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Another look at global disinflation

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Abstract

This paper highlights relative price adjustments taking place in the global economy as important sources of the lower levels of inflation rates observed in the recent decades. Using a markup model, it shows substantial effects from declines in wage costs and import prices relative to consumer prices. Out of the 5 percentage point decline in the inflation rates in eight OECD countries from 1970-1989 to 1990-2006, global shocks to two relative prices account for more than 1.5 percentage points, while a monetary policy shock accounts for another 1 percentage point.

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Contents

Introduction[1]

The dramatic decline in both the rate and the volatility of global inflation over the past decades can be seen as one of the most remarkable developments in the global economy. Despite extensive research conducted both in central banks and academia, consensus has not yet emerged regarding what factors account for this favourable outcome. Very broadly, they can be classified into those attributable to changes in the structure of the economy, those simply attributable to good luck, and those attributable to changes in the conduct of monetary policy (Melick and Galati (2006)). In this context, an issue regarding how and to what extent "globalisation" has affected this change in the inflation process has recently attracted particular attention from researchers—see Borio and Filardo (2007), IMF (2006), Pain, Koske and Sollie (2006), Cecchetti et al (2007), Ihrig et al (2007) and Sbordone (2007), among others. While many observers refer to globalisation, or the closer integration of labour-abundant emerging market economies with the global economy, as one of the most important structural changes that the global economy has experienced, some are quite sceptical about its impact on inflation. These include Ball (2006), who states that "[T]here is little reason to think that globalisation has influenced inflation significantly".

Against this backdrop, this paper focuses on the impacts of relative price adjustments taking place in the global economy. An intuition simply comes from an observation that in industrial countries, two markups, a markup over wage costs $(p-p^w)_t$ and that over import prices $(p-p^m)_t$, have widened significantly in the past decades (Figure 1). This is equivalent to saying that two relative prices, real wage costs $(p^w - p)_t$ and real import prices $(p^m - p)_t$, have dropped as such. These adjustments in relative prices, which are possibly associated with globalisation, appear to be strongly correlated with past developments in the inflation rate (Figure 2).

In this paper, the link between relative price adjustments and the levels of inflation rates is established by a markup model. This type of model has a long history and numerous empirical applications—see, for example, the surveys by Bronfenbrenner and Holzman (1963) and Frisch (1983). The paper exploits an open-economy version of a markup model originally developed by de Brouwer and Ericsson (1998) for Australia. Banerjee and Russell (2001), Banerjee, Cockerell and Russell (2001), Sekine (2001) and Heath, Roberts and Bulman (2004) estimate a similar model for various countries, and more recently, Pain, Koske and Sollie (2006) use it to analyse global disinflation. This paper can be seen as a complement to the last paper, which does not calculate each factor's contribution.

The paper further extends the single-equation approach of a markup model to a multivariate analysis, where two *global* shocks to relative prices are identified. These not only appear to track globalisation, but also account for a significant part of global disinflation. More than 1.5 percentage points are due to these shocks out of a 5 percentage point decline in the inflation rate from 1970-1989 to 1990-2006 in the sample industrial countries, while another 1 percentage point is due to a monetary policy shock. The substantial contributions of the global relative price shocks may provide one explanation for the large effect of an international common factor on the historical decline in the levels of national inflation rates found by Ciccarelli and Mojon (2005) and Mumtaz and Surico (2006).

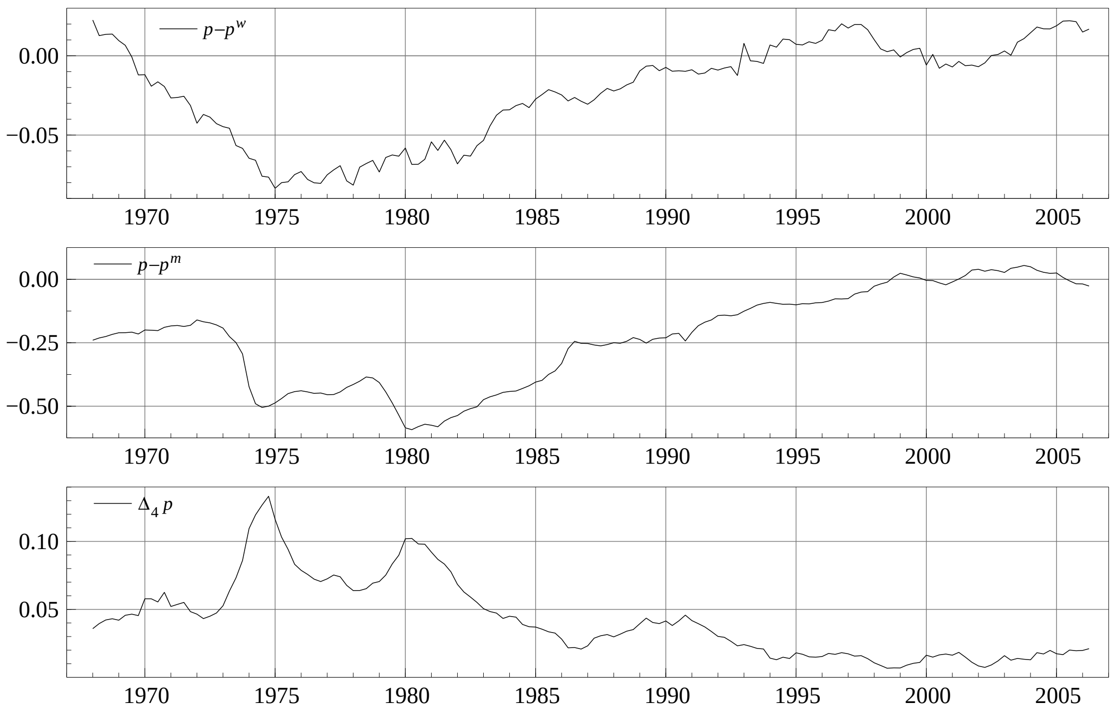
The rest of the paper is structured as follows. Section 1 introduces an openeconomy version of a markup model. Section 2 estimates it and shows large contributions coming from two markups. Section 3 extends the analysis to a multivariate dimension and quantifies the

[1] This paper is based on research conducted when the author was an economist at the Bank for International Settlements. I am grateful to Piti Disyatat, Andy Filardo, Tsutomu Watanabe, an anonymous referee and participants at the BIS seminar and the 2007 TRIO Conference for helpful comments and discussions. The views expressed in this paper do not necessarily reflect those of the BIS or the Bank of Japan.

impacts of the global relative price shocks as well as the monetary policy shock. Section 4 concludes.

