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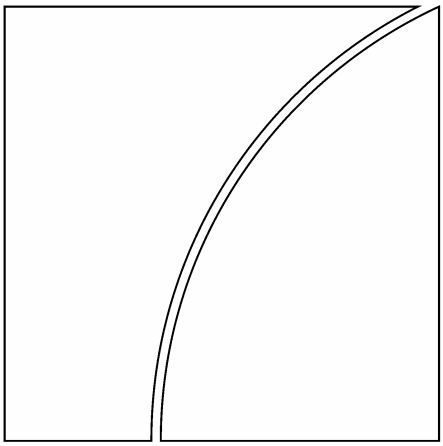

BIS Working Papers

No 185

Has the inflation process changed?

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Monetary and Economic Department

November 2005

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JEL Classification Numbers: J31, J52
Keywords: Inflation, Inflation persistence, Monetary Policy Regimes

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Copies of publications are available from:

Bank for International Settlements
Press & Communications
CH-4002 Basel, Switzerland

E-mail: publications@bis.org

Fax: +41 61 280 9100 and +41 61 280 8100

This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)

ISSN 1682-7678 (online)

Foreword

On 18-19 June 2004, the BIS held a conference on “Understanding Low Inflation and Deflation”. This event brought together central bankers, academics and market practitioners to exchange views on this issue (see the conference programme in this document). This paper was presented at the workshop. The views expressed are those of the author(s) and not those of the BIS.

Third BIS Annual Conference

Understanding Low Inflation and Deflation

Brunnen, Switzerland, 18-19 June 2004

Conference programme

Friday, 18 June **Inflation and deflation dynamics**

09.00 *Opening remarks (William White, BIS)*

Morning sessions (Chair: Lars Heikensten, Sveriges Riksbank)

09.15 *Session 1: Changes in the inflation process (Stephen Cecchetti, Brandeis University and Guy Debelle, BIS)*

Discussants: Ignazio Angeloni, ECB; Jordi Galí, Centre de Recerca en Economia Internacional (CREI)

11.00 *Session 2: Deflation in historical perspective (Michael Bordo, Rutgers University and Andrew Filardo, BIS)*

Discussants: Patrick Minford, Cardiff Business School; Fernando Restoy, Bank of Spain

Afternoon sessions (Chair: Vittorio Corbo, Central Bank of Chile)

14.00 *Session 3: Price setting and deflation in Asia (Hans Genberg, Graduate Institute of International Studies)*

Discussants: Laurence Ball, John Hopkins University; Steven Kamin, Federal Reserve Board

15.45 *Session 4: Panel on 'Deflation and the financial system' (Presenters: Lesley Daniels-Webster, JP Morgan Chase; Takumi Shibata, Nomura Securities)*

Discussant: Philipp Hildebrand, Swiss National Bank

Saturday, 19 June **Implications for monetary policy**

Morning sessions (Chair: David Longworth, Bank of Canada)

08.45 *Session 5: Deflation in Japan: causes, consequences and policy options (Masaaki Shirakawa and Kazuo Ueda, Bank of Japan)*

Discussants: Michael Mussa, Institute for International Economics; Marc Olivier Strauss-Kahn, Banque de France

10.30 *Session 6: Beyond current policy frameworks (Charles Goodhart, London School of Economics)*

Discussants: Edwin Truman, Institute for International Economics; Ignazio Visco, Banca d'Italia

Afternoon session (Chair: Malcolm Knight, BIS)

13.30 *Session 7: Overview panel (Ben Bernanke, Federal Reserve Board; Willem Buiter, EBRD; Lucas Papademos, ECB)*

15.00 *Conference adjourns*

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Has the inflation process changed?

Stephen Cecchetti, Brandeis University and NBER
and Guy Debelle[1], Bank for International Settlements and
Reserve Bank of Australia

1. Introduction

Low inflation has been a fact of economic life in many countries now for at least a decade. While some have had low inflation since the early 1980s (at least), the 1990s was notable for the widespread incidence of low inflation, including amongst a large number of formerly high inflation economies in Latin America and eastern Europe.[2]

On a number of occasions, the advent of low inflation has coincided with changes in the monetary policy framework, which in many cases has involved the adoption of a form of inflation targeting. But in other countries, there has been no marked change in the policy regime. This raises the important question of whether the nature of the inflation process has changed in a manner which has helped entrench low inflation. One means by which this could occur would be if the inflation process has become less persistent; that is, a given shock to the price level which boosts the inflation rate now has a smaller and/or less protracted impact on the rate of ongoing inflation.

If inflation persistence has declined, why has it occurred? One possible explanation is that the decline in persistence itself is related to a change in the conduct of monetary policy. Taylor (1998, 2000) makes this general argument, while Sargent (1999) provides a detailed account of the interaction between inflation persistence and the monetary framework in the United States. The case centres on the observation that over the past decade or so, monetary policy has been much more focussed on achieving low inflation, and less on exploiting short-run output gains. These policies have been successful, leading to an increase in the credibility of monetary policy. Increased credibility has, in turn, anchored inflation expectations at a low (and constant) rate of inflation - at the inflation target in those countries that have such a formal target. The dramatic consequence is that inflation expectations are unlikely to adjust to temporary increases in the inflation rate. This reduces the persistence of shocks to both the price level and the inflation rate.

In this paper we address these questions by studying the univariate inflation process in a number of countries. Levin and Piger (2003) and Gadzinski and Orlandi (2003) conduct a similar exercise.[3] However, we examine not only the consumer price index (CPI) in aggregate, but also its components. This helps us to identify if changes in the inflation process have a common source. From a monetary policy perspective, the aggregate inflation process is probably the most relevant, but the disaggregated data may reveal some useful insights about the nature of the price-setting process. Also, the disaggregated data may reveal whether the observed persistence (or lack thereof) may be influenced by the statistical methodology employed in calculating the consumer price index.

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[1] We would like to thank Dimitrios Karampatos for his invaluable hard work, the members of the Eurosystem's Inflation Persistence Network for their help, particularly Benoit Mojon, our discussants at the BIS Conference on Understanding Low Inflation and Deflation, Ignazio Angeloni and Jordi Galí, and Alexandra Heath, David Lebow and Karl Whelan for helpful comments. The following central bank colleagues were indispensable in the construction of the data set we used: Fabio Rumler (Austria), Tim Bulman (Australia), Emmanuel Dhyne (Belgium), James Rossiter (Canada), Matias Tapia Gonzalez (Chile), Benoit Mojon (Europe), Nicole Jonker (Netherlands), Troy Matheson (New Zealand), Pablo Duarte Neves (Portugal), Luis Álvarez (Spain), Tor Jacobson (Sweden), Kenny Turnbull and Iain de Weymarn (United Kingdom), and Guhan Venkatu (United States). A revised version of this paper was presented at the 42nd panel meeting of Economic Policy in London in October 2005. The views expressed are those of the authors and not necessarily those of the BIS or RBA.

[2] According to the IMF's World Economic Outlook database, by 2002, Zimbabwe and Angola were the only countries with inflation over 100%. Over the previous two decades, 48 countries experienced triple-digit inflation for at least one year, with 23 countries having episodes in excess of 1000%.

[3] See also Anderton (1997).

A similar approach has been taken by Ernst and Mojon (2004), focusing on euro area countries. The use of disaggregated cross-country price data also allows us to test whether various theories of price setting are consistent with what we see in the data.

The analysis in this paper focuses on identifying changes in both the mean and the persistence of inflation, as well as the interaction between the two. As other authors observe, there is an important relationship between the mean and persistence of an economic time series. Much of the work analyses the inflation process (see Perron (1989) and Levin and Piger (ibid)). We show that after allowing for changes in the mean of inflation (normally one mean break is sufficient), inflation has generally not had a particularly high level of persistence, similar to the results in Levin and Piger and Gadzinski and Orlandi (ibid). Importantly, and as this result suggests, measures of inflation persistence depend crucially on the sample period over which they are calculated, with estimates over the post 1990 period indicating a very low level of persistence in most cases. These results are common across all categories of prices that we examine. We do find some evidence of a decline in persistence in the recent period, even when a change in the mean of the inflation process is allowed for, but the order of magnitude of this decline is often less than that found previously in the literature.

Thus our primary conclusion is that the principal change in the inflation process over the past two decades has (not surprisingly) been the decline in the mean. The decline in the persistence of the process has generally been of second order importance, and in some cases has been trivial. Hence the common view that inflation persistence is high is not supported by our results.

The timing of the decline in the mean of the inflation process is often difficult to link directly to marked changes in monetary policy frameworks, but in several countries there is some evidence of a simultaneous decline in mean across the different price components that coincides with a change in the policy framework. An examination of the effects of changes in monetary frameworks on the persistence of inflation expectations rather than the inflation rate may be a more fruitful line of research.

Our results raise questions about the mapping of various theories of price determination to movements in aggregate inflation. The previous literature argues that the finding of high levels of persistence is inconsistent with most of the standard theories. Our finding of low inflation persistence is thus more supportive of these theories. However, when we examine the link between our estimates of persistence for the disaggregated CPI data, and estimates obtained from other studies of the duration of price-setting, the results obtained are still at odds with conventional theories. Finally, our analysis also reveals that in some cases, statistical methodology for calculating the CPI can influence the time series properties of the data.

2. Theoretical motivation

Theories of aggregate inflation persistence have generally been derived from microeconomic models of price setting that can be classified into three broad categories (and which need not be mutually exclusive): time-dependent models, limited information models and menu-cost or state-dependent models.[4] Many of these models imply high persistence in the price level, which then translates into very low or even negative persistence in the inflation rate.

The canonical time-dependent model of price-setting was developed by Taylor (1980). In Taylor's model, prices are set as a markup over marginal cost in a sequence of overlapping wage contracts which last for a fixed number of periods, n. Each contract is set to take account of both the wages in existing contracts and the wages expected to be set in future contracts. At any point in time, the aggregate price level is the average of the level of prices over the past n periods. In this setup, shocks today affect wages, and hence the price level, for the next $n - 1$ periods, as each of the n contracts is renegotiated. Furthermore, the longer the length of the contract, the more persistent will be the effect of shocks on wages and on the price *level*. The implications for aggregate *inflation* are straightforward.

Take the simple case in which

[4] Taylor (1999) provides a comprehensive survey of the literature.

$p_t = \rho p_{t-1} + \varepsilon_t$

where p_t is the log of the price level, ρ is a coefficient, and ε is a white noise disturbance.[5] If one estimates an AR(1) on the first difference of p_t, the resulting autocorrelation estimate will be $\frac{1}{2}(\rho - 1)$. So, for the cases in which the price level has positive persistence, inflation will have negative autocorrelation.[6] Fundamentally then, the Taylor model is one of price level persistence rather than inflation rate persistence.

Similarly the much used model of Calvo (1983) implies persistence in the price level. In this model, firms change their prices in response to a signal they receive with a fixed probability each period. When prices change, firms reset them to minimise deviations from the expected optimal price level. Because only a subset of prices is changed each period, changes are staggered. The timing of the changes generates the persistence in the price level in response to a shock. But since the price setters are forward looking, basing their decisions in part on expectations, the result is that the inflation rate has no persistence. Instead inflation moves immediately to its new level in response to a shock.

These models of overlapping contracts have been criticised for their assumption of an exogenous fixed contract length (and fixed probability of receiving a signal). An alternative strategy is to assume state-dependent price setting, such as that implied by menu-cost models. Caplin and Spulber (1987) show that standard menu-cost based models of price adjustment do not generate a straightforward mapping between individual price changes and the behaviour of the aggregate price level. Indeed, the relationship can vary considerably over time, depending on the shocks that precipitate the price changes. As a result, the persistence of the price level depends on the size and timing of the shocks, and has no direct implications for inflation persistence.

Limited information models generate some persistence in both the price level and inflation. The Lucas (1972) islands' model of price setting is the basis for models of this genre. In the face of increased demand for her product, a price-setter is unsure whether this reflects general upward pressure on prices or an idiosyncratic shock. This creates a signal extraction problem where individuals have to ascertain the extent to which the observed price change is economy - wide or firm - specific. Price setters will only gradually adjust their prices upwards as the information problem is resolved. The limited information slows down the price adjustment process inducing some persistence in the aggregate inflation rate as price setters learn what the true signal is.

Variants of the Calvo and Taylor time-dependent price-setting models are a central part of many New Keynesian models (for example, Woodford (2003)). The assumption of forward-looking inflation expectations that is made in this framework means that such models imply that aggregate inflation has no persistence.

This aspect of these models has been criticised by Ball (1994), Fuhrer and Moore (1995) and Rudd and Whelan (2001) inter alia. Ball (ibid) pointed out that traditional time-dependent models imply that (credible) disinflations are costless, and, in some cases, can even be associated with a boom in output. This is clearly at odds with the practical experience. Fuhrer and Moore (ibid) observe that the nature of the inflation process implied by such models does not match that of the process seen in the United States, most notably the apparent high persistence of US inflation. However, as discussed in more detail below, Fuhrer and Moore do not allow for changes in the mean of the inflation process when estimating the features of the US inflation process.

To better match the aggregate inflation persistence that they find in the US data, Fuhrer and Moore (ibid) develop a model of overlapping contracts based on Buiter and Jewitt (1981) where workers care about relative real wages; that is, the current wage is set relative to past and expected future wages. Prices are again a markup over wages. As Roberts (1997) points out, this effectively "slips a derivative", transforming the Taylor/Calvo models of price level persistence into models of inflation persistence.

Roberts (1998) criticises the Fuhrer and Moore motivation, noting that it implies that labour supply is a function of the change in the relative real wage, rather than the level of the real wage as is the case in

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[5] A general *n* period model will yield a high-order autoregressive process. In all cases, the persistence in the price level will depend not only on the length of the contracts, but also on things like the relative-price elasticity of demand.

[6] Whelan (2004) demonstrates this in a more general context.

standard microeconomic models of labour supply. However, Roberts goes on to argue that their structure can be better explained as a departure from complete rational expectations. In the Fuhrer-Moore framework, inflation expectations can be written as a weighted average of backward and forward-looking inflation expectations, where the backward-looking component is simply lagged inflation. Allowing for a backward-looking component in expectations formation has been a common approach in modelling inflation in applied policy research.

The influence of the monetary policy framework, and particularly an announced inflation target, on the inflation process can be modelled in terms of their influence of the degree to which inflation expectations are forward looking. A perfectly credible inflation target would cause all price setters to adopt completely forward-looking inflation expectations, anchored on the inflation target, resulting in a world very similar to that in most New Keynesian models. The announcement of a credible inflation target would thereby lead to a marked decline in inflation persistence from the previous regime where there was a strong backward-looking element to expectations (Taylor 1998).

Erceg and Levin (2003) and Orphanides and Williams (2003) develop models of this sort. They show that inflation persistence can come from the public's limited information about the central bank's policy objectives. The persistence arises because the public only gradually learns about changes in the central bank's policy framework. When there is no change in the framework, or the framework is credible, they show that inflation persistence should be low. Similarly Orphanides and Williams simulate a model with similar features and show that the absence of a long-run inflation objective for the central bank results in markedly higher inflation persistence than a world where the inflation objective is clearly understood by price-setters.

The argument can be illustrated very simply with a basic Phillips curve inflation equation where expectations are a mixture of backward and forward expectations where the forward component is the inflation target, $\bar{\pi}$:

$$\pi_t = \pi_t^e + \beta(y_t - \bar{y}_t) + \varepsilon_t$$

$$\pi_t^e = \alpha\pi_{t-1} + (1-\alpha)\bar{\pi}$$

The persistence of the inflation process is given by the parameter α, the weight on the backward-looking term in the equation for inflation expectations. As the weight on the inflation target increases, α declines and observed inflation persistence declines, until in the limit, with perfect credibility of the inflation target, $\alpha = 0$ and there is no persistence in the univariate inflation process (except to the extent that the output gap term is autocorrelated).

Using a similar argument, Sargent (1999) links inflation persistence directly to the central bank's understanding of the inflation process and its monetary framework (see also Cogley and Sargent (2001)). He argues that the inflation of the late 1960s and early 1970s resulted from the adoption of an inappropriate monetary framework by the Federal Reserve (a similar argument can be made for other countries). The Federal Reserve misinterpreted the evidence of low inflation persistence in the 1950s and 1960s as implying an exploitable trade-off between inflation and output. The objectives of the central bank did not change, rather their understanding of the economy was incorrect.

Effectively, estimates of the inflation equation above failed to take account of the expectations equation, namely that inflation expectations might adjust to a rise in inflation. Over time, following the rise in inflation that resulted from this mistaken approach, the central bank gradually learned the true process for inflation. Policymakers observed the persistence in aggregate inflation as expectations adjusted upwards. As the central bank changed its monetary policy framework to take account of the re-estimated model of the economy that embodied this inflation persistence, policy was once again directed at reinstating low inflation, through the disinflations of Volcker and Greenspan. Sargent expresses the concern that the low persistence being observed currently may again result in central banks mis-estimating the inflation equation. This might tempt the central bank into trying to exploit the Phillips Curve trade-off, thinking incorrectly that the inflationary consequences of a rise in inflation induced by an increase in output will be minor.

