 0.001.

Estimation results, shown in Table 2, are clearly consistent with the existence of a satiation level of money demand. Parameter δ is significantly positive, since the null hypothesis $\delta = 0$ can be rejected at the 5% significance level (p-value = 0.011). This result of $\delta > 0$ is consistent with the cointegration test, which suggests that log-log function (4) is inappropriate for the long-run money demand function. The result also implies that equation (2) can be approximated by semi-log function (3) when $\delta >> i_t$. When condition $\delta >> i_t$ is not satisfied, however, equation (2) differs from semi-log function (3). Graph 13 displays a plot of k_t versus ii_t. The solid line in this graph shows fitted values when parameters are estimated without any constraint, and the dashed line shows fitted values when non-satiation is imposed ($\delta = 0$).

Table 2

Estimation results of equation (6)

Parameter restriction	α	β	γ	δ	se	*J*-test	*LR*(1)
Unrestricted	0.924	0.137 (0.012)	−1.869 (0.046)	0.000155 (0.000127)	0.0874	5.520 [0.479]	–
$\delta = 0$	0.924	0.115 (0.091)	−1.784 (0.039)	–	0.0864	11.980 [0.101]	6.460 [0.011]

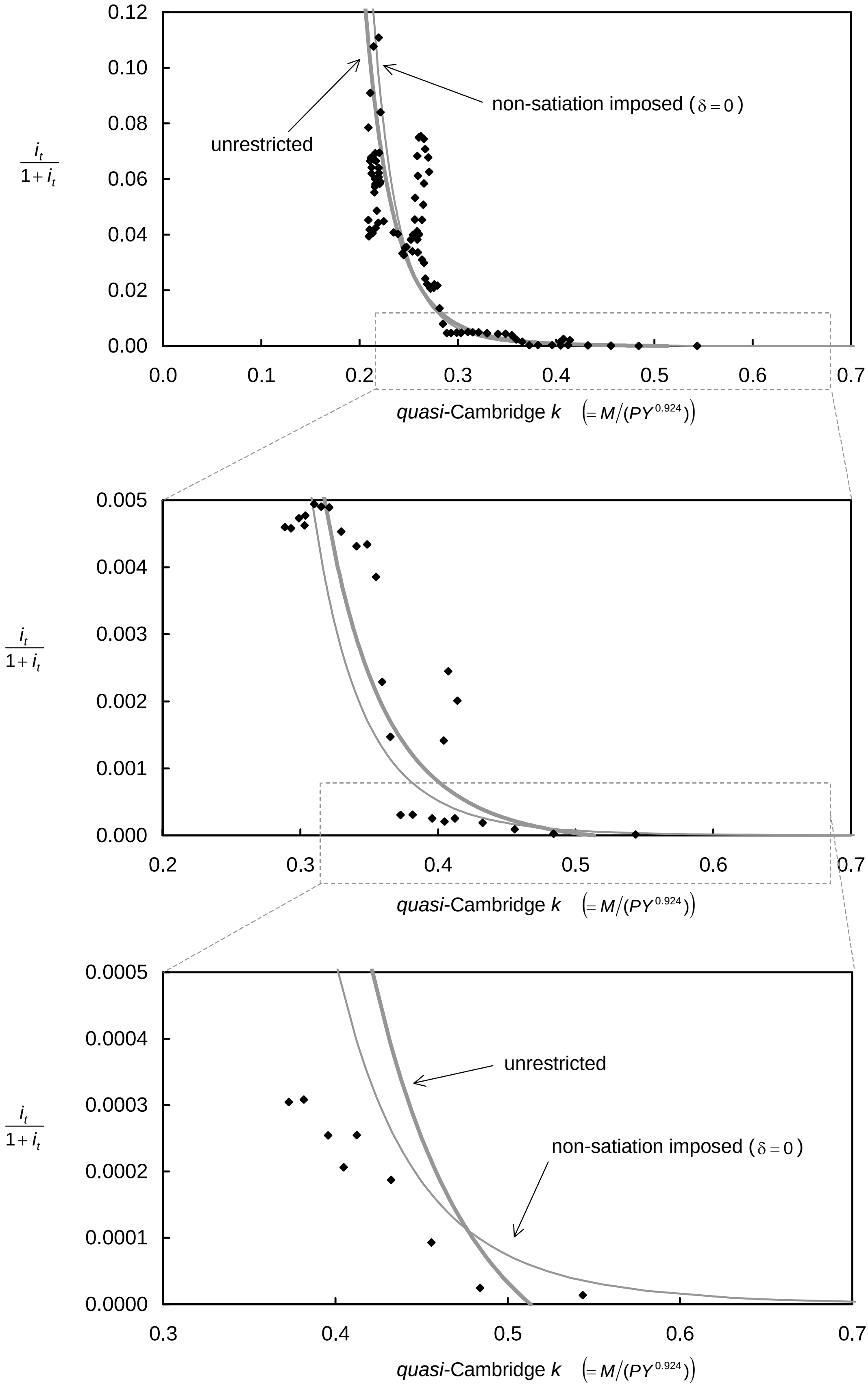
Notes: 1. This table reports GMM estimates of the parameters of equation (6). The sample period is 1978:Q1 to 2002:Q1. Instruments used include four lags of k_t, four lags of ii_t, and a constant term. A four-lag Newey-West estimate of the variance-covariance matrix is used. Numbers in parentheses are standard errors. 2. Due to difficulty in calculation convergence, the estimation of the parameter α is carried out by a grid search method. The search is carried out over the range $0.5 \leq \alpha \leq 1.5$ at intervals of 0.001. 3. The column *J*-test corresponds to the Hansen test of the overidentifying restrictions. Numbers in brackets are p-values, for testing the null hypotheses. 4. The column *LR*(1) corresponds to the likelihood ratio-type test of the parameter constraint $\delta = 0$. The number in brackets is a p-value, for testing the null hypothesis $\delta = 0$.

In order to confirm that equation (2) is appropriate for the long-run money demand function, we also conduct a unit root test for the error term ε_t in equation (6). When equation (2) is appropriate for the long-run money demand function, we will find that ε_t naturally follows a stationary process. Graph 14 shows the results of ADF test and Phillips-Perron test. Both tests suggest that the null hypothesis that ε_t follows a non-stationary process can be statistically rejected.

Although we may need more data from the zero interest rate period to estimate the money demand function with much precision, we can tentatively conclude that equation (2) with strictly positive δ is appropriate for the long-run desired money function, and reject Hypothesis I in Section 4.3. There is a satiation level of money demand at zero interest rates, which leaves room for the monetary base channel to work even at zero interest rates. But, to what degree does the monetary base channel work? Taking the results of the time-varying VAR into account, Hypothesis II in Section 4.3 seems to be supported: the effect, if any, of the monetary base channel at zero interest rates is very small (or negligible). In order to support this view, in the next section we estimate the model that includes both aggregate demand and aggregate supply equations and examine whether the monetary base enters these equations significantly.

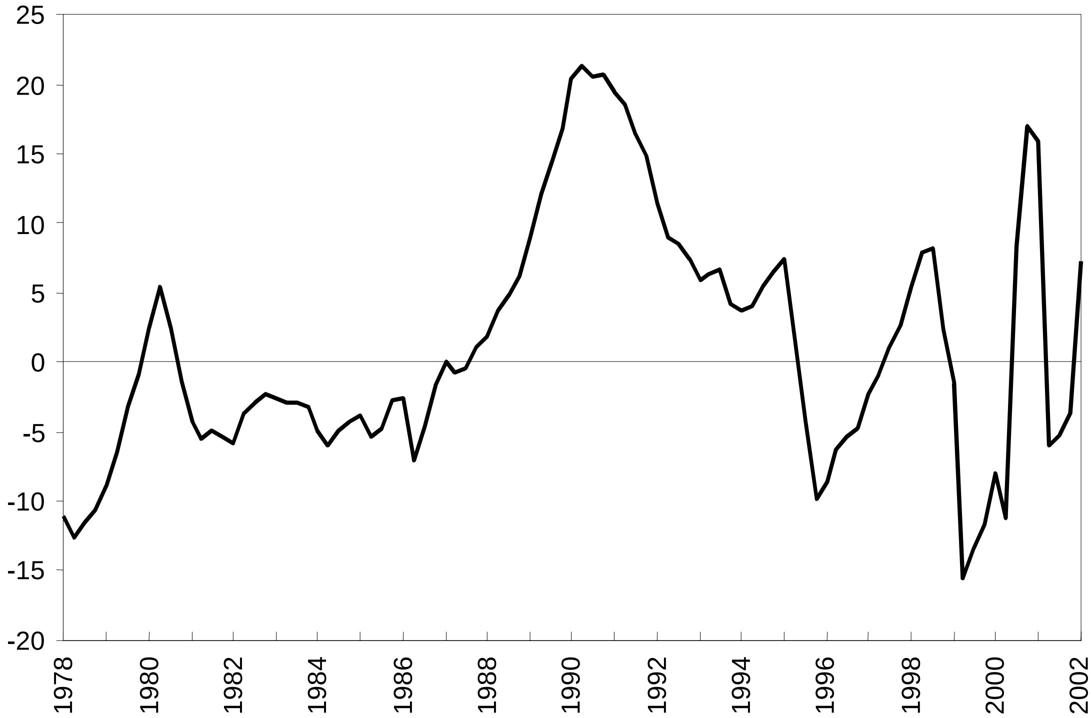
Graph 13

Money demand function: estimated curves and actual data



Graph 14

Percentage deviation of actual money balances from long-run desired money balances (ε_t)



Unit root tests					
ADF test			**Phillips-Perron test**		
Lags	Statistics	*p*-value	Lags	Statistics	*p*-value
4	–2.906	0.004	4	–13.412	0.011

Notes: 1. The null hypothesis is that the ε_t follows a unit root process. 2. The sample period is 1978:Q1 to 2002:Q1.

6. Effectiveness of the monetary base channel

Our model is small-scale but a standard macroeconomic model which comprises four basic equations: aggregate demand function (IS curve), aggregate supply function, money demand function (LM curve) and monetary policy rule. The aggregate demand function relates total demand to either money or interest rates and to expected inflation. The aggregate supply function relates the inflation rate to either the output gap or real money gap and to inflation expectations. The money demand function relates real cash balances to total expenditure and the interest rate. The monetary policy rule relates the interest rate to the difference between inflation and the central bank's inflation target. The model determines the values of output, inflation, the interest rate and money growth. Much recent research on monetary policy is based on variants of this four-equation system.

Using the four-equation system, we first estimate the model, as a benchmark, where money plays no role in determining output and inflation. Such a model is often called a "passive money paradigm".

Then, we estimate the model where money plays an explicit role in determining output and inflation. This model is often called an "active money paradigm".[26]

6.1 Passive money paradigm: benchmark model

Our benchmark model based on a passive money paradigm is described as follows:

(AD) $$y_t - y_t^n = \phi(y_{t-1} - y_{t-1}^n) - \sigma\left(i_{t-1} - E_{t-1}[\Delta p_t] - r_{t-1}^n\right) + \eta_t^{AD} \quad (7)$$

(AS) $$\Delta p_t = \theta \Delta p_{t-1} + (1-\theta)\Delta p_{t-2} + \lambda(y_{t-1} - y_{t-1}^n) + \eta_t^{AS} \quad (8)$$

(LM) $$\Delta rm_t - \Delta rm_t^n = \tau(\Delta rm_{t-1} - \Delta rm_{t-1}^n) - \psi(\varepsilon_{t-1}) + \eta_t^{LM} \quad (9)$$

where $$\varepsilon_t = \frac{\dfrac{M_t}{P_t} - e^{\gamma} Y_t^{\alpha}\left(\dfrac{i_t}{1+i_t} + \delta\right)^{-\beta}}{e^{\gamma} Y_t^{\alpha}\left(\dfrac{i_t}{1+i_t} + \delta\right)^{-\beta}} \approx rm_t - \alpha y_t + \beta \log\left(\frac{i_t}{1+i_t} + \delta\right) - \gamma$$

$$rm_t = m_t - p_t$$

and $$rm_t^n = \alpha y_t^n - \beta \log\left(\frac{i_t^n}{1+i_t^n} + \delta\right) + \gamma$$

(MP) $$i_t = \frac{i_t^* + \sqrt{(i_t^*)^2 + \omega}}{2} + \eta_t^{MP} \quad (10)$$

where $$i_t^* = i_t^n + \mu\left[\frac{(\Delta p_t - \pi_t^*) + (\Delta p_{t-1} - \pi_{t-1}^*)}{2}\right] + \nu(y_t - y_t^n)$$

$$i_t^n = \pi_t^* + r_t^n \text{ and } r_t^n = \Delta y_t^n + \text{constant}$$

Explanation of symbols in the above equations.[27]

y_t, output; y_t^n, potential output; $y_t - y_t^n$, output gap; Δy_t^n, potential growth rate; p_t, price level; Δp_t, inflation rate; m_t, nominal money balance (monetary base); rm_t, real money balance; Δrm_t, real money growth; rm_t^n, long-run desired real money balance; ε_t, percentage deviation of actual money balances from long-run desired money balances; i_t, call rate; i_t^*, desired call rate prescribed by simple policy rule; i_t^n, equilibrium nominal interest rate; r_t^n, equilibrium real interest rate; π_t^*, central bank's inflation target; $i_t - E_t[\Delta p_{t+1}]$, real interest rate; η_t^{AD}, demand shock; η_t^{AS}, supply shock; η_t^{LM}, monetary shock; η_t^{MP}, interest rate shock; ϕ, σ, θ, λ, τ, ψ, ω, μ, all the parameters are expected to be positive ($1 > \phi \geq 0$, $1 \geq \tau \geq 0$, $\omega > 0$, $\mu > 1$).

The aggregate demand function (7) and aggregate supply function (8) are conventional IS and Phillips curves.[28, 29] The money demand function (9) is a standard error correction model. Taking the zero

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[26] See Laidler (1999) and Engert and Selody (1998).

[27] See the data appendix for a detailed description of the data.

[28] In recent research on monetary policy, the IS curve and Phillips curve range from purely backward-looking specifications (eg in Rudebusch and Svensson (1999)) to forward-looking, theory-based optimising specifications. Here, we focus on the backward-looking model.

[29] Since we use the GDP deflator as inflation rate Δp_t, we do not need to add the exchange rate (or import prices) to the Phillips curve.

interest rate bound into account, we explicitly incorporate the non-negativity constraint on interest rates into the policy rule (10). Call rate i_t is equal to desired rate i_t^* prescribed by the simple policy rule when i_t^* is above zero, while i_t is set at zero when i_t^* is below zero.[30] This defines two linear relationships between i_t and i_t^* (if $i_t^* > 0$, $i_t = i_t^*$, otherwise $i_t = 0$). We assume that the relationship between the actual call rate and desired rate is slightly smoother than suggested by the linear formulas. We assume that this is approximated by a hyperbola with the two lines as asymptotes. The parameter ω in equation (10) measures the extent to which the hyperbola is distant from the two lines. As clear from the IS curve (equation (7)), we here assume that monetary policy operates with a one-period lag.

An important feature of the above model based on a passive money paradigm is that the real money stock (or its growth rate) appears in neither the IS nor the Phillips curve. This model therefore limits the influence of monetary policy on output and inflation to its effect on the real interest rate.[31] Money itself does not play any active role in the transmission mechanism of monetary policy.

We estimate the above model using GMM.[32] Since single-equation and system estimates sometimes differ a great deal, we conduct system estimation in order to appropriately evaluate the relationships between economic variables.[33] Fixing the starting point of regressions at 1978:Q1, we conduct rolling regressions and examine the stability of estimated parameters. We use the dummy variables, aiming to control for a Y2K-related temporary surge in liquidity demand during the final quarter of 1999. Graph 15 shows estimates of parameters from rolling regressions with the horizontal axis showing the end of the sample period for each regression. All the estimated parameters have the expected sign (positive) and are significant. In addition, all parameters, excluding τ and ψ in the money demand function, are stable. Around the final quarter of 2000, the persistence of money growth (τ) begins to increase and the adjustment speed of the money stock (ψ) begins to fall. The background of this result is not clear, but is partly due to the very low opportunity cost of holding money, which will reduce private agents' incentives to adjust cash balances quickly.

It should also be noted that the parameter μ in equation (10) statistically exceeds 1, that is, the so-called "Taylor principle" is satisfied.[34, 35] One piece of conventional wisdom to emerge from the recent study on monetary policy rules is that policy is stabilising when the central bank raises the nominal interest rate more than one-for-one with the inflation rate. Put differently, under a stabilising policy, in response to a rise in the inflation rate, nominal interest rates should rise sufficiently to increase real interest rates. This implies that monetary policy based on the interest rate channel stabilises the economy unless the non-negativity constraint on interest rates is binding.

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30 Consider the case when the central bank's loss function is the unconditional expectation of the discounted sum of quadratic deviations of output from potential and quadratic deviations of inflation from a target of zero. Given this assumption and the model comprising equations (7) to (9), the linear-quadratic nature of the problem implies that a simple representation of the optimal policy takes the following form similar to the Taylor rule, unless the non-negativity constraint on interest rates is binding:

$$i_t^* = i_t^n + \mu_1(\Delta p_t - \pi_t^*) + \mu_2(\Delta p_{t-1} - \pi_{t-1}^*) + \nu(y_t - y_t^n)$$

See Gerdesmeier et al (2002) for details. Here, we assume $\mu_1 = \mu_2$, which leads to equation (10).

31 Our benchmark model includes only short-term interest rates, not other yields of financial assets, such as exchange rates and equity prices. However, this does not imply that our model excludes the effects of monetary policy through a change in those yields. Our benchmark model adequately summarises this transmission mechanism with a single policy rate under two assumptions: first, monetary policy operates by changing some short-term interest rate; second, all other interest rates and asset prices are linked, directly or indirectly, to the policy rate through stable and predictable arbitrage relationships. However, when this is not the case, that is, when such a transmission cannot be summarised by a single policy rate due to the non-negativity constraint on interest rates, the monetary base may play a role in structural equations for aggregate demand or aggregate supply as a proxy for changes in the various yields of financial assets. This issue is treated in the next section.

32 The parameter of the long-run money demand function (α, β, γ, δ) is fixed at the value estimated over the full sample (see Table 2). We also set the parameter ω in equation (10) at 0.01 a priori.

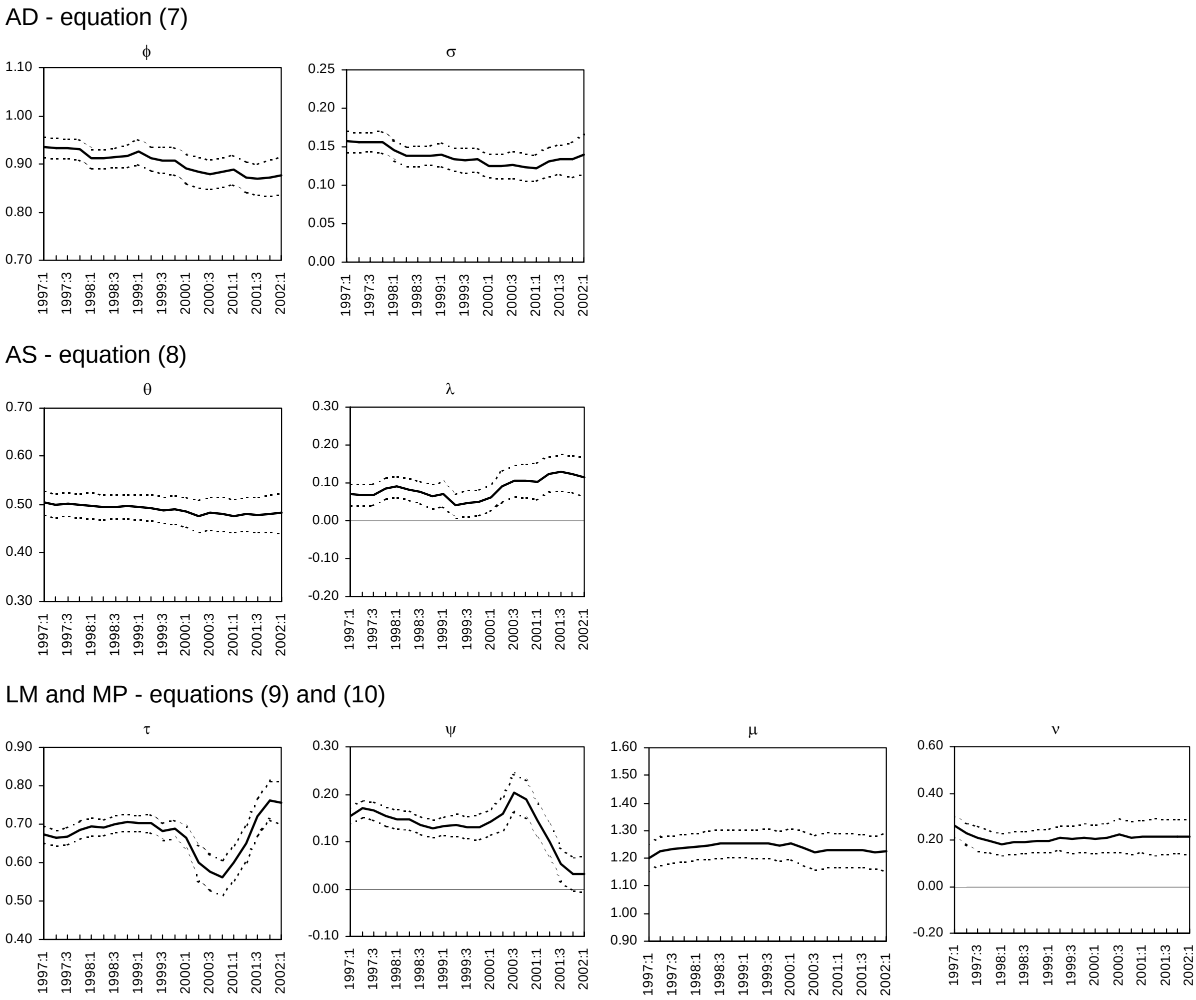
33 See, for example, Leeper and Zha (2001).

34 The estimated parameters of policy rule (10), $\mu \approx 1.2$ and $\nu \approx 0.2$, are slightly smaller than those of the original Taylor rule ($\mu = 1.5$, $\nu = 0.5$), but they are roughly the same.

35 See, for example, Taylor (1999) and Clarida et al (1999).

Graph 15

Passive money paradigm



Notes: 1. This graph shows estimates of parameters from rolling regressions with the horizontal axis showing the end of sample for each regression. The starting point of regression is fixed at 1978:Q1. 2. Dotted lines show the interval estimates of ±2 standard errors. 3. Effects of the Y2K problem (2000:Q1) and the removal of blanket deposit insurance for time deposits, etc (2002:Q1) are adjusted by dummy variables.

However, once shocks to aggregate demand and/or supply push the economy into a sufficiently deep recession, the zero bound in equation (10) renders the interest rate channel completely ineffective. Because of maintaining expectations of continuing deflation, a zero interest rate policy may not suffice for keeping the real interest rate below its equilibrium level. With a shock large enough to keep the short-term real interest rate above its equilibrium level, aggregate demand is suppressed further sending the economy into a deflationary spiral. This implies that the system comprising equations (7) to (10) is globally unstable. In the next section, we examine whether we can resolve this global instability, focusing on the monetary base channel that may continue to operate even when the interest rate channel is ineffective.

6.2 Active money paradigm

Modifying the benchmark model, we build a model based on an active money paradigm. There are two routes which allow the monetary base channel to work. The first is the possible presence of money terms in the aggregate demand function. The second is the possible presence of money terms in the aggregate supply function. If either route is secured, the central bank can still provide stimulus to the economy even at zero interest rates by increasing the monetary base. In the following, we investigate how effective these routes are.

Case 1 Effect of an increase in the monetary base on aggregate demand

Following Meltzer (1999a) and Nelson (2000), we add the monetary base as a determinant of aggregate demand to the conventional IS curve (7). The IS curve which we estimate here is as follows:

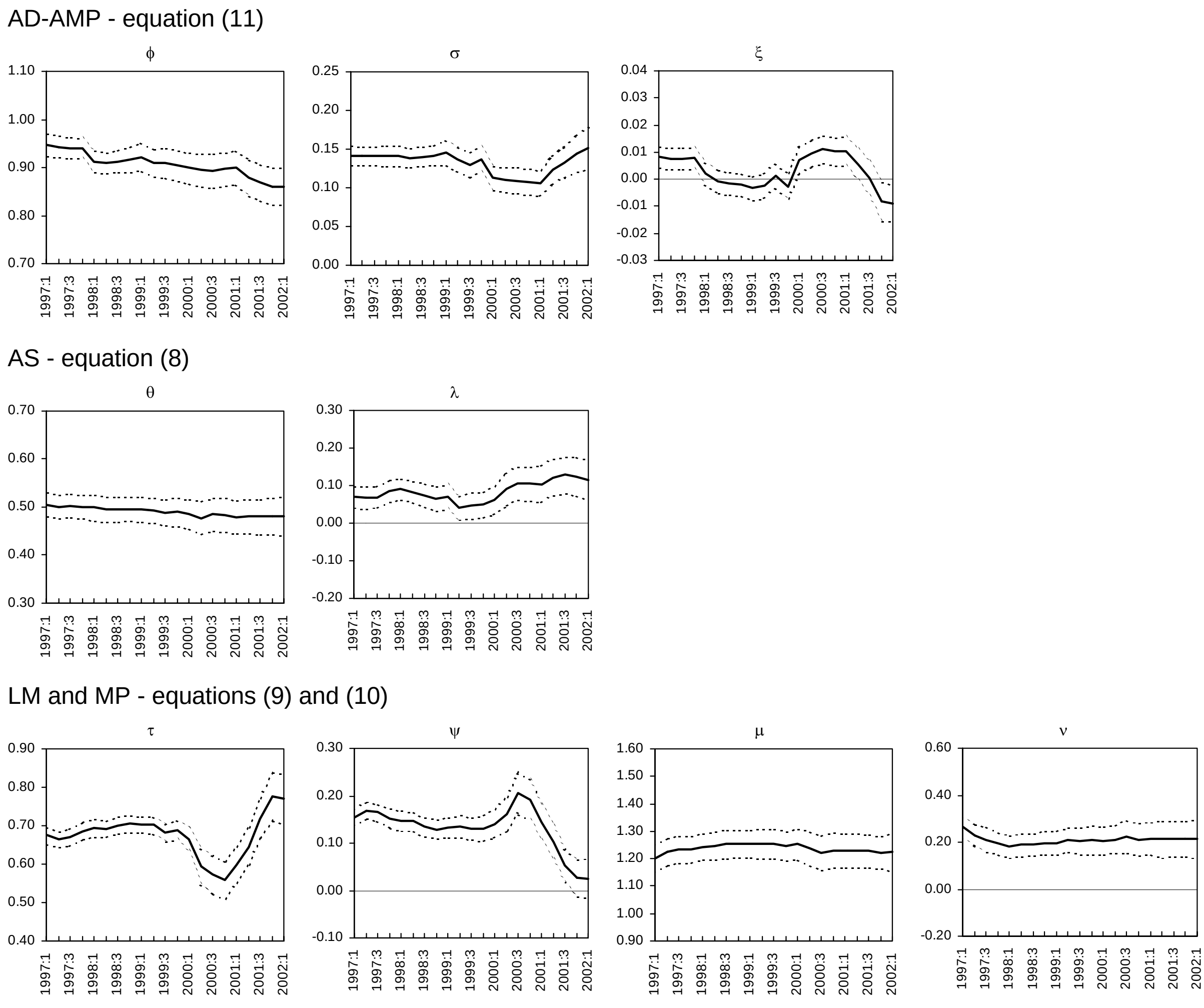
$$\text{(AD-AMP)} \qquad y_t - y_t^n = \phi(y_{t-1} - y_{t-1}^n) - \sigma\left(i_{t-1} - E_{t-1}[\Delta p_t] - r_{t-1}^n\right) + \xi(\Delta rm_{t-1} - \Delta rm_{t-1}^n) + \eta_t^{AD} \qquad (11)$$

where a one-period lag of real monetary base growth (less long-run desired growth), $\Delta rm_{t-1} - \Delta rm_{t-1}^n$, is added to the IS curve.

Conducting rolling regressions using GMM, we estimate equations (8), (9), (10) and (11). Estimation results are shown in Graph 16. Overall, adding real monetary base growth to the IS curve does not

Graph 16

Active money paradigm (Case 1)



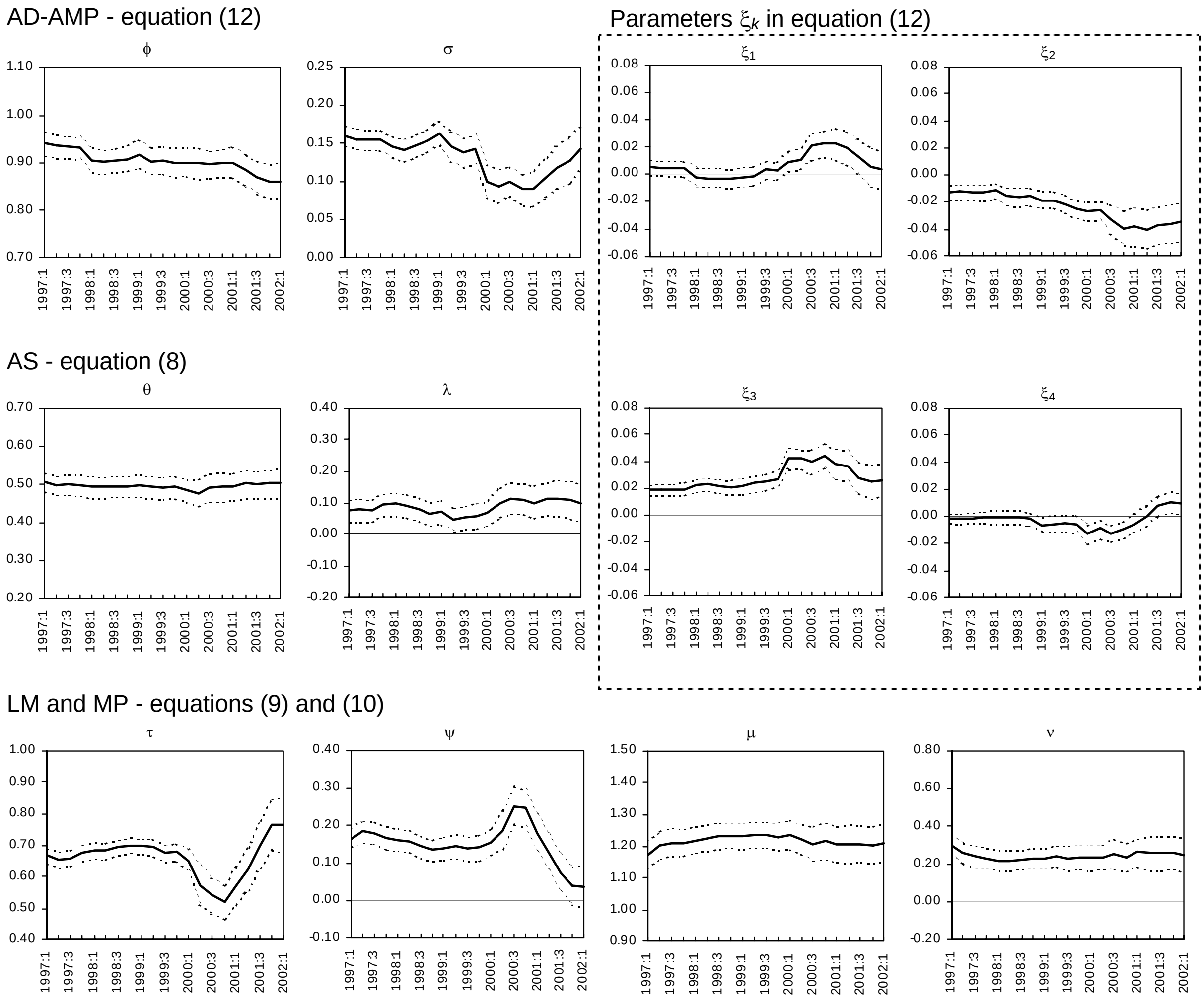
Notes: 1. This graph shows estimates of parameters from rolling regressions with the horizontal axis showing the end of sample for each regression. The starting point of regression is fixed at 1978:Q1. 2. Dotted lines show the interval estimates of ±2 standard errors. 3. Effects of the Y2K problem (2000:Q1) and the removal of blanket deposit insurance for time deposits, etc (2002:Q1) are adjusted by dummy variables.

lead to a change in the estimated parameters. All parameters, excluding parameter ξ, remain unchanged, and they are almost the same as those estimated under the passive money paradigm. What we should point out here is that the sensitivity of the output gap to a change in the monetary base (ξ) is very unstable. It varies considerably depending on the data set (the end of sample). For example, parameter ξ is significantly positive in 1997 and around the final quarter of 2000, but not so in 1999. Moreover, estimation with the full sample (1978:Q1-2002:Q1) results in a significant but wrong (negative) sign for parameter ξ. Even when parameter ξ is significantly positive, the size is rather small, 0.01 at most. This implies a long-run parameter of around 0.1 at most, which is below one seventh of that found for the United States and the United Kingdom by Nelson (2000).[36]

We now report several robustness checks.

Graph 17

Robustness check



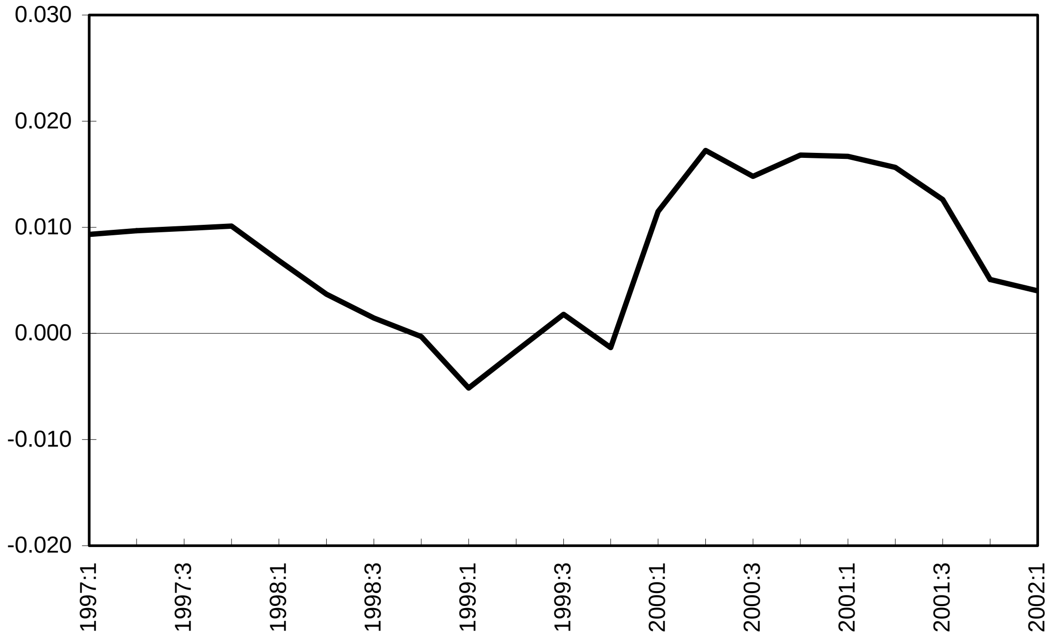
Notes: 1. This graph shows estimates of parameters from rolling regressions with the horizontal axis showing the end of sample for each regression. The starting point of regression is fixed at 1978:Q1. 2 Dotted lines show the interval estimates of ±2 standard errors. 3. Effects of the Y2K problem (2000:Q1) and the removal of blanket deposit insurance for time deposits, etc (2002:Q1) are adjusted by dummy variables.

[36] The long-run parameter on real monetary base growth is calculated as $\xi/(1-\phi)$. Nelson (2000) finds that the long-run parameter on real monetary base growth ranges from 3.0 to 3.84 for the United States and the United Kingdom. Since he does not annualise real monetary base growth, we divide his estimates by 4 to compare it with our results fairly.

Graph 18

Robustness check

$\sum_{j=1}^{4} \xi_j$



***p*-values of** $H_0 : \sum_{j=1}^{4} \xi_j = 0$

Notes: 1. The *p*-values are based on the likelihood ratio-type tests. The horizontal axis shows the end of sample for each test. The starting point of regression is fixed at 1978:Q1. 2. The dotted line shows the 5% significance level.

First, to check the sensitivity of the results to the lag specification, we estimate the following IS curve including the longer and more flexible lag of real monetary base growth:

$$y_t - y_t^n = \phi(y_{t-1} - y_{t-1}^n) - \sigma\left(i_{t-1} - E_{t-1}[\Delta p_t] - r_{t-1}^n\right) + \sum_{j=1}^{4} \xi_j (\Delta rm_{t-1-j} - \Delta rm_{t-1-j}^n) + \eta_t^{AD} \tag{12}$$

where four lags of real monetary base growth are added. Estimation results, shown in Graphs 17 and 18, suggest that all parameters, excluding ξ_i, remain unchanged and that the sum of estimated parameters ξ_i, $\Sigma\xi_i$, is roughly the same as parameter ξ in equation (11). The *p*-value of the null hypothesis of $\Sigma\xi_i = 0$ indicates that the effectiveness of the monetary base channel is highly uncertain. $\Sigma\xi_i$ is significantly positive in some periods, but not in others. Unlike the results of Graph 16, estimation with the full sample (1978:Q1-2002:Q1) results in an expected sign (positive) of $\Sigma\xi_i$, but it is not statistically significant. In addition, even the highest value of $\Sigma\xi_i$ is around 0.02, which is still very small.

Second, to check the robustness of our results, we have re-estimated the model by replacing real monetary base growth with the real money stock (less desired money demand), ε_t, in the IS curve.[37]

(AD-AMP) $$y_t - y_t^n = \phi(y_{t-1} - y_{t-1}^n) - \sigma\left(i_{t-1} - E_{t-1}[\Delta p_t] - r_{t-1}^n\right) + \xi(\varepsilon_{t-1}) + \eta_t^{AD} \tag{13}$$

Although we omit the results, this replacement does not change inferences about the effectiveness of the monetary base channel; namely, if any, it is highly uncertain and very small.

Finally, we estimate the model by adding nominal monetary base growth (less long-run desired growth) to the policy rule. When the monetary base channel works, it is optimal for the central bank to respond to the change in the monetary base in order to stabilise the economy.[38] Leeper and Zha (2001) suggest the possibility that estimating the model with different policy rules may result in different estimated parameters of the structural equation. To examine this possibility, we replace equation (10) with the following policy rule and then estimate the system comprising equations (8), (9), (11) and (14).

(MP) $$i_t = \frac{i_t^* + \sqrt{(i_t^*)^2 + \omega}}{2} + \eta_t^{MP} \tag{14}$$

where $$i_t^* = i_t^n + \mu\left[\frac{(\Delta p_t - \pi_t^*) + (\Delta p_{t-1} - \pi_{t-1}^*)}{2}\right] + \nu(y_t - y_t^n) + \rho(\Delta m_t - \Delta m_t^n)$$

$$\Delta m_t^n = \pi_t^* + \Delta rm_t^n$$

However, neither does this replacement change our main results. (Estimation results are omitted.[39])

Overall, these results suggest that the effectiveness of the monetary base channel is very uncertain, and we cannot find any certain route through which the central bank can provide stimulus to the economy at zero interest rates.

Case 2 Effect of an increase in the monetary base on inflation

Following Gerdesmeier et al (2002) and Gerlach and Svensson (2000), we replace the Phillips curve equation (8) with the following *P*-star model (henceforth *P**) as an aggregate supply function.[40]

(AS-AMP) $$\Delta p_t = \theta\Delta p_{t-1} + (1-\theta)\Delta p_{t-1}^* + \lambda(p_{t-1}^* - p_{t-1}) + \eta_t^{AS} \tag{15}$$

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[37] See Orphanides and Wieland (2000) for this specification.

[38] See Gerdesmeier et al (2002).

[39] The estimation results are available on request.

[40] The *P** model was originally proposed in Hallman et al (1991).

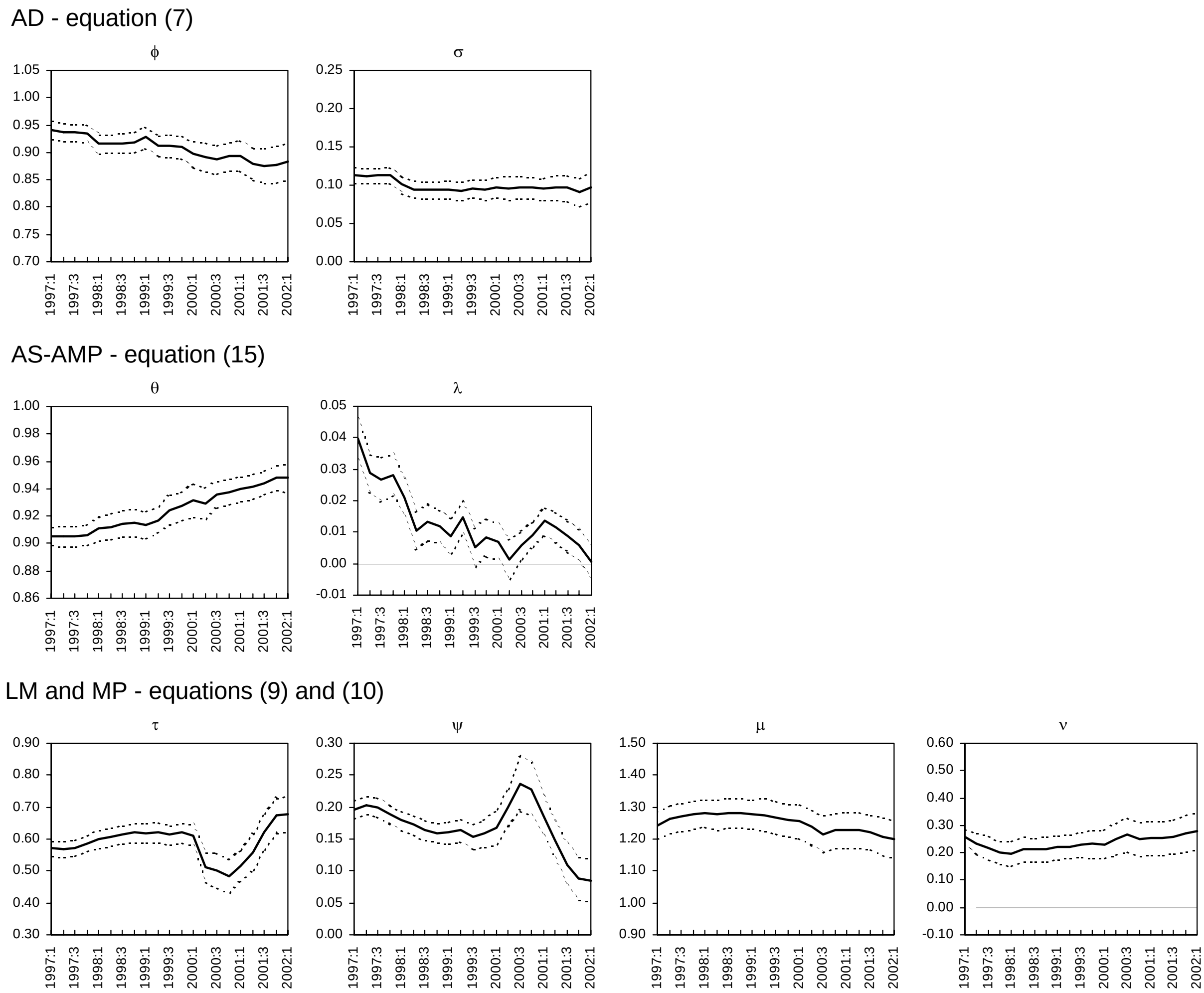
where $$p_t^* = m_t - \alpha y_t^n + \beta \log\left(\frac{i_t^n}{1+i_t^n} + \delta\right) - \gamma$$

$$p_t^* - p_t = rm_t - \left[\alpha y_t^n - \beta \log\left(\frac{i_t^n}{1+i_t^n} + \delta\right) + \gamma\right]$$

The P^* model assigns an active role to monetary developments in inflation dynamics. Although the microeconomic foundations of the P^* model are not well developed, the model can be implicitly related to the view that monetary disequilibria result in greater spending and thus more demand pressures (eg Laidler (1999)).[41] Specifically, inflationary pressure is related to the real money gap

Graph 19

Active money paradigm (Case 2)



Notes: 1. This graph shows estimates of parameters from rolling regressions with the horizontal axis showing the end of sample for each regression. The starting point of regression is fixed at 1978:Q1. 2. Dotted lines show the interval estimates of ±2 standard errors. 3. Effects of the Y2K problem (2000:Q1) and the removal of blanket deposit insurance for time deposits, etc (2002:Q1) are adjusted by dummy variables.

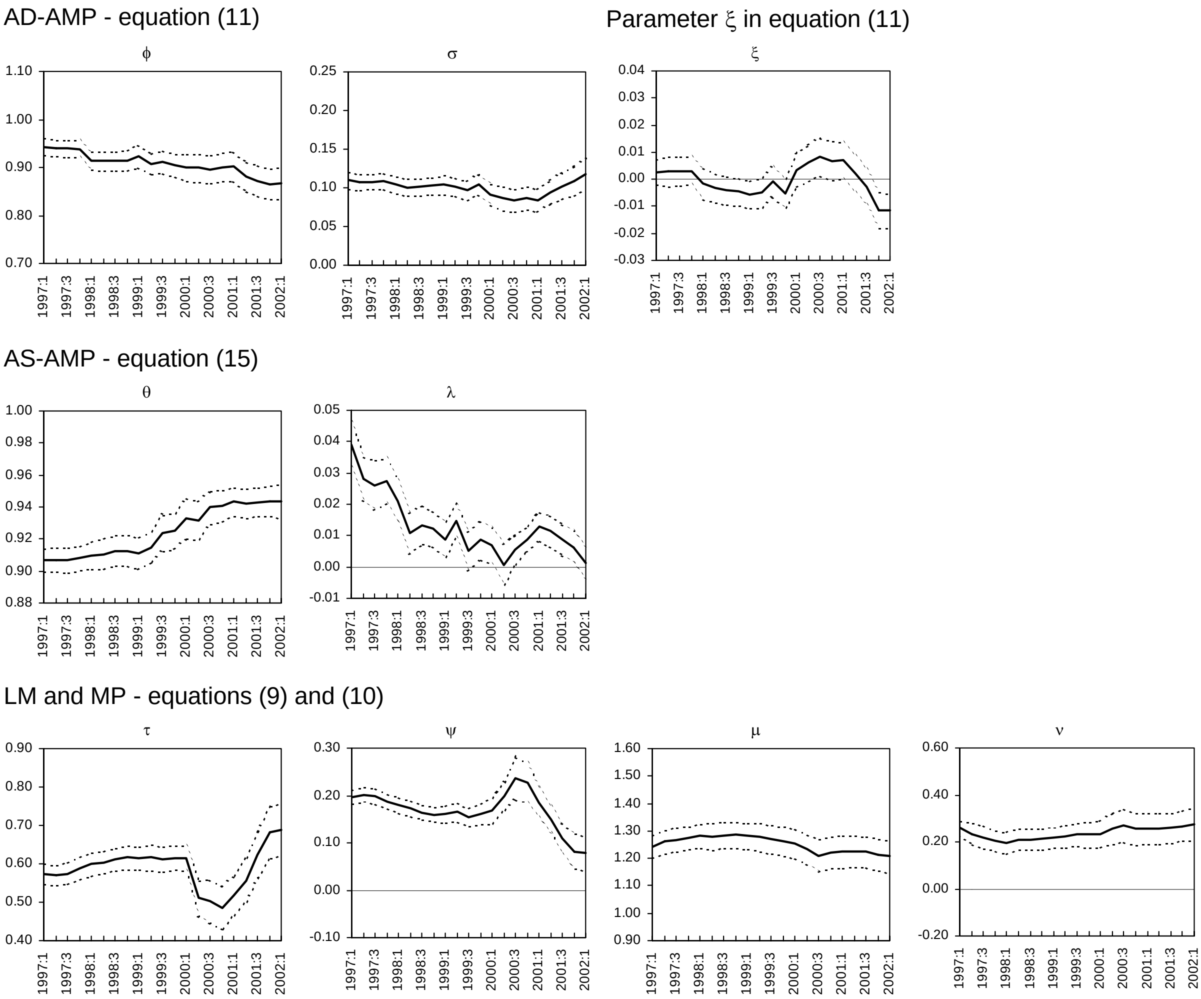
[41] More generally, the P^* model can be seen as a reduced form representing a monetary transmission with a long pedigree, namely one that places imperfections in the financial system, monetary expansions and the resulting credit booms and busts at the heart of explanations of macroeconomic developments (eg Friedman and Schwartz (1982), Kindleberger (1987) and Minsky (1982)).

$(p_t^* - p_t)$, which measures the excess of real money over that consistent with monetary equilibrium. Prices revert to the level implied by monetary equilibrium through an error correction process.[42]

Conducting rolling regressions using GMM, we estimate equations (7), (9), (10) and (15). Estimation results are shown in Graph 19. The sensitivity of the inflation rate to the real money gap (λ) is significantly positive when it is estimated over the subsample excluding the recent five years (1978:Q1-1997:Q1). However, it has continued to decline for the past five years. Parameter λ estimated over the full sample (1978:Q1-2002:Q1) is very close to zero. In addition, the sensitivity of the inflation rate to the change in the price level implied by monetary equilibrium, 1 – θ, has also continued to decline. Since the estimated parameter reflects the average effectiveness of the

Graph 20

Active money paradigm (Case 3)



Notes: 1. This graph shows estimates of parameters from rolling regressions with the horizontal axis showing the end of sample for each regression. The starting point of regression is fixed at 1978:Q1. 2. Dotted lines show the interval estimates of ±2 standard errors. 3. Effects of the Y2K problem (2000:Q1) and the removal of blanket deposit insurance for time deposits, etc (2002:Q1) are adjusted by dummy variables.

[42] Gerlach and Svensson (2000), Kimura (2001) and Orphanides and Porter (2000) apply the *P** model to Europe, Japan and the United States, respectively. They all find that the real money gap is a significant determinant of inflation.

monetary base channel during the long sample period, such a drastic decline in parameters λ and $1 - \theta$ may imply that the monetary base channel has hardly worked in the recent period, that is, at zero interest rates. Such an interpretation is consistent with the result of the time-varying VAR in Section 4.2.

Case 3 Effect of an increase in the monetary base on aggregate demand and inflation

Finally, consider the case combining Case 1 and Case 2. We assume that the monetary base is a determinant of both aggregate demand and aggregate supply by using equations (11) and (15). Estimation results are shown in Graph 20. The sensitivity of the output gap to the change in the monetary base (ξ) is not statistically significant, or does not have the expected sign. Like the results of Case 2, parameters λ and $1 - \theta$ in the P^* model have continued to decline for the past five years.

In sum, the results of this section suggest that the effectiveness, if any, of the monetary base channel is highly uncertain and very small. We cannot find any certain route through which the central bank can provide stimulus to the economy at zero interest rates.

7. Discussion

The results reported in the last two sections indicate that there is a satiation level of money demand and thus there may remain room for the monetary base channel to work even at zero interest rates, but that its effect, if any, is very uncertain and small. Why is it so uncertain and small? We first need to point out that since long-term interest rates were already at a very low level when the Bank of Japan adopted quantitative easing, room for further reducing them through monetary policy was limited, which is a factor weakening the expectation channel. In addition, Japan's economy has faced various kinds of uncertainties about the future course, including the NPL problem and structural adjustment of the economy as well as the short-run global economic outlook. These uncertainties have increased the risk premium of a wide range of financial and real assets, which seems to far exceed the quantitative magnitude of the effect of an increase in the monetary base. Let us briefly discuss two more hypotheses of the uncertain and small effects of the monetary base channel, focusing on a structural aspect of Japan's financial market in recent years.

The first is that precautionary demand for money reflecting financial system instability is highly volatile, which weakens the effect of the monetary base channel and makes its effect uncertain. Precautionary demand for liquidity increased substantially at the end of 1999 in preparation for the Y2K problem and in early 2001 during the process of introducing real-time gross settlement (RTGS). It also increased in September 2001 because of the terrorist attacks in the United States, the bankruptcy of a large retailer, and a fall in equity prices raising concerns over liquidity. Given a supply of the monetary base, the increase in precautionary demand for money reduces excess money which would otherwise be translated into demand for other assets and, ultimately, via effects on relative yields, into nominal spending.

The second hypothesis is that concerns about capital positions at private banks prevent them from taking risks, which fails in raising the relative price of risky assets and weakens the effect of the monetary base channel. The quantitative easing measures since March 2001 have not apparently changed banks' lending behaviour. Specifically, the declining trend in bank lending has mildly accelerated, while the growth in the money stock, deposits held by households and corporations, has changed little at an annual rate of around 3%. The decline in bank lending and moderate growth in deposits should result in an increase in some other investment. So far, banks have increased investment in government bonds and current accounts at the Bank of Japan, both of which are free of credit risks. Then, why has bank lending not increased? Financial institutions have faced the risk of their capital being impaired by external factors such as an accumulation of NPLs following a downturn in asset prices and the restructuring of industries and firms. Capital is the buffer against unexpected risks and losses. It is difficult for the management of financial institutions to take risks when they are concerned about their capital position. Therefore, the Bank's efforts to expand liquidity, current account balances at the Bank or the monetary base, do not lead to an increase in broad money, that is, liquidity held by the corporate and household sectors, and consequently do not push up prices and the level of business activity.

In sum, money cannot play a role as the superior index of monetary policy effects, at least not when precautionary demand for money is highly volatile or banks cannot take risks due to concerns about their capital position.

Still, a question may remain: even if the effects of the monetary base channel are very uncertain and small, why does the Bank not aggressively try the "unconventional" policy of purchasing some specific assets such as stocks and property in order to affect their prices? The problem is that, to have any promise of significant results, such unconventional policy operations would probably need to be implemented on a very large scale. However, beyond the fact that it would have to be very large, next to nothing is known about the magnitude of monetarisation required to achieve a given result. Moving in this direction is understandably difficult, since the cost of such unconventional policies increases substantially when uncertainty about the effects of the monetary base channel is taken into account.[43]

8. Concluding remarks

The Bank of Japan adopted a new monetary easing framework in March 2001. It is still too early to draw definite conclusions on the effects of the framework and, in this regard, conclusions in this paper are tentative until more data become available. As mentioned at the outset, the current state of Japan's economy is unprecedented in that it is confronted with both a zero interest rate boundary and sizeable NPLs, and thus we will continue to examine the tentative conclusions of this paper by cross-checking them in the light of facts and theories.

As to the most evident effects, we can point out that the abundant and flexible provision of liquidity under the quantitative easing framework successfully maintained extremely easy monetary conditions, thereby preserving financial market stability. Recall the difficulties we have experienced since the end of 2000, namely, a global economic retreat triggered by the bursting of the global IT bubble and the tragic events of 11 September. Additionally, Japan suffered from the adverse impact of structural adjustment and rising concerns over the financial system. It is thus significant that the Bank's flexible and abundant provision of liquidity calmed down market participants' concerns over liquidity financing. There is little doubt such accommodative monetary conditions played a key role in preventing a deflationary spiral.

Apart from this role in mitigating negative impacts, what other positive effects has the increase in the monetary base had on the economy? While we can enumerate several routes of the monetary base channel which suggest that expansion of the monetary base can have some expansionary effect on the economy, our analyses suggest that the quantitative magnitude of any such effect is highly uncertain and very small. Of course, we still cannot deny the possibility that the positive effect will increase and lead to a change in the portfolios of economic agents and ultimately stimulate economic activity in the long run. Once structural reforms such as the disposal of NPLs and the adjustment of industry-wide structure progress to a satisfactory degree, the quantitative easing policy will support them by alleviating the negative shocks occurring in a transition period, and might have stronger effects on the economy.[44] Based on the analysis of the policy effects and the economic situation, one should discuss what macro- and microeconomic policy should be sought for Japan's economy.

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[43] Another essential issue with respect to unconventional policy is the governance of a central bank in a democratic society. If a central bank purchases a variety of assets aggressively as a monetary policy, it is effectively stepping into the territory of fiscal policy. The reason is that the bank, by subsidising specific parties or by holding risky assets, has to incur a loss, which will be transferred to taxpayers in the end, and engages in micro policy regarding resource allocations. See Yamaguchi (2001) for details.

[44] On 11 October 2002, the Policy Board of the Bank of Japan approved basic guidelines on the purchase of stocks held by commercial banks. This approval was made in response to the Bank's announcement of 18 September 2002 ("New initiative toward financial system stability"), in which the Bank stated that it would explore possible policy measures to enhance financial institutions' efforts to reduce their shareholdings. The Bank does not regard the purchase of stocks as a liquidity provision measure in the form of monetary policy, and its decision is based on the understanding that market risk pertaining to the shareholdings of Japanese banks has become a significant destabilising factor for their management. On 11 October, the Bank also published a comprehensive review of the NPL problem entitled "Japan's nonperforming loan problem", which also responded to the "new initiative". The purpose of these actions is to facilitate resolution of the NPL problem and to secure financial system stability.

Data appendix

(1) Monetary base (m_t)

Seasonally adjusted by *X*12-ARIMA. The change in the reserve requirement ratio is also adjusted.

Source: Bank of Japan, *Financial and economics statistics monthly*.

(2) Output (y_t)

Real GDP seasonally adjusted by *X*12-ARIMA.[45] Outliers are adjusted in 1989:Q1 and 1997:Q1. This adjustment is aimed at capturing the temporary surge in demand ahead of the consumption tax hike.

Source: Cabinet Office, *National accounts*.

(3) Potential output (y_t^n)

Estimated by using the Hodrick-Prescott filter on y_t.

(4) Overnight call rate (i_t)

Uncollateralised rate (monthly average) is used for the sample after 1985:Q1, while the collateralised rate (monthly average) is used for that before 1984:Q4.

Source: Bank of Japan, *Financial and economics statistics monthly*.

(5) Price level (p_t) and inflation rate (Δp_t)

GDP deflator seasonally adjusted by *X*12-ARIMA. Level shifts are adjusted in 1989:Q2 and 1997:Q2. This adjustment is aimed at capturing the upward shift due to the consumption tax hike.

Source: Cabinet Office, *National accounts*.

(6) The Bank's inflation target (π_t^*)

We assume that the target range of the inflation rate is between 0.5 and 2.5% and that the target rate has a smooth underlying trend. Then, we estimate the following sigmoid function:

$$\pi_t = \pi_t^* + \zeta_t, \quad \pi_t^* = 2.5 - \frac{2}{1 + \exp[\rho(T - t)]}, \quad \rho > 0$$

where ζ_t is the error term. For very large ρ, π_t* essentially collapses to a step function that equals 2.5% when $t < T$ and equals 0.5% (=2.5 − 2) when $t > T$. In this case, the estimate of T offers the best estimated location of the structural break. We estimate this sigmoid function by non-linear least squares. The estimated midpoint of the transition (determined by T) is 1987:Q2. The estimated value of parameter ρ is 0.139.

(7) The inflation rate, interest rate, and growth rate of the monetary base are all measured in percentages at an annual rate.

[45] The sample after 1980:Q1 is based on 93SNA, while that before 1979:Q4 is based on 68SNA.

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Asset price movements and monetary policy in South Korea

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1. Introduction

In a market economy the prices of both financial assets and goods have the role of providing information. They give signals regarding the distribution of resources in the economy. This means that fluctuations in asset prices are useful as long as they reflect changes in expectations regarding the fundamental development of the economy. Optimistic expectations of future growth in the entire economy or in a particular industry can be expressed, for instance, in the form of rising share prices, as there are then expectations of a strong development in profits and a high real return on investment (ROI). However, in general, investors are often over-optimistic regarding future profits and asset prices rise more than is later proved to be warranted. Asset price bubbles can also be created by imperfections in the financial markets. Bonus systems designed to enable brokers to benefit when the stock market rises, while others have to bear the costs of a fall in share prices, are examples of this type of imperfection.

If households increase their consumption as a result of exaggerated increases in the value of assets, it could lead to the build-up of large real and financial imbalances. In addition, companies can increase their investments as a result of lower financing costs on a risk capital market with overvalued share prices, but also because a rise in the value of a company's assets increases its credit rating. Therefore, when the bubble bursts and asset prices fall, it could lead to heavily indebted households and companies increasing their savings considerably and to a fall in consumption and investment. Falling asset prices thus risk triggering processes that could eventually lead to a recession.

Following the widespread financial deregulation and increased globalisation of capital markets since the early 1980s, industrial economies have witnessed a clear upward trend in asset prices. However, in some cases, such as Japan and Scandinavia during the late 1980s and early 1990s, the asset price collapse after the boom turned out to have serious disruptive effects on the domestic financial system and contributed to prolonged recessions. Furthermore, as the harmful effect of large asset price movements appeared again in emerging markets in the Asian financial crisis, debate about the appropriate response of monetary policy to asset price movements has intensified recently. Nevertheless, to obtain an appropriate monetary policy response to asset price fluctuations, a better understanding of asset price movements and the linkages between asset prices and inflation is required.

This paper examines whether asset price bubbles have ever developed in South Korea and explores the relationship between changes in asset prices and inflation in order to present implications about monetary policy. Section 2 provides an interpretation of asset price changes to find whether asset price movements have been driven by fundamentals in South Korea. MRS, unit-root and cointegration tests are performed in this section. Section 3 investigates the relationship between asset price movements and inflation in South Korea to verify whether asset price movements serve as a leading indicator of upcoming inflation. A graphical analysis and an investigation of cross correlations are initially performed. Then, an empirical analysis using ordinary least squares (OLS) estimation is implemented to check the predictive power of asset price movements for future inflation. Based upon the results of the analyses given in Sections 2 and 3, Section 4 presents some implications for monetary policy with a focus on the response to asset price fluctuation. Section 5, which sets out concluding remarks, summarises the empirical results of this paper and presents some conclusions.

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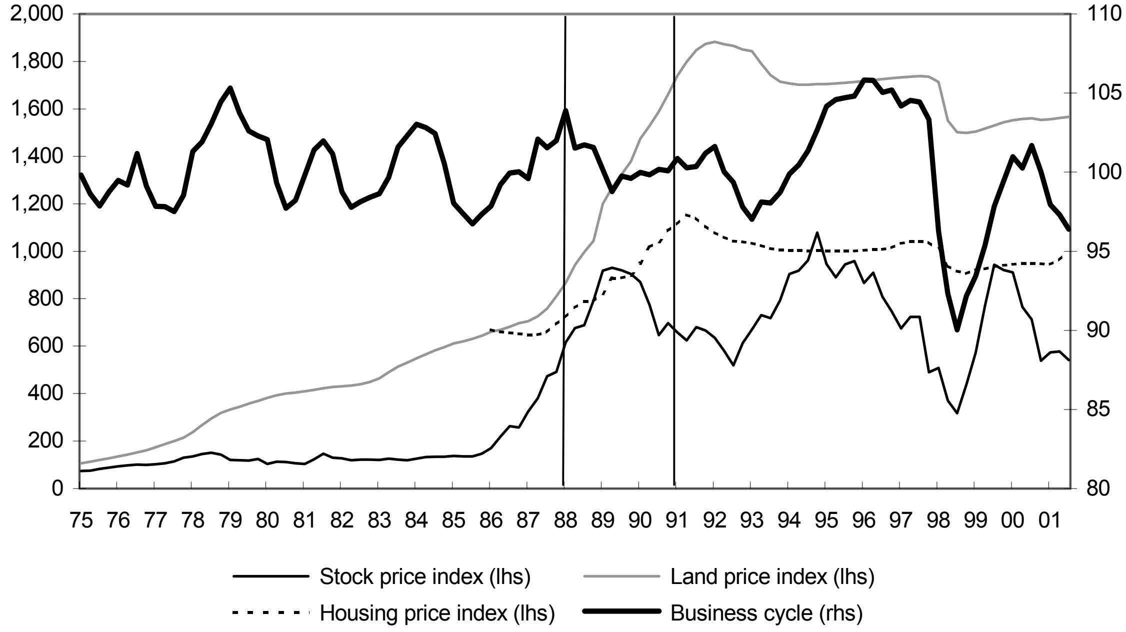
2. Interpreting asset price movements

For monetary policy to respond to asset price movements appropriately, it is crucial to distinguish asset price movements driven by economic fundamentals from asset price bubbles. However, the interpretation of asset price changes is not a straightforward task due to the various ways of deriving the asset price determined by fundamentals.