Figure 1

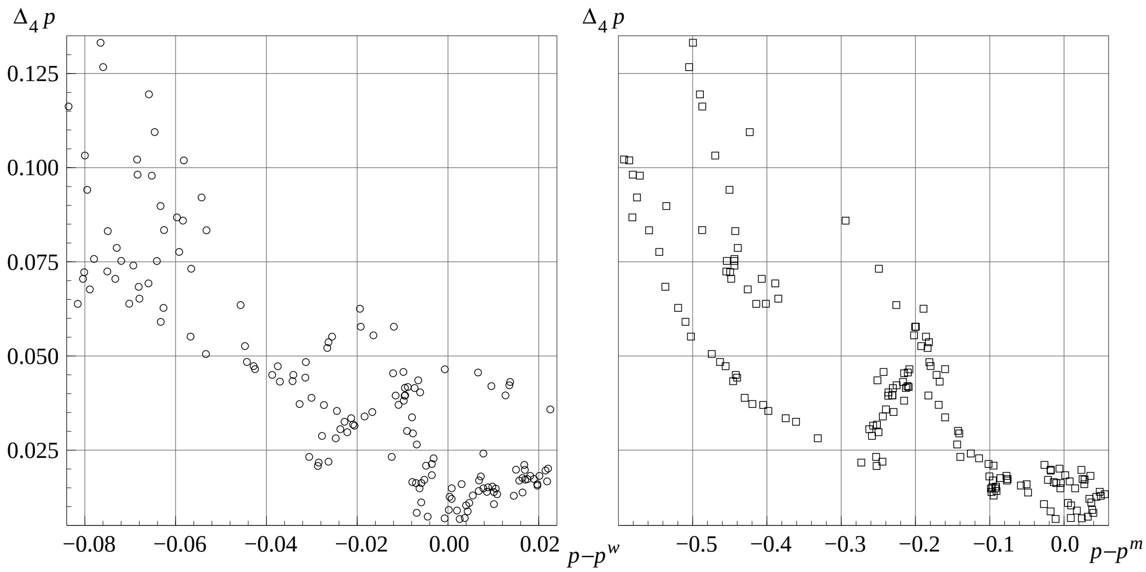
Two markups and inflation



Note: 8 OECD countries averaged by PPP GDP weights in 2000. The two upper panels are normalised at zero in 2000. p is log consumer prices; p^w is log wage costs; p^m is log import prices; and $\Delta_4 p$ is the fourth difference of p.

Figure 2

Correlation between two markup and inflation



Note: See note for Figure 1.

1. Two markups

An open-economy version of a markup model takes into account two types of markups: one from wages and the other from import prices.

$$\Delta p_t = \alpha_0 + \alpha_1 (p - p^w)_{t-1} + \alpha_2 (p - p^m)_{t-1} + \sum_{j=1}^{2} \beta_j \Delta p_{t-j} + \sum_{j=0}^{2} \gamma_j \Delta p_{t-j}^w + \sum_{j=0}^{2} \delta_j \Delta p_{t-j}^m + u_t, \tag{1}$$

where p_t is consumer prices at time t, p_t^w is wage costs, p_t^m is import prices and u_t is an error term. All variables are in logarithm and Δ denotes the first difference operator. $(p-p^w)_t$ is the price markup over labour costs and $(p-p^m)_t$ is that over import costs.

The equation can be transformed into an error-correction representation such as

$$\Delta p_t = \alpha_0 + a(p - p^*)_{t-1} + \sum_{j=1}^{2} \beta_j \Delta p_{t-j} + \sum_{j=0}^{2} \gamma_j \Delta p_{t-j}^w + \sum_{j=0}^{2} \delta_j \Delta p_{t-j}^m + u_t,$$

where

$$p^* = bp^w + (1-b) p^m, \tag{2}$$

and $a=\alpha_1+\alpha_2$, $b=\alpha_1/(\alpha_1+\alpha_2)$. If the deviation between p and p^* is corrected subsequently, then $a < 0$. Furthermore, if we assume $1 > b > 0$, then the signs of α_1 and α_2 are negative. The Appendix derives the long-run solution (2) from marginal cost pricing.

Another way of interpreting equation (1) is that the two markups, $(p-p^w)_t$ and $(p-p^m)_t$, represent relative prices: ie, the relative prices of wage costs p_t^w and import prices p_t^m vis-à-vis consumer prices p_t. The equation embeds the mechanism by which inflation is adjusted by relative price movements. In the long run, once these relative price adjustments work out, inflation will converge to some constant, the level of which is supposed to depend on, among others, the nominal anchor of the economy provided by the central bank. On that score, inflation is ultimately determined by monetary policy (Ball (2006)), although this aspect is treated as an off-model item of equation (1).