Most of these theories of price-setting assume a seamless mapping from the firm-level price setting decision to aggregate inflation. However, aggregation issues may be critical. That is, it is possible that there is an important difference between thinking about inflation as though there was only one good in the economy rather than the reality that the consumer price index is an amalgam of many different prices. Hence is it meaningful to talk about persistence in the aggregate inflation rate versus

persistence in the components? In terms of Lucas' island model, one can think of all prices rising through time with a common component given by the inflation target and relative price movements around that common mean. There may well be persistence in the individual goods categories, as a result of staggered price changes by individual producers of each good in response to a shock to that particular good, but this would not necessarily translate into inflation persistence in the aggregate inflation process, where the effect of the common stable mean would tend to dominate. Alternatively, as discussed above, Caplin and Spulber (ibid) and Caplin and Leahy (1997) show that the relationship between individual behaviour and the aggregate price data can be quite imprecise.

3. Methodology and existing evidence on inflation persistence

The previous literature on inflation persistence has used a number of approaches to measure persistence. These have included the coefficient on the lagged dependent variable in an inflation equation, the sum of the lagged coefficients in an AR(*n*) model of inflation, and the half-life of a shock to the inflation process (see Andrews and Chen (1994) for a discussion of these issues). Generally, it has been found that all of these measures give broadly similar estimates of inflation persistence (Clark (2003)). In this paper we use two measures: the simplest measure, namely the AR(1) coefficient; and a measure calculated as the sum of the coefficients of an AR(12) process for monthly price series and an AR(4) process for quarterly price series.[7]

If the estimates of persistence are close to one (that is, inflation is close to a unit root process), Hansen (1999) shows that the point estimates can be biased downwards and provides a bootstrap procedure to calculate the estimates of persistence as well as their confidence intervals. However, as we will show in the next section, many of our estimates are relatively small (in absolute value) and so this is not a major issue.

Estimates of persistence have been obtained in univariate models of inflation, models of the Phillips curve which also take account of the influence of the output gap, exchange rate changes and oil prices on inflation, as well as in larger macroeconomic models. We are more interested in the inflation process itself and its links to pricing theories and hence have concentrated on the univariate models.

The use of a univariate model means that we are omitting other potential drivers of the inflation process. This omitted variable bias may influence our estimates of persistence. It also does not allow us to identify the source of the observed persistence. For example, in a new Keynesian model, much of the persistence in the inflation process may derive from the process determining the output gap. However, again, the purpose of this exercise is primarily to document the statistical properties of the inflation process.

Using these various approaches, much of the previous literature has tended to find that the inflation process tends to be highly persistent. The AR coefficient is generally found to be close to one in a large number of countries when estimated on inflation data over the past 20 years or so (Clark (ibid), Gadzinski and Orlandi (ibid), Levin and Piger (ibid), Batini (2002), Batini and Nelson (2001), O'Reilly and Whelan (2004), Stock (2001)). This is the stylised fact which has motivated much of the subsequent theoretical work.

More recently, some papers have examined whether this estimate of persistence has changed over time. Debelle and Wilkinson (2002), Levin and Piger (ibid) and O'Reilly and Whelan (ibid) used rolling regressions to examine the evolution of the AR coefficient. Debelle and Wilkinson show that persistence has declined considerably over the past decade in Australia, the United Kingdom, Canada and New Zealand, but there was little evidence of a decline in persistence in the United States. Using more recent data Levin and Piger show that in the United States, persistence has also declined by a similar order of magnitude, but only relatively recently. O'Reilly and Whelan and Gadzinski and Orlandi (ibid) find little evidence of a change in persistence in euro area countries. These rolling regressions can indicate whether persistence has changed, but are not very precise in determining the exact

[7] Hereafter, a reference to an AR(12) model should be translated to AR(4) for Australia and New Zealand which only have quarterly CPI data.

timing of the change in persistence and hence it is difficult to map the change in persistence to factors such as a change in the monetary policy framework.

In obtaining these estimates of high inflation persistence, and measuring the change in persistence over time, very few papers allow for the possibility of a shift in the mean of inflation over the sample period. Perron (ibid) shows that failing to account for a shift in the mean of a process will give misleading estimates of persistence. Against this, allowing for too many shifts in the mean can lead to an under-estimate of persistence. In the extreme, controlling for a shift in the mean each period would generate an estimate of zero persistence. In this paper we take an agnostic view on the appropriate number of mean shifts to allow for. Our primary purpose is to demonstrate the significant impact that mean shifts can have on existing estimates of persistence. As will be discussed in the results below, the largest decline in the estimate of persistence tends to occur when only one mean shift is allowed for.

Clark (ibid) and Levin and Piger (ibid) do allow for an explicit shift in the mean, and demonstrate that, even so, inflation persistence is markedly lower in the more recent period. For example, Clark finds that allowing for a break in the mean of inflation in 1993 Q1, inflation persistence in the United States in an AR model is reduced substantially from around 0.9 to around 0.13. Similarly, the results in Levin and Piger show that once a structural break is allowed for, the null hypothesis of a unit root can be rejected at the 95% confidence level for 29 of the 48 inflation series that they examined, whereas the null hypothesis could only be rejected for eight series when no structural break was allowed for. Gadzinski and Orlandi (ibid) also find that once shifts in the mean are controlled for, persistence has generally been low in euro area countries and the United States. Demers (2003) investigates this issue in Canada using a Phillips-curve framework. He finds that once a shift in the mean is allowed for, Canadian inflation also exhibits inflation persistence close to zero, compared to around 0.8 if no break is estimated.

To test for shifts in the mean, we use the methodology described in Bai (1999). First we conduct a Quandt (1960) test on the AR(1) and AR(12) models of inflation. This finds the maximum value of the Chow test over all possible break points. Once we have identified this point, we re-estimate the model allowing for a structural break in the mean at this date and obtain a second estimate of persistence. We then adopt the same procedure to identify a mean break in the sub-samples either side of the first mean break, thereby obtaining two more breakpoints (Bai shows that this is asymptotically equivalent to re-testing for another break on the full sample adjusted for the first mean break). We then obtain three more estimates of persistence: one allowing for each of the two additional mean breakpoints in combination with the original breakpoint, and the third allowing for all three mean breaks.[8] Levin and Piger (ibid) find that Bayesian methods of testing for structural breaks generate very similar results to the approach we have adopted here.

We also conduct the same Quandt procedure to identify a structural shift in persistence in both the original AR(1) and AR(12) regressions with no mean breaks, as well as the regressions which include one break in the mean of the series.

In addition to testing for persistence in the aggregate CPI, which has tended to be the focus of much of the previous literature, we also examine the persistence properties of disaggregated components of the CPI (Ernst and Mojon (ibid) adopt a similar approach using euro area data). Along with the use of cross-country data, this allows us to investigate where the changes in the properties of the aggregate CPI series are coming from. If the change in the mean or the persistence parameter is associated with a change in the monetary policy framework, then it is likely that the timing of the change will be similar for the disaggregated components. As a result we have obtained CPI data at the first level of disaggregation, which generally includes the following categories of goods and services: food, alcohol tobacco, clothing & footwear, housing, furniture, health, transport, recreation, communication and education.[9]

We can also investigate whether the statistical methodology used to calculate the CPI from the raw price data may be artificially generating some of the persistence. For example, the calculation of the

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[8] Where the sample size of any of the sub-samples was insufficient to test for a mean break, we then looked for a third breakpoint in the two new sub-samples created after the location of the second break point.

[9] The data are seasonally adjusted using the X-12 procedure in all cases except where we were able to obtain seasonally adjusted data directly from the national statistical agency. The seasonal adjustment is particularly important for some components where there tends to be a large shift in the price level once a year, such as education.

housing component of the CPI in some countries involves an estimate of owner's equivalent rent that embodies a moving average component. In some countries, the treatment of price falls due to the timing of sales has also changed.

Bils and Klenow (2002) use even more disaggregated price data than those employed in this paper, examining the properties of 123 price components of the CPI. They find that few of these series exhibit much persistence and find little relationship between the frequency of price change and the persistence (and volatility) of the price series. Clark (ibid) uses a similar data set and finds that again, once a structural shift in the mean is controlled for, there is very little evidence of persistence in either the aggregated or disaggregated data.

4. Results

The results fall naturally into three groups for each of the AR(1) and AR(12) models. First, there is the set based on the aggregate inflation data. Here we have data on 17 countries over various time periods, the majority of which begin in 1990. Second, we present results based on data covering prices in 12 disaggregated categories for 16 of the countries. Finally, we look at the timing of the breaks to see if they coincide either within countries or across commodities.

Aggregate inflation

We begin with the measures of persistence in the aggregate inflation series, conditional on allowing for up to three breaks in the mean of the series. The results in Tables 1a and 1b are ordered by the estimate of the persistence that assumes no breaks in the time series. Note the following general characteristics of the results. First, the AR(12) estimates of persistence are higher than the AR(1) estimates. Those countries which have higher persistence on the AR(1) measure also tend to have higher persistence on the AR(12) measure. Second, allowing for breaks in the mean reduces estimated persistence in both models.

Third, the major drop in estimated persistence comes after allowing for the first break. Fourth, after allowing for one break, none of the AR(1) estimates of persistence exceed one half, and with three breaks, none exceed one third! With the AR(12) estimates, two countries have persistence in excess of two thirds after one break, while only three have persistence in excess of one half after two mean breaks. Finally, with the exception of Portugal, the euro area countries for which we have data exhibit low aggregate persistence, even when there are no mean breaks in the AR(1), and one mean break in the AR(12).

The bulk of the results in Table 1 are obtained using data beginning in 1990. For six countries, we have longer time series, so we are able to examine the importance of the sample period. The results comparing the full sample with the shorter sample beginning in 1990 are reported in Tables 2a and 2b. The six countries show a marked decline in measured persistence once we go to the shorter sample. In fact, if we were to restrict ourselves to the last decade and a half we would conclude that inflation in these countries showed the same lack of persistence evident in the euro area data. Alternatively, if we had a longer run sample for the euro area countries, there may be evidence of higher persistence and/or a higher mean in earlier periods, although Gadzinski and Orlandi (ibid) tend not to find this.

These results highlight the importance of controlling for mean breaks when estimating persistence. If one does not allow for any break in the mean, then aggregate inflation persistence tends to be higher and close to one, as has been found previously (eg, Fuhrer and Moore (ibid), Rudd and Whelan (ibid)). However, allowing for even one break in the mean substantially reduces the estimates of persistence, as Levin and Piger (ibid) and Gadzinski and Orlandi (ibid) have also demonstrated.

If we test for a change in persistence without allowing for a break in the mean, we find a statistically significant decline in AR(1) persistence in all countries, with the exception of the Netherlands and Luxembourg where persistence rises in the second half of the sample from a low negative number. These results are consistent with those obtained from rolling regressions such as in Debelle and Wilkinson (ibid) and Levin and Piger (ibid). For the AR(12) measures, the results are not quite so clear cut. Inflation persistence declines in nearly every case but the decline is only significant for eight of the 17 countries. Again, account must be taken of the fact that we only have a relatively recent sample of data for the euro area countries.

Table 1a

Persistence in aggregate inflation AR(1) model

	No breaks	One break	Two breaks	Three breaks
New Zealand	0.78	0.45	0.37	0.32
Chile	0.70	0.41	0.26	0.15
Portugal	0.65	0.20	0.15	0.10
Australia	0.64	0.37	0.31	0.29
United States	0.63	0.38	0.33	0.33
United Kingdom	0.59	0.44	0.31	0.22
Italy	0.44	0.06	0.02	0.00
Canada	0.34	0.28	0.08	0.08
Finland	0.26	0.02	–0.02	–0.06
Sweden	0.24	0.14	0.03	0.03
Spain	0.21	0.11	0.05	0.03
France	0.09	0.01	–0.01	–0.02
Netherlands	0.06	–0.04	–0.08	–0.10
Austria	–0.05	–0.16	–0.21	–0.25
Germany	–0.20	–0.22	–0.26	–0.28
Belgium	–0.27	–0.28	–0.30	–0.30
Luxembourg	–0.33	–0.40	–0.42	–0.43
Median	**0.26**	**0.11**	**0.03**	**0.03**
EU Aggregate	0.30	0.15	0.12	0.10

Computed as the coefficient in a first-order autoregression. Breaks are determined by sequential Quandt (1960) tests on individual series. The countries are sorted from most to least persistent, as measured by the case without breaks.

Table 1b

Persistence in aggregate inflation AR(12/4) model

	No breaks	One break	Two breaks	Three breaks
Portugal	0.94	0.45	0.38	0.10
United States	0.91	0.60	0.43	0.41
Italy	0.88	0.45	0.34	0.35
Canada	0.87	0.83	0.47	0.27
Chile	0.87	0.76	0.70	0.61
Australia	0.86	0.61	0.56	0.55
New Zealand	0.82	0.46	0.29	0.18
United Kingdom	0.82	0.66	0.60	0.60
Sweden	0.80	0.65	0.39	0.37
Finland	0.79	0.30	0.06	–0.30
Austria	0.70	0.33	0.16	–0.19
Spain	0.60	0.23	0.04	–1.03
Netherlands	0.55	–0.02	–0.05	–0.06
France	0.46	0.25	–0.14	–0.51
Luxembourg	0.13	–0.62	–0.70	
Belgium	0.00	–0.11	–0.86	–1.03
Germany	–0.15	–0.34	–0.33	
Median	**0.80**	**0.45**	**0.29**	**0.27**
EU Aggregate	0.74	0.82	0.42	0.46

Computed as the sum of the coefficients in an AR(12) model except AR(4) in Australia and New Zealand. Breaks are determined by sequential Quandt (1960) tests on individual series. The countries are sorted from most to least persistent, as measured by the case without breaks.

Table 2a

Impact of sample period on estimated persistence AR(1) model

	Sample	No breaks	One break	Two breaks	Three breaks
Australia	Long	0.64	0.37	0.31	0.29
	Short	0.12	0.06	–0.02	–0.07
Canada	Long	0.34	0.28	0.08	0.08
	Short	0.09	0.00	–0.02	–0.03
New Zealand	Long	0.78	0.45	0.37	0.32
	Short	0.06	–0.01	–0.14	–0.23
Sweden	Long	0.24	0.14	0.03	0.03
	Short	0.26	0.04	0.01	0.01
United Kingdom	Long	0.59	0.44	0.31	0.22
	Short	0.36	0.16	0.14	0.12
United States	Long	0.63	0.38	0.33	0.33
	Short	0.32	0.26	0.25	0.23

Short samples all begin in 1990. Long samples begin in 1969 in Australia, 1955 in Canada and Sweden, 1975 in New Zealand, 1980 in the United Kingdom and 1978 in the United States.

Table 2b

Impact of sample period on estimated persistence AR(12/4) model

	Sample	No breaks	One break	Two breaks	Three breaks
Australia	Long	0.86	0.61	0.56	0.55
	Short	0.40	0.21	0.15	0.05
Canada	Long	0.87	0.83	0.47	0.27
	Short	–0.04	–0.11	–0.11	–0.25
New Zealand	Long	0.82	0.46	0.29	0.18
	Short	0.11	–0.06	–0.33	–0.35
Sweden	Long	0.80	0.65	0.39	0.37
	Short	0.45	0.23	0.22	0.19
United Kingdom	Long	0.82	0.66	0.60	0.60
	Short	0.38	0.29	0.04	0.02
United States	Long	0.91	0.60	0.43	0.41
	Short	0.10	–0.02	–0.28	–0.76

Short samples all begin in 1990. Long samples begin in 1969 in Australia, 1955 in Canada and Sweden, 1975 in New Zealand, 1980 in the United Kingdom and 1978 in the United States. AR(12) models except AR(4) for Australia and New Zealand.

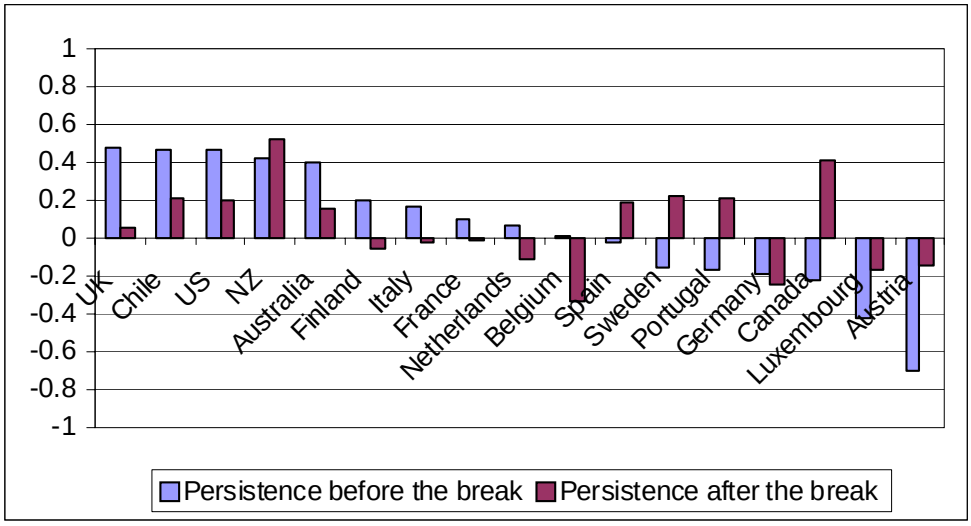
Finally, we look to see whether the persistence changes, once we allow for a single break in the mean. That is, we first find the most likely date for a break in the mean, and then the most likely date for a break in the slope of the AR(1) and AR(12) regressions. The results are reported in Figure 1. The AR(1) point estimates show declines in persistence in 11 of the 18 countries. Nearly of all of these changes have conventional t-ratios below –1.6. (One half of the increases have t-ratios above +1.6). The pattern suggests a clear decline in the absolute value of the persistence parameter. Of particular

note is the statistically significant decline in the positive persistence in Australia, Chile, the United Kingdom and the United States. The decline in persistence in Chile, the United Kingdom and United States occurs around the start of the disinflation in 1990, while in Australia it occurs following the recession in the early 1980s. The rises in persistence in Canada and Sweden occur around the time of the oil shock in 1973.