Graph 1 shows the stock, land and housing price indices and the business cycle in South Korea. The trends of these indices indicate that whereas the business cycle was moving into a trough from the late 1980s to the early 1990s, all the asset price indices were increasing. Therefore, if there have been asset price bubbles in South Korea in the recent past, this graphical information shows that they may have appeared in this period, from the late 1980s to the early 1990s.

Graph 1

Asset price indices and the business cycle



The bulk of the bubble-testing literature may be divided according to the use of one of the three types of tests. The first type examines the relationship between the observed price and the present-value price or the fundamentals used to forecast it. For example, tests of the bubble hypothesis in exchange rates - Meese (1986), Chinn and Meese (1995) and Taylor (1995) - examine the existence of a long-run equilibrium (cointegrating) relationship among the exchange rate, money supply and prices. Tests of the bubble hypothesis in stock markets - Campbell and Shiller (1987) and Campbell et al (1997) - examine the existence of equilibrium (cointegrating) relationships between prices and dividends. A second type of bubble test compares the volatilities of observed prices and the present-value prices, for example Shiller (1981), LeRoy and Porter (1981), Mankiw et al (1985) and West (1987). The third type of test is more elaborate and indirect: it estimates a reduced-form price equation by two alternative methods and verifies whether the parameter values are the same.

For the analyses in this section, the first- and second-type bubble tests[2] are chosen due to their simple structure.

[2] I would like to thank Dr Seong-Hun Yun (Research Department, The Bank of Korea) for allowing me to quote his MRS test results in “Impact of Rapid Asset Price Movements on Consumption” (2002).

2.1 Volatility tests

The bubble test initially suggested by Shiller (1981) uses volatilities of asset prices as a measure of determining whether or not the asset prices form a bubble. Shiller's test may be summarised as follows.

Consider the standard present value relation:

$$P_t = \sum_{k=0}^{\infty} \gamma^{k+1} E_t D_{t+k} \tag{1}$$

where P_t is the price of the stock (or other asset) at time t, D_{t+k} is the dividend paid at time $t+k$, E_t is the expectation conditional on information available at time t, and γ is the discount factor, or $1/(1+r)$, where r is the required rate of return.

Define P_t^* as the "perfect foresight", or "ex post rational" stock price. That is:

$$P_t^* = \sum_{k=0}^{\infty} \gamma^{k+1} D_{t+k} \tag{2}$$

P_t^* is the present value of actual, rather than expected, dividends. Since $P_t = E_t(P_t^*)$, $P_t^* = P_t + \nu_t$ where ν_t is the error in forecasting P_t^*. As a rational forecast error, ν_t is uncorrelated with information available at time t, for example P_t. Thus:

$$V(P_t^*) = V(P_t) + V(\nu_t) \tag{3}$$

where $V(x)$ is the variance of x. Therefore:

$$V(P_t^*) \geq V(P_t) \tag{4}$$

The variance of P_t^* thus presents an upper bound to the variance of the observed stock price in an efficient market. However, as there is a possibility of a non-normal distribution problem in Shiller's test with a small sample size, Mankiw et al (1985) suggest a modified volatility test (MRS test), which is immune to the problem.

Let P_t^0 be some "naive forecast" stock price:

$$P_t = \sum_{k=0}^{\infty} \gamma^{k+1} F_t D_{t+k} \tag{5}$$

where $F_t D_{t+k}$ denotes a naive forecast of D_{t+k} made at time t. This naive forecast need not be a rational one. It is important, however, that the rational agents at time t have access to this naive forecast. From this identity:

$$P_t^* - P_t^0 = (P_t^* - P_t) + (P_t - P_t^0) \tag{6}$$

We can derive an equation as follows:

$$E_t(P_t^* - P_t^0)(P_t - P_t^0) = 0 \tag{7}$$

since P_t and P_t^0 are known at time t. Squaring both sides of equation (6) and taking the expectation this produces:

$$E_t(P_t^* - P_t^0)^2 = E_t(P_t^* - P_t)^2 + E_t(P_t - P_t^0)^2 \tag{8}$$

This equality implies:

$$E_t(P_t^* - P_t^0)^2 \geq E_t(P_t^* - P_t)^2 \tag{9}$$

and

$$E_t(P_t^* - P_t^0)^2 \geq E_t(P_t - P_t^0)^2 \tag{10}$$

As equations (9) and (10) are derived under the assumption that the market is efficient, the violations of these inequalities indicate that there are bubbles in the asset prices.

2.1.1 Testing for stock prices

To verify whether there have been bubbles present in stock prices, an MRS test is performed. For the actual price, the average price of stocks traded in the market is used. Earnings per share (EPS), instead of the dividend,[3] are discounted using the discount rate to derive the ex post rational stock price. The discount rate is determined by the real rate of return, which is assumed to be 10-15%. The naive value at $t+k$ is computed under the assumption that the EPS at $t+k$ continue in the future. As can be seen from Table 1, equations (9) and (10) are violated at the discount rates of both 10% and 15%. Therefore, the existence of asset price bubbles is demonstrated by an MRS test. Despite uncertainty as to the precise period, Graph 1 strongly implies that it lasted from the late 1980s to the early 1990s.

Table 1

MRS test for stock prices[1]

Mankiw-Romer-Shapiro test [2]

$E_t(P_t^* - P_t^0)^2 \geq E_t(P_t^* - P_t)^2$ and $E_t(P_t^* - P_t^0)^2 \geq E_t(P_t - P_t^0)^2$

Discount rate	$E_t(P_t^* - P_t^0)^2$	$E_t(P_t^* - P_t)^2$	$E_t(P_t - P_t^0)^2$
10%	0.137	0.477	0.761
15%	0.092	0.232	0.352

[1] Time period: 1981-2000. [2] The actual stock price is used as a weight for the derivation to prevent the impact of the stock price level on the mean square error.

2.1.2 Testing for housing prices

Due to problems of data availability for land prices, the MRS test is applied only for housing prices. Since only the index is available for housing prices, the actual, ex post rational and naive housing prices are derived[4] using the monthly housing and house-leasing price index announced by Housing and Commercial Bank of Korea. As shown in Table 2, equation (10) is violated. Therefore, the existence of asset price bubbles is proved by the MRS test. Also, Graph 1 strongly implies that the period when the bubble existed was from the late 1980s to the early 1990s.

[3] Earnings per share are more closely related to actual stock prices than are dividends in South Korea.

[4] I assume that the ratio of the house-leasing price to the housing price is 60% and that the housing price is 1,000 in November 2001. Then, the monthly housing prices and house-leasing prices are derived using the housing and house-leasing price index. To obtain the ex post rational housing price which is the sum of the discounted monthly rent, the monthly rent is calculated from the multiplication of the house-leasing price and market interest rate. For the discount rate,

Table 2

MRS test for housing prices[1]

Mankiw-Romer-Shapiro test [2]

$$E_t(P_t^* - P_t^0)^2 \geq E_t(P_t^* - P_t)^2 \text{ and } E_t(P_t^* - P_t^0)^2 \geq E_t(P_t - P_t^0)^2$$

Discount rate	$E_t(P_t^* - P_t^0)^2$	$E_t(P_t^* - P_t)^2$	$E_t(P_t - P_t^0)^2$
1%	0.102	0.021	0.117
1%[3]	0.096	0.022	0.115

[1] Time period: January 1986-March 2001. [2] The actual housing price is used as a weight for the derivation to prevent the impact of housing price levels on the mean square error. [3] The MRS test statistics are adjusted to minimise the impact on monthly rent of the unusually high market interest rate right after the financial crisis in 1997.

2.2 Unit-root and cointegration tests

An asset price bubble may be thought of as an explosive component of the asset price which is not present in the underlying fundamentals such as the dividend and which, therefore, induces an explosive wedge between the stock price series and the underlying fundamentals. If stock prices and dividends are realisations of I(1) processes, in the absence of bubbles the standard present-value model of stock prices implies cointegration between the stock price and dividend series, implying that the difference between the stock prices and a multiple of the dividend should define a stationary process - Campbell and Shiller (1987), Diba and Grossman (1988) and Campbell et al (1997).

Consider the ex post stock return r_{t+1}, defined as:

$$r_{t+1} \equiv \log(P_{t+1} + D_{t+1}) - \log(P_t) \tag{11}$$

where P is the stock price and D is the dividend. Taking a Taylor series approximation of equation (11), Campbell et al (1997) derive the relationship:

$$r_{t+1} \approx k + \rho_{t+1} + (1-\rho)d_{t+1} - p_t \tag{12}$$

where $\rho \equiv \dfrac{1}{[1+\exp(d-p)]}$, $k \equiv -\log(\rho) - (1-\rho)\log(\dfrac{1}{\rho} - 1)$ and d–p is the average log dividend-price ratio, where lower-case letters denote the logarithms of the variables. Solving equation (12) forwards, imposing the transversality condition that:

$$\lim_{j \to \infty} \rho^j p_{t+1} = 0 \tag{13}$$

and taking expectations conditional on information at time t, we obtain:

$$p_t = \frac{k}{1-\rho} + E_t\left[\sum_{j=0}^{\infty} \rho^j [(1-\rho)d_{t+1+j} - r_{t+1+j}]\right] \tag{14}$$

Rearranging this equation, we can derive an equation for the log dividend-price ratio:

$$d_t - p_t = \frac{k}{1-\rho} + E_t\left[\sum_{j=0}^{\infty} \rho^j [-\Delta d_{t+1+j} - r_{t+1+j}]\right] \tag{15}$$

an average long-term deposit rate (1986-2001) is used. The naive housing price at $t + k$ is derived under the expectation that the future monthly rent is the same as the one at $t + k$.

Equation (5) indicates that the log dividend-price ratio will be a stationary I(0) process if and only if the stock price return series r_t is generated by a stationary process under the assumption that d_t and p_t are each generated by I(1) processes. However, testing for stationarity of the log dividend-price ratio is not eligible in the non-stationary r_t model. Therefore, equation (15) is rearranged as:

$$d_t - p_t - \frac{1}{1-\rho} r_t = \frac{k}{1-\rho} + E_t\left[\sum_{j=0}^{\infty} \rho^j [-\Delta d_{t+1+j} + \frac{1}{1-\rho} \Delta r_{t+1+j}]\right] \tag{16}$$

which only requires a test for cointegration between the log dividend-price ratio and the stock return to verify the presence of a bubble in stock prices. In the presence of bubbles in stock prices, cointegration between the log of prices and the log of dividends, or between the log dividend-price ratio and the real rate of return cannot be established.

The procedure for testing for bubbles is as follows. First, unit-root tests for stationarity of the log dividend-price ratio and the ex post rate of return are performed. Then, if r_t is tested to be non-stationary, cointegration between the log dividend-price ratio and the rate of return is examined through cointegration tests. If the log dividend-price ratio series and the ex post return series were both stationary, or if the log dividend-price ratio series and ex post returns cointegrated to a stationary series, this would suggest a rejection of the hypothesis of stock price bubbles.

2.2.1 Testing for stock prices

Results of unit-root tests for stock prices in South Korea are provided in Table 3. Whereas the MRS tests apply annual data, monthly data are used for unit-root tests. Since the I(1) null hypothesis can be rejected at the 5% level for r_t and $(d - p)_t$, without the assumption of the non-stationarity of d_t and p_t, it is concluded that there have been no bubbles in the stock prices. However, as the non-stationarity of d_t is rejected in the Phillips-Perron test and that of p_t is rejected in both the ADF and Phillips-Perron tests, the claim that there have been no bubbles is not persuasive. Furthermore, due to the stationarity of r_t, no additional cointegration tests between r_t and $(d - p)_t$ can be applied in this model. Therefore, the existence of bubbles in stock prices cannot be decided by unit-root and cointegration tests.

Table 3

Unit-root tests[1] on d_t, p_t, $(d - p)_t$ and r_t[2]

	ADF test		Phillips-Perron test	
	I[3]	II[4]	I[3]	II[4]
d_t	–1.8453	–2.1269	–6.2979*	–8.1541*
p_t	–3.0612*	–3.6714*	–6.1498*	–6.2401*
$(d - p)_t$	–4.1412*	–4.4562*	–3.2835*	–3.0090*
r_t	–7.7829*	–7.8299*	–23.4129*	–23.5522*

* Significant at the 5% level.

[1] The 5% critical values for I and II (ADF test) are –2.8777 and –3.4359 for d_t, p_t and $(d - p)_t$, and –2.8771 and –3.4350 for r_t. For the Phillips-Perron test, the 5% critical values for I and II are –2.8767 and –3.4344 for d_t, p_t and $(d - p)_t$, and –2.8768 and –3.4345 for r_t. [2] Time period: January 1986-November 2001. [3] Regression with an intercept. [4] Regression with an intercept and a linear trend.

2.2.2 Testing for housing prices

While the unit-root and cointegration tests for stock prices have been performed frequently, tests for housing prices have not been tried. Regarding housing prices and house-leasing prices, P_t and D_t, respectively, Table 4 shows the results of unit-root tests for d_t, p_t, r_t and $(d - p)_t$. Although the null hypothesis of non-stationarity for $(d - p)_t$ cannot be rejected in the ADF test and Phillips-Perron test in

Table 4, we cannot determine that there have been bubbles in housing prices due to the non-stationarity of r_t indicated by the results of the ADF test.

Table 4

Unit-root tests[1] on d_t, p_t, $(d - p)_t$ and r_t[2]

	ADF test		Phillips-Perron test	
	I[3]	II[4]	I[3]	II[4]
d_t	–2.5198	–2.0239	–2.2716	–1.8205
p_t	–3.2805*	–3.1149	–2.0121	–1.5136
$(d - p)_t$	–2.2955	–2.1419	–2.5146	–2.3278
r_t	–2.2585	–2.7076	–7.2651*	–7.2615*

* Significant at the 5% level.

[1] The 5% critical values for I and II (ADF test) are –2.8777 and –3.4359 for d_t, p_t and $(d - p)_t$, and –2.8771 and –3.4350 for r_t. For the Phillips-Perron test, the 5% critical values for I and II are –2.8767 and –3.4344 for d_t, p_t and $(d - p)_t$, and –2.8768 and –3.4345 for r_t. [2] Time period: January 1986-November 2001. [3] Regression with an intercept. [4] Regression with an intercept and a linear trend.

Therefore, to find evidence for the presence of bubbles, residual-based tests for cointegration of r_t and $(d - p)_t$ are employed. Besides the ADF test, the Phillips-Ouliaris-Hansen (1990) test is applied to consider the spurious regression problem generated by using a non-stationary process, r_t and $(d - p)_t$. Since r_t and $(d - p)_t$ are proved not to have a deterministic trend, test statistics for the model without a deterministic time trend are reported in Table 5. All the test statistics indicate that the null hypothesis of non-cointegration can be rejected at the 5% significance level. Therefore, the results of the tests suggest that there have been no bubbles in housing prices.

Table 5

Residual-based tests[1] for cointegration of r_t and $(d - p)_t$

ADF test[2]	**Phillips-Ouliaris-Hansen test[2]**	
	$Z\rho$[3]	Z_t[3]
–7.8261*	–33.4714*	–4.2949*

* Significant at the 5% level.

[1] The 5% critical value for the ADF test is –3.37. For the Phillips-Ouliaris-Hansen test, the 5% critical values for Z_ρ and Z_t are –20.5 and –3.37. [2] Regression with intercept. [3] See appendix for the derivation of Z_ρ and Z_t.

2.3 Implications from the results of the tests

While the results of the MRS tests performed in Section 2.1 suggest that there have been bubbles in asset prices in South Korea, the unit-root and cointegration tests performed in Section 2.2 reject the presence of bubbles in some asset prices, for example housing prices. Therefore, the results of tests depend heavily on the frequency of data and the type of test.

Even though the graphical information in Graph 1 suggests that the bubbles could exist from the late 1980s to the early 1990s, empirical tests do not provide us with any decisive information about the presence of bubbles. As mentioned before, this implies that distinguishing bubbles from the fundamentals is not a straightforward task.

3. Change in asset prices and inflation

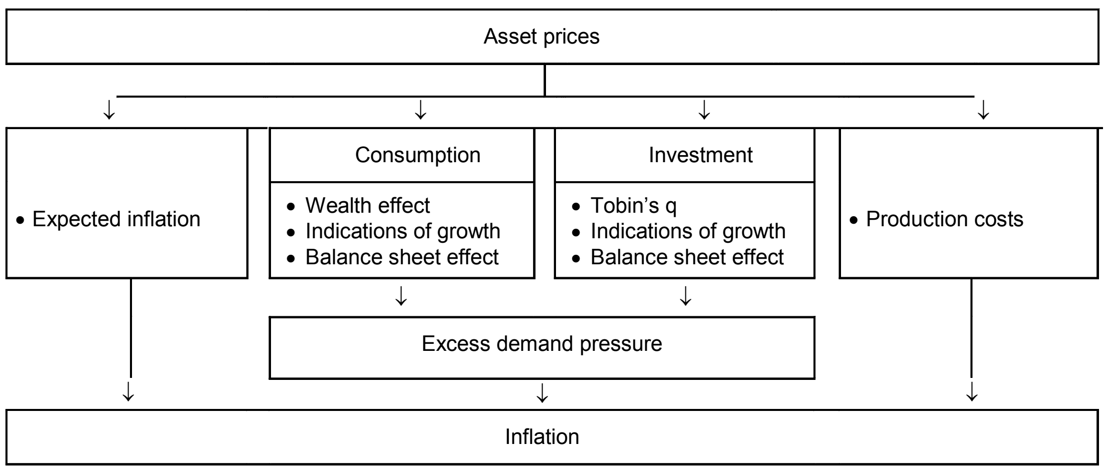
A private agent in an economy has various assets such as bonds, equities and foreign exchange categorised as financial assets and a house and land grouped as real estate. Recent research - Borio et al (1994), Goodhart and Hofmann (2000) and Ray and Chatterjee (2001) - suggests that asset price fluctuations have predictive content for future inflation, such as the expected inflation rate reflected in asset price movements, and induce future inflation via transmission channels running from asset prices to inflation.

First, the predictive power of asset price movements for future inflation can be understood by the Fisher equation. The Fisher equation, $i = r + \pi^e$, where i, r and π^e denote the nominal interest rate, the real interest rate and the expected inflation rate, respectively, shows that the information content of financial asset prices as embodied in nominal interest rates can be assessed in the absence of risk premia and money illusion and with r as a constant. Assuming a relationship can be drawn between the expected inflation rate and the actual future inflation rate, the one-to-one relationship between the nominal interest rate and expected inflation rate in the Fisher equation implies information about the future inflation rate. Some empirical studies - Fama (1977) and Mishkin (1990a) - have generally confirmed that current asset prices, for example nominal interest rates, provide reliable forecasts of future inflation up to a certain period.

Second, it has been argued that the impact of asset price movements is transmitted to inflation via various channels (see Figure 1). The two main channels are private consumption and investment. Rising asset prices, such as stock or property prices, affect private consumption by raising lifetime wealth, signalling higher expected wage incomes and increasing the value of collateral, which influences the borrowing capacity of private agents. An increase in asset prices affects investment by lowering the cost of new capital relative to existing capital (Tobin’s q), providing an impetus to current investment based on expected future growth of output (the “flexible accelerator” model) and improving banks’ balance sheets and thus inducing banks to lower interest charges on loans. Empirical evidence - Kent and Lowe (1997) and Browne et al (1998) - confirms the impact of stock and property prices on private consumption and investment in industrialised countries, although the magnitude of the effect varies, depending on the share of the assets in national wealth and the nature of corporate and banking laws.

Figure 1

A transmission mechanism of asset prices to inflation



Based on the implications suggested in the above discussion, the relationship between asset price movements and the inflation rate in South Korea is investigated in the following subsections. For this purpose, recent trends in the nominal interest rate, interest rate spreads, stock prices and property prices are first reviewed. For stock prices and property prices, their troughs and peaks are compared with those of the inflation rate. In addition, cross correlations between asset prices and the inflation rate are checked. The predictive power of asset price movements for the inflation rate is examined by the estimation of the inflation forecasting models in the final subsection.

3.1 Relationship between asset prices and the inflation rate[5]

3.1.1 Nominal interest rate and interest rate spreads

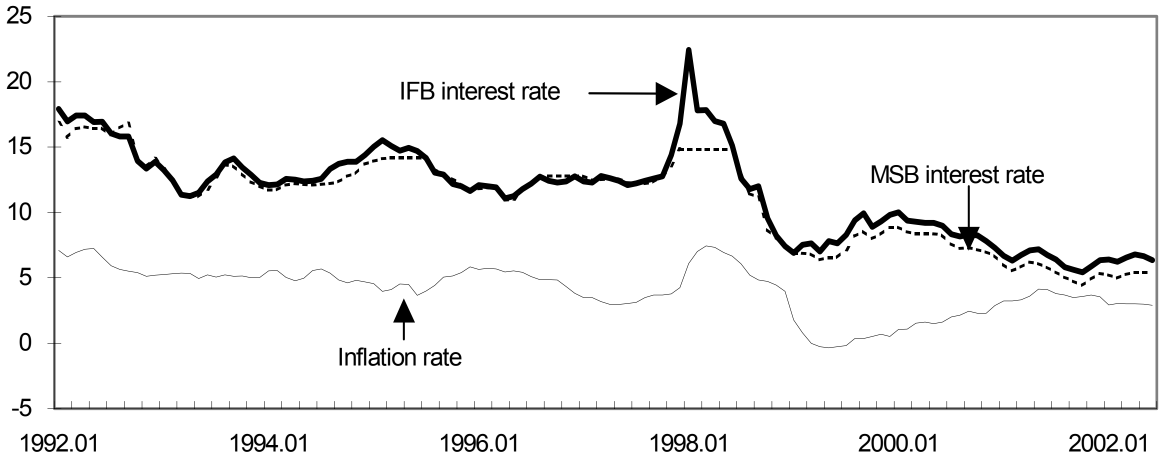
The period selected for investigation in this analysis is 1992-2001 in view of the fact that the first stage of interest rate deregulation was carried out in late 1991. For long-term interest rates, yields on monetary stabilisation bonds (one year) and industrial finance bonds (three years) are employed. For short-term interest rates, yields on certificates of deposit (CDs) (91 days) are used. A modified consumer price index (CPI) excluding farm products[6] and petroleum prices is employed in this subsection to minimise the effect of exogenous components, such as weather and foreign product prices, on the inflation rate index.

The trends of the nominal interest rate and the inflation rate in Graph 2 do not reveal any graphically detectable correlation. In particular, the nominal interest rate does not lead the inflation rate during the period 1992-2001. However, the trend in the interest rate spread in Graph 3 indicates that it has led the change of the inflation rate[7] by approximately four quarters since the mid-1990s.

Graph 2

Trends in the nominal interest rate and the inflation rate

In percentages



Note: IFB = industrial finance bonds; MSB = monetary stabilisation bonds.

The graphical analysis performed in the above discussion shows that the interest rate spread has more information about the future inflation rate than the nominal interest rate.

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5 I would like to thank Mr Jong Wook Kim (Research Department, The Bank of Korea) for allowing me to cite his paper "Analysis of change in asset prices as predictors of inflation" (2002).

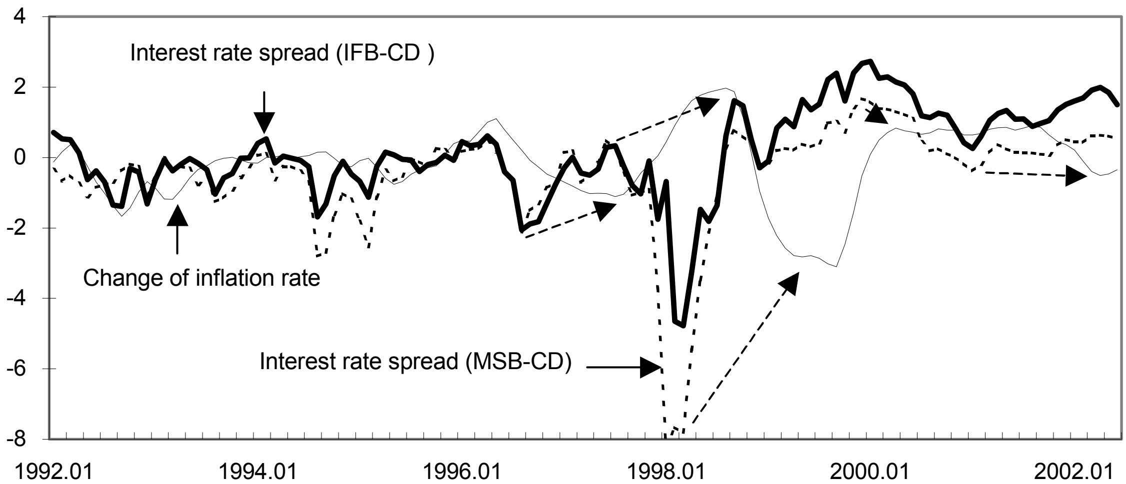
6 Only grain prices are included in this modified CPI (core inflation).

7 Change of the inflation rate is defined as the gap between the average inflation rate in the previous four quarters and the inflation rate four quarters before, based on the inflation forecasting equation - Mishkin (1990a, 1990b).

Graph 3

Trends in interest rate spread and change of inflation rate

In percentages



To confirm this result, cross correlation coefficients between the nominal interest rate and the inflation rate and between the interest rate spread and the change of the inflation rate are derived. Table 6 indicates that while the cross correlation coefficient between the nominal interest rate and the inflation rate is large in the same lag but becomes smaller as the time lag increases, the other cross correlation coefficient between the interest rate spread and the change of the inflation rate turns to a positive value from a negative one as the time lag increases by more than four quarters. Recent trends in the interest rate spread and the change of the inflation rate show an apparent positive cross correlation in five-quarter time lags. These results also imply that the interest rate spread is suitable as a leading indicator of future inflation.

Table 6

Cross correlation coefficients[1]

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
INF, MSB	0.71	0.67	0.56	0.41	0.29	0.17	0.10	0.01	–0.04	–0.08	–0.08	–0.05	–0.01
INF, IFB	0.71	0.68	0.54	0.38	0.19	0.06	0.00	–0.06	–0.09	–0.11	–0.10	–0.04	0.02
INF, SP1[2]	–0.54	–0.51	–0.34	–0.13	0.18	0.28	0.25	0.24	0.25	0.26	0.26	0.19	0.03
1992-1997	0.07	0.15	0.21	0.04	–0.19	–0.39	–0.39	–0.20	0.05	0.21	0.32	0.30	0.13
1998-2001	–0.71	–0.65	–0.43	–0.14	0.31	0.44	0.40	0.34	0.26	0.19	0.11	0.04	–0.07
INF, SP2[3]	–0.71	–0.62	–0.47	–0.26	–0.04	0.04	0.05	0.11	0.18	0.25	0.30	0.26	0.14
1992-1997	0.23	0.36	0.37	0.22	–0.01	–0.23	–0.30	–0.16	0.01	0.09	0.17	0.10	–0.09
1998-2001	–0.82	–0.65	–0.37	–0.02	0.39	0.50	0.45	0.37	0.27	0.17	0.08	0.00	–0.10

[1] Cross correlation coefficients between the inflation rate (*INF*) in period *t* and the yield on MSBs (*MSB*), the yield on IFBs (*IFB*) in period $t - i$ and the interest rate spread (*SP1*, *SP2*) for 1992:1-2001:4. [2] *SP1*: yield on MSBs (one year) - yield on CDs (91 days). [3] *SP2*: yields on IFBs (three years) - yields on CDs (91 days).

3.1.2 Stock prices

The relationship between stock prices and the inflation rate is investigated using a systematic cyclic analysis[8] for time series considering the close correlation between stock prices or the inflation rate and the business cycle. The troughs and peaks of the rate of change in the stock price index (*KSP*) and the inflation rate in Table 7 show that *KSP* and the inflation rate have had three and five cycles, respectively, since the mid-1980s (see also Graph 4). The cycles in Table 7 reveal that troughs and peaks of *KSP* lead those of the inflation rate by four to eight quarters.

Table 7

Cycles of the inflation rate and the rate of change in the stock price index (*KSP*)

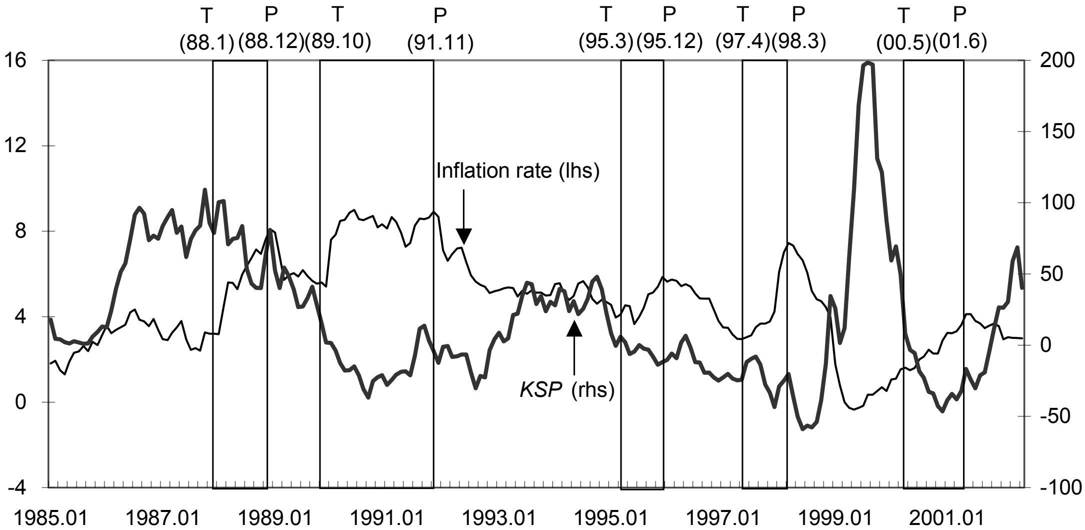
Inflation rate			*KSP*			
Cycle	**Trough**	**Peak**	**Trough**	**Lead period[1]**	**Peak**	**Lead period[1]**
1st	Jan 1988	Dec 1988	Sep 1985	28	–	–
2nd	Oct 1989	Nov 1991	–	–	Mar 1989	32
3rd	Mar 1995	Dec 1995	Aug 1992	31	Nov 1994	13
4th	Apr 1997	Mar 1998	–	–	–	–
5th	May 2000	Jun 2001	Jun 1998	23	Dec 1999	18

[1] In months.

Graph 4

Trends in the inflation rate and the rate of change in the stock price index (*KSP*)

In percentages



[8] The Bry-Boschan analysis method is used for detecting cycles applying enough time series data for the analysis. The inflation rate is deseasonalised by X-12 ARIMA.

The cross correlations between *KSP* and the inflation rate and between *KSP* and excess real demand pressure (*GAP*) are derived in Table 8. The cross correlation between *KSP* and excess real demand pressure indicates an indirect impact of *KSP* on the inflation rate via excess real demand caused by an increasing wealth effect and a forthcoming growth effect.

KSP in Table 8 shows a positive correlation with the GDP gap rate[9] and with the inflation rate after two and seven quarters, respectively. This implies that the fluctuation of *KSP* affects the inflation rate through changes of real demand.

Table 8

Cross correlation coefficients between *KSP* and other macroeconomic variables[1]

	0	1	2	3	4	5	6	7	8	9	10	11	12
GAP, KSP	0.08	0.21	0.28	0.30	0.29	0.22	0.18	0.13	0.09	0.10	0.11	0.12	0.13
INF, KSP	–0.39	–0.33	–0.23	–0.11	–0.02	0.09	0.19	0.29	0.36	0.41	0.44	0.43	0.42

[1] Cross correlation between the inflation rate (*INF*) or GDP gap rate (*GAP*) and the rate of increase of the stock price index (*KSP*) for 1985:1-2002:4.

3.1.3 Real estate prices

The troughs and peaks of the rate of change in housing prices (*KHP*) and the inflation rate in Table 9 obtained by systematic cyclic analysis show that *KHP* and the inflation rate have had four and five cycles, respectively, since the mid-1980s (see also Graph 5). In addition, the cycles in Table 9 indicate that the troughs and peaks of *KHP* lead those of the inflation rate by two to five quarters.

Table 9

Cycles of the inflation rate and the rate of change in housing prices (*KHP*)

Inflation rate			*KHP*			
Cycle	Trough	Peak	Trough	Lead period[1]	Peak	Lead period[1]
1st	Jan 1988	Dec 1988	Aug 1987	5	–	–
2nd	Oct 1989	Nov 1991	–	–	Apr 1991	7
3rd	Mar 1995	Dec 1995	Oct 1993	17	Dec 1994	12
4th	Apr 1997	Mar 1998	Jan 1996	15	Oct 1997	5
5th	May 2000	Jun 2001	Nov 1998	18	Nov 1999	19

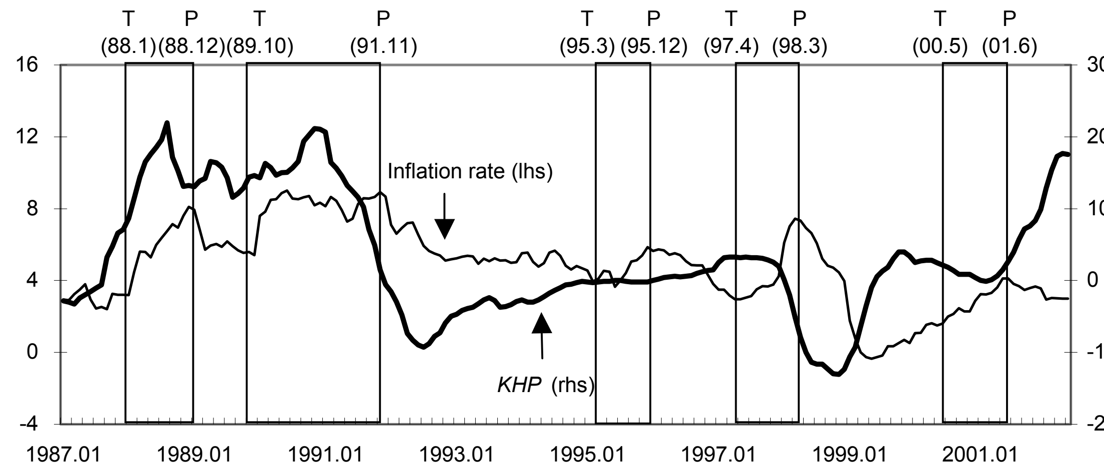
[1] In months.

[9] GDP gap rate = (actual GDP/potential GDP − 1) × 100.

Graph 5

Trends in the inflation rate and the rate of change in housing prices (*KHP*)

In percentages

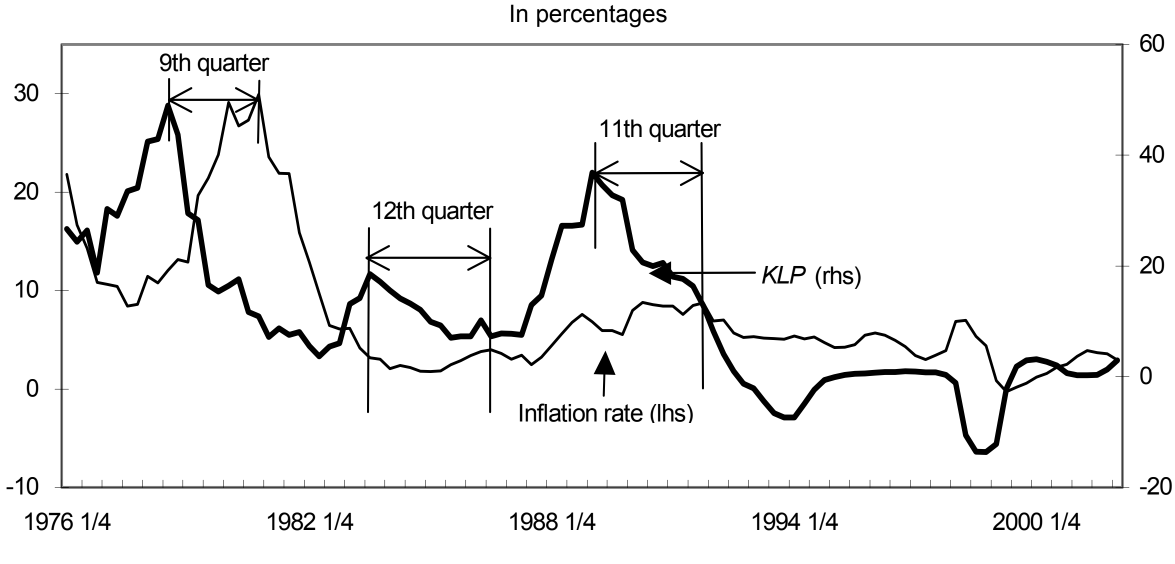


For land prices, the analysis applied for *KSP* and *KHP* is not employed since they do not show any noticeable fluctuation in the short run and have no high-frequency data (monthly). Therefore, the trends in the rate of increase of land prices (*KLP*) and the inflation rate are compared in Graph 6. *KLP* shows steep increases in 1978, 1983 and 1989. The inflation rate then shows an upward trend mirroring each increase of *KLP*, two to three years later.

Graph 6

Trends in the inflation rate and the rate of change in land prices (*KLP*)

In percentages



The cross correlations between *KHP* or *KLP* and *GAP* or the inflation rate are derived in Table 10. The positive cross correlations between *KHP* or *KLP* and *GAP* are largest in the same quarter. However, for the inflation rate, it becomes largest in the fourth or fifth quarter. These results imply that the impact of real property price movements on the inflation rate may be effected via the cost transmission channel as well as the real demand transmission channel.

Table 10

Cross correlation coefficients between *KHP* or *KLP* and other macroeconomic variables[1]

	0	1	2	3	4	5	6	7	8	9	10	11	12
GAP, KHP	0.38	0.34	0.25	0.13	0.02	–0.04	–0.11	–0.14	–0.14	–0.14	–0.13	–0.13	–0.14
INF, KHP	0.39	0.56	0.67	0.72	0.71	0.65	0.60	0.56	0.52	0.48	0.43	0.37	0.32
GAP, KLP	0.30	0.24	0.17	0.08	0.00	–0.05	–0.09	–0.10	–0.10	–0.09	–0.08	–0.09	–0.11
INF, KLP	0.45	0.56	0.65	0.72	0.74	0.74	0.72	0.70	0.68	0.63	0.60	0.54	0.48

[1] Cross correlation between the inflation rate (*INF*) or GDP gap rate (*GAP*) and the rate of increase of housing prices (*KHP*) or the increasing rate of land prices (*KLP*) for 1987:1-2001:4.

3.2 Asset price movements as a leading indicator of inflation

As the interest rate spread, *KSP*, *KHP* and *KLP* were shown to have cross correlations with the inflation rate in the above subsections, an empirical analysis is performed to check whether or not asset price movements have predictive power for future inflation.

3.2.1 The model and estimation

A multivariate inflation forecasting model without asset prices is set as a basic model as in Borio et al (1994) or Goodhart and Hofmann (2000). The basic model, which is a reduced-form equation, is as follows:

$$\pi_{t+i} = \alpha + \beta_0\pi_{t-j} + \beta_1\Delta WG_{t-j} + \beta_2\Delta M_{t-j} + \beta_3 GAP_{t-j} + \beta_4\Delta PIM_{t-j} + \varepsilon_{t+j} \tag{17}$$

with $i = 4, 6, 8$ $\quad j = 0, 1, 2, \ldots$

where π is inflation, ΔWG is the rate of change in unit labour costs, ΔM is the rate of change in total liquidity, *GAP* is the rate of the GDP gap, and ΔPIM is the rate of change in import goods prices. The forecasting horizons are assigned as four, six and eight quarters based on the cross correlations between asset prices and the inflation rate.

With so many regressors, the question of how to determine lag lengths becomes crucial. As a first measure to save degrees of freedom, only information of the current and the previous year is taken into account when assessing future inflation. However, this measure alone would still have left 41 coefficients to be estimated in the basic model. Therefore, to economise on the number of freely estimated parameters, the average of lags 0-3 and 4-7 is included for each variable in the regression. This also avoids arbitrary restriction on the lag lengths.[10] In addition, significance was assessed on the basis of Newey-West autocorrelation and heteroskedasticity-consistent standard errors.

The estimated coefficients of the basic model in Table 11 indicate that the coefficient of the GDP gap rate (*GAP*) is significantly different from zero at the 5% level at four-quarter horizons but not at six- and eight-quarter horizons. The coefficient of the rate of change in import goods prices (ΔPIM) also implies that the impact of the fluctuation of import goods prices on the inflation rate is not strong enough to be significant. However, the coefficients of the rates of change in unit labour costs and in total liquidity are significantly different from zero at the 5% level.

[10] See Goodhart and Hofmann (2000).

Table 11

Estimated coefficients in the basic model[1]

Forecasting horizon (Dependent variable)[2]	Independent variable at time *t*					$\bar{R}^2$
	ΔWG	ΔM	GAP	ΔPIM	α	
4 (π_{t+4})	0.23* (5.75)	0.12* (4.11)	0.18* (2.53)	0.03* (1.71)	0.50* (1.98)	0.88
6 (π_{t+6})	0.16* (4.32)	0.17* (4.56)	0.05 (1.18)	–0.05* (3.75)	0.19 (1.31)	0.86
8 (π_{t+6})	0.12* (1.87)	0.14* (2.61)	–	–0.07* (3.28)	1.23 (1.66)	0.77

* = significance at the 5% level; *t*-statistics in brackets.

[1] Time period: 1988:1-2001:4. [2] In quarters.

Based on the estimation of the basic model, an extended model, which is the basic model with each asset price variable, is estimated to check the predictive power of each asset price for the inflation rate. Table 12 presents the estimated coefficient for each variable. The third column shows that the interest rate spread has predictive power for future inflation at four-quarter horizons. The fifth column reveals that housing prices provide effectual information for future inflation at four- and six-quarter horizons. In addition, as shown in the eighth and 10th columns, land and stock prices are suitable as leading indicators of future inflation at six- and eight-quarter horizons. These results coincide with the implications presented by the analyses performed in the previous subsections.

Table 12

Estimated coefficients in the extended model[1]

Forecasting horizon (Dependent variable)[2]	Basic mode l	Added asset price variable at time *t*							
		Interest rate spread[3]		*KHP*		*KLP*		*KSP*	
	$\bar{R}^2$	Co-efficient	$\bar{R}^2$	Co-efficient	$\bar{R}^2$	Co-efficient	$\bar{R}^2$	Co-efficient	$\bar{R}^2$
4 (π_{t+4})	0.88	0.80* (2.62)	0.90	0.06* (2.61)	0.90	0.03 (1.49)	0.88	0.00 (0.15)	0.88
6 (π_{t+6})	0.86	0.63 (1.55)	0.87	0.04* (1.80)	0.87	0.04* (2.00)	0.87	0.01* (2.44)	0.88
8 (π_{t+6})	0.77	–0.56 (0.87)	0.77	0.00 (0.06)	0.77	0.05* (1.81)	0.79	0.02* (2.62)	0.82

* = significance at the 5% level; *t*-statistics in brackets.

[1] Time period: 1988:1-2001:4. [2] In quarters. [3] Time period: 1992:1-2001:4.

3.2.2 *Simulation and ex ante forecasting*

To ascertain how greatly asset prices contributed to the forecast of the inflation rate in 1990-2001, an ex post simulation is performed with significant asset price variables at four- and eight-quarter horizons.

In general, as can be seen from Table 13, the forecasting error significantly decreases in the forecasts with asset prices considering the mean absolute error (*MAE*) and the root mean square error (*RMSE*). While the forecasting error in the basic model is 0.56% (*MAE*), it decreases by 0.07 percentage points per quarter with *IRS* and by 0.05 percentage points per quarter with *KHP* at four-quarter horizons. At eight-quarter horizons, also, the forecasting error decreases by 0.10 percentage points with *KSP* and by 0.05 percentage points with *KLP*.

However, the predictive power of the model depends on the time period of the data. In particular, whereas the improvement in forecasting ability is considerable in 1990-93 owing to the addition of asset prices, it is not in 1994-97. In 1998-2001, only the interest rate spread and *KHP* contribute to the forecast of the inflation rate. When the excess real demand induces ongoing inflation, asset price movements serve as a leading indicator. However, in the case of inflation induced by high costs, the information from asset price movements for future inflation is not useful.

Table 13

Results of simulation[1]

Forecasting horizon	Added variable	1990-93		1994-97		1998-2001		1990-2001	
		RMSE	***MAE***	***RMSE***	***MAE***	***RMSE***	***MAE***	***RMSE***	***MAE***
Fourth quarter	(Basic model)	0.78	0.70	0.65	0.45	0.71	0.55	0.71	0.56
	IRS[2]	–	–	0.63	0.48	0.58	0.50	0.61	0.49
	KHP	0.53	0.49	0.63	0.49	0.66	0.54	0.61	0.51
Eighth quarter	(Basic model)	1.21	1.03	0.74	0.67	1.28	0.94	1.10	0.88
	KSP	0.70	0.61	0.73	0.65	1.25	1.07	0.93	0.78
	KLP	0.99	0.81	0.73	0.64	1.46	1.03	1.10	0.83

[1] $RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}$, $MAE = \frac{1}{T}\sum_{t=1}^{T}\left|Y_t^s - Y_t^a\right|$, where Y_t^s is a forecasted value, and Y_t^a is an actual value for time *t*.

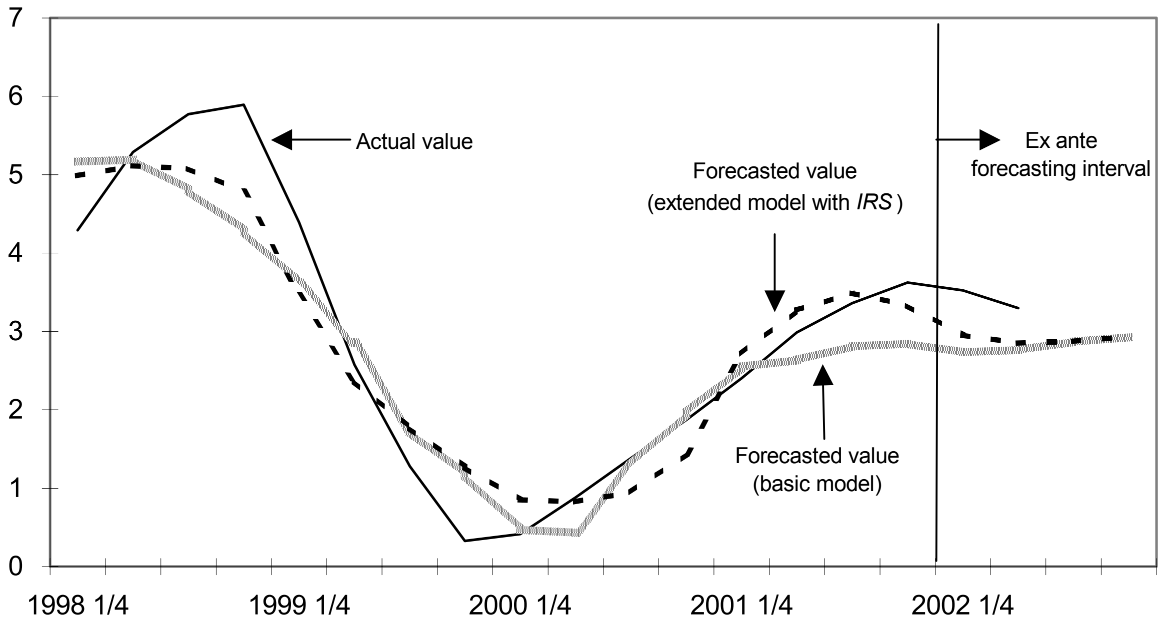
[2] Interest rate spread.

As shown in Graphs 7 and 8, ex ante forecasting for the four-quarter horizon indicates that the values forecasted by the extended models approach the actual values more closely than the values forecasted by the basic models. This implies that while the basic model does not adequately capture the impact of asset price movements, for example rising housing prices, on the inflation rate, the extended model reflects the impact of the fluctuation of asset prices on the inflation rate owing to the addition of housing prices, *KHP*. However, ex ante forecasting for the eight-quarter horizon did not show any crucial improvement in the predictive power through the addition of asset prices (Graphs 9 and 10).

Graph 7

Actual and forecasted values of the interest rate spread[1]

In percentages

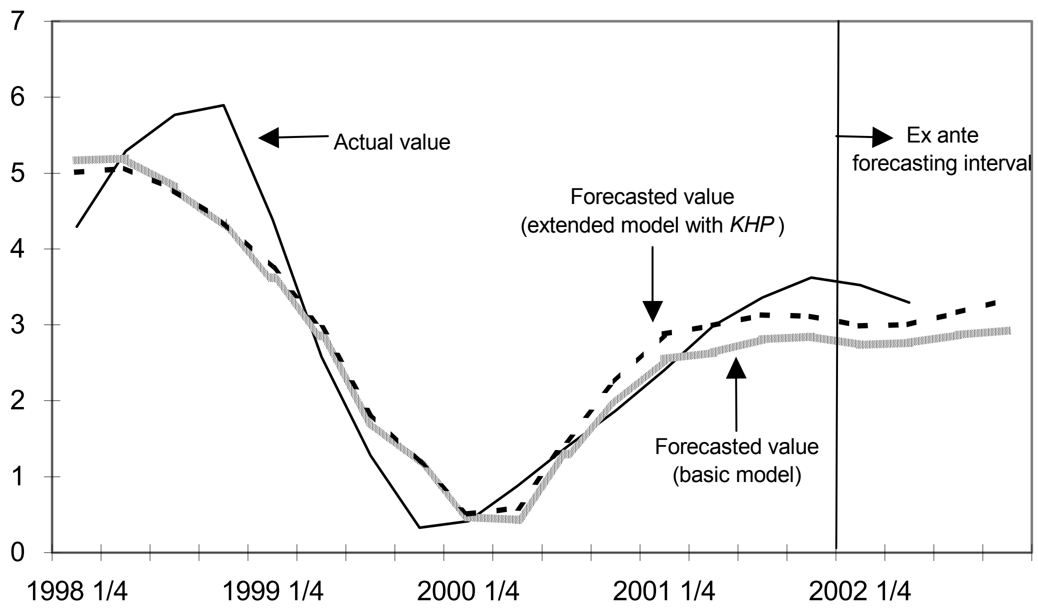


[1] Forecasting horizon is four quarters.

Graph 8

Actual and forecasted values of housing prices (*KHP*)[1]

In percentages

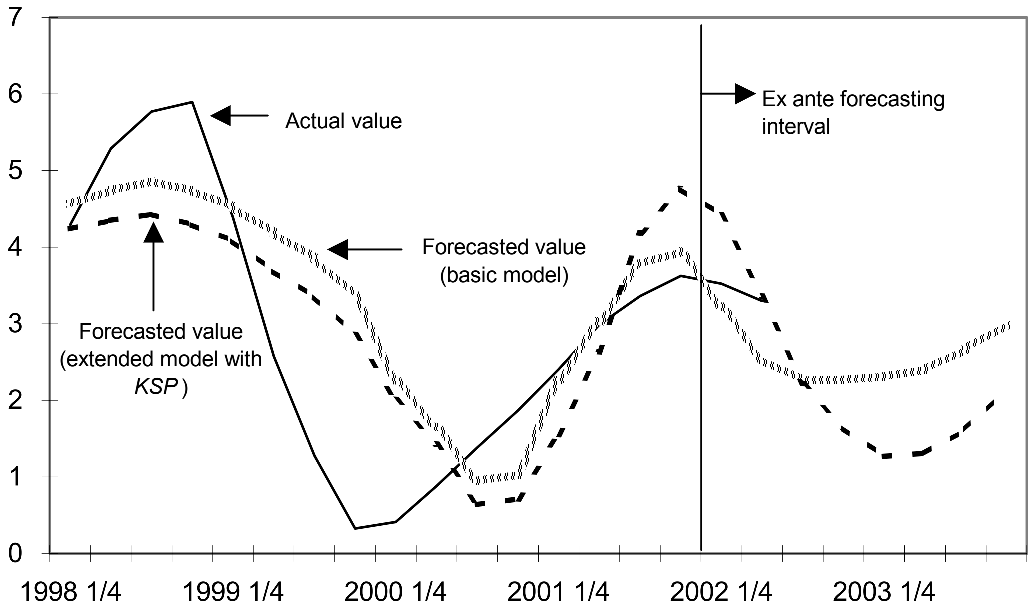


[1] Forecasting horizon is four quarters.

Graph 9

Actual and forecasted values of the stock price index (*KSP*)[1]

In percentages

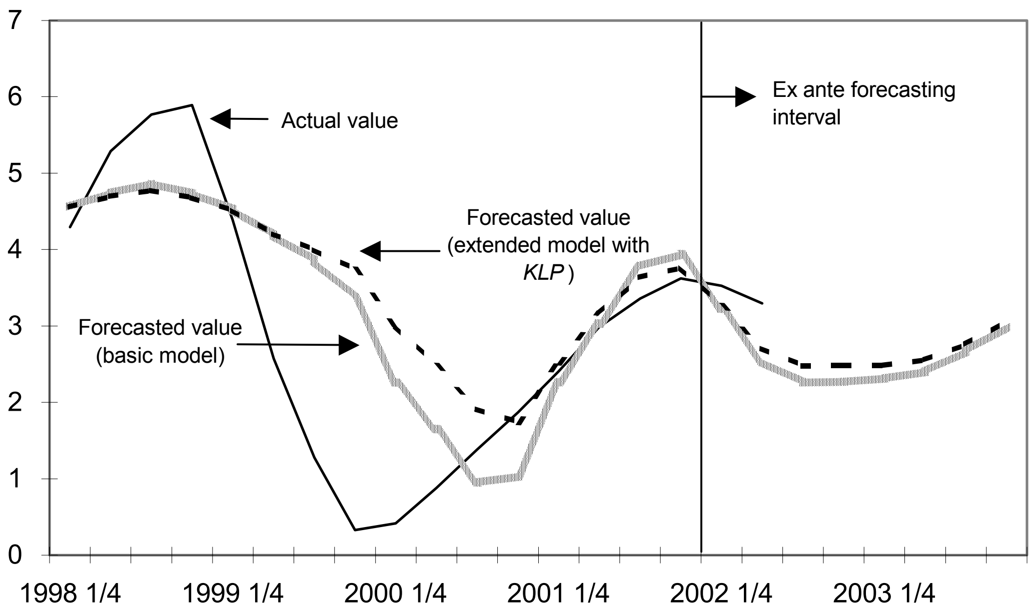


[1] Forecasting horizon is eight quarters.

Graph 10

Actual and forecasted values of land prices (*KLP*)[1]

In percentages



[1] Forecasting horizon is eight quarters.

4. Implications for monetary policy

4.1 Main views in the recent literature

There have been two main views in the literature about how the central bank should respond to asset price movements to achieve sustainable price stability. One of them is that the central bank should respond to asset price fluctuations directly - Kent and Lowe (1997) and Cecchetti et al (2000, 2002). The possible instability of the economy following the financial disturbance caused by asset price fluctuations is one of the reasons for their assertion. In general, the bursting of a bubble after a boom has been sustained for a long period causes a serious imbalance in the balance sheets of financial institutions through insolvencies of lendings backed by collateral. This aggravates the weakness of financial institutions and induces them to reduce or to be more cautious about corporate lending. Therefore, the possible credit crunch could contract investment and, finally, trigger recession. In addition, they argue that the crucial role of the impact of asset price movements on consumption and investment via the monetary transmission mechanism is another reason for monetary policy to respond to asset price movements. Rises and falls in asset prices affect real economic activity mainly through channels such as consumption via the wealth effect and investment through capital gains due to changes in collateral and net asset prices.

However, the prevailing consensus among economists and central bankers is that monetary policy should not directly target asset prices, but should respond to the effects of asset price fluctuations insofar as they signal changes in expected inflation - Bernanke and Gertler (2000) and Batini and Nelson (2000). First, the difficulty of distinguishing asset price movements driven by excess optimism from those led by fundamentals forces the central bank to hesitate about targeting asset prices for monetary policy. For example, to attain the information on a discounted future dividend stream from fluctuation in the stock price index is not straightforward due to the irrational exuberance reflected in stock price index movements. Second, even if the central bank were able to distinguish asset price movements driven by irrational expectations, it does not have adequate policy tools to excise the bubble alone. The obscurity of the relationship between interest rates and asset prices prevents it from responding to asset price fluctuations efficiently. However, the cited authors argue that by focusing on reducing the inflationary or deflationary pressures generated by excess real demand, a central bank can respond effectively to the harmful side effects of asset booms and busts without getting into the business of deciding what is or is not a fundamental.

4.2 Asset price movements and inflation targeting in South Korea

Financial markets in South Korea experienced rapid structural changes in the 1990s owing to a four-stage interest rate deregulation plan, the opening of financial markets, and the liberalisation of the foreign exchange and capital markets. Aligned to the changing financial environment, the provisions of the revised Bank of Korea Act, which came into effect on 1 April 1998, required The Bank of Korea to assume the responsibility for setting an annual target inflation rate, and the conduct of monetary policy in order to attain it (Table 14). Since an inflation targeting regime is a forward-looking pre-emptive framework for monetary policy, which is generally based on a medium-term inflation target, a strong capacity for inflation forecasting ability is required for the success of inflation targeting. From this viewpoint, the results of the analyses in Section 3, indicating that asset price movements are reliable leading indicators for future inflation, imply that the application of information signalled by asset price movements would enhance the inflation forecasting capacity.

For monetary policy to respond to asset price fluctuations effectively, it is essential to find out whether the asset price movements are driven by fundamentals. Regarding this question, the results of research in The Bank of Korea have shown that if the central bank is able to detect bubbles in asset prices, a monetary policy targeting inflation and asset prices is more effective in controlling the business cycle than one with only inflation targeting. However, they suggest that the conduct of a monetary policy that targets inflation and asset prices without detecting the presence of bubbles in asset prices may induce an aggravation of the recession after the bubbles burst.

As shown in Section 2, the disagreement between the results of MRS tests and those of unit-root and cointegration tests about the presence of asset price bubbles shows the difficulty of distinguishing bubbles from fundamentals. In addition, the difficulty of calculating precisely an ex post real asset value for the derivation of the wedge between actual and ex post real asset prices adds another reason for the monetary policy authority to hesitate about responding to asset price movement directly. This implies that further research is necessary for the central bank to investigate the presence of bubbles in asset prices in order to implement an inflation and asset price targeting regime. However, although the central bank cannot perfectly distinguish asset price bubbles from fundamentals, the current inflation targeting regime in South Korea, which responds to the excess real demand pressure on inflation caused by asset price fluctuation, has been to some degree effective in stabilising asset price movements. Furthermore, as shown in Section 3, since it is more evident when asset price movements put pressure on real demand due to the predictive power of asset prices for future inflation, the inflation targeting regime in South Korea is expected to become more effective than in the past.

Table 14

Key points of the sixth revision of the Bank of Korea Act

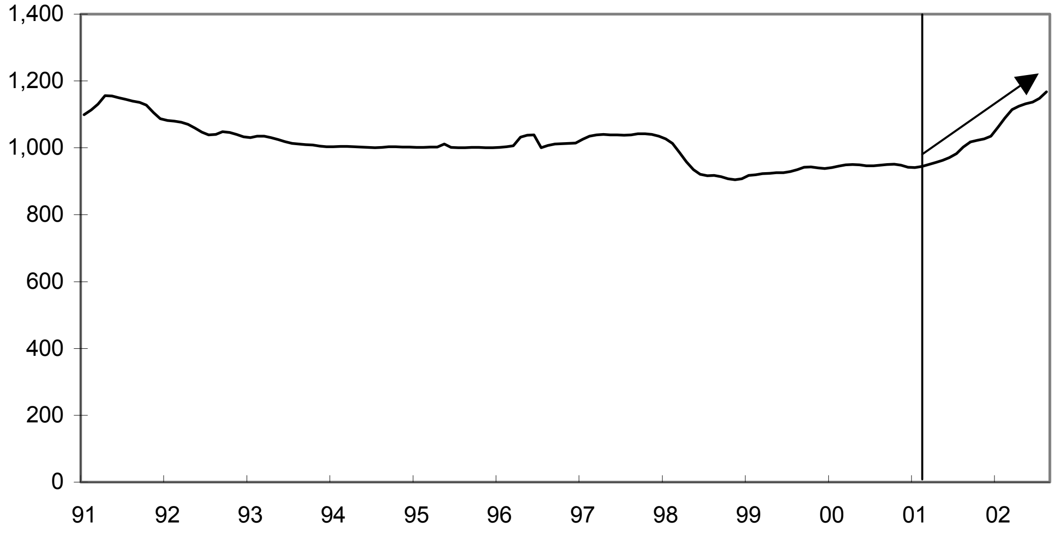
Previous	Revised
Objective - Stabilisation of the value of money and maintenance of the soundness of the banking and credit system	- Price stability
Policymaking body - Minister of Finance and Economy also served as Chairman of the Monetary Board	- Governor of The Bank of Korea (BOK) also serves as the Chairman of the Monetary Policy Committee
Monetary policies - (Added)	- The BOK determines an annual price stability target in consultation with the government and formulates and publishes an operational plan for monetary and credit policies that includes the said target
Relationship with the National Assembly - (Added)	- At least once a year, the BOK shall prepare a report on the implementation of its monetary and credit policies and submit it to the National Assembly
- (Added)	- At the request of the National Assembly or its committees, the Bank Governor should attend and answer the questions of the National Assembly or its committees concerning the report

One of the recent notable features of asset price movements in South Korea is that the housing price index has shown a steep upward trend since early 2001, as shown in Graph 11. The ratio of housing prices to national disposable income per capita (NDI) in South Korea, as may be seen from Graph 12, also indicates that housing prices in South Korea have been increasing steeply, at rates comparable to those of the United States and Spain. Furthermore, the increasing gap between the rate of return on housing prices and yields on corporate bonds in Graph 13 suggests that the upward tendency of housing prices will continue for the time being.

As the excess real demand pressure on inflation caused by increasing housing prices is expected to come to the surface after four or six quarters according to the analysis in Section 3, a response by the monetary policy authority could be considered. However, since an increase in the interest rate causes a rise in the financial costs of consumption and investment and destabilises the financial market, the central bank should be cautious about conducting monetary policy in reaction to asset price movements so as not to unsettle the economy.