The two markups also play an important role in a more structural model such as an open-economy New Keynesian Phillips Curve (NKPC). An NKPC is typically expressed as (see Woodford (2003), Chapter 3)

$$\Delta p_t = \phi E_t \Delta p_{t+1} + \lambda rmc_t + const. + u_t, \tag{3}$$

where rmc_t is the real marginal cost and often represented by the labour share. In a number of empirical applications estimating equation (1)—this paper included—p^w is represented by the unit labour cost. If this is the case, the labour share is nothing but $-(p-p^w)_t$ in equation (1).[2] In an open economy setup, Batini, Jackson and Nickell (2005) show that the real marginal cost also depends on the price of imported materials such that

$$rmc_t = -\ln\alpha - (p - p^w)_t - \mu(p - p^m)_t.$$

See Leith and Malley (2002), Razin and Yuen (2002) and Rumler (2005) for alternative specifications of the open-economy NKPC. Although details of these specifications differ depending on the complexity of the model setups, they share the common feature that, on

[2] $$\ln\frac{WL}{PY} = -\left(\ln P - \ln\frac{WL}{Y}\right) = -(p - p^w).$$

where W is nominal wages, L is labour inputs, P is output prices and Y is real outputs. WL/PY is the labour shares and WL/Y is the unit labour costs.

top of the labour share, the markup over imported material prices $(p - p^m)_t$ is included in the equation.

There are a number of fundamental differences between the reduced (equation (1)) and the structural form (equation (3)), but as far as factor contributions are concerned, these two approaches may not differ much. One of the key differences between them is the forward-looking inflation expectation $E_t\Delta p_{t+1}$ in equation (3). Since this is not directly observable, in practice the term is often estimated by instrument variables Z_t in the form of a GMM estimation or an auxiliary VAR such as

$$E_t\Delta p_{t+1} = \psi Z_t + v_t.$$

If we use lags of own and explanatory variables as these instruments and try to calculate factor contributions by substituting instruments to $E_t\Delta p_{t+1}$, an open-economy version of equation (3) may yield a very similar result to equation (1)—or more precisely its restricted versions (4)-(6) below.

The usefulness of equation (1) comes from the fact that it covers various channels through which globalisation is supposed to have affected inflation. First, the most frequently discussed channel is through lower import price inflation Δp_t^m. Over the past decade or so, imports—especially those of manufactured goods—from emerging market economies to industrial countries have swelled, a development which has been associated with lower import price inflation. For instance, Kamin, Marazzi and Schindler (2006) estimate that Chinese exports alone have lowered annual import price inflation in major industrial countries by 0.25 percentage points since 1993. However, this impact has been mitigated by higher prices of energy and other commodities due to increasing demand from some emerging market economies (Pain, Koske and Sollie (2006)). As a result, some observers argue that the overall effects of this channel may not be obvious. For instance, in his speech on globalisation, Bernanke (2007) states, “When the offsetting effects of globalization on the prices of manufactured imports are considered together, there seems to be little basis for concluding that globalization overall has significantly reduced inflation in the United States”.

Yet, just looking at the sign of Δp_t^m may understate the impact of globalisation.[3] To the extent that import prices have risen at a slower rate than consumer prices, globalisation puts additional downward pressure on domestic prices through the wider wedge between import and domestic prices $(p - p^m)_t$ (Figure 1). In addition, globalisation may have also widened the wedge between labour costs and output prices $(p-p^w)_t$ or lower labour shares. An increase in imports of labour-intensive products from emerging market economies coupled with greater labour mobility and the credible threat of relocating production is thought to have acted to reduce the labour shares in industrial countries. Indeed, Guscina (2006) and IMF (2007) show that globalisation, together with rapid technological changes, has had a significant impact on the trend decline in the labour shares.[4]

Some researchers further argue that globalisation has changed the parameters of the inflation process. These include greater sensitivity of domestic inflation to import prices such as larger coefficients on Δp_t^m and $(p - p^m)_t$ (IMF (2006), Pain, Koske and Sollie (2006), Ihrig et al (2007)).[5] Borio and Filardo (2007) show domestic inflation has become less sensitive to

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3 See BIS (2006, Chapters II and IV) for the roles of greater global competition in an increase in markups.

4 See Ellis and Smith (2007) and Lawless and Whelan (2007) for an alternative view. Global competitive pressure may lead to margin compression as argued by Chen, Imbs and Scott (2004), but the rise in profit rate in recent years and wider wedges of the two markups appear inconsistent with this view (Kohn (2006)).

5 On the other hand, Sekine (2006) reports a decline in pass-through from import price inflation Δp_t^m to consumer price inflation Δp_t.

the domestic output gap—in fact, this is a theoretical prediction of an open-economy NKPC such as that in Clarida, Galí and Gertler (2002) and Razin and Yuen (2002)—but now more sensitive to the global output gap. Some of these issues will be examined below as a sample split estimation.

2. Estimation results

2.1 Data

All the data, unless otherwise noted, come from the OECD Economic Outlook database. p_t is the log of private final consumption deflator; Δp_t^w is the log of unit labour cost of the total economy; and Δp_t^m is the log of imports of goods and services deflator. Figure 3 plots the annual inflation $\Delta_4 p_t$ together with two markups for each sample country.