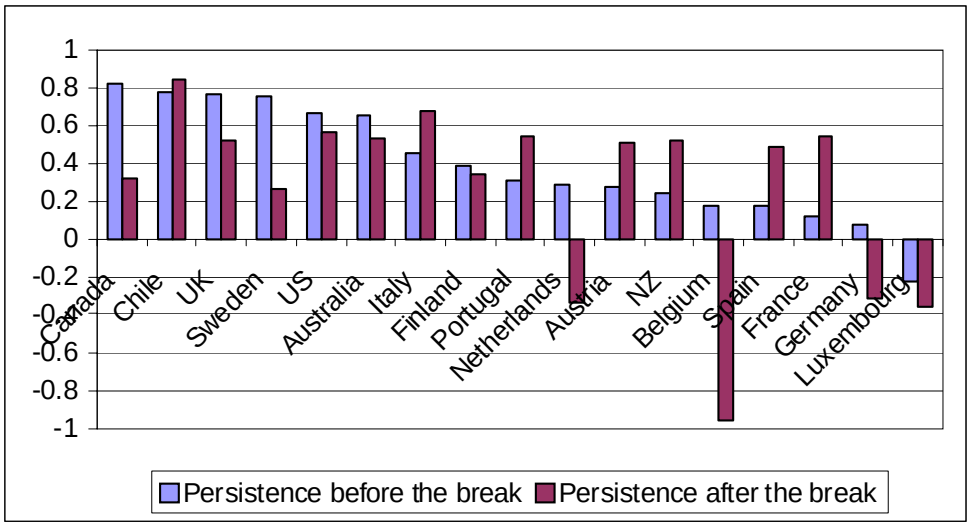
Figure 1

Changes in persistence of aggregate inflation

A. AR(1) model



B. AR(12/4) model



Estimates for the AR(1) coefficient and sum of AR(12) or AR(4) coefficients before and after an estimated break, assuming one break in the mean of series, using the full sample.

Again the AR(12) estimates in the bottom panel show more mixed results. There are large declines in persistence in Belgium, Canada, Germany, Netherlands, Sweden and the United Kingdom, but in other countries there are only small changes and in some cases, measured persistence increases.

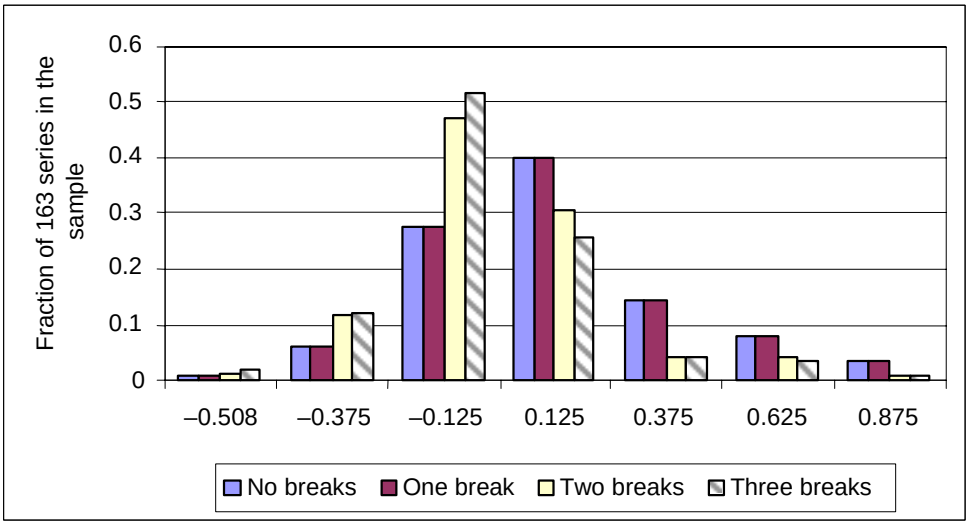
The disaggregated data

Turning to the component series, we study roughly 12 consumption categories for 15 countries. In total, we have 163 times series that can be used in estimating the AR(1) model, and 151 series that we can use to estimate the AR(12) model.[10] To get a flavour of the results, we begin with a histogram that displays the frequencies of the estimated AR(1) and AR(12) parameters, conditional on the number of assumed breaks in the mean of the individual inflation series. Figure 2 shows both the decline in estimated persistence once mean breaks are introduced, as evidenced by the leftward shift in the distribution, and the wide range of estimates across countries and components.

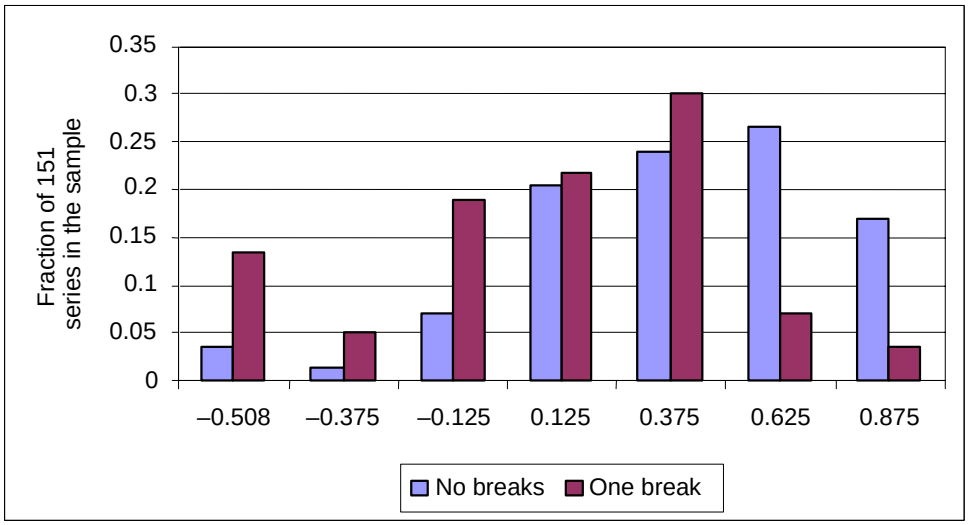
Figure 2

Frequency distribution of persistence in components of inflation

AR(1) model



AR(12/4) model



[10] For the remaining 12 series the estimates of the sum of the AR(12) parameters exceeded one in absolute value, and so these were ignored.

The descriptive statistics in Tables 3a and 3b bear out the importance of the mean breaks. As we allow for breaks, the median of the AR(1) estimates falls from +0.08, to 0.00, and then becomes negative. Importantly, the fraction of estimates that are positive shrinks from 66%, with no mean breaks, to 49% allowing for one break, and then 40% when there are two breaks. Results for the 10 European countries show generally less persistence, again possibly reflecting the use of the more recent sample period.

Table 3a

Descriptive statistics for persistence in inflation subaggregates

AR(1) regression

	No breaks	**One break**	**Two breaks**	**Three breaks**
Full sample (15 countries, 163 series)				
Minimum	–0.50	–0.51	–0.51	–0.52
25th percentile	–0.04	–0.12	–0.14	–0.17
Median	0.07	0.00	–0.04	–0.06
75th percentile	0.25	0.12	0.05	0.04
Maximum	0.89	0.82	0.81	0.76
Percent >0	66%	49%	40%	34%
European countries only (10 countries, 120 series)				
Minimum	–0.50	–0.51	–0.51	–0.52
25th percentile	–0.09	–0.16	–0.17	–0.20
Median	0.03	–0.03	–0.06	–0.08
75th percentile	0.18	0.07	0.01	0.00
Maximum	0.67	0.55	0.46	0.42
Percent >0	58%	42%	32%	25%
Non European countries (five countries, 43 series)				
Minimum	–0.20	–0.42	–0.44	–0.45
25th percentile	0.09	–0.05	–0.06	–0.08
Median	0.29	0.13	0.05	0.04
75th percentile	0.66	0.35	0.29	0.28
Maximum	0.89	0.82	0.81	0.76
Percent >0	88%	70%	63%	60%

Computed using the estimated AR(1) coefficients from regressions of the 151 components of inflation. Estimates use the full sample.

Table 3b

Descriptive statistics for persistence in inflation subaggregates

AR(12/4) regression

	No breaks	One break
Full sample (15 countries, 151 series)		
Minimum	–0.99	–0.95
25th percentile	0.14	–0.17
Median	0.41	0.17
75th percentile	0.66	0.37
Maximum	0.94	0.85
Percent >0	88%	63%
European countries only (10 countries, 101 series)		
Minimum	–0.99	–0.95
25th percentile	0.14	–0.25
Median	0.38	0.06
75th percentile	0.61	0.31
Maximum	0.9	0.82
Percent >0	87%	57%
Non European countries (Five countries, 41 series)		
Minimum	–0.49	–0.59
25th percentile	0.11	–0.06
Median	0.49	0.34
75th percentile	0.76	0.49
Maximum	0.94	0.85
Percent >0	90%	76%

Computed using the estimated AR(12) coefficients from regressions of the 163 components of inflation. Estimates use the full sample.

For the AR(12), the estimates of persistence are clearly higher, but again they are markedly lower once a mean break is allowed for, with the median declining from 0.41 to 0.17.

Moreover, Table 3 also shows that most of the estimates of persistence are small, even if there is no mean break. Even in the case of the non-European countries, which tend to have higher positive persistence, three-quarters of the series have estimates of AR(1) persistence below 0.67 while for the AR(12) persistence estimates, three-quarters of the series have estimates below 0.49 allowing for one mean break.

In terms of the influence of the statistical methodology on the properties of the inflation series, there was a change in the timing of sales for some components of the euro area inflation data, most notably clothing, which clearly affected the identification of breaks in the time series.

It is interesting to take the estimates and compute averages across product categories. Table 4 reports the results of this exercise. Included is the average together with a t-ratio for the test of whether the estimate is zero. (The t-ratio is constructed in the conventional way using

heteroskedasticity-robust standard errors computed using a simple regression.) Again, the AR(12) estimates are noticeably higher than the AR(1) estimates. Once we allow for breaks, very few components show any sizeable amount of positive persistence in either case.

Looking at Table 4a, we see that the components fall into three rough groups. The most persistent are food, housing and transportation all of which have some signs of positive persistence. Then come alcohol and tobacco, furniture and health, with positive but very low persistence. The third group, all with small negative persistence, is communication, miscellaneous, recreation, clothing, restaurants and education.

Table 4a

Average persistence across countries within components

AR(1) regression

Component	No breaks	One break	Two breaks	Three breaks
Alcohol	0.10 1.54	0.04 0.73	0.01 0.23	0.00 –0.05
Clothing	0.01 0.06	–0.07 –0.80	–0.09 –1.05	–0.10 –1.16
Communication	0.03 1.01	–0.03 –0.87	–0.05 –1.78	–0.06 –2.12
Education	0.01 0.28	–0.14 –4.05	–0.17 –4.86	–0.18 –5.30
Food	0.23 3.35	0.13 2.18	0.09 1.54	0.06 1.06
Furniture	0.28 3.41	0.08 1.21	0.02 0.28	–0.01 –0.14
Health	0.14 1.98	0.06 0.97	0.02 0.40	–0.01 –0.28
Housing	0.20 2.45	0.12 1.62	0.07 0.98	0.05 0.67
Miscellaneous	0.09 1.54	–0.03 –0.66	–0.08 –2.00	–0.10 –2.81
Recreation	0.06 0.63	–0.08 –1.24	–0.13 –1.96	–0.14 –2.16
Restaurants	0.12 1.59	–0.05 –0.84	–0.09 –1.81	–0.11 –2.23
Transportation	0.18 2.99	0.10 1.91	0.07 1.31	0.05 0.99
Number positive **with t ratio >1.6**	**12** **6**	**6** **2**	**6** **0**	**3** **0**

In Table 4b, only furniture and housing have noticeable positive persistence when one mean break is allowed for. In the latter case, this is likely to be partially a statistical artefact reflecting the methodology used to calculate this component of the CPI. For example, in the United States, the calculation of the owner's equivalent rent component of the housing index involves a smoothed series. In other countries, the methodology has, at times, included a measure of mortgage interest costs which are directly linked to policy interest rates. Policy rates tend to be adjusted in a smooth fashion (see, for example, Bernanke (2004) and the references therein) thereby inducing smoothness in this price component.

Table 4b

Average persistence across countries within components

AR(12/4) regression

Component	No breaks	One break
Alcohol	0.19 3.31	–0.23 –1.80
Clothing	0.20 0.87	0.03 0.16
Communication	0.17 3.78	–0.26 –1.77
Education	0.27 1.80	0.18 1.73
Food	0.38 4.45	0.13 1.51
Furniture	0.62 10.48	0.34 5.80
Health	0.34 4.55	–0.03 –0.35
Housing	0.46 7.56	0.24 4.40
Miscellaneous	0.50 6.63	0.03 0.24
Recreation	0.29 2.38	–0.20 –1.20
Restaurants	0.48 3.97	0.20 1.70
Transportation	0.40 7.00	0.15 3.24
Number positive **with t ratio >1.6**	**12** **11**	**8** **5**

The theory discussed in Section 2 suggests that persistence should be related to two things: the time between price changes and the degree to which pricing decisions are backward looking. The longer the time between price changes - the longer the Taylor-style contracts - the more persistence there will be in the *price level*, and the more negative the persistence in price changes. By contrast, the more backward looking pricing decisions are, the more positive the persistence in the price changes.[11]

For eight European countries plus the United States we have been able to collect data on the duration of price changes in categories that roughly match the persistence data. We have computed simple regressions with and without country fixed effects. The results are reported in Table 5. Country fixed effects are clearly important - Spain and the United States have systematically higher levels of AR(1) persistence, while Finland's inflation shows below average persistence. Once we include these fixed effects, and allow for breaks in the mean when estimating persistence, we find that the longer the time between price changes, the lower the amount of persistence in inflation. That is, the coefficient in the

[11] The elasticity of demand for a product will also have an impact on persistence. The more elastic demand, the more costly it is for a firm's price to deviate from that of its competition, and so the more persistent prices will be.

regression is negative. A possible explanation for this is that the more costly it is to change a price, the more forward looking the price setter.[12]

Table 5a

The relationship between persistence and duration

AR(1) regression

	No breaks	**One break**	**Two breaks**	**Three breaks**
Regression without fixed effects				
Duration	**0.10** **2.34**	0.02 0.66	–0.01 –0.24	–0.02 –0.74
Regression with fixed effects				
Duration	0.00 –0.06	0.00 –1.38	**–0.01** **–1.81**	**–0.01** **–1.85**
Austria	–0.01 –0.07	0.02 0.23	0.00 –0.07	–0.03 –0.48
Belgium	0.02 0.22	0.01 0.20	–0.01 –0.11	–0.02 –0.42
Spain	0.20 2.58	0.16 2.68	0.14 2.63	0.11 2.15
Finland	–0.05 –1.19	–0.07 –1.90	–0.09 –2.50	–0.11 –2.95
France	0.11 1.71	0.02 0.38	–0.02 –0.35	–0.04 –0.78
Italy	0.21 1.91	0.09 0.95	0.05 0.61	0.03 0.39
Netherlands	0.00 –0.05	–0.05 –1.13	–0.08 –1.61	–0.09 –1.85
Portugal	0.15 1.94	0.03 0.47	0.01 0.11	–0.01 –0.14
United States	0.38 3.23	0.24 2.53	0.18 2.44	0.17 2.28

Regression of persistence in component inflation series on time between changes for the component.

Turning to the results using the AR(12) data in Table 5b, we find a similar story. Once we include a single break in the mean, it is unclear whether the fixed effects belong in the regression at all. And with the simple bivariate regression we come to the same conclusion as we did with the AR(1) model. The results suggest a negative relationship between persistence and duration - the longer the time between price changes, the lower the persistence in inflation.

[12] We simply note that if we include commodity group fixed effects in place of country fixed effects, we find no relationship between duration and persistence. There are several possible explanations for this. One is that different commodities face different costs of price adjustment, leading to differences in duration, which is better measured by the dummy variables than by the direct estimates of the time between price changes. Alternatively, the variation in persistence could be driven by differences in the elasticity of demand across commodities, which are then proxied by the fixed effects. Without some independent source of information there is no way to disentangle these various explanations.