Graph 11

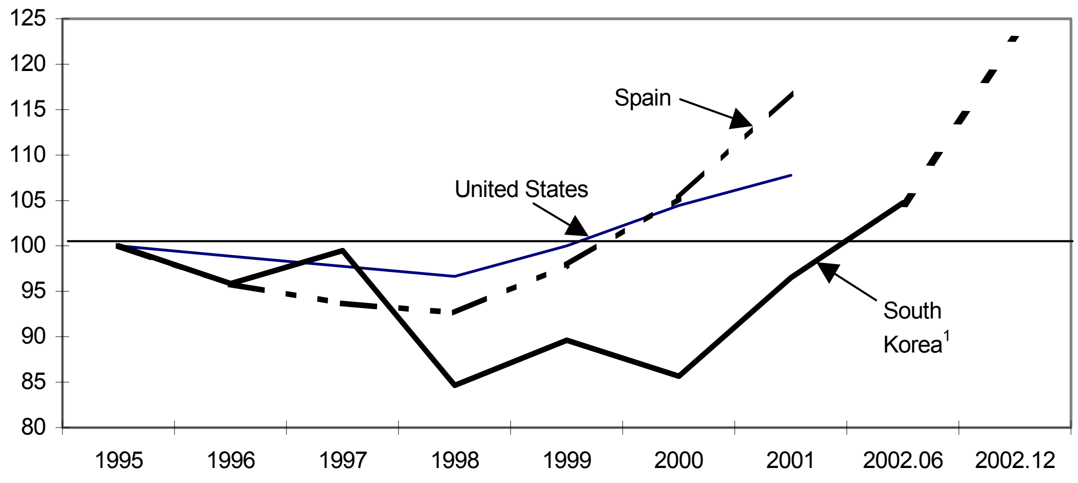
The housing price index in South Korea



Graph 12

Ratio of housing prices to NDI in South Korea and other countries

1995 = 100



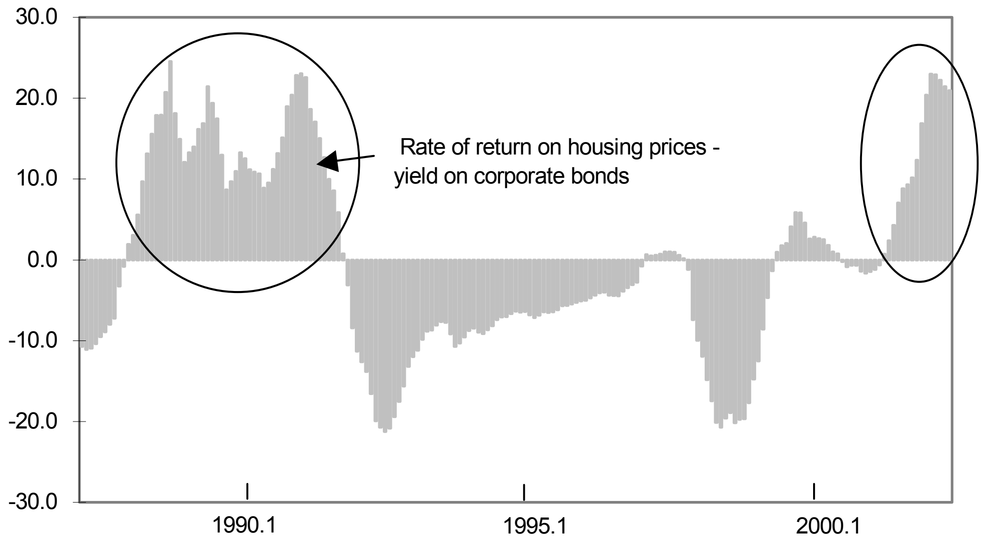
NDI = national disposable income per capita.

[1] Average apartment price in Seoul.

Graph 13

The gap between the rate of return on housing prices and the yield on three-year corporate bonds

In percentage points



5. Concluding remarks

The Asian currency crisis in 1997-98 reminded central banks that the impact of asset price movements on the economy should not be ignored in the conduct of monetary policy. However, without distinguishing bubbles from fundamentals, a direct response to asset price movements from monetary policy could well aggravate the recession after the bubbles burst.

To verify whether there have been bubbles in asset prices in South Korea, trends of asset prices were visually inspected in Section 2. While the graphical information suggests that bubbles could exist from the late 1980s to the early 1990s, empirical tests do not provide us any decisive information about the presence of bubbles. This suggests that distinguishing bubbles from fundamentals is not a straightforward task.

Section 3 checked whether asset price movements have predictive power for future inflation. First, the trends of asset prices, the interest rate spread, and stock and real estate prices show that asset prices lead inflation by four to eight quarters. Second, to confirm this result by empirical analysis, OLS estimations of inflation forecasting models were provided. These estimations show that the interest rate spread has predictive power for future inflation at four-quarter horizons; housing prices provide effective information for future inflation at four- and six-quarter horizons; and land and stock prices could serve as leading indicators at six- and eight-quarter horizons.

Based on the results obtained in the above analyses, the implications of asset price volatility for the conduct of monetary policy were stated in Section 4. While there is little agreement over how monetary policy should react to asset price movements within the literature, it is the mainstream position that central banks should refer to asset price movements only as an information variable for expected inflation. The difficulties of calculating precise ex post real asset values and specifying the period when bubbles exist, as described in Section 2, strongly suggest that a direct response from the central bank to asset price movements is inappropriate.

The inflation targeting regime in South Korea, which responds to excess real demand pressure on inflation by adjusting the interest rate, has been successful in controlling the variability of both the inflation rate and output since it was introduced in 1998. Therefore, even though the central bank may not be able to pinpoint the causes of asset price movements, the conduct of monetary policy that seeks to reduce the excess real demand pressure on inflation caused by asset price movements appears promising. However, research to find the causes of asset price movements and specify the periods when bubbles exist should be continued in order to raise the effectiveness of monetary policy in view of the crucial role of asset price movements in the business cycle.

Appendix

Let y_t be an $(n \times 1)$ vector partitioned as

$$\underset{(n\times 1)}{y_t} = \begin{bmatrix} \underset{(1\times 1)}{y_{1t}} \\ \underset{(g\times 1)}{y_{2t}} \end{bmatrix} \tag{1}$$

for $g \equiv (n-1)$. Consider the regression

$$y_{1t} = \alpha + \gamma' y_{2t} + u_t \tag{2}$$

Let $\hat{u}_t$ be the sample residual associated with OLS estimation of (2) in a sample of size T:

$$\hat{u}_t = y_{1t} - \hat{\alpha}_T - \hat{\gamma}'_T y_{2t} \text{ for } t = 1, 2, \ldots T \tag{3}$$

The residual $\hat{u}_t$ can then be regressed on its own lagged value $\hat{u}_{t-1}$ without a constant term:

$$\hat{u}_t = \rho \hat{u}_{t-1} + e_t \text{ for } t = 2, 3, \ldots, T \tag{4}$$

yielding the estimate

$$\hat{\rho}_T = \frac{\sum_{t=2}^{T} \hat{u}_{t-1}\hat{u}_t}{\sum_{t=2}^{T} \hat{u}_{t-1}^2} \tag{5}$$

Let s_T^2 be the OLS estimate of the variance of e_t for the regression of equation (4):

$$s_T^2 = (T-2)^{-1} \sum_{t=2}^{T} (\hat{u}_t - \hat{\rho}_t \hat{u}_{t-1})^2 \tag{6}$$

and let

$$\hat{\sigma}_{\hat{\rho}_T} = s_T^2 \Big/ \left\{ \sum_{t=2}^{T} \hat{u}_{t-1}^2 \right\} \tag{7}$$

Finally, let $\hat{a}_{j,T}$ be the jth sample autocovariance of the estimated residuals associated with equation (4):

$$\hat{a}_{j,T} = (T-1)^{-1} \sum_{t=j+2}^{T} \hat{e}_t \hat{e}_{t-j} \text{ for } j = 0, 1, 2, \ldots, T-2 \tag{8}$$

for $\hat{e}_t \equiv \hat{u}_t - \hat{\rho}_T \hat{u}_{t-1}$; and let the square of $\hat{\lambda}_T$ be given by

$$\hat{\lambda}_T^2 = \hat{a}_{0,T} + 2\sum_{j=1}^{q} [1 - j/(q+1)] \hat{a}_{j,T} \tag{9}$$

where q is the number of autocovariance to be used. Phillips's Z_ρ statistic (1987) can be derived as follows:

$$Z_{\rho,T} = (T-1)(\hat{\rho}_T - 1) - (1/2)\{(T-1)^2 \hat{\sigma}_{\hat{\rho}_T}^2 \div s_T^2\}\{\hat{\lambda}_T^2 - \hat{a}_{0,T}\} \tag{10}$$

Similarly, Phillips's Z_t statistic associated with the residual autoregression equation (4) would be

$$Z_{t,T} = (\hat{a}_{0,T} / \hat{\lambda}_T^2)^{1/2} t_T - (1/2)\{(T-1)\hat{\sigma}_{\hat{\rho}_T} \div s_T\}\{\hat{\lambda}_T^2 - \hat{a}_{0,T}\} / \hat{\lambda}_T \tag{11}$$

and for t_T, the usual OLS t-statistic for testing the hypothesis $\rho = 1$:

$$t_T = (\hat{\rho}_T - 1) / \hat{\sigma}_{\hat{\rho}_T} \tag{12}$$

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Fear of floating or fear of inflation? The role of the exchange rate pass-through

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Abstract

This paper examines the exchange rate pass-through in the transition to low and stable inflation environments. The purpose is to test if low and stable inflation environments lead to low levels of exchange rate pass-through and thus contribute to weakening the "fear of floating" phenomenon experienced by some small open economies. The results presented are in line with this hypothesis. For a group of small open economies, which have recently experienced an inflation reduction process, it is shown that the level of exchange rate pass-through weakens as the level of inflation falls. Therefore, it is argued that once nominal variables are stable, the "fear of inflation", which any central bank should have, no longer implies a "fear of floating".

1. Introduction

This paper examines the exchange rate pass-through in the transition to low and stable inflation environments. The purpose is to test if such environments lead to low levels of exchange rate pass-through and thus contribute to weakening the "fear of floating" phenomenon experienced by some small open economies. It is argued in the debate between "hard pegs" and "floats" that the stability of nominal variables, among other issues, should play a key role since it affects the strength of exchange rate pass-through and thus the immediate benefits of flexible exchange rate arrangements.

Over a number of years small open economies have been affected by external shocks such as volatile capital flows. The consequences have not been mild and therefore the debate over which set of policies is most effective in containing the potentially perverse effects of such types of shocks has been revisited. In this debate there is consensus about the importance of price and financial stability, strict financial regulation and sound fiscal policy. However, at the centre of this debate there is still a controversy over the best exchange rate regime available. This specific question is particularly relevant for emerging market economies.

The case of Mexico is interesting since the country is still in the process of consolidating its macroeconomic stability, ie in the transition to a low and stable inflation environment. However, another factor has contributed to putting the Mexican case at the centre of this debate. Over the last two decades the economy has experienced large exchange rate depreciations and high inflation. Not surprisingly the level of exchange rate pass-through in Mexico has been high and thus exchange rate depreciations are likely to cause inflationary pressures. In the light of this record one would expect that limited exchange rate flexibility would best contribute to the inflation reduction process. However, the flexible exchange rate arrangement in recent years has proven successful in lowering the inflation rate, providing macroeconomic stability.

[1] The authors are grateful for helpful comments from Daniel Garcés, Julio Santaella, participants in the European Central Bank's Preparatory Workshop for the Madrid Seminar of the Eurosystem and Latin American Central Banks in 2002, participants in the Bank for International Settlements' Autumn 2002 Central Bank Economists' Meeting and Daniel Sámano, who also provided excellent research assistance. The opinions expressed in this article are solely those of the authors and do not necessarily represent the point of view of the Bank of Mexico. Correspondence: abaqueiro@banxico.org.mx, adiazl@ banxico.org.mx and atorres@banxico.org.mx.

The issue that motivates the analysis presented in this paper is that, in the debate between “hard pegs” and “floats” for small open economies, the inflation environment has not received attention as one of the key elements in the debate. A hypothesis recently discussed in the literature states that the level of the exchange rate pass-through depends on the inflation environment, ie as the inflation environment becomes stable, characterised by a low inflation rate and competitive markets, the strength of the pass-through weakens.[2] This statement implies that only when price stability is achieved can the benefits of a floating regime fully materialise since the low level of exchange rate pass-through diminishes the “fear of floating” phenomenon.

To address this hypothesis, the paper is organised as follows. Section 2 presents a brief review of some of the issues in the old debate on fixed versus flexible exchange rate regimes and shows that in recent times the debate has been polarised between the extremes of “hard pegs” and “pure floats”. The evidence reviewed shows that there is no consensus as to which arrangement produces better macroeconomic performance. Section 3 reviews the arguments that have recently been used against the convenience of flexible exchange rates in economies which face difficulties in allowing the exchange rate to move freely. These arguments are then used to identify one of the key elements in the “fear of floating” hypothesis: the exchange rate pass-through. Section 4 analyses the relationship between the exchange rate pass-through and the inflation environment in a group of small open economies with flexible exchange rate regimes and which have moved to low-inflation environments in recent years. Section 5 concludes.

2. The debate on fixed versus flexible exchange rate regimes

One of the oldest debates in economic literature is the one regarding exchange rate arrangements. Many papers have been written on this subject and the basic elements of the debate appear in textbooks on international economics. Among those studies, Edwards (2002a, 2002b) and Velasco (2002) present recent reviews of the debate.

Traditionally the main argument in favour of flexible exchange rate arrangements is that monetary policy is not constrained by the predetermined level of the exchange rate. Thus, monetary policy sets interest rates in order to achieve domestic equilibrium (ie price stability) while the nominal exchange rate adjusts to balance the external accounts. Under this regime monetary policy itself is the nominal anchor of the economy and, once price stability has been achieved and is expected to be maintained, interest rates can be set by the monetary authorities in order to smooth the business cycle: a countercyclical monetary policy is then an option. Another point in favour of flexible exchange rates is that whenever the economy is hit by an adverse shock to the terms of trade, the requisite real exchange rate depreciation is achieved faster by allowing the nominal exchange rate to depreciate rather than by waiting for the domestic price level to decrease. It is also argued that a flexible exchange rate allows interest rates to be less volatile and thus the real sector is better protected against external shocks.

On the other side of the debate, the main argument in favour of fixed exchange rates is that this arrangement fosters credibility in economic policies by imposing an automatic mechanism that regulates the amount of money and thus sets interest rates accordingly. Fixing the exchange rate implies abandoning an independent monetary policy but it also means that the monetary policy from the other country, with its credibility, is imported. Another advantage of this arrangement is that the role of the nominal exchange rate as the nominal anchor of the economy is easier for the public to understand than the more abstract concept of monetary policy being the anchor. As a result, price stability is, in theory, achieved faster.

The traditional reasoning in favour of one or the other regime used to be expressed in terms of price rigidities and the exposure of the economy to terms-of-trade shocks. An economy in which a large component of exports is commodities has a large exposure to such shocks and therefore could benefit more by allowing the nominal exchange rate to absorb them. Conversely, if the exposure to external

[2] See Taylor (2000) and Devereux and Engel (2001).

shocks is not an important issue, then the economy could be best served by the stability provided by a fixed exchange rate.

The debate at a theoretical level has always been centred on the two pure regimes: flexible versus fixed. However, in practice, countries have adopted arrangements which combine features of both, so that, in most countries, the actual exchange rate regime lies in between the extremes of “pure floats” and “hard pegs”. A classic example is the setting of exchange rate bands, where the exchange rate is allowed to fluctuate within a certain range but is not allowed to move beyond the band’s limits. However, in recent times several countries have modified their exchange rate policy and have moved towards the extremes and thus formed what is now known as the bipolar view.[3] On the one hand, the increased role of transparency of economic policy and the effective communication device that inflation targeting provides has triggered shifts towards more flexible exchange rate regimes. In addition, different types of “dirty floats” have become closer to “pure floats” as currency markets deepen and the effectiveness of foreign exchange intervention is questioned. On the other hand, the importance of credibility in the sustainability of the exchange rate regime has pushed some countries in the opposite direction, towards fixed exchange rates. In some cases the “soft pegs” have been transformed into “hard pegs” (ie currency boards and dollarisation).

So far the empirical evidence has not been conclusive on which regime produces better macroeconomic performance. Edwards (1993) analyses evidence from developing countries during the 1980s which suggests that countries with fixed exchange rates experience lower inflation rates than countries that float. The study argues that one reason for this result is that fixed exchange rates impose more discipline on monetary authorities. However, in another study Ghosh et al (1995) find that for upper middle-income countries exchange rate flexibility is not associated with higher rates of inflation. Their finding suggests that among these countries “hard pegs” and “pure floaters” experience lower inflation rates than “intermediate floaters”. With respect to output performance, the evidence has also not been conclusive. A study by the IMF (1997) shows that for the period 1975-96 there are no significant differences between GDP growth rates experienced by countries under either of the two types of exchange rate regime. Furthermore, Levy-Yeyati and Sturzenegger (2002) find that for developing countries less flexible exchange rate regimes are associated with slower output growth and greater output volatility, while for industrial countries the exchange rate regime does not appear to have a significant impact on growth.

The above suggests that the debate on fixed versus flexible exchange rate regimes is not only unsettled but has recently been further polarised between the extremes of “hard pegs” and “pure floats” (bipolar view). Furthermore, newly available evidence on the macroeconomic performance of countries with different exchange rate arrangements seems to provide no clue as to the direction the debate will follow in the future, not least because macroeconomic performance is also determined by other important factors such as fiscal policy. Since it can be argued that unsound fiscal policy dominates over monetary and exchange rate policy in many developing economies, direct comparisons of the performance of different foreign exchange rate arrangements become more difficult.

3. Recent criticism of flexible exchange rates

As mentioned before, it is well known that under a flexible exchange rate regime monetary policy is independent of exchange rate policy. That is, interest rates could be set to achieve price stability while at the same time the nominal exchange rate could adjust in order to attain equilibrium in the external accounts. However, several authors have argued that, for small open economies which face difficulties in letting the nominal exchange rate adjust freely, an independent monetary policy is not a feasible option. These arguments have been proposed mainly by Calvo and Reinhart (2002) with the “fear of floating” hypothesis and by Eichengreen and Hausmann (1999) with the “original sin” hypothesis. They argue that the textbook advantages of a pure float are not attainable in emerging markets due to lack of credibility in their institutions. Therefore, since the problem is endemic in their view, these countries should adopt “hard pegs” to solve the credibility problem.

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3 See Fischer (2001).

The basic argument against a flexible exchange rate regime is based on the hypothesis that for some countries nominal exchange rate depreciations have negative effects and, consequently, although their exchange rate is flexible in theory, in practice they try to minimise exchange rate movements. The immediate implication of this argument is that monetary policy is effectively constrained and plays an accommodating role to achieve exchange rate stability. In this case the flexible exchange rate arrangement becomes a de facto peg, that is a "soft peg". Then, the argument goes, the valid comparison is not between "hard pegs" and "floats" but between "hard pegs" and "soft pegs". Finally, between these two options the credibility issue favours the choice of "hard pegs".

The key element in the previous argument is to understand why depreciations have negative effects and therefore are to be avoided by monetary authorities. There are two main reasons for this. First, the "original sin" hypothesis suggests that depreciations are costly in countries where economic agents are unable to borrow long-term domestically and cannot borrow abroad in their own currency, and are thus forced to borrow in foreign currency. In this case the currency exposure restricts the ability of monetary policy to accommodate a negative terms-of-trade shock through a nominal depreciation and thus drives up interest rates.[4] A second reason for which monetary authorities may choose not to let the exchange rate depreciate is when there is a high level of pass-through from the nominal exchange rate to the domestic price level. In this case the main problem is that the authorities are inclined to minimise the effect of the adverse shock on the domestic price level by raising interest rates and not allow the exchange rate to depreciate. As mentioned above, in these circumstances the formally flexible exchange rate arrangement ends up as a de facto "soft peg".

Recently some authors have presented empirical evidence which suggests that in some countries the nominal exchange rate presents remarkable stability while officially it is said to float freely. Calvo and Reinhart (2002) conclude that in most countries with official flexible exchange rates monetary policy is set in order to minimise the volatility of the nominal exchange rate. Their conclusion is supported by a cross-sectional analysis of the volatility of interest rates, monetary aggregates, international reserves, commodity prices and nominal exchange rates in a set of 153 countries. They find that exchange rate volatility in countries that claim to float is smaller than that of more committed floaters such as the United States. Their conclusion that this has been the result of deliberate policy is based on their finding that the volatility of interest rates, monetary aggregates and international reserves is higher than that observed in the traditional floaters.

In another study, Hausmann et al (1999) analyse the performance of some Latin American countries, again using cross-sectional analysis. They conclude that flexible exchange rate regimes have not been able to provide the benefits that an independent monetary policy should bring. Their evidence suggests that, in some of the Latin American countries with flexible exchange rates, it has been necessary to allow large swings in interest rates in order to keep the inflation rate under control. This policy, they argue, has resulted in higher and more volatile real interest rates, smaller financial systems, wage indexation, more sensitivity of domestic interest rates to international interest rates and a procyclical monetary policy.

From the previous arguments it is clear that one of the key issues behind the "fear of floating" criticism of flexible exchange rates is the level of exchange rate pass-through. In the following section it is argued that the inflation environment should be considered when analysing alternative exchange rate regimes since it directly influences the level of exchange rate pass-through and thus the evaluation of flexible exchange rate arrangements.

4. Exchange rate pass-through and the transition to low and stable inflation environments

As mentioned in the previous section, the basic argument against flexible exchange rate arrangements is that if they do not provide the anticipated benefits in practice, then the country should adopt a "hard peg". However, a hypothesis that has not been fully discussed in the literature is that in order to have some of the benefits of a flexible exchange rate arrangement, it is first necessary to have a relatively low and stable inflation rate. Taylor (2000) suggests that the level of exchange rate pass-through

[4] For more on the relationship between balance sheet effects, the exchange rate regime and macroeconomic performance, see Cespedes et al (2000).

declines the lower the level of inflation, mainly because the pricing power of firms declines as well. Therefore, under this hypothesis it might be possible, specially for emerging market countries, to experience a transition period, from high and unstable inflation environments to low and stable ones, during which the full benefits of a floating regime might not be present. However, once inflation stabilises at low levels, the pass-through weakens and movements of the exchange rate put less pressure on inflation, allowing the economy to fully benefit from the flexible exchange rate.

In a recent study, Choudhri and Hakura (2001) explore the Taylor hypothesis using cross-sectional evidence from 71 countries. Their results support the hypothesis that the level of exchange rate pass-through depends on the inflation environment, since they find that lower levels of exchange rate pass-through are associated with lower levels of average inflation. However, attention is focused on the performance of the exchange rate pass-through over time for only a few countries. In another study, Goldfajn and Werlang (2000) analyse the determinants of the exchange rate pass-through, also in a sample of 71 countries, and find that for developing countries real exchange rate misalignments are the most important determinant of the pass-through, although the output gap plays an important part as well. However, for developed economies they find that the initial rate of inflation is the most important determinant of the exchange rate pass-through. The main focus of the study is on the determinants of the exchange rate pass-through but, again, not on the performance of this pass-through over time. Finally, another recent paper which analyses the determinants of the exchange rate pass-through is by Campa and Goldberg (2002). Their analysis goes beyond testing the influence of macroeconomic variables on the exchange rate pass-through. They find, for a sample of 25 OECD countries, that while the inflation level and exchange rate volatility are weakly associated with higher exchange rate pass-through to import prices, its most important determinants are microeconomic and related to the industry composition of a country's import bundle. Again, in this paper the performance of the exchange rate pass-through over time is not analysed in detail.

The purpose in this paper is to show that the level of the exchange rate pass-through changes over time with the inflation environment. Thus, the emphasis here is precisely to document the behaviour of the pass-through over episodes characterised by different inflation environments.[5] Then, some of the determinants of the exchange rate pass-through are also analysed to deepen the hypothesis that the pass-through from the exchange rate to prices depends on the inflation environment.

4.1 Selection of countries

In order to support or reject the hypothesis that the exchange rate pass-through depends on the inflation environment, the analysis includes the experience of small open economies that satisfy two important criteria. First, they must have flexible exchange rates, so that results can shed some light in the discussion currently taking place in emerging market economies on whether flexible or fixed exchange rate regimes are preferable. Second, these countries must have experienced an inflation reduction process over the last 20 years, so that the analysis can cover both "high" and "low" inflation episodes for each country.

Following these criteria, the analysis includes 16 countries. This group is obviously not exhaustive; however, it is representative since their record includes a variety of episodes which enrich the robustness of the analysis. Colombia, the Czech Republic, Hungary, Mexico, Peru and Poland are emerging market economies in the process of consolidating price stability. Australia and New Zealand succeeded in consolidating their inflation reduction process under flexible exchange rate arrangements and are considered today as "pure floaters". Finally, Canada, Finland, France, Italy, Norway, Portugal, Spain and Sweden represent small open developed economies with close links to the business cycle of large industrialised economies such as the United States and the European Union.

Table 1 shows that the economies included in the analysis are small open economies. With respect to size, Canada is the largest while Peru and Hungary are the smallest. In terms of export and import shares of GDP, most countries seem to be in similar ranges, the Czech Republic and Hungary having

[5] In the case of Mexico, Santaella (2002) estimates and compares the exchange rate pass-through between two overlapping periods (1969-2000 versus 1996-2000). However, that paper makes no explicit comment on the relationship between its results and the inflation environment of each period.

the highest shares and Peru and Colombia the smallest. It is also interesting to note similar magnitudes of net exports across all countries.

Table 1

GDP and trade shares

Average for the 1990s

Country	**GDP** (in billions of USD)	**Exports** (as a percentage of GDP)	**Imports** (as a percentage of GDP)
Australia	350.4	18.6	19.5
Canada	596.5	34.9	33.1
Colombia	73.8	16.1	19.6
Czech Republic	12.4	55.8	57.6
Finland	29.8	33.8	28.4
France	340.2	18.6	17.7
Hungary	11.6	48.0	49.5
Italy	284.0	23.0	20.3
Mexico	361.8	26.8	28.1
New Zealand	13.0	29.6	28.6
Norway	34.6	39.8	33.2
Peru	11.6	13.4	17.5
Poland	36.4	26.1	29.9
Portugal	23.2	21.3	32.4
Spain	136.4	22.2	22.9
Sweden	58.3	37.2	32.4

Source: IMF.

4.2 Sample periods

As mentioned before, the purpose of the paper is to show that the level of exchange rate pass-through is related to the inflation environment of the economy and that through time, as the inflation environment changes, the pass-through varies as well. In this exercise the level of inflation is used to describe the inflation environment and, later, additional variables will be considered to complement the analysis. For the purpose of this exercise a cross-sectional analysis is not adequate, since the level of the pass-through depends on the inflation environment as well as on other country-specific factors, so that a cross-country comparison could lead to erroneous conclusions if all of these factors are not considered in the exercise. For example, if the pass-through is higher in a country with higher inflation, it would be wrong to conclude that this result supports the hypothesis of the inflation environment influencing the level of pass-through, since each country has idiosyncratic elements which affect the result. Therefore, the appropriate comparison should be between a period with "high" inflation and a period with "low" inflation for the same country.[6] On this basis, the exercise would show that for that country the hypothesis holds. Thus, the inclusion of several countries in the analysis is intended to show how robust

[6] It is also possible that period-idiosyncratic elements other than the inflation environment, such as random shocks, may affect the result.

the results are, but not to directly support or reject the hypothesis tested. This is achieved by comparing for each country the exchange rate pass-through in the "high" inflation period with that of the "low" inflation period.

To analyse the behaviour of the pass-through over time, it is necessary to have at least two sample periods for each country, one that will be labelled as "high" and the other as "low" inflation. In this respect it is important to mention that "high" inflation only means that the average inflation experienced in that period is higher than that observed in the "low" inflation period. However, it is possible for the "low" inflation rate of one country to be higher than the "high" inflation rate of another country. Again, the comparison across countries is not the key element of this exercise.

For most of the countries considered in the analysis, data from the IMF are available from 1976.[7] However, some of these economies have experienced hyperinflation or triple digit inflation episodes after 1976. To avoid the influence that these extreme episodes may have on the results, the first criterion for selecting a sample period is that the annual inflation rate must be below 30%. Once the hyperinflation episodes have been ruled out, the second criterion is to divide the sample into "high" and "low" inflation periods.[8] In doing so, the purpose is to have two different periods that represent different inflation environments for the same country. That will allow for a proper characterisation of the results, one from a "high" inflation period against one from the "low" inflation episode. Thus, the criterion used is to divide the sample when the difference in average inflation between periods is the largest.

Graph 1 shows the sample periods defined for the countries included in the analysis and illustrates the criteria just explained above. Inflation is computed using consumer price indices from the IMF International Financial Statistics. Consider, for example, the case of Colombia, where the thick line represents the annual inflation rate. The thin line shows for every specific date the difference between the average inflation rate during the years immediately prior to the current date and the average inflation rate during the immediate subsequent years. Thus, when the thin line reaches a maximum, it indicates that the difference in the inflation rate before and after that date is maximised.[9] In the case of Colombia the sample starts in April 1994, because from this point on the inflation rate consistently remained below 30%, and the differential line (thin) reaches a maximum in March 1999 (vertical line). Therefore, the "high" inflation period for Colombia is defined as extending from April 1994 to March 1999 and the "low" inflation period from April 1999 to December 2001. In the case of Canada, instead of dividing the sample into two periods, three periods ("high", "medium" and "low" inflation) are selected based on the performance of the inflation rate and on the two peaks shown by the differential line. In the cases of Finland, Hungary, Mexico, Peru and Portugal the maximum difference is found at the beginning of the sample, which clearly does not leave enough observations for the "high" inflation period. Therefore, in these cases the second maximum difference is taken to define the "high" and "low" inflation periods.

A quick overview of the inflation and exchange rate performance in the selected sample periods is presented in Table 2. According to the criteria used to select the sample periods, average inflation is considerably higher (at least twice the level for the "low" inflation episodes) for the periods of "high" inflation. To document the performance of the nominal exchange rate during the sample periods, the nominal effective exchange rate (NEER) from the IMF International Financial Statistics is used. It is interesting to note that there is not a clear relationship between average depreciation and average inflation. In some cases the average depreciation is lower in the "low" inflation period while in others it is lower for the "high" inflation episodes. This suggests that the effect of exchange rate depreciations on inflation does not necessarily depend on whether the exchange rate varies nor on the magnitude of its variations.

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7 For Australia and New Zealand data are quarterly while for the other countries they are monthly. Given that Finland, France, Italy, Portugal and Spain joined European monetary union in 1999, their sample periods end in 1998.

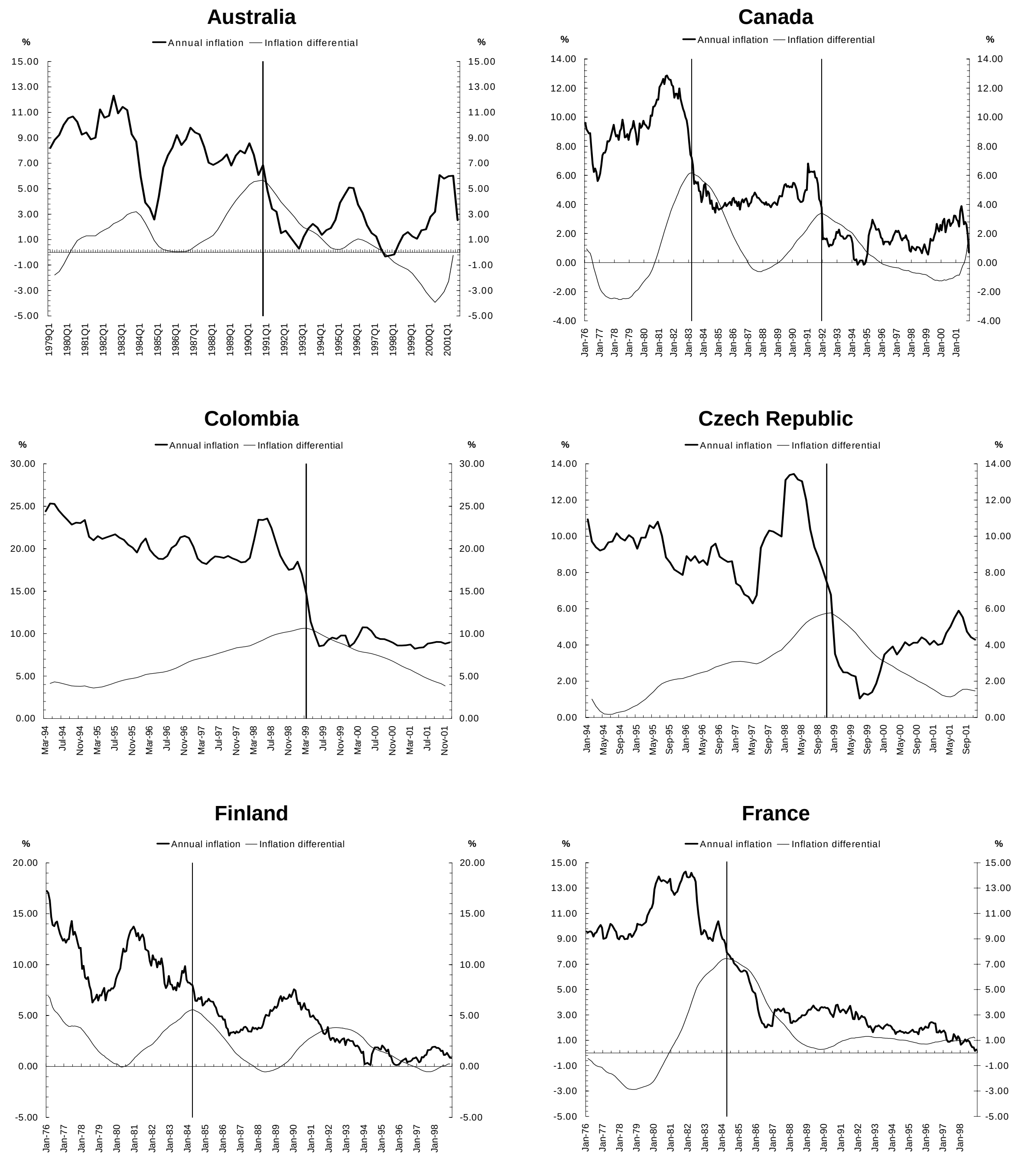
8 Choudhri and Hakura (2001) define high-inflation episodes as those where average inflation is higher than 30%, episodes of moderate inflation as those where average inflation is between 10 and 30%, and episodes of low inflation as those where average inflation is below 10%.

9 The number of years considered to compute the moving average inflation before and after a specific date is four. However, results are robust when the number of years considered is either two or six. In the cases of Poland and Hungary the number of years considered to compute the moving average inflation before and after a specific date is one because of the sample size.

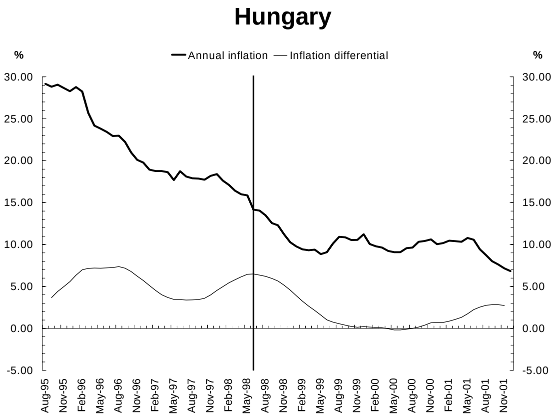
Another interesting feature is that, for all countries, the average exchange rate depreciation is smaller than the average inflation rate during the “high” inflation periods. This result is in line with the “fear of floating” criticism of flexible exchange rate arrangements. However, for Canada, Colombia and Peru, once inflation is reduced (“low” inflation periods), the average exchange rate depreciation is larger than the average inflation rate. These cases suggest that the “fear of floating” phenomenon is not necessarily a characteristic of small open economies with flexible exchange rate arrangements.

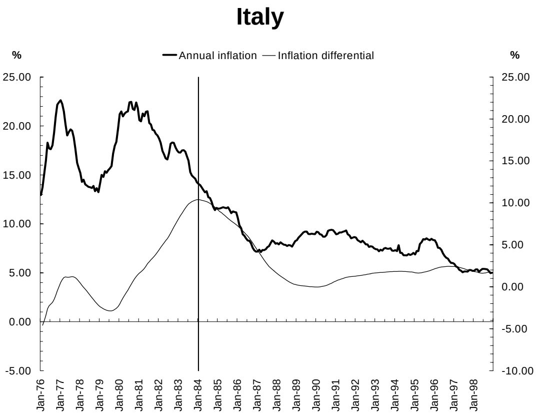
Graph 1

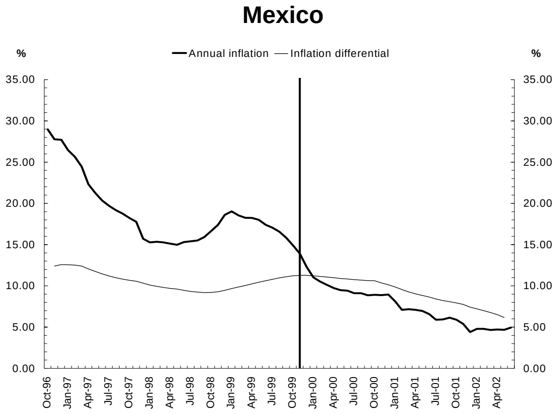
Inflation episodes

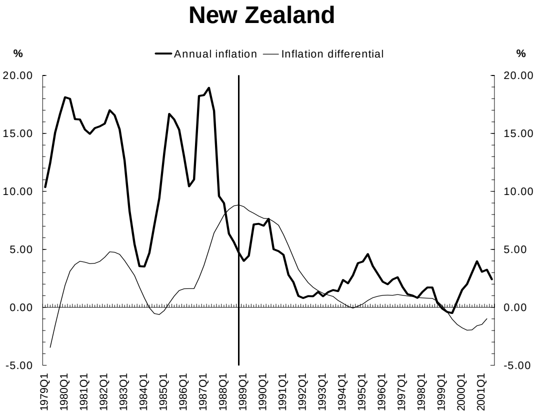


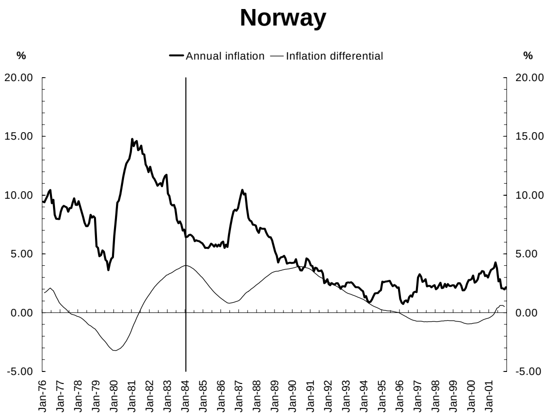
Graph 1 (cont)

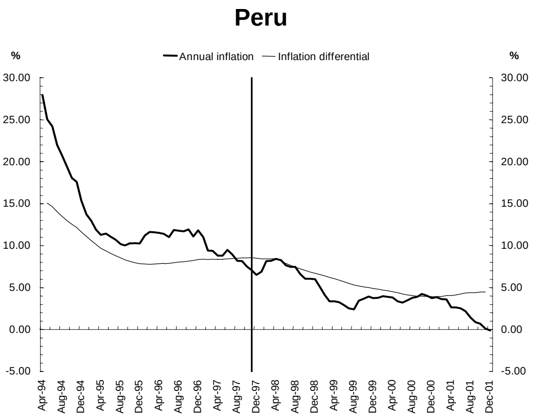

Hungary
Annual inflation
Inflation differential
%


Italy
Annual inflation
Inflation differential
%

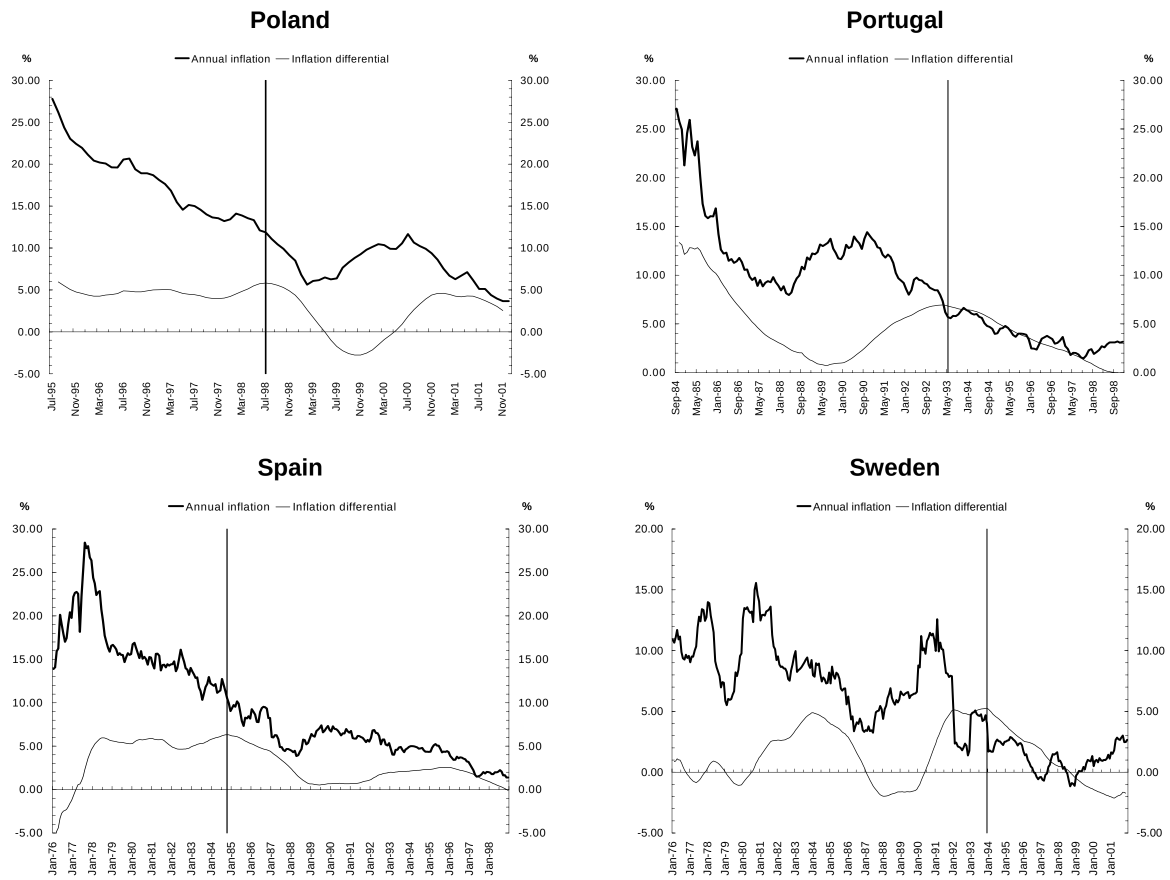

Mexico
Annual inflation
Inflation differential
%


New Zealand
Annual inflation
Inflation differential
%


Norway
Annual inflation
Inflation differential
%


Peru
Annual inflation
Inflation differential
%

Graph 1 (cont)



4.3 Pass-through estimation

The theoretical framework used as background is found in De Brouwer and Ericsson (1995), which assumes the price level as a Cobb-Douglas function on the price of inputs such as the exchange rate and wages. However, due to the lack of data on wages for some of the periods and countries considered, the exchange rate pass-through is estimated following Hausmann et al (2000). The relationship between prices and the exchange rate is estimated using an OLS estimation of the following equation:

$$\ln p_t = \beta_0 + \beta_1 \ln er_t + \varepsilon_t \qquad (1)$$

In this case (β_1) represents the level of pass-through from the exchange rate to prices but because of the omission of wages (and other input prices as well) it is possible that this coefficient will be upwardly biased, ie the estimated level of exchange rate pass-through will be higher than it actually is.[10] However, for the purpose of the exercise this is not a problem since the idea is to compare the evolution of the exchange rate pass-through across different periods and not to estimate the precise level. In other words, conclusions will be drawn from *changes* in the coefficient β_1 over time and not from the *level* of the coefficient.

[10] In a strict sense, the magnitude of the bias in the coefficient depends on the relationship between prices, wages and other variables that influence prices such as public and international prices.

Table 2

Description of inflation episodes

Country and "type" of inflation		Sample period (months: 1-12; quarters: I-IV)		Average annual inflation rate	Average annual variation of nominal exchange rate[1]
		From	To	In percentages	
Australia	"High"	1979: I	1990: IV	8.02	0.70
	"Low"	1991: I	2001: III	2.36	1.03
Canada	"High"	1976:01	1983:03	9.51	2.37
	"Medium"	1983:04	1991:12	4.59	−0.19
	"Low"	1992:01	2001:11	1.70	2.70
Colombia	"High"	1994:03	1999:03	20.57	6.39
	"Low"	1999:04	2001:12	9.22	11.77
Czech Republic	"High"	1994:01	1998:12	9.44	−0.26
	"Low"	1999:01	2001:12	3.59	−1.98
Finland	"High"	1976:01	1984:04	9.83	1.11
	"Low"	1984:05	1998:12	3.25	0.94
France	"High"	1976:01	1984:03	10.29	3.57
	"Low"	1984:04	1998:12	2.77	−0.65
Hungary	"High"	1995:08	1998:06	21.26	13.18
	"Low"	1998:07	2001:12	10.04	4.47
Italy	"High"	1976:01	1984:01	16.70	7.39
	"Low"	1984:02	1998:12	5.40	2.43
Mexico	"High"	1996:10	1999:11	18.76	8.55
	"Low"	1999:12	2002:06	7.47	−1.25
New Zealand	"High"	1979: I	1988: IV	11.85	4.11
	"Low"	1989: I	2001: III	2.51	1.96
Norway	"High"	1976:01	1984:01	8.98	0.14
	"Low"	1984:02	2001:12	3.76	1.10
Peru	"High"	1994:04	1997:11	12.72	6.80
	"Low"	1997:12	2001:12	4.17	7.27
Poland	"High"	1995:07	1998:07	17.78	7.01
	"Low"	1998:08	2001:12	7.92	−0.21
Portugal	"High"	1984:09	1993:03	11.68	4.60
	"Low"	1993:04	1998:12	3.73	1.90
Spain	"High"	1976:01	1984:10	16.32	6.29
	"Low"	1984:11	1998:12	5.37	1.53
Sweden	"High"	1976:01	1993:12	8.06	3.23
	"Low"	1994:01	2001:12	1.19	1.09

[1] An appreciation is indicated by a negative value.

Results of the estimated pass-through coefficient (β_1) are reported in Table 3.[11] Given that the variables are defined in levels, the LR test statistic from the Johansen cointegration test is reported for

[11] For all countries, consumer price indices are seasonally adjusted and the exchange rate is defined as the nominal effective exchange rate expressed in units of domestic currency per unit of foreign currency.

two and 12 lags.[12] The evidence rejects the null hypothesis of no cointegration between prices and the exchange rate for two lags and, in most of the cases, for 12 lags.

Table 3

Exchange rate pass-through

Country and "type" of inflation		**Sample period (months: 1-12; quarters: I-IV)**		**Pass-through coefficient (β_1)**	**Johansen cointegration test**	
		From	To		1-2 lags (LR)	1-12 lags (LR)
Australia	"High"	1979: I	1990: IV	1.27[1]		
	"Low"	1991: I	2001: III	0.19	30.92[2]	14.19[3]
Canada	"High"	1976:01	1983:03	1.34[1]		
	"Medium"	1983:04	1991:12	–0.51[1]		
	"Low"	1992:01	2001:11	0.54[1]	33.88[2]	21.06[2]
Colombia	"High"	1994:03	1999:03	2.56[1]		
	"Low"	1999:04	2001:12	0.77[1]	31.20[2]	25.91[2]
Czech Republic	"High"	1994:01	1998:12	0.61		
	"Low"	1999:01	2001:12	–0.59[1]	17.76[2,4]	7.62
Finland	"High"	1976:01	1984:04	1.02[1]		
	"Low"	1984:05	1998:12	0.01	54.88[2]	19.63[2]
France	"High"	1976:01	1984:03	2.05[1]		
	"Low"	1984:04	1998:12	–0.01	25.12[2]	17.92[2]
Hungary	"High"	1995:08	1998:06	1.03[1]		
	"Low"	1998:07	2001:12	0.77[1]	22.02[2]	10.67
Italy	"High"	1976:01	1984:01	2.09[1]		
	"Low"	1984:02	1998:12	0.59[1]	33.07[2]	7.56
Mexico	"High"	1996:10	1999:11	1.35[1]		
	"Low"	1999:12	2002:06	–0.48	26.84[2]	34.14[2]
New Zealand	"High"	1979: I	1988: IV	1.98[1]		
	"Low"	1989: I	2001: III	0.08	26.66[2]	17.04[2,3]
Norway	"High"	1976:01	1984:01	1.05[1]		
	"Low"	1984:02	2001:12	0.25[1]	36.27[2]	13.62
Peru	"High"	1994:04	1997:11	1.94[1]		
	"Low"	1997:12	2001:12	0.70[1]	31.93[2]	10.64
Poland	"High"	1995:07	1998:07	1.69[1]		
	"Low"	1998:08	2001:12	–0.54[1]	16.29[2]	34.32[2]
Portugal	"High"	1984:09	1993:03	2.29[1]		
	"Low"	1993:04	1998:12	1.36[1]	38.99[2]	25.07[2]
Spain	"High"	1976:01	1984:10	2.24[1]		
	"Low"	1984:11	1998:12	1.61[1]	86.00[2]	37.89[2]
Sweden	"High"	1976:01	1993:12	1.41[1]		
	"Low"	1994:01	2001:12	–0.36[1]	44.98[2]	19.54[2]

[1] Statistically significant at the 5% level. [2] Rejects the hypothesis of no cointegration vector at the 5% significance level. [3] Test includes one to four lags only. [4] Test includes one lag only.

[12] Tests are performed for the complete sample of each country, from the beginning of the "high" period to the end of the "low" period.

The estimates of the pass-through coefficient for the “high” inflation periods are positive and statistically different from zero, except in the case of the Czech Republic, where it is positive but statistically not different from zero. In all cases, the coefficients for the “low” inflation periods are smaller than the ones found for the “high” inflation periods.[13] This result is consistent with the hypothesis that the level of exchange rate pass-through varies as the inflation environment changes. Furthermore, it also shows that this level changes over time. Thus, it means that as the inflation rate decreases, the level of exchange rate pass-through weakens, providing more flexibility to monetary policy.

As mentioned before, Goldfajn and Werlang (2000) find that real exchange rate overvaluation as well as the output gap have an influence on the exchange rate pass-through. However, these factors seem to have no influence on the implications of the previous results since the conclusions from Table 3 hold even when the exchange rate pass-through (β_1) is estimated while simultaneously controlling for the real exchange rate overvaluation[14] and for the output gap (results not shown).[15] Thus, regardless of the performance of the real exchange rate and of the business cycle, the exchange rate pass-through seems to weaken as inflation is reduced.

Also as previously noted, the coefficients of exchange rate pass-through are smaller for the periods of “low” inflation in all cases. To confirm that this result is in line with the hypothesis that low inflation leads to low levels of exchange rate pass-through, it is interesting to clarify the statistical reasons for which the coefficients decreased from one period to the other. The reduction in the pass-through coefficients could occur in either of the following two scenarios: (i) if the covariance between the price level and the exchange rate decreases (numerator of coefficient β_1); or (ii) if the variance of the exchange rate increases (denominator of coefficient β_1). Clearly, the hypothesis that the exchange rate coefficient weakens as inflation is reduced is not supported if the reduction in the coefficient is explained by an increment in the exchange rate variance. Conversely, if the reduction in the coefficient is the result of a reduction in the covariance between prices and the exchange rate, the hypothesis tested is corroborated.

The decomposition of the exchange rate pass-through coefficient is presented in Table 4. In all cases, the covariance between prices and the exchange rate is higher for the “high” inflation periods. Furthermore, it is also shown that for almost all countries (except for Finland and Norway) the variance of the exchange rate is smaller in the “low” inflation period. Therefore, these results confirm that the reduction in the exchange rate pass-through coefficients is explained by a weaker relationship between prices and the exchange rate. In other words, the smaller covariance shows that low-inflation environments are associated with weaker relationships between the exchange rate and prices and thus impose fewer restrictions on the implementation of monetary policy.

The results presented above are in line with the hypothesis that the level of exchange rate pass-through is affected by the inflation environment. Thus, when evaluating the costs and benefits of a flexible exchange rate regime, it is important to consider the inflation environment. Results suggest that if a country succeeds in reducing inflation, then the exchange rate pass-through is likely to be reduced as well and the traditional benefits of flexible exchange rate arrangements gradually become available.

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13 For each country, results from Chow tests (not presented) suggest that the estimated relationship between prices and the exchange rate experienced a structural change in the transition from the “high” to the “low” inflation period. However, since the variables included in the estimation are non-stationary and cointegrated, Chow tests should be treated with caution.

14 The real exchange rate overvaluation is estimated as the log difference between the actual real effective exchange rate (IMF definition) and its Hodrick-Prescott trend.

15 For each country, industrial production is used as an approximation to output. The output gap is estimated as the log difference between actual output and its Hodrick-Prescott trend.

Table 4

Exchange rate pass-through decomposition

Country and "type" of inflation		Sample period (months: 1-12; quarters: I-IV) From	To	Exchange rate variance	Exchange rate and price level covariance
Australia	"High"	1979: I	1990: IV	0.01951	0.02484
	"Low"	1991: I	2001: III	0.00480	0.00095
Canada	"High"	1976:01	1983:03	0.00640	0.00863
	"Medium"	1983:04	1991:12	0.00307	–0.00158
	"Low"	1992:01	2001:11	0.00415	0.00225
Colombia	"High"	1994:03	1999:03	0.02177	0.05587
	"Low"	1999:04	2001:12	0.00573	0.00446
Czech Republic	"High"	1994:01	1998:12	0.00106	0.00065
	"Low"	1999:01	2001:12	0.00088	–0.00052
Finland	"High"	1976:01	1984:04	0.00290	0.00297
	"Low"	1984:05	1998:12	0.00864	0.00011
France	"High"	1976:01	1984:03	0.00767	0.01575
	"Low"	1984:04	1998:12	0.00226	–0.00003
Hungary	"High"	1995:08	1998:06	0.00621	0.00645
	"Low"	1998:07	2001:12	0.00129	0.00100
Italy	"High"	1976:01	1984:01	0.02010	0.04219
	"Low"	1984:02	1998:12	0.01978	0.01179
Mexico	"High"	1996:10	1999:11	0.00916	0.01243
	"Low"	1999:12	2002:06	0.00048	–0.00023
New Zealand	"High"	1979: I	1988: IV	0.02532	0.05036
	"Low"	1989: I	2001: III	0.00786	0.00067
Norway	"High"	1976:01	1984:01	0.00097	0.00103
	"Low"	1984:02	2001:12	0.00289	0.00073
Peru	"High"	1994:04	1997:11	0.00582	0.01131
	"Low"	1997:12	2001:12	0.00669	0.00468
Poland	"High"	1995:07	1998:07	0.00397	0.00672
	"Low"	1998:08	2001:12	0.00309	–0.00167
Portugal	"High"	1984:09	1993:03	0.01118	0.02569
	"Low"	1993:04	1998:12	0.00035	0.00048
Spain	"High"	1976:01	1984:10	0.02495	0.05592
	"Low"	1984:11	1998:12	0.00896	0.01447
Sweden	"High"	1976:01	1993:12	0.02487	0.03519
	"Low"	1994:01	2001:12	0.00238	–0.00087

4.4 Determinants of the exchange rate pass-through

The evidence presented in the previous subsection shows that the level of the exchange rate pass-through depends on the level of the inflation rate. As inflation decreases, the relationship between prices and the exchange rate weakens. However, it is possible that changes in the inflation environment are not fully described by the level of average inflation, since other variables may have an effect on the pass-through beyond the one already captured by the reduction in the level of inflation. For example, as credibility in price stability rises, it may be possible for the exchange rate pass-through to decrease. Another example is the competitive structure of domestic markets. When a market is more competitive, firms are likely to have less flexibility to pass through cost increases to consumers. Thus, in this exercise the analysis goes beyond the effect of the level of inflation on the exchange rate pass-through and tries to identify other determinants which may be associated with changes in the inflation environment.

The analysis in this section follows Choudhri and Hakura (2001) and Campa and Goldberg (2002) in using the results from the pass-through estimation in the previous section to run second-stage regressions over the pass-through coefficients of the following form:

$$\beta_1^{ij} = \alpha + \phi X^{ij} + \varepsilon^{ij} \tag{2}$$

where β_1^{ij} represents the exchange rate pass-through coefficient from Table 3 for country "i" and for inflation period "j" ("high" or "low" inflation) and X^{ij} represents a vector of regressors which are country ("i") and period ("j") specific. Thus, the sample in this cross-sectional exercise contains 33 observations.[16] With such a specification it is possible to test the relationship between variables other than average inflation and the exchange rate pass-through.

Since the pass-through coefficients were estimated for periods with different average inflation, it is necessary to control for this effect so that the results for the other variables are not biased. Therefore, the first regressor to be included is the average inflation rate. Then, by adding additional variables to equation (2), it is possible to test if average inflation alone provides a sufficient description of the inflation environment (ie no other variable has a significant effect on the pass-through coefficient), or if additional variables complement the information contained in the level of inflation and thus, by including them in the analysis, the relationship between prices and the exchange rate is better understood.

Equation (2) is estimated using weighted least squares, where the weights are defined as the inverse of the standard error of the estimated pass-through coefficients from the previous exercise (Table 3). The results of the exercise are presented in Table 5. The right-hand regressors included are average inflation, nominal exchange rate volatility (coefficient of variation), the trade balance (net exports) as a percentage of GDP and the average spread between consumer (CPI) and producer (PPI) prices indices.

Table 5

Determinants of exchange rate pass-through

Regressor (*X*)	**Specification 1**	**Specification 2**	**Specification 3**	**Specification 4**
Constant	–0.063	–0.826[1]	–0.487[1]	–0.323[1]
Average inflation	0.112[1]	0.074[1]	0.045[1]	0.040[1]
Exchange rate volatility		11.043[1]	10.056[1]	8.492[1]
Trade balance			–8.902[1]	–13.178[1]
CPI-PPI spread				–2.244[1]
Adjusted R^2	0.860	0.931	0.948	0.956
Number of observations	33	33	33	31[2]

[1] Statistically significant at the 5% level. [2] Portugal omitted due to lack of PPI data.

[16] Two periods per country and three for Canada.

As expected, the coefficient for average inflation is positive and statistically significant. The fact that the coefficients for the other variables are also statistically significant suggests that the inflation environment is not fully described by average inflation. Results suggest that higher exchange rate volatility leads to higher levels of exchange rate pass-through; thus the inflation environment is not only described by the level of nominal variables but also by their volatility. This is consistent with the theoretical results from Devereux and Engel (2001), which show that the level of exchange rate pass-through decreases as nominal variables become more stable since firms wish to set their prices in the currency of the country with the most stable monetary policy. Another result is that larger trade deficits (smaller net exports) lead to higher levels of exchange rate pass-through. This suggests that sound macroeconomic fundamentals, which include sustainable external accounts, are also part of the inflation environment. As the trade deficit increases it becomes more difficult to finance and the probability of an exchange rate depreciation rises, which in turn drives more firms to pass through any exchange rate movement to their prices.

Another interesting result is found with the average spread between CPI and PPI. The effect of this variable is also statistically significant and the negative sign suggests that when the spread between consumer and producer prices is reduced, the pass-through coefficient increases since firms have no room to accommodate a cost increase without passing it on to consumers. On the other hand, a larger spread can be associated with more flexibility in firms to absorb cost increases. This result suggests that an interesting line for further research would be to analyse the process through which firms set their prices, particularly in competitive markets, where, as argued by Rotemberg (2002), the reaction of consumers may be the major concern for a firm when setting prices. In this framework the frequency of price adjustments depends on economy-wide variables observed by consumers (an unstable macroeconomic environment would lead to frequent price changes and higher pass-throughs).

Results confirm that the relationship between prices and the exchange rate weakens when inflation is low. A stable macroeconomic framework induces a weaker exchange rate pass-through and thus fosters the benefits of flexible exchange rate arrangements.

5. Conclusions

The analysis presented in this paper suggests that the level of the exchange rate pass-through depends on the inflation environment. For a group of small open economies that in recent years have experienced disinflation processes, it is shown that the level of exchange rate pass-through weakens as the level of inflation falls. This result suggests that when a low and stable inflation environment is achieved, agents' expectations are likely to be in line with the authorities' inflation target and thus to be less influenced by short-term exchange rate variations. Under such circumstances it is possible to infer that the "fear of inflation", which any central bank should have, no longer implies a "fear of floating". Credibility in monetary policy as well as competitive markets are likely to be at the heart of this result.

The analysis suggests that the inflation environment should be considered as an important element when evaluating alternative exchange rate regimes. This is likely to be of particular importance for emerging market economies, where low and stable inflation environments are not necessarily the norm. Thus, with respect to the empirical debate between the benefits different economies may attain under a "floating" or a "hard peg" regime, the evidence presented in this paper suggests that the appropriate comparison should be between "hard pegs" and "floats", but only when the "floating" economies have achieved low and stable inflation environments.

In this paper it is argued that a low and stable inflation environment, associated with weaker exchange rate pass-through, is not only described by the level of inflation but also by stability in nominal variables and by the environment in which firms set their prices. Both monetary policy and the structure of markets seem to have an important effect on the relationship between prices and the exchange rate. Understanding the interaction between monetary policy and firms' price setting behaviour would appear to be an interesting exercise in an effort to fully identify the determinants of the exchange rate pass-through.

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Financial stability in low-inflation environments[1]

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Abstract

Price stability does not seem to have reduced the possibility of boom-bust cycles in asset markets and banking crises. This paper identifies common underlying patterns for financial crises over the period 1970-2002. Crises tend to be correlated with one another and concentrated in specific subperiods.

1. Introduction

There has been increased attention in the recent literature to the factors underlying financial crises. A common feature of many of these studies is the finding that weak economic fundamentals contribute to crises by allowing imbalances to accumulate (eg Mishkin (2000)). However, although the probability of crises may well be reduced in countries where the fundamentals appear to be sound, it does not fall to zero (Bordo et al (2000)). This study therefore analyses the characteristics of crises that occur in periods of (apparent) macroeconomic stability. How real, at present, is the possibility of crises developing in advanced countries, and are there patterns that are typical of these crises? In order to retain the relevance for the industrialised world, we do not include other countries in our assessment as crises in these countries may be due to factors that do not apply in industrialised economies (Mehrez and Kaufmann (1999)).

We focus on banking crises and on bust periods in asset markets. Both of these can have significant macroeconomic impacts - and may feed on each other. Another potential source of crises, exchange rate movements, has become less important. Most of the countries we consider have abandoned fixed exchange rate regimes, thereby removing a potential source of macroeconomic tension. Instead, they have joined a currency union or have chosen freely floating exchange rates.

The paper continues in Section 2 with a discussion of how crises can develop. Section 3 contains an empirical analysis of crisis episodes and patterns of key variables around these crises. Conclusions are drawn in Section 4.

2. Anatomy of crises

Two main types of financial crises in industrialised economies are problems at individual financial institutions (banking crises) and asset price busts. Banking crises are particularly devastating when a problem in one or a few institutions spreads unchecked across the financial system. This systemic risk results from institutions having various exposures with one another.

Banking and asset price crises can be interrelated. Asset market busts are likely to cause financial sector troubles if balance sheets of both financial and non-financial firms are weak. This is particularly

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[1] This paper was prepared for the BIS Autumn Central Bank Economists' Meeting on "Monetary policy in a changing environment" on 14-15 October 2002 in Basel. The views presented are the authors' and do not necessarily reflect the position of the Netherlands Bank. We gratefully acknowledge many helpful discussions with Bryan Chapple. Martin Admiraal, René Bierdrager and Carry Mout provided expert research assistance.

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the case for financial firms, as an asset price crash can seriously compromise their financial health. Non-financial sector balance sheets also matter, since declining net worth in combination with asymmetric information problems may amplify financial crises (Bernanke and Gertler (1989)). Expectations play an important role in the triggering and spread of banking and asset price crises, due to the lack of full information on underlying values of investment projects.

2.1 Price stability and crises

In an environment with price stability, inflation and inflationary expectations are low and stable. In the countries covered in this paper, inflation has been mostly below or close to 3% since the mid-1980s. In theory, threats to financial stability are less likely to emerge in an environment with price stability (eg Schwartz (1995), Mishkin (2000)). First, price stability tends to reduce uncertainty regarding future economic conditions. This fosters balanced risk-return decision-making and reduces financial risks. Second, in such an environment, volatility in nominal interest rates is less likely. Mishkin (1991) shows that in the US most financial crises began with a sharp monetary policy contraction. Third, with price stability, debt contracts tend to be of a long duration and denominated in domestic currency. This makes an economy less vulnerable to sentiments of both domestic and foreign creditors.

However, price stability is no guarantee of financial stability. It can be argued that the credibility of the central bank's commitment to price stability, by anchoring inflationary expectations at low and stable levels, can make prices and wages stickier. This will reduce the inflationary pressures usually associated with unsustainably strong demand, but it can also allow financial imbalances to build up (Borio and Lowe (2002)). If temporary favourable supply side developments in times of strong economic performance and price stability are incorrectly perceived as permanent, excessive optimism about economic prospects and asset prices may emerge. This can lead to overinvestment and excessive credit growth. In this context, asset price inflation and credit growth may reinforce each other: higher collateral values allow for higher credit expansion, resulting in further asset purchases at higher prices. Accordingly, an unsustainable asset inflation-credit spiral may develop.