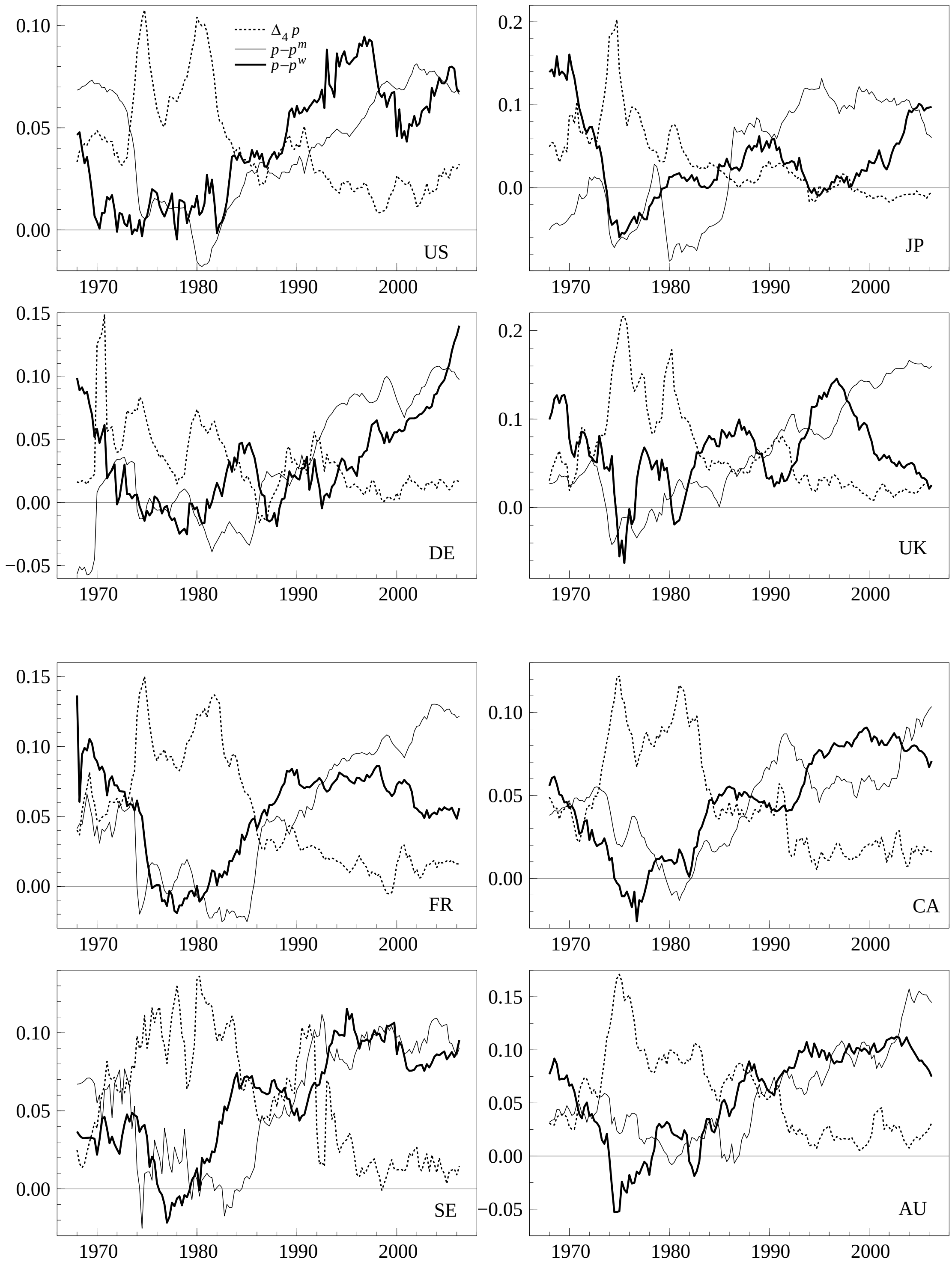
Although short- to medium-term fluctuations differ considerably, all countries show a clear trend increase in the wage markup. To a certain extent, this can be seen as a rebound from the sharp drop in the wage markup in the early 1970s. Recently, the wage markup seems to have begun dropping in cyclically advanced countries like the United Kingdom and Australia. On the other hand, in Japan and Germany, an increase in the wage markup appears to have lagged behind the other countries and shows few signs of abating (especially in Germany).

The import price markup started to rise in the middle of the 1980s in all countries. The fact that a trend increase is observed not only in countries whose effective exchange rates became stronger over the past three decades (Japan, Germany), but also in weaker currency countries (Australia, Sweden) implies that this large shift in import prices relative to consumer prices is not attributable to exchange rate movements. Recently, reflecting higher raw material prices, the import price markup seems to have stopped rising, especially in countries whose currencies depreciated at the same time (the United States, Japan).

There is ambiguity regarding the stationarity of the two markups $(p - p^w)_t$ and $(p - p^m)_t$. Panel unit root tests for these variables cannot reject the null hypothesis of nonstationarity (Table 1). Furthermore, without a deterministic time trend, the presence of a unit root in the consumer price inflation rate Δp_t cannot be rejected at the 1% critical level. These observations are consistent with Banerjee and Russell (2001) and Banerjee, Cockerell and Russell (2001), who show that the inflation rate and the two markups are cointegrated. Since equation (1) takes the form of an autoregressive distributed lag model, it can capture possible cointegration relationships (Pesaran and Smith (1995), Pesaran and Shin (1998)). Alternatively, these variables might be I(0) but subject to breaks in deterministic terms (a constant term and a time trend). Unit root tests are known to have low power in the case of breaks in trends. Indeed, the rolling test statistics of Banerjee, Lumsdaine and Stock (1992), which allow for a break at an unknown point in the sample period, reject the unit-root null for $(p - p^w)_t$ in Japan and France and for $(p - p^m)_t$ in Germany and France at the 5% critical level.

Figure 3

Two markups and infaltion



Note: The two markups, $p - p^w$ and $p - p^m$, are adjusted so that their means and ranges fit those of the annual inflation rate $\Delta_4 p$ in the corresponding countries. US = the United States; JP = Japan; DE = Germany; UK = the United Kingdom; FR = France; CA = Canada; SE = Sweden and AU = Australia.

Table 1

Panel unit root tests

	no time trend			with time trend		
	Fisher[1]	**1% CV[2]**	**5% CV[2]**	**Fisher[1]**	**1% CV[2]**	**5% CV[2]**
Δp	55.4	66.4	54.6	124.1	90.4	78.5
Δp^w	88.7	61.4	53.5	155.4	87.2	77.7
Δp^m	168.2	65.6	55.7	210.6	91.4	80.5
$p - p^w$	34.3	59.5	52.1	69.5	88.1	77.8
$p - p^m$	20.4	62.6	53.3	65.4	91.2	80.1

1. Fisher statistics based on Maddala and Wu (1999). The null hypothesis is an examined variable has a unit root for all countries. 2. The corresponding critical values (CV) are obtained from bootstrap simulations of 10,000 replications.