Table 5b

The relationship between persistence and duration

AR(12/4) regression

	No breaks	One break
Regression without fixed effects		
Duration	0.22 1.24	–0.33 –1.45
Regression with fixed effects		
Duration	0.01 0.87	0.02 1.14
Austria	0.06 0.20	–0.49 –1.21
Belgium	–0.76 –0.99	–1.26 –1.33
Spain	0.03 0.13	–0.45 –1.24
Finland	0.08 0.46	–0.55 –1.97
France	0.30 1.93	–0.21 –0.76
Italy	0.33 1.27	–0.36 –1.02
Netherlands	0.24 1.54	–0.34 –2.05
Portugal	0.50 2.59	–0.19 –0.73
United States	0.51 3.13	0.15 0.56

Regression of AR(12) persistence in component inflation series on time between changes for the component.

The timing of the breaks

We can look at the timing of the estimated breaks in the inflation process to address several interesting questions:

1. Do the breaks in the mean occur at the same time across commodity groups within a country? Or, alternatively, are they to be seen at the same time within commodity groups across countries?
2. Do the estimated changes in persistence (conditional on one mean break) occur at the same time either across commodity groups within a country, or within a commodity group across countries?
3. Finally, we can look to see if the mean and persistence breaks occur at the same time.

If policy shifts are primarily responsible for the changes in the inflation process, then we should see less variance in the timing of the shifts within countries than between. And if the policy changes that are responsible for the shifts in the mean of the inflation process also reduced its persistence, then the two sets of breaks should occur close together.

To address the questions about the commonality of breaks either within countries or commodity groups we measure how close the breaks dates fall to each other. For a particular country or commodity group we start by computing the median break date, and then calculate the mean absolute number of months from that median. The results for within countries are in Table 6; while the ones for commodity groups are in Table 7. What stands out immediately is how large these numbers are. Even within countries, break dates are quite spread out, with estimated average distance from the median of more than three years. For the commodity groups, the numbers are even bigger, with the maximum in excess of four years.

Table 6a

Mean absolute deviation from median of break date across commodities within countries

AR(1) regression in months

	Mean break	**Persistence break**
Austria	44.25	53.25
Belgium	41.08	49.58
Germany	14.33	21.33
Spain	29.92	33.92
Finland	25.17	23.67
France	18.25	22.42
Italy	21.58	39.25
Luxembourg	12.42	17.83
Netherlands	11.58	16.83
Portugal	34.83	29.33
Australia[1]	40.91	31.64
Chile	10.75	13.87
New Zealand[1]	46.13	31.62
United Kingdom[1]	32.00	43.87
United States[1]	28.37	41.63

[1] Results for Australia, New Zealand, the United Kingdom and the United States use the shorter sample beginning in 1990.

Table 6b

Mean absolute deviation from median of break date across commodities within countries

AR(12/4) regression in months

	Mean break	Persistence break
Austria	31.17	42.83
Belgium	28.17	33.00
Germany	13.42	16.50
Spain	26.75	32.08
Finland	19.00	15.33
France	23.25	35.25
Italy	24.25	30.17
Luxembourg	9.08	11.08
Netherlands	14.50	21.17
Portugal	24.91	24.82
Australia[1]	13.87	11.75
Chile	21.27	22.09
New Zealand[1]	28.00	20.12
United Kingdom[1]	22.70	26.40
United States[1]	38.38	36.87

[1] Results for Australia, New Zealand, the United Kingdom and the United States use the shorter sample beginning in 1990.

Table 7a

Mean absolute deviation from median of break date across countries within commodities

AR(1) regression in months

	Mean break	Persistence break
Alcohol	38.36	41.00
Clothing	51.80	24.40
Communication	26.69	39.00
Education	38.75	29.75
Food	40.00	28.57
Furniture	36.60	45.40
Health	39.36	34.57
Housing	49.79	43.43
Miscellaneous	37.27	34.40
Recreation	42.27	22.64
Restaurants	35.00	46.62
Transportation	38.85	45.15

Table 7b

Mean absolute deviation from median of break date across countries within commodities

AR(12/4) regression in months

	Mean break	Persistence break
Alcohol	32.42	34.00
Clothing	37.62	31.69
Communication	27.17	33.08
Education	40.36	36.73
Food	32.00	24.57
Furniture	30.21	28.79
Health	29.47	31.33
Housing	38.67	33.27
Miscellaneous	33.00	43.07
Recreation	30.29	32.86
Restaurants	25.20	19.27
Transportation	30.73	29.47

Looking more closely, we see that in a number of countries the spread is relatively small for the AR(1) results. Chile, the Netherlands, Germany, Luxembourg, and France stand out.[13] This suggests the possibility that a common shock is responsible for the changes in these countries. Importantly, though, persistence breaks are less synchronised than the mean breaks.

For the AR(12) results, although it is not that evident in Table 6b, for some countries there is evidence of a clustering of breaks in mean and persistence at particular dates when we look at the longer sample. For New Zealand, there is commonality in break points around 1987, when the country embarked on a major program of reform, including to its monetary policy framework. In the United States, there is also some clustering of break points in the early 1980s during the Volcker disinflation. There is also a notable similarity in the mean break points of the food series and the aggregate CPI series for six of the countries.

To address the final question of whether the mean and persistence breaks are simultaneous, we plot data on the frequency of the breaks in the mean and persistence. Figure 3 shows a histogram of the dates, grouped by year. There is some evidence of clustering around the time of the disinflation that occurred in a number of countries in the early 1990s, and also some evidence of clustering around the time of the slowdown in late 2000-01. It is hard to argue that, overall, these are close together.[14]

[13] The median break in these countries occurred in 1998:09 for Chile, 2000:04 in Luxembourg and the Netherlands, 2000:08 in Germany, and 1993:04 in France.

[14] We note that a study of the mean absolute time between the changes within individual countries leads to the same conclusion as the plot in Figure 3. The minimum mean absolute time is 17 months in Chile. For the remainder of the countries, the mean absolute time is between 20 and 50 months.

Figure 3

The timing of the breaks in mean and persistence

AR(1) model

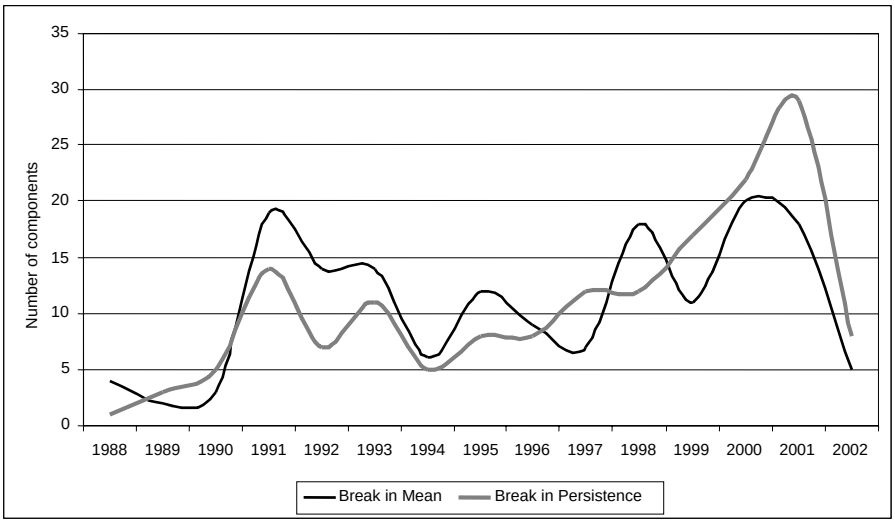
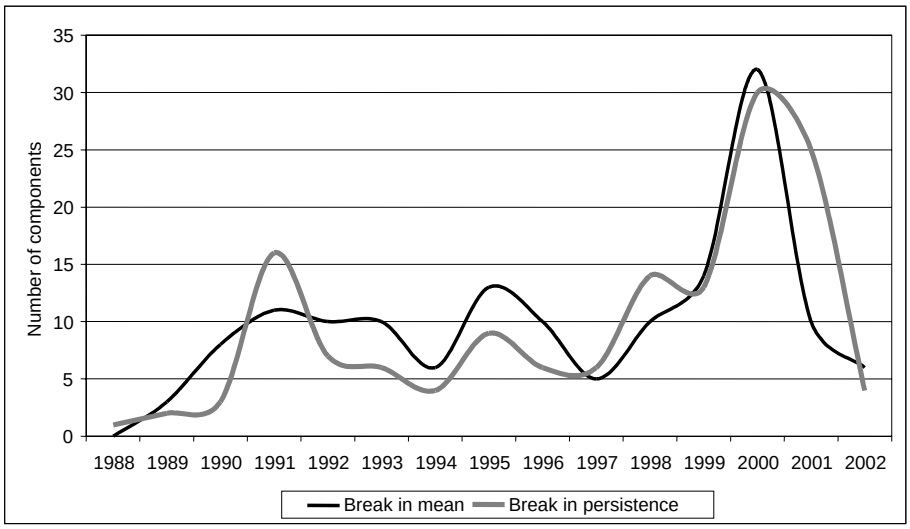


Figure 3 (cont)

The timing of the breaks in mean and persistence

AR(12/4) model



Data are the frequency of the first break in the mean of the data, and the break in the persistence conditional on the mean break. Date are grouped into years, and plotted as a smoothed line.

5. Conclusion

The main result of this paper is that the most significant change in the inflation process has, not surprisingly, been in its mean. We show that the conventional wisdom that inflation has a high level of persistence is not robust. Once one controls for a break in the mean of inflation, measured persistence is considerably lower. This is true at the aggregate CPI level, as well as at for more disaggregated price data. We do find some support for a decline in inflation persistence over the past few decades, but this is generally from a level that is already relatively low.

While one can argue that the changes in monetary policy frameworks have contributed to a reduction the mean of inflation, it is much harder to make the case that they have had a meaningful impact on persistence. Examining the timing of mean breaks across commodities within individual countries suggests that the relationship between changes in the monetary framework and changes in the mean of inflation is far from perfect (although the data for the euro area may post date the significant changes in monetary frameworks in those countries). There are some exceptions, including the disinflations in the United States in the early 1980s and in New Zealand in the late 1980s. Both episodes arguably entailed a change in the monetary framework.

The finding of little change in persistence also implies that the slope of the short-run aggregate supply curve - that is, the elasticity of inflation with respect to transitory changes in output - has been stable, once account is taken of change in the mean of inflation. Put another way, the sacrifice ratio has not changed much, even in the face of changes in monetary policy regime. But the important role played by changes in the mean of inflation in our results highlights the need to take account of changes in inflation expectations when considering sacrifice ratios. It is likely that the change in the mean is directly related to changes in inflation expectations, and hence that examining the persistence of inflation expectations may be a more fruitful area of future research. If inflation expectations have less persistence because of increased credibility in the monetary framework, then there will not be a need for the central bank to engineer a decline in output below potential to return inflation to its desired level.

We find occasional large shifts in the mean, which one might think of as extremely persistent (ie permanent) responses to shocks. But the rest of the time, persistence is modest. So occasionally there are shocks coupled with monetary policy reactions that allow or engender shifts in the mean of inflation, but the rest of the time, the monetary policy response, or the credibility of the framework, ensures that the shocks do not translate into mean shifts.

Our results also suggest that standard theories of price setting are not as far from matching the properties of the inflation data as some of the previous literature has suggested. That said, our examination of the relationship between persistence and duration suggests that there remain some anomalies. Modified Calvo or Taylor models which include elements of state-dependence along the lines of Caplin and Spulber model may be the most fruitful theoretical approach.

Appendix A:
Data sources

Price data

All data were seasonally adjusted using X-12, except for the United States where the data were seasonally adjusted by the Bureau of Labour Statistics.

Australia: *Quarterly* CPI data published by the Australian Bureau of Statistics, provided by the RBA. Sample from September 1969 to September 2003 for CPI, food, alcohol, clothing, housing, furniture (household goods), health and transport; from September 1980 for communication; from March 1982 for education, recreation; from September 1989 for miscellaneous.

Austria: Harmonised index of consumer prices (HICP) data published by Eurostat, provided by the European Central Bank (ECB). Sample from January 1987 to January 2003.

Belguim: HICP data published by Eurostat, provided by the ECB. Sample from January 1991 to February 2003.

Canada: CPI data published by Statistics Canada, provided by the Bank of Canada and the Bank for International Settlements (BIS). Sample from January 1955 to January 2004 for the CPI.

Chile: CPI data published by the National Bureau of Statistics, provided by Banco Central de Chile. Sample from May 1989 to December 2003 for the CPI, February 1997 to December 2003 for food, housing, furniture (home appliances), clothing, transportation, health and miscellaneous.

Finland: HICP data published by Eurostat, provided by the ECB. Sample from January 1987 to January 2003 for CPI, food, alcohol; from January 1995 to January 2003 for other components.

France: HICP data published by Eurostat, provided by the ECB. Sample from January 1990 to January 2003.

Germany: HICP data published by Eurostat, provided by the ECB. Sample from January 1995 to December 2003.

Italy: HICP data published by Eurostat, provided by the ECB. Sample from January 1987 to January 2003.

Luxembourg: HICP data published by Eurostat, provided by the ECB. Sample from January 1995 to January 2003.

Netherlands: HICP data published by Eurostat, provided by the ECB. Sample from February 1995 to February 2003, except the aggregate HICP from November 1987 to February 2003.

New Zealand: *Quarterly* CPI data published by Statistics New Zealand, provided by the RBNZ. Sample from March 1975 to September 2003 for CPI, food, clothing (apparel), transportation, alcohol, household operation, credit services; from March 1989 to September 2003 for housing, recreation and education, health.

Portugal: HICP data published by Eurostat, provided by the ECB. Sample from January 1987 to January 2003; except housing, furniture, recreation, restaurants and miscellaneous: January 1988 to January 2003; education January 1995 to January 2003.

Spain: HICP data published by Eurostat, provided by the ECB. Sample from January 1992 to January 2003.

Sweden: CPI data from the BIS database. Sample from January 1955 to January 2004.

United Kingdom: CPI data published by the Office for National Statistics, provided by the Bank of England. Sample from January 1980 to February 2004, except personal and leisure goods from January 1987 to February 2004.

United States: CPI data published by the Bureau of Labour Statistics, provided by the Federal Reserve Bank of Cleveland. Sample from January 1978 to March 2004. The Research series was used for the measure of the aggregate CPI.

Duration data

Austria:	From Fabio Fumler, Oesterreichische Nationalbank.
Belgium:	Table 2 from Aucremanne and Dhyne (2004).
Finland:	Table 4 from Vilmunen and Paloviita (2004).
France:	Table 7 from Baudry et al (2004).
Italy:	Table 10 from Fabiani et al (2004).
Netherlands:	From Nicole Jonker, De Nederlansche Bank.
Spain:	From Luis Julián Álvarez, based on Álvarez and Hernando (2004).
Portugal:	From Pablo Neves, based on Dias et al (2004).
United States:	Computed from Bils and Klenow (2002) Table 3.

Appendix B:
AR(1) estimates

Table B1a

Size and timing of breaks

Australia (full sample)

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.01	–0.05	–0.06	–0.08	–0.22	0.19	1987.07	1974.07
Clothing & footwear	0.66	0.44	0.36	0.38	0.76	–0.86	1990.10	1994.07
Communication	0.22	0.07	0.03	0.01	0.41	–0.39	1987.10	1983.01
Education	0.51	–0.04	–0.06	–0.06	–0.02	–0.09	1191.10	1993.01
Food	0.46	0.24	0.14	0.13	–0.77	0.98	1989.10	1972.07
Furniture	0.40	0.13	0.05	0.04	0.33	–0.39	1991.01	1976.01
Health	0.12	0.10	0.06	0.04	0.09	0.12	1983.10	1984.04
Housing & utilities	0.72	0.55	0.71	0.49	0.49	0.10	1989.10	1989.01
Miscellaneous	0.05	0.03	–0.04	–0.07	–0.46	0.92	1991.01	1992.01
Recreation & culture	0.50	0.11	0.03	0.03	0.25	–0.35	1991.01	1987.10
Restaurants & hotels								
Transportation	0.21	–0.03	–0.05	–0.05	0.20	–0.38	1991.01	1981.07
All items/HICP	0.64	0.37	0.31	0.29	0.39	–0.24	1991.01	1983.07

Table B1b

Size and timing of breaks

Australia (post-1990 sample)

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.35	0.24	0.16	0.11	0.24	0.05	1996.04	2000.10
Clothing & footwear	–0.03	–0.09	–0.08	–0.03	–0.09	–0.04	1991.07	2000.10
Communication	0.16	0.09	–0.02	–0.02	0.10	–0.14	2000.04	2000.10
Education	0.03	–0.22	–0.26	–0.28	–0.31	0.32	1992.07	1995.04
Food	–0.09	–0.19	–0.28	–0.28	–0.20	–0.37	2000.04	2002.01

Table B1b (cont)

Size and timing of breaks

Australia (post-1990 sample)

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Furniture	0.13	–0.01	–0.10	–0.28	–0.02	0.04	1991.10	2000.10
Health	0.04	–0.06	–0.07	–0.14	–0.44	0.40	1992.04	1992.04
Housing & utilities	0.58	0.49	0.46	0.45	0.66	–0.82	1998.10	1998.04
Miscellaneous	0.04	0.00	–0.03	–0.06	–0.38	0.89	1993.10	1993.10
Recreation & culture	–0.21	–0.27	–0.28	–0.31	–0.28	0.18	1998.07	1998.07
Restaurants & hotels								
Transportation	–0.25	–0.27	–0.31	–0.40	–0.20	–0.41	2001.07	2002.10
All items/HICP	0.12	0.06	–0.02	–0.07	0.04	–0.63	1999.07	2000.10