2.2 Liberalisation and crises

Financial market reform[3] and capital account liberalisation have also been associated with crises, as discussed in, for example, Demirgüç-Kunt and Detragiache (1998) or Bakker and Chapple (2002). Prior to reform, lending levels and interest rates have typically been kept artificially low by direct government controls. In such a situation, credit rationing is common practice, with lending decisions based on close relationships between banks and customers. Reform and liberalisation are likely to boost competition, forcing financial institutions to change their behaviour in order to remain competitive. The removal of credit rationing promotes an increase in the supply of credit, while banks may also be keen to expand lending in order to gain market share. However, risk and credit assessment skills do not necessarily keep pace with the changing market environment. The increased availability of credit, combined with a view that reforms have increased the potential economic growth rate, is likely to result in asset price rises. As noted in Section 2.1, such increases in asset prices can become self-sustaining for a certain period of time.

2.3 After the crisis

A severe financial crisis will disrupt financial intermediation as adverse selection and moral hazard problems increase, causing a sharp drop in lending. Because of the central role of the financial sector in industrial countries, this will damage the macroeconomy. In response to lower lending, the private sector will cut spending, resulting in a contraction of the real economy. In addition, monetary policy will be hampered by a banking crisis, as financial institutions are a pivotal link in the chain of monetary transmission. Distortions or poor corporate governance in the financial sector may amplify monetary

[3] "Reform" refers to reform of the domestic financial markets while "liberalisation" is taken to refer to capital account liberalisation. Often the two proceed in parallel.

policy errors, since they can lead to insufficient risk assessment in an environment with strong credit and asset price increases.

3. Empirical analysis

We analyse quarterly data over the period 1970 Q1-2002 Q2 for a group of 20 industrial countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. We first examine the incidence of crisis episodes over time to see whether these can be related to each other and to more general macroeconomic developments. We subsequently analyse the average pattern of key macroeconomic variables before and after financial crises.[4] Potential leading indicators have been selected on the basis of theoretical considerations and data availability.

3.1 Data and definitions

We consider two types of financial crises: banking crises and asset market busts, where the latter are further split into housing market and stock market crises. These crisis episodes are determined as follows:

- **Banking crises** are characterised by financial distress resulting in the erosion of most or all aggregate banking system capital. For the identification of these crises, we rely on existing studies. An episode is considered a banking crisis if it qualifies as such according to either Bordo et al (2001) or Mehrez and Kaufmann (1999).

- Our definition of an **asset market crisis**, both for stock and property, is based on the methodology of Bordo and Jeanne (2002). Asset price crises are determined on the basis of moving averages of the growth rate in asset prices in comparison to their long-run historical average. More specifically, a bust is defined as a period in which average growth over a 12-quarter window is smaller than a threshold. This threshold is the average growth rate in the asset price in all countries over the entire sample ($\bar{g}$), minus x times its standard deviation v:

  $$\sum_{l=1}^{12} \frac{g_{i,t-l}}{12} \leq \bar{g} - xv$$

  Similarly, boom periods occur when:

  $$\sum_{l=1}^{12} \frac{g_{i,t-l}}{12} \geq \bar{g} + xv$$

  The three-year window is also chosen by Bordo and Jeanne (2002), and is sufficient to filter out short-term volatility. The parameter x is calibrated such that the main boom and bust periods in the stock market and the housing market are selected, without including too many observations.[5] Although this methodology is ad hoc, it is reassuring that most of the boom-bust periods are plausible when compared to other sources. In particular, most boom-bust patterns closely match the results of Bordo and Jeanne (2002), despite some differences between their

[4] Our analysis builds on recent empirical work on financial crises by Kaminsky and Reinhart (1999) and Borio and Lowe (2002).

[5] The average annual growth rates are 1.5 and 3.4%, respectively, for house prices and share prices (both in real terms, deflated by CPI). The corresponding standard deviations are 7.5 and 23.1%. To determine thresholds, we use $x = 1.0$ for house prices and $x = 0.8$ for stocks. Bordo and Jeanne (2002) find for their sample average growth rates of 1.1 and 2.9% and standard deviations of 5.8 and 13.6%, respectively, and take $x = 1.3$ for both categories. According to our calculations, stock market busts cover 18.6% of all observations, while housing market busts take place 17.9% of the time.

data set and ours.[6] Following our procedure, 25 major stock market crashes and 23 residential property crises have occurred since 1970 in the 20 industrialised countries concerned.

The macroeconomic variables we consider around crisis periods are: short-term and long-term interest rates, inflation, industrial production, the ratio between credit outstanding and nominal GDP, money and credit growth, and asset prices (shares and residential property).[7]

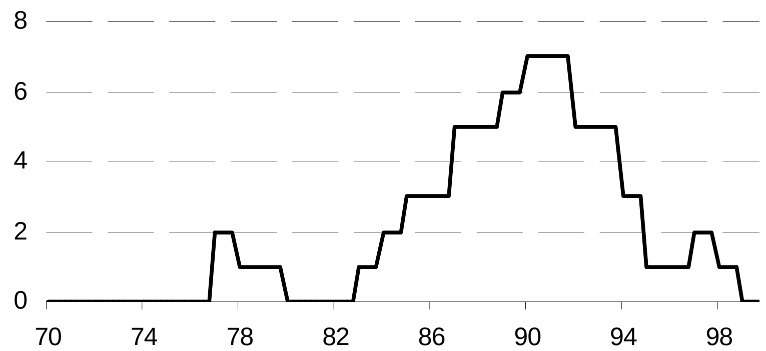
3.2 The incidence of crises

Graphs 1-3 summarise the crisis periods for all countries in our sample. For asset prices, we include both the boom and bust episodes, the latter presented with a negative sign. Some striking differences can be seen across subperiods. During the 1970s there were only two banking crises, but quite a few asset market busts. The practical absence of banking crises must be seen against the background of highly regulated financial markets in those years. Stock market crises were heavily concentrated in the high-inflation years 1973-77, when real economic prospects were bleak. Presumably, there was a flight into property, the traditional safeguard against high inflation, which partly explains the high frequency of property booms in the mid-1970s. These house price increases turned out to be excessive, since in the late 1970s many property markets collapsed.

Graph 1

Banking crises

Number of ongoing banking crises per quarter



In the early 1980s, there was a boom in stock markets, but a bust in property prices. The decline in inflation and high real interest rates were important factors behind the poor performance of property markets. These factors, together with an improvement in economic prospects, made stocks more attractive to investors.

Most banking crises in our sample are concentrated in the period 1984-93. One of the explanations for this may be that there were high and increasing real interest rates undermining the profitability of the banking sector. In the early 1980s, US real interest rates reached their highest level in the postwar period. In addition, the high frequency of banking crises in the 1980s and early 1990s can be partly attributed to financial market reform and capital market liberalisation, which often took place in the years preceding these crises. Interestingly, these crises developed despite a high degree of price stability in the years concerned. They occurred after a boom in stock prices in the early 1980s, and more or less coincided with stock market crises (1987, early 1990s) and bad performance on property markets (early 1990s). These factors are in line with our theoretical considerations in Section 2, and is discussed in greater detail below.

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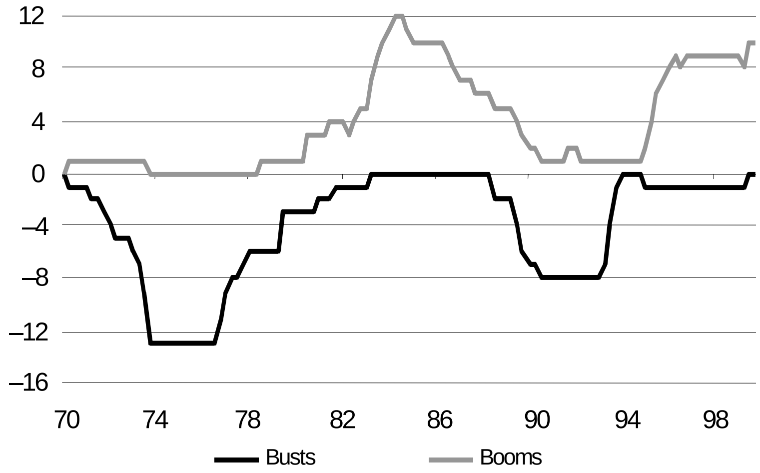
6 Bordo and Jeanne (2002) analyse annual rather than quarterly data and also include Ireland, but not Austria, Belgium, Korea, New Zealand, Portugal and Switzerland.

7 Our data come from various sources (national statistics, IFS, BIS, etc) and are available upon request.

Graph 2

Stock market booms/busts

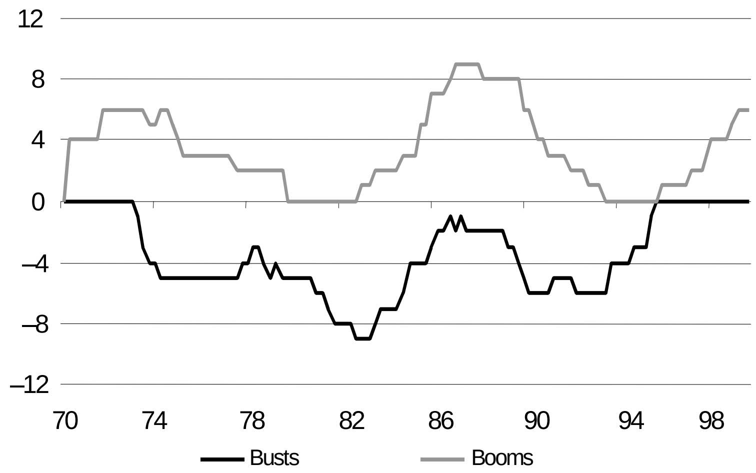
Number of ongoing booms/busts per quarter



Graph 3

Housing market booms/busts

Number of ongoing booms/busts per quarter



In the 1990s, stock and property markets moved much more in tandem than in the 1970s. This is not surprising, given reduced inflation and liberalised capital markets in these years. Interestingly, stock markets seem to lead property markets. In both markets, boom-bust cycles have occurred since 1985 despite price stability and free capital markets in most countries during this subperiod. Hence, these factors are no guarantee of financial stability.

Over the whole period, it is striking that both banking and asset price crises seem to occur in bunches. This is most clearly visible for stock markets, which is no surprise as these are strongly intertwined internationally. Although property markets and banking are more nationally oriented, crises in these markets also tend to be particularly concentrated in specific subperiods. Especially in the early 1990s, the three types of crisis coincided. While these patterns suggest that crises have common roots, the concentration of financial crises may also signal contagion.

3.3 Behaviour of variables around crises

In this section, we consider average patterns of some key macroeconomic variables 12 quarters before and after crisis periods. Graph 4 shows the extent to which these variables deviate from their levels at the start of a crisis during the run-up phase (periods –12 to 0) and how much they depart from their levels in the aftermath of these episodes (periods 0 to 12). The crisis period itself is not considered here.[8] The data shown are averages, which may of course mask important differences across episodes. In the Appendix, we present the same graph plus a range determined by adding and subtracting one standard deviation, as a rough measure of dispersion, to check the robustness of average patterns. One should be cautious, however, of interpreting this range as a confidence interval, as the distributions of individual cases tend to be non-symmetric while the standard deviations are sometimes increased substantially by one or two outliers.[9]

- Short- and long-term **interest rates** rise significantly during the quarters preceding both housing market and stock market busts, whereas they remain more or less constant prior to banking crises. Short-term interest rates rise particularly rapidly prior to stock market busts - almost 4 percentage points in two years. This suggests that interest hikes are one of the proximate causes of such crises.

- In this context, it is also interesting to observe that **inflation** increases prior to bust periods in stock markets - about 2 percentage points, on average - and, albeit not very significantly, before property crises. By contrast, there is no clear pattern for inflation just before banking crises. Presumably, contractionary monetary policy to control inflation is an important trigger for crises in asset markets. After a banking crisis, inflation drops significantly - about 3 percentage points - while stock market busts are initially followed by higher inflation.

- Another, more forward-looking way to examine interest rates and inflation pressures is by considering the **yield curve**, ie the difference between the long- and short-term interest rates presented in the first two panels. About two to three years before a stock market crisis, the yield curve steepens significantly, which correctly signals an acceleration in inflation. One year before the stock market crisis starts, however, the yield curve flattens again, which is largely due to a strong increase in the short-term interest rates. The yield curve also flattens on average prior to a property market crisis, but this pattern is not very robust across different episodes (see the Appendix). In the case of bank crises, the yield curve does not even show any clear pattern, in line with the behaviour of interest rates. Altogether, changes in the yield curve suggest that especially the stock market is forward-looking, implying that expectations play a greater role in triggering a stock market bust than in the case of both other types of crisis.

- Particularly in the run-up phase to a stock market crisis, **industrial production growth** increases, while it does not show a clear pattern before the other two types of crisis. Consistent with the inflation patterns described above, stock market crises typically develop in periods of a booming economy - reflecting a positive perception that the boom will continue - while many banking crises and housing market busts may be the result of an economic slowdown. Note, however, that just before a stock market crisis, the acceleration in industrial production growth slows significantly, probably due to the short-term interest rate increase. Asset crisis episodes are immediately followed by a significant slowdown. Negative wealth effects possibly play a role here, in combination with reduced future prospects, reflected by forward-looking share prices.

- Excessive credit growth is often seen as an important underlying cause of asset bubbles and (to some extent) relatedly, banking crises. In particular, Borio and Lowe (2002) stress the

[8] In other words, for the observations –12 to 0, the level at the start of the crisis is subtracted, while for the observations 0 to 12 the level in the final quarter of the crisis episode is subtracted. Hence, the crisis period ("period 0") is excluded, so the observations just before and after period 0 are not connected. Crisis periods have very different lengths, which makes it difficult to include them in our cross-national analysis.

[9] Patterns of all individual cases are not presented in order to save space, but are available upon request.

importance of the **credit/GDP ratio** as a leading indicator of financial crises.[10] This finding is especially corroborated for property crises and banking crises, which are preceded by a significant increase in this ratio, while after the crisis periods this increase slows somewhat.[11] By contrast, prior to a stock market crisis the credit/GDP ratio rises only marginally; our dispersion measure shows that this increase is not robust (see the Appendix). This difference between on the one hand housing and banking crises and on the other hand stock market crises might be due to the fact that the former two categories are more closely related to the domestic economies, while share prices are typically correlated with the major stock markets abroad. This also explains our finding above, in Graph 2, that stock market crises in various countries are more concentrated in particular years than both other crisis categories. Hence, excessive domestic credit growth is more likely to cause financial problems in domestic markets than in internationally oriented stock markets. To some extent, this may be seen as a refinement of Borio and Lowe's results, which are primarily based on an aggregate index including both property and equity prices.

- Given the behaviour of the credit ratio, it may be interesting to look at the patterns of **money** and **credit** growth rates. Before all three types of crisis, money growth (both M1 and M3) slows on average, albeit not very significantly (see the Appendix), while credit growth does not follow a clear pattern. All in all, the credit ratio appears to be a more reliable indicator for financial strains than money and credit growth, which underscores the importance of cumulative processes rather than growth rates.
- Finally, we consider the behaviour of **asset prices**. Typically, the growth rate of both stock and house prices drops significantly prior to a banking crisis, which suggests they may be one of the underlying causes. After a stock market bust, share prices continue their downward path for some time (about four quarters). The growth rate of real house prices drops after all three types of crisis, including a stock market crisis, when the growth rate drops by 15 percentage points in six quarters. This is in line with Graphs 1-3, which indicate that stock markets seem to lead property markets.[12]

By and large, the patterns shown in Graph 4 are in line with the discussion in Section 2 and with previous empirical studies (see, for example, Borio and Lowe (2002)). At the same time, one should be cautious when interpreting our results for two reasons. First of all, we have mainly presented stylised facts; in order to draw stronger conclusions one should formulate stricter hypotheses and carry out more rigorous testing. For instance, it would be interesting to analyse combinations of variables, to correct for country-specific factors, and to look more precisely at different subperiods. Second, our analysis is only of limited use for predicting crises. We focus on the behaviour of some key variables around crisis episodes, which does not imply that these are *always* good leading indicators for financial crises. This would require a further analysis of type one and type two errors. We are planning to address these issues in future work.

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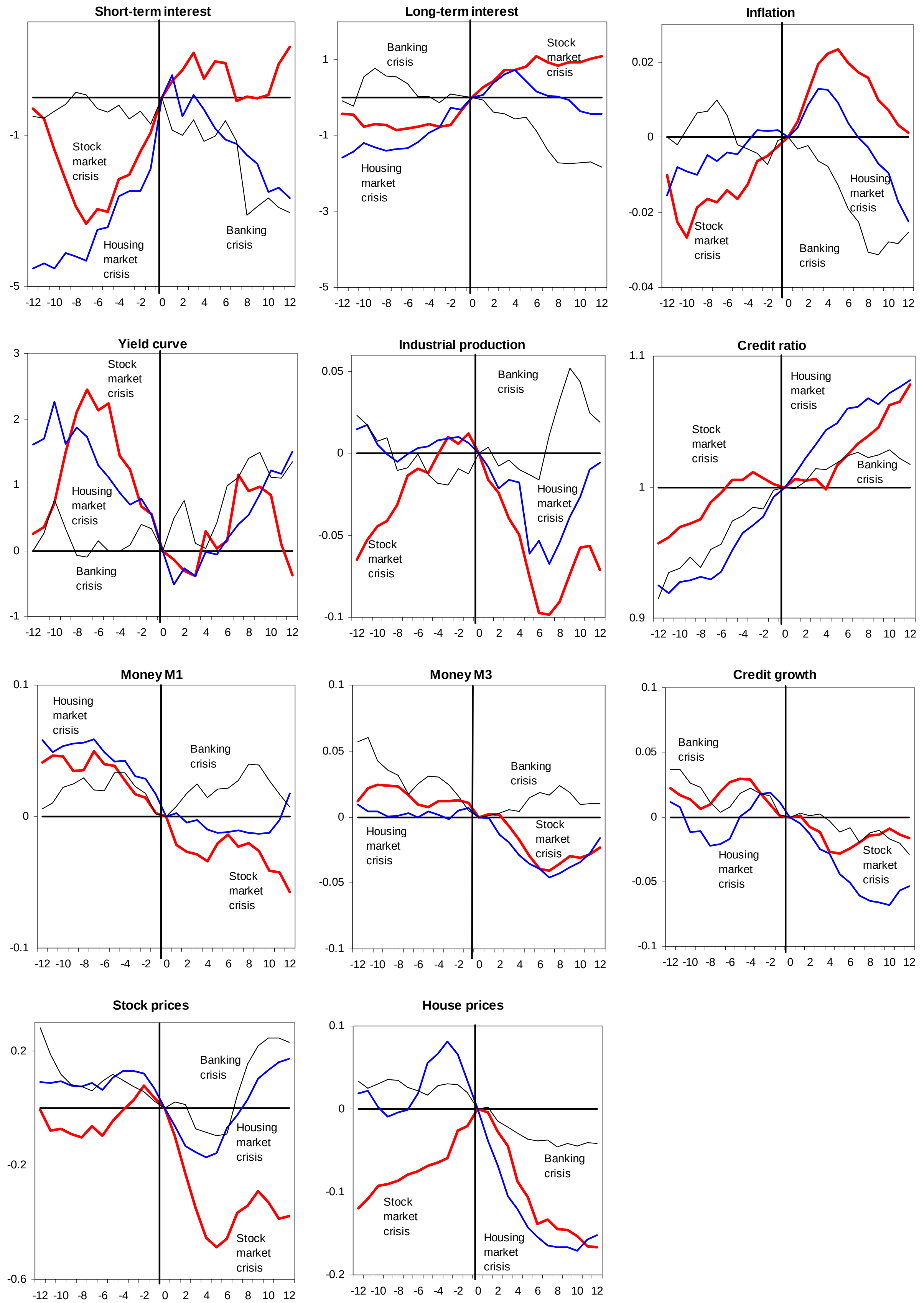
[10] We present this variable in a slightly different way. Instead of *subtracting* the first observation of a crisis from observations −1 to −12 and the last observation of a crisis from +1 to +12, we now *divide* by these first and last observations of crisis periods, respectively. This is because we consider a level now, rather than a growth rate, which makes it less useful to take simple averages because countries with a high credit ratio - eg reflecting a well developed financial sector - will dominate the results. In addition, for some countries we only have indices, which makes it even more difficult to interpret the results. By dividing instead of subtracting, all data in the graphs are normalised at their level at time 0.

[11] On average, the ratio does not decrease after a crisis, which one might have expected. To some extent, this reflects the gradual increase in the ratio in most countries over time, as a result of financial development.

[12] An interesting question is to what extent there exists a causal relationship running from the stock market to the housing market. Some indirect evidence of this relationship for the Netherlands is presented in Netherlands Bank (2002). This study shows that house prices not only follow share prices with a lag, but that this correlation is also higher for more expensive categories than for the cheaper segments of the housing market. As households in the higher segment are more sensitive to the stock market - they own more shares - this pattern is consistent with a causal link between share prices and house prices. In addition, Sutton (2002) finds that stock prices explain a substantial part of house price changes for a group of industrial countries, also taking into account other explanatory factors (economic growth, interest rates).

Graph 4

Patterns of variables around crises

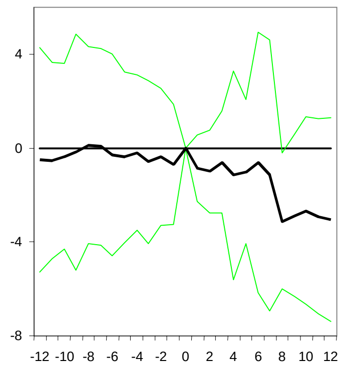


4. Concluding remarks

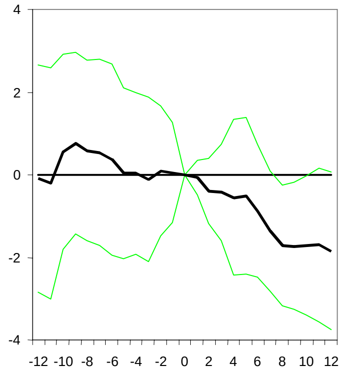
For more than a decade now, the industrialised world has experienced overall macroeconomic stability. This is an important change from the 1970s and early 1980s, which were characterised by both high and volatile inflation, as well as heavily regulated domestic and international capital markets. With price stability and liberalised capital markets more or less in place in the western world, prospects for long-run economic performance are favourable. However, as our paper illustrates, banking and asset market crises can occur in spite of macroeconomic stability. A key lesson of recent decades is that monetary policy needs to be forward-looking to address risks to price stability. Theory suggests that in doing so, monetary policy contributes to financial stability, since price stability makes financial crises less likely to emerge. Monetary policy must also be forward-looking to address financial stability risks if we are to avoid the damage to the real economy caused by downward corrections that threaten the banking system and financial stability. However, it is very difficult to identify financial imbalances in advance, particularly in the current environment of price stability. A central bank with a high degree of credibility runs the risk that inflationary pressures first manifest themselves in asset markets rather than goods markets. We have presented some evidence that an increase in the credit/GDP ratio indicates a build-up in financial strains, especially during the run-up to housing market busts and banking crises. This result is in line with Borio and Lowe (2002). We have also investigated several other indicators. An important conclusion is that interest rate hikes - although they are less likely in an environment of price stability - seem to have remained an important trigger for asset price crises. This is particularly so for short-term interest rates. Another finding is that banking crises and property crises are more nationally oriented. This arises from the fact that they are less correlated internationally, and seem to have a stronger relationship with domestic credit growth. Finally, a result that warrants further research is that bust periods in the housing market systematically follow stock market crises. Although this may simply be due to the fact that stock prices are more forward-looking, there might also be a causal relationship.

Appendix:
Banking crises

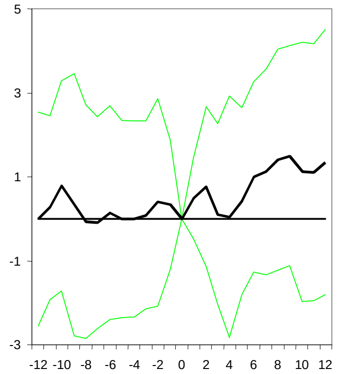
Short-term interest



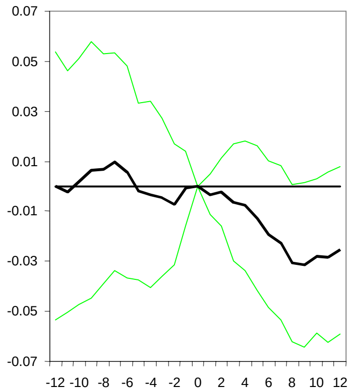
Long-term interest



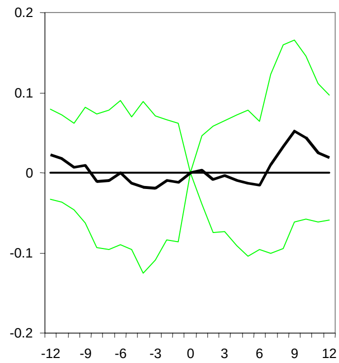
Yield curve



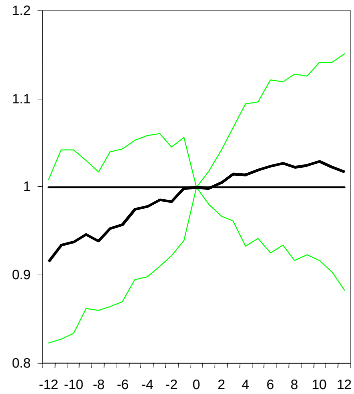
Inflation



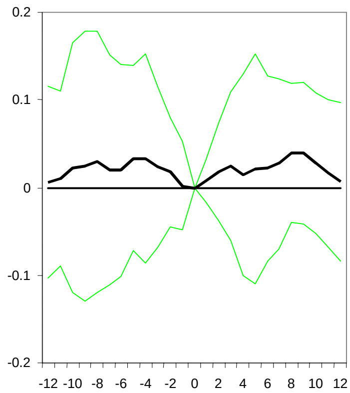
Industrial production



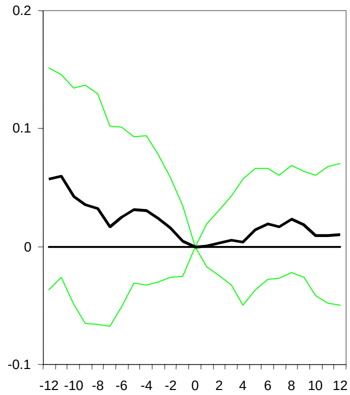
Credit ratio



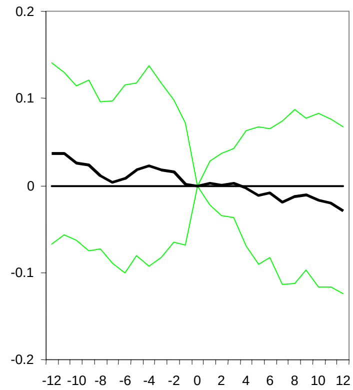
M1



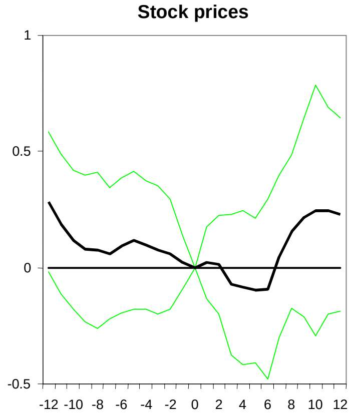
M3



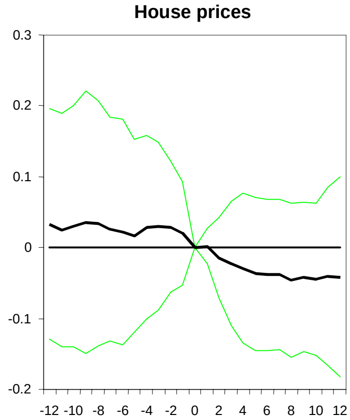
Credit growth



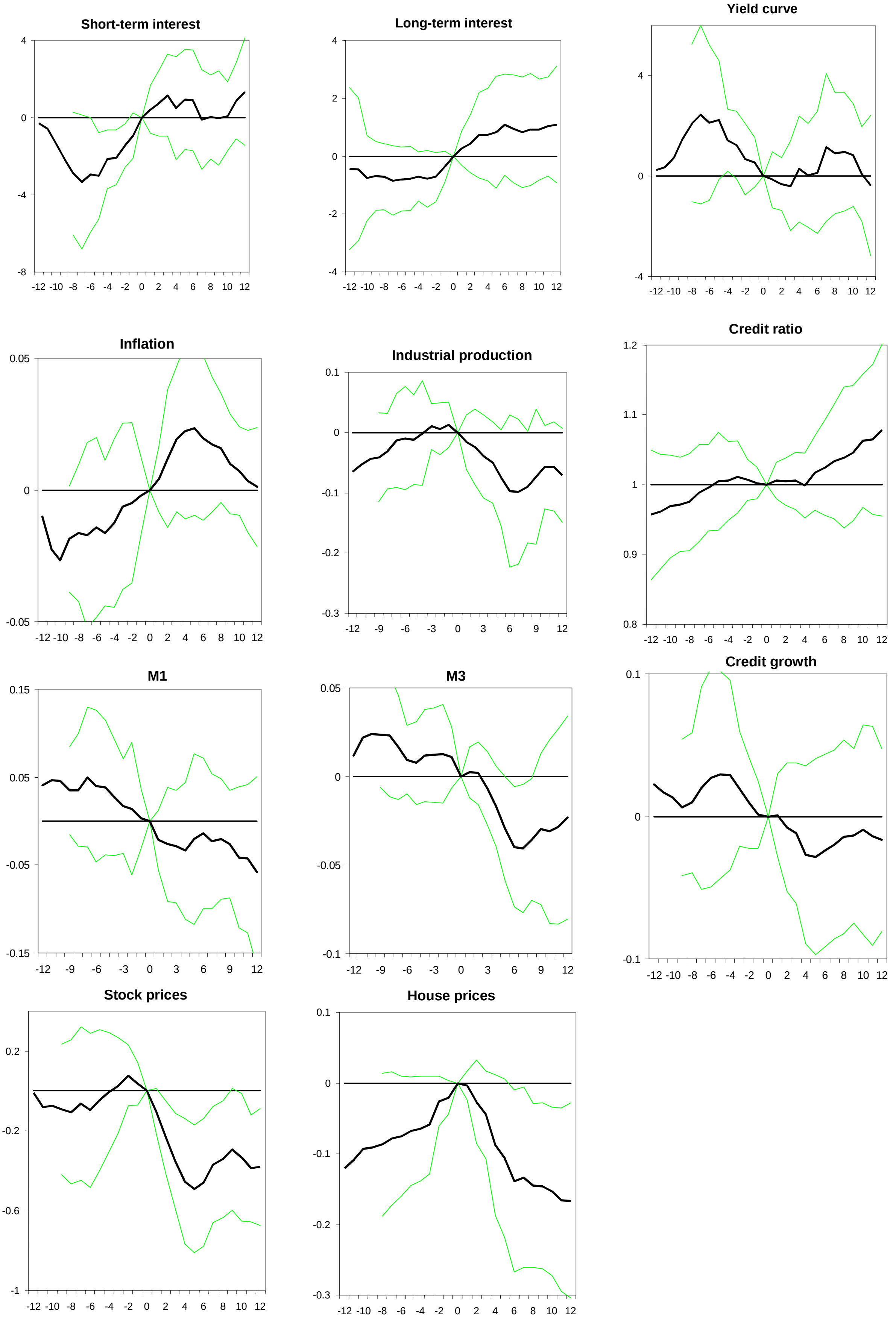
Stock prices



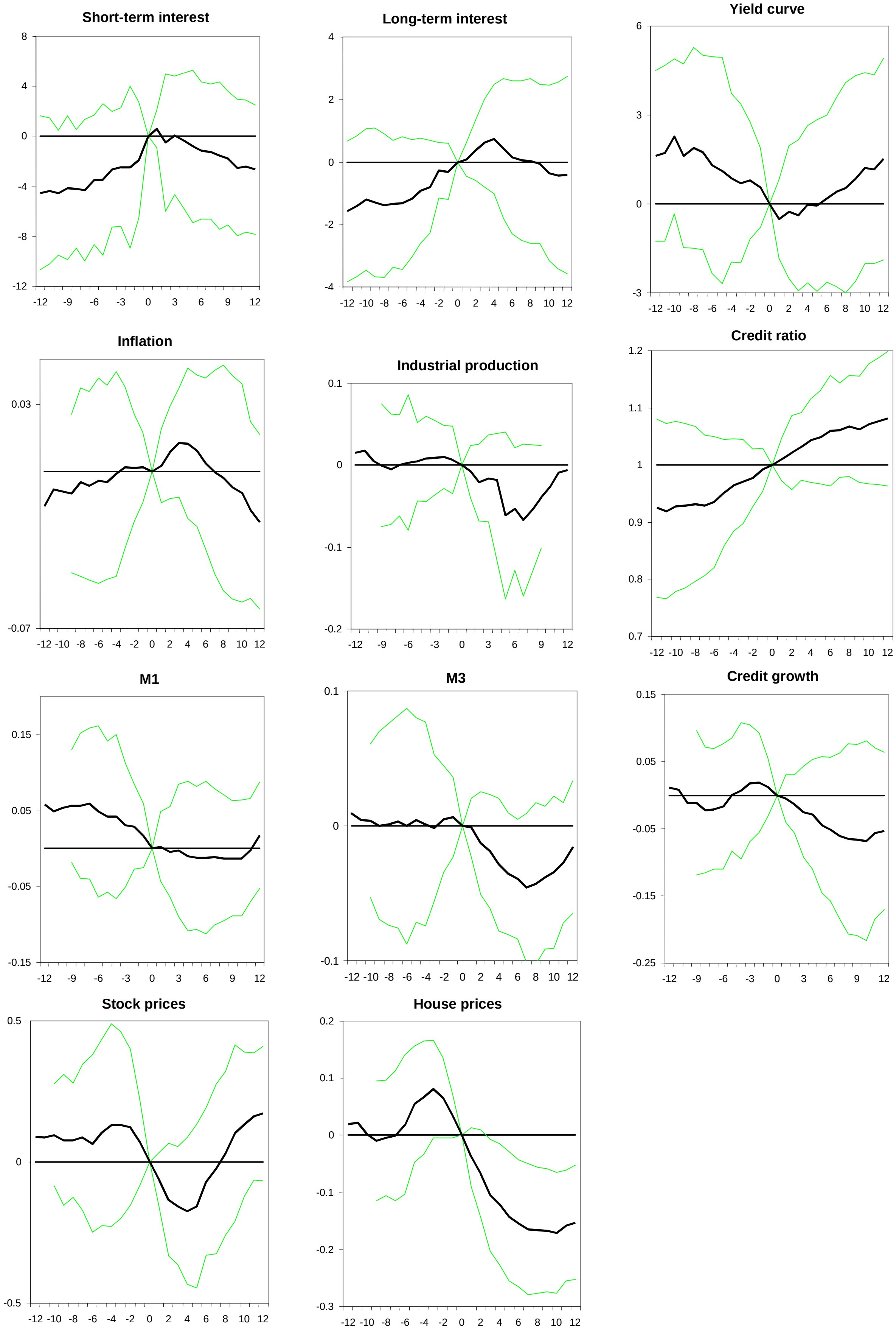
House prices



Appendix (cont): Stock market crises



Appendix (cont): Housing market crises



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Monetary policy in real time: the role of simple rules[1]

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Abstract

Setting the interest rate in an inflation targeting regime requires a total assessment, often translated into forecasts, of the outlook for inflation and real activity. In the assessment process, it is useful to have some references or cross-checks, in terms of *simple rules*. Although simple rules should not be followed mechanically, they provide a device for structuring and disciplining assessments. In addition, simple rules can also be useful as a checkpoint on whether or not monetary policy is “on track”. The Taylor rule is one such, but is in practice difficult to calculate in real time. Data on output are often revised substantially, making real-time estimates of the output gap highly uncertain. We therefore consider alternative Taylor-type rules that do not require information about current gross domestic product (GDP). The rules are assessed by their ability to mimic the ex post Taylor rule. Despite uncertainty about the natural rate of unemployment, we find that the unemployment gap is a good indicator of the “true” output gap, ie the output gap that can be calculated ex post with the benefit of hindsight. An alternative that combines information on wage and credit growth is also able to mimic the behaviour of the ex post Taylor rule quite closely. The role of simple rules as a tool for detecting monetary policy misalignments is discussed with reference to monetary policy in Norway after 1995.

1. Introduction

It is a stylised fact that monetary policy affects inflation with long and variable lags. Moreover, although the forward-looking element of price determination has received considerable attention in the theoretical literature in recent years, there is evidence of relatively high persistence in inflation, so that current inflation is an important determinant of future inflation. These properties of the inflation process imply that inflation targeting central banks need to be forward-looking when setting the interest rate. Most inflation targeting central banks base their interest rate decisions on, and publish, forecasts of inflation and real activity. In Norway, where an inflation target of 2.5% was introduced in March 2001, the Central Bank of Norway (Norges Bank) sets the interest rate in such a way that, under most economic conditions, the interest rate is increased (decreased) if the inflation forecast two years ahead is above (below) the inflation target. The inflation forecast may therefore be interpreted as an intermediate target of monetary policy, as pointed out by Svensson (1997).

The process of producing an inflation forecast is far less mechanical in practice than commonly assumed in the theoretical literature. The inflation forecast and thus the interest rate are set on the basis of an overall assessment of the inflation outlook. In assessing the outlook, most central banks, including the Central Bank of Norway, use economic models. The outcomes from the various models are weighted together and adjusted using a considerable degree of judgment. Within a framework of inflation forecast targeting, producing an inflation forecast and deciding on the interest rate could be seen as an integrated process and are in practice two sides of the same coin. Although there is in practice hardly any alternative to this cumbersome and somewhat turbid process of producing the basis for monetary policy decisions, the approach has some limitations of which one should be aware.

[1] This paper was prepared for the Autumn Economists’ Meeting held at the BIS on 14-15 October 2002. The views expressed in the paper are those of the authors and should not be attributed to the Central Bank of Norway. We would like to thank Bjørn Roger Wilhelmsen for data assistance.

First, the principal inputs in the assessment process are economic data. Econometric models are never better than the data on which they are built. Moreover, judgments on the economic outlook require data that give a correct picture of the current and past state of the economy. Unfortunately, many data series are not as good as one would like. In particular, data on GDP and productivity, which are important determinants of inflation, are often revised considerably relative to the first figures published (estimates). For example, national accounts data for Norway were revised substantially in June 2002. For the period 1995-99, growth in GDP for mainland Norway was revised up by on average close to 1% per year. The largest revision came for the year 1999. As late as May 2002, we believed that growth in GDP in 1999 was 1.1%. Revised figures now show a growth rate of 2.7%.

Second, there is uncertainty about the relevance of the economic models in use. Although models are rarely run without some add-factor adjustments based on judgment, the properties of economic models are often important elements in the overall assessment process, as they summarise economic theory and historical statistical correlations. However, one can never be sure that the economic relationships specified in the models will not break down or that they are not misspecified in the first place. The ghost called the Lucas critique, which may haunt econometric forecasting models, is usually invisible in real time.

Third, the central bank's forecast is not the only forecast available. Other institutions produce forecasts that may differ from those produced by the central bank. Although analytical integrity of central banks is important, one should not follow this line into arrogance by failing to pay attention to the assessments of other competent forecasters. But how the information from competing forecasts should be integrated into the central bank's own assessments is a question with no clear answer.

Due to the above-mentioned weaknesses of the assessment process leading to monetary policy decisions, there is a need for simple cross-checks that can serve as references for policy advice. The role of simple policy rules is to provide such a cross-check.

In this paper, we will first consider simple rules that can provide useful references in the assessment process. A requirement is that the rule must depend on variables that have sufficient informational content in real time. For example, the Taylor rule depends on the output gap, which is only known with some certainty after several years due to extensive revisions in GDP data series and uncertainty about trend output. We thus consider alternative simple rules that make use of variables with higher informational content in real time than the output gap. When searching for alternative real-time variables, we use the output gap estimated ex post using revised GDP data as the normative benchmark. The aim of the paper is limited to pointing towards some *potential* alternatives to the output gap in monetary policy rules and illustrating what it would have implied for the interest rate had the central bank followed such a rule. A more thorough analysis of optimal indicators of the output gap is left for future research. Moreover, we do not focus on uncertainty concerning the appropriate method of estimating the output gap. We would also like to stress that even if we use the Taylor rule as a benchmark in this exercise, it does not imply that we consider the Taylor rule with the "correct" output gap as the optimal reference for monetary policy. However, since the Taylor rule has indeed been shown to perform quite well in a variety of models, the rule satisfies some of the criteria for being a useful cross-check. After considering alternative Taylor-type rules that do not require information about the output gap, we go on to discuss whether simple rules could provide a useful device for detecting whether monetary policy is "off track".

2. Simple policy rules

A simple instrument rule is a mathematical relationship between the monetary policy instrument and some economic variables. It is important to distinguish between simple rules and optimal rules. Optimal instrument rules represent, as the name indicates, how the interest rate optimally should respond to all relevant variables given an objective function (loss function) and an economic model. With reasonably realistic models, optimal rules tend to become quite complex. Moreover, optimal rules are in general model-specific, and a rule that is optimal within one particular model may perform poorly in other models. Simple rules, however, state the instrument as a function of just a few variables. They are generally not optimal in any realistic model, but a good simple rule should be able to produce reasonably good results in a variety of models.

2.1 The Taylor rule

The best known example of a simple rule is the Taylor rule, proposed by John Taylor (1993). The Taylor rule can be written as:

$$i_t = r^* + \pi^* + \alpha(\pi_{t-n} - \pi^*) + \beta(y_{t-m} - y^*_{t-m}) \tag{2.1}$$

where i_t is the short-run nominal interest rate, r^* is the equilibrium real interest rate, π is inflation, π^* is the inflation target, y is (the log of) output (GDP) and y^* is (the log of) potential output. The subscripts $t-n$ and $t-m$ refer to the observation lag, where n and m denote how long it takes before data on output and inflation respectively are available. The original Taylor rule has the coefficients $\alpha = 1.5$ and $\beta = 0.5$. In addition to performing well in a variety of models,[2] the Taylor rule has a clear intuitive appeal, since the rule specifies that monetary policy should respond directly to what are generally considered the ultimate goal variables for monetary policy, namely inflation and output stability. In addition, the current inflation rate and output gap are determinants of future inflation. The rule may therefore seem to be an ideal reference for assessing the appropriate monetary policy stance.

Despite its attractive features, the Taylor rule has a number of weaknesses as a cross-checking device in the assessment process. First, to be operational, the rule requires estimates of both the equilibrium real interest rate and the output gap. Both are, in practice, subject to considerable uncertainty. Second, one needs to choose appropriate coefficients on inflation and the output gap, since the original coefficient values may not be appropriate for all countries. Third, the observation lag for national accounts data on GDP is quite long. Fourth, first releases of national accounts data on GDP are often erroneous. Since monetary policy assessments take place in "real time", one cannot wait for subsequent revisions. In this paper, we shall focus on the issue of data revisions and disregard uncertainty about appropriate coefficient values, uncertainty about the equilibrium real interest rate and uncertainty about the methods for estimating potential output. In particular, we will discuss alternative rules that do not require information about current GDP and are therefore potentially more robust to data uncertainty.

The output gap is the difference between actual output (GDP) and its potential level. Errors in measuring the output gap can come from both incorrect estimates of potential output and measurement errors in the national accounts data on output. Due to revisions in the data series, there are often substantial differences between the real-time estimates of the output gap and the final estimates. Using historical sources, Orphanides (1998) found that the real-time estimate of the output gap for the United States for the period 1980-92 on average was –3.99%, while the final estimate was only –1.64%. Using the original Taylor rule as a reference, this implies that the interest rate should have been on average more than 1 percentage point higher than it was. Moreover, Orphanides et al (2000) found that the measurement error in the output gap is highly persistent, so that one tends to drag earlier misperceptions into the future. Nelson and Nikolov (2001) performed a similar study for the United Kingdom and found that the average real-time estimate of the output gap in the period 1965-95 was –4.78%, while the final estimate was 0.06%. In terms of the Taylor rule, this suggests that the interest rate was on average 2.36 percentage points too low in this period.

Due to data limitations, we have not been able to produce "real-time" series for the output gap for Norway. To illustrate the problem with data revisions, we have calculated output gaps based on both the information we have now and on the information we had before national accounts figures were substantially revised earlier this year. The solid line in Graph 1 shows the "revised" output gap for Norway, ie the estimated output gap based on the information we have today.[3] The dashed line represents the "unrevised" output gap, which uses information that was available in May this year before the national accounts figures were revised. As we see, there are major discrepancies between the two output gaps, and the difference widens over time. We have reason to believe that the output gap calculations in real time would have been even more "flawed".

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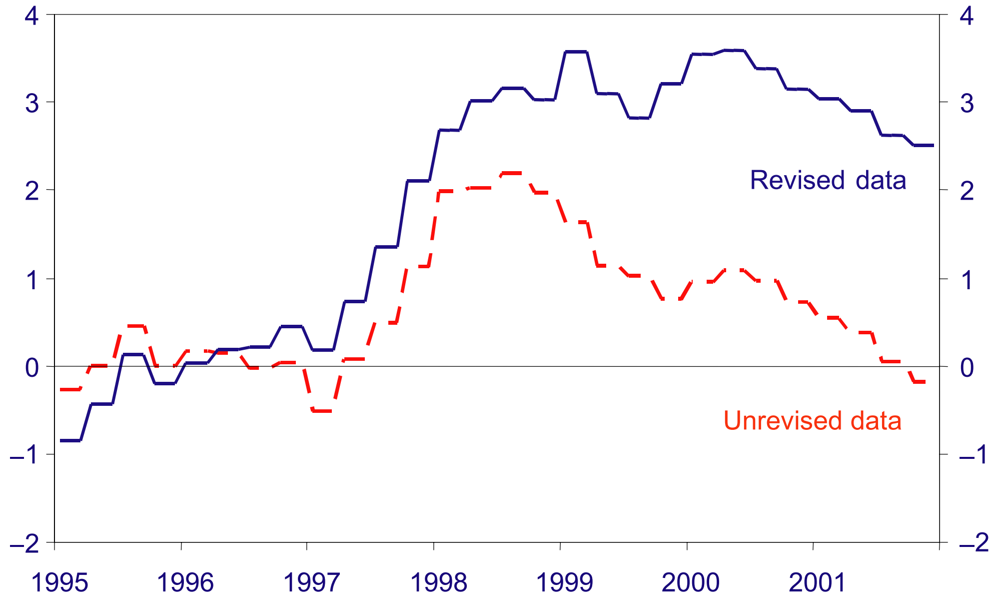
[2] See, for example, the articles collected in Taylor (1999).

[3] The output gap series were constructed using a production function method where a linear trend captures productivity growth and the development in the capital stock, which was omitted due to uncertainty about the capital stock. Specifically, potential output was estimated with OLS as $y^* = c + \alpha T + \beta H$, where c is a constant, T the trend and H the hours worked. The estimation period was 1978-98.

Graph 1

Output gap

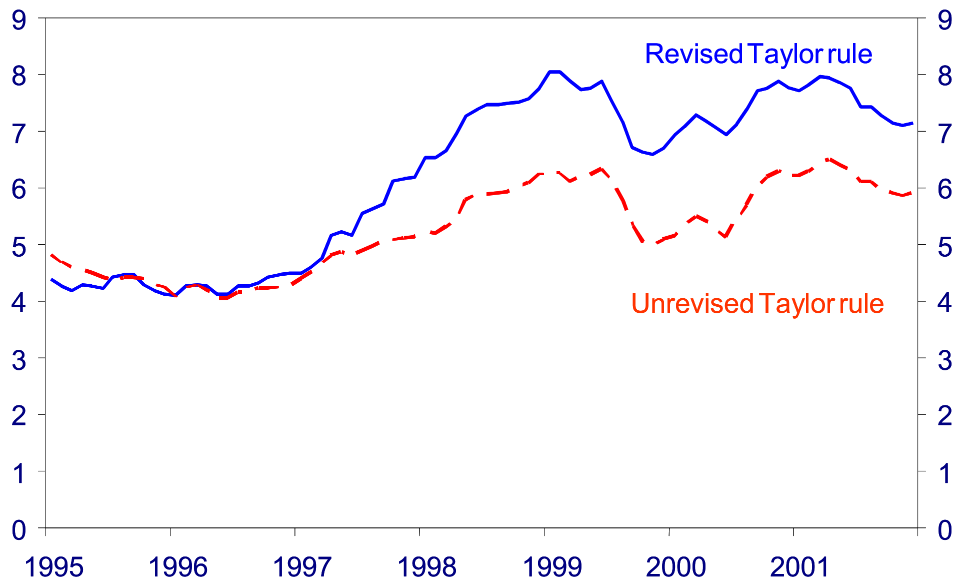
In percentages



Graph 2

Taylor rule interest rate

In percentages



Graph 2 translates the difference between the unrevised output gap and the revised output gap into the interest rate implied by the Taylor rule. As seen from the graph, the Taylor rate is on average 1.5 percentage points higher with the revised data than with real-time data in the period from 1998 to 2001.

2.2 Inflation-only rule

Uncertainty and observation lag of the output gap provide good reason to consider alternatives to the standard Taylor rule as references and cross-checks for policy advice. The most agnostic approach is simply to remove the output gap from the Taylor rule, so that the interest rate responds only to the rate of inflation:

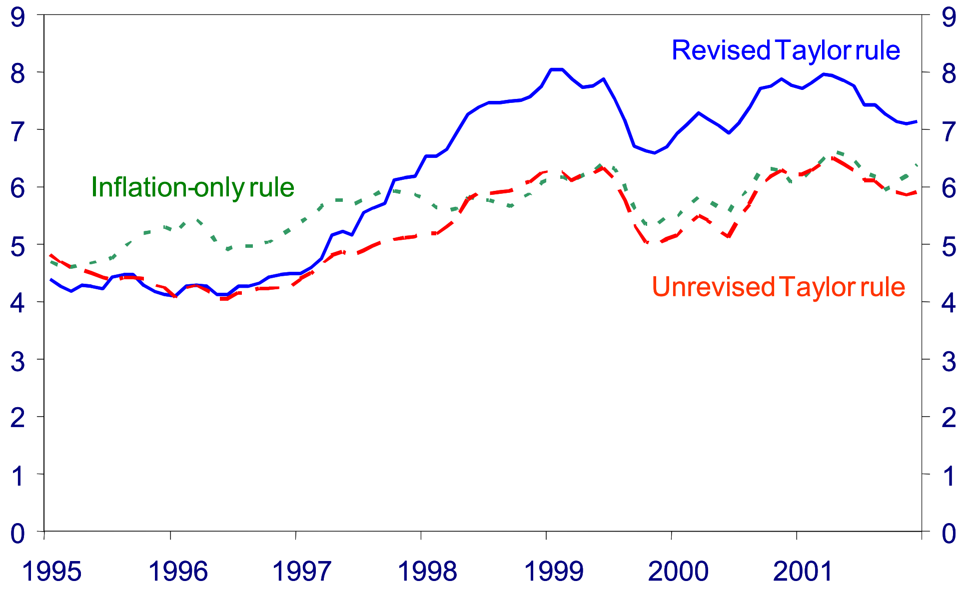
$$i_t = r^* + \pi^* + \alpha(\pi_{t-n} - \pi^*) \tag{2.2}$$

Disregarding the output gap may seem inappropriate, since the output gap is both a determinant of future inflation and a target variable itself. However, if the errors in estimating the output gap are sufficiently large, one may do worse when responding to the gap than when disregarding it. A counterfactual analysis performed by Orphanides (1999) suggests that a simple rule with only inflation outperforms a traditional Taylor rule when one takes account of the measurement errors in the output gap. Graph 3 illustrates the "inflation-only rule" in comparison with the "revised Taylor rule" and the "unrevised Taylor rule".[4] The inflation-only rule does not mimic the development in the revised Taylor rule any better than the unrevised Taylor rule. Thus, despite the attractiveness of a rule as simple as the inflation-only rule, the rule seems to be too simple to serve as a reference in monetary policy assessments.

Graph 3

Simple policy rules

In percentages



In order to improve the inflation-only rule, one may extend it by including the *change* in inflation in addition to the level, as suggested by Leitemo and Lønning (2001):

$$i_t = r^* + \pi^* + \alpha(\pi_{t-n} - \pi^*) + \gamma(\pi_{t-n} - \pi_{t-1-n}) \tag{2.3}$$

The idea is based on an "accelerationist Phillips curve": if output (or employment) is above its natural rate, inflation increases. If it is below the natural rate, inflation decreases. Using the change in inflation as a proxy for the output gap is, however, less valid if the Phillips curve is based on (partly) forward-looking rather than backward-looking expectations or if the variance of cost-push shocks is high. For Norwegian data, the correlation between the (revised) output gap and the change in inflation appears to be very small, which suggests that the above rule does not resolve the problem of poor output data in practice.

Orphanides et al (2000) advocate replacing the output gap with the change in the output gap and argue that this is subject to less uncertainty and, in particular, will counteract the high persistence in measurement errors mentioned above. Related to this is the proposal made by McCallum (1998) and later by Orphanides (1999) to let the interest rate respond to growth in nominal income. Although such "difference" rules are immune to misperceptions about potential output, they are still subject to uncertainty about current output, which is the main focus of this paper. Thus, we focus attention on simple rules that are not dependent on information about output.

[4] In the illustration, we have set $\alpha = 1.5$ for comparison with the original Taylor rule.

2.3 Unemployment gap rule

There is a close relationship between output and unemployment, known as Okun's law. One obvious alternative to the standard Taylor rule is thus to replace the output gap with the unemployment gap (ie, actual unemployment minus some measure of natural unemployment). An alternative to the simple Taylor policy rule could therefore be:

$$i_t = r^* + \pi^* + \alpha(\pi_{t-n} - \pi^*) + \delta(u_t - u_t^*) \qquad (2.4)$$

where u_t is the actual and u_t^* the natural unemployment rate.

Replacing the output gap with the unemployment gap has the advantage that the statistics on the number of registered unemployed are produced with only a few days lag after the end of each month, so that the observation lag is negligible. Furthermore, the unemployment data are not revised, since they are full counts of the number of registered unemployed each month.

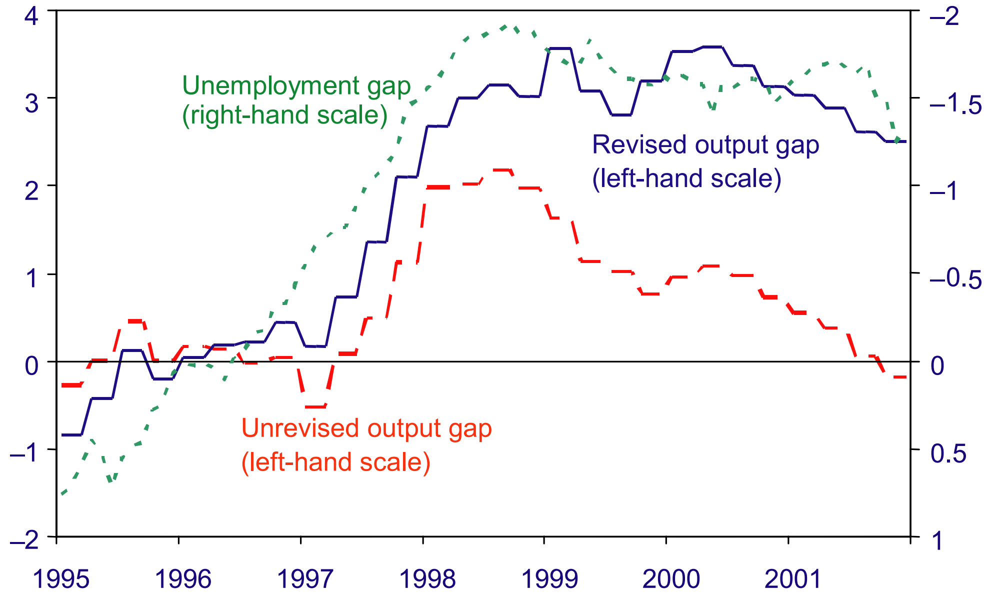
However, in order to make such a rule operational, one needs an estimate of the natural rate of unemployment. Estimating the natural rate is subject to the same problems as estimating potential output, and the natural rate probably shifts over time. Moreover, it is not clear which concept of the natural rate (structural, equilibrium, NAIRU, NAWRU, etc) is relevant. However, we will not go into a discussion of how to estimate the natural rate in this paper. To illustrate the "unemployment gap rule", we simply specify the unemployment gap as the deviation of actual unemployment from the average unemployment rate during the 1990s. In this period, wage growth averaged around 4.5%, which is consistent with our inflation target of 2.5%, given a plausible estimate of productivity growth. Since the range of variation for the unemployment rate has been about half of the range for the output gap, we set the coefficient for the unemployment gap at 1.[5]

Graph 4 shows that the unemployment gap tracks the revised output gap well. Using the revised Taylor rule as a normative benchmark, Graph 5 shows that the unemployment gap rule performs far better than the unrevised Taylor rule for the whole period considered. Thus, despite uncertainty about the natural rate of unemployment, the unemployment gap rule seems to be an interesting alternative to the standard Taylor rule.

Graph 4

Output gap and unemployment gap

In percentages and percentage points

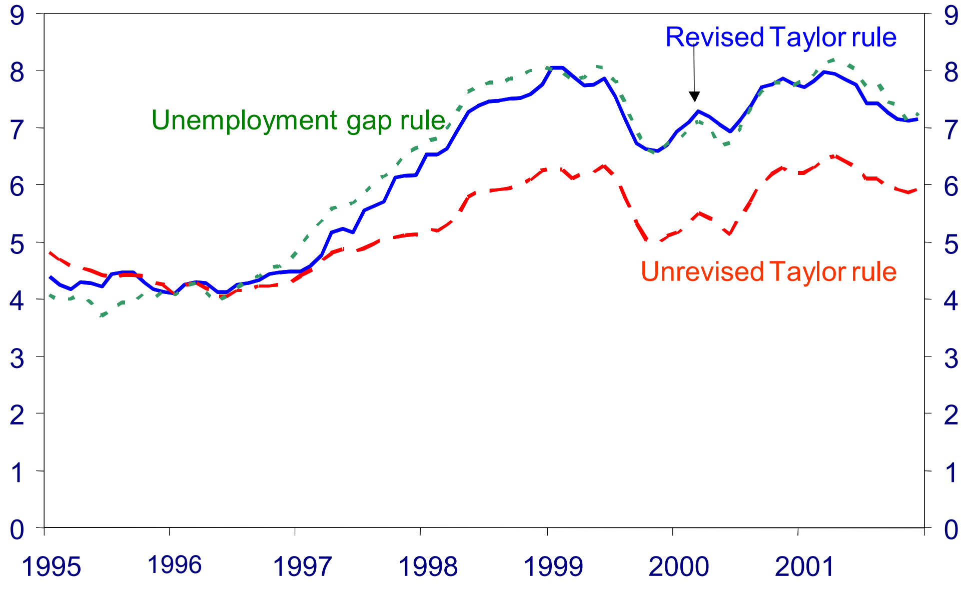


[5] The coefficient could, of course, be refined by a more thorough estimation of Okun's law, but for the purposes of illustration, a rough coefficient choice is sufficient.

Graph 5

Simple policy rules

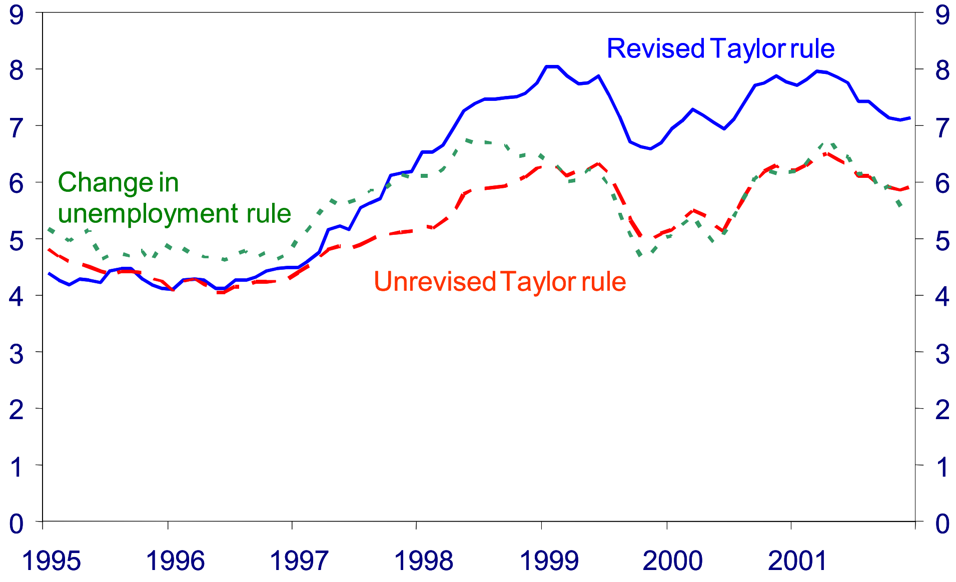
In percentages



Graph 6

Simple policy rules

In percentages



Due to the uncertainty about the natural rate, one may consider responding to inflation and changes in unemployment, as suggested by Orphanides and Williams (2002). The motivation is similar to the argument for substituting the output gap with output growth, as discussed above. Such a rule does not require knowledge of the natural rate of unemployment for setting policy and is consequently immune to the likely misperceptions in these concepts. In a world with no uncertainty about the natural rate, such a rule would, however, perform far worse than a rule with the unemployment level. For example, in a recession where unemployment is high, the "unemployment change rule" implies that, with inflation on target, the interest rate should be above neutral when unemployment starts to move down to the natural rate. An unemployment gap rule, however, would imply that the interest rate should be below neutral as long as unemployment is higher than the natural rate. Nevertheless, if misperceptions about the natural rate are sufficiently large, the unemployment change rule might still outperform an unemployment gap rule. However, Graph 6 shows that the unemployment change rule does not track the revised Taylor rule much better than the unrevised Taylor rule, at least not after 1998.

2.4 Wage gap rule

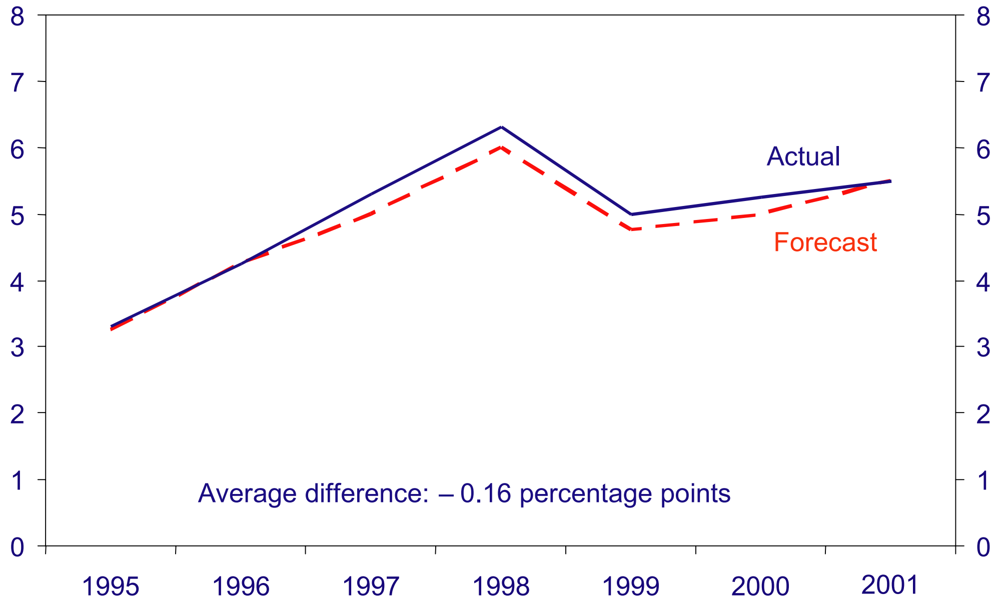
One way to try to overcome the problem of uncertain estimates of the natural rate of unemployment is to define the tightness of the labour market by way of wage growth. One crude definition could be as follows: when wage growth is high, the labour market could be characterised as tight. When wage growth is low, the opposite could be said to be true.[6]

In Norway, wage negotiations take place once a year in all sectors. Each spring, we obtain a direct measure of the tightness of the labour market through the outcome of these negotiations. Based on the outcome of all the sector-level wage settlements, we are able to make a fairly accurate forecast of annual wage growth by the end of the second quarter each year (Graph 7).