The NKPC is obtained from an approximation around a steady state with a certain inflation rate. In this regard, it may be more sensible to de-mean all the variables prior to estimation. However, a constant term in equation (1) is supposed to have the same effect. Presumably, for this reason, empirical studies of the NKPC such as Galí and Gertler (1999) do not de-mean the variables. Note that contributions calculated below (Tables 3 and 5) are invariant to whether or not to de-mean as long as a constant term is time-invariant. The effect of its time-variance will be examined by a split sample estimation.

2.2 Baseline specification

Table 2 summarises the estimation results of equation (1) as static long-run solutions (full estimation results can be obtained from the author upon request). Estimation is carried out for eight OECD countries (the United States, Japan, Germany, the United Kingdom, France, Canada, Sweden and Australia) during 1970Q1-2006Q2. Coefficients of individual countries are obtained by Seemingly Unrelated Regression (SUR), and those of the country averages are obtained by Generalised Least Square (GLS) as proposed by Swamy (1970).[6]

Estimation results are broadly in line with prior expectations. Coefficients on two markup terms are negative and statistically significant except for Germany. Those on ULC growth Δp^w and import price inflation Δp^m are positive and statistically significant in most cases.

Table 3, using the regression coefficients of equation (1), calculates the contribution of each factor to lower inflation during the recent decades. The consumer price inflation in the sample countries has dropped by 5 percentage points (in terms of an annualised quarterly change), from 7% during 1970-1989 to 2% during 1990-2006. Out of the 5 percentage point decline, import price inflation ($\sum \Delta p^m_{-j}$ in the table) explains only 0.5 percentage points. Although this is larger than the impact (0.1 percentage points) on the United States quoted by Bernanke (2007), as often argued in the literature, import price inflation itself does not account for a significant part of inflation stability.

6 All estimation is conducted by Ox (Doornik (2006)).

Table 2

Static long-run coefficients (baseline)[1, 2]

	$p-p^w$	$p-p^m$	Δp^w	Δp^m	**const**	**σ**	**adj R^2**
US	−0.035** (0.011)	−0.011** (0.002)	0.206** (0.059)	0.146** (0.016)	0.004** (0.001)	0.002	0.88
JP	−0.031** (0.011)	−0.005** (0.002)	0.572** (0.040)	0.045** (0.013)	0.001 (0.001)	0.006	0.79
DE	0.006 (0.017)	−0.007 (0.006)	0.447** (0.062)	0.122** (0.036)	0.004** (0.001)	0.008	0.41
UK	−0.078** (0.019)	−0.020** (0.003)	0.398** (0.052)	0.072* (0.032)	−0.004** (0.001)	0.006	0.77
FR	−0.048** (0.012)	−0.016** (0.003)	0.346** (0.054)	0.144** (0.020)	0.002** (0.001)	0.004	0.89
CA	−0.033** (0.010)	−0.017** (0.004)	0.336** (0.056)	0.137** (0.031)	0.004** (0.001)	0.004	0.83
SE	−0.046** (0.010)	−0.022** (0.006)	0.125 (0.066)	0.122** (0.031)	0.004** (0.001)	0.008	0.55
AU	−0.063** (0.013)	−0.010* (0.005)	0.257** (0.052)	0.055 (0.029)	−0.005** (0.002)	0.005	0.78
8 OECD	−0.034* (0.014)	−0.013** (0.003)	0.359** (0.072)	0.105** (0.016)	0.001 (0.001)	0.007	0.74

1. Coefficients obtained by SUR and GLS estimation of equation (1). Static long-run coefficients are calculated as $\alpha_1/(1-\sum\beta_j)$ for wage markup $(p-p^w)$; $\alpha_2/(1-\sum\beta_j)$ for import markup $(p-p^m)$; $\sum\gamma_j/(1-\sum\beta_j)$ for ULC growth Δp^w; $\sum\delta_j/(1-\sum\beta_j)$ for import price inflation Δp^m; and $\alpha_0/(1-\sum\beta_j)$ for a constant term. 2. Figures in parentheses are standard errors. "**" and "*" denote statistical significance at the 1% and 5% levels, respectively. σ stands for equation standard errors.

However, this argument omits the level effect. The wider wedge between import and domestic prices ($(p-p^m)_{-1}$ in the table) as well as falling labour shares ($(p-p^w)_{-1}$ in the table) account for 1.4 and 1.0 percentage points of the average disinflation, respectively. Taken together, these two variables account for about a half of the decline in inflation. More interestingly, either or both of these effects tend to be larger for small open economies compared to the G3 economies (the United States, Japan and Germany). This may point to some global force behind these factors.

Table 3

Contribution of each factor (baseline)[1]

	Average 1970-1989	Average 1990-2006	Difference between 1970-1989 and 1990-2006					
			Actual	Explained by				
				$\sum \Delta p_{-j}$	$(p-p^w)_{-1}$	$(p-p^m)_{-1}$	$\sum \Delta p^w_{-j}$	$\sum \Delta p^m_{-j}$
US	5.5	2.3	−3.2	−1.0	−0.5	−0.8	−0.4	−0.6
JP	5.6	0.0	−5.6	−0.4	−0.2	−1.2	−3.3	−0.1
DE	4.3	1.8	−2.5	0.2	0.1	−0.7	−1.8	−0.4
UK	9.1	2.9	−6.1	−0.7	−0.6	−2.7	−2.3	−0.5
FR	8.0	1.6	−6.4	−1.2	−0.8	−1.5	−1.8	−0.9
CA	6.7	1.9	−4.8	−1.2	−1.0	−0.8	−1.3	−0.5
SE	8.3	2.8	−5.6	0.7	−2.7	−2.5	−0.9	−0.9
AU	8.7	2.4	−6.3	−1.5	−2.4	−0.9	−1.3	−0.3
Avg[2]	7.0	2.0	−5.1	−0.7	−1.0	−1.4	−1.6	−0.5

1. 1970-1989 and 1990-2006 averages are based on annualised quarterly changes, in per cent. Contributions are calculated using regression coefficients of equation (1). 2. Cross-country averages are simple averages of individual countries' contributions.