Table B2

Size and timing of breaks

Austria

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	–0.53	–0.07	–0.78	–0.12	–0.53	0.17	2001.12	1993.12
Clothing & footwear	–0.15	–0.28	–0.30	–0.30	–0.15	–0.29	1995.03	2001.10
Communication	0.02	–0.03	–0.04	–0.05	0.02	–0.07	1988.03	1991.11
Education	0.04	0.03	0.02	0.01	0.04	0.03	2001.09	2001.11
Food	–0.17	–0.18	–0.20	–0.23	–0.17	–0.39	1988.06	1994.08
Furniture	0.00	–0.12	–0.17	–0.21	0.00	–0.44	1995.03	1988.12
Health	0.04	0.03	0.00	–0.01	0.04	0.05	2000.09	2001.06
Housing & utilities	0.07	0.01	–0.08	–0.11	0.07	–0.12	1989.01	1989.04
Miscellaneous	0.15	0.11	0.01	–0.08	0.15	0.02	1994.03	1992.02
Recreation & culture	–0.23	–0.26	–0.27	–0.28	–0.23	–0.25	1995.05	2000.08
Restaurants & hotels	0.04	–0.05	–0.11	–0.12	0.04	–0.54	1995.04	2000.01
Transportation	0.12	0.11	0.10	0.09	0.12	0.28	1990.11	1989.05
All items/HICP	–0.05	–0.16	–0.21	–0.25	–0.05	–0.70	1994.10	1990.11

Table B3

Size and timing of breaks

Belgium

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.21	0.17	0.17	0.17	0.12	0.07	1994.04	1992.06
Clothing & footwear	–0.50	–0.50	–0.51	–0.51	–0.50	0.00	2001.08	2001.09
Communication	–0.02	–0.06	–0.07	–0.07	–0.10	0.05	1997.02	1993.09
Education	–0.10	–0.17	–0.19	–0.20	–0.11	–0.24	2002.03	2002.03
Food	–0.12	–0.14	–0.15	–0.16	–0.06	–0.48	2000.06	2001.07
Furniture	0.19	0.06	–0.09	–0.11	–0.16	0.51	1993.03	2000.09
Health	0.24	0.14	0.11	0.08	0.34	–0.40	1995.02	1993.11
Housing & utilities	0.03	0.02	0.01	–0.06	0.04	–0.11	1992.04	2000.10
Miscellaneous	0.05	0.01	–0.01	–0.01	0.07	–0.07	2000.01	1992.04
Recreation & culture	–0.10	–0.17	–0.19	–0.20	–0.11	–0.24	2002.03	2002.03
Restaurants & hotels	–0.08	–0.16	–0.17	–0.19	0.02	–0.25	1992.07	1993.05
Transportation	0.24	0.14	0.11	0.08	0.34	–0.40	1995.02	1993.11
All items/HICP	–0.27	–0.28	–0.30	–0.30	0.01	–0.35	1994.09	1997.07

Table B4

Size and timing of breaks

Chile

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco								
Clothing & footwear	–0.05	–0.06	–0.07	–0.09	–0.10	0.27	1998.04	1999.11
Communication								
Education	–0.01	–0.42	–0.44	–0.45	–0.47	0.32	1998.04	1998.05
Food	0.12	0.03	0.01	–0.02	–0.12	0.74	1998.03	2002.09
Furniture	0.69	0.31	0.27	0.21	0.01	0.46	1998.12	1999.06
Health	–0.10	–0.19	–0.21	–0.26	–0.41	0.29	1998.09	1998.06

Table B4 (cont)

Size and timing of breaks

Chile

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two		None	One	Two	
Housing & utilities	0.21	0.20	0.05	0.05	0.21	–0.02	2001.02	2001.02
Miscellaneous	0.09	–0.07	–0.09	–0.09	–0.16	0.51	1999.02	2001.03
Recreation & culture								
Restaurants & hotels								
Transportation	0.29	0.23	0.17	0.14	–0.05	0.31	2001.06	1999.05
All items/HICP	0.70	0.41	0.34	0.15	0.46	–0.25	1993.11	1990.11

Table B5

Size and timing of breaks

Finland

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	–0.12	–0.22	–0.23	–0.23	–0.29	0.40	1992.01	1992.02
Clothing & footwear	–0.16	–0.17	–0.17	–0.18	–0.21	0.09	1998.04	1998.03
Communication	0.12	0.08	0.05	0.04	–0.15	0.37	1998.06	1998.09
Education	–0.19	–0.22	–0.27	–0.29	–0.10	–0.25	1996.11	2000.10
Food	0.07	0.04	–0.03	–0.04	0.08	–0.55	1992.01	2002.02
Furniture	0.01	–0.03	–0.04	–0.06	–0.09	0.50	1998.04	2000.10
Health	0.03	–0.01	–0.01	–0.02	–0.06	0.16	1999.11	2001.05
Housing & utilities	–0.14	–0.15	–0.18	–0.20	–0.11	–0.12	1999.11	2001.02
Miscellaneous	0.08	–0.12	–0.14	–0.17	–0.21	0.22	1998.03	1999.07
Recreation & culture	–0.16	–0.24	–0.29	–0.30	–0.31	–0.14	1997.01	1998.04
Restaurants & hotels	–0.03	–0.03	–0.04	–0.04	–0.53	0.51	2001.09	1997.03
Transportation	–0.08	–0.10	–0.12	–0.16	–0.12	0.16	2001.06	2001.07
All items/HICP	0.26	0.02	–0.02	–0.06	0.19	–0.26	1993.05	1990.11

Table B6

Size and timing of breaks

France

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.08	0.06	0.03	0.02	0.10	–0.55	1994.03	1997.03
Clothing & footwear	–0.40	–0.41	–0.41	–0.41	–0.18	–0.39	1991.08	1995.02
Communication	0.01	–0.02	–0.02	–0.02	–0.25	0.26	1995.03	1995.09
Education	0.25	–0.01	–0.06	–0.10	0.13	–0.24	1993.05	1991.03
Food	0.03	0.00	–0.04	–0.05	–0.08	0.21	1999.10	1997.03
Furniture	0.23	0.05	0.01	–0.05	0.17	–0.23	1992.11	1996.08
Health	0.15	0.01	–0.04	–0.06	0.13	–0.24	1993.10	1999.10
Housing & utilities	0.18	0.12	0.08	0.04	0.31	–0.36	1991.03	1997.02
Miscellaneous	0.39	0.24	0.08	0.06	0.06	0.40	1993.05	2000.05
Recreation & culture	–0.09	–0.31	–0.35	–0.37	–0.37	0.40	1992.09	1999.06
Restaurants & hotels	0.36	0.07	–0.02	–0.06	–0.08	0.26	1993.03	2001.01
Transportation	0.14	0.12	0.10	0.10	0.25	–0.24	1996.11	1996.11
All items/HICP	0.09	0.01	–0.01	–0.07	0.10	–0.11	1991.12	1991.09

Table B7

Size and timing of breaks

Germany

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.02	0.00	0.00	0.01	–0.07	0.17	2002.01	2003.01
Clothing & footwear	0.00	–0.03	–0.05	–0.06	–0.23	0.22	2002.04	2000.10
Communication	0.22	0.18	0.10	0.10	0.10	0.26	2000.11	2000.02
Education	0.00	–0.08	–0.08	–0.08	0.03	–0.15	1999.03	1996.03
Food	0.22	0.21	0.10	0.08	0.19	0.12	2002.02	2002.02
Furniture	0.24	0.20	0.02	–0.06	0.04	0.35	2002.02	2000.12
Health	0.04	0.00	–0.05	–0.08	0.27	–0.32	1999.02	1998.09

Table B7 (cont)

Size and timing of breaks

Germany

Commodity group	Estimates of persistence with breaks in mean only		Estimates of persistence assuming one break		Date of breaks		Commodity group	
	None	One	Two		None	One	Two	
Housing & utilities	0.13	0.11	0.04	0.04	–0.27	0.40	2001.07	1996.09
Miscellaneous	0.00	–0.05	–0.06	–0.07	–0.08	0.17	1998.03	1999.03
Recreation & culture	–0.50	–0.51	–0.51	–0.52	–0.32	–0.22	2000.04	1997.04
Restaurants & hotels	–0.45	–0.45	–0.47	–0.47	–0.45	–0.01	2000.07	2001.02
Transportation	–0.11	–0.12	–0.16	–0.17	–0.21	0.37	1999.04	2001.07
All items/HICP	0.21	0.00	–0.03	–0.04	–0.20	–0.05	2000.06	2001.01

Table B8

Size and timing of breaks

Italy

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	–0.06	–0.09	–0.10	–0.10	–0.10	0.02	1996.03	1996.01
Clothing & footwear	–0.32	–0.34	–0.34	–0.34	–0.35	0.03	1992.10	2001.04
Communication	0.00	–0.03	–0.04	–0.04	–0.01	–0.03	1997.06	1991.04
Education	–0.05	–0.25	–0.27	–0.29	–0.25	–0.01	1993.01	2000.11
Food	0.67	0.55	0.46	0.43	0.55	–0.03	1996.06	2002.02
Furniture	0.47	0.00	–0.06	–0.08	0.05	–0.16	1996.01	1991.12
Health	–0.02	–0.03	–0.07	–0.08	0.01	–0.14	1995.06	1997.04
Housing & utilities	0.09	0.01	–0.05	–0.09	–0.56	0.57	1991.03	1989.10
Miscellaneous	0.17	0.03	–0.01	–0.05	0.01	0.09	1995.12	2001.04
Recreation & culture	0.31	0.12	0.03	0.01	0.16	–0.29	1991.01	1995.06
Restaurants & hotels	0.52	0.07	0.00	–0.01	0.12	–0.23	1993.01	1996.01
Transportation	0.01	–0.11	–0.13	–0.14	–0.20	0.19	1996.01	1995.02
All items/HICP	0.44	0.06	0.02	0.00	0.16	–0.19	1995.12	1991.07

Table B9

Size and timing of breaks

Luxembourg

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.04	0.00	–0.15	–0.21	–0.04	0.16	1997.09	2001.10
Clothing & footwear	–0.49	–0.50	–0.50	–0.50	–0.50	0.07	2000.08	2001.09
Communication	–0.07	–0.17	–0.20	–0.21	–0.23	0.09	1997.11	1997.11
Education	–0.17	–0.21	–0.22	–0.21	–0.37	0.22	2001.10	1997.12
Food	0.20	0.27	–0.03	–0.09	0.03	–0.53	2000.02	2002.03
Furniture	–0.47	–0.48	–0.49	–0.50	–0.47	–0.05	1999.02	1999.09
Health	–0.01	–0.07	–0.06	–0.17	–0.02	–0.16	2001.09	2000.07
Housing & utilities	–0.01	–0.02	–0.11	–0.14	–0.21	0.30	2001.01	1999.12
Miscellaneous	–0.38	–0.42	–0.42	–0.40	–0.52	0.14	2000.08	1999.03
Recreation & culture	–0.35	–0.41	–0.42	–0.43	–0.23	–0.21	2000.08	1997.05
Restaurants & hotels	0.16	–0.10	–0.13	–0.15	–0.14	0.11	1999.12	2002.01
Transportation	–0.11	–0.13	–0.17	–0.17	–0.14	0.11	1999.03	2001.08
All items/HICP	–0.33	–0.40	–0.42	–0.43	–0.43	0.26	1999.02	2001.02

Table B10

Size and timing of breaks

Netherlands

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.14	0.09	0.07	0.06	0.14	–0.18	2000.06	2001.03
Clothing & footwear	–0.26	–0.27	–0.30	–0.31	–0.30	0.21	2002.02	1999.10
Communication	–0.02	–0.06	–0.08	–0.11	–0.09	0.07	1996.03	1997.01
Education	–0.20	–0.25	–0.25	–0.25	–0.47	0.25	2002.01	1997.10
Food	0.04	–0.03	–0.04	–0.06	0.03	–0.35	2000.04	2002.02
Furniture	0.36	0.09	0.02	0.00	0.09	–0.26	2000.04	2001.03
Health	0.07	–0.03	–0.06	–0.07	0.15	–0.68	2001.10	2001.10

Table B10 (cont)

Size and timing of breaks

Netherlands

Commodity group	Commodity group				Commodity group		Commodity group	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Housing & utilities	–0.18	–0.18	–0.19	–0.20	–0.17	–0.09	2000.10	2001.12
Miscellaneous	–0.03	–0.24	–0.30	–0.30	–0.14	–0.24	2000.08	2001.03
Recreation & culture	–0.01	–0.09	–0.13	–0.13	–0.09	0.05	2000.04	2000.02
Restaurants & hotels	0.17	0.11	0.08	0.07	0.11	–0.56	2000.02	2002.03
Transportation	0.06	0.00	–0.04	–0.04	0.25	–0.30	1999.01	1997.09
All items/HICP	0.06	–0.04	–0.08	–0.10	0.07	–0.18	2000.05	1993.09

Table B11a

Size and timing of breaks

New Zealand (full sample)

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.38	0.17	0.05	0.00	0.02	0.33	1987.01	1986.07
Clothing & footwear	0.74	0.23	0.15	0.06	0.37	–0.22	1987.07	1978.01
Communication								
Education								
Food	0.51	0.18	0.10	0.02	0.31	–0.24	1987.01	1982.01
Furniture	0.65	0.32	0.28	0.26	0.50	–0.24	1987.01	1976.07
Health	0.12	–0.16	–0.28	–0.32	–0.23	0.45	1992.07	1993.04
Housing & utilities	0.62	0.56	0.51	0.33	–0.05	0.70	1990.07	1990.10
Miscellaneous								
Recreation & culture	0.16	–0.23	–0.26	–0.29	–0.07	–0.31	1991.04	1990.07
Restaurants & hotels								
Transportation	0.68	0.35	0.27	0.26	0.50	–0.40	1987.07	1985.07
All items/HICP	0.78	0.45	0.37	0.32	0.42	0.10	1987.01	1987.01

Table B11b

Size and timing of breaks

New Zealand (post-1990 sample)

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.34	0.30	0.24	0.23	0.18	0.21	1992.04	2000.04
Clothing & footwear	0.26	0.21	0.10	–0.07	0.11	0.25	2002.10	1998.07
Communication								
Education								
Food	0.35	0.27	0.20	0.19	–0.19	0.82	1995.10	1996.07
Furniture	0.05	0.01	–0.05	–0.05	–0.07	0.39	2000.10	1999.10
Health	0.04	–0.21	–0.25	–0.28	–0.29	0.53	1992.07	1993.04
Housing & utilities	0.61	0.55	0.35	0.35	0.63	–0.24	1992.10	1996.07
Miscellaneous								
Recreation & culture	–0.23	–0.29	–0.31	–0.33	–0.42	0.21	2001.01	1994.10
Restaurants & hotels								
Transportation	0.14	0.08	–0.02	–0.08	0.46	–0.70	1999.01	2001.01
All items/HICP	0.06	–0.01	–0.14	–0.23	0.02	–0.26	2000.01	2001.01

Table B12

Size and timing of breaks

Portugal

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.35	0.24	0.23	0.24	0.55	–0.59	1989.05	1989.05
Clothing & footwear	0.39	0.23	0.22	0.21	0.12	0.26	1988.05	1997.02
Communication	–0.13	–0.19	–0.20	–0.21	–0.26	0.21	1997.08	1992.03
Education	–0.04	–0.06	–0.15	–0.15	–0.18	0.59	1999.11	1998.05
Food	0.25	0.08	0.06	0.05	0.12	–0.16	1992.05	1997.05
Furniture	0.53	0.05	0.01	0.00	0.15	–0.41	1992.10	1993.10
Health	0.09	0.02	0.02	–0.09	0.01	0.33	1998.03	1990.06

Table B12 (cont)

Size and timing of breaks

Portugal

Commodity group	Commodity group				Commodity group		Commodity group	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Housing & utilities	–0.26	–0.40	–0.42	–0.43	–0.59	0.36	1992.08	1990.03
Miscellaneous	0.05	–0.07	–0.09	–0.10	–0.08	0.02	1990.03	1992.08
Recreation & culture	0.35	0.11	0.04	0.02	0.25	–0.26	1989.03	1993.05
Restaurants & hotels	–0.01	–0.30	–0.32	–0.33	–0.27	–0.10	1995.11	1990.09
Transportation	0.21	0.05	–0.03	–0.04	–0.45	0.55	1992.08	1990.05
All items/HICP	0.65	0.20	0.15	0.10	–0.17	0.38	1992.07	1988.05

Table B13

Size and timing of breaks

Spain

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	–0.08	–0.11	–0.12	–0.12	–0.13	0.16	1997.11	1999.01
Clothing & footwear	0.24	0.24	0.23	0.23	0.15	0.18	2001.09	2001.10
Communication	0.00	–0.06	–0.07	–0.08	–0.22	0.18	1994.10	1994.03
Education	0.08	0.01	0.00	–0.04	0.31	–0.39	1993.12	1994.04
Food	0.31	0.03	0.18	0.05	–0.28	0.63	2000.06	1993.07
Furniture	0.35	0.24	0.18	0.17	0.32	–0.23	1996.05	2001.07
Health	–0.12	–0.13	–0.14	–0.17	–0.08	–0.20	1993.04	1999.01
Housing & utilities	0.39	0.27	0.26	0.25	0.31	–0.08	1995.04	1999.09
Miscellaneous	0.51	0.17	0.09	0.04	0.23	–0.24	1993.07	1995.07
Recreation & culture	–0.02	–0.04	–0.04	–0.06	–0.03	–0.03	2000.09	2000.09
Restaurants & hotels	0.29	0.09	0.05	0.01	–0.04	0.24	1993.03	2001.11
Transportation	0.19	0.15	0.13	0.08	–0.03	0.21	1993.09	1994.02
All items/HICP	0.21	0.11	0.05	0.03	–0.03	0.21	1996.06	1999.08