Graph 7

Annual wage growth

In percentages



Note: The graph shows forecasts in the second quarter of the same year and actual growth using data available four quarters later.

In the long run, real wages must be compatible with the value added that is generated by workers, ie labour productivity. Over time, the increase in real wages is therefore determined by developments in labour productivity. In Norway, productivity growth has averaged 2% over the last 20 years. If this trend continues, an increase in nominal labour costs of around 4.5% in the long term will be consistent with the inflation target of 2.5%.

An alternative to both the output gap and the unemployment gap in a simple monetary policy rule could therefore be the wage gap, ie the deviation between actual wage growth and the rate of growth that would be consistent with the inflation target over time:

6 One needs, of course, to take into account special occurrences that generate wage shocks that do not reflect the tightness of the labour market.

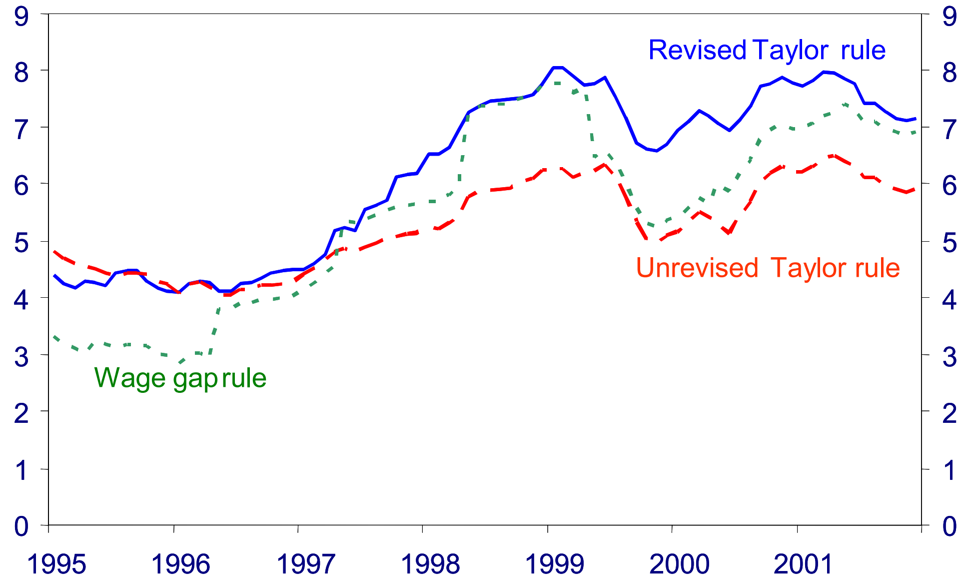
$$i_t = r^* + \pi^* + \alpha(\pi_{t-n} - \pi^*) + \varphi(\Delta w_{t-k} - \Delta w^*) \qquad (2.5)$$

where Δw is wage growth and Δw^* is wage growth consistent with the inflation target.

Graph 8

Simple policy rules

In percentages



The variation in the output gap is somewhat larger than the variation in the wage gap. This would suggest a somewhat higher wage gap coefficient than the coefficient of 0.5 on the output gap in the original Taylor rule. In the "wage gap rule", we have chosen a wage gap coefficient of 1. Graph 8 shows the wage gap rule compared with the revised Taylor rule and the unrevised Taylor rule. As seen from the graph, the wage gap rule mimics the behaviour of the revised Taylor rule better than the unrevised Taylor rule during most of the period from 1995 to 2001. This suggests that when using the Taylor rule as a reference and cross-check in the monetary policy assessment process in real time, one should consider replacing the estimate of the output gap with the wage gap.

2.5 Asset prices and credit flows

There is extensive literature on the role of asset prices in monetary policy. Some authors support the view that monetary policy should respond to asset prices. We do not want to pursue this discussion here, but will instead focus on alternatives to the output gap in simple rules. It is well known that asset prices, such as stock prices and bond prices, are able to some extent to predict output.[7] In addition, since asset prices are observable in real time and are measured with almost absolute accuracy, one could argue that asset prices represent an alternative to the output gap in simple rules. However, asset prices such as stock and bond prices are subject to considerable "noise" due to shifting sentiments in financial markets and variable risk premia. An interest rate that responds directly to asset prices may therefore generate fluctuations in inflation and the real economy. One could, of course, develop some measure of "underlying" asset price movements, where such "noise" is filtered out. This would, however, reduce the value of the rule as a simple reference. Moreover, as pointed out by Woodford (1994), responding to asset prices may reduce their informational content, since agents in financial markets will take the central bank's reaction into account.

[7] See, for example, Stock and Watson (2001).

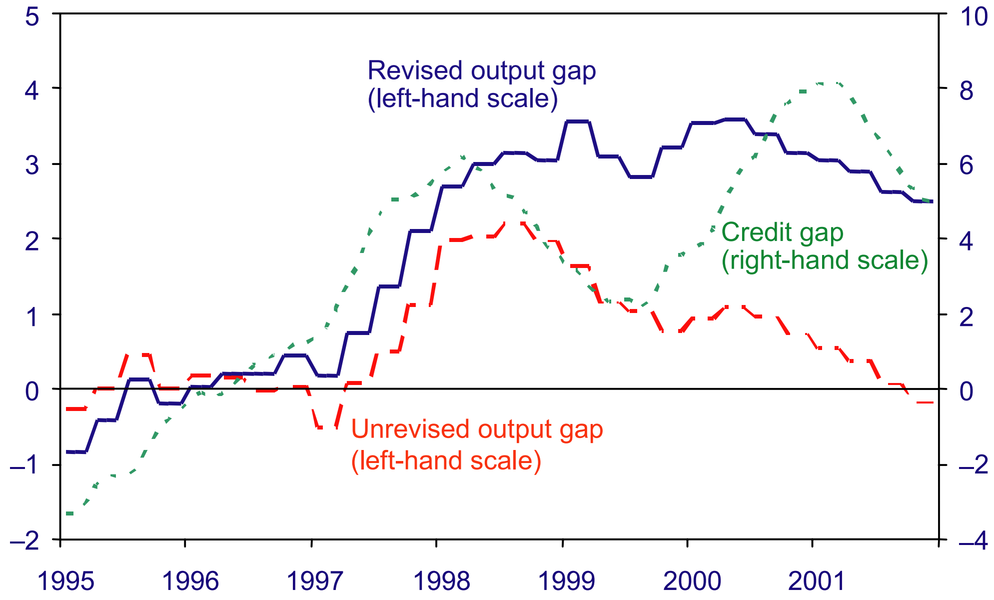
A more robust alternative is *credit growth*. As shown by Bårdsen et al (1999), credit growth in Norway is highly correlated with output. Data on domestic credit growth are, in addition, generally reliable and published with very short lags. Moreover, there are reasons to respond to credit growth per se, for example due to financial stability considerations.

Graph 9 compares the "revised" output gap and the "credit gap", which is defined as the deviation between domestic credit growth and trend growth. We assume that in steady state, nominal gross credit grows at the same rate as nominal GDP, which is assumed to have a trend growth of around 5% given an inflation target of 2.5%. As seen in the graph, the credit gap could be a useful indicator of pressures in the economy.

Graph 9

Output gap and credit gap

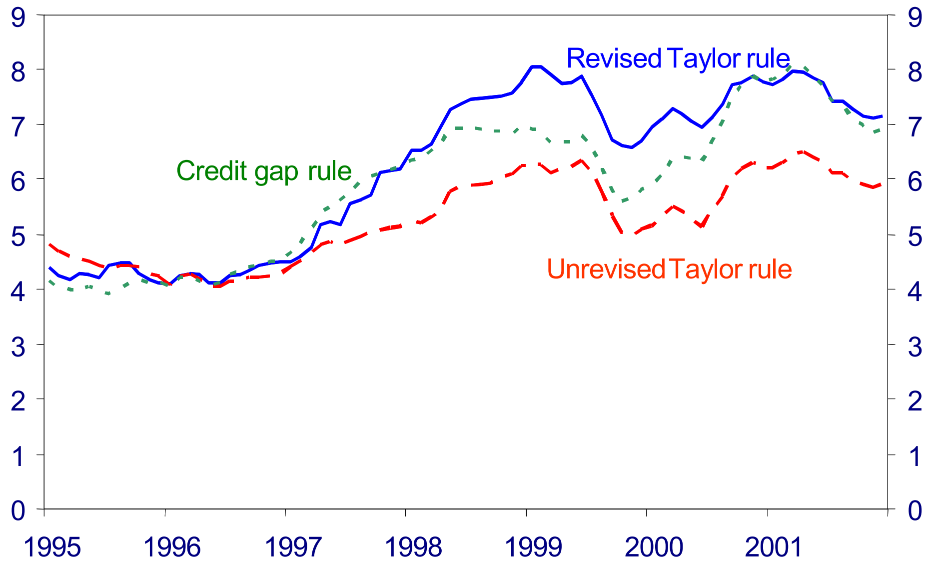
In percentages



Graph 10

Simple policy rules

In percentages



An alternative to both the output gap and the unemployment gap in a simple monetary policy rule could therefore also be the credit gap:

$$i_t = r^* + \pi^* + \alpha(\pi_{t-n} - \pi^*) + \tau(\Delta c_{t-k} - \Delta c^*) \tag{2.6}$$

where Δc is credit growth and Δc^* is trend credit growth.

The variation in the credit gap is larger than the variation in the output gap. This would suggest that the coefficient for the credit gap is somewhat lower than the output gap coefficient of 0.5 in the original Taylor rule. In the "credit gap rule", we have chosen a credit gap coefficient of 0.2.

Graph 10 shows the credit gap rule in comparison with the revised Taylor rule and the unrevised Taylor rule. As indicated in the graph, the credit gap rule also mimics the behaviour of the revised Taylor rule better than the unrevised Taylor rule during most of the period from 1995 to 2001.

2.6 Which indicator wins?

In the above, we have discussed various indicators of real economic pressures that can serve as alternatives to the output gap, since the data on GDP are subject to considerable "noise". Visual inspection suggests that the unemployment gap rule is the superior rule among all the alternatives examined, at least for the time period 1995-2001. Thus, the exercise performed in this paper suggests that when using the Taylor rule as a reference in "real-time" monetary policy assessments, the output gap should be substituted by the unemployment gap due to considerable uncertainty about GDP data in real time. The superiority of the unemployment gap as an indicator of the ex post revised output gap is particularly encouraging given that we did not make any serious attempt to estimate the natural rate of unemployment. However, only time will show if the unemployment gap will continue to be a good proxy for the "true" output gap.

Due to the uncertainty of the estimates of the natural unemployment rate, it is also of interest to consider a rule that consists of variables that do not require such information. Specifically, we consider a rule that consists of the wage gap, the credit gap and the change in the unemployment rate, where the coefficients are optimised. In other words, we take the revised Taylor rule to be the normative benchmark, and construct a rule that mimics this rule as closely as possible. We would like to stress, however, that treating the revised Taylor rule as the normative benchmark for alternative simple rules is only an analytical exercise and does not necessarily indicate that we consider the interest rate implied by this rule to be the appropriate rate.

Including the wage gap, the credit gap and the change in the unemployment rate and using optimised coefficients, so that the rule mimics the revised Taylor rule as closely as possible, gives the following rule:

$$i_t = r^* + \pi^* + 1.0(\pi_{t-n} + \pi^*) + 0.4(\Delta w_{t-k} - \Delta w^*) + 0.2(\Delta c_{t-l} - \Delta c^*) \tag{2.7}$$

The coefficient of the change in the unemployment rate in the best fit rule was (close to) 0. Graph 11 shows this combined "optimised" rule compared with the unemployment gap rule, the revised Taylor rule and the unrevised Taylor rule. As seen in the graph, by combining the wage gap and the credit gap it is possible to come fairly close to the revised Taylor rule and the unemployment gap rule. As stressed in the introduction, however, these results are only indicative. The robustness of the rules considered needs to be examined using longer time periods and more indicator variables.

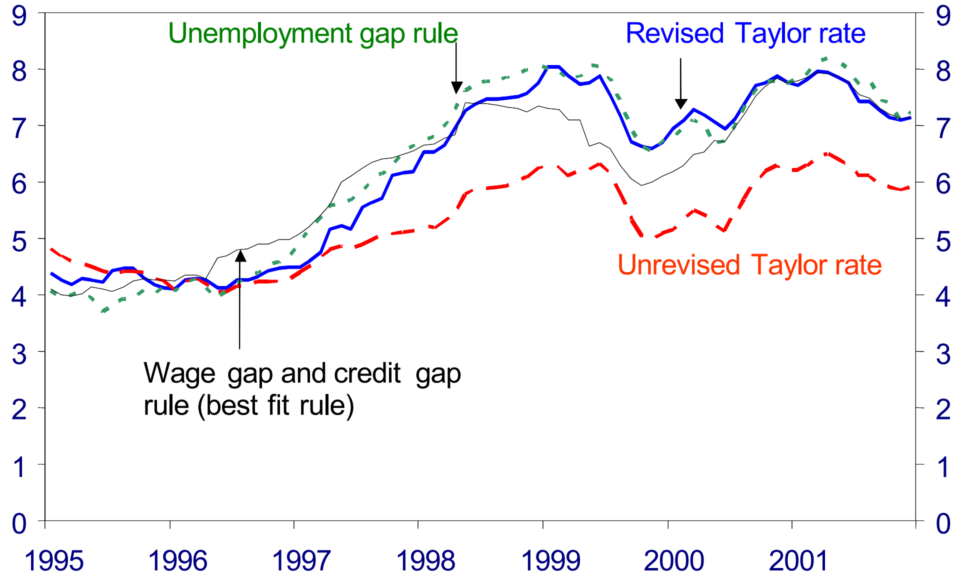
3. Using simple rules to detect monetary policy misalignments

One may argue that in most cases interest rate decisions can be characterised as "fine-tuning". The interest rate is rarely changed by more than ½ percentage point in one step. Although such fine-tuning may be challenging enough, one may argue that what is most important for monetary policy is to avoid major policy mistakes that contribute to destabilising the economy. One feature of an appropriately specified simple rule, such as the Taylor rate, is that it ensures that the "Taylor principle" is satisfied. The Taylor principle says that when inflation rises, the interest rate should increase by more than the rise in inflation. This principle is a necessary condition for real equilibrium determinacy in most forward-looking sticky price models and a condition for stability in most backward-looking models. Moreover, the Taylor principle is a condition for stability in expectation formation in models that (realistically) assume that agents form their expectations as an adaptive learning process.[8] The Taylor principle may therefore be considered a minimum requirement for a sound monetary policy. Policies that do not follow this principle may contribute to destabilising prices and economic activity.

Graph 11

Simple policy rules

In percentages



Since the coefficient on inflation in the original Taylor rule is 1.5, it satisfies the Taylor principle. In addition, as mentioned above, the Taylor rule is a natural cross-check in monetary policy assessments, since it appears to perform reasonably well across a variety of models. For illustration, we will therefore use the Taylor rule as a normative benchmark for detecting possible monetary policy misalignments in Norway. One should, however, note that the Taylor rule may not be as appropriate for a small open economy like Norway as for a large economy like the United States, since the rule does not include the exchange rate, which arguably is an important determinant of inflation and output in a small open economy.[9]

Graph 12 shows the alternative simple rules discussed above and the actual interest rate in Norway after 1995. The simple rules suggest that monetary policy in Norway was too lax in the period 1997-98. The key interest rate was lowered from 1996 to 1997 despite higher inflation and lower unemployment. Thus, not only was the Taylor principle violated, since the nominal interest rate did not keep track of the rise in inflation, the nominal rate was indeed *lowered* when inflationary pressures started to become worrying. How could monetary policy be that misaligned?

From 1994 until inflation targeting was adopted in March 2001, the mandate for monetary policy in Norway was stability in the exchange rate against European currencies. A target range was implicitly defined in the mandate but with no obligation on the part of the central bank to intervene. In the event of significant changes in the exchange rate, the mandate required the central bank to orient instruments with a view to returning the exchange rate to its initial range over time. The low interest rate in 1997 was a result of a relatively low rate in Germany. In addition, there were appreciation pressures on the krone exchange rate. In order to prevent the krone exchange rate from being too strong, the interest rate differential between Norway and Germany could not be too high. A higher

8 See Bullard and Mitra (2002).

9 Ball (1999) derives an "MCI Taylor rule" which in his framework is optimal for small open economies. See also Batini et al (2001) for a comparison of various policy rules within an optimising open economy model.

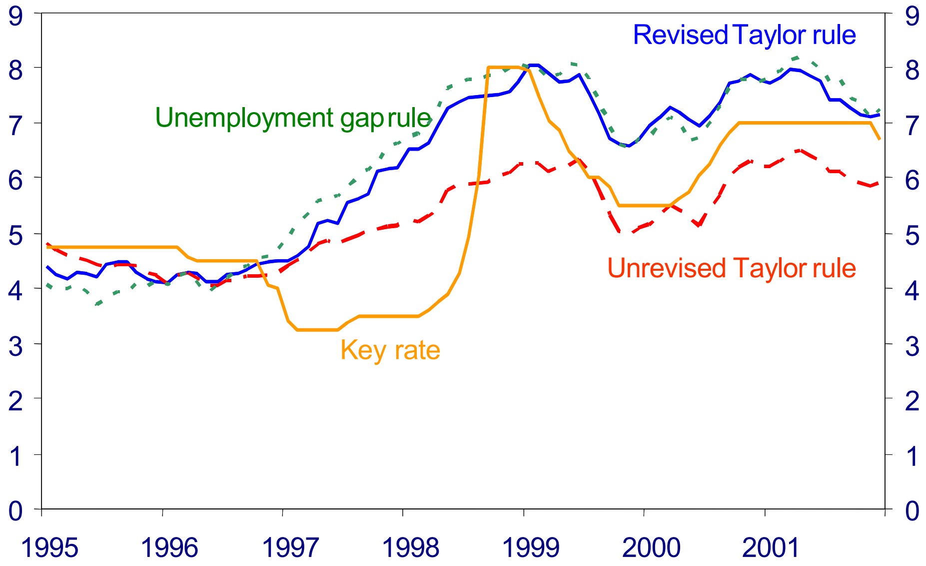
interest rate would probably have fuelled appreciation pressures and would have been in conflict with the mandate for monetary policy as it was interpreted at the time.

In the period 1996-2001, during which large oil revenues were channelled into government budgets, the task of counteracting increased economic pressures through a tight fiscal policy became increasingly difficult. In a letter to the government in 1997, the Central Bank of Norway asked for permission to put more weight on stabilising inflation and real activity than implied by the monetary policy mandate. The central bank also invited a group of international experts on monetary policy to analyse the existing monetary policy framework and assess possible alternatives. Their assessments are collected in Christiansen and Qvigstad (1997). During 1998, mounting wage growth and plummeting oil prices turned the sentiment in the krone market, leading to depreciation pressures. According to Graph 12, the sharp increase in the key rate during 1998 brought the interest rate up to a level more in line with what is suggested by the simple rules.

Graph 12

Simple policy rules and the key rate

In percentages



Measured by the revised Taylor rule, the key interest rate was again set too low in 1999. Although one could argue that this was the case ex post, one should bear in mind that the economic outlook for the world economy was particularly gloomy at the time. The fact that the economy did not evolve as negatively as expected does not in itself prove that the interest rate decisions were wrong in "real time", contrary to what was arguably the case in 1996-98. In fact, market participants expected the interest rate to be reduced even more than it was, as indicated by forward interest rates.[10] Since the autumn of 1998, the simple policy rules we have considered do not detect any significant policy misalignments. The interest rate may not have been "optimal" at every point in time, but the rules nevertheless suggest that monetary policy has been roughly "on track" in this period.

[10] See Qvigstad (2001).

4. Summary and final remarks

The output gap is an important variable in the theoretical literature on monetary policy. In addition, many simple policy rules, such as the Taylor rule, prescribe that the interest rate should respond directly to the output gap. Due to real-time uncertainty about current GDP and uncertainty concerning potential output, the output gap has some operational limitations, which are often neglected in the theoretical literature. In this paper, we have discussed these operational limitations and proposed various potential indicators of the output gap that are observed more accurately in real time. For the sake of illustration, we treated the Taylor rule with the output gap estimate based on the latest revision of national accounts as the normative benchmark. Deriving optimal indicators of the "true" output gap is an important area of research, which has not as yet reached any clear conclusions. In this paper, we have limited our ambitions to examining some variables that could potentially be useful indicators of the output gap. Specifically, we have considered unemployment, wage growth and credit growth. Our preliminary findings suggest that the "unemployment gap" is a better indicator of the output gap estimated ex post on revised data than the real-time estimate of the output gap. Alternatively, a weighted average of the "wage gap" and the "credit gap" as a real-time indicator seems to fit the ex post output gap quite well. Contrary to the "unemployment gap rule", this combined rule does not require any estimate of the natural rate of unemployment. Our results are, however, only indicative, and more research on robustness and other potential indicators of the output gap is required.

The output gap is not only useful in the internal assessment process. The Central Bank of Norway was recently evaluated by "Norges Bank Watch", which is an external and independent committee of academics and financial sector representatives that presents an annual report on the central bank. This year, it was led by Professor Lars E O Svensson.[11] Among other things, Norges Bank Watch wanted the central bank to publish estimates of output gaps and use these explicitly in the monetary policy assessment process as a tool for communicating policy.

Although the output gap is a fruitful concept, since it summarises and quantifies the degree of real economic imbalances, we have argued that the concept has several operational limitations. There is no single answer as to how the output gap should be estimated. It is not often that we get so little help from economic theory and econometrics as when we try to quantify the output gap. The degrees of freedom with respect to the choice of method, estimation period, etc, imply that the estimate must be based on substantial subjective judgments. That may, of course, not be an argument against publishing estimates of the output gap, since many assessments relevant to monetary policy have to be based on subjective judgments. However, it will be difficult, if not impossible, for the public to assess ex post whether the central bank was right in its assessment of real economic pressures. Moreover, the output gap is a difficult measure in itself and equally difficult to communicate to the majority of the public. Thus, although we have focused on data problems in this paper, there are also reasons other than uncertain GDP data for considering alternatives to the output gap for the purposes of assessment and communication.

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[11] The report can be downloaded from http://www.princeton.edu/~svensson/norway/nbw.htm.

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Inflation and higher moments of relative price changes in Sweden

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1. Introduction and summary

This paper analyses the relationship between inflation and relative prices in the Swedish economy. In particular, the relationship between inflation and the skewness of relative price changes is studied and Phillips or price curves are estimated for Swedish data in which skewness is incorporated as a proxy measure of nominal rigidity. This is an alternative to new Keynesian Phillips curves in which forward-looking firms base price decisions on future expected marginal cost. The empirical results show that there is a significant positive relationship between inflation and the second and third moments of relative price changes. It is also shown that the skewness variable improves the Phillips curve significantly.

2. Inflation and relative prices in theory

There is a statistically significant positive relationship between the mean of price changes, ie the rate of inflation, and the second and third moments[2] of relative price changes in many countries. According to a standard classical dichotomised macroeconomic model, inflation and relative prices are independent. However, several arguments have been raised to explain why there may be a relationship between inflation and the dispersion of relative prices, and there is no one-way causality between the variables: inflation may affect the variance of relative price changes and the variance of relative price changes may affect inflation. It is likely that the relationship is positive. Several empirical studies have been done in which the causality between inflation and the second moment of the distribution of relative price changes has been examined. Some studies have been done in which other variables has been included as well and been allowed to affect both inflation and the distribution of relative price changes. One result in some studies is that some third variable (such as oil price shocks) is the driving force behind both inflation and the variance of relative price changes.

The main reason for causality running from inflation to relative prices is the existence of short-run nominal rigidity, ie costs associated with changing prices (menu costs). This was shown by Sheshinski and Weiss (1977), who analysed the behaviour of a price setting monopolist with costs associated with changing prices, facing inflation but no other shocks. The profit-maximising behaviour implies that prices are fixed in time intervals that depend on the rate of inflation and the cost of changing prices. The frequency of price changes depends positively on the rate of inflation and negatively on the cost of changing prices. If costs associated with changing prices vary across firms then an increase in the rate of inflation will increase the variability of relative price changes. This occurs even if inflation is fully *expected*. Another explanation of the relationship can be found in Assarsson (1986) and Parks (1978), where there is a positive relationship between the variance of relative price changes and the rate of

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[1] I am grateful for comments on an earlier version of this paper from Michael J Andersson and Pernilla Meyersson.

[2] See Aarstol (1999a,b), Assarsson (1986), Blejer and Leiderman (1980, 1982), Bomberger and Makinen (1993), Bossone (1992), Buck (1990), Debelle and Lamont (1996), Glezakos and Nugent (1986a,b), Goel and Ram (1993), Haubrich (1993), Jaramillo (1999), Jinushi (1990), Jurkovic (1989), Kandel et al (1991), Karasulu (1998), Lach and Tsiddon (1993), Mizon (1991), Mizon et al (1989, 1990), Murty (1984), Parks (1978), Parsley (1996), Ram (1988a,b), Sellekaerts and Sellekaerts (1984, 1986), Smith and MacKinnon (1987), Stockton (1988), Tommasi (1992), Vining and Elwertowski (1976), Balk (1978) for the Netherlands, Blejer and Leiderman (1980) for Argentina, Assarsson (1986) for Sweden for the variance and Balke and Wynne (2000), Ball and Mankiw (1993) and Bryan and Cecchetti (1999) for the United States and the skewness.

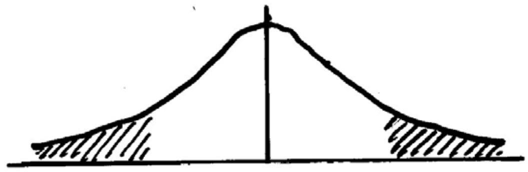
unexpected inflation. This is established in non-stochastic models in which the variance of relative prices is endogenous and depends on supply and demand variables. In the stochastic Lucas island parable model (Lucas (1972, 1973)), a positive relationship between the variance of relative price changes and the variance of inflation can be found.[3] This relationship depends on agents having imperfect information about absolute/relative prices. Lucas's model is an example of where causality goes from a third variable, monetary shocks or relative demand shocks, to inflation and relative price changes. Another example can be found in the Scandinavian model of inflation, in which productivity shocks cause both inflation and the variance of relative price changes to move in the same direction.[4]

There are also examples where the causality runs from the variance of relative price changes to inflation, eg in models[5] with asymmetric price changes and downward rigidity in prices.

Several studies also find a positive relationship between the rate of inflation and the third moment of the distribution of relative price changes, the skewness. At least three explanations for this correlation are available in the literature, causally going from skewness to the rate of inflation. The first explanation is based on menu costs.[6]

Graph 1

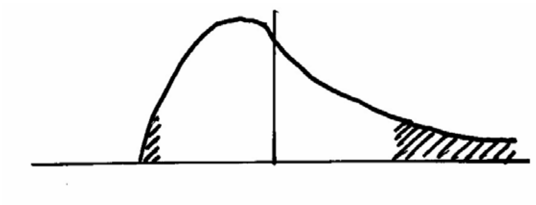
A uniform distribution of relative shocks



Graph 1 illustrates a uniform distribution of relative shocks, which may be thought of as supply shocks. The mean of these is by definition zero. In the presence of menu costs, prices will only be changed due to shocks that are big enough to yield benefits, ie coming closer to the desired optimal price, that outweigh the cost of changing the price. These shocks are the shaded areas of the distribution in Graph 1, whereas the blank area depicts a *range of inaction*. If the distribution is uniform, there is no effect on inflation, since the relative price *increases* are offset by the relative price *decreases*. Consider instead the distribution with positive skewness in Graph 2.

Graph 2

Distribution of relative shocks with positive skewness



A positively skewed distribution has relatively more large relative price increases (negative supply shocks) and many small relative price decreases (positive supply shocks). Due to the cost of price changes, the large negative shocks add to inflation while the small positive shocks do not fully balance

3 On the relationship in Lucas's model, see also Cukierman and Wachtel (1979) and Cukierman (1979, 1983).

4 See Aukrust (1970).

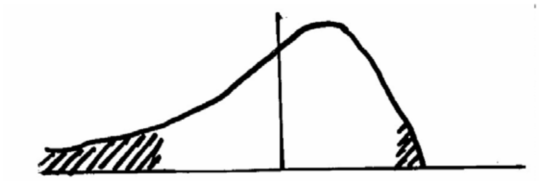
5 See Schultz (1959), Ball and Doyle (1959) and Tobin (1972).

6 This theory is based on Ball and Mankiw (1993).

the negative ones, though the mean of the relative shocks is still zero. Hence, inflation rises with positive skewness and falls with negative skewness, as in Graph 3 below.

Graph 3

Distribution of relative shocks with negative skewness



The second explanation is not based on nominal rigidities[7] but shown in a dynamic general equilibrium model in which the positive correlation depends on a particular process for productivity shocks. The third explanation is a statistical explanation put forward by Bryan and Cecchetti (1999), where the positive correlation is a small sample bias problem in a situation where the distribution of relative price changes has high kurtosis (fat tails). This problem is explained in economic terms by Balke and Wynne (2000), where a certain process for productivity shocks produces both fat tails and a positive correlation between inflation and the skewness of relative price changes. Finally, a fourth explanation of the relationship between inflation and skewness is offered by combining the business cycle model in Bils and Klenow (1998) with the nominal rigidity/skewness model in Ball and Mankiw (1993). In a peak, the demand for durables and luxuries increases more than the demand for other goods. Therefore, aggregate shocks have implications not only for inflation but for relative prices as well. If the production structure of firms is characterised by cyclical utilisation (rather than increasing returns), then marginal costs and relative prices on durables and luxuries as well as the skewness of relative prices are likely to be procyclical.

Ball and Mankiw (1993, p 165) also show that if the distribution of relative price changes is skewed, an increased variance will magnify the effect of skewness on inflation: a larger variance is inflationary when the distribution of relative price changes is skewed to the right and deflationary when it is skewed to the left.

3. Price setting and the Phillips curve

In a standard price equation the price level is determined as a markup on marginal cost. The equation, derived from profit maximisation, is:

$$p_t = \left[1 - \frac{H_t}{\varepsilon_t}\right]^{-1} mc_t \tag{1}$$

where p_t is the price level, $0 \le H_t \le 1$ is an index of the degree of competition where $H_t = 0$ for free competition and $H_t = 1$ for monopoly, ε_t is the price elasticity of demand and mc_t is marginal cost. All variables are assumed to vary over time and are therefore indexed by *t*. mc_t is the derivative of a cost function $C(p_t^I, y_t)$ where y_t is output and p_t^I is a vector of input prices. $mc_t \equiv C'(p_t^I, y_t)$ and the price equation can be written:

$$p_t = \left[1 - \frac{H_t}{\varepsilon_t}\right]^{-1} C'(p_t^I, y_t) \tag{2}$$

[7] See Balke and Wynne (2000).

This equation is probably a reasonable description of long-run price behaviour. In the short run, however, prices presumably are affected by nominal rigidities, especially at high data frequencies as in monthly or quarterly data. It is important to try to capture the short-run dynamics of prices, for instance with respect to the monetary transmission mechanism.

In the empirical literature several restrictions are usually put on equation (2) at the outset. H_t and ε_t are often arbitrarily treated as constants despite the fact that other relevant literature finds them varying quite substantially, maybe even more than marginal cost.[8]

Several attempts have been made to incorporate the effects of nominal rigidities in the Phillips curve. One attempt is the staggered wage contracts model in Taylor (1980). This leads to the Phillips curve equation:

$$\pi_t = \pi_{t-1} + \gamma\left[y_t - y_t^*\right] + z_t \tag{3}$$

where $\pi_t \equiv \Delta \log p_t$, y_t^* is the log of potential output and z_t is a vector of supply shocks.

Another possibility was proposed by Calvo (1983). In his model, for a number of identical firms there is a fixed probability $1 - \theta$ for each firm to change its price, a probability which is assumed to be independent of the time elapsed since the last price revision. The average time over which a price is fixed is then given by $(1-\theta)\sum_{k=0}^{\infty} k\,\theta^{k-1} = \frac{1}{1-\theta}$. The aggregate price level then evolves as a convex combination of the lagged price level p_{t-1} and the optimal price p_t^*:

$$p_t = \theta p_{t-1} + (1-\theta)p_t^* \tag{4}$$

where the optimal price depends on future expected marginal costs. The Phillips curve can be written:

$$\pi_t = \lambda \sum_{k=0}^{\infty} \beta^k E_t\left[mc_{t+k}\right] \tag{5}$$

where β is the discount factor, $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$ and E_t is the expectations operator. According to Bårdsen et al (2002) and Roberts (1995), equation (5) may be represented by:

$$\pi_t = \gamma_1 E_t \pi_{t+1} + \gamma_2 x_t \tag{6}$$

where x_t is some approximation to (the change in) marginal costs, such as the output gap. Both $E_t\pi_{t+1}$ and mc_t are unobservables. Various approximations have been used but there is no consensus among researchers about which measures or approximations to adopt. Note also that the models in the recent literature assume that firms are identical and that H_t and ε_t are constants.

Several attempts have been made to estimate and test new Keynesian Phillips curves, but it seems to be difficult to settle for a particular specification or estimation method,[9] which in view of equation (6) is not very surprising. Some authors, like Bårdsen et al (2002) or Lindé (2001), stress the need to incorporate the forcing variables as well as the rate of inflation in a system of equations. Bårdsen et al (2002) also argue that it is difficult to evaluate models with respect to goodness of fit since the fit of new Keynesian Phillips curve models is well approximated by simple statistical models. Instead Bårdsen et al (2002) suggest testing the parameter on the forward term in equation (6) and report rather disappointing but somewhat mixed results for the new Keynesian model.

8 For instance, in estimations of price elasticities, flexible functional form cost functions are preferred that imply varying price elasticities, see Edgerton (1996).

9 See Bårdsen et al (2002).

In equation (6) the term $\gamma_1 E_t \pi_{t+1}$ represents the effect of nominal rigidity (menu costs). This effect may also be represented by the skewness, σ_{rp}^3 of relative price changes, which is proposed here. An alternative Phillips curve then is:

$$\pi_t = \gamma_1 \sigma_{rp}^3 + \lambda_2 x_t \tag{7}$$

Ball and Mankiw (1993) perform a similar exercise and specify a Phillips curve:

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \alpha_2 \left[u_t - u_t^* \right] + \alpha_3 z_t + \alpha_4 \sigma_{rp}^2 + \alpha_5 \sigma_{rp}^3 + \alpha_6 \left[\sigma_{rp}^2 \sigma_{rp}^3 \right] \tag{8}$$

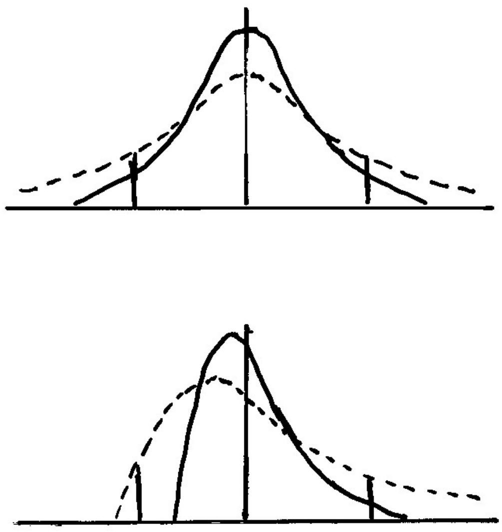
where the last four terms are supposed to capture the effect of supply shocks. They find the effects of the terms with higher moments important and raise the goodness of fit from 0.360 to 0.898 on US annual producer price data for the period 1949-89.[10] Ball and Mankiw include both supply shock variables like food, energy and raw materials prices (the *z* variable in equation (8)) alongside the σ variables. Another interpretation is then that the last three terms in equation (8) capture nominal rigidity rather than the effect of supply shocks.

4. Empirical results I: the relationship between inflation and higher moments of the distribution of relative price changes

Ball and Mankiw (1993) show that the effect of the skewness of relative price changes on the rate of inflation depends on the variance. A large variance magnifies the effect of skewness.

Graph 4

The interaction of variance and skewness



This can be seen in Graph 4. In the upper part, an increase in the variance of shocks affects the tails symmetrically and consequently has no effect on inflation. In the lower part, where the distribution is asymmetric, an increase in the variance has a larger effect on the right-hand than on the left-hand tail

[10] Ball and Mankiw (1993) used a Hodrick-Prescott filter to compute the trend in unemployment, u_t^*.

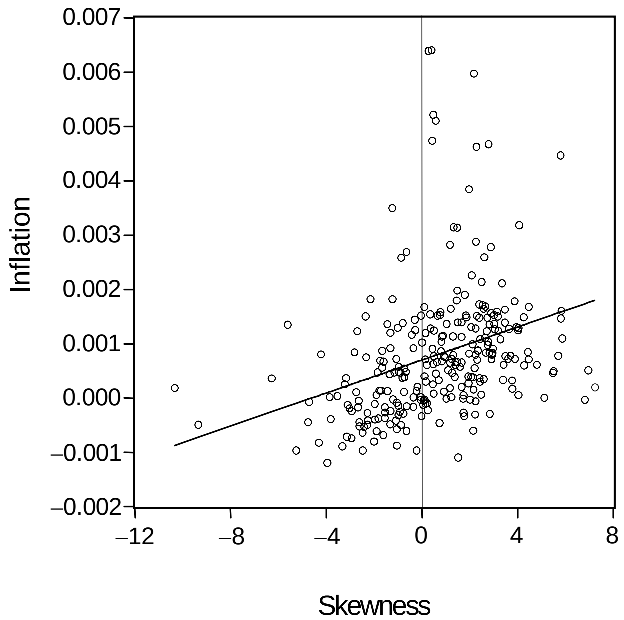
and hence strengthens the effect of skewness on the rate of inflation. I therefore include a variance/skewness interaction term in the regressions below.

The data consist of 71 consumer goods items in the Swedish consumer price index (CPI). The individual price is denoted p_{it} and the general price level $\log p_t = \sum_{i=1}^{71} w_{it} \log p_{it}$ where $w_{it} = \frac{p_{it} q_{it}}{\sum_{j=1}^{71} p_{jt} q_{jt}}$ is the budget share, q_{it} is the volume of item j at time t while $p_{it} q_{it}$ is the expenditure. The relative price is then defined as $\frac{p_{it}}{p_t}$ and the mean of relative price changes as $\sum_{i=1}^{71} w_{it} [\Delta \log p_{it} - \Delta \log p_t] = 0$. The variance of relative price changes is defined as $\sigma_{rp}^2 = \sum_{i=1}^{71} w_{it} (\Delta \log p_{it} - \Delta \log p_t)^2$ and the skewness as $\sigma_{rp}^3 = \frac{\sum_{i=1}^{71} w_{it} (\Delta \log p_{it} - \Delta \log p_t)^3}{\sqrt{\sigma_{rp}^2}}$. In theory, there is a positive correlation between inflation and σ_{rp}^2 and σ_{rp}^3 respectively. If relative prices are normally distributed, we also expect $\sigma_{rp}^3 = 0$ in the long run and the positive correlation between inflation and skewness to be a short-run phenomenon, presumably associated with nominal rigidities.

The variance and skewness measures are calculated for both monthly and quarterly data. Since skewness is assumed to capture effects of nominal rigidity, the time interval of the data is likely to be important and may affect the results. The econometric models below are dynamic and include lagged dependent variables. Therefore, the equations may be affected by temporal aggregation.[11] Another possible econometric problem is simultaneity since both the variance and the skewness possibly depend on inflation, whether expected or unexpected.[12]

Graph 5

Inflation and skewness



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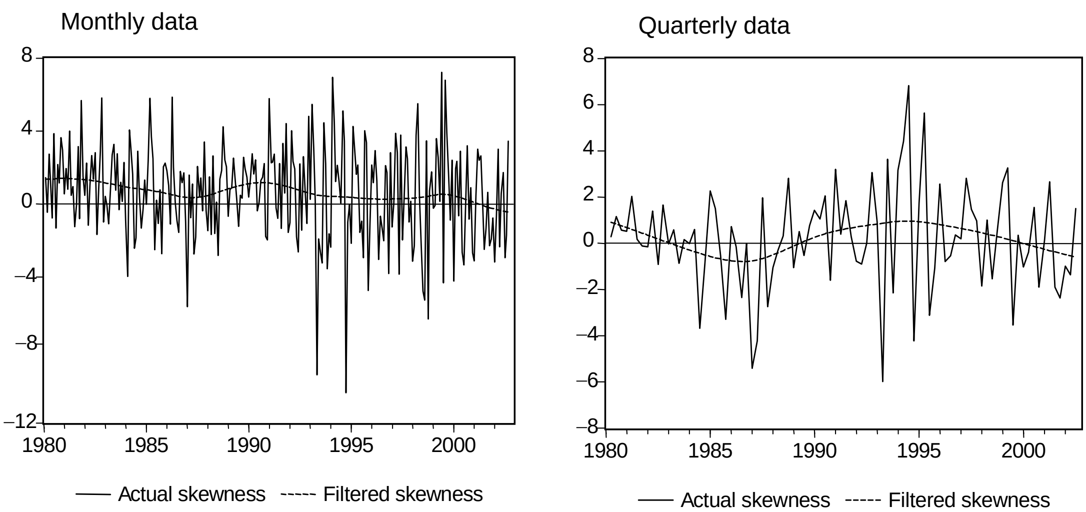
[11] I try to remedy this possible negative effect on the specification by including a moving average term. However, this term was never significant, not even with quarterly data. On this, see Ermini (1991,1993), Wei (1978) and Weiss (1984).

[12] This can clearly be seen in models where variance or skewness is endogenous, as in Assarsson (1986) and Parks (1978), where variance and skewness depend on inflation and various demand and supply factors like domestic and foreign input prices and income.

Graph 5 shows the data and draws a positively sloped regression line. In Graph 6 the time series of monthly and quarterly data for the data period 1980-2002 are shown. A filtered[13] series is also drawn in order to show the long-run development. One would expect the distribution to be symmetric in the long run with zero skewness, but for the monthly data in the left panel of Graph 6 skewness seems to be positive even in the long-run. This has also been found for other countries.[14] In Graph 7 we also show the recursive mean of the monthly and quarterly skewness series, and it can be seen that the monthly but not the quarterly series has a long-run positive skewness. This long-run positive skewness is attributed to trend inflation. With a positive rate of inflation, the range of inaction with respect to price change moves to the left, since a price decrease can be effected through inaction. Therefore, a price increase is more likely than a price decrease and the distribution of actual price changes has a tendency to be positively skewed.

Graph 6

Actual and filtered skewness of relative price changes



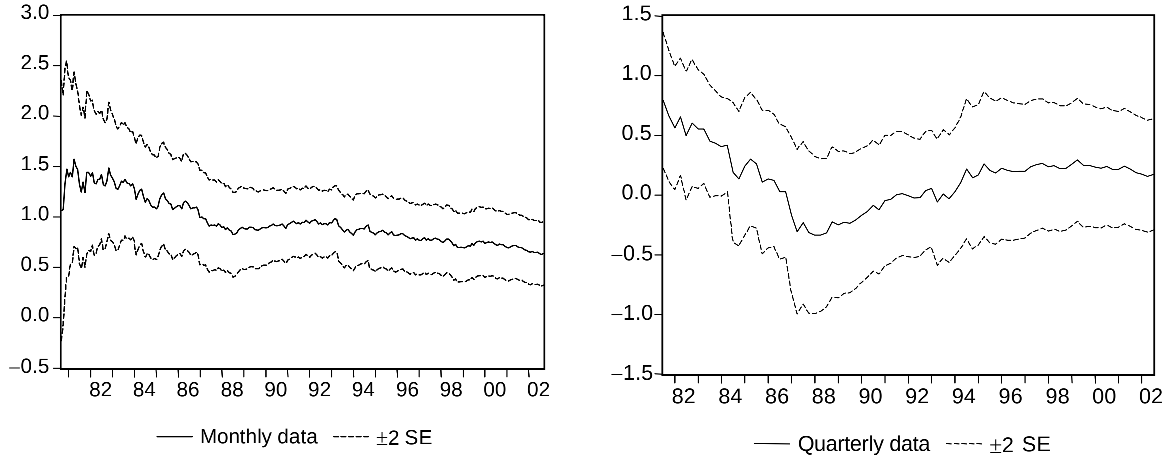
This is, however, not the case here for quarterly data. One explanation for this finding is that the longer the time intervals of the data, the less important are the nominal rigidities. More likely, however, is that at reasonably low inflation rates, most prices will be changed on a quarterly rather than on a monthly basis and the rate of inflation in the sample at hand is relatively low. This result may depend on the level of aggregation in the data. It is more likely that a chronic positive skewness will be found if the data are more disaggregated.

13 A Hodrick-Prescott filter was used.

14 See Aucremanne et al (2002).

Graph 7

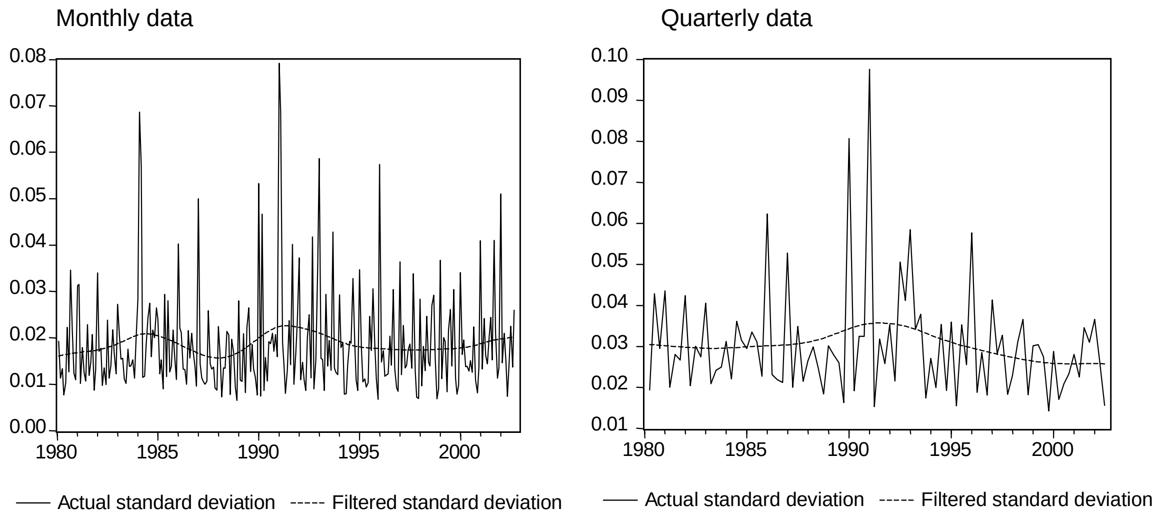
Recursive mean of skewness of relative price changes



In Graph 8 the development of the second moment of relative price changes is shown for monthly and quarterly data. There is no clear tendency over time in the monthly data, while for quarterly data there is a tendency towards decreasing variance during the last decade. With decreasing variance, the effect of skewness on the rate of inflation would be reduced. Decreasing variance and a tendency towards lower skewness imply a smaller effect of relative prices on the rate of inflation.

Graph 8

Actual and filtered standard deviation of relative price changes



During the late 1990s, inflation was overpredicted by many forecasters. During this period skewness was rather large but declining according to the quarterly data in Graph 6. If forecasts were done with models that neglected the effect of skewness and the forecasts were based on current information, it is likely that inflation forecasts one to two years ahead were too high, since current inflation was due to the high but decreasing skewness. Likewise, current forecasts that neglect skewness may underpredict inflation one to two years ahead since skewness is currently negative and probably increasing.

We now turn to the regression equations, where lagged inflation and the second and third moments as well as the interaction between the moments are included as regressors. Regressions are run for the whole data period 1980-2002 and are also divided into two sub-periods: 1980-89 and 1990-2002. The division is carried out in order to distinguish between the high- and low-inflation periods with different monetary policy regimes. Unrestricted regressions are run as well as restricted regressions in which only skewness is included and the effects of variance excluded. The difference between the even and odd-numbered columns in Table 1 is therefore the effect of the standard deviation of relative price changes: a direct effect and an indirect effect through skewness as discussed above. The regression equation can be written $\pi_t = \alpha_0 + \alpha_1\pi_{t-1} + \alpha_2\sqrt{\sigma_{rp}^2} + \alpha_3\sigma_{rp}^3 + \alpha_4\sqrt{\sigma_{rp}^2}\sigma_{rp}^3 + \varepsilon_t$ and the partial effect of skewness in the unrestricted regressions can be calculated as $\alpha_3 + \alpha_4\sqrt{\sigma_{rp}^2}$. The effect varies over time. The effect and the corresponding p-value is calculated at the mean value of $\sqrt{\sigma_{rp}^2}$.

Table 1

Dependent variable: inflation π

Monthly data

	(1) 1980-2002	**(2) 1980-2002**	**(3) 1980-89**	**(4) 1980-89**	**(5) 1990-2002**	**(6) 1990-2002**
Constant	–0.001464 (0.1419)	0.000397 (0.6918)	0.000416 (0.7678)	0.002188 (0.1186)	–0.004570 (0.0003)	–0.000752 (0.5777)
π_{t-1}	0.282825 (0.0000)	0.258330 (0.0000)	0.166770 (0.0374)	0.101641 (0.2420)	0.157248 (0.0124)	0.233702 (0.0032)
$\sqrt{\sigma_{rp}^2}$	0.145803 (0.0000)		0.156398 (0.0009)		0.268787 (0.0000)	
σ_{rp}^3	–0.000059 (0.7684)	0.000800 (0.0000)	–0.000045 (0.8974)	0.001058 (0.0000)	–0.000199 (0.3991)	0.000587 (0.0001)
$\sqrt{\sigma_{rp}^2}\sigma_{rp}^3$	0.036917 (0.0000)		0.049156 (0.0001)		0.030531 (0.0020)	
R^2	0.527	0.411	0.582	0.478	0.653	0.417
Ser	0.004188	0.004657	0.003771	0.004175	0.003624	0.004662
Effect of skewness	0.000630 (0.0000)	–	0.000820 (0.0001)	–	0.000396 (0.0008)	–

Note: p-values in parentheses. Effect of skewness at mean standard deviation.

Notation: π_{t-1} = lagged inflation; $\sqrt{\sigma_{rp}^2}$ = standard deviation of relative price changes; σ_{rp}^3 = Skewness of relative price changes; R^2 = multiple correlation coefficient; Ser = standard error of regression.

Column (1) in Table 1 shows the unrestricted regression for the sample period 1980-2002. Column (2) excludes the standard deviation. Columns (3) and (4) show the corresponding results for the high-inflation period 1980-89 and columns (5) and (6) the results for the later low-inflation period 1990-2002. From what can be seen in Table 1, the effect of the variance is more important in the later period, where the standard error of regression decreases relatively more than in the earlier period. The effect of skewness is also smaller in the later period.

The relative importance of lagged inflation as compared to variance and skewness can be evaluated by excluding lagged inflation. Then R^2 drops from 0.53 to 0.46 while if the distribution variables are excluded R^2 drops to 0.31. Therefore variance and skewness seem potentially important in explaining inflation. During the later period this is even more pronounced, where R^2 drops from 0.65 to 0.42 when the distribution variables are excluded but only to 0.64 when lagged inflation is excluded. This is consistent with the view that nominal rigidities become more important in low-inflation regimes.

Nominal rigidities are likely to be more important at high than at low data frequencies. Table 2 shows the results for quarterly data, which are rather similar to the results for monthly data, but somewhat weaker. Skewness is now significant at the 7% significance level during the whole sample period and during the later period. Again, when the lagged inflation term is excluded, R^2 drops from 0.48 to 0.36, while the fall is to 0.32 when the distribution terms are excluded. For the later period the drop is from 0.70 to 0.67 when the lagged inflation term is excluded but down to 0.35 when the distribution terms are dropped. Therefore, the same conclusions hold with quarterly data: the distribution terms are important, particularly during the later period.

Table 2

Dependent variable: inflation π

Quarterly data

	(1) 1980-2002	**(2) 1980-2002**	**(3) 1980-89**	**(4) 1980-89**	**(5) 1990-2002**	**(6) 1990-2002**
Constant	–0.001303 (0.0597)	0.000617 (0.2279)	0.001458 (0.3263)	0.002733 (0.0053)	0.002677 (0.0003)	–0.000100 (0.8558)
π_{t-1}	0.390698 (0.0000)	0.403508 (0.0001)	0.137296 (0.4525)	0.123480 (0.4928)	0.186582 (0.0755)	0.291859 (0.0396)
$\sqrt{\sigma^2_{rp}}$	0.080404 (0.0006)		0.050997 (0.2774)		0.113101 (0.0000)	
σ^3_{rp}	0.000065 (0.7992)	0.000212 (0.0423)	0.000075 (0.8826)	0.000342 (0.0951)	0.000302 (0.2858)	0.000247 (0.0447)
$\sqrt{\sigma^2_{rp}}\sigma^3_{rp}$	0.003344 (0.6590)		0.008423 (0.5591)		–0.004519	
R^2	0.484	0.351	0.322	0.290	0.695	0.407
Ser	0.001904	0.002110	0.002000	0.001981	0.001458	0.001986
Effect of skewness	0.000166 (0.0769)	–	0.000320 (0.1200)	–	0.000161 (0.0700)	–

For an explanation of the notation, see Table 1.

5. Empirical results II: higher moments of relative price changes in the Phillips curve

We now turn to the Phillips curve estimations. We follow Ball and Mankiw (1993) and specify a simple version which includes a lagged inflation term (to capture expected inflation), an excess demand or output gap term (the actual rate of unemployment) and the change in oil prices to capture supply shocks. To this we add the distribution terms (Table 3). The distribution terms are significant in all the regressions. Again, the direct effect of standard deviation is significant in all regressions except for the earlier data period with quarterly data.

It is interesting to compare the performance of a traditional Phillips curve to that of an extended version with distribution terms. For quarterly data (Table 4), R^2 drops from 0.65 to 0.36 when the conventional variables are excluded[15] and to 0.53 when the distribution terms are excluded. For the later period, however, the results are different: R^2 drops from 0.82 to 0.58 when the conventional

[15] That is, all variables except the distribution variables.

Phillips curve is used but is 0.67 for the Phillips curve with only the distribution terms. Hence, again the results are consistent with the view that nominal rigidity has become more important during the low-inflation regime. The results are similar for monthly data.[16]

Table 3

Phillips curve estimation. Dependent variable: inflation π

Monthly data

	(1) 1980-2002	**(2) 1980-2002**	**(3) 1980-2002**	**(4) 1980-89**	**(5) 1990-2002**
Constant	0.001885 (0.0528)	0.003822 (0.0001)	0.004368 (0.0000)	0.000908 (0.6056)	–0.000649 (0.5772)
π_{t-1}	0.160577 (0.0006)	0.148808 (0.0037)	0.155670 (0.0038)	0.158096 (0.0414)	0.118720 (0.0188)
u_t	–0.068174 (0.0000)	–0.067698 (0.0000)	–0.072206 (0.0000)	–0.022215 (0.6636)	–0.034799 (0.0025)
Δp_t^{oil}	0.043815 (0.0000)	0.052289 (0.0000)	0.060115 (0.0000)	0.029176 (0.0027)	0.073302 (0.0000)
$\sqrt{\sigma_{rp}^2}$	0.148276 (0.0000)			0.145888 (0.0016)	0.210507 (0.0000)
σ_{rp}^3	0.000016 (0.9271)	0.000538 (0.0000)		0.000249 (0.4734)	–0.000313 (0.0837)
$\sqrt{\sigma_{rp}^2}\,\sigma_{rp}^3$	0.023019 (0.0011)			0.024273 (0.0957)	0.030731 (0.0001)
R^2	0.663	0.586	0.542	0.620	0.807
Ser	0.003564	0.003935	0.004131	0.003633	0.002749
Effect of skewness	0.000445 (0.0000)	–	–	0.000676 (0.0011)	0.000286 (0.0020)

Note: p-values in parentheses. Effect of skewness at mean standard deviation.
Notation: π_{t-1} = lagged inflation; $\sqrt{\sigma_{rp}^2}$ = standard deviation of relative price changes; σ_{rp}^3 = skewness of relative price changes; u_t = unemployment rate; Δp_t^{oil} = relative change in oil price; R^2 = multiple correlation coefficient; Ser = standard error of regression.

The results in Tables 3 and 4 are preferred in the estimations, though this implies a rejection of the non-accelerationist hypothesis and there is a long-run relationship between inflation and unemployment as in the preferred specification the actual unemployment rate was preferred to the unemployment gap $u_t - u_t^*$. If we instead estimate the equation $\Delta\pi_t = \alpha_0 + \alpha_1[u_t - u_t^*] + \alpha_2 z_t + \alpha_3\sigma_{rp}^2 + \alpha_4\sigma_{rp}^3 + \alpha_5\sigma_{rp}^2\sigma_{rp}^3$ the results are similar compared to those in the tables: the distribution variables are statistically important and relatively more important in the later data period.[17]

[16] R^2 drops from 0.66 to 0.54 if the conventional model is used and to 0.46 with only the distribution terms. For the later period the graphs are 0.61 and 0.64 respectively. Hence, the distribution terms seem to be quite important in terms of goodness of fit.

[17] A theoretically reasonable estimation of this equation would show $\alpha_0 = 0; \alpha_1 < 0; \alpha_2 > 0$. The last three terms would drop out in the long run with $\sigma_{rp}^2 = \sigma_{rp}^3 = 0$. The theoretically correct parameters cannot be rejected, except for α_1 which is positive but insignificant.

Table 4

Phillips curve estimation. Dependent variable: inflation π

Quarterly data

	(1) **1980-2002**	**(2)** **1980-2002**	**(3)** **1980-2002**	**(4)** **1980-1989**	**(5)** **1990-2002**
Constant	0.001391 (0.0704)	0.003066 (0.0000)	0.002837 (0.0001)	0.001339 (0.4487)	–0.000607 (0.4539)
π_{t-1}	0.135228 (0.1247)	0.118209 (0.2202)	0.119785 (0.2262)	0.048983 (0.7950)	0.034754 (0.7029)
u_t	–0.040360 (0.0000)	–0.043313 (0.0000)	–0.040052 (0.0001)	0.014761 (0.7700)	–0.021676 (0.0176)
Δp_t^{oil}	0.014357 (0.0006)	0.016683 (0.0003)	0.018776 (0.0000)	0.015924 (0.0958)	0.015445 (0.0003)
$\sqrt{\sigma_{rp}^2}$	0.062134 (0.0020)			0.038558 (0.4106)	0.092936 (0.0000)
σ_{rp}^3	0.000024 (0.9165)	0.000207 (0.0225)		–0.000123 (0.8112)	0.000159 (0.4934)
$\sqrt{\sigma_{rp}^2}\sigma_{rp}^3$	0.004816 (0.4528)			0.012492 (0.3888)	–0.000778 (0.9146)
R^2	0.649	0.563	0.533	0.387	0.817
Ser	0.001597	0.001760	0.001807	0.001968	0.001168
Effect of skewness	0.000169 (0.0413)			0.000241 (0.2593)	0.000135 (0.0611)

For an explanation of the notation, see Table 3.

6. Conclusions

Several studies for various countries show that inflation is significantly correlated with both the variance and the skewness of relative price changes. One explanation for this is nominal rigidities in prices - due to menu costs - but other explanations exist as well. The present paper has shown that the relationships for Swedish data are quite strong. Phillips curves can be seen as price setting curves, where the price is basically a markup on marginal cost and the markup depends on the degree of competition and the price elasticity of demand. Nominal rigidities have been introduced into Phillips curves in various ways, but there is presently no consensus about the best way. New Keynesian Phillips curves are based on forward-looking elements and are difficult to estimate.

In this paper the inclusion of higher moments of the distribution of relative price changes are proposed as an alternative to capture the effects on inflation of nominal rigidity, in line with the theory in Ball and Mankiw (1993). The empirical results show that these distribution variables - variance, skewness and the interaction between them - has quite a strong influence on the Phillips curves estimated for Swedish monthly as well as quarterly data. There is a significant positive relationship between skewness/variance and the rate of inflation. Skewness appears to be positive *in the long run* in monthly data but zero in quarterly data. Neglecting skewness/variance in the Phillips curve seems to be a possible explanation for previous inflation forecast errors in Sweden.
A drawback with the distribution variables in the Phillips curve is that they, as in the present paper, are

exogenous and less useful when forecasting. However, endogenous models for relative prices and hence for the higher moments of relative prices exist but tend to become very complex.[18]

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A financial conditions index for Switzerland

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1. Introduction

Freedman (1994) first proposed the construction of a monetary conditions index (MCI), arguing that the MCI, being a weighted sum of the short-term interest rate and the exchange rate, is preferable to the interest rate alone as an operating target for a small open economy. The brief experience of countries using the MCI as an operating target is limited to Canada and New Zealand. MCIs, however, continue to be calculated by central banks and international organisations as simple indicators for the stance of monetary policy.[2]

The recent high volatility in stock and property prices has renewed the interest in the role of asset prices for monetary policy. Diverging movements in equity and housing prices have raised concerns about the appropriate stance of monetary policy when markets are moving in different directions. To measure the offsetting influence between asset prices, the exchange rate and the interest rate, efforts have been made recently to extend the MCI to include other assets such as stocks or housing prices. Such measures, labelled the financial conditions index (FCI), have been constructed by Goodhart and Hofmann (2001) for the G7 countries and Mayes and Virén (2001) for 11 European countries. Their results are promising in the sense that they find that housing prices especially are helpful in providing additional information on future inflationary pressure.

The role of housing and stock prices in the monetary transmission mechanism in Switzerland has not been fully explored yet. Housing and stock prices are routinely monitored by the Swiss National Bank (SNB), yet they do not formally enter the SNB's models and indicators, one of which is the MCI. The objective of this paper is to expand the MCI into an FCI by adding housing prices. The weights of the FCI components are estimated with the medium-sized macro-model used by the SNB.

Section 2 briefly outlines the MCI and discusses how it can be extended to an FCI through the inclusion of alternative assets. Section 3 considers econometric issues important for the interpretation and construction of an MCI/FCI. Section 4 presents the empirical results. Section 5 concludes.

2. From the MCI to the FCI

The MCI is usually defined as:

$$MCI_t = \Sigma_i w_i (p_{it} - p_{i0})$$

where the p_{it} are directly or indirectly related to monetary policy actions. The MCI is the weighted sum of changes in the variables p_{it} from their values in a base period. The level of the MCI has no meaning, as the MCI is not stationary. A relationship of the following form is assumed for output or inflation:

$$y = f(p_1, \dots, p_s, X) \quad or \quad \pi = g(p_1, \dots, p_s, X)$$

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[2] See Hansson and Lindberg (1994) for Sweden, Jore (1994) for Norway, Lengwiler (1997) for Switzerland, Dennis (1997) and Nadal-De Simone et al (1996) for New Zealand, and Duguay (1994) for Canada.

with X representing other variables not related to monetary policy, but influencing output or inflation. The weights, w_i, of the MCI components are the partial derivatives of the respective variables in f or g, depending on whether the weights are based on output or inflation.