2.3 Alternative specifications

In order to address possible endogeneity, contemporaneous terms of ULC growth Δp_t^w and import price inflation Δp_t^m are dropped from equation (1). The simplified model becomes

$$\Delta p_t = \alpha_0 + \alpha_1 (p - p^w)_{t-1} + \alpha_2 (p - p^m)_{t-1} + \sum_{j=1}^{2} \beta_j \Delta p_{t-j} + \sum_{j=1}^{2} \gamma_j \Delta p^w_{t-j} + \sum_{j=1}^{2} \delta_j \Delta p^m_{t-j} + u_t, \quad (4)$$

Estimated coefficients and factor contributions for 8 OECD countries are shown in the second columns of Tables 4 and 5—corresponding results of individual countries are reported in Table S.1 and S.2 in the Supplement. They do not differ materially from those of the baseline model (the first columns of Tables 4 and 5). In particular, coefficients and contributions of two markup terms, $(p - p^m)_{-1}$ and $(p - p^w)_{-1}$, are almost the same as those in the baseline case.

Further simplification by dropping Δp^w_{t-j} and Δp^m_{t-j}, which are often neglected by the NKPC, such that

$$\Delta p_t = \alpha_0 + \alpha_1 (p - p^w)_{t-1} + \alpha_2 (p - p^m)_{t-1} + \sum_{j=1}^{2} \beta_j \Delta p_{t-j} + u_t, \quad (5)$$

yields the larger negative coefficients on these two markup terms and hence the larger negative contributions from them (the third columns of Tables 4 and 5; individual countries are in Tables S.3 and S.4 in the Supplement).

Table 4

Static long-run coefficients (8 OECD)[1, 2]

	Baseline[3]	**Simple (1)**	**Simple (2)**	**Repara.**	**Sample-split**	
Specification	**Eq (1)**	**Eq (4)**	**Eq (5)**	**Eq (6)**	**Eq (1)**	**Eq (1)**
Sample period	**70Q1-06Q2**	**70Q1-06Q2**	**70Q1-06Q2**	**70Q1-06Q2**	**70Q1-89Q4**	**90Q1-06Q2**
$p - p^w$	−0.034* (0.014)	−0.041* (0.019)	−0.077** (0.027)	−0.059* (0.025)	−0.051** (0.017)	−0.058** (0.020)
$p - p^m$	−0.013** (0.003)	−0.015** (0.003)	−0.022** (0.006)	−0.022** (0.004)	−0.017** (0.005)	−0.028** (0.010)
Δp^w	0.359** (0.072)	0.238** (0.062)	...	...	0.340** (0.095)	0.210* (0.087)
Δp^m	0.105** (0.016)	0.076** (0.015)	...	...	0.104** (0.019)	0.083** (0.024)
$\Delta(p - p^w)$	...	...	...	−0.347** (0.122)	...	...
$\Delta(p - p^m)$	...	...	...	−0.112** (0.025)	...	...
const	0.001 (0.001)	0.002 (0.002)	0.002 (0.003)	0.003 (0.002)	−0.000 (0.003)	0.002 (0.001)
σ	0.007	0.007	0.008	0.007	0.008	0.007
adj R^2	0.74	0.54	0.48	0.54	0.64	0.28

1. Coefficients obtained by GLS estimation from 8 OECD panel data. 2. Figures in parentheses are standard errors. “**” and “*” denote statistical significance at the 1% and 5% levels, respectively. σ stands for equation standard errors. 3. The “baseline” column is same as the last row of Table 2.

Without loss of generality, equation (4) can be reparameterised as

$$\Delta p_t = \alpha_0 + \alpha_1 (p - p^w)_{t-1} + \alpha_2 (p - p^m)_{t-1} + \sum_{j=1}^{2} \tilde{\beta}_j \Delta p_{t-j} + \sum_{j=1}^{2} \tilde{\gamma}_j \Delta (p - p^w)_{t-j} + \sum_{j=1}^{2} \tilde{\delta}_j \Delta (p - p^m)_{t-j} + u_t, \quad (6)$$

where $\tilde{\beta}_j = \beta_j + \gamma_j + \delta_j$, $\tilde{\gamma}_j = -\gamma_j$ and $\tilde{\delta}_j = -\delta_j$. The equation expresses that the current inflation is determined by the levels and changes in the two markups as well as its own lags. This enables us to calculate overall contributions of the markups (both levels and changes). These effects may arguably be assumed to be independent from monetary policy shocks, at least in the long run, as they are real variables—the issue will be revisited in the multivariate analysis below.

Estimation results are in the fourth columns of Tables 4 and 5 and the corresponding results of individual countries are in Tables S.5 and S.6 in the Supplement. Although the coefficients on changes in the two markups are statistically significant, since they are mean-reverting, the contributions of those variables are small, −0.1 percentage points each. Meanwhile, the contributions of the levels of the markups remain same as the simplified case (4).

Table 5

Contribution of each factor (8 OECD average)[1]

	Baseline[2]	Simple (1)	Simple (2)	Repara.	Sample-split
Specification	**Eq (1)**	**Eq (4)**	**Eq (5)**	**Eq (6)**	**Eq (1)**
$\sum\Delta p_{-j}$	−0.7	−1.3	−1.9	−2.2	−0.4
$(p - p^w)_{-1}$	−1.0	−1.0	−1.3	−1.0	−1.4
$(p - p^m)_{-1}$	−1.4	−1.7	−2.1	−1.7	−1.6
$\sum\Delta p^w{}_{-j}$	−1.6	−0.8	...	...	−1.7
$\sum\Delta p^m{}_{-j}$	−0.5	−0.3	...	...	−0.6
$\sum\Delta(p - p^w)_{-j}$	...	...	...	−0.1	...
$\sum\Delta(p - p^m)_{-j}$	...	...	...	−0.1	...
const	0.0	0.0	0.0	0.0	0.6

1. Contributions to a decline in inflation rate of 8 OECD countries from 1970-1989 to 1990-2006 (−5.1 percentage points, annualised quarterly changes). 2. The "baseline" column is same as the last row of Table 3.