Table B14a

Size and timing of breaks

United Kingdom (full sample)

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.27	0.12	0.03	0.01	0.08	0.05	1981.04	1981.03
Clothing & footwear	0.03	–0.10	–0.14	–0.16	–0.07	–0.34	1998.06	2002.09
Communication								
Education								
Food	0.09	0.00	–0.05	–0.07	–0.36	0.51	1982.06	1982.07
Furniture	0.11	–0.06	–0.12	–0.15	0.17	–0.59	1992.02	1996.07
Health								
Housing & utilities	0.26	0.20	0.16	0.14	0.16	0.53	1990.11	1997.06
Miscellaneous								
Recreation & culture	0.42	0.08	–0.05	–0.06	0.33	–0.35	1997.09	1991.03
Restaurants & hotels	0.40	0.22	0.12	0.10	0.33	–0.27	1991.05	1981.04
Transportation	0.23	0.18	0.15	0.14	0.23	–0.30	1981.09	1997.12
All items/HICP	0.59	0.44	0.31	0.22	0.48	–0.42	1982.02	1990.11

Table B14b

Size and timing of breaks

United Kingdom (post-1990 sample)

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.22	–0.09	–0.13	–0.15	–0.13	0.04	1991.05	1991.04
Clothing & footwear	–0.10	–0.20	–0.23	–0.25	–0.15	–0.28	1998.07	2002.09
Communication								
Education								
Food	0.01	–0.05	–0.06	–0.11	–0.51	0.62	1991.12	1993.11
Furniture	–0.03	–0.18	–0.23	–0.28	0.14	–0.57	1991.09	1996.09
Health								

Table B14b (cont)

Size and timing of breaks

United Kingdom (post-1990 sample)

Commodity group	Commodity group				Commodity group		Commodity group	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Housing & utilities	0.31	0.32	0.27	0.26	0.45	–0.17	1991.04	1991.04
Miscellaneous								
Recreation & culture	0.36	0.05	–0.07	–0.08	0.53	–0.54	1997.09	1991.03
Restaurants & hotels	0.29	–0.07	–0.13	–0.14	–0.29	0.19	1991.07	1991.04
Transportation	0.21	0.16	0.12	0.11	0.26	–0.30	1992.03	1998.03
All items/HICP	0.36	0.16	0.14	0.12	0.20	–0.26	1991.03	2000.07

Table B15a

Size and timing of breaks

United States (full sample)

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	–0.20	–0.22	–0.24	–0.26	0.11	–0.73	2002.10	1999.04
Clothing & footwear	0.19	0.05	0.03	0.02	0.30	–0.33	1993.03	1987.12
Communication								
Education	0.06	–0.13	–0.19	–0.20	–0.03	–0.26	1993.03	1983.08
Food	0.49	0.27	0.23	0.21	0.33	–0.37	1980.12	1991.07
Furniture								
Health	0.76	0.51	0.29	0.28	0.45	–0.22	1993.06	1983.03
Housing & utilities	0.64	0.22	0.20	0.19	0.27	–0.07	1981.10	1980.07
Miscellaneous								
Recreation & culture	–0.01	–0.09	–0.11	–0.12	–0.21	0.19	1997.04	1995.07
Restaurants & hotels								
Transportation	0.44	0.35	0.33	0.33	0.47	–0.33	1981.03	1999.05
All items/HICP	0.63	0.38	0.33	0.33	0.46	–0.27	1981.10	1990.11

Table B15b

Size and timing of breaks

United States (post-1990 sample)

Commodity group	Estimates of persistence with breaks in mean only				Estimates of persistence assuming one break		Date of breaks	
	None	One	Two	Three	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	–0.21	–0.22	–0.25	–0.29	0.12	–0.73	2002.10	1999.04
Clothing & footwear	0.13	0.00	–0.03	–0.05	0.28	–0.35	1993.03	1991.09
Communication								
Education	0.15	–0.10	–0.15	–0.16	–0.18	0.22	1993.07	2001.04
Food	0.09	0.04	0.01	0.00	0.19	–0.20	1991.07	1991.07
Furniture								
Health	0.72	0.36	0.23	0.17	0.43	–0.23	1993.06	1992.04
Housing & utilities	0.06	–0.02	–0.04	–0.14	–0.13	0.20	1991.03	2000.01
Miscellaneous								
Recreation & culture	–0.01	–0.09	–0.11	–0.12	–0.21	0.19	1997.04	1995.07
Restaurants & hotels								
Transportation	0.23	0.22	0.22	0.20	0.61	–0.45	1991.12	1991.04
All items/HICP	0.32	0.26	0.25	0.23	0.28	–0.04	1991.02	2000.04

Appendix C:
AR(12) estimates

Table C1a

Size and timing of breaks

Australia (full sample)

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.11	–0.11	–0.17	0.38	–0.48	1987.07	1976.01
Clothing & footwear	0.85	0.80	0.74	0.82	–1.34	1975.01	2000.10
Communication	0.29	–0.22	–0.35			1989.01	1981.10
Education	0.84	0.42	0.33	0.58	–0.22	1991.01	1990.10
Food	0.69	0.39	0.24	–0.12	0.37	1989.10	1973.10
Furniture	0.78	0.49	0.46	0.65	–0.36	1990.07	1976.01
Health	0.08	–0.06	–0.35	–0.05	–0.02	1997.07	1997.07
Housing & utilities	0.81	0.63	0.59	0.82	–0.24	1990.01	1989.10
Miscellaneous	–0.03	–0.16	–0.26	–0.91	1.36	1994.01	1993.10
Recreation & culture	0.68	0.10	0.01	0.12	–0.49	1991.01	1991.01
Restaurants & hotels							
Transportation	0.62	0.25	0.18	0.27	–0.15	1991.01	1991.01
All items/HICP	0.86	0.61	0.56	0.65	–0.11	1989.10	1975.10

Table C1b

Size and timing of breaks

Australia (post-1990 sample)

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.31	0.16	0.06	0.31	0.03	1996.01	1997.01
Clothing & footwear	–0.46	–0.47	–0.29	–0.22	–0.56	2000.07	2000.10
Communication	0.06	–0.18	–0.73	0.82	–2.06	2000.04	1999.10
Education	0.40	0.54	0.52	0.53	–0.06	1994.04	1999.01
Food	0.05	–0.32	–0.43	–0.35	0.04	2000.04	2000.04
Furniture	0.32	0.21	0.26	0.22	–0.04	2000.04	2000.10

Table C1b (cont)

Size and timing of breaks

Australia (post-1990 sample)

Commodity group	Commodity group			Commodity group		Commodity group	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Health	0.05	–0.06	–0.22	–0.06	0.01	1997.07	1997.07
Housing & utilities	0.62	0.51	0.52	0.45	–0.05	1998.01	1995.04
Miscellaneous	0.03	–0.14	–0.22	–1.88	2.28	1994.01	1993.10
Recreation & culture	–0.22	–0.33	–0.53	–0.30	0.26	1998.04	1998.04
Restaurants & hotels							
Transportation	0.10	0.00	–0.38	0.08	–2.03	1999.04	2001.07
All items/HICP	0.40	0.21	0.15	0.31	–0.79	1999.07	2000.10

Table C2

Size and timing of breaks

Austria

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	–0.06	–0.25	–0.40	–0.13	–1.93	2002.02	1995.02
Clothing & footwear	0.68	–1.47	–1.70	–0.83	–1.46	1995.03	1997.02
Communication	0.17	0.22	0.09	0.31	–0.68	1990.10	2000.07
Education	–0.05	–0.14	–0.85	–0.08	–0.04	1990.01	1990.01
Food	0.10	–0.02	–0.35	0.11	0.01	1994.10	1993.09
Furniture	0.75	0.31	0.21	0.37	0.01	1993.06	1993.06
Health	0.11	–0.13	–0.63	0.01	–1.08	2000.09	2001.01
Housing & utilities	0.56	0.47	0.13	0.49	0.00	1996.08	1991.06
Miscellaneous	0.59	0.47	0.17	–0.03	0.46	1993.03	1991.05
Recreation & culture	–0.06	–0.94	–1.34	–0.59	–0.67	1994.05	1998.09
Restaurants & hotels	0.68	0.46	0.19	0.48	0.29	1993.04	1999.07
Transportation	0.08	–0.09	–0.41	–0.04	–0.15	1996.11	2001.01
All items/HICP	0.70	0.33	0.16	0.27	0.23	1994.10	2001.01

Table C3

Size and timing of breaks

Belgium

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.24	–0.20	–0.25	0.46	–0.71	1994.04	1994.05
Clothing & footwear	–6.78	–8.71	–0.89	–0.54	5.46	1995.07	2000.09
Communication	0.04	–0.86	–1.05			1997.10	1992.02
Education	–0.99	0.00					
Food	0.00	–0.36	–0.68	–0.37	0.17	2000.06	1997.06
Furniture	0.57	0.49	–0.01	0.62	–0.38	2000.02	2000.03
Health	0.50	–0.20	–0.27	–0.87	0.48	1995.02	1994.01
Housing & utilities	0.35	0.31	–0.28	0.65	0.11	2000.12	2000.12
Miscellaneous	0.02	–0.66	–1.38	–0.61	–0.39	2000.01	2000.03
Recreation & culture	–0.79	–0.82	–0.90	–3.12	1.81	1994.09	2000.11
Restaurants & hotels	0.34	0.30	–0.95	0.12	–1.17	2001.04	1994.10
Transportation	0.41	0.37	0.03	0.29	1.04	2000.10	2001.03
All items/HICP	0.00	–0.11	–0.86	0.17	–1.13	2000.02	2000.09

Table C4

Size and timing of breaks

Chile

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco							
Clothing & footwear	–0.42	–1.13	–2.63	–2.81	2.46	2000.01	2000.02
Communication							
Education	0.46	0.41	0.52	0.46	–0.70	2001.11	2002.02
Food	–0.49	–0.59	–0.59	–0.97	–0.44	2001.11	2000.11
Furniture	0.76	0.85	1.02	1.09	–0.55	2000.05	2000.05
Health							
Housing & utilities	–0.02	–0.22	–0.80	–0.34	–0.71	2000.01	2001.02

Table C4 (cont)

Size and timing of breaks

Chile

Commodity group	Commodity group			Commodity group		Commodity group	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Miscellaneous	0.48	–0.20	–0.23	–0.19	–0.39	2000.01	2000.03
Recreation & culture							
Restaurants & hotels							
Transportation	0.48	0.06	–0.02	0.32	–0.46	2001.06	2000.12
All items/HICP	0.87	0.76	0.70	0.78	0.06	1993.11	1992.06

Table C5

Size and timing of breaks

Finland

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.40	–0.82	–1.34	–0.68	–0.17	1992.03	1991.06
Clothing & footwear	–2.49	–2.58	–3.12	–1.11	–1.26	1998.04	1998.03
Communication	–0.49	–1.84	–1.97	–1.63	0.77	1998.08	1998.10
Education	–0.25	–0.25	–0.12	0.72	–1.48	2000.02	1998.01
Food	0.51	0.41	0.06	0.36	0.24	1992.01	1998.07
Furniture	0.35	–0.14	–0.39	–0.94	1.34	1998.03	1998.05
Health	–0.28	–1.06	–1.06	–2.91	2.25	2000.01	2000.01
Housing & utilities	0.14	–0.04	–0.26	0.16	–0.96	1999.02	2001.02
Miscellaneous	0.61	0.20	–0.13	1.05	–0.57	1998.03	2000.01
Recreation & culture	0.44	0.01	0.01	–0.53	0.67	1999.06	2000.02
Restaurants & hotels	–0.58	–0.84	–2.19	–0.84	0.71	2000.09	2000.10
Transportation	0.03	–0.05	–0.64	–1.70	2.09	1999.04	1999.06
All items/HICP	0.79	0.30	0.06	0.39	–0.05	1993.05	1993.06

Table C6

Size and timing of breaks

France

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.11	–0.33	–1.02	0.21	–0.52	1994.05	1994.04
Clothing & footwear	–0.55	–2.37	–2.54	–1.42	–2.70	1993.07	2000.01
Communication	0.05	–0.53	–0.67	–0.58	0.12	1996.06	1996.08
Education	0.65	0.82	0.54	0.84	–0.13	1995.12	1993.09
Food	0.33	0.00	–0.05	–0.20	0.34	1999.10	1997.06
Furniture	0.58	0.30	0.26	0.47	–0.24	1993.02	1995.11
Health	0.60	0.04	–0.15	0.80	–0.71	1993.12	1993.03
Housing & utilities	0.34	–0.13	–0.45	–0.15	1.22	1997.02	2001.01
Miscellaneous	0.79	0.80	0.66	0.90	–0.24	1998.11	1997.04
Recreation & culture	0.72	0.16	–0.30	0.25	–0.04	1993.01	1999.06
Restaurants & hotels	0.77	0.52	0.24	0.27	0.26	1993.02	2001.01
Transportation	0.28	0.11	–0.07	0.07	1.82	1996.11	2001.01
All items/HICP	0.46	0.25	–0.14	0.12	0.43	1996.04	2000.04

Table C7

Size and timing of breaks

Germany

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	–0.05	–1.90	–2.14	–2.26	2.95	2002.01	2002.01
Clothing & footwear	–0.17	–0.34	–0.47	0.55	–1.27	2002.02	2002.02
Communication	0.41	0.29	–0.02	–0.45	1.01	2000.11	1999.03
Education	0.09	–1.29	–1.48	–0.71	–0.39	2000.03	1999.02
Food	0.29	0.27	–0.32	0.31	–0.42	2002.02	2001.11
Furniture	0.40	0.45	0.04	–0.12	0.72	2002.02	2001.02
Health	0.38	0.11	0.45	0.16	–0.03	1998.09	2000.02

Table C7 (cont)

Size and timing of breaks

Germany

Commodity group	Commodity group			Commodity group		Commodity group	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Housing & utilities	0.29	0.18	–0.25	0.19	–0.48	2001.07	2001.10
Miscellaneous	0.30	–0.59	–0.77	–1.30	1.49	1999.02	1998.10
Recreation & culture	–1.21	–1.46	–3.43	–1.53	0.73	2000.12	2000.01
Restaurants & hotels	–1.25	–1.52	–1.55	–4.72	4.47	2000.12	2001.05
Transportation	0.22	0.02	–0.67	0.06	–0.61	1999.04	2001.07
All items/HICP	–0.15	–0.34	–0.33	0.07	–0.40	1993.03	2001.02

Table C8

Size and timing of breaks

Italy

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	–0.02	–1.71	–2.02			1996.11	
Clothing & footwear	0.05	–1.54	–3.09	–0.01	0.05	1992.11	2001.03
Communication	–0.10	–0.66	–0.77	–0.73	0.41	1998.12	1992.07
Education	0.79	0.19	–0.63	0.09	–0.84	1991.08	1995.05
Food	0.82	0.63	0.50	0.58	0.19	1996.06	2001.03
Furniture	0.88	0.49	0.31	0.38	–0.15	1996.01	1996.01
Health	0.20	0.06	–0.43	–0.17	0.40	1995.06	1996.07
Housing & utilities	0.57	0.24	0.06	0.16	0.35	1991.03	1991.08
Miscellaneous	0.51	–0.17	–0.77	0.14	–0.20	1996.07	1995.07
Recreation & culture	0.74	0.44	0.21	0.41	–0.06	1993.08	1991.01
Restaurants & hotels	0.90	0.50	0.30	–0.70	1.31	1992.12	1992.12
Transportation	0.55	–0.11	–0.41	–0.32	0.22	1995.12	1995.03
All items/HICP	0.88	0.45	0.34	0.45	0.23	1995.08	2001.03

Table C9

Size and timing of breaks

Luxembourg

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.05	–0.77	–1.36	–1.41	0.87	1998.01	1998.05
Clothing & footwear	–1.90	–4.16	–4.13	–3.18	–1.80	2000.09	1999.01
Communication	0.16	–1.24	–1.91	–5.56	0.01	1998.06	1996.02
Education	0.23	–0.46	–0.66	0.34	–1.24	2001.04	2000.10
Food	0.62	0.28	0.16	0.13	0.18	1999.10	2000.06
Furniture	–2.25	–5.10		–8.46	4.21	1999.02	1999.01
Health	0.24	–0.22	–0.49	–2.82	2.38	2001.04	2000.02
Housing & utilities	0.37	0.33	0.01	0.58	–0.70	1999.02	2001.01
Miscellaneous	–0.06	–1.47	–1.72	–2.10	1.74	2001.01	2000.02
Recreation & culture	0.20	–0.95	–1.29	–0.95	0.13	2000.08	1999.06
Restaurants & hotels	0.74	0.19	0.13	0.01	0.29	1999.11	2000.12
Transportation	0.30	0.21	–0.57	0.03	0.45	2000.12	2001.02
All items/HICP	0.13	–0.62	–0.70	–0.23	0.13	1999.02	1999.09