Although the definition of an MCI is quite general, in practice only two variables enter the MCI: the short-term interest rate (to capture effects of monetary policy through the interest rate channel) and the exchange rate (to capture effects through the exchange rate channel):

$$MCI_t = w_1(r_t - r_0) + w_2(e_t - e_0)$$

where r is the short-term interest rate and e the natural logarithm of the exchange rate. The ratio of the weights, w_1/w_2, is termed the MCI ratio. The higher this ratio is, the more important is the interest rate channel compared to the exchange rate channel in the transmission of monetary policy. For example, a 3:1 ratio indicates that a 1 percentage point interest rate change has three times the effect of a 1% change in the exchange rate.

An MCI can be constructed in real or nominal terms. Since it is mostly used for short-term comparisons, the difference is negligible. Usually, real variables are used to estimate an underlying model, while nominal variables are used for the construction of MCIs. The following strategies are used to estimate the weights of the MCI components:

- simulations in a structural macroeconometric model;
- estimation of a reduced-form aggregate demand equation;
- estimation of structural vector autoregression (VAR) systems.

Calculations based on structural macro-models are superior to the other methods because more variables are taken into account and, unlike in the reduced equation approach, structural shocks can be constructed. Most central banks, governments, and some international organisations have structural macro-models. Peeters (1998) and Mayes and Virén (1998) use the NIGEM model for Finland to calculate MCI weights, and the Organisation for Economic Co-operation and Development (OECD) bases the weights of its MCIs on the OECD Interlink Model.[3]

Most MCI estimations are, however, based on reduced-form aggregate demand equations. Reduced-form models usually consist of a demand equation relating the output (gap or growth) to the interest rate, the exchange rate and possibly some other explanatory variables. This approach has been chosen by most central banks publishing an MCI. The advantages of this approach are its simplicity and modest requirements concerning data and econometric modelling. The reduced-form approach suffers most from the criticisms in Eika et al (1996) detailed in Chapter 3.

VAR models impose only minimal structure and can also be used to calculate MCI weights. Their advantage lies in the fact that they are not based on a particular view of the transmission mechanism. Goodhart and Hofmann (2001) calculate FCI weights using structural VAR models.

Housing prices

The global upswing in stock prices in the 1990s and the sharp downturn since 2000, combined with strongly rising housing prices in many countries, have sparked interest in the role of asset prices for monetary policy. Equity and housing prices are natural candidates for the extension of an MCI to an FCI due to their links to monetary policy. While traditional MCIs only consider the interest rate channel and the exchange rate channel, the inclusion of other asset prices may improve the assessment of the monetary policy stance by accounting for wealth and balance sheet channel effects.

Like many other European countries, Switzerland experienced a housing bubble in the second half of the 1980s. The bursting of the bubble in the early 1990s led to serious problems in the banking sector.

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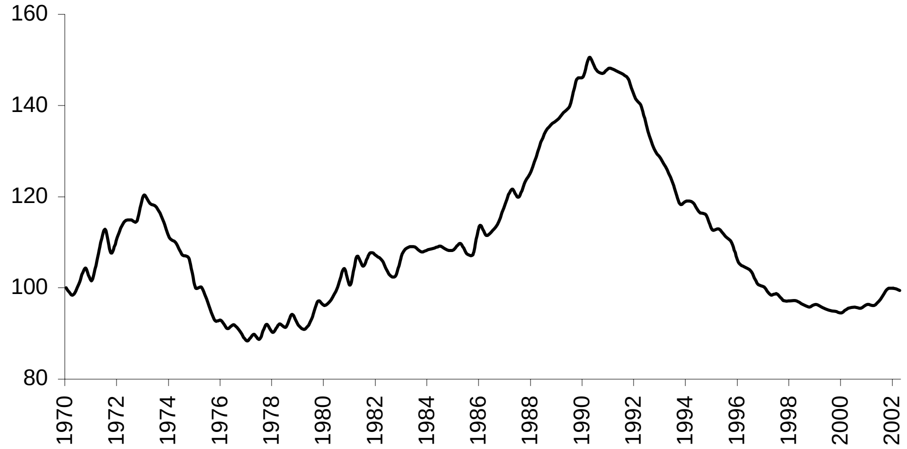
3 See *OECD Economic Outlook* 59 (June 1996), p 31.

Graph 1 shows the long process of deflation in the housing sector in the 1990s. Housing prices[4] (deflated by the CPI) bottomed out in 2000 below their 1970 level.

Graph 1

Real housing price index



By international standards, Swiss property prices remain high even after the strong decline beginning in 1991. Switzerland is a densely populated country and land is scarce. Contributing to the high price level is the non-competitive construction sector, which profits from a high degree of protection and regulation. Further reasons include the high quality standards and large amount of conveniences usually demanded by occupants. The financing of costly real estate is offset by low mortgage rates. Swiss short-term and long-term interest rates are usually considerably lower than comparable eurorates. The low and stable interest rates, the easy availability of mortgages, a high degree of job security, and the deductibility of interest rate payments on mortgages from taxable income encourage Swiss homeowners to take on large debts.

Credit granted to households in Switzerland was almost 100% of gross domestic product (GDP) in 1993 (Graph 2). This is a larger fraction than in any other country, including the United Kingdom, the United States and Japan.

The Swiss debt market is heavily collateralised: 73% of total loans to the non-government sector are backed by real estate collateral. This again is more than in any other country: the share of real estate collateral is around 60% in most English-speaking countries and Sweden and lower in the remaining countries (Borio (1995), Table 16). The large fraction of real estate collateral implies that the high indebtedness of the Swiss private sector is mainly due to the purchase of property and houses. Swiss homeowners are therefore highly leveraged to housing prices. This suggests that housing prices are a good means for capturing wealth channel effects of monetary policy.

Switzerland also boasts a record stock market capitalisation in relative terms.[5] However, a significant fraction can be assumed to be held by foreigners. Direct holdings of shares by individuals are probably less common than in the United States. The indirect holdings of shares through public and private pension funds are believed to be larger than the direct holdings. Furthermore, because the return of pension funds (at least in the short and medium term) is fixed in nominal or real terms and independent of the actual performance of the underlying assets, the influence of stock market

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[4] Housing prices depicted in Graph 1 and used in the following estimations are constructed from equally weighted prices of apartments, rented flats, houses, industrial space and office floorspace (see the appendix for details). The index therefore not only measures housing prices in a narrow sense, but also includes property prices. However, the overall evolution of the components is very similar.

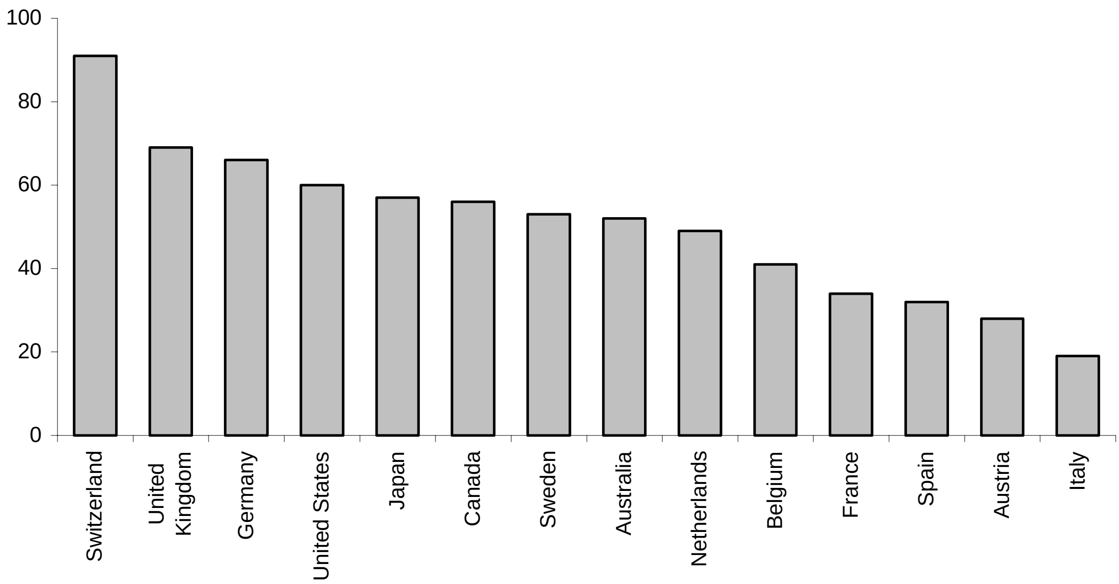
[5] In 1999, stock market capitalisation was 320% of GDP in Switzerland, 230% in the United Kingdom, 150% in the United States and 70% in Germany (Rajan and Zingales (2000)).

fluctuations on future rents is not immediately obvious to the individual. Therefore, the wealth effect through equity prices is probably smaller and more difficult to trace than the effect of housing prices. In Fischer et al (2001), housing prices were found to be more robust and significant than stock market prices in predicting economic activity and in improving the empirical fit of a Taylor rule. The analysis in this paper therefore focuses solely on housing prices as an additional asset in the MCI.

Graph 2

Credit to households, 1993

As a percentage of GDP



Source: Adapted from Borio ((1995), Tables 2 and 4).

3. Preliminary thoughts on the construction of an MCI/FCI

Before going into the details of the estimation and calculation of an FCI for Switzerland, some problems highlighted by Eika et al (1996) are addressed in this section.

3.1 Stationarity

Using a macro-model, MCI/FCI weights are calculated from the effects of simulated shocks. The order of integration is important because it affects the nature of the simulated shock (permanent or transitory) and the measurement of its effects on output or prices. Assumptions on the order of integration are implicitly made in calculating and interpreting any MCI, yet they are problematic and not always transparent.

To highlight this issue, consider the stylised response of a time series to a shock, illustrated in Graph 3: the first time series (i) is I(1) with the shock having a permanent effect, the second (ii) corresponds to the first derivate of (i) and is stationary with respect to the shock considered, and the third (iii) is the second derivate of (i).

The response of the first time series to a shock is best measured as the shift of the level of the series. This measure (a) is independent of the chosen time horizon if the horizon is long enough. An alternative, but imperfect measure is (b), measuring the growth rate attained during this shift. Measure (b) depends on the timing; if measured too early or too late, no effect is found. Even more problematic is the case of an overdifferenced time series (iii), as the signs of the measured effect change depending on the chosen horizon. Therefore, effects of permanent shocks to non-stationary time series should best be measured using levels. Table 1 shows an overview of a unit root and stationarity test for the relevant Swiss variables covering the 1973:1-2002:1 period.

Graph 3

Stylised impulse response function

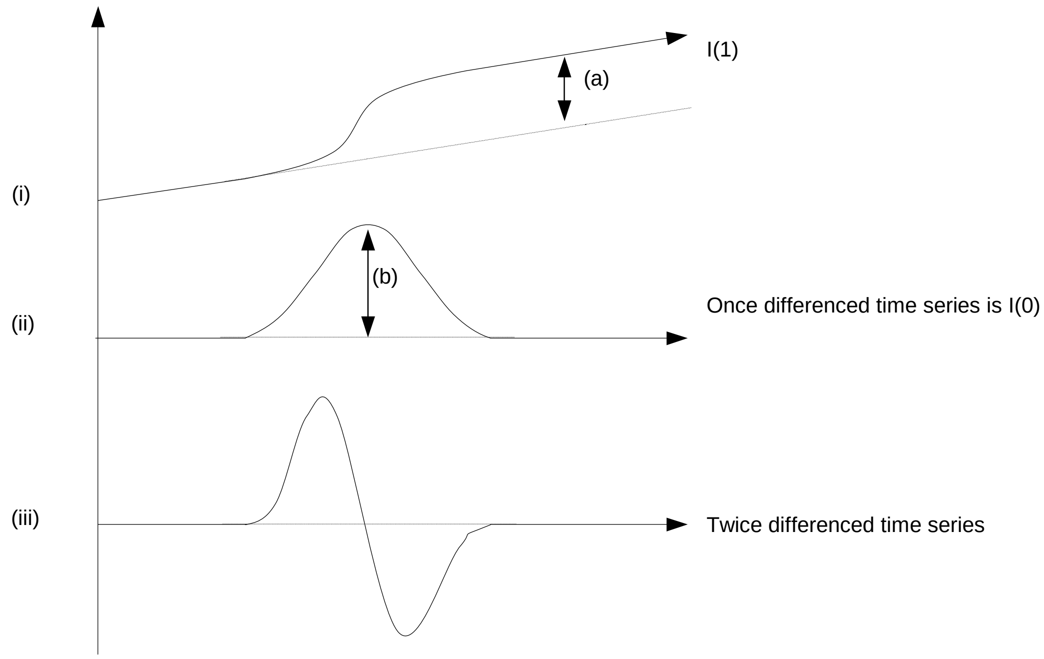


Table 1

Overview of unit root and stationarity tests

	ADF unit root test	KPSS stationarity test
log(CPI)		***
CPI annual inflation	***	
log(real housing prices)		**
Annual real housing price changes	**	
log(real GDP)		
Annual real GDP growth	***	
log(real exchange rate)	*	
Annual real exchange rate changes	***	
Real short-term interest rate	***	**
Nominal short-term interest rate	**	*

Note: ADF unit root test (with automatic lag length selection according to the Schwarz info-criterion) and stationarity test of Kwiatkowski et al (1992) using the Bartlett kernel estimator and Newey-West automatic bandwidth selection. Trends are included for CPI inflation and the level variables. Details about the variables can be found in the appendix. The time period is 1973:1-2002:1 using quarterly values.

* Denotes rejection at the 10% level. ** Denotes rejection at the 5% level. *** Denotes rejection at the 1% level.

3.2 Measuring the output and price effects of shocks

Assumptions about the order of integration of output and prices strongly affect the measurement of the effects of simulated shocks.

Consumer price index (CPI) inflation seems to be trend-stationary in Switzerland. If inflation is trend-stationary, shocks only have temporary effects.[6] The reaction to shocks and therefore the MCI/FCI weights will then strongly depend on the measurement horizon. A better alternative to measuring inflation effects is to measure the CPI level effect of a shock.[7] Trend-stationarity of the inflation rate is sometimes rejected in other countries where inflation is assumed to be I(1).[8] Only in that case is it useful to measure inflation effects. In this investigation both inflation-based and CPI-level-based weights are calculated.

The unit root test finds the logarithm of output to be either I(1) or trend-stationary. If output is trend-stationary, basing MCI/FCI weights on output growth effects is questionable, as the initial output growth effects of a shock have to reverse after some time in order for output to return to its equilibrium.[9] The estimated growth effects will therefore strongly depend on the horizon chosen and will be wrongly signed at some horizons. Note that, in the structural VAR literature, output neutrality with respect to monetary policy shocks (which is about equivalent to assuming output to be stationary) is a common assumption for the identification of monetary shocks. If output is trend-stationary, output effects should best be measured by the output gap (which is equivalent to measure (b) in Graph 3) or even the integrated output gap (equivalent to (a) in Graph 3). Only if output is I(1) does it make sense to measure growth effects. The uncertainty about the correct assumption about the order of integration of output is one reason why FCI ratios will not be based on output effects, but on price effects.

3.3 Simulating shocks to the exchange rate, housing prices and the interest rate

Assumptions about the order of integration of the exchange rate, housing prices and interest rates determine the nature of the simulated shocks. Different weights and a different interpretation of an MCI/FCI will result, depending on whether permanent or transitory shocks to exchange rates, housing prices, and interest rates are simulated.

The stationarity and unit root tests find the real exchange rate to be either I(1) or trend-stationary.[10] It is well known that deviations from exchange rate equilibria are extremely persistent. It can therefore be preferable to treat the real exchange rate as I(1). This assumption fits the Swiss case well, because the appreciation of the Swiss franc can be viewed as a series of one-time permanent shocks. Consequently, for the calculation of FCI weights in Section 4, a *permanent* shock to the exchange rate is simulated.

Real housing prices, ie housing prices deflated by the CPI, are found to be I(1). To calculate the weight for housing prices, permanent shocks are therefore applied to housing prices. The unit root assumption in the real exchange rate and real housing prices is consistent with the market efficiency hypothesis that asset prices follow a martingale.

Interest rates are often treated as stationary variables, yet stationarity of the nominal and real interest rate is rejected. If interest rates are stationary, only temporary shocks can be applied to interest rates. The traditional MCI interpretation, however, implies permanent shocks to the interest rate and therefore implicitly assumes non-stationary interest rates. In order to be comparable to other MCI/FCI investigations, interest rates are therefore also assumed to be I(1). Under this assumption, the

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6 This corresponds to the case where inflation is depicted by (ii) in Graph 3.

7 This corresponds to measuring (a) using the CPI.

8 This corresponds to inflation being the time series as depicted by (i) in Graph 3.

9 This corresponds to output being described by the time series in (ii) and output growth by (iii).

10 The trend is due to the annual appreciation by 0.7% on average over the past 25 years. This trend is regarded by the SNB as a structural appreciation.

FCI ratio can then be interpreted as indicating how much interest rates have to be changed permanently to offset a permanent change in the exchange rate or in housing prices.[11]

Note that, by implicitly assuming non-stationarity of the components, an MCI/FCI which is the sum of these components is also non-stationary and should therefore not be used for long-term comparisons.

3.4 Interpretation of the MCI

In the traditional MCI setting, it is assumed that both the interest rate and the exchange rate are determined largely by monetary policy. The Swiss franc is, however, not always driven by monetary policy actions. The Swiss currency is used internationally as a denomination of assets and debts and remains a safe haven in times of crisis. The SNB has only a reduced influence on exchange rate movements. If the SNB tried to target an MCI as an operational target, this would result in large swings of the short-term interest rate, where the zero lower bound (ZLB) could become binding. Ruling out interventions, the SNB would probably not always succeed in maintaining the targeted MCI. The short-term rate is thus the only feasible operating target. Thus, the Swiss MCI is not only a measure of "monetary" conditions, ie conditions which are entirely or mainly induced by monetary policy, but it is a relatively broad measure of "overall" demand conditions and must be interpreted accordingly.

3.5 Endogeneity

Although it was argued that the exchange rate is to a certain extent an exogenous variable, there still remains an endogeneity problem. On the one hand, the MCI weights should be interpretable as structural weights for policy purposes, ie they should answer the question of how large an interest rate shock needs to be to offset an exchange rate shock. For that purpose, the weight of the interest rate should be based on the effect of a *structural* interest rate shock, ie a shock which also allows exchange rates (and housing prices in the case of an FCI) to react. On the other hand, I define a *"restricted"* interest rate shock to be a shock where the exchange rate and housing prices are *not* allowed to react. Concerning the exchange rate and housing prices, policymakers are probably interested in the effects of restricted shocks, ie assuming no change in the interest rate.

The estimated MCI weights depend strongly on whether structural or restricted shocks are applied to a model. For the *interpretation* of the MCI weights for monetary policy purposes, a *structural* monetary policy shock, restricted exchange rate, and restricted housing price shocks are relevant. However, for the *construction* of the MCI or FCI, only restricted shocks must be used. Only then can the MCI/FCI be calculated as a weighted sum of changes in variables relative to a base period.[12] Therefore, *different weights* for policy analysis and for the actual construction of the index must be used.

To illustrate the difference between structural and restricted shocks, suppose monetary policy is tightened by raising interest rates. This leads to an appreciation of the domestic currency. If the interest rate component enters the index weighted according to its structural effect, a reaction of the exchange rate is expected and already accounted for. However, the exchange rate reaction also enters the index. Thus, the exchange rate reaction to the change in interest rates is accounted for twice. To avoid this, a weight of the interest rate component has to be used which corresponds only to the pure interest rate effect through the interest rate channel. A structural interest rate shock is simply a linear combination of a reduced interest rate shock, a reduced exchange rate shock and a reduced housing price shock.

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[11] If interest rates are assumed to be stationary and temporary shocks to the interest rate are simulated to calculate weights, the FCI ratio must then be interpreted as indicating how long and by how much interest rates have to deviate from an equilibrium in order to offset a permanent shock to the exchange rate or to housing prices. This would result in a different (more difficult, but maybe more useful) interpretation of the MCI/FCI. This view of monetary policy would go along the lines of Borio and Lowe (2002), who view monetary disequilibria as *cumulative* processes, ie integrals of deviations from an equilibrium over time.

[12] An MCI or FCI could in principle also be calculated using the structural interest rate shock weight. This, however, would imply that the index cannot be calculated as the sum of the changes of its components. A change in the interest rate would then imply a certain change in the exchange rate to have the full structural effect. Only the deviation of the actual exchange rate from the implied reaction of the exchange rate to the structural shock would then have to be added to the MCI or FCI.

3.6 Dynamics, parameter constancy and omitted variables

FCI ratios will be based on the effects of shocks on prices. For inflation effects, a horizon of 12 quarters is chosen, which is consistent with the SNB's inflation forecast horizon. However, differing weights result at other horizons. A horizon of 36 quarters seems adequate for calculating effects on the level of the CPI.

The parameter constancy issue is dealt with by the inclusion of several dummy variables in the macro-model. The omitted variables problem is undoubtedly less important in a macro-model than in a reduced-form equation or in a VAR.

Concerning housing prices, there could be a potential bias towards an overestimation of the housing price effect, because the model contains neither money, nor credit variables, nor stock prices, which are probably all positively correlated with housing prices. Effects of money, credit or stock prices not accounted for by the model might thus be wrongly attributed to housing prices. Furthermore, housing prices move with a very low frequency. Other, yet unexplained, low-frequency movements might also be (erroneously) attributed to housing prices, which could bias the results.

4. Constructing an FCI for Switzerland

The current Swiss monetary policy concept, which was introduced in 2000, is based on three elements. One element is the definition of price stability as a rate of inflation below 2% measured by the CPI. Another element is the use of three-month Libor as an operating target. Three-month Libor is controlled by repo operations with a maturity from one day up to three weeks. The main element of the strategy is the inflation forecast, which is published twice a year. The inflation forecast extends 12 quarters into the future, yet the internal range of the forecasts extends even further into the future as it may take more than three years until the full effects of monetary policy actions have set in.

4.1 The macro-model used by the SNB

The SNB bases its inflation forecast on several models and indicators. Apart from VAR models and a small structural model, an important model for forecasts and simulations is a medium-sized structural model of the Swiss economy. The macro-model used by the SNB, described in detail by Stalder (2001), is a quarterly structural model with 30 stochastic equations. The model consists of an aggregate demand part, a supply block and a monetary block. Long-term dynamics are captured through error correction terms. The CHF/EUR exchange rate depends on the spread between Swiss and euro short- and long-term interest rates, the balance of the external account, and the difference of the lagged real exchange rate from a PPP measure. The short-term interest rate is determined by a Taylor-type rule depending on inflation, European short-term rates, the output gap, and unemployment. The EUR/USD exchange rate is treated as an exogenous variable. Expectations are not model-consistent, ie long-term interest rates are not the mean of shorter-term rates and the exchange rate is not determined by the uncovered interest rate parity. Changes in long-term interest rates are a function of changes in European and Swiss short rates and of the interest rate differential between German and Swiss rates. The elasticity of the long-term rate to the short-term rate is 0.2, ie a 1 percentage point change to the short rate translates into a 0.2 percentage point change in long rates. Apart from their exchange rate effect, short-term rates do not affect real variables; the interest rate channel works only through the long-term interest rates. Data for estimation have been available since 1980.

4.2 Adding housing prices

To extend the MCI into an FCI, housing prices have to be integrated into the model. This is done by adding housing prices as an endogenous variable. A housing demand equation relates housing price inflation to past housing inflation, long-term interest rates, and growth of total real demand. Apart from the autoregressive coefficient, the coefficients are not significant, but correctly signed. On the one hand, housing prices are expected to have an effect on consumption and investment through the wealth or credit channel. On the other hand, they also influence sector prices. Specifically, housing prices enter the following equations:

- Wealth effects affecting private consumption are difficult to establish. Housing prices are found to enter the consumption equation with a non-significant short-run elasticity of 0.24. Private consumption is about 60% of domestic demand.
- However, significant effects on investment are found. They can be explained by a credit-channel-type effect where rising house and property prices allow or even stimulate further investment, whereas falling prices restrict investment. The effects are limited to the construction sector. Instead of a credit channel effect, this could also be explained by a virtuous (or vicious) circle in construction and a tendency to boom and bust behaviour. Housing prices deflated by the CPI enter the business construction equation with a non-significant short-run elasticity of 0.18 and a highly significant long-term coefficient of 0.86 in the error correction term. The short-run elasticity of housing investment is 0.10 and the long-run coefficient is 0.14, neither of which is significant. Business construction is about 2% of domestic demand and housing investment is about 5% of domestic demand.
- Housing prices are also related to the construction price index with a significant coefficient of 0.18 in the short run and 0.16 in the long run and to the housing rent price index with a non-significant short-run elasticity of 0.06 and a highly significant long-run coefficient of 0.19.

4.3 Simulation of shocks

To calculate FCI weights, adverse shocks to the interest rate, the EUR/CHF exchange rate, and housing prices are simulated.[13] The size of the shocks is 1 percentage point for the interest rate and 1% for the exchange rate and housing prices. As most variables enter the model in nominal terms and the FCI is mainly used for short-term comparisons, shocks to nominal variables are simulated.

Based on the stationarity discussion in the previous section, permanent shocks are simulated. After the first period where the shock sets in, the shocked variable is exogenised and forced to follow the path forecasted by the model if there had been no shock, although on a level which differs by the size of the initial shock.[14] The reactions of prices and output are then calculated as the difference to a base scenario where no shocks are assumed.[15]

To gain an understanding of the endogeneity problem, “structural” and “restricted” shocks are applied to the interest rate. A structural shock allows the exchange rate and housing prices to react to the interest rate shock, whereas, in the case of a restricted interest rate shock, exchange rates and housing prices are exogenised and forced to follow the path of the no-shock base scenario. For the exchange rate and housing prices, only restricted shocks are applied and the other two FCI variables are forced to follow their base path. Simulating a restricted shock of 1 percentage point to short-term rates is equivalent to simulating a 0.2 percentage points shock to long-term rates, because, apart from the effect on exchange rates and long-term rates, the short-term interest rate plays no role in the model.

4.4 Reaction of output and prices

Graph 4 shows impulse response functions of annualised quarterly inflation, the CPI, annualised quarterly real growth, and real output.

The effect of a structural interest rate shock on prices or output is significantly larger than the effect of a restricted interest rate shock. This implies that only a small fraction of the overall effect of a structural interest rate shock is due to the pure interest rate channel through long-term rates on consumption or investment; most of the structural interest rate shock effect is due to the reaction of the exchange rate

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[13] A shock to the euro exchange rate is equivalent to a shock to the total external value of the Swiss franc as the only other exchange rate variable in the model is the exogenous dollar exchange rate, which is fixed in relation to the euro.

[14] Note that, contrary to an impulse response analysis in a VAR system, no autoregressive dynamics of the shocked variable after the first simulation period are allowed.

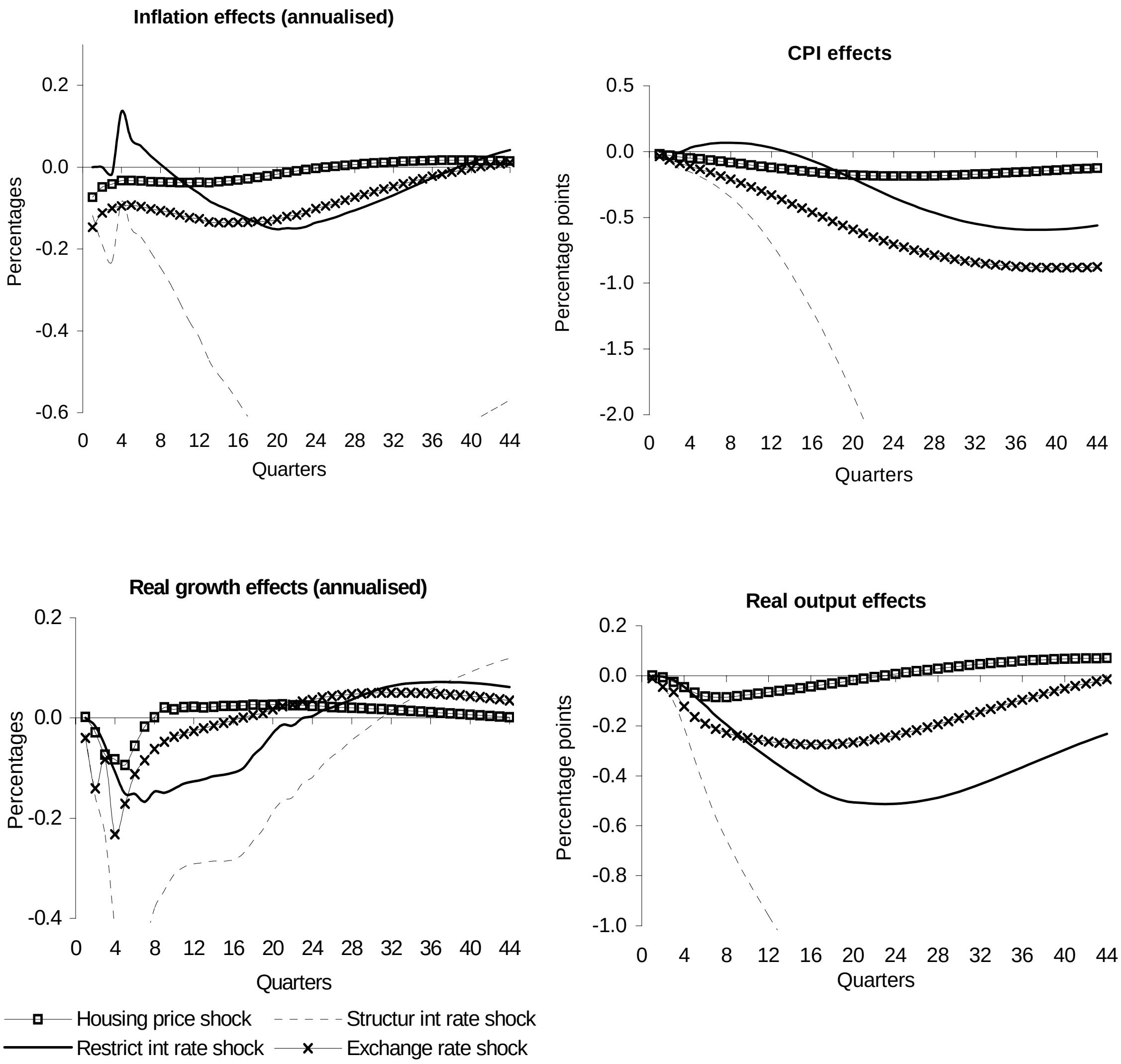
[15] Strictly speaking, the reaction of the simulation depends on the starting point of the simulation. However, differences due to different starting dates of the simulations have been found to be small, therefore the simulation arbitrarily starts in the first quarter of 1996.

and therefore to the exchange rate channel. The result is not surprising given that imports are more than 40% of GDP in Switzerland.

The spike in inflation three quarters after an adverse interest rate shock occurs because housing rents are indexed to long-term rates by law: a change in mortgage rates by 1 percentage point translates into a change in housing rents of 8-12%. A rise in short-term rates leads to a rise in long-term rates, which in turn increases housing rents. Housing rents represent about 20% of the CPI. This link seriously undermines the effects of monetary policy during the first quarters after a change in monetary policy.

Graph 4

Impulse response functions



4.5 FCI weights

FCI weights are based on inflation effects and CPI level effects and not on output effects for several reasons. First, as already mentioned, if output is trend-stationary, growth effects cancel out over time and the estimated weights will strongly depend on the horizon selected. Indeed, in the long run, the simulated shocks are neutral with respect to real output, and, consequently, real output growth reverses signs (see Graph 4). Second, when relying on growth effects, direct price effects of an exchange rate shock through import prices, which are important in Switzerland, are neglected. Third, an adverse housing price shock, although having the desired effect of lowering inflation, soon increases GDP growth rates through its supply side effect by lowering investment costs, which yields a wrong sign of the housing price component in the FCI. Table 2 summarises the calculated weights. The effect of an exchange rate shock is normalised to 1.

Table 2

Relative effects on inflation and prices

	Effect of interest rate shock	Effect of exchange rate shock	Effect of housing price shock
Structural shock based on inflation effects at $t = 12$	3.5	1	–0.28
Structural shock based on CPI level effects at $t = 36$	5.3	1	–0.18
Restricted shock based on inflation effects at $t = 12$	0.6	1	–0.28
Restricted shock based on CPI level effects at $t = 36$	0.7	1	–0.18

4.6 Structural and restricted ratios

Independent of whether the weights are based on inflation or price level effects, the estimated weights are quite similar. A structural interest rate shock at a horizon of 12 quarters has a 3.5 times larger effect on inflation than an exchange rate shock, or, at a horizon of 36 quarters, has a 5.3 times larger effect on the CPI level than an exchange rate shock. The relative weight of housing prices is –0.18 (based on the CPI level) or –0.28 (based on inflation). The effects of a restricted interest rate shock are about six to seven times smaller than the effects of a structural interest rate shock. A restricted interest rate shock is simulated with the exchange rate not being allowed to react to the interest rate change. It is a well known feature of the macro-model used by the SNB that monetary policy mainly works through the exchange rate.

The obtained weights for the reduced interest rate shock critically depend on the transmission of shocks from the short to the long rate. In the model, the short-term rate works only through long-term rates and the exchange rate. A restricted short-term rate shock therefore only works through the long-term rate. The estimated elasticity of the long-term rate to the short-term rate is 0.2. A full 1:1 transmission of short- to long-term rates would increase the effect of the restricted interest rate shock fivefold and thus result in a restricted MCI ratio of about 3:1.

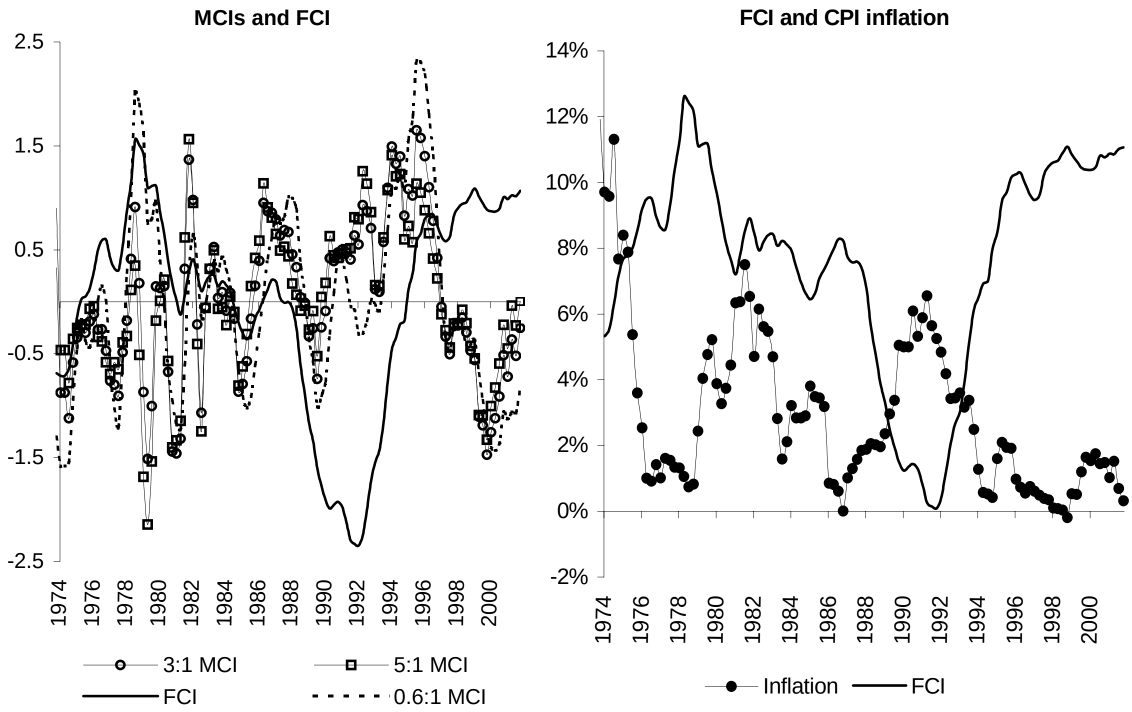
4.7 Assessing the FCI

The MCI with weights of 3:1 and 5:1 from Lengwiler (1997), an MCI using the weights of 0.6:1 and the FCI with weights of 0.6:1:0.28 (the ratio based on inflation effects) are compared in Graph 5 (left-hand panel). To facilitate a long-run comparison, *real* values are used. The inverse correlation of the FCI with inflation, at least since 1986, is striking (Graph 5, right-hand panel). Note that, although real variables are used, due to structural breaks and non-stationarities, comparing levels is problematic. However, it is appropriate to interpret changes in the MCI/FCI as changes in the stance of monetary policy.

The three MCIs do not differ significantly as they are mostly driven by exchange rate fluctuations. However, the FCI is mainly determined by housing price movements. The MCIs, on the one hand, and the FCI, on the other, deviate strongly from each other after about 1985; while the MCIs show a significant tightening of monetary policy from 1985 to 1987, the FCI barely moves, because the rising value of the Swiss franc is offset by rising housing prices. The FCI then indicates a record expansion of monetary conditions lasting well into the year 1991. The rise in inflation starting in 1987 and peaking in 1991 is better explained by the FCI than by the MCIs, which only show a moderate expansion lasting from 1986 to 1989. The deterioration of monetary conditions indicated by the rise of the FCI starting in 1992 and lasting until 1996 is more marked than the deterioration indicated by any of the MCIs. Furthermore, contrary to the MCIs, the FCI stayed very high throughout the second half of the 1990s, indicating a tight stance of monetary policy, which can well explain the record low inflation rates prevailing in Switzerland since 1994, despite strong GDP growth in 1999 and 2000.

Graph 5

MCIs, FCI and CPI inflation



Note: The MCIs and the FCI are moving averages over three quarters, normalised, using real variables and detrended exchange rate and housing prices.

Table 3 presents a more systematic assessment of the forecasting power of the MCIs and the FCI. The change in annual inflation between t and $t - 12$ is regressed on the annual change in oil prices in Swiss francs (to account for supply side effects), annual German real growth (to account for non-monetary demand side effects), and annual differences of the MCI and FCI at horizons of $t = -10$, -6, -2 (because not only changes at $t = -2$ can be expected to influence inflation, but also, to a lesser degree, changes at a closer horizon).

Almost all the MCI and FCI coefficients are correctly signed and many are significant. The adjusted R^2 of the regressions including the MCIs improves with an increasing exchange rate weight. The regression including the MCI with the largest relative weight on the exchange rate (0.6:1) is superior to the other MCIs, as all three lagged MCI coefficients are highly significant and the R^2 is highest among the MCIs. Using the FCI instead of an MCI improves the fit further. The inclusion of housing prices clearly increases the forecasting performance for inflation. However, the good performance of the new MCI and the FCI is largely due to the inclusion of lags at time $t - 6$ and $t - 2$ which are below the target horizon, while the coefficient at lag 10 is relatively less significant. This is due to the large weight of the exchange rate, which has its largest effect on inflation at short lags. By contrast, the 3:1 and even more the 5:1 MCI give a larger weight to the real rate, which affects inflation only after longer lags so that longer lags are more significant.

Disregarding housing prices, the estimated MCI ratios of about 0.6:1 (based on inflation effects) or 0.7:1 (based on CPI level effects) are well below the 3:1 and 5:1 ratios currently applied by the SNB (Lengwiler (1997)). Although an MCI ratio below 1 seems probably too low, a ratio between 1 and 3 for Switzerland might not be unreasonable. Many studies find MCI ratios between 1 and 3 for countries which are less open than Switzerland. Ericsson et al (1998, p 36) present a comprehensive overview of estimations of MCI ratios. For Switzerland, the authors list two MCI ratios: 6.4 (by Deutsche Bank) and 1.7 (by JP Morgan). JP Morgan assigns ratios of below 1 to Belgium (0.4) and the Netherlands (0.8). The median values of the listed results for Spain (which is certainly less open than Switzerland) and Sweden (which has a comparable import share of GDP to Switzerland) are both 2.

Table 3

OLS regression of changes in inflation on changes in the MCI and FCI

	Variable	Coefficient	*t*-statistic	Probability
5:1 MCI Adjusted R^2: 0.32	Δ 4*MCI*(–10) Δ 4*MCI*(–6) Δ 4*MCI*(–2)	–0.042 –0.010 0.004	–2.13 –0.41 0.17	0.036 0.681 0.865
3:1 MCI Adjusted R^2: 0.34	Δ 4*MCI*(–10) Δ 4*MCI*(–6) Δ 4*MCI*(–2)	–0.085 –0.056 –0.035	–2.91 –1.63 –1.12	0.005 0.107 0.268
0.6:1 MCI Adjusted R^2: 0.42	Δ 4*MCI*(–10) Δ 4*MCI*(–6) Δ 4*MCI*(–2)	–0.131 –0.132 –0.166	–3.25 –3.04 –3.91	0.002 0.003 0.000
FCI Adjusted R^2: 0.60	Δ 4*FCI*(–10) Δ 4*FCI*(–6) Δ 4*FCI*(–2)	–0.054 –0.114 –0.156	–2.15 –3.90 –5.78	0.034 0.000 0.000

Note: Dependent variable: change in annual inflation between *t* and *t* – 12. "Δ4" denotes relative annual changes. Sample: 1977:2-2002:1. Other variables included in the regression, but not listed here, are a constant, annual oil price inflation (in Swiss francs) at time *t* and annual German real output growth at time *t* – 10, all of which are significant and correctly signed. The MCI and FCI are not normalised and the size of the coefficients is therefore not comparable.

As opposed to most other studies, the estimated MCI ratios in this investigation are based on price effects and not on output effects. MCI ratios based on real growth would be larger than those based on prices: as Graph 4 (bottom left-hand panel) shows, the growth effect of a restricted interest rate shock is larger than the effect of an exchange rate shock after a horizon of five quarters, resulting in MCI ratios of 0.4:1 at four quarters, 2.4:1 at eight quarters and 4.9:1 at 12 quarters.

The main reason why inflation-based ratios are lower than growth-based ratios is the link of housing rents to interest rates, which considerably weakens the effects of changes in the interest rate. A second important reason lies in the fact that, in the macro-model used at the SNB, interest rate changes work mainly through the exchange rate and only to a small degree through the pure interest rate channel via long-term rates on investment and consumption, which results in a relatively weak estimated effect of a restricted interest rate shock in relation to a structural interest rate shock or an exchange rate shock.

Table 4 compares the FCI ratios found for Switzerland with those put forward by Goodhart and Hofmann (2001) and Mayes and Virén (2001) for other countries. The macro-model suggests that the weight of housing prices should be 18% or 28% of the weight of the exchange rate. While Goodhart and Hofmann find a weight for housing prices which is (on average) substantially larger than the weight of the exchange rate, Mayes and Virén find a relative weight of about 70%, which is still more than twice the housing price weight found for Switzerland. The low relative weight of housing (compared to the exchange rate) can be attributed to the important role of the exchange rate channel in Switzerland and does not necessarily mean that housing prices are not important in Switzerland. Comparing the weight of interest rates with the weight of housing prices yields less divergent results across studies: the weight of housing prices is always below the weight of the interest rate and amounts to 25-85% of the weight of the interest rate.

Table 4

Comparison of FCI weights

	Effect of interest rate shock	Effect of exchange rate shock	Effect of housing price shock
Restricted shock macro-model based on inflation effects at $t = 12$	0.6	1	0.28
Restricted shock macro-model based on CPI level effects at $t = 36$	0.7	1	0.18
Goodhart and Hofmann (2001) reduced-form approach	3.3	1	1.5
Goodhart and Hofmann (2001) VAR approach	4.3	1	3.7
Mayes and Virén (2001) reduced-form approach	1.7	1	0.7

Note: The weights of Goodhart and Hofmann (2001) are average weights for seven countries. The weights of Mayes and Virén (2001) are the median of eight different estimation methods using a panel consisting of five European countries. Both studies also include share prices, which are ignored here.

5. Summary and conclusions

By including housing prices in the medium-sized structural macro-model used by the SNB, an FCI for Switzerland was constructed. Housing prices increase the predictive power for inflation of the new FCI compared to traditional MCIs. Normalising the weight of the exchange rate component to 1, a weight of the interest rate of below 1 and a weight of housing prices of 0.18 or 0.28 are found.

Swiss inflation during the past 15 years is well explained by the FCI. The FCI indicates a slightly expansionary or neutral stance during the first half of the 1980s and a strong expansion starting in 1986, thereby better explaining the increase in inflation rates from 1987 to 1991 than the MCIs. The fall in housing prices from the peak of the bubble in 1991 until the trough in 1999 implies a stronger tightening of financial conditions and a more restrictive monetary policy stance than indicated by the MCIs, which could explain the persistently low inflation rates experienced since 1994.

The estimated MCI ratios are lower than the ratios found by Lengwiler (1997). The main reason is that weights are based on inflation and not on output effects. The link of housing rents to interest rates dampens the impact of interest rate changes. Furthermore, direct price effects of an exchange rate shock through import prices are neglected when using output effects. Policymakers in an open economy should therefore be aware that “monetary conditions” may differ depending on whether one has in mind inflation or growth. Another reason for the low estimated MCI ratios lies in the modelling of the transmission mechanism in the macro-model, where a change in interest rates mainly works through the exchange rate channel.

The macro-model suggests that only long-term interest rates matter for the pure interest rate channel. One issue for further exploration might be the addition of the long-term interest rate to the MCI and FCI or even the replacement of the short-term interest rate by the long-term interest rate in the MCI and FCI.

A further important issue is the differentiation between a structural and a restricted interest rate shock. While weights based on structural shocks may be used for policy analysis, different weights based on restricted shocks are necessary for the construction of an MCI and FCI. The weights needed for construction should not be used for policy analysis. Policymakers should be aware of the difference.

Stationarity assumptions are crucial for the construction and interpretation of an MCI or FCI. Depending on the underlying assumptions, different results and interpretations can be obtained.

Summing up, while constructing an FCI for Switzerland, many conceptual and econometric questions are raised, but not many can be answered satisfyingly. On the surface, an MCI or FCI seems to be innocuous and easy to understand. However, this simplicity may be deceptive and dangerous, as it may induce policymakers to rely too strongly on the MCI or FCI. Policymakers ought to be aware of the deficiencies of such indices, namely that they are intricate objects and are based on strong assumptions. The low importance of the MCI in Swiss monetary policy seems fully justified. A deeper understanding of the MCI and FCI could still be useful.

One insight is that housing prices probably contain useful information for identifying the stance of monetary policy. However, the MCI or FCI framework seems too restrictive an environment for addressing this question. Further investigation is necessary to identify the actual role of housing prices in the transmission mechanism of monetary policy in Switzerland.

Data appendix

Variables		Source
Consumer prices	Seasonally adjusted, end of period	Bundesamt für Statistik (Federal Office of Statistics)
Oil prices	In Swiss francs, average of period	SNB
Housing prices	Constructed by aggregating the mean of quarterly growth rates of the following sub-indices: office floorspace (*Büroflächen*), apartments (*Eigentumswohnungen*), houses (*Einfamilienhäuser*), industrial space (*Gewerbeflächen*), new and old rented flats (*Mietwohnungen*)	Wüest & Partner
Short-term interest rate	Three-month Libor, end of period	SNB
Real GDP Germany	Seasonally adjusted	SNB
Exchange rate	Real export-weighted exchange rate, end of period	SNB

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The informational content of empirical measures of real interest rate and output gaps for the United Kingdom

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Abstract

In many economies, the monetary policy instrument is the level of short-term nominal interest rates, but the monetary policy stance might be better characterised by the ex ante real interest rate that this nominal rate implies, relative to some "neutral" or "natural" real rate of interest.

In this paper, we estimate the natural rate of interest and the real interest rate gap - the difference between the actual and the "natural" real rate of interest - applying Kalman filtering techniques to a small-scale macroeconomic model of the UK economy. In this model, the real interest rate gap, the output gap and inflation are related via IS curve and Phillips curve relationships. The natural rate of interest is defined as the level of (ex ante) real interest rates that is consistent with an output gap of zero, that is output at its "natural" level, in the medium term.

Based on these estimates, we examine whether empirical measures of the real interest rate are a useful tool for policymakers - do they contain additional information relative to the estimated output gap, and does the real rate gap have leading indicator properties for the output gap and inflation? Are these gap estimates of practical use in a policy setting?

We find that the real rate gap has leading indicator properties for both output gap and inflation. Importantly, these properties have varied considerably over time: breaking our sample into four subsamples, we find the leading indicator properties for both the output and real rate gap to be substantially stronger for the subsample that comprises most of the 1980s. After the introduction of the inflation target, post 1992, the relationship between the real interest rate gap and the output gap strengthens, but neither gap has leading indicator properties for inflation, as we would expect given an inflation targeting regime.

1. Introduction

The natural rate of interest is an object of interest to monetary policymakers: depending on the exact definition of the concept, the natural rate may tell the policymaker *exactly* what the policy rate should be (Woodford (1999) in his interpretation of Wicksell (1898, reissued 1958)), or, combined with the current policy rate and a measure of inflation expectations, indicate the current policy stance. In this paper, we pursue the second interpretation by applying Kalman filtering techniques to UK macroeconomic data to estimate jointly unemployment, output and real rate gaps, along with expected inflation. The baseline model is a simple macro model where a positive real rate gap, the difference between the expected short-term real interest rate and the natural rate, causes a negative output gap (the difference between the actual and the natural level of output) which in turn is related to the

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unemployment gap (the difference between the actual and the natural rate of unemployment) via a variant of Okun's law. Inflation expectations are formed according to a generalised Phillips curve.[2] The natural real rate of interest, according to this definition, is the real interest rate consistent with an output gap of zero in the medium term.

In principle, the model should be estimated jointly, but practical considerations force us to estimate the model using a more restrictive approach, where we first estimate the model parameters in blocks, and then jointly filter the data to obtain estimates for the gaps.[3]

Armed with these parameter estimates, we can identify the time-varying natural level of output, the natural rate of unemployment and the natural rate of interest. We can then, in a straightforward empirical exercise, assess the extent to which these measures are useful in a practical policy setting. We first ask whether the estimated gaps are consistent with our priors about economic history and policy developments - that is, do the estimates pass the "plausibility test"? To what extent do the estimates provide meaningful insights on the developments in output, inflation and interest rates? Second, we address the issue of which measure is most useful as an indicator of future inflation or of "inflationary pressure". While a policymaker will always want to consider more than one indicator, it is nonetheless sensible to ask which gap is measured with greatest precision, and which has the strongest indicator properties for future inflation. Third, we ask what advantage we have from imposing a model structure and using a maximum-likelihood estimation technique. Would we be equally well off using simple univariate filtering techniques? A key point of the exercise is to demonstrate that joint estimation of a model of this nature results in an informational gain.

We find that the sample we study is characterised by substantial variation in the behaviour of all the variables. In summary, the estimates of the real interest rate and the output and the unemployment gap look plausible, and accord with our priors on the impact of economic events over time. We find the estimated natural rate of interest to be negative towards the end of the 1970s, in line with our ex ante real interest rate estimates. But since the mid-1980s, both ex ante and natural real rates of interest have been positive. We interpret these estimates as being consistent with the proposition that policy in the first period was relatively unresponsive to inflation, while policy in the latter period has been more directly focused on controlling inflation. In terms of indicator properties, we find that while both the output gap and the real interest rate gap have desirable indicator properties for inflation over the sample as a whole, in line with the finding by Neiss and Nelson (2001), this relationship has changed substantially over time. Breaking our sample into four subsamples, we find the leading indicator properties for both the output and real rate gap to be substantially stronger for the subsample that comprises most of the 1980s. After the introduction of the inflation target, post 1992, the relationship between the real interest rate gap and the output gap strengthens, but neither gap has leading indicator properties for inflation. We argue that this is consistent with the notion that nominal interest rates affect the output gap via the real rate gap, and that policy is conducted with the aim of keeping expected inflation constant and actual inflation close to target: in the language of policy rules, *if* policy were implemented by changing the real interest rate gap, using short-term nominal rates as the instrument, in response to changes in the output gap and differences between expected inflation and the target rate, then the deviation between the *actual* inflation rate and target rate will be close to white noise; and, with a constant target rate, there will be no correlation between the real interest rate and output gaps on the one hand, and inflation on the other.[4]

The theoretical structure we impose on the data is deliberately relatively sparse. The reasoning behind this choice is essentially one of simplicity and empirical robustness. Essentially, our model consists of generalised IS and Phillips curves, with additional, largely statistical, assumptions about the behaviour

[2] We use the terminology "natural" and "gaps" for output, real interest rates and unemployment. In principle, we should always use inverted commas: there is nothing natural about the natural rate of interest, and, perhaps more importantly, there is a range of different definitions of what constitutes "natural" and a "gap". It is not suggested that the UK monetary authorities either did identify or respond, or indeed should have identified or responded, to the particular concepts as defined and estimated here.

[3] We are still pursuing joint estimation of all model parameters.

[4] Please note footnote 2. There is no suggestion in this line of argument that UK monetary policy can be described by or has followed such a rule.

of the natural rate of interest, the natural level of output, and the natural rate of unemployment: we impose relatively little structure, and “let the data speak”.

Laubach and Williams (2001) add further structure by assuming that the natural rate of interest is related to trend growth of output, by reference to the “standard” consumption Euler equation from an optimal growth model. Svensson (2002), in his discussion of Laubach and Williams (2001) at the AEA Annual Meetings, points out that even with such an additional assumption, the model structure is still insufficient relative to the “minimum necessary model structure” that is needed to identify the natural rate of interest. Svensson argues that a fully specified dynamic general equilibrium model, with sufficient structure to identify the real interest rate in a flexible price economy, is the minimum necessary set of assumptions needed to produce a measure of the natural rate of interest that can be given a structural interpretation.

Svensson’s interpretation of the concept of the natural rate of interest essentially coincides with that of Woodford (1999) and Neiss and Nelson (2001). On this view, the natural rate of interest is the real interest rate in an economy characterised by fully flexible prices, or, equivalently, the real interest rate that equates actual output with potential output in a sticky price economy. By this precise definition, it immediately follows that a dynamic general equilibrium structure is necessary, but also sufficient: if a precise model has been specified, then there is no need to use a statistical technique, such as the Kalman filter, to uncover latent variables, because these can be computed directly from the model. And the resulting estimates can be treated as precise guides to monetary policy: if optimal monetary policy entails setting actual output equal to potential, then the natural rate of interest calculated from this model provides a direct read on the right level of real interest rates.

At the other end of the modelling spectrum, where less or no structure is imposed, the “natural rate of interest” could be estimated by applying simple filtering techniques, such as linear detrending, moving averages or Hodrick-Prescott filtering, of measures of the real interest rates, or simply as long-term real interest rates on real assets, such as (forward) real interest rates implied by indexed linked gilts in the United Kingdom or Treasury Inflation Protected Securities in the United States. Using such an approach, no structural interpretations of the estimates are possible, and the estimates cannot be construed as a direct guide to monetary policy.

We argue that a modelling approach in between these extremes should provide a useful tool for monetary policymakers. Conceptually, the dynamic general equilibrium approach is desirable, because it provides a direct read on optimal policy and a framework in which the movements in the natural rate of interest can be given a structural interpretation. But in practice, constructing and estimating a model that would be considered “credible” by policymakers, by virtue of desirable features or some measure of fit with the data, is not a straightforward task. And solution techniques and calibration techniques provide an additional obstacle: as Laubach and Williams (2001) point out, models that rely on log-linear approximations around a non-stochastic steady state cannot be used to make inferences about low-frequency movements in the natural rate of interest, because the long-run natural rate, by construction, is constant. The state of dynamic general equilibrium modelling in the field of monetary economics is clearly progressing at a rapid rate, with models such as Christiano et al (2001) and Smets and Wouters (2002) providing clear improvements over the simplest baseline models, such as Cooley and Hansen (1989), and policy models, such as those developed by some central banks (see, for example, Hunt et al (2000)), relying increasingly on structural features. On the other hand, a statistical approach, with no economic model at all, is less useful in a policy context, because of the lack of structural interpretation. If the natural rate measure derived from such a model has leading indicator properties, are these permanent/structural features, or functions of the shocks hitting the economy in a particular period?

An approach that includes some structure but allows for more empirical flexibility is useful when assessing the real interest rate and the output gap in the United Kingdom. Over the sample we are considering, the UK economy is characterised by a number of large shocks and structural changes, so it is unlikely that a model without some allowance for changes in structural variables, such as the level of the natural rate of interest, will provide an adequate tool when making an assessment over time. By pursuing an approach that entails less structure than a dynamic general equilibrium model, we, loosely speaking, lose the ability to provide a structural interpretation of the data, but gain a better fitting explanation. The main focus of the paper is to provide a useful tool for interpreting the data, and provide a feel for the extent to which the estimates of the output and real rate gaps are useful, in the sense of having informational content, in a policy context.

With this approach, we are clearly not in a position to identify the estimated natural rate of interest as the “optimal interest rate” in the sense proposed by Woodford (1999). We follow Laubach and Williams

(2001) by interpreting the natural rate estimates as broadly measuring the intercept term in a policy rule, but, in line with Woodford's definition, doing so from the real side. We do not, at this stage, model policy: thus, nominal interest rates are taken as exogenously given, and, unlike Plantier and Scrimgeour (2002), we do not attempt to characterise policy in the form of a policy rule.

We have also estimated the natural rate of unemployment, but this plays only a small role in our analysis - we do not claim that these estimates are particularly accurate or interesting in themselves, and acknowledge the fact that estimation of the natural rate of unemployment is a difficult task in its own right. The estimated unemployment gap provides a useful cross check on the estimates of the real rate and the output gap.

The remainder of the paper is organised as follows. In Section 2 we outline the model, while Section 3 discusses the estimation procedure and the parameter estimates. Section 4 discusses the properties of our estimates and assesses their usefulness is a practical setting. Section 5 concludes.

2. The model

The key component in our modelling strategy is a relationship between the real rate and the output gap, which we describe as a "generalised IS curve":

$$y_t^C = \phi(L)y_t^C + \kappa(L)\left((i_t - \pi_{t+1|t}) - r_t^N\right) + \varepsilon_t^{yC} \qquad (1)$$

The output gap, or the cyclical component of output, is the difference between (log) output and the natural level of output, y_t^N, which in turn is assumed to follow a random walk with drift δ:

$$y_t^N = y_{t-1}^N + \delta + \varepsilon_t^{yN} \qquad (2)$$

We have assumed that the drift term, δ, is constant over time - effectively assuming that trend growth in the United Kingdom is constant over the sample. We discuss this assumption later.

The real rate gap is the difference between the expected real rate in period t, $(i_t - \pi_{t+1|t})$ and the natural rate of interest, r_t^N. Here i_t is the policy rate, that is a nominal risk-free rate for period t, while π_{t+1} is inflation in period t, ie from t to $t + 1$. The subscript $|t$ indicates expectation of π_{t+1} conditional on information at time t.

A key assumption of our model is that the parameters in the IS curve, ϕ and κ, are constant over time. The error terms and the addition of lagged values of the output gap will account for transitory shocks and for short-run dynamics, but low-frequency changes are assumed to be accounted for by movements in the natural rate of interest. The natural rate of interest is assumed to evolve according to a random walk:[5]

$$r_t^N = r_{t-1}^N + \varepsilon_t^N \qquad (3)$$

So, as mentioned in the introduction, unlike Laubach and Williams (2001) we do not impose any theoretical priors on movements in the natural rate in general, and in particular postulate no relationship between the drift term δ and the natural rate of interest.

Inflation expectations are modelled as a "generalised Phillips curve", à la Hamilton (1985). Actual inflation in period t is equal to expected inflation plus a random error, and we model expected inflation as a function of expected and actual past output gaps, of past inflation, and of past expected inflation:

$$\pi_t = \pi_{t|t-1} + \varepsilon_t^{\pi} \qquad (4)$$

$$\pi_{t|t-1} = \beta_0 + \sum_{j\geq 1}\beta_j y_{t-j|t-1}^C + \sum_{j\geq 1}\gamma_j \pi_{t-j|t-j-1} + \sum_{j\geq 1}\psi_j \pi_{t-j} + \varepsilon_t^{\pi e} \qquad (5)$$

[5] We have also experimented with an AR(2) specification.

Our measure of inflation is a consumer price index, the retail price index. We have not excluded any components of the index to arrive at a "core" measure, and equally have not included any exogenous variables, such as oil or commodity prices, as explanatory variables. The functional form we have adapted is sufficiently flexible, in our view, to deal even with large shocks, provided these are simultaneous or near-simultaneous shocks to inflation and inflation expectations. To give the Phillips curve a sensible long-run interpretation, we have imposed the restriction that the coefficients on the lags of actual and expected inflation sum to 1 - that is $\Sigma_j \gamma_j + \Sigma_j \psi_j = 1$. This ensures equality between the inflation terms on the left- and the right-hand side of equation (5), so that, in the long run, there is no relation between cyclical output and inflation.

As the final component of the model, we assume that the cyclical component of unemployment, u_t^C, is related to the output gap, in what we label a "generalised Okun's law", that is:

$$u_t^C = \alpha(L) y_t^C + \varepsilon_t^{uC} \tag{6}$$

Our model of the natural rate of unemployment, u_t^N, is particularly simple, assuming that the natural rate evolves according to a random walk:

$$u_t = u_t^N + u_t^C \tag{7}$$

$$u_t^N = u_{t-1}^N + \varepsilon_t^{uN}$$

As mentioned in the introduction, the natural rate of unemployment plays only a small role in our analysis - we do not claim that these estimates are particularly accurate or interesting in themselves, and acknowledge the fact that estimation of the natural rate of unemployment is a difficult task in its own right. We emphasise that this minimalist approach to modelling unemployment reflects that we wish to exploit potential information in unemployment data for the estimation of output and real interest rate gaps while not imposing excessive constraints on the estimation problem.

We allow both the natural rate of interest and the natural rate of unemployment to evolve according to a random walk. For the unemployment *rate*, this clearly implies mis-specification, as the rate is bounded below at zero and above at one. And arguably, the natural rate of interest cannot permanently be negative, and is hence bounded below. In either case, by making the random walk assumption, we can capture very persistent, near-unit root behaviour in a convenient way, but the issue should obviously be kept in mind when interpreting the resulting estimates. However, given the persistent behaviour of unemployment and inflation over our sample, specifying the natural rates of interest and unemployment as random walks allows us to model the gaps as stationary processes. That all the gaps in the model are stationary is clearly a desirable property for our model.

3. Estimating the model parameters

Our empirical implementation of the model discussed in the last section is summarised by the following set of equations:

$$y_t^C = \sum_{j=1}^{2} \phi_j y_{t-j}^C + \kappa\left(\left(i_{t-1} - \pi_{t|t-1}\right) - r_{t-1}^N\right) + \varepsilon_t^{yC} \tag{8}$$

$$\pi_{t|t-1} = \beta_0 + \sum_{j=1}^{4} \beta_j y_{t-j|t-1}^C + \sum_{j=1}^{4} \gamma_j \pi_{t-j|t-j-1} + \sum_{j=1}^{4} \psi_j \pi_{t-j} + \varepsilon_t^{\pi e} \tag{9}$$

$$u_t^C = \alpha y_{t-1}^C + \varepsilon_t^{uC} \tag{10}$$

$$\pi_t = \pi_{t|t-1} + \varepsilon_t^{\pi} \tag{11}$$

$$r_t^N = r_{t-1}^N + \varepsilon_t^N \tag{12}$$

$$u_t = u_t^N + u_t^C \tag{13}$$

$$u_t^N = u_{t-1}^N + \varepsilon_t^{uN} \tag{14}$$

$$y_t = y_t^N + y_t^C \tag{15}$$

$$y_t^N = y_{t-1}^N + \delta + \varepsilon_t^{yN} \tag{16}$$

Here, we assume that an AR(2) is sufficient to characterise the dynamics of the output gap, conditional on just one lag of the real rate gap. We have assumed that only one lag of the real rate gap enters the IS curve; we have experimented with two and more lags, but, as discussed in further detail below, estimating κ proves difficult, and more lags would increase the dimensionality of these problems.