2.4 Split sample estimation

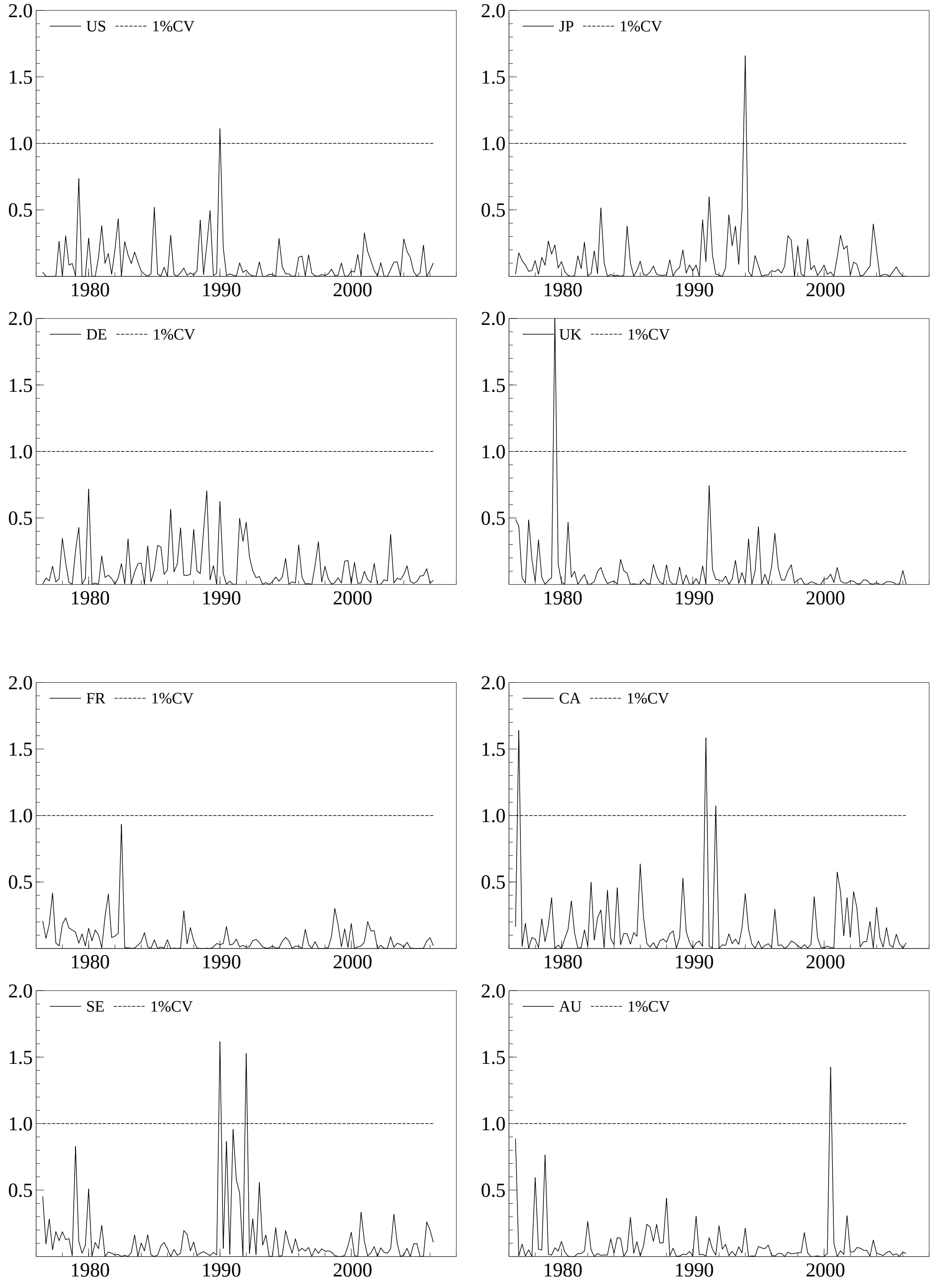
In order to see possible effects of parameter changes, equation (1) is reestimated during the sample periods 1970-1989 and 1990-2006 (the fifth and sixth columns of Table 4; individual countries are in Tables S.7 and S.8 in the Supplement). These two sample periods are chosen in the light of a number of existing studies examining parameter changes in the early 1990s (BIS (2005, Chapter II), Pain, Koske and Sollie (2006), Borio and Filardo (2007), etc). Indeed, recursive Chow tests conducted by estimating equation (1) on an equation-by-equation basis detect structural breaks in the early 1990s in four (the United States, Japan, Canada and Sweden) out of eight sample countries (Figure 4).

In line with BIS (2005), point estimates of static long-run coefficients on import price inflation Δp_t^m have declined from 0.104 in the former sample period to 0.083 in the latter sample period. Moreover, coefficients on $(p - p^m)$ tend to take somewhat larger negative values, which yield larger negative $(1 - b)$ in equation (2)—from −0.025 to −0.032—as observed in Pain, Koske and Sollie (2006).

However, statistical evidence of these parameter changes is mixed, as the differences in the above coefficients are not statistically significant in the above system equations. Since equation-by-equation OLS regressions, as conducted by BIS (2005), suggest that the declines in static long-run coefficients on Δp_t^m are statistically significant in four countries (the United States, Germany, Canada and Sweden; estimation results are not shown in this text), the insignificance of these parameter changes in the system equations may indicate the importance of taking into account cross-equation residual correlations. On the other hand, the declines in static long-run coefficients on $(p - p^m)$ are not significant for all sample countries even in equation-by-equation OLS regressions. The difference from Pain, Koske and Sollie (2006), who recorded significant declines in $(1 - b)$, may arise from sample coverage (Pain, Koske and Sollie cover 21 OECD countries) and/or treatment of variables (they multiply $(p - p^m)$ by the import share).