Table C10

Size and timing of breaks

Netherlands

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.06	–0.89	–0.88	–0.51	–0.57	2000.06	2000.08
Clothing & footwear	–0.67	–0.69	–0.11	–0.29	3.52	1999.09	1999.10
Communication	0.24	0.28	–0.25	0.36	–0.80	2000.11	2001.03
Education	1.05	0.43	0.43	–0.09	0.67	2000.09	2001.04
Food	0.34	–0.15	–0.25	0.99	–1.02	2000.04	1998.01
Furniture	0.66	0.06	–0.20	0.53	–0.62	2000.03	2001.02
Health	0.38	–0.49	–0.67	–0.21	–0.61	2001.01	2000.10

Table C10 (cont)

Size and timing of breaks

Netherlands

Commodity group	Commodity group			Commodity group		Commodity group	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Housing & utilities	0.27	0.10	–0.18	0.20	–0.80	2000.01	2001.02
Miscellaneous	0.83	0.05	–1.23	–2.70	2.30	2000.08	1998.01
Recreation & culture	0.15	–0.71	–1.95	–3.87	3.96	2000.10	2000.02
Restaurants & hotels	0.59	0.04	–0.19	–1.55	1.20	2000.03	1998.09
Transportation	0.50	0.14	–0.03	0.28	–0.75	1999.01	2000.09
All Items/HICP	0.55	–0.02	–0.05	0.29	–0.63	2000.05	2001.04

Table C11a

Size and timing of breaks

New Zealand (full sample)

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.49	–0.14	–0.22	0.06	–0.25	1989.10	1982.10
Clothing & footwear	0.88	0.56	0.55	0.56	0.01	1987.01	1987.01
Communication							
Education							
Food	0.74	0.38	0.35	–1.86	3.17	1987.01	1987.01
Furniture	0.77	0.41	0.41	0.51	–0.26	1987.01	1987.01
Health	0.31	–0.53	–0.82	0.06	–0.02	1992.10	1992.07
Housing & utilities	0.59	0.49	0.41	0.61	–0.45	1987.01	1998.01
Miscellaneous							
Recreation & culture	0.59	0.53	0.57	0.48	–0.39	1999.07	1992.07
Restaurants & hotels							
Transportation	0.71	0.21	0.03	1.81	–0.49	1987.07	1976.04
All items/HICP	0.82	0.46	0.29	0.24	0.28	1987.01	1987.01

Table C11b

Size and timing of breaks

New Zealand (post-1990 sample)

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.11	0.06	–0.15	–0.07	–0.95	2000.04	2000.10
Clothing & footwear	0.43	0.39	0.37	0.34	–0.27	1997.07	1998.10
Communication							
Education							
Food	0.36	0.18	0.07	–0.71	1.08	1995.10	1996.01
Furniture	–0.31	–0.70	–1.51	–0.76	0.64	2000.10	1999.10
Health	0.29	0.17	0.09	0.10	0.34	1993.07	1999.04
Housing & utilities	0.59	0.50	0.29	0.66	–0.49	1998.01	1998.01
Miscellaneous							
Recreation & culture	0.05	–0.12	–0.11	–0.15	–0.39	2001.01	1999.07
Restaurants & hotels							
Transportation	0.25	0.05	–0.12	0.40	–0.95	1999.01	2001.01
All items/HICP	0.11	–0.06	–0.33	–0.03	–0.23	2000.01	2001.01

Table C12

Size and timing of breaks

Portugal

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.53	0.07	–0.01	0.31	–0.50	1990.08	1990.05
Clothing & footwear	0.80	0.32	0.45	0.43	–0.37	1992.09	1998.01
Communication	0.30	–0.88	–1.35	–0.80	–0.11	1987.08	1991.03
Education	0.34	0.32	–0.11	0.58	–0.29	1999.12	1999.11
Food	0.62	–0.30	–0.37	0.08	–0.46	1992.05	1992.05
Furniture	0.88	0.17	0.17	0.07	0.01	1992.12	1992.06
Health	0.61	0.40	0.35	0.50	–0.20	1995.09	1995.09

Table C12 (cont)

Size and timing of breaks

Portugal

Commodity group	Commodity group			Commodity group		Commodity group	
	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence	None
Housing & utilities	0.81	0.31	0.12	2.28	–1.87	1991.03	1992.02
Miscellaneous	0.72	–0.18	–1.05	0.31	–0.07	1991.12	1991.01
Recreation & culture	0.83	0.40	0.09	0.53	–0.45	1995.11	1991.02
Restaurants & hotels	0.75	–0.14	–0.61	–0.11	–0.04	1992.08	1991.01
Transportation	0.78	0.50	0.35	1.27	–0.57	1991.03	1991.04
All items/HICP	0.93	0.45	0.23	0.31	0.23	1992.07	1992.07

Table C13

Size and timing of breaks

Spain

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	–0.27	–2.00	–2.20	–1.79	0.18	1998.03	1996.01
Clothing & footwear	–0.80	–0.81	–1.17	0.53	–1.79	2001.03	2001.02
Communication	0.13	–0.41	–0.85			1995.03	1993.02
Education	0.41	0.42	0.51	0.45	–0.02	2000.02	2001.02
Food	0.51	0.46	0.14	0.31	0.23	1995.04	1995.01
Furniture	0.51	0.25	–0.03	0.37	0.03	1996.05	2001.04
Health	–0.10	–0.11	–0.35	–0.07	–0.13	1996.07	1998.12
Housing & utilities	0.56	0.17	0.16	0.32	0.00	1995.06	1999.09
Miscellaneous	0.61	0.33	0.26	0.30	0.04	1995.03	1995.03
Recreation & culture	–0.81	–1.33	–1.46	–1.19	–0.39	1995.05	2000.09
Restaurants & hotels	0.36	0.29	0.08	0.49	–0.74	2000.04	2000.05
Transportation	0.52	0.44	0.40	0.70	–1.22	2000.12	2000.12
All items/HICP	0.60	0.23	0.04	0.17	0.31	1995.05	1998.09

Table C14a

Size and timing of breaks

United Kingdom (full sample)

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.43	0.05	–0.10	–0.18	0.32	1991.05	1991.05
Clothing & footwear	0.73	0.36	0.16	0.40	–0.05	1997.02	2001.02
Communication							
Education							
Food	0.54	0.22	–0.03	0.39	–0.45	1991.12	1991.11
Furniture	0.68	0.34	0.25	0.44	–0.78	1991.09	1996.07
Health							
Housing & utilities	0.48	0.28	0.26	0.27	0.02	1990.05	1985.04
Miscellaneous							
Recreation & culture	0.91	0.66	0.52	0.97	–0.44	1996.05	1991.05
Restaurants & hotels	0.77	0.36	–0.02	0.68	–0.28	1991.08	1991.05
Transportation	0.36	0.16	–0.05	0.22	–0.24	2000.07	1990.11
All items/HICP	0.82	0.66	0.60	0.76	–0.25	1990.09	1990.05

Table C14b

Size and timing of breaks

United Kingdom (post-1990 sample)

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.66	0.53	0.48	0.64	–0.50	1993.05	1993.05
Clothing & footwear	0.57	–0.12	–0.43	0.06	–0.52	1998.07	2002.02
Communication							
Education							
Food	0.11	–0.13	–0.22	–0.06	–0.04	1996.05	1993.09
Furniture	0.61	0.44	0.25	0.53	–0.31	1996.04	1995.08
Health	0.69	0.45	–0.35	0.43	–0.14	1998.09	1995.02

Table C14b (cont)

Size and timing of breaks

United Kingdom (post-1990 sample)

Commodity group	Commodity group			Commodity group		Commodity group	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Housing & utilities	0.12	–0.39	–0.40	–0.97	1.25	1994.02	1993.12
Miscellaneous							
Recreation & culture	0.81	0.41	0.43	0.54	–0.42	1997.09	1993.12
Restaurants & hotels	0.69	0.44	0.39	0.46	–0.10	1993.05	1993.05
Transportation	0.46	0.08	–0.42	0.20	–0.43	2000.07	1998.03
All items/HICP	0.38	0.29	0.04	0.65	–0.03	1998.06	1993.03

Table C15a

Size and timing of breaks

United States (full sample)

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.30	0.36	0.11	0.95	–1.42	1999.02	1999.02
Clothing & footwear	0.69	0.05	–0.20	0.22	–0.22	1993.03	1989.12
Communication							
Education	0.83	0.64	0.28	0.68	0.04	1982.04	1982.07
Food	0.77	0.43	0.23	0.56	–0.17	1981.01	1980.12
Furniture							
Health	0.94	0.83	0.51	0.79	0.04	1982.12	1982.09
Housing & utilities	0.89	0.32	0.29	–0.24	0.68	1981.10	1981.10
Miscellaneous							
Recreation & culture	0.31	–0.53	–1.31	–0.25	–0.48	1997.09	1997.04
Restaurants & hotels							
Transportation	0.66	0.26	0.23	0.34	–0.21	1981.04	1999.05
All items/HICP	0.91	0.60	0.43	0.66	–0.09	1981.03	1981.08

Table C15b

Size and timing of breaks

United States (post-1990 sample)

Commodity group	Estimates of persistence with breaks in mean only			Estimates of persistence assuming breaks in persistence		Date of breaks	
	None	One	Two	Initial estimate	Change in persistence	First mean break	Break in persistence
Alcohol & tobacco	0.28	0.13	0.06	0.91	–1.55	1997.09	1999.02
Clothing & footwear	0.44	–0.01	–1.02	0.81	–2.10	1998.09	1994.12
Communication							
Education	0.80	0.34	0.16	–2.73	3.38	1993.02	1993.02
Food	0.07	0.05	–0.06	0.24	–0.37	1994.05	1995.01
Furniture							
Health	0.80	0.62	0.55	0.62	0.04	1993.06	2002.04
Housing & utilities	0.36	0.33	–0.08	0.42	0.01	2001.03	2001.04
Miscellaneous							
Recreation & culture	0.31	–0.53	–1.31	–0.25	–0.48	1997.09	1997.04
Restaurants & hotels							
Transportation	0.01	0.03	–0.08	0.33	–1.14	2002.03	2001.12
All items/HICP	0.04	–0.04	–0.28	0.04	0.83	2001.07	2000.12

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"Has the inflation process changed?" by S Cecchetti and G Debelle

Discussion by I Angeloni[1]
ECB

Cecchetti and Debelle could hardly have chosen a more relevant and timely topic for their paper. Research on inflation dynamics has been very active lately, focusing mainly on the existence of persistence - the tendency of inflation to converge gradually, or sluggishly, to its long run value - and on the causes and implications of this. The reason why this is a highly attractive area of research is clear: inflation persistence is, simultaneously, one of the most solid empirical regularities in macroeconomics and one of the most difficult things to incorporate in standard general equilibrium models. Hence a puzzle, naturally calling for theoretical and empirical work.

Thinking about inflation persistence is also important for policy, particularly at this point in time. Since the 1990s, global inflation has been moderate, in sharp contrast with the preceding two decades. It also remained under control in the second part of that decade and in the more recent years, while the monetary policy stance in the main currency areas was turning more expansionary. Roughly at the same time as this performance improvement was taking place, the conduct of monetary policy changed radically: independence, accountability, clarity of goals, focus on price stability, have become the rule almost everywhere. Are the two developments related? Should we, as a consequence, consider low inflation as an established conquest? Studying the inflation process in detail, across time periods, countries and sectors, as Cecchetti and Debelle do, can help answer these important questions. The European case can be particularly enlightening, because the recent creation of the ECB, with its stronger and more explicit price stability orientation, helps identifying a change in the monetary policy regime. Given the importance of this area of research, the Eurosystem has launched a multi-year project to study the patterns, determinants and implications of inflation persistence in the euro area. The research is conducted by a Eurosystem-wide team, the Inflation Persistence Network; preliminary results will be presented in a conference at the ECB in December 2004.

Cecchetti and Debelle's approach is to use the simplest model one can think of for analysing inflation dynamics: one where quarterly inflation depends only on a lag of itself (with coefficient, say, ρ) and a constant (κ), plus a random error.

$$\pi = \kappa + \rho\pi_{-1} + \varepsilon \qquad (1)$$

In such a model, the inflation process can change for only two reasons: if the mean inflation (κ) changes, presumably because the central bank has changed its monetary policy objective, and/or if the autoregressive parameter ρ changes. The latter can reflect eg explicit or implicit indexation mechanisms existing in the economy, due perhaps to a slow-moving expectation formation process. Most of the analysis in the paper revolves around the estimates of these two parameters and their interaction. The central finding is that if one estimates ρ as being conditional on a certain number of changes in the "policy regime" (κ), the value of ρ turns out to be fairly low and stable. This result incidentally is not new, having been mentioned already by other recent papers that Cecchetti and Debelle quote (some of which are associated with the work of the Eurosystem Network). After establishing this fact, Cecchetti and Debelle move on to examine the timing of the changes in the inflation mean, in a disaggregated way across sector and product categories. Here their evidence is much more tentative and preliminary, hence I will not focus my comments on this part of the paper.

[1] I wish to thank Benoit Mojon and Michael Ehrmann for comments, and all members of the Inflation Persistence Network for continuing discussions on issues related to the analysis of inflation dynamics. The views expressed here are personal and do not involve the ECB or the Eurosystem.

My main comment concerns the interpretation of the central finding - that ρ is low if one allows for mean breaks.[2] How should we interpret the interplay between the two parameters, κ and ρ? The interpretation offered in the paper is that one should consider κ as a proxy of the monetary policy regime, and ρ as a measure of structural inflation persistence. Hence, the results imply that if one takes the changes in policy into account, structural persistence is generally low. This sounds appealing to central bankers: credible policy actions can control inflation easily, unhampered by structural frictions in the price setting process and with little cost in terms of output and employment variability.

My concern with accepting this conclusion too quickly is that it could depend on reading too much into the results of a very simple model. In a slightly more general context, the same results could have different interpretations. To illustrate, we can consider a slightly more structural version of (1) as follows:

$$\pi = \alpha_1 \pi_{-1} + \alpha_2 \pi^e + \alpha_3 \Delta + \varepsilon \qquad (2)$$

where consumer price inflation π depends on its own lag, expected inflation π^e, and a driver of the inflation process, Δ. For example, following the "new-Keynesian" literature[3] we can think of the driver as being, for example, a measure of the output gap or of marginal costs. The latter are often approximated, in empirical work, by the aggregate labour share. For π^e we can assume a gradual learning mechanism such as

$$\pi^e = c\,\pi_{-1} + (1-c)\,\pi_{GOAL} \qquad (3)$$

where $(1-c)$ is a measure of central bank credibility: when $(1-c) = 1$, expectations adjust immediately to the central bank goal π_{GOAL}. Putting (2) and (3) together one can compare the parameters of the two models, arriving at:

$$\rho = \alpha_1 + \alpha_2 c$$

$$\kappa = \alpha_2 (1-c)\,\pi_{GOAL} + \alpha_3 \Delta$$

The second expression shows that the constant term κ depends, in addition to the policy regime, also on the inflation driver. Typically, labour costs and the labour share are very persistent over time: as Table 1 and Chart 1 show, in the largest euro area countries, labour cost growth and the share of labour in total incomes have been steadily trending downward in the last 30 years. The dynamics of labour costs can conceivably respond to policy changes with considerable lags. Hence, even if we accept the finding that allowing for mean breaks in model (1) reduces the estimate of ρ, it does not follow that inflation will necessarily display little persistence in response to monetary policy shocks. In the simple specification (1) there may be elements of persistence hidden in the constant term that one cannot account for simply by using mean breaks. For this reason we should, I think, regard the evidence coming from the simple model as useful, but only as first step toward more extensive analyses of a structural nature.

A second remark relates to the implications of the recent change in statistical treatment of sales (seasonal or other periodic discounts) by European statistical offices. In recent years, the CPI calculation methodology has changed in several European countries to take sales into account. The effect on short-term inflation dynamics was dramatic in some CPI components: as an example, Chart 2 shows the change of seasonality that occurred in the price index for clothing.[4] The change in the dynamic properties of the aggregate indices also is likely to have been significant, considering that seasonal sales affect, to varying degrees, about 30% of the Harmonised Index of Consumer Prices. The result should probably be a spurious decline in the estimated coefficient of persistence in more

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[2] This effect can be generalised further: in fact, if one allows for a, possibly non-linear, trend in the constant one can drive the estimated persistence parameter all the way down to zero. See Robalo Marques (2004), a contribution prepared in the Eurosystem Inflation Persistence Network.

[3] Eg Galí and Gertler (2000).

[4] This chart was prepared for an Inflation Persistence Network meeting by the team from the Banque Centrale de Luxembourg.

recent years, which is precisely what Cecchetti and Debelle detect. My suggestion would be to try to net out this effect from the data before testing for changes in the persistence parameter over time.