Under the assumption that the error terms are normally distributed, the estimation problem can be described as determining estimates of the parameters $\{\phi_1, \phi_2, \kappa, \beta_0, \beta_j, \gamma_j, \psi_j, \delta\}$, $j = 1, 2, 3, 4$ and the seven series of shocks with their associated standard errors $\{\sigma_{yC}, \sigma_{yN}, \sigma_{uC}, \sigma_{uN}, \sigma_{\pi}, \sigma_{\pi e}, \sigma_{rN}\}$. The model can be cast in state-space form, with $(r_t^N, y_t^N, u_t^N, \pi_t^e)$ constituting the unobserved state variables.[6]

3.1 The block approach

In principle, this model can be estimated by maximum likelihood using standard Kalman filtering, yielding parameter estimates and, by subsequent filtering, estimates of the unobserved variables. In practice, this approach has proved unsuccessful on UK data: we cannot estimate the parameters of the model by a system approach and obtain "sensible" and interpretable estimates of the parameters of the unobserved state variables. Our interpretation of this problem is partly one of dimensionality, and partly one of the relatively poor fit of the IS curve to UK data, in particular a problem of determining the parameter estimate of κ. We discuss this issue in detail below. We have tried to reduce the problem of dimensionality by reducing the number of parameters in the Phillips curve: while this substantially improves the significance and precision of the parameter estimates in the Phillips curve, it does not materially improve our ability to provide significant estimates of κ.

Having failed to obtain reasonable system-based maximum likelihood estimates, we proceed instead by applying maximum likelihood techniques to blocks of the models. Having obtained parameter estimates from this, we filter the model to obtain joint estimates of the natural rates and levels and the standard errors of the associated shocks. In the following, we first discuss this block approach before turning our attention to the joint filtering stage.

Because the model is a set of simultaneous equations with unobserved variables, we cannot straightforwardly apply single equation techniques. We proceed by first obtaining initial estimates of the output and unemployment gap, and then use these gaps to estimate the remaining model parameters, conditional on these initial gap estimates. In practice, we do this by exploiting the state-space representation of the Hodrick-Prescott filter (see, for example, Stock and Watson (1999)) to obtain initial estimates of the output and unemployment gaps. We replace the equations characterising the natural rate of unemployment (equation (14)) and natural level of output (equation (16)) with the following set of equations:

$$u_t^N = 2u_{t-1}^N - u_{t-2}^N + \varepsilon_t^{uN} \tag{17}$$

$$y_t^N = 2y_{t-1}^N - y_{t-2}^N + \varepsilon_t^{yN}$$

while maintaining the assumption that $u_t^C = \alpha y_t^C$. Furthermore, we assume that the signal/noise ratio - that is, the ratio between the standard errors of the shocks to the natural and cyclical components of output and unemployment - can be characterised by two constants, q_1 and q_2, so that:

$$\sigma_{yN} = \sqrt{q_1}\sigma_{yC}; \quad \sigma_{uN} = \sqrt{q_2}\sigma_{uC} \tag{18}$$

This in turn implies that:

$$\sigma_{uC} = \alpha\sigma_{yC}; \quad \sigma_{uN} = \alpha\sqrt{q_2}\sigma_{yC} \tag{19}$$

so that for a fixed (q_1, q_2), the problem reduces to estimating α and σ_{yC}. In calibrating q_1, the ratio between the shock to natural and that to cyclical output, we follow Stock and Watson (1999) and set

6 The state vector also includes lags of these variables.

$q_1 = 0.675/1000$. Based on experimentation with various values, we calibrate the second ratio as $q_2 = q_1/10$.[7]

From this first stage, we obtain a preliminary estimate of the output gap, which we label $\tilde{y}_t^C$. We then proceed to estimate the parameters of the Phillips curve (equation (9)), that is $\{\beta_j, \gamma_j, \psi_j, \sigma_\pi, \sigma_{\pi e}\}$, treating the output gap as an exogenous variable by replacing $\{y_{t-j|t-1}^C\}$ with $\tilde{y}_{t-j}^C$. From this estimation procedure, we also obtain a series for expected inflation, $\tilde{\pi}_t^e$, which we use in the subsequent estimation of the IS curve (equation (8)).

Table 1 presents a summary of all the parameter estimates obtained using our block estimation approach. Starting with the output and unemployment block, we find that we obtain a negative value for the Okun's law coefficient, significantly less than zero and also greater than -1, according reasonably with what we would expect for this relationship. The estimate of the standard error of shocks to the output gap is 1.8% and statistically significant. This value is quite large, but this is unsurprising given the nature of the multivariate HP filter. The estimates of the Phillips curve parameters are all insignificant, apart from the estimate of β_3, the second lag of the output gap, and σ_π, the standard error of the shocks to actual inflation.

The insignificance of the parameter estimates is, at least in part, down to the number of lags we have allowed: testing down for significance, we can obtain a specification where all the parameters are significant. We report these estimates in the third and fourth column of Table 1. With this specification we find that the constant term is insignificantly different from zero, which accords with our rational expectations specification. Reassuringly, we also find that the output gap has a positive impact on inflation, at one lag, as we expect from economic theory and also as we require for the logic underlying our model.

As mentioned, estimating equation (8) conditional on $\tilde{y}_t^C$ and $\tilde{\pi}_t^e$ proves difficult. Unlike typical results for the United States (see, for example, Watson (1986) or Kuttner (1994)), the coefficient on the second lag of the output gap, ϕ_2, is insignificant and poorly determined, and we cannot obtain significant estimates of κ, the parameter that governs the sensitivity of the output gap with respect to the real interest rate gap. The fact that ϕ_2 is insignificant and with large standard errors is less worrying and accords with findings that UK GDP growth is less persistent than what is found for the United States (see, for example, Holland and Scott (1998)). But an insignificant estimate for κ constitutes a problem in the sense that it suggests no significant relationship between the output and real interest rate gap. As mentioned, a more comprehensive lag structure provides no solution to the problem: we have experimented with further lags, and have found that while we obtain more sizeable estimates, the parameters remain insignificant, and tend to be offsetting numerically. The parameters may be poorly determined for a whole host of reasons: even if there is a significant relationship between the output and real rate gap, it may, for instance, be difficult to estimate if parameters are varying over time. Our interpretation of the estimation results is that the likelihood function is so flat that this key parameter is difficult to estimate, and instead we proceed by calibrating κ carefully, and subjecting the resulting series to sensitivity analysis.

The variability of the real interest rate is, at this stage of the estimation procedure, intimately linked to κ: we plot the relationship between κ and the estimated standard deviation of the natural rate of interest in Graph 1(a). Conditional on an output gap series, $\tilde{y}_t^C$, a lower value of κ implies less variability in the estimated natural rate of interest. Or, put in terms of the way we are modelling the conditionality, if r_t^N is highly time-varying, the real rate gap will tend to be smaller and less persistent. This implies that a larger κ will be required to match the (at this stage given) variation in $\tilde{y}_t^C$. A natural lower bound for κ is hence the *highest* value that implies an (approximately) constant natural rate of interest. There is no natural upper bound for κ: in principle, the variability of the natural rate of interest

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7 Whether these values are plausible is, lacking any firm metric, a matter of taste. But we note that the choice of q_2 only affects the natural level of unemployment and the estimated Okun's coefficient, α, where the first becomes more volatile while the second increases in absolute size as q_2 decreases. In the subsequent stages of the block approach, only the output gap plays a role, so the choice of the value of q_2 does not affect these results substantially.

could exceed that of the ex ante real interest rate (see, for example, Rotemberg and Woodford (1997)).

Table 1

Parameter estimates[1]

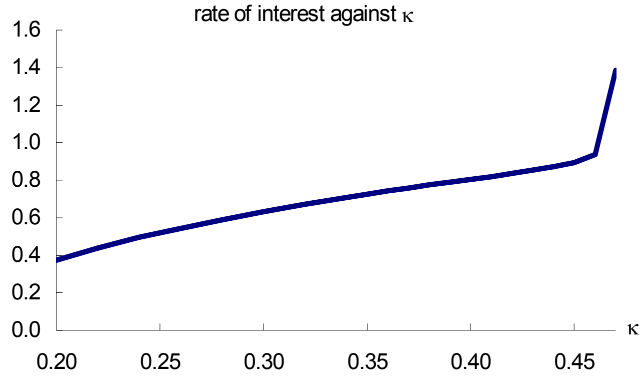
Block	Parameter	Block model	Reduced model	Joint model
Output and unemployment	δ			0.006 (0.0006)
	α	–0.7085 (0.0609)	–	–
	σ^{yc}	0.0178 (0.0010)	–	–
Phillips curve	β_0	0.0000 (0.0004)	0.0000 (0.0007)	–
	β_1	–0.0067 (0.0792)	0.1121 (0.0499)	–
	β_2	0.3184 (0.1113)	–	–
	β_3	–0.2289 (0.3121)	–	–
	β_4	–0.0092 (0.2079)	–	–
	γ_1	1.0299 (0.8527)	0.7934 (0.1028)	–
	γ_2	–0.6582 (0.8369)	–	–
	γ_3	1.2127 (0.7108)	–	–
	γ_4	–0.0879 (0.9777)	–	–
	φ_1	–0.1079 (0.4479)	–	–
	φ_2	–0.2822 (0.6801)	–	–
	φ_3	–0.0324 (0.2336)	0.1768 (0.0650)	–
	φ_4	–0.0740	0.0298	–
Standard deviations of shocks	$\sigma^{\pi e}$	–0.0000 (0.1073)	0.0063 (0.0012)	0.0071 (0.0004)
	σ^{π}	0.0075 (0.0021)	0.0067 (0.0008)	0.0056 (0.0006)
	σ^{yn}			0.005 (0.0007)
	σ^{un}			0.0026 (0.0010)
	σ^{rn}			0.0015 (0.0007)

[1] Standard errors in parenthesis.

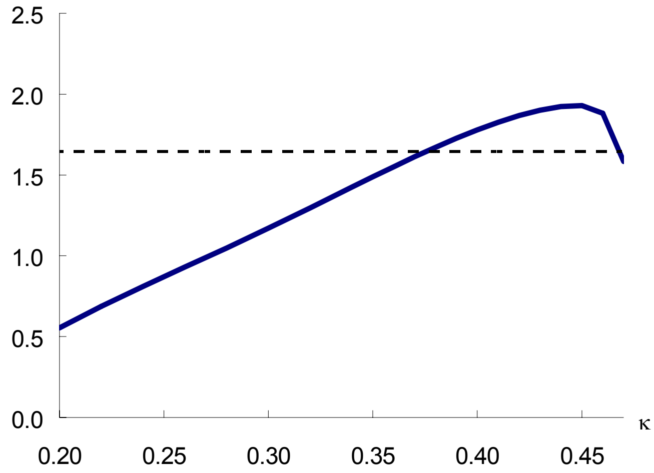
Graph 1

Choosing κ

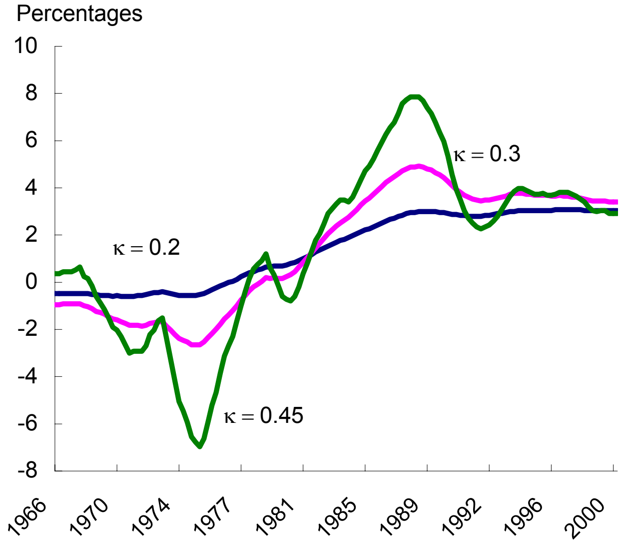
(a) Standard deviation of natural rate of interest against κ



(b) t-statistics on standard errors of shocks to natural rate against κ



(c) The natural real interest rate



As for the choice of a benchmark value, a well determined estimate of σ_{rN} , the standard error of the shocks to the natural rate of interest, imposes tight limits on the appropriate choice of κ: it is only for a very narrow range of κ that the standard error is significant at the 10% level. Graph 1(b) plots the *t*-statistics for the estimates of σ_{rN} as a function of ϖ, and from the graph we infer that it is only for values of κ in the region of 0.45 that σ_{rN} is significant. We settle on $\kappa = 0.45$ as benchmark, which in practice implies substantial variation in the natural rate of interest over the sample. For values of κ significantly greater than 0.45, the natural rate of interest becomes very volatile, so, for the purposes of the sensitivity analysis, we also consider $\kappa = 0.45$ an upper bound, and analyse the implications of lower values of κ.

We report the parameter estimates for three calibrations of κ - $\kappa = 0.2$, 0.3 and 0.45 - in Table 2 and show the corresponding estimates for the natural real interest rate in Graph 1(c). In each of the three specifications we find a significantly positive value for the first lag of the output gap and for the standard error of shocks to the IS curve. We are unable to estimate the second lag of the output gap as significantly different from zero. The standard error of shocks to the IS curve is estimated as about 0.96 in all three specifications. As discussed above, the choice of κ is crucial for our being able to estimate the standard errors of the shocks to the natural real rate as being significantly different from zero. With $\kappa = 0.45$ we estimate the standard error of the shocks to the natural real interest rate as 0.36, slightly smaller than our estimate for the standard error of shocks to the IS curve and to actual and expected inflation.

Table 2

The IS curve[1]

	Block model		
	$\kappa = 0.45$	$\kappa = 0.3$	$\kappa = 0.2$
ϕ_1	0.7518 (0.1025)	0.7969 (0.0837)	0.7964 (0.0806)
ϕ_2	−0.0048 (0.0858)	−0.0095 (0.0740)	−0.0018 (0.0703)
σ_{rw}	0.0036 (0.0018)	0.0018 (0.0016)	0.0012 (0.0022)
σ_{is}	0.0096 (0.0005)	0.0097 (0.0004)	0.0096 (0.0003)

[1] Standard errors in parenthesis.

Our preferred value for κ is similar to values estimated in other papers. For example, Nelson and Nikolov (2002) present an estimate for the IS slope coefficient of 0.36 for the United Kingdom, obtained from an instrumental variable estimation of a similarly specified IS curve. There are a number of estimates of the slope of the IS curve from US and euro area studies (see, for example, Smets and Wouters (2002) and Rudebusch and Svensson (1999)). Notably, estimates for the US and euro area are typically lower than our estimates (see, for example, the comparison in Nelson and Nikolov (2002)). This is consistent with the notion that in a relatively small, open economy, such as the United Kingdom, the IS curve may be flatter due to net trade being more interest-elastic than domestic demand.[8] But, at this stage, we have no further substantial evidence to underpin this estimate.

[8] See Neiss and Nelson (2001) for a detailed discussion of this matter.

3.2 Jointly estimating the gaps

While estimation of the three blocks provides estimates of the real rate gap, these are conditional on the preliminary estimates of expected inflation, $\tilde{\pi}_t^e$, obtained when estimating the Phillips curve block of the model, and, more importantly, conditional on the preliminary estimate of the output gap, $\tilde{y}_t^C$, obtained in the initial stage, where u_t^N and y_t^N are jointly estimated using a multivariate HP filter. The interdependence of the output and the real rate gap is a key issue for this paper, so, to investigate this further, we treat the estimation of $\left\{y_t^N, u_t^N, r_t^N, \pi_t^e\right\}$ and the associated shocks with standard errors $\{\sigma_{yN}, \sigma_{uN}, \sigma_{rN}, \sigma_{\pi e}\}$ as a pure filtering problem, taking the parameters estimated in the block stage as given. Put differently, we filter output, unemployment, interest rates and inflation, using the system (8) to (16), *calibrating* the parameter values at the values obtained in the block stage. The only additional parameter that we estimate is the drift in equation (16).[9] These additional parameter estimates are also reported in Table 1.

4. Interpreting the gaps

In this section, we characterise our estimates for the output and real rate gap to gauge the informational content of these estimates. We start with a fairly general characterisation of inflation and nominal interest rates with an interpretation of our estimates of expected inflation and real interest rates - before turning our discussion to the behaviour of the two main estimation objects, the output and the real rate gap. Initially, the context is economic and policy developments: while a historic description of the estimates is not the key component of the exercise, it is nonetheless an important ingredient because it provides an idea of the extent to which the estimates fit our prior expectations and the consensus interpretation of economic events - that is, do the estimates pass the plausibility test? Such a description is also helpful for the subsequent discussion of the statistical properties of the various gaps: in this discussion, we focus on the extent to which the real interest rate gap and output gap are useful leading indicators for inflation, and whether these properties vary over time. We also discuss the extent to which our model approach implies an informational gain relative to techniques, such as HP filtering, that rely less on assumptions about the structure of the economy.

4.1 The data

Graph 2 shows annualised UK retail price inflation (RPI), nominal interest rates on three-month Treasury bills and real GDP growth from 1966 Q3 to 2000 Q2, and Table 3 provides the information on mean and standard deviation of the same variables. We have divided the sample into four subsamples of roughly equal length - eight years - but have adjusted the sample to fit our priors about the dates at which the series break. As is well known, the behaviour of UK inflation and nominal interest rates has changed substantially over this period: in particular, the period from 1973 Q4 to 1982 Q1 stands out as a period of high and volatile inflation and nominal interest rates, with peaks in inflation in late 1974 and early 1979, following the two sharp increases in oil prices. In this part of the sample, average inflation is more than double the full sample average, and more than double the average in any of the three other samples we study, with the standard deviation of inflation following a similar pattern. Nominal interest rates, while also high, did not pick up to the same extent - so ex post real interest rates over the period are substantially negative. And output growth in this period is substantially below the full-sample mean.

The subsequent periods, from 1982 Q2 to 1992 Q3 and from 1992 Q4 to 2000 Q3, are characterised by falling inflation and nominal interest rates, and substantially higher and less volatile output growth. The first period is characterised by inflation rates falling substantially more than nominal interest rates, compared to the previous period. In this period, the standard deviation of inflation falls substantially, back to levels lower than those observed in the period from 1966 Q3 to 1973 Q3, prior to the pickup in

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9 At this stage, we also take the standard deviation of the shocks to the IS curve, σ_y^c, as given, and calibrate to the value obtained in the block stage.

inflation. The inflation targeting period, from 1992 Q4 to 2000 Q3, is characterised by both low and stable inflation, with mean inflation of 2.75% with a standard deviation of 1.75%, and low and stable nominal interest rates. Average output growth in this period was close to the level observed in the preceding period, but substantially less volatile.

Graph 2

UK inflation, interest rates and GDP, 1966-2000

In percentages

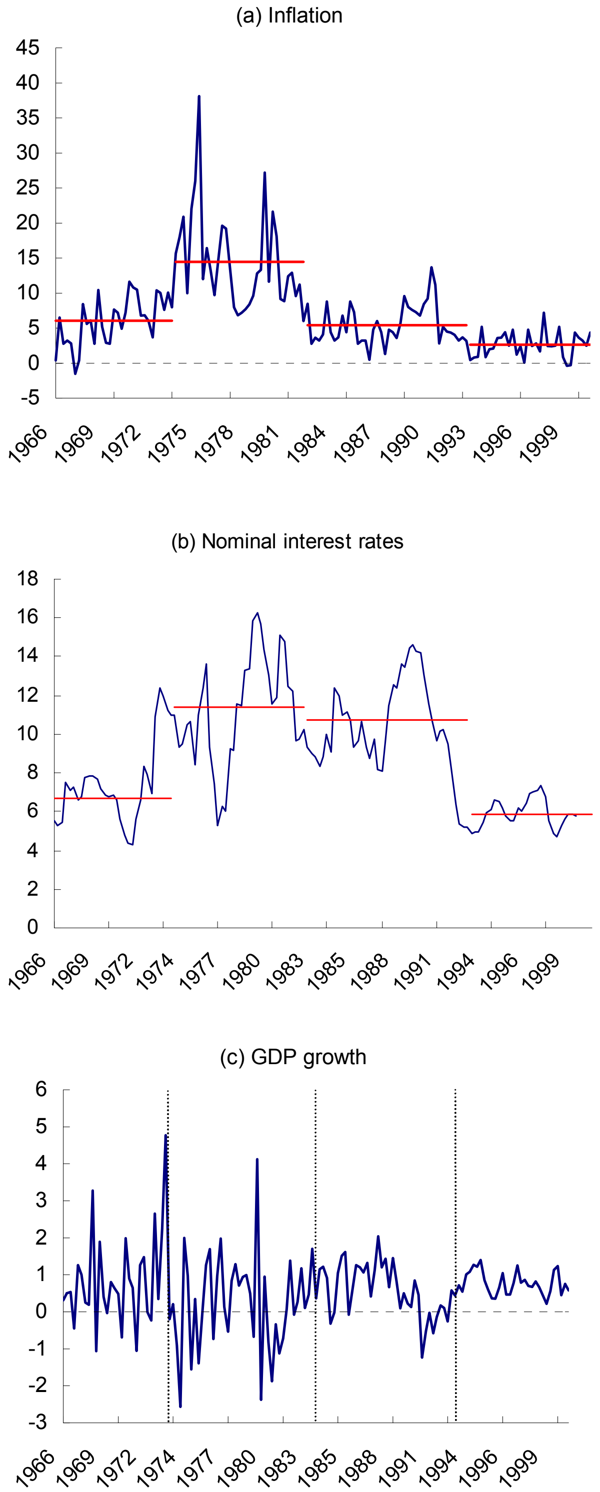


Table 3

UK inflation, nominal interest rates and GDP growth

	Actual inflation		Nominal interest rate		Output growth	
	Mean	SD[1]	Mean	SD[1]	Mean	SD[1]
1966-2001	7.18	6.02	8.91	3.02	0.58	1.02
1966 Q3-1973 Q3	6.06	3.42	6.68	1.32	0.78	1.25
1973 Q4-1982 Q1	14.45	7.29	11.37	2.78	0.17	1.38
1982 Q2-1992 Q3	5.09	2.94	10.27	2.47	0.62	0.70
1992 Q4-2000 Q3	2.75	1.75	5.92	0.73	0.77	0.32

[1] Standard deviation.

4.2 Evaluating the estimates

Having characterised the data, we next turn to a discussion of our estimates of inflation expectations and real interest rates, and subsequently of the natural rates and gaps.

Given our assumptions that link inflation expectations closely to actual inflation, it is unsurprising to observe that expected inflation, whether the series estimated in the block approach or the series from the subsequent joint filtering exercise, closely maps the behaviour of actual inflation. We have reported the statistics of the estimated series in Table 4, together with the statistics for actual inflation and mapped the series for expected inflation from the joint filtering stage against actual inflation in Graph 3(a) and compared it to the block estimate in Graph 3(b). Both series pick out the peaks in actual inflation in 1974 and 1979, and inflation expectations exhibit a sustained increase, in line with actual inflation towards the end of the 1980s and the early 1990s, corresponding to large peaks in aggregate demand, rapid rises in house prices and credit growth. And inflation expectations have followed the subsequent disinflation and stability.

In terms of model properties, we note that, as we would expect, expected inflation is less volatile than actual inflation in all subsamples, and expected inflation less "spiky" than actual. The estimated forecast errors from the block and joint filtering stage are closely related, with the jointly filtered estimates being slightly less volatile than the block estimates. Both are stationary, and the autocorrelation function, not shown here, indicates that the errors are white noise, as implied by the model assumptions embedded in equation (11).

Table 4

Actual and expected UK inflation

	Actual		Expected (joint)		Expected (block)	
	Mean	SD[1]	Mean	SD[1]	Mean	SD[1]
1966-2001	7.18	6.02	7.19	5.05	7.16	4.86
1966 Q3-1973 Q3	6.06	3.42	6.42	2.66	7.34	3.02
1973 Q4-1982 Q1	14.45	7.29	14.27	5.17	13.52	5.12
1982 Q2-1992 Q3	5.09	2.94	4.98	2.44	4.98	1.86
1992 Q4-2000 Q3	2.75	1.75	2.76	0.79	2.67	0.77

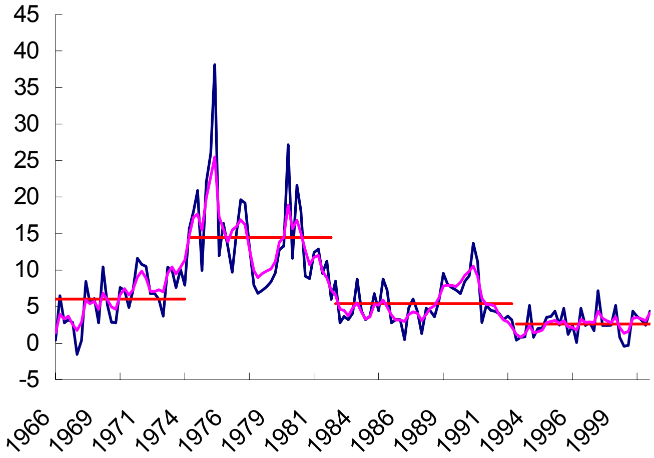
[1] Standard deviation.

Graph 3

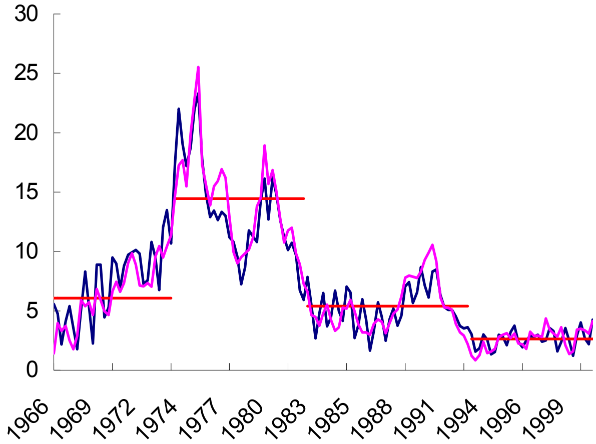
UK inflation, 1966-2000

In percentages

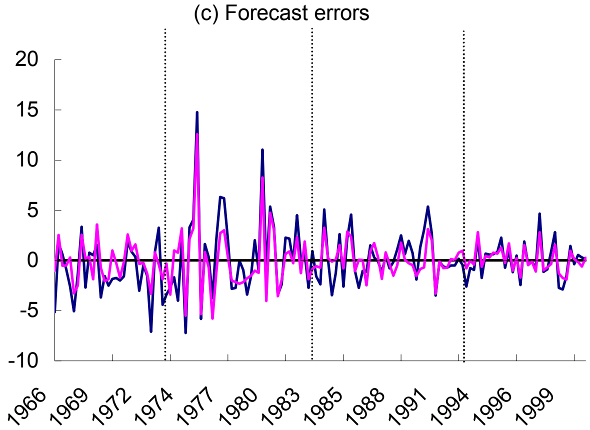
(a) Actual and expected inflation



(b) Inflation expectations



(c) Forecast errors



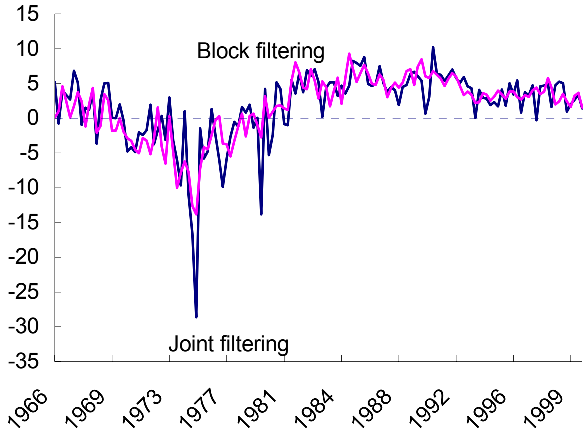
The ex ante real interest rate estimates implied by these inflation expectations are shown in Graph 4 (a) and (b) and compared to ex post rates. Table 5 gives further details. Given the properties of our estimates of expected inflation, it is unsurprising that ex ante and ex post real rates exhibit similar behaviour. In terms of first moments, real interest rates are negative over the period from 1973 Q4 to 1982 Q1, but positive for all subsequent periods. In this period, real interest rates were substantially more volatile than in subsequent periods, reflecting both the rise in inflation expectations and the fact that the nominal rates used here, the three-month Treasury bill rate, failed to respond strongly to the changes in expected inflation. Ex ante real rates increased strongly in the period from 1982 to 1992, reflecting the increased responsiveness of nominal rates and the fall in expected inflation. Since the introduction of inflation targeting, real interest rates have fallen from the high level observed in the 1980s, and are substantially less volatile than observed in the previous periods.

Graph 4

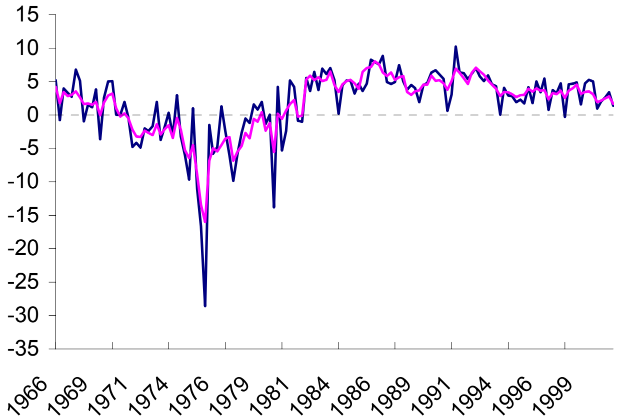
UK real interest rates, 1966-2000

In percentages

(a) Real interest rates



(b) Ex post and ex ante real interest rates



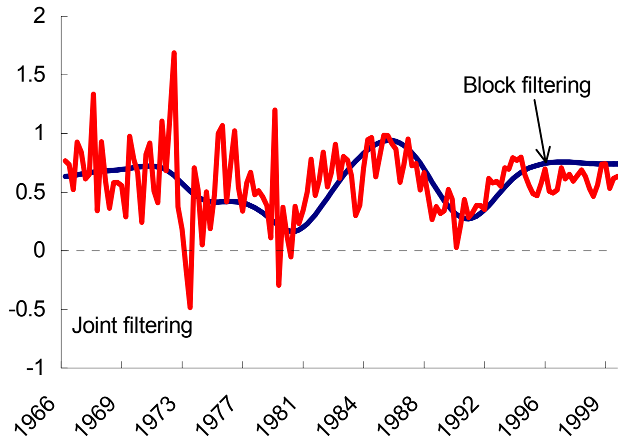
We characterise the estimated natural level of output and associated output gaps in Table 6 and Graph 5. Because of the non-stationarity of output, we have characterised the natural level in terms of growth rates. Both estimates of the natural level are less volatile than actual output growth, with the estimate from the block stage being the least volatile. Given the nature of the model and the techniques used for filtering out the unobserved level, this is, of course, unsurprising; the block estimate is the least volatile, as this is, in essence, an HP trend. Theoretically, there is no reason why a smoothed measure of natural output should be preferred: indeed, the motivation for the literature on estimation of New Keynesian Phillips curves (see, for example, Galí and Gertler (1999)) is motivated by the fact that smoothed or detrended output is a poor proxy for the natural level of output.

Graph 5

UK output, 1966-2000

In percentages

(a) Natural output growth



(b) Output gap

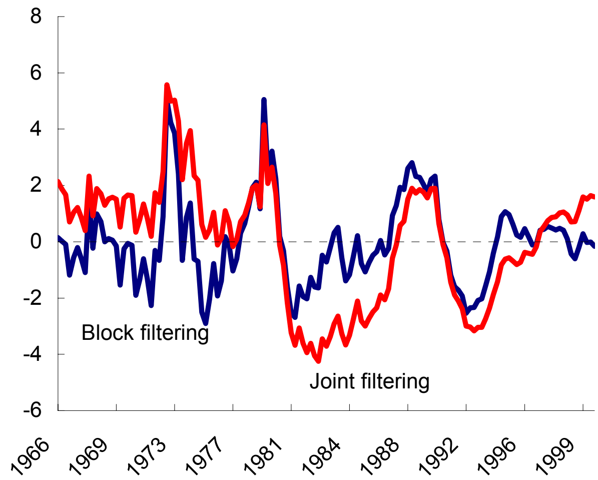


Table 5

Real interest rates: ex post and ex ante

	Real rate (ex post)		Real rate (joint)		Real rate (block)	
	Mean	SD[1]	Mean	SD[1]	Mean	SD[1]
1966-2001	1.73	5.19	1.71	4.22	1.75	4.35
1966 Q3-1973 Q3	0.61	3.33	0.25	2.44	–0.66	3.03
1973 Q4-1982 Q1	–3.08	7.09	–1.61	0.58	–2.16	4.97
1982 Q2-1992 Q3	5.18	1.99	5.29	1.28	5.29	1.67
1992 Q4-2000 Q3	3.17	1.58	3.16	0.67	3.25	0.91

[1] Standard deviation.

In output gap space, the difference between the two estimates is less striking: there is some discrepancy in levels, but excluding the last five years of the sample, the correlation is substantial at 0.68. The two series peak at the same times and at the same level, corresponding to the three peaks in inflation discussed previously. The troughs occur at times of weak growth in aggregate demand, following the oil price shocks in 1973 and 1979, and the period immediately after the Gulf war in 1991. And negative output gaps are associated with falling inflation. These observations, essentially, are consistent with our Phillips curve specification.

Table 6

Natural output growth and the output gap

	Natural (joint)		**Natural (block)**		**Gap (joint)**		**Gap (block)**	
	Mean	SD[1]	Mean	SD[1]	Mean	SD[1]	Mean	SD[1]
1966-2001	0.58	0.29	0.58	0.20	0.03	2.09	–0.01	1.53
1966 Q3-1973 Q3	0.70	0.33	0.68	0.04	1.70	1.30	0.10	1.65
1973 Q4-1982 Q1	0.43	0.37	0.34	0.11	0.61	2.23	–0.08	1.92
1982 Q2-1992 Q3	0.59	0.24	0.61	0.24	–1.54	1.87	–0.16	1.60
1992 Q4-2000 Q3	0.62	0.10	0.72	0.05	0.19	0.48	0.19	0.48

[1] Standard deviation.

The divergence between the two gap estimates provides additional insights. Given the nature of the block estimates, the output gap estimates from this stage are essentially independent of inflation and interest rates. In the first part of the sample, up until the first spike in inflation, the continued increase in inflation gives rise to a positive output gap when we allow for inflation dependence, while the fall in inflation post 1981 has a negative impact on the estimate of the output gap from the joint filtering stage. Neither of these effects is picked up by the block estimates: the multivariate HP filter smooths out these effects on the output gap, because the pickup in output growth in these periods was relatively gradual. Unemployment should affect both estimates of the output gap - recall that the block stage includes a joint filtering of the output and unemployment - but this does not provide any substantial help in explaining the difference, because unemployment was increasing at the same time as inflation.

However, from 1995 onwards, the gaps have diverged, while inflation has remained low and stable: the natural level of output in the jointly estimated stage is consistently lower than estimates from the block stage. Part of this is down to the well known problems with using HP filters towards the end of the sample - the fact that we have used multivariate filtering does not change this issue, so some divergence towards the end of the sample is expected. But it is possible that the constant drift assumption plays a major part: in the joint filtering stage, we have prevented low-frequency movement in the drift term, δ, while such moves will clearly be picked up by the HP filter. Laubach and Williams (2001) take account of such movements by modelling low-frequency movements in drift.[10]

Our estimates of the natural rate of interest and the associated real rate gaps are plotted in Graph 6 (a) and (c) and the associated standard statistics are reported in Table 7. The divergence between the natural rates is substantial, and though both natural rates are negative for sustained periods of time, the period over which they are negative differs. And we note that, as we observed with the output gap, there is divergence towards the end of the sample - the higher output gap estimate for the joint filtered estimates translates into an increase in the natural rate of interest. The level implied by the joint stage towards the end of the sample seems, a priori, too high.

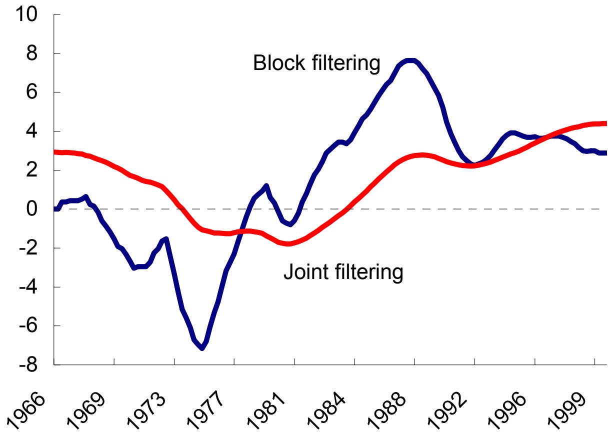
[10] We are continuing to study the implications of this assumption.

Graph 6

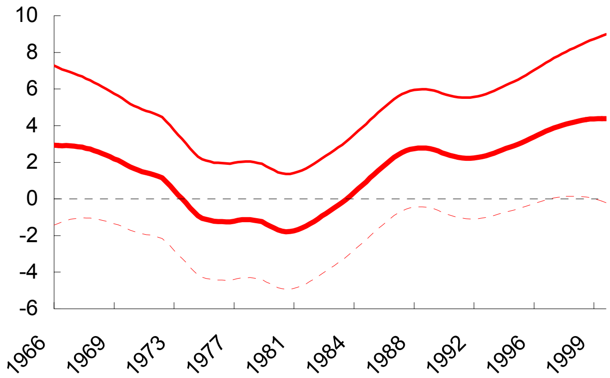
UK natural real interest rates, 1966-2000

In percentages

(a) Natural real interest rate



(b) Natural real interest rate[1]



[1] Joint filtering technique, and showing the 90% confidence bands.

(c) Real rate gap

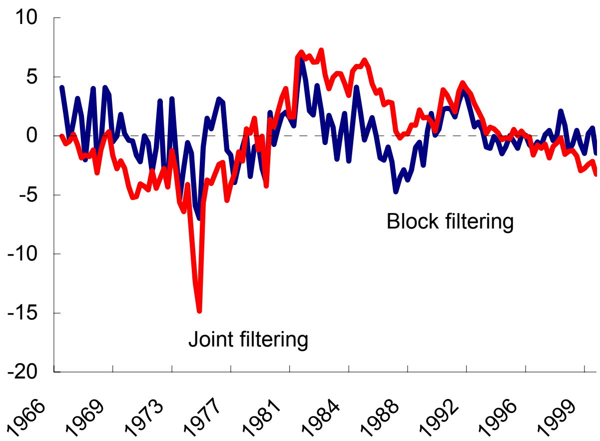


Table 7

The natural rate of interest and the real rate gap

	Natural (joint)		Natural (block)		Gap (joint)		Gap (block)	
	Mean	SD[1]	Mean	SD[1]	Mean	SD[1]	Mean	SD[1]
1966-2001	1.43	1.90	1.42	3.57	0.31	3.77	0.33	2.34
1966 Q3-1973 Q3	2.07	0.75	–1.21	1.36	–1.82	1.86	0.55	2.37
1973 Q4-1982 Q1	–1.19	0.48	–2.24	2.87	–1.72	4.92	0.08	3.15
1982 Q2-1992 Q3	1.55	0.92	4.57	1.87	3.75	1.76	0.72	2.21
1992 Q4-2000 Q3	3.69	0.61	3.48	0.36	–0.53	1.06	–0.23	0.84

[1] Standard deviation.

Unsurprisingly, the natural rate estimate from the block stage follows the ex ante real interest rate more closely than the natural rate estimate at the joint filtering stage - the real rate gap from the joint filtering stage is more volatile. But for most of the sample, the correlation between the gaps is reasonable: for the period up until 1995, the correlation is 0.54, and the post 1995 sample is the most substantially different, corresponding to the similar divergence for the output gap.

In Graph 6 (b), we have plotted the jointly filtered estimate of r_t^N with 90% confidence bands: unsurprisingly, the standard error bands are large with the clear implication that relatively little weight should be given to point estimates of the natural rate at any particular point in time.

Our estimates of the natural rate of unemployment and the associated unemployment gap are shown in Graph 7. The estimates of the natural rate of unemployment that we obtain from the block approach are fairly similar to those obtained in other studies, while the jointly filtered estimates differ by not showing any substantial peak in 1985-86 and in 1994. The block stage estimates closely follow the actual unemployment rate - as we would expect, given the nature of the filtering process. But even at the joint filtering stage, the simple relationship we have imposed on the link between output and unemployment gap produces reasonable estimates.

A key finding in this exercise is the fact that our ex ante measures of real interest, and subsequently our estimates of the natural rate of interest, are negative for a substantial period in the mid to late 1970s. Without modelling and estimating the behaviour of nominal interest rates, it is impossible, on the basis of the preceding discussion, to draw firm conclusions about the behaviour of monetary policy. We nonetheless try to relate our findings by appealing to the interpretation of the natural rate in this framework as "intercept in a policy rule". For ease of reference, take a simple policy rule such as that given below, where real interest rates will depend on the natural rate of interest, the output gap, the difference between inflation and any inflation target the monetary authority may be pursuing, given by π^*, and shocks ε:

$$i - \pi^e = r^n + \beta_y(y^c) + \beta_\pi(\pi - \pi^*) + \varepsilon \qquad (20)$$

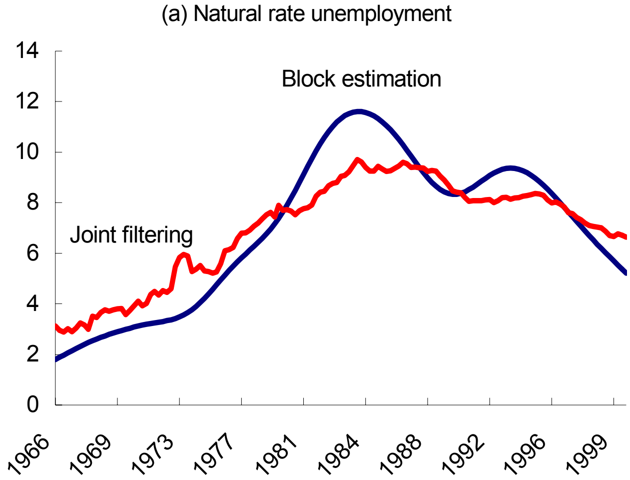
In the simplest version of this rule, the parameters are constant - but in principle, and in practice, for this rule to be a useful description of the data, time-varying parameters are needed. We assume that shocks are not (strongly) serially correlated, consistent with the interpretation low-frequency movements should be picked up by the natural rate of interest.

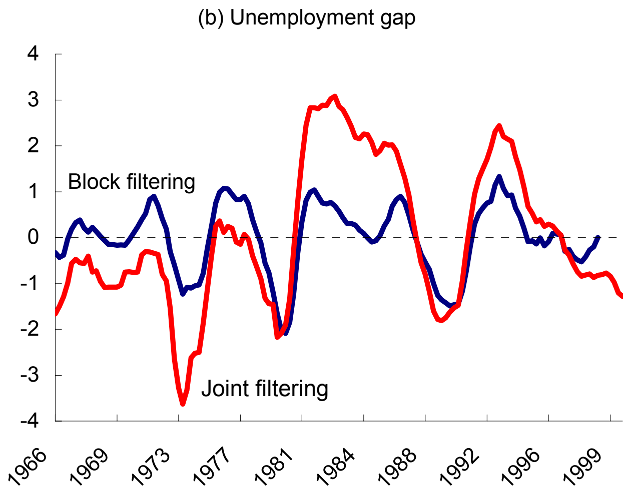
How can we interpret the persistently negative estimates of the r^N? Actual ex ante real interest rates over this period were persistently negative, and to explain this using equation (20), we could appeal to either changes in the response parameters β_y or β_π, a change in the target rate π^* or policy shocks. If the response parameters were constant, then persistently negative real interest rates would require that the target rate would need to be increasing faster than a rapidly rising inflation rate, or that policy shocks would need to be very persistent. So, if policy in the 1970s were to be characterised by a rule

Graph 7

UK unemployment, 1966-2000

In percentages





that allowed for changes in the natural rate of interest, then, given the negative ex ante real interest rates, it is unsurprising that the estimates of the natural rate of interest are negative. But, as documented by Nelson and Nikolov (2002), policy in the 1970s was not directed towards managing inflation - other policies, such as income policies and price controls, were used. Only in the 1980s was policy redirected towards controlling inflation: in this period, our estimates of the natural and ex ante real interest rates turn positive. Even as inflation peaked in 1990, the natural rate of interest remained positive. This broad characterisation is consistent with the characterisation of "monetary policy neglect" in Nelson and Nikolov (2002), which suggests that policymakers in the 1970s did not regard monetary policy as a suitable tool for controlling inflation: a policymaker that followed a policy rule, with a positive and constant natural rate of interest in our interpretation, would have responded to the inflation shocks with higher nominal interest rates. Nelson and Nikolov (2002) also present evidence on the "real-time output gap mismeasurement" hypothesis, advanced in a US context by Orphanides (see, for example, Orphanides (2000, 2001)). Based on this hypothesis, both sets of authors suggest that revisions to official data and estimates of the output gap played a substantial role in explaining the lack of response of monetary policymakers. While we can provide no additional evidence on the real-time data issue we use the latest UK National Accounts data throughout - we will return to the issue of output gap mismeasurement in the next section.

4.3 Indicator properties/informational gain

Having discussed the properties of the estimated time series, we now turn our attention to assessing the use of the real interest rate and output gaps as forward-looking indicators for inflation. In Graph 8, we consider the cross-correlation functions for the real interest rate gap, the output gap and ex ante real interest rates, together with the cross correlation between the real rate gap and output. In the left-hand column are the cross correlations from the jointly filtered stage, while the right-hand column shows the cross correlations from the block stage. The graph is constructed so that high correlations to the left of zero indicate leading indicator properties. The dotted lines indicate 90% confidence bands.

Looking at the entire sample, the model, whether estimated in blocks or by joint filtering, has desirable indicator properties: both the real rate gap and the output gap lead inflation, with the expected sign on the correlation being correct, and the real rate gap leads the output gap significantly. The results from the joint filtering stage, where we allow for more interaction between the real interest rate and the output gap, are stronger. These results accord with the DGE-based findings in Neiss and Nelson (2001).

That said, there are, of course, some less desirable properties. First, the cross-correlation functions for the real rate gap and inflation are virtually flat, with contemporaneous correlation being as high as leads of the gap. And the ex ante real interest rate itself is a stronger leading indicator than the real rate gap: if we had assumed that the natural rate of interest were constant over the entire sample, the real rate gap would have had stronger leading indicator properties.

But this performance over the entire sample masks substantial differences over subsamples. Graph 9 provides the same cross correlations as Graph 8, but broken into the subsamples previously discussed; in these graphs, we have left out standard error bands to preserve clarity. Notice that the number of observations in each subsample is fairly small - around 40 - so, although we offer fairly clear-cut interpretations, it is clear that a (further) degree of caution should be exercised when interpreting these statistics.

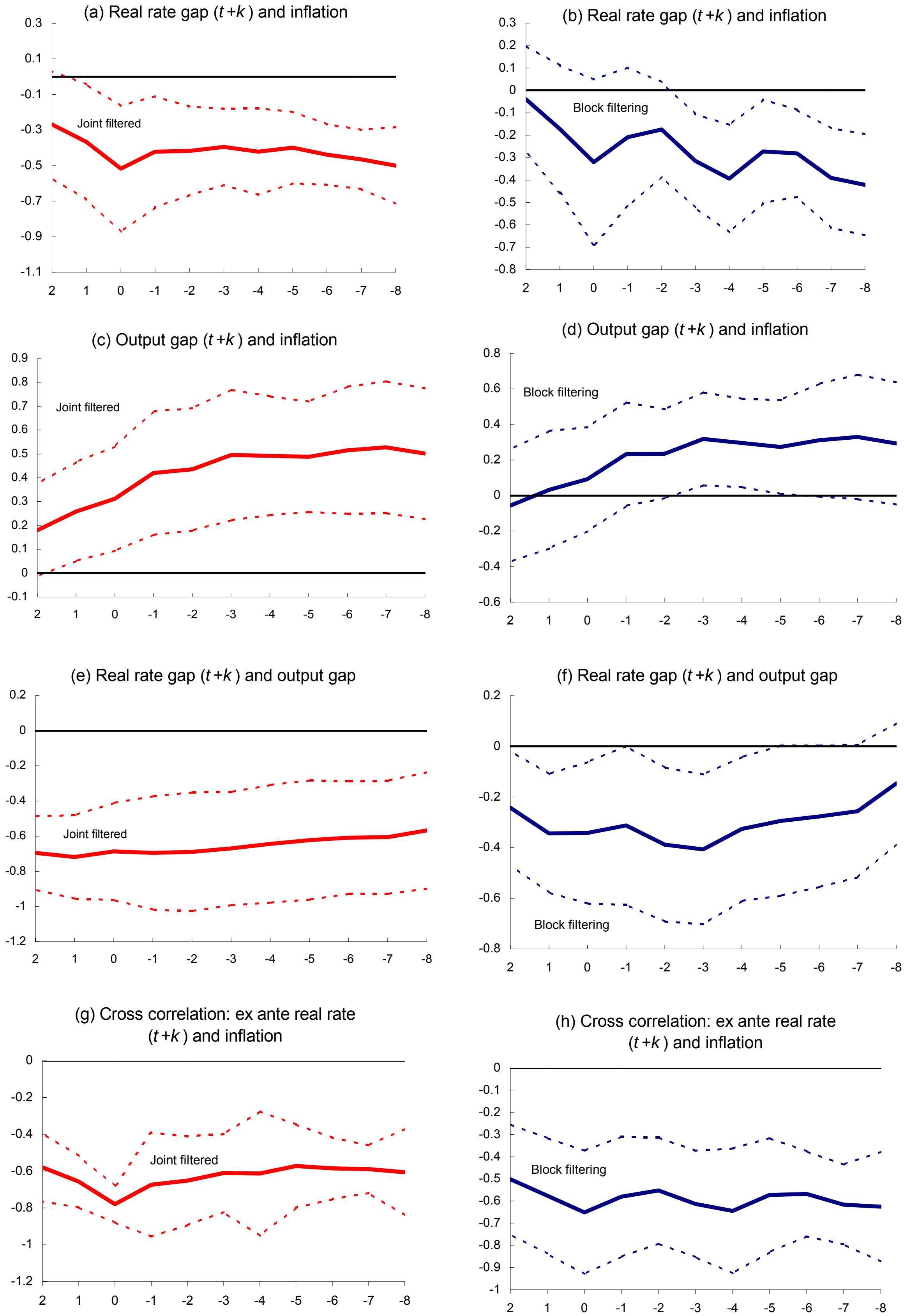
Broadly characterised, we observe that:

- In all subsamples, we estimate the expected negative (or insignificant) relationship between the real interest rate gap and inflation. Similarly, the relationships between the output gap and inflation, and between the output gap and the real rate gap, have the expected correlation.
- The contemporaneous cross correlation between the real interest rate gap and inflation is strongest in the early subsamples, running up to 1982, but the leading indicator properties are strongest for the 1980s. The cross correlation for the inflation targeting period is close to zero, and the estimated cross correlations from the joint filtering stage are insignificant at all leads and lags. In the block stage and for the two subsamples covering the 1980s and 1990s, we observe that the correlations at lags of the real rate gap are higher than contemporaneous correlations.
- The picture for the output gap is similar in the sense that the correlations are stronger in the 1980s than in both the later and earlier part of the sample.
- But notably, for the joint filtering estimates, the relationship between the real interest rate gap and the output gap is strong in both the 1980s and the 1990s. The picture for the block estimates is more mixed, as we would expect given that we in that stage have not allowed the real interest rate gap to affect the output gap estimates.

We interpret these results as follows. The relatively strong model performance in the 1982-92 sample coincides with a period we have characterised as one where inflation and interest rates are more stable, and where ex ante real interest rates are consistently positive: following the Nelson and Nikolov interpretation, which we cannot substantiate further without modelling policy behaviour explicitly, this is a period where monetary policy was directed towards controlling inflation, and the links that we emphasise in this model are more clearly understood.

Graph 8

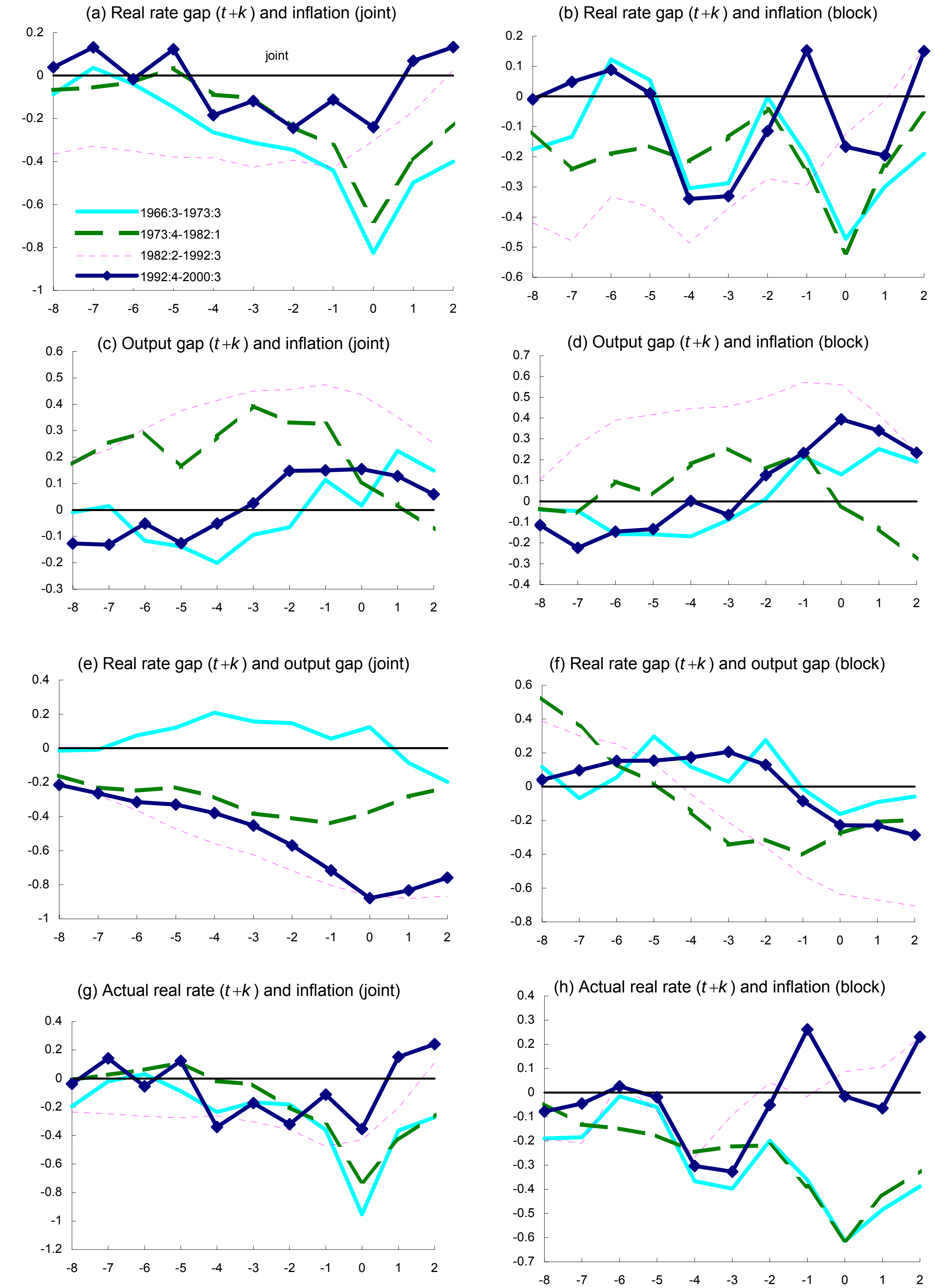
Cross correlations[1]



[1] Shown with the relevant 90% confidence bands.

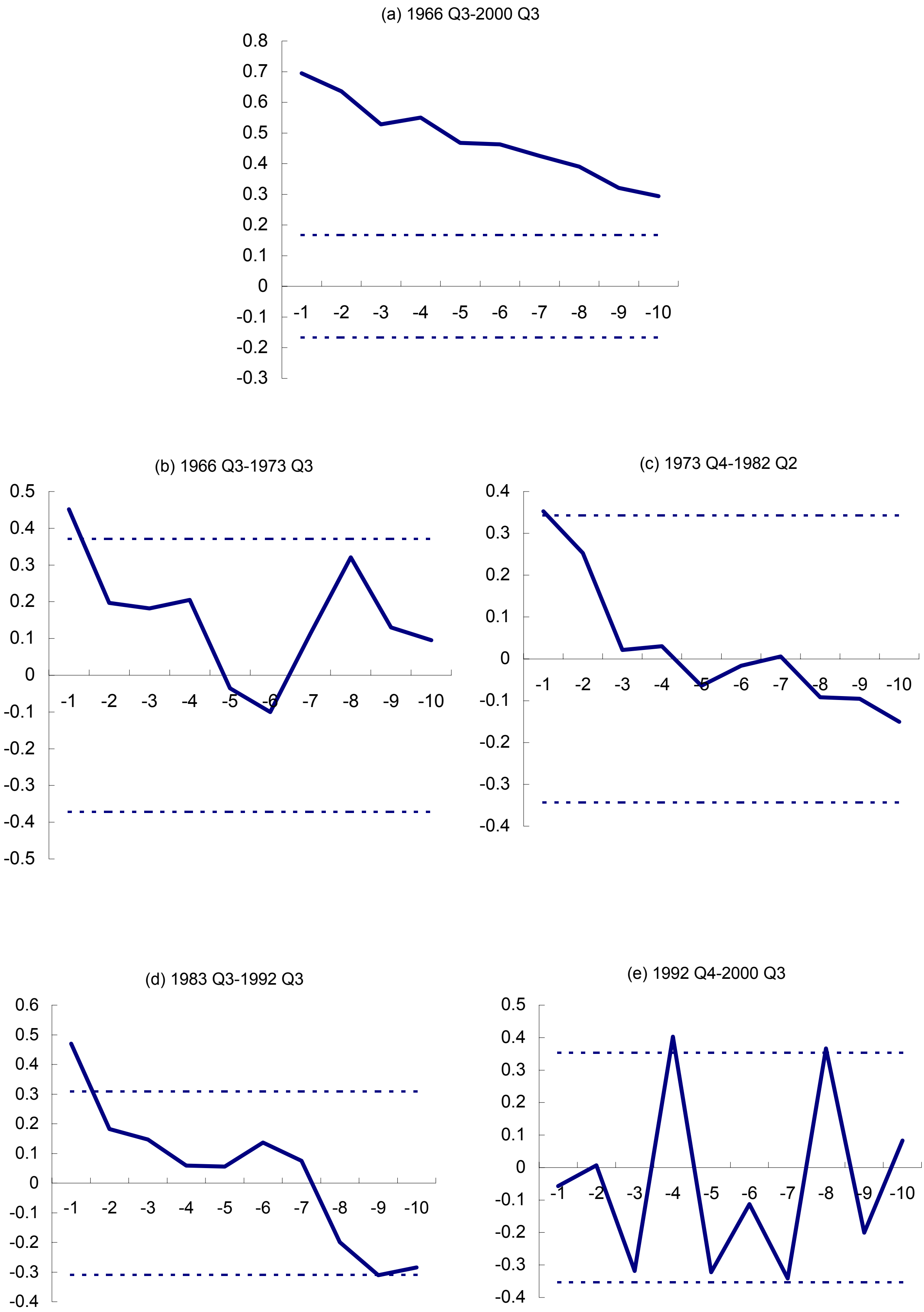
Graph 9

Cross correlations: subsamples



Graph 10

Autocorrelation functions for inflation

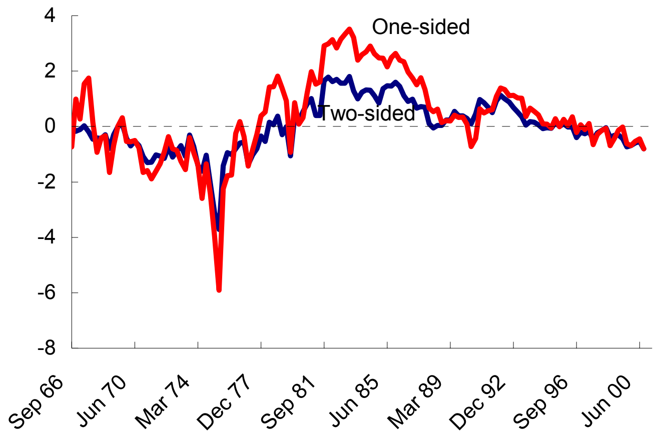


Graph 11

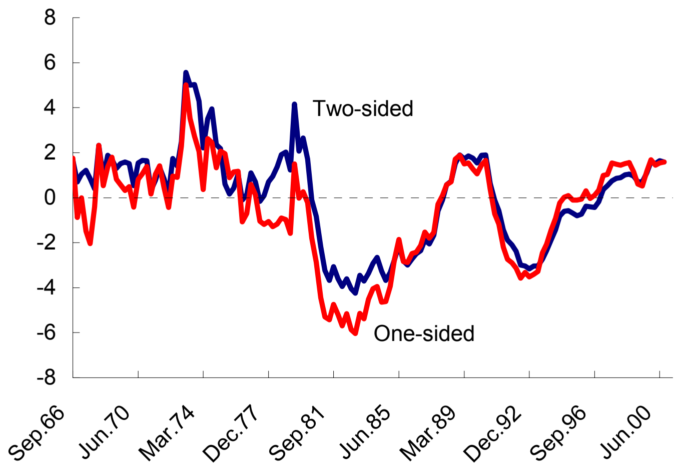
One-sided and two-sided estimates, 1966-2000

In percentages

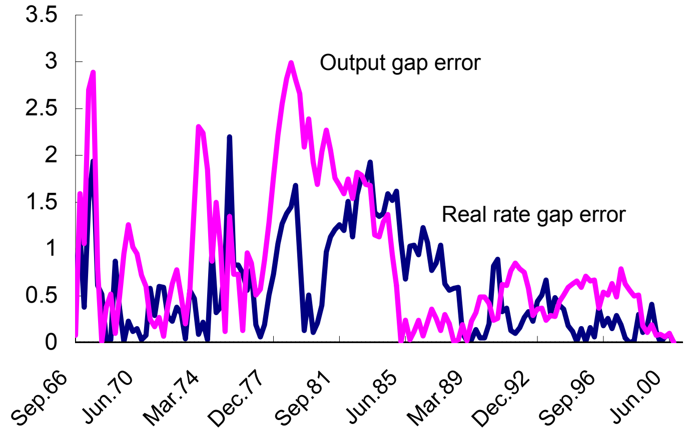
(a) UK real rate gap



(b) UK output gap



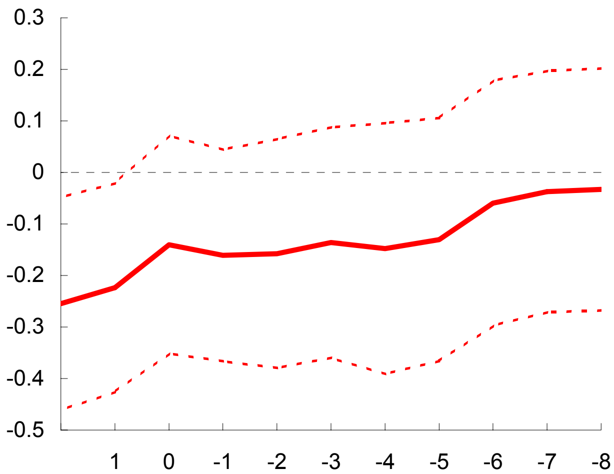
(c) Errors in gaps



Graph 12

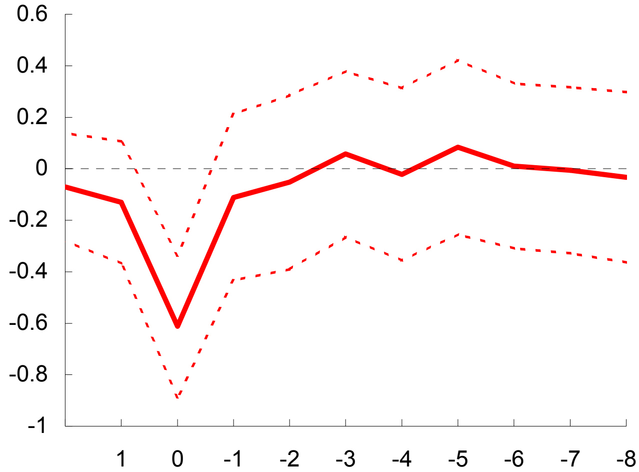
Cross correlations: one-sided estimates

(a) One-sided real rate gap ($t+k$) and inflation



(b) HP-filtered ex ante (one-sided) real rate gap ($t+k$) and inflation

(c) HP-filtered ex post real rate gap (t+k) and inflation



But why do the relationships between the gaps and inflation break down post 1992? We have previously identified our assumption that the drift term δ in equation (16) is assumed constant as a factor that could change the dynamics of both the output gap and the real interest rate gap. Another is that the "mix of shocks" may have changed - this is an explanation on which we can offer limited evidence given the relatively sparse formulation of the model. A third is that a monetary policy where interest rates respond strongly to predictions about future output gaps in order to stabilise inflation would lead to inflation becoming less persistent and closer to white noise. If interest rates affect inflation as suggested by this model, then such a policy would maintain or strengthen the link between the real rate gap and the output gap - this is the means by which policy affects inflation - and weaken the link between the gaps and inflation. Put another way, consider the following manipulation of equation (20):

$$\pi - \pi^* = \frac{1}{\beta_\pi}\left[(i - \pi^e - r^n) - \beta_y(y^c)\right] + \varepsilon \qquad (21)$$

Assume that the target rate remains unchanged. If inflation persistently deviates from target, then the difference between actual inflation and the target rate would be correlated with the real interest rate and output gaps. But under a credible inflation target, expected inflation will be equal to the target, and the deviation between actual inflation and the target will be white noise. In this case, there will be no link between inflation and the gaps - but the gaps will continue to be correlated, if the real rate gap responds to (expected) changes in the output gap. The autocorrelation function for inflation, shown in Graph 10, is consistent with this interpretation: inflation has become less persistent since 1992.[11]

Clearly, any of the conclusions we have drawn on the basis of these estimates should be treated with caution: for the latter comparisons, the samples are fairly small, and the standard errors large. And, as stressed previously, we cannot draw firm conclusions about policy without modelling policy explicitly.

We next assess whether the real rate or the output gap is "measured most precisely in real time". The inverted commas indicate the limited scope of the exercise: we simply compare one- and two-sided estimates of the gaps, that is the difference between gaps estimated conditional on information available at the time, and those smoothed estimates based on the full sample. We ignore the issue of data revision, which will play a substantial role in the estimation of the gaps. We report these gaps in Graph 11, where panel (c) shows the root of the squared "errors", the difference between the one-sided and the two-sided gaps, measured in percentage points. The output gap error is clearly bigger than the real rate gap error on average - at 0.85 and 0.58 percentage points respectively - but there is no consistent picture over time.

[11] Benati (2002) provides a much more comprehensive analysis of this issue.

Finally, in Graph 12, we compare the one-sided estimates with a simple (two-sided) HP-filtered version of the real rate gap to assess the extent to which our modelling approach provides additional information compared to an approach with no structure. We compare the one-sided estimate with a gap measure based on HP filtering of the estimated ex ante real interest and with a gap measure based simply on the ex post measure.[12] In either case, the HP-filtered gaps have weaker indicator properties than the model-based estimates.

5. Conclusion

In this paper, we have assessed the usefulness of empirical estimates of the natural rate of interest and the real rate gap, estimated in a model that allows for interaction between the real rate and the output gap. We find that, despite empirical difficulties, these estimates are broadly plausible in terms of accounting for the development of inflation, output growth and real interest rates in the United Kingdom. Both output and real rate gaps have desirable indicator properties but these change substantially over time, in close relation to the dynamics of inflation.

While we think our estimates are useful in a policy context, we stress that we cannot interpret these measures as an indication of the "correct" level of the policy rate or of a definitive output gap. The lack of model structure prevents such an interpretation - and as with any such estimates, there is sufficient uncertainty around any point estimates to shy away from focusing on point estimates.

Our analysis clearly identifies that, in periods with substantial structural change, an econometric structure with constant parameters may struggle to provide interpretable estimates. An obvious, but substantial, extension to our work is to consider time-varying parameters, particularly in the relationship between the real interest rate and the output gap. Allowing for changes in this relationship may substantially change the estimates of the natural rate of interest, particularly in periods, such as the 1970s, that were characterised by a less coherent policy framework than the current.

Given that we have focused on interpreting the estimates of the natural rate of interest as "intercept in a policy rule", a natural next step is to estimate policy rules, as done by Laubach and Williams (2001) for the United States and Plantier and Scrimgeour (2002) for New Zealand. Even if, as is the case for both these countries and for the United Kingdom, policy is not conducted according to a rule, a flexible rule - that allows for substantial variation both in response to gaps and for changes in targets guiding policy - would be a useful way of describing policy.

Data

The data used in the paper are as follows. The output series is the quarterly growth rate of seasonally adjusted UK GDP at constant market prices. The inflation data are seasonally adjusted quarterly changes in UK retail price inflation. From 1992 onwards, the unemployment data are LFS unemployment. From 1979 to 1992 the annual LFS unemployment numbers have been interpolated using the quarterly pattern in the Claimant Count, and prior to this the annual numbers from the OECD Labour Force Stats book have also been interpolated using the quarterly pattern in the Claimant Count. The interest rate data are the three-month Treasury bill, where this has been de-annualised to correspond to the return over three months.

[12] Of course, the latter is only available with a one-period lag.

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Distinguishing trends from cycles in productivity

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1. Introduction and summary

Productivity growth has long been a focus of both policymakers and economists. At least since Solow's (1956) pioneering work on long-term growth, economists have understood that productivity growth is the only source of sustainable increases in living standards. It is also important for short-term policy analysis, as any assessment of "output gaps" or growth "speed limits" ultimately derives from some assessment of trend productivity growth. But on a quarterly basis, productivity growth is extremely volatile. It is also cyclical, typically rising during an expansion and falling at the onset of a recession. Thus it is often only with hindsight that any change in its long-term trend can be discerned.

It is widely believed that this difficulty contributed significantly to the economic instability of the 1970s, as policymakers and economists were unaware of the slowdown in productivity growth for many years, and only much later were able to date the slowdown at approximately 1973. Policymakers thus overestimated potential GDP (at least so the conventional wisdom goes) and left interest rates too low, and double digit inflation followed not long after.

In recent years, attention has turned once again to productivity because of speculation that growth rates may be picking up again. The growth rate of non-farm output per hour increased by approximately 1% beginning in 1996 relative to the period 1991-95, and by about 1.3% relative to 1973-95. The acceleration of productivity puts its growth rate during this five-year period close to where it was during the most recent period of strong growth, from roughly 1948 to 1973. This has provoked a debate over whether we can expect an extended period of more rapid productivity growth. Robert Gordon (2000), for example, attributes about half of the acceleration to a "cyclical" effect, and much of the remainder to measured productivity growth in the technology sector. Others (eg Stiroh, forthcoming) find evidence that productivity growth has spilled over into other sectors through capital deepening.

Much of the difficulty in evaluating the arguments in this debate relates to the issue of separating trend from cycle in the data. For example, if Gordon had assumed an acceleration in trend GDP, then he would have found a smaller or non-existent output gap, and consequently would have been unable to attribute the productivity acceleration to cyclical effects. Thus without more information, either story (new economy: accelerating productivity and output; or old economy: increased productivity growth confined to information technology (IT) sector, all else is cyclical) seems consistent with the productivity data. This is a problem that plagues any effort to distinguish trend from cycle in a single time series over a relatively short period of time. Moreover, even apart from the difficulty of distinguishing trend from cycle, it is reasonable to question whether much of anything can be learned from five or six years of data on a series as volatile as productivity growth.

In this paper we attack this problem with a multivariate approach, drawing on standard neoclassical growth theory to help us identify variables other than productivity - namely consumption and labour compensation - that should help to identify the trend in long-term growth. We treat that trend as a process with two "regimes", high- and low-growth, with some probability of switching between the two at any point in time. We model the business cycle as a stationary process common to all of the variables in the analysis, also with two regimes of its own, based on the so-called "plucking" model of Friedman (1969, 1993).

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There are several advantages to this approach. First, we argue that aggregate productivity data alone do not provide as clear or as timely a signal of structural change as does the joint signal from the series we examine. Second, we do not have to choose break dates a priori, as we let the data speak for themselves. Third, the model not only provides information about when regime switches occurred, it also provides estimates of how long the regimes are likely to last. This last property contrasts with even the most sophisticated structural break tests, such as those described by Hansen (2001).

Our analysis picks up striking evidence of a switch in the second half of the 1990s to a higher long-term growth regime, as well as a switch in the early 1970s in the other direction. While these conclusions may come as no big surprise, our analysis has further implications. First, one could not conclude that there was a switch to a higher regime on the basis of productivity data alone, or even with the addition of a variable to control for the business cycle. Only the corroborating evidence from consumption and labour compensation can swing the balance in favour of a regime switch. Second, the ability to discern the switch to a higher-growth regime based on our analysis has appeared relatively recently. Only with data up to the end of 1999 could one conclude that with fairly high probability a switch had occurred.

2. Background: the neoclassical growth model

Some 40 years ago, Nicholas Kaldor (1961) established a set of stylised facts about economic growth that have guided empirical researchers ever since. His facts are: (1) labour and capital's income shares are relatively constant; (2) growth rates and real interest rates are relatively constant; (3) the ratio of capital to labour grows over time, and at roughly the same rate as output per hour, so that the capital-output ratio is roughly constant. To these facts, more recent research has added another: that measures of work effort show no clear tendency to grow or shrink over time on a per capita basis. The important implication of this additional fact is that wealth and substitution effects roughly offset each other. This means, for example, that a permanent change in either the level or growth rate of labour productivity has no permanent impact on employment.

Of course, closer inspection suggests that none of the above "stylised facts" is literally true. Indeed, the premise of much work on US productivity is that growth was systematically higher from 1948 to 1973 than it was over the subsequent 20-plus years. But they still provide a starting point for modelling economic growth. That starting point is generally referred to as the neoclassical growth model. The linchpins of this approach are typically a constant returns-to-scale Cobb-Douglas production technology in capital and labour, constant elasticity-of-substitution preferences for consumption, and exogenous labour-augmenting technological progress.

In our analysis we allow for exogenous changes in preferences between consumption and leisure to account for any long-term movements in work effort (as measured by hours) that show up in the data. Specifically, if we let C denote aggregate consumption, Y aggregate output, N population (measured in person-hours and growing at rate n), K capital, and E effective labour per unit of labour input, and L aggregate labour input (in hours), we assume that there is a production function:

$$Y = K^{\alpha}(LE)^{1-\alpha}$$

and preferences defined in terms of a present discounted value of utility:

$$U = \ln(C/N) + \Lambda v(1-\ell)$$

where $\ell \equiv L/N$ represents the proportion of available hours devoted to work. The term $\Lambda v(1-\ell)$ therefore represents the utility of leisure, where v is a concave function, and Λ is a taste parameter that might shift over time.

Let $c \equiv C/(NE)$, $y \equiv Y/(NE)$, and $k \equiv K/(NE)$. If we assume for the moment that E grows at a constant rate g and that Λ is constant, then the economy described by the above preferences and technology has a steady state in which y, k, ℓ and c will be constant (see Technical Appendix A). This implies that the capital-labour ratio $K/L = kE$ and the ratio of consumption to hours of work $C/L = cE$ will both grow at rate g, as will output per hour Y/L. Also, if we assume that labour is compensated according to its marginal product, then labour compensation per hour W will simply equal $(1 - \alpha)Y/L$ and will also grow at the same rate. To summarise:

Result 1. *With constant technological progress (g) and no shifts in labour supply (Λ), the capital-labour ratio, consumption relative to hours worked, real labour compensation per hour, and output per hour should all have the same long-term trend, with growth rate g*.

(*Proof:* See Proposition 1 and its Corollary in Appendix A.)

The preceding result neatly characterises the relationships between variables of interest under the assumption that g and Λ are constant over time. Of course, this paper is predicated on the possibility that both (and g in particular) may have experienced important changes in the postwar period. To dispense with the easy case first, level changes in Λ have no impact on the conclusions of the previous paragraph: the permanent components of the capital-labour ratio, output per hour, consumption relative to hours, and labour compensation per hour, should all continue to move together except for transitory variation in response to changes in labour supply. For example, if Λ falls, the result will be an increase in L/N, but K and C will adjust proportionally.

Result 2. *Exogenous variation in labour supply (Λ) implies only transitory differences in the behaviour of the four variables considered in Result 1*.

(*Proof:* See Proposition 2 in Appendix A.)

Result 3. *Exogenous variation in g has only a transitory impact on labour supply.*

(*Proof:* See the Lemma in Appendix A.)

These two results are particularly helpful for understanding the relationship between employment and long-term growth: any impact in either direction is transitory. Trends in employment are primarily a function of demographic and "taste" factors.[2] The practical implication of this is that we can safely detrend employment without fear of discarding important information about underlying trends in per capita growth.

If the underlying growth rate of the economy g changes, the situation is a little more complicated with regard to the other variables. A sustained change in g implies a sustained change in the capital-labour ratio. This is essentially because a change in the growth rate requires a change in the real interest rate in the same direction. Faster growth, for example, raises future consumption relative to current levels, and therefore discourages saving and capital accumulation. The result is that the capital-labour ratio, while ultimately growing faster as well, also experiences a downward shift in its level. A corollary of this effect is that the output-capital ratio shifts upwards. This effect can be seen rather strikingly in Graph 1A, which depicts the output-capital ratio over the period 1948-95. This ratio should shift in the same direction as the underlying growth rate, which it clearly does. Moreover, the size of the shift is roughly what one would expect from the model using plausible parameter values.

The level shifts in output per hour, labour compensation per hour and consumption per hour, on the other hand, should all be the same, so that those three variables should have the same permanent component even in the face of regime shifts in growth (Graph 1B).

Result 4. *If the economy experiences a sustained change in its underlying growth rate, output per hour, hourly labour compensation and consumption/hour will display a common trend, while the capital-labour ratio will experience a level shift relative to the other series.*

(*Proof:* See Proposition 3 and its Corollary in Appendix A.)

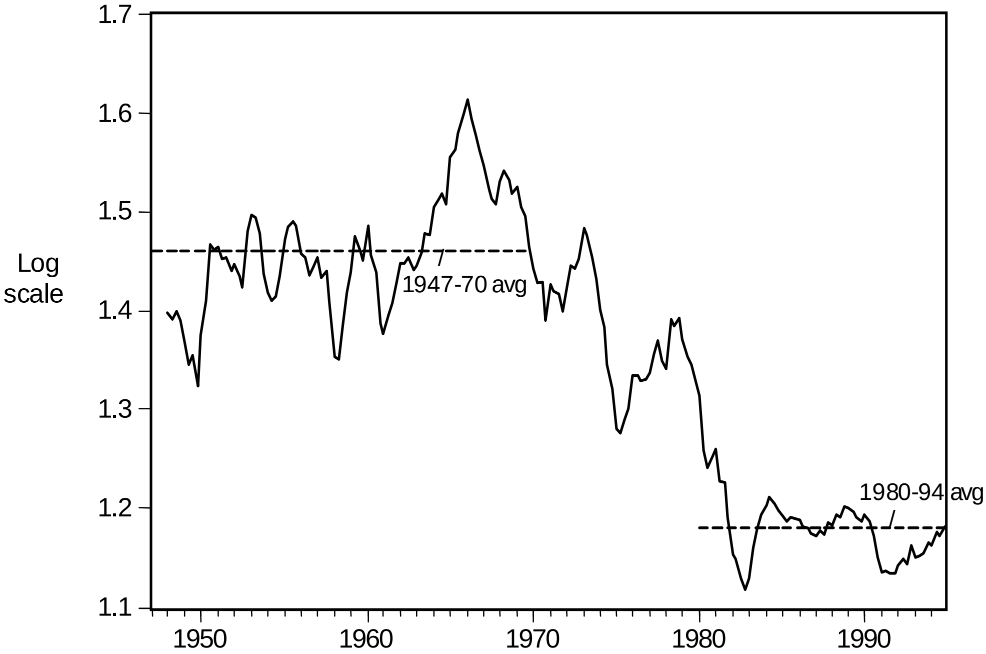
The upshot of this foray into the neoclassical growth model is that other data, notably labour compensation and consumption relative to hours, may provide auxiliary information about the trend in output per hour. This is not to say that the information is completely independent, and indeed the source of errors in one series may be present in the other series as well. For example, an inaccurate price deflator could result in common mismeasurement across multiple series. Nonetheless, the theory

[2] Of course, it is possible that growth affects demographics, and vice versa. For example, sustained higher growth seems to be related to lower fertility rates. But such relationships are unlikely to be apparent over a few decades.

suggests that considering these series together should provide better information about underlying trends than consideration of any of them alone.

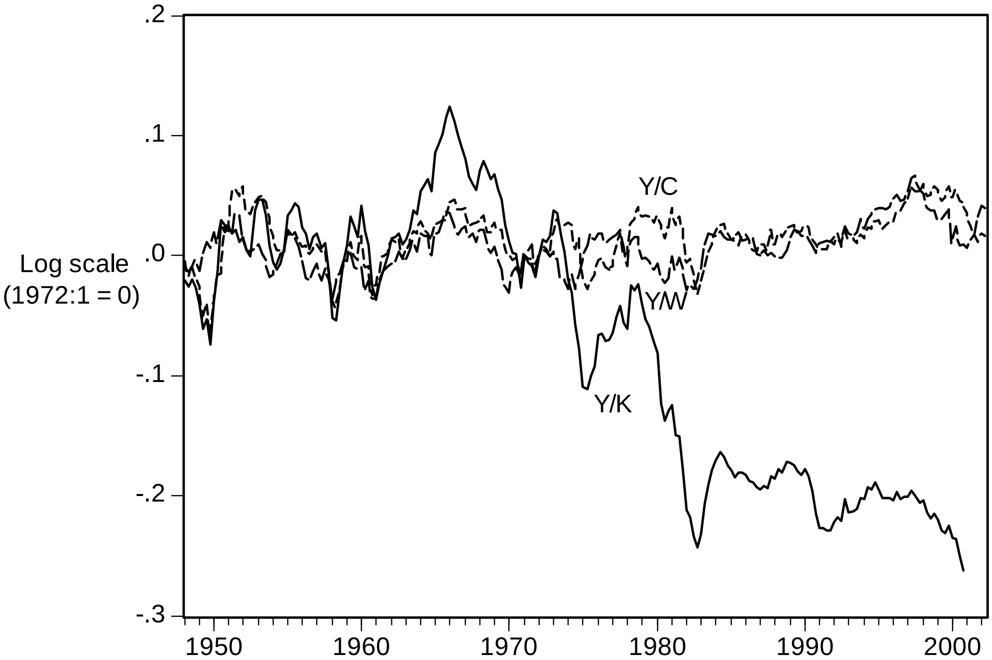
Graph 1A

The US output-capital ratio, 1947-94



Graph 1B

The relative importance of level shifts in *K*, *C* and *W*



3. Econometric specification

Our estimation strategy draws upon the regime-switching dynamic factor model recently proposed by Kim and Murray (2002). The essence of our approach is to examine a number of related economic time series and to use their co-movement in order to identify two shared factors: a common permanent component and a common transitory component. The common permanent component relates to the movements in the series associated with their secular growth rate. On the other hand, the common transitory component relates to movements in the series associated with the business cycle. These components provide a basis to distinguish between long- and short-run changes in the series as well as to gauge their relative importance over particular historical episodes.

While there are other time series models that also include permanent and transitory components, the Kim and Murray (2002) model is unique in that it allows for the possibility that the components may be subject to changes in regime. That is, there may be periodic changes in the underlying process generating the common permanent and common transitory components.

For the purpose of analysing the trend and cyclical movements in productivity, the regime-switching in the model has several attractive features. First, the regime-switching common transitory component allows us to account for possible asymmetries across booms and recessions. In particular, we can capture the idea proposed in Friedman's (1964, 1993) "plucking model" that economic fluctuations are largely permanent during expansions and largely transitory during recessions. Second, the regime-switching permanent component allows us to account for changes in secular growth. Consequently, we cannot only address the issue of a post-1973 productivity growth slowdown, but also a post-1995 productivity growth resurgence. Last, while the model allows for periodic changes in the process generating the common permanent and common transitory components, the timing of the switches does not need to be specified prior to estimation. Rather, the timing of the switches is determined as one of the outcomes from the estimation procedure.

Following Kim and Murray (2002), we can describe the regime-switching dynamic factor model as follows.[3] Suppose we consider a number of time series indexed by i. Let ΔY_{it} denote the growth rate of the i th individual time series. It is assumed that the movements in each series are governed by the following process:

$$\Delta Y_{it} - D_i + \gamma_i \Delta \Pi_t + \lambda_i \Delta x_t + z_{it}$$

where D_i is the average growth rate of the series, $\Delta\Pi_t$ denotes the growth rate of a permanent component that is common to all series, Δx_t denotes the growth rate of a common transitory component, and z_{it} denotes an idiosyncratic component. The parameter γ_i (the permanent "factor loading") indicates the extent to which the series moves with the common permanent component. Similarly, the parameter λ_i indicates the extent to which the series is affected by the transitory component.[4]

The common permanent component is assumed to be subject to the type of regime-switching proposed by Hamilton (1989) in which there are periodic shifts in its growth rate:

$$\Delta\Pi_t = \mu(S_{1t}) + \phi_1 \Delta\Pi_{t-1} + \cdots + \phi_p \Delta\Pi_{t-p} + \upsilon_t, \upsilon_t \sim iid\, N(0,1)$$

$$\mu(S_{1t}) = \begin{cases} \mu_0 & \text{if } S_{1t} = 0 \\ \mu_1 & \text{if } S_{1t} = 1 \end{cases}$$

$$\Pr[S_{1t} = 0 | S_{1,t-1} = 0] = q_1 \text{ and } \Pr[S_{1t} = 1 | S_{1,t-1} = 1] = p_1$$

where S_{1t} is an index of the regime for the common permanent component. The transition probabilities q_1 and p_1 indicate the likelihood of remaining in the same regime. Under these assumptions, the common permanent component Π_t grows at the rate $\mu_0/(1-\phi_1-...-\phi_p)$ when $S_{1t} = 0$, and at the rate $\mu_1/(1-\phi_1-...-\phi_p)$ when $S_{1t} = 1$.

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3 Additional details are provided in Appendix B.

4 As we demonstrate shortly, the formulations for the common permanent component and common transitory component have different implications for their effects on the individual time series. Specifically, the level of the common permanent component can increase over time, while the level of the common transitory component is stationary.

The common transitory component x_t is also subject to regime-switching, as in Kim and Nelson (1999):

$$x_t = \tau(S_{2t}) + \phi_1^* x_{t-1} + \phi_2^* x_{t-2} + ... + \phi_p^* x_{t-p} + \varepsilon_t \text{ and } \varepsilon_t \sim \text{iid}N(0,1)$$

$$\tau(S_{2t}) = \begin{cases} 0 & \text{if } S_{2t} = 0 \\ \tau & \text{if } S_{2t} = 1 \end{cases}$$

$$\Pr[S_{2t} = 0 | S_{2,t-1} = 0] = q_2 \text{ and } \Pr[S_{2t} = 1 | S_{2,t-1} = 1] = p_2$$

where S_{2t} is an index of the regime for the common transitory component, with transition probabilities q_2 and p_2. The permanent and transitory regimes are assumed to be independent of each other. The parameter τ represents the size of the "pluck," with $\tau < 0$ implying that the common transitory component is plucked down during a recession. Finally, the idiosyncratic components are assumed to have the following structure:

$$z_{it} = \psi_{i1} z_{i,t-1} + \psi_{i2} z_{i,t-2} + ... + \psi_{ip} z_{i,t-p} + \eta_{it} \text{ and } \eta_{it} \sim \text{iid}N(0, \sigma_i^2)$$

where all innovations in the model are assumed to be mutually and serially uncorrelated at all leads and lags.

While the two regimes are not directly observable, it is nevertheless possible to estimate the parameters of the model and to extract estimates of the common components.[5] An important by-product from the estimation procedure is that we can draw inferences about the likelihood that each common component is in a specific regime at a particular date. The inferences can be based on a "real time" assessment, which provides an estimate of the current regime as of date *t* based only on information up to date *t*, or a "retrospective" assessment that incorporates information for the entire sample.[6] Of course the retrospective assessment is a more reliable estimate of past regimes because it incorporates subsequent data, but the real-time assessment is useful as a gauge of what analysts and policymakers could realistically have known at the time.

Our data consist of four quarterly series on labour productivity, real compensation per hour, consumption deflated by hours of work, and hours of work itself. All of the data except aggregate consumption refer to the private non-farm sector, and all series cover the period 1947 Q1 to 2002 Q2.

The selection of the series and their subsequent transformation for the estimation are motivated by consideration of their usefulness for identification of the common permanent component and common transitory component. With regard to the hours series, as we have seen, there is little reason to believe that its underlying trend should be fundamentally related to that of the other three series. Consequently, where we include this series in the analysis to help refine the estimate of the common transitory component, we detrend it using the Hodrick-Prescott (1980) filter.

With regard to the dynamic specification of the common and idiosyncratic components, our diagnostic checking procedure suggested that the common permanent component should include one lagged value of $\Delta\Pi_t$, the common transitory component should include two lagged values of x_t, and that the idiosyncratic component should include one lagged value of z_{it} for each series. We also drew upon theory to impose restrictions on the γ_i which represent the permanent factor loadings in the model. Specifically, we restricted the estimated permanent factor loadings for productivity, real compensation per hour, and consumption per hour to be equal. In addition, we set the value of the permanent factor loading for detrended hours to be equal to zero.

5 Kim and Murray (2002) discuss how the regime-switching dynamic factor model can be cast in a state-space representation and estimated using the Kalman filter. More details of how we applied their methods to the present study are available on request.

6 The designation "real time" is potentially misleading on two counts. First, the parameter estimates are based on the entire sample. Second, the data may have undergone subsequent revisions that would have been unavailable as of the time of the assessment.

4. Results

As described above, our benchmark model uses the three variables that growth theory suggests should have approximately the same permanent components: real output per hour (variable 1), real labour compensation per hour (variable 2), and consumption relative to hours (variable 3). We also include detrended hours (variable 4) to help capture the transitory or business cycle component of the data. As we have seen, while the capital-labour ratio should also exhibit the same growth as output per hour within a growth regime, both theory and the data suggest that it can jump substantially between regimes, so we exclude it from our system.

One final specification issue relates to the synchronisation of the data. The three trending variables were selected primarily with a view to helping identify the common permanent component. They are not necessarily "coincident indicators" with respect to the transitory component. Since allowing for a more general lead/lag structure in our system would greatly increase the complexity of the model as well as the number of parameters to estimate, we instead examined the cross-correlations of the four series. We found that the first two variables (productivity and labour compensation per hour) tended to lead the other two series over the business cycle by about three quarters. To capture this in the estimation, we lagged variables 1 and 2 by three quarters in the system described above.[7]

The first set of results in Table 1 provides the parameter estimates for our benchmark model with these four variables. As mentioned, we restrict γ (the loading factor on the common permanent component) to be the same for the three trending variables, a restriction that we test and fail to reject for this specification. The sample covers 1947 Q1-2002 Q2. The results indicate that the model yields fairly precise estimates of most of the parameters of interest: the loading factors on both the permanent and transitory components, the transition probabilities, and the shift parameters connected with the regimes (μ_0, μ_1, τ) are all statistically significant. The difference between the low and high permanent regimes works out to be $\gamma(\mu_0 - \mu_1)/(1-\phi) = 0.367$, which corresponds to roughly 1.5% on an annualised basis. The transition probabilities for the permanent regimes imply that the unconditional probability of being in the high-growth regime is 0.593, which, as we shall see, reflects the inference that the economy was in the high-growth regime 59.3% of the time between 1947 and the present.

The transitory process is estimated to be a "hump-shaped" autoregressive process typical of the business cycle, but with a significant negative pluck. The four λ_i coefficients, which represent the loading factors on the transitory process, are all estimated very precisely, and with the expected signs. Note that λ_3, the loading factor for consumption/hour, is negative, reflecting the fact that hours is more cyclical than consumption. The positive estimates for the loading factors on the real compensation and productivity variables mean that those two variables associate positively with the transitory component, but leading by three quarters relative to the other two variables (since they enter the system lagged by three quarters).

Before further describing the permanent and transitory components of productivity growth, however, it is instructive to examine the inferred probability of being in the high- or low-growth state over time. There are two ways to look at this. First, in "real time", ie given only the information analysts would have had at each point in time, what probability would they have assigned to being in the high-growth state? The second way is retrospectively: given what has happened up to 2002 Q2, what can we say looking back over time about the likelihood of being in the high-growth state? (Obviously the two assessments coincide at the end, ie as of 2002 Q2.) The retrospective version is plotted in Graph 2A. The vertical axis is the probability of being in the high-growth regime. The data present a very clear picture: the economy was in a high-growth state until the early 1970s, followed by a roughly 20-year low-growth regime, followed by a switch back to high growth in the mid-1990s. Perhaps the only surprise here is how unambiguous the current assessment is: the probability that the economy was in a sustained high-growth regime (given what we now know[8]) by 1998 Q4 is estimated to be about 0.94. Note that because productivity enters lagged three quarters, this would date its acceleration at 1998 Q1.

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[7] A drawback to this procedure is that the last three observations of variables 1 and 2 are not used in assessing the trend, even though they are known. We are looking at methods for addressing this problem.

[8] But ignoring the last three observations of productivity and labour compensation.

Table 1

Estimation of model

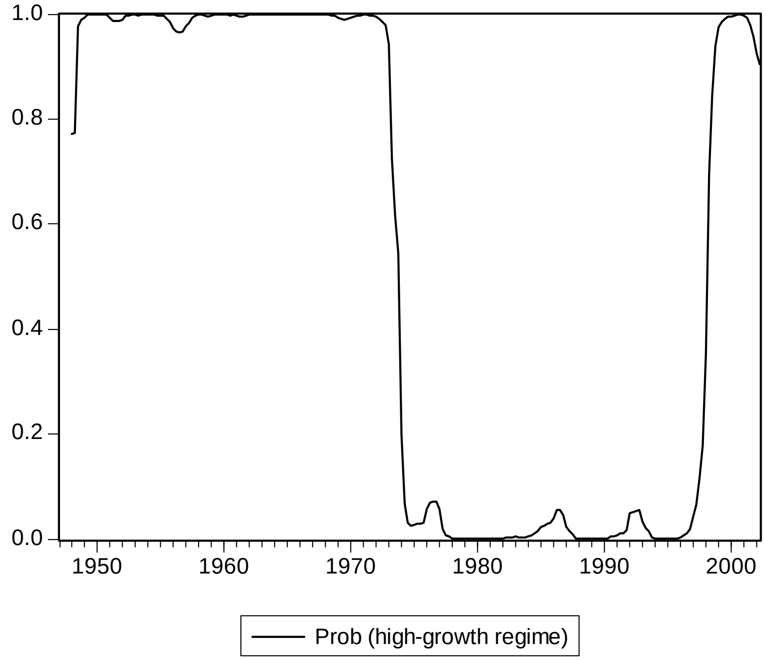
Coefficient	Four-equation system	Two-equation system
p_1	0.989 (0.012)	0.992 (0.011)
q_1	0.984 (0.014)	0.992 (0.011)
p_2	0.982 (0.016)	0.952 (0.038)
q_2	0.555 (0.280)	0.509 (0.153)
ϕ	–0.381 (0.147)	–0.096 (0.162)
ϕ_1^*	1.424 (0.097)	1.439 (0.075)
ϕ_2^*	–0.576 (0.084)	–0.565 (0.072)
ψ_{11}	–0.246 (0.079)	–0.710 (0.233)
ψ_{21}	–0.011 (0.087)	–
ψ_{31}	–0.636 (0.087)	–
ψ_{41}	0.494 (0.070)	–0.026 (0.279)
γ	0.273 (0.041)	0.802 (0.123)
λ_1	0.212 (0.041)	0.156 (0.038)
λ_2	0.118 (0.031)	–
λ_3	–0.444 (0.049)	–
λ_4	0.434 (0.047)	0.581 (0.058)
μ_0	0.822 (0.228)	0.206 (0.126)
μ_1	–1.035 (0.271)	–0.173 (0.118)
τ	–2.926 (0.769)	–2.128 (0.458)

Note: The estimation also produces estimates of the variances of the idiosyncratic errors, not reported here.

As the previous discussion makes clear, however, this does not mean that as of the end of 1998 we actually could have made such an optimistic assessment. Graph 2B plots the "real time" version of Graph 2A, which indicates that as of the end of 1998 we would have only assessed the probability of being in the high-growth regime as 0.3. Thus it is only with hindsight that we think the probability of being in the high-growth regime was very high at that point in time. And it is easy to understand why, looking at Graph 2B. In real time there were a lot of "false alarms", post-1973 episodes when it appeared that productivity growth might have shifted into high gear. These tended to occur during the early phase of expansions, when productivity growth did in fact increase, and when it was too soon to tell - notwithstanding an effort to disentangle cycle from trend - whether the higher growth rate would be sustained.

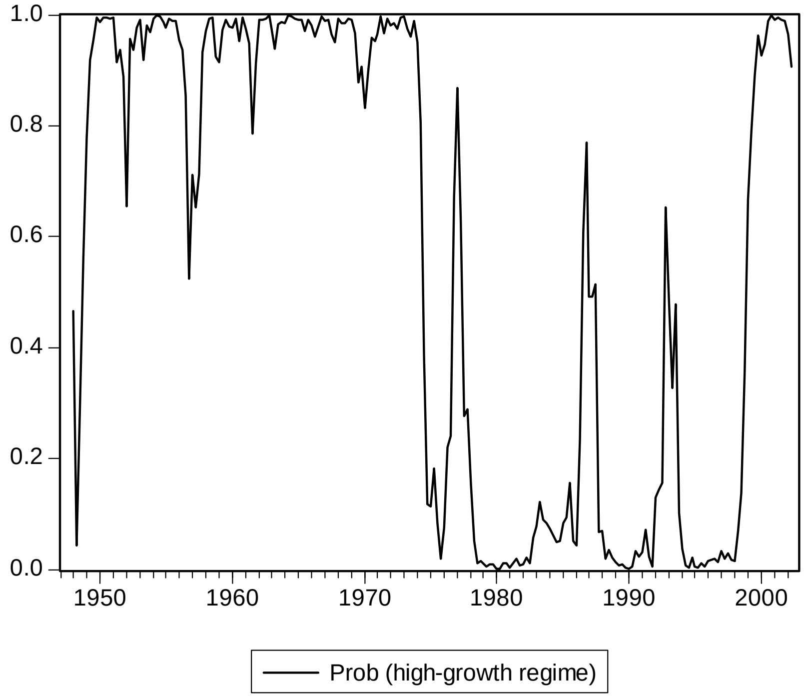
Graph 2A

Retrospective assessment of growth regimes



Graph 2B

Real-time assessment of growth regimes



Nonetheless, even in real time it would have been clear from these techniques based on data only up to 1999 that there had been a change in regime back to high growth - this after only four years of relatively strong productivity growth in the middle of an expansion. While certainly the idea of a "new economy" with strong productivity growth had gained many adherents well before the end of 1999, there were also plenty of naysayers, and few of the optimists would have ventured to base their views on objective statistical analysis.[9]

For completeness, we can also look at the assessment of transitory regimes. The (retrospective) probability of being in the "plucked down" state is plotted in Graph 3A. Here the probability assessments are a little more ambiguous, which is not surprising considering that the regimes themselves are relatively transitory. Nonetheless, the more prominent spikes all coincide with NBER-defined recessions, though several recessions (most notably the 1990-91 recession) are missed entirely, and several others show up with a relatively low probability. It is perhaps instructive that the 1990-91 recession does not register in this picture. The idea of a pluck is a sharp downturn followed by an equally sharp recovery sufficient to get the economy back to trend. The 1990-91 recession was characterised by a relatively mild downturn followed by an unusually slow and gradual recovery. If we instead look at the total common transitory component (which includes an autoregressive process as well as the pluck) in Graph 3B, we see that this recession does in fact register (as do all of the postwar recessions), albeit very mildly.

If we examine the permanent component of productivity growth directly (Graph 4A), we see that the permanent component clearly indicates changes in trend in the early 1970s and mid-1990s, with no apparent cyclical residue.[10] At the same time, however, the model still assigns a lot of variation to the "idiosyncratic" component (Graph 4B). Presumably this reflects the fact that productivity movements are often out of phase with other cyclical variables, though it also reflects our choice of variables to include in the system. This choice was geared entirely towards variables that would help to pick up the permanent component, regardless of their cyclical behaviour.

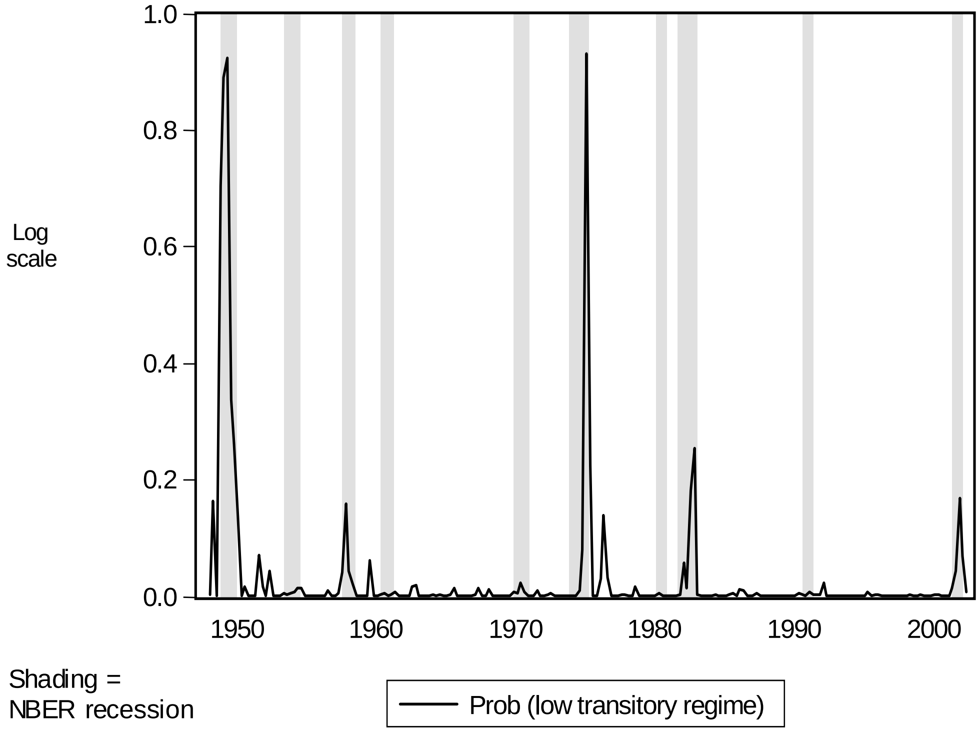
Finally, from a methodological perspective, one may ask how important is the use of additional series in helping to identify changes in trend growth. To answer this, we use the same econometric model, but with only two series, non-farm output per hour and detrended hours (variables 1 and 4 from the previous analysis). Thus we are looking to estimate trend growth with productivity data alone, using the detrended hours series to control for the business cycle. The result of this exercise is the second set of estimates in Table 1. Note first that the estimates of the transition probabilities are very similar to the earlier estimates, suggesting that the fundamental properties of the regime-switching dimension of the model will be similar. Second, while many other parameters are similar, it is clear that the nature of the permanent component is very different from the previous estimate. Not only is the factor loading much higher (0.802-0.273) - not surprising since it is the only trending variable - but its dynamics are different. This is indicated by the statistically insignificant estimated AR coefficient (ϕ) of -0.096, versus the estimate of -0.381 from the four-equation system that was both larger in absolute value and statistically significant.

9 Indeed, optimistic views go back as early as 1997 (see, for example, "Measuring productivity in the 1990s: optimists vs skeptics", by Louis Uchitelle, *New York Times*, 2 August 1997), though they appear to have been based more on scepticism about the data than on direct signals generated by the data (see Corrado and Slifman (1999)). Of course, pessimists have also based their views on scepticism about the data, eg Roach (1998).

10 This contrasts with Kim and Murray (2002), whose estimated permanent aggregate component shows substantial downward movement during recessions.

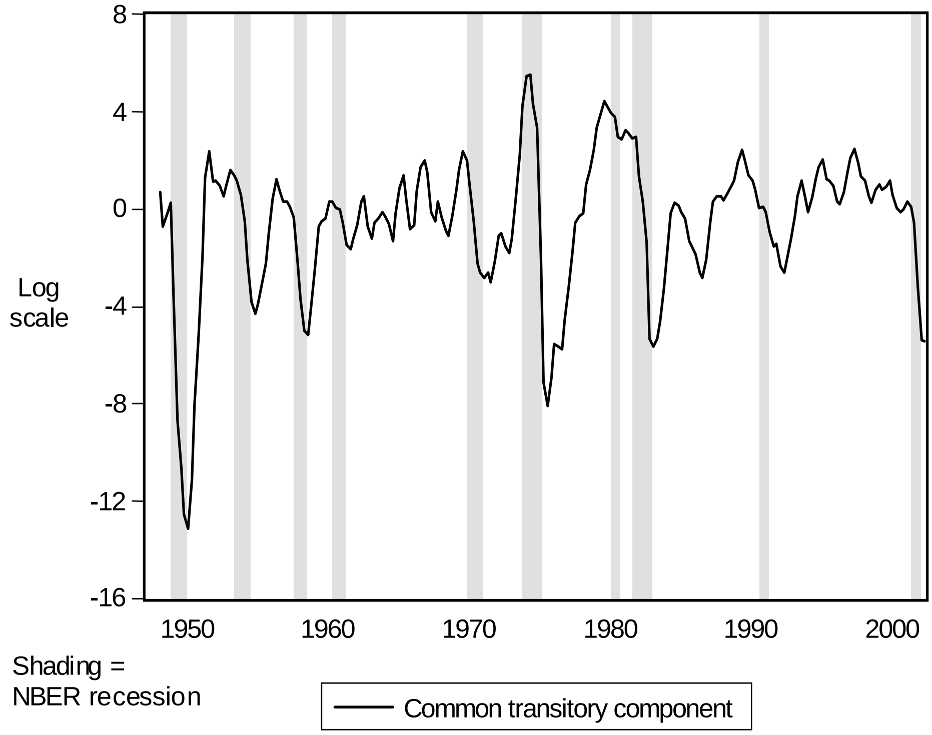
Graph 3A

Probability of a negative pluck



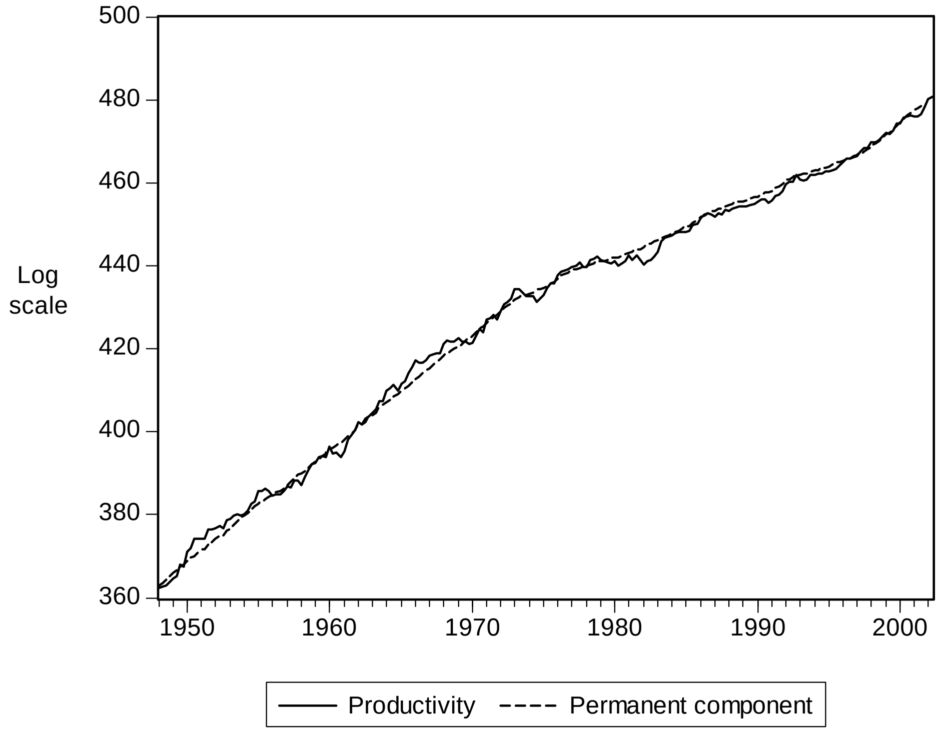
Graph 3B

Total common transitory component



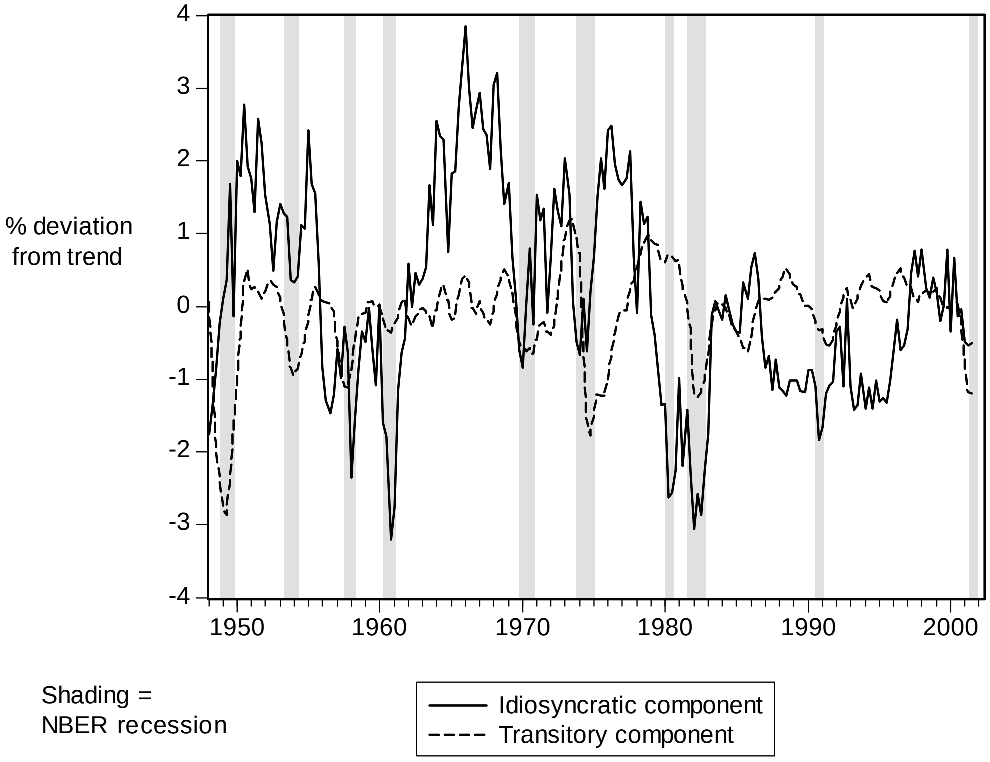
Graph 4A

Productivity and its permanent component



Graph 4B

Transitory and idiosyncratic components of productivity

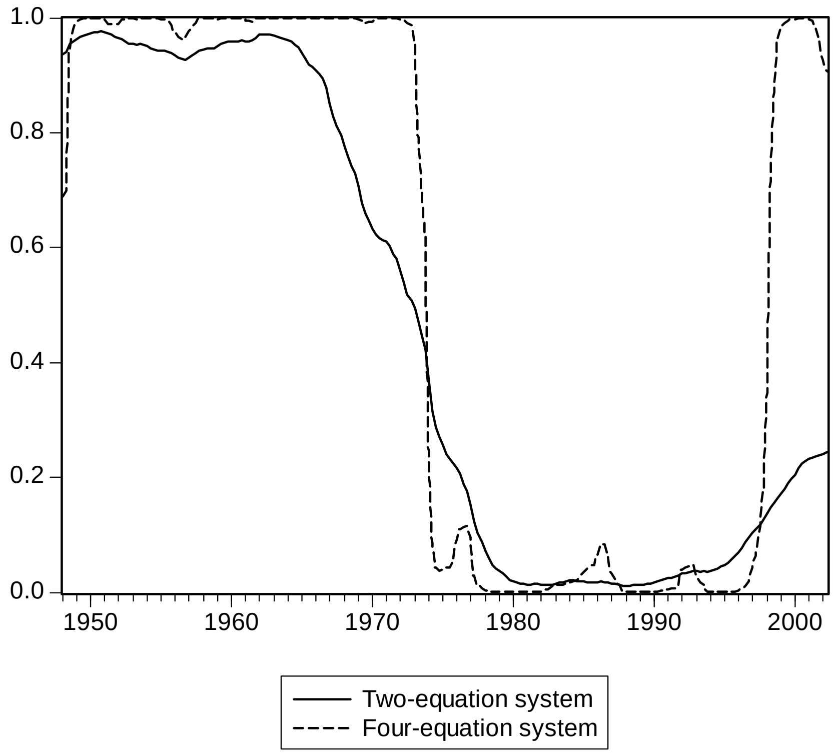


These differences are reflected in the retrospective regime assessments (Graph 5). Compared to the previous estimates, the estimated probability spends a lot more time in "grey areas" between transitions, and, most importantly, ends up well below 0.5, meaning that the two-variable system still cannot tell which growth regime the economy resides in. The difficulty in distinguishing trend from cycle is also manifested in the volatility of the estimated permanent component (Graph 6A). Now most of the movements in productivity are viewed as permanent, because there is little other information in the two-variable system to help filter out the noise. While the two-variable system arguably does a better job of getting at the transitory component (Graph 6B), as the remaining idiosyncratic component is smaller than in the four-variable system, from the point of view of identifying changes in underlying trends, the simpler approach appears to fall short.

Graph 5

The importance of additional variables

Prob (high-growth regime)

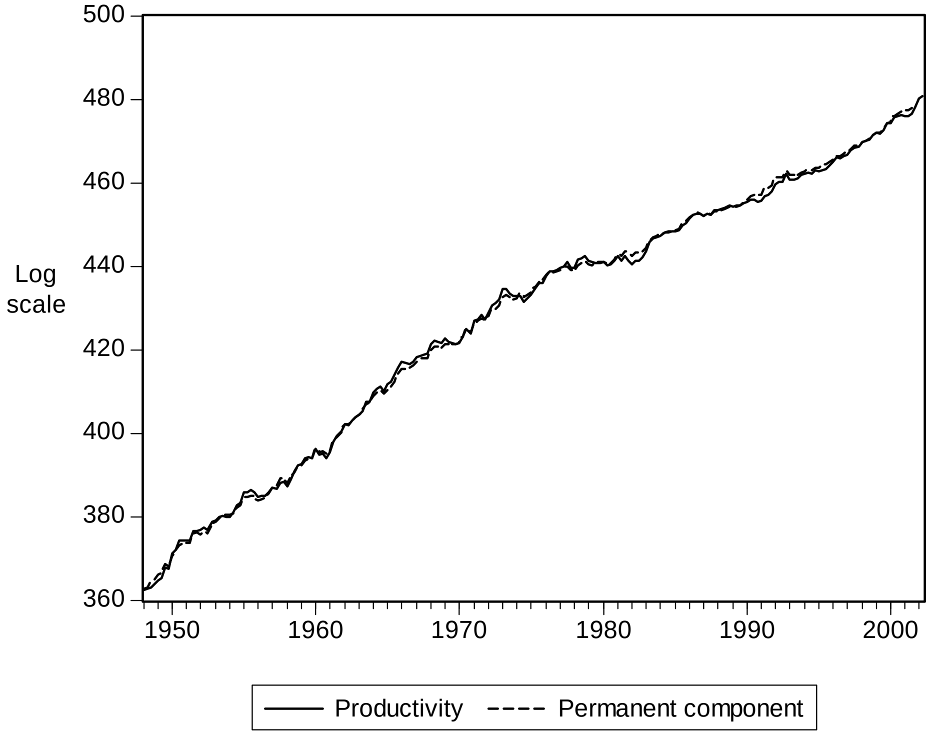


Of course, we have not shown that the two-variable system does a poorer job of characterising productivity trends. Perhaps the trends really are uncertain and the four-variable system is "overfitting" the data. To address this, we use the two models to forecast productivity at one- to four-quarter horizons.[11] The idea here is that if the four-variable system is overfitting the data, the root mean square error of its forecasts will be larger than that of the two-variable system. We constructed forecasts beginning in 1972 Q2 using the formulas outlined in Hamilton (1994). Consequently, the sample for the one-quarter forecast horizon covers the period 1971 Q3-2001 Q4, while the sample for the four-quarter forecast horizon covers the period 1972 Q2-2002 Q2. To obtain one-year horizon forecasts, we simply added the one- to four-quarter forecasts. Table 2 provides the results of this exercise. For both forecast horizons, the root mean square error of the two-variable system is larger, suggesting that the four-variable system is doing a better job, notwithstanding the fact that its primary intention is not short-term forecasting.

[11] Some caution may be needed with our use of the term "forecast". Because the model involves a three-quarter lag in the productivity growth series, only the observation relating to the four-quarter-ahead forecast would not be contained in the current information set.

Graph 6A

Productivity and its permanent component (two-equation system)



Graph 6B

Transitory and idiosyncratic components of productivity (two-equation system)

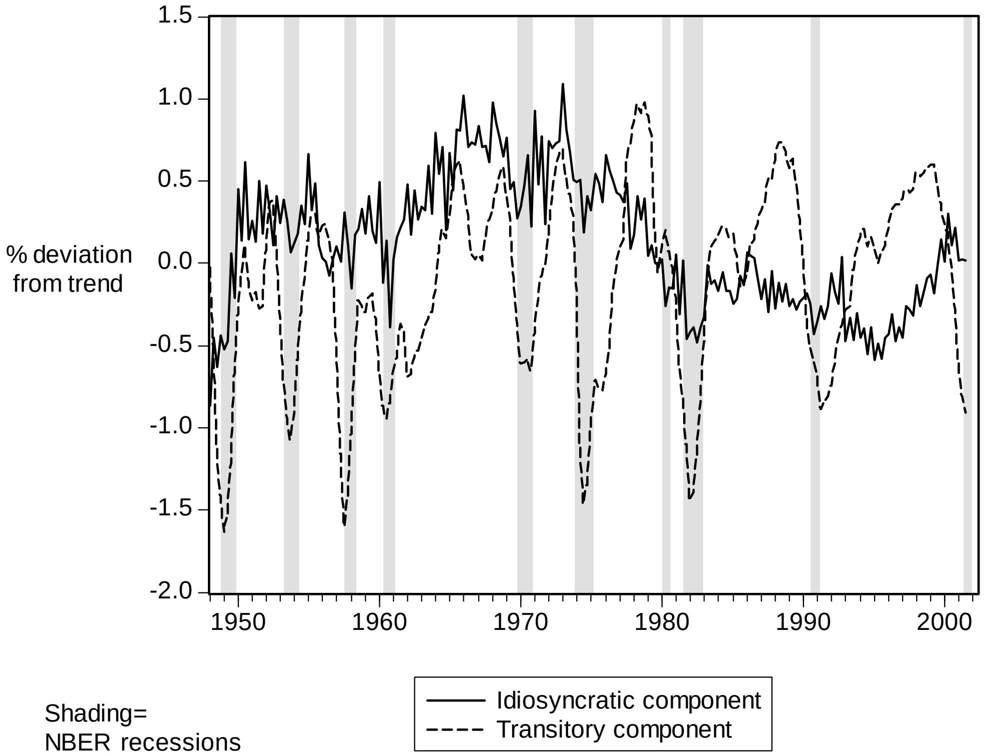


Table 2

Forecast performance

	Two-variable system	Four-variable system
	Root mean square errors	
One-quarter horizon	2.999	2.940
One-year horizon	1.503	1.432
	Non-farm productivity growth forecast (four quarters ahead; in percentages)	
2002 Q3	2.5	3.4

Note: All figures are at annualised percentage rates.

Table 2 also provides forecasts (four-step-ahead, because productivity enters the model lagged by three quarters) of productivity growth for 2002 Q3. The four-variable system predicts substantially stronger productivity growth (3.4% vs 2.5% on an annualised basis), primarily because of its assessment of a relatively high probability of being in a high-growth regime. Of course, productivity growth is a very noisy series, so a forecast for any given quarter cannot be made with much confidence, but the difference reflects different assessments of underlying trends, and provides some idea of the potential usefulness of the approach adopted in this paper.

5. Conclusions

The view that higher productivity growth is likely to be sustained has only really gained something approaching a consensus with the recent recession. Prior to 2001, one could more easily argue that the increased growth rates experienced since 1995 were merely cyclical or otherwise ephemeral. That lack of agreement not only reflects the difficulty of separating a time series into its trend and cycle, but also the sensitivity of the results to various assumptions used in the decomposition. In the case of productivity, the problematic nature of the decomposition is only likely to be exacerbated by the inherent volatility of the series. Economists faced the same difficulty (albeit in the opposite direction) in the mid-1970s when the dramatically slowing productivity growth coincided with a severe recession.

We explore the issue of the long-term trend in productivity by adopting a modelling strategy that integrates both theoretical considerations and recently developed statistical methods. In contrast to previous univariate analyses, we undertake a multivariate analysis in which we exploit information from additional variables that should be helpful in the identification of the trend and cycle in productivity. Specifically, we extend the data set to include consumption and labour compensation as well as detrended hours.

For our empirical framework we adopt the regime-switching dynamic factor model recently proposed by Kim and Murray (2002). This approach has a number of attractive features. First, it allows for the estimation of a common permanent component and a common transitory component, consistent with our interest in the trend and cycle in the productivity data. Second, the model allows for rich dynamics and can account for periodic changes in the underlying processes generating the common components. The latter consideration is not only important for providing a better characterisation of the data, but is central to any discussion about a possible shift to the secular growth rate of productivity. Last, the nature and timing of the regime changes is determined as an outcome of the estimation procedure rather than imposed a priori. In fact, one could view the implied regime changes and their reasonableness as an additional metric by which to judge the adequacy of our modelling strategy.

We find strong support in the data for the notion that the economy (and productivity growth in particular) switched from a relatively low-growth to a high-growth regime in the mid-1990s. The annualised difference between the mean growth rates in the two regimes is estimated to be approximately 1.5%. We also show that these techniques could have provided conclusive signals of the regime shift by the end of 1999. Finally, from a methodological standpoint, we argue that the incorporation of additional information from other time series is crucial to the strength of our conclusions.

In subsequent work we hope to improve on our method for dealing with the lead-lag relationships in the data. In this paper we simply entered productivity and labour compensation lagged by three quarters to reflect the fact that these two series appeared to lead the others by that amount over the business cycle. This results in our approach ignoring the last three quarters of data for these series, a potentially crucial omission in any effort to assess current conditions. We also plan to deal with other aspects of the data that we have neglected here - for example, the apparent decline in volatility of productivity growth over time. Finally, we are also constructing a truly “real time” data set for productivity, one that recreates the data actually available at each point in time, and can therefore more definitively answer the question of how well this methodology can detect shifts in underlying growth trends.

Appendix A

The first-order conditions for the maximisation problem are as follows:

$$c+\dot{k}+(n+g)k=F(k,\ell)$$
$$1/c=\lambda$$
$$\Lambda v'(1-\ell)=\lambda F_2(k,\ell)$$
$$\dot{\lambda}/\lambda=n+g-F_1(k,\ell)$$

where λ is the shadow value of the resource constraint embodied in the first equation, and the other variables are as defined in the paper. In a steady state both λ and k will be constant, so the system

$$c+(n+g)k=F(k,\ell) \quad (1)$$
$$1/c=\lambda \quad (2)$$
$$\Lambda v'(1-\ell)=\lambda F_2(k,\ell) \quad (3)$$
$$0=n+g-F_1(k,\ell) \quad (4)$$

can be solved for the steady-state values of c, k, λ and ℓ for fixed values of g and Λ.

Proposition 1: *The per capita quantities C/N, K/N and Y/N all grow at rate g in the steady state*.

Proof: This follows from the constancy of c, k and y, and their definitions.

Corollary 1: Since L/N is constant, C/L, K/L and Y/L also grow at rate g in the steady state.

The following results relate to scenarios in which Λ and/or g undergo permanent changes.

Proposition 2: *The steady-state values of* c/ℓ, k/ℓ *and* y/ℓ *do not depend on* Λ.

Proof: The homogeneity of F implies that (1) and (4) can be expressed in terms of c/ℓ, k/ℓ *and* y/ℓ. Since Λ only enters (3), and $F_2(k/\ell)$ is only a function of k/ℓ, ℓ and λ can vary with Λ to keep $\Lambda v'(1-\ell)/\lambda$ constant, and c can vary with λ to keep (2) satisfied.

On the other hand, a permanent change in g clearly cannot be so "neutral", except with respect to labour supply, as the following results show.

Lemma: With Cobb-Douglas technology, the steady-state value of ℓ does not depend on g.

Proof: Let $y=k^{\alpha}\ell^{1-\alpha}$. Then $F_1=\alpha(k/\ell)^{\alpha-1}$, $F_2=(1-\alpha)(k/\ell)^{\alpha}$ and $y/\ell=F(k/\ell)/\ell=(k/\ell)^{\alpha}$. It follows from (1) and (4) that $F_2/c=(1-\alpha)/\alpha$ for any value of g. Substituting this result and (2) into equation (3) proves that ℓ is constant.

Proposition 3: *The steady-state values of* c/ℓ, k/ℓ, y/ℓ *and* F_2 *vary with g*.

Proof: Equation (4) implies immediately that k/ℓ depends (negatively) on g. Since y/ℓ is a function of k/ℓ, it changes as well. Equation (3) then implies that λ must change with g, since the Lemma shows that ℓ is constant. Equation (2) then implies that c/ℓ must vary with g.

Corollary 3: The permanent movements in c, F_2 and y with respect to changes in g are proportional to each other, but the change in k is not.

The intuition behind Proposition 3 (and the corollary) is simply that higher growth makes individuals feel wealthier, and therefore increases desired consumption. The interest rate (ie the marginal product of capital) must then rise to counter the increased demand.

Appendix B

We employ the following state-space representation for our model:

Measurement equation: $\Delta y_t = H\xi_t$ and $\Delta y_t = (\Delta y_{1t}, \ldots, \Delta y_{4t})'$

Transition equation: $\xi_t = \alpha(S_t) + F\xi_{t-1} + V_t$

with $E(V_t V_t') = Q$

and where (after we restrict $\gamma_1 = \gamma_2 = \gamma_3 \equiv \gamma$, and set $\gamma_4 = 0$)

$$H = \begin{bmatrix} \gamma & \lambda_1 & -\lambda_1 & 1 & 0 & 0 & 0 \\ \gamma & \lambda_2 & -\lambda_2 & 0 & 1 & 0 & 0 \\ \gamma & \lambda_3 & -\lambda_3 & 0 & 0 & 1 & 0 \\ 0 & \lambda_4 & -\lambda_4 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\xi_t = \begin{bmatrix} \Delta\Pi_t \\ x_t \\ x_{t-1} \\ z_{1t} \\ z_{2t} \\ z_{3t} \\ z_{4t} \end{bmatrix} \qquad \alpha(S_t) = \alpha(S_{1t}, S_{2t}) = \begin{bmatrix} \mu_0(1 - S_{1t}) + \mu_1(S_{1t}) \\ \tau S_{2t} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \qquad V_t = \begin{bmatrix} \upsilon_t \\ \varepsilon_t \\ 0 \\ \eta_{1t} \\ \eta_{2t} \\ \eta_{3t} \\ \eta_{4t} \end{bmatrix}$$

$$F = \begin{bmatrix} \phi_1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \phi_1^* & \phi_2^* & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \psi_{11} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \psi_{21} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \psi_{31} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \psi_{41} \end{bmatrix} \qquad Q = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \sigma_1^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \sigma_2^2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \sigma_3^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \sigma_4^2 \end{bmatrix}$$

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