Finally, considering our limited knowledge of the actual degree of persistence in the economy, it may be useful to think of the implications of this type of uncertainly for monetary policy decisions. Two ECB colleagues and I have approached this issue in a recent paper,[5] where we calculate optimal monetary policy rules in the presence of uncertainty regarding a few key parameters of the economy, including inflation persistence, within a Dynamic-General-Equilibrium model of the euro area.[6] In the exercise we assume that the central bank chooses a policy to minimise the expected loss, or alternatively the maximum possible loss, that occurs if the persistence parameter is different from the assumed one. The analysis is done under two alternative classes of policy rules: simple ones, weighing linearly inflation and output only, and optimal ones. The results are in Table 2. The main message is that assuming a relatively high value of ρ (between 0.7 and 0.8) is the right choice: in this way the central bank minimises both the expected and the maximum possible value of the loss. The intuition of this result is that erring on the high side is better than making the opposite mistake, because if the central bank underestimates the effective degree of persistence and hence reacts too mildly or late to inflationary shocks, relatively large deviations from target will result, compared to the opposite case.

To conclude my comments: I enjoyed this paper, and I appreciated its simplicity and clarity. Before subscribing to the conclusions and, even more, to its policy interpretations, however, I would like to see further analyses using more complete structural models. Both micro- and macroeconomic data are likely to be useful in conducting further tests, and in this sense the approach proposed by Cecchetti and Debelle is, I think, the right one. In the meantime, risk-averse central bankers conducting monetary policy under uncertainly should probably continue to assume that a significant degree of inflation inertia exists.

Table 1

Labour share and growth of unit labour costs

	Labour share			**Unit labour costs (percentage change)**		
	1974-83	**1984-93**	**1994-2003**	**1974-83**	**1984-93**	**1994-2003**
Germany	0.64	0.60	0.54	4.49	2.41	0.54
France	0.56	0.53	0.52	11.67	2.10	0.68
Italy	0.51	0.46	0.42	16.98	5.80	1.58
Spain	0.52	0.49	0.50	16.53	6.93	2.69
Netherlands	0.57	0.52	0.51	5.87	1.09	2.19
Euro area	0.53	0.51	0.50	8.92[1]	3.81	1.03
United Kingdom	0.60	0.56	0.55	13.31	5.42	2.73
United States	0.58	0.58	0.57	7.29	2.76	1.24

Note: [1] Average 1980-83.

Source: OECD.

[5] Angeloni et al (2003).

[6] Smets and Wouters (2003).

Chart 1

Labour shares

Compensation of employees/GDP

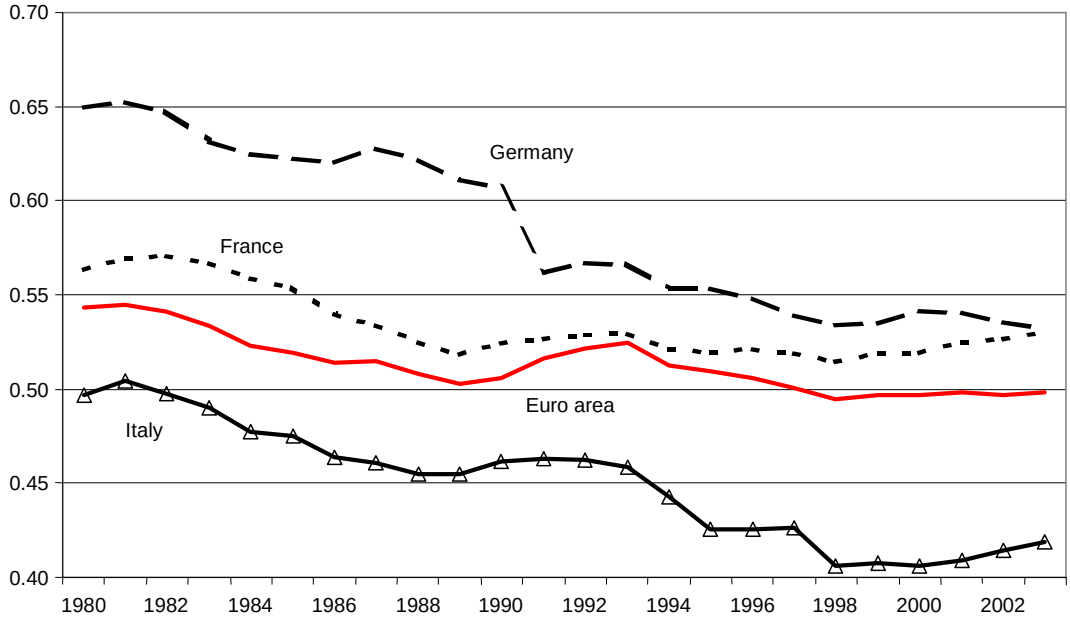

Chart 2

Effect of the change in the statistical treatment of end-season sales on the price of clothing

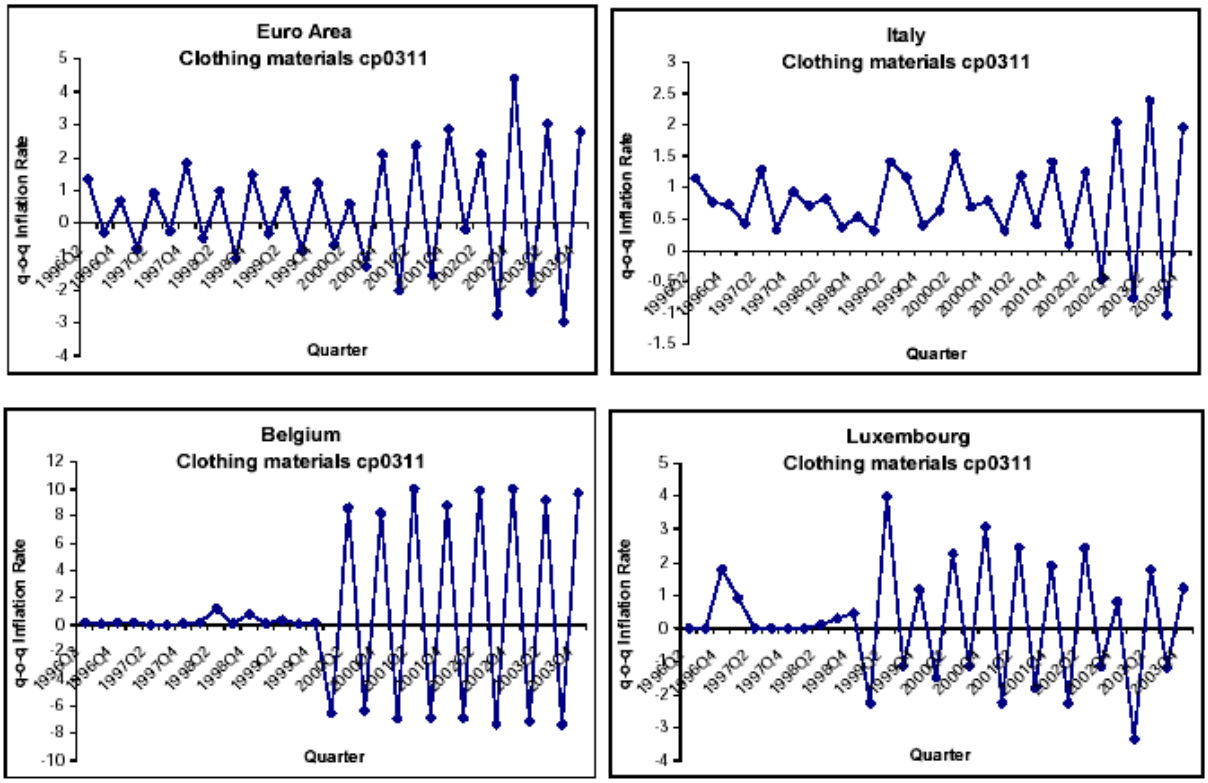

Table 2

Optimal monetary policy when inflation persistence is uncertain

Welfare losses in per cent

		Assumed values of ρ								
		0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
Optimal simple rule	Mean	2.6	2.4	2.1	1.8	1.4	1.0	0.9	1.4	3.2
	Max	15.6	14.5	13.0	11.1	8.7	6.0	3.3	2.6	5.3
Optimal rule under commitment	Mean	1.3	1.1	0.9	0.7	0.5	0.4	0.3	0.4	0.7
	Max	6.6	5.9	5.1	4.2	3.3	2.3	1.3	0.7	1.0

Source: Angeloni et al (2003). Each cell shows the average (or maximum) per cent loss of welfare when the central bank assumes the corresponding value of ρ. The average and the maximum are calculated over all possible "true" values of ρ in the (0, 1) range.

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Has the inflation process changed? A comment[1]

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Introduction

The paper by Cecchetti and Debelle makes an interesting contribution to the growing literature on inflation dynamics. The first part of the paper is largely descriptive, and complements other recent attempts to identify the presence of significant changes over time in the time series properties of inflation measures. Cecchetti and Debelle's analysis makes use of aggregate and sector-level CPI inflation data for a number of OECD countries. They conclude that the presence of a change in the mean of inflation, observable for most countries and CPI components, is the dominant feature of the data. Once that change in mean is accounted for, the degree of inflation persistence is relatively small, and does not display a significant decline over time in most cases. Furthermore, and with few exceptions, neither observed changes in the mean nor in the persistence measures can be mapped clearly to the changes in monetary policy regime that have taken place for many of the countries in their sample during the period considered. The previous statistical results compiled by Cecchetti and Debelle are a valuable addition to the current stock of evidence on the properties of inflation. Most significantly, some of Cecchetti and Debelle's findings question both the results and conclusions drawn by other authors.

In the second part, Cecchetti and Debelle try to go beyond a simple statistical characterisation, aiming instead at providing an assessment of existing structural price-setting models in light of the evidence of a cross-sectional connection (or lack thereof) between Cecchetti and Debelle's inflation persistence measures and the indicators of price rigidities developed by several authors in the context of the ECB's Inflation Persistence Network. Cecchetti and Debelle show that no significant relationship between those measures can be detected. Independently of the previous evidence, the finding of relatively low inflation persistence leads Cecchetti and Debelle to conclude that early criticism of optimising forward-looking price-setting models that was grounded on the apparent inconsistency between the latter and the presence of high inflation persistence may have been misplaced.

My discussion below focuses on what I view as an important caveat in Cecchetti and Debelle's interpretation of the sort of reduced-form evidence found in the present paper, a caveat that is also found in some of the related literature.

Inflation persistence and optimising price-setting models

Underlying much of Cecchetti and Debelle's analysis and its motivation is the notion - stressed by authors like Fuhrer and Moore (1995) - that the evidence pointing to high inflation persistence is inconsistent with the optimising price-setting models that have been widely adopted in the recent monetary business cycle literature. Those models, Cecchetti and Debelle claim, generate high persistence in the price level (which would be increasing in the degree of stickiness), but not in its first difference (ie, in the rate of inflation). The evidence of very low persistence uncovered by Cecchetti and Debelle (when proper treatment of shifts in means is made) is thus presented as reconciling (at least partly) the univariate evidence on inflation persistence with the above-mentioned structural models. But to what extent do optimising, forward-looking models necessarily imply low inflation persistence? Next, I show by means of three simple examples that the connection between price stickiness and persistence is not an obvious one.

[1] Based on the discussion of Cecchetti and Debelle's paper "Has the inflation process changed?".

Example #1: inflation persistence with an exogenous output gap

Consider an economy for which inflation dynamics are described by the difference equation

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \kappa_\theta x_t$$

where x_t is the output gap, β is the discount factor, and κ_θ is a coefficient inversely related to the degree of price stickiness (see, eg, Galí and Gertler (1999) for a derivation). The previous inflation equation, based on a price-setting model originally due to Calvo (1983) and usually referred to as the New Keynesian Phillips curve (NKPC), is a key building block of the workhorse framework used for monetary policy analysis. It implies that inflation is a purely forward-looking variable, in the sense that past inflation does not play an independent role in determining current inflation. Instead the latter depends exclusively on current and expected future values for the output gap. Suppose next that the output gap follows an exogenous AR(1) process

$$x_t = \rho_x x_{t-1} + u_t$$

where $\rho_x \in [0, 1)$ and u_t is white noise. In that case it is easy to show that inflation will also follow an AR(1) process of the form

$$\pi_t = \rho_x \pi_{t-1} + \frac{\kappa_\theta}{1-\beta\rho_x} u_t$$

In other words, inflation will inherit the persistence of the output gap. An increase in the degree of price stickiness would reduce κ_θ and, as a result, would lower the variance of inflation. But it would not have any effect on its persistence. Hence, on the basis of the previous analysis, there is no reason to expect any connection (across countries or sectors) between measures of inflation persistence on the one hand, and indicators of the degree of price stickiness on the other. Furthermore, the eventual finding of high inflation persistence cannot be interpreted as evidence of any "structural" dependence of current inflation on past inflation: as illustrated in the example above, that dependence may be non-existent, without that implying any constraints on the persistence of inflation itself.

Of course, the assumption of an exogenous output gap is clearly unrealistic, so perhaps one may suspect that any eventual influence of price stickiness on inflation might work through its effect on the output gap. Evaluating the previous hypothesis requires laying down a fully-fledged model, so the answer is likely to depend on some details of the model. The following example, based on a standard model from the literature, illustrates how the persistence of inflation is not necessarily related to the degree of price stickiness, even when we endogenise the output gap.

Example #2: inflation persistence under a simple Taylor rule

Suppose that, in addition to the NKPC introduced above, the economy's equilibrium is described by a new IS-type equation

$$x_t = E_t\{x_{t+1}\} - \frac{1}{\sigma}\left(r_t - E_t\{\pi_{t+1}\} - r_t^*\right)$$

together with a simple Taylor rule determining the short term nominal rate r_t

$$r_t = \phi_\pi \pi_t$$

where $\phi_\pi > 1$ (a sufficient condition for a determinate equilibrium), and an exogenous process for the natural real rate r_t^* (which by definition must be independent of both the degree of price stickiness and the monetary policy rule):

$$r_t^* = \rho_r r_t^* + v_t$$

The solution to the model above yields the following reduced form process for inflation:

$$\pi_t = \rho_r \pi_{t-1} + \psi v_t$$

where ψ can be shown to be a decreasing function of the degree of price stickiness (in addition to showing a negative relation with the inflation coefficient ϕ_π in the Taylor rule). But, most importantly for our purposes, the persistence of inflation is independent of the degree of price stickiness and the strength of the central bank's response to inflation. Instead, inflation inherits the persistence of the natural real rate (given by ρ_r), which is by definition independent of the degree of price stickiness or the monetary regime.

Example #3: inflation persistence with a hybrid NKPC

Finally, let me consider an economy in which a fraction of price setters follow a simple backward-looking rule of thumb that makes their newly set prices depend partly on lagged inflation, whereas all other firms behave in an optimising forward-looking way as in the basic Calvo model. In that case, and as shown in Galí and Gertler (1999) the dynamics of inflation are given by the hybrid NKPC

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t\{\pi_{t+1}\} + \lambda x_t$$

where γ_b and γ_f are, respectively, increasing and decreasing in the fraction of backward-looking firms and with the output gap following the same exogenous AR(1) process considered in our first example. The reduced form process for inflation is given by

$$\pi_t = \delta_1 \pi_{t-1} + \frac{\lambda}{\delta_2 \gamma_f} \frac{1}{1-\rho_x \delta_2^{-1}} x_t$$

where $\delta_1 \equiv \frac{1-\sqrt{1-4\gamma_b\gamma_f}}{2\gamma_f}$. In contrast with the previous examples, the persistence of inflation in this case does depend on characteristics of the economy other than the persistence of the output gap itself. In particular, it can be shown (after some tedious algebra) that δ_1 is increasing in the fraction of backward-looking firms (as one would anticipate), but decreasing in the degree of price stickiness (a somewhat less intuitive result). Hence, in the context of the hybrid NKPC model proposed above, low levels of inflation persistence (as detected in the Cecchetti and Debelle paper) will emerge in economies with (i) a small fraction of backward-looking firms, and (ii) high degrees of price stickiness, a configuration consistent with the structural estimates in Galí and Gertler (1999), among others. Nevertheless, and as illustrated by examples #1 and #2 above, that property is far from being robust to the specification of the environment. Further work is clearly needed in order to understand better the connection between inflation persistence, price stickiness and other features of the price-setting process before we can jump to any hard conclusions in the light of reduced form evidence like that presented by Cecchetti and Debelle in their paper.

Inflation persistence and measurement error

Let me conclude my discussion of the Cecchetti and Debelle paper with a brief comment on an aspect of their evidence that could easily be missed by the casual reader. Cecchetti and Debelle carry out their empirical analysis using CPI data for 17 countries. With the exception of Australia and New Zealand, for which quarterly data are used, the frequency of the time series analysed is *monthly*, corresponding to month-to-month changes in the (log) CPI. That choice, which contrasts with the more common use of quarterly inflation data in the related literature, is potentially problematic. The reason is simple and well-known to anyone who has ever plotted a month-to-month inflation series (Cecchetti and Debelle refrain from doing so): such series are extremely volatile, possibly because of measurement error or temporary factors unrelated to underlying inflation trends. The excess noise associated with those series may account for much of the low persistence uncovered in the data, relative to other studies. A formal analysis of the implications for the estimated of inflation persistence of the data frequency chosen lies beyond the scope of the present paper, but should certainly be kept in mind, especially when attempting comparisons across studies.

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