Figure 4

Recursive Chow tests



Note: Recursive Chow tests are calculated by individually estimating equation (1) for each country. Test statistics are scaled by 1% critical values, indicated by the horizontal line.

More importantly for the purpose of this paper, the economic significance of these parameter changes may not be large. Contributions calculated from the coefficients of these split sample estimations (the fifth column of Table 5) are broadly in line with those of the baseline case (the first column).

3. Multivariate extension

So far, our discussion has proceeded as if the two markups represent some globalisation force. However, of course, globalisation is not the sole potential explanation of developments of these variables. For instance, rapid productivity growth, notably in information and communication technology, may raise the wage markup $(p - p^w)_t$ by reducing the unit labour cost. The absence of large negative supply shocks as experienced in the 1970s, which might be considered as good luck or the absence of bad luck in the above discussion, may also account for a wider import price markup $(p - p^m)_t$ as well as slower import price inflation Δp_t^m. Identification of these effects requires a model in which the two markups are endogenously determined.

Another drawback of single equation analysis of estimating equation (1) is that the approach cannot identify the effect of monetary policy, to which a number of researchers attribute disinflation in recent years (the good policy hypothesis). Since the model is not conditional on variables reflecting monetary policy, the equation cannot capture the effects of changes in the monetary policy process. Moreover, the explanatory variables in inflation regressions are themselves influenced by changes in the underlying monetary policy regime. This is especially so for inflation expectations, which are omitted in a reduced-form equation (1). Further complication arises if one takes into account the possibility that the parameters of the model may be influenced by changes in monetary policy.

In order to address (some of) these issues, we endogenise developments of the two markups and the interest rate in the following system equations.

$$\Delta p_{k,t} = a_{0k} + a_{1k}(p - p^w)_{k,t-1} + a_{2k}(p - p^m)_{k,t-1} + a_{3k}(L)X_{k,t-1} + u_{k,t}^p, \tag{7}$$

$$\Delta(p - p^w)_{k,t} = b_{0k} + b_{1k}(p - p^w)_{k,t-1} + b_{2k}(p - p^m)_{k,t-1} + b_{3k}(L)X_{k,t-1} + u_{k,t}^w, \tag{8}$$

$$\Delta(p - p^m)_{k,t} = c_{0k} + c_{1k}(p - p^w)_{k,t-1} + c_{2k}(p - p^m)_{k,t-1} + c_{3k}(L)X_{k,t-1} + u_{k,t}^m, \tag{9}$$

$$y_{k,t} = d_{0k} + d_{1k}(p - p^w)_{k,t-1} + d_{2k}(p - p^m)_{k,t-1} + d_{3k}(L)X_{k,t-1} + u_{k,t}^y, \tag{10}$$

$$i_{k,t} = e_{0k} + e_{1k}\Delta p_{k,t} + e_{2k}y_{k,t} + e_{3k}(L)i_{k,t-1} + u_{k,t}^i, \tag{11}$$

where $X_{k,t} = \begin{bmatrix} \Delta p_{k,t} \\ \Delta(p - p^w)_{k,t} \\ \Delta(p - p^m)_{k,t} \\ y_{k,t} \\ i_{k,t} \end{bmatrix}$

and $a_{3k}(L)$, $b_{3k}(L)$, $c_{3k}(L)$, $d_{3k}(L)$ and $e_{3k}(L)$ are lag polynomials where L is a lag operator—we include up to two-quarter lag.[7] Subscript k represents country k. Equation (7) corresponds to equation (6) augmented by the output gap $y_{k,t}$ and the policy interest rate $i_{k,t}$.[8]

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7 $a_{3k}(L)$, $b_{3k}(L)$, $c_{3k}(L)$ and $d_{3k}(L)$ are vector values.

8 In the empirical analyses below, $y_{k,t}$ is the output gap calculated by the HP filter on real GDP (the bandwidth is 1,600). $i_{k,t}$ is the money market interest rates obtained from the OECD Economic Outlook database. For Sweden, the series prior to 1982Q1 is obtained from the national source through the BIS Data Bank.

Equations (7)-(11) can be seen as an identified VAR, in which relative price adjustments are embedded as an error correction mechanism in equations (7)-(10) and an identification restriction of the policy reaction function and policy shocks is imposed in the manner of Boivin and Giannoni (2006) in equation (11). A presumption for the identification is that the central bank reacts to inflation and the output gap somewhat similar to the Taylor rule and a change in the central bank's behaviour, including a more aggressive response to inflation, may be captured by a residual $u_{k,t}^{i}$ in equation (11).[9] However, this approach cannot capture effects that do not reveal themselves in the central bank's interest rate setting behaviour. For instance, if the introduction of an inflation targeting monetary policy framework coupled with a greater degree of transparency and accountability has better anchored inflation expectations without changing the policy reaction of the interest rate setting, the estimated monetary shock understates the true effect of the monetary policy. At the same time, to the extent that changes in the central bank's behaviour have been driven by global factors as discussed by BIS (2006, Chapter IV), the contributions of the estimated monetary policy shocks $u_{k,t}^{i}$ are overstated.

Furthermore, we estimate a common factor of markup shocks across sample countries using a single dynamic factor model.

$$u_{k,t} = \gamma_k f_t + \xi_{k,t}, \tag{12}$$

$$f_t = \phi_1 f_{t-1} + \phi_2 f_{t-2} + \omega_t, \tag{13}$$

$$\xi_{k,t} = \psi_{k1}\xi_{k,t-1} + \psi_{k2}\xi_{k,t-2} + \varepsilon_{k,t}, \tag{14}$$

where ω_t and $\varepsilon_{k,t}$ follow i.i.d. $N(0,1)$. $u_{k,t}$ is either the residual of the wage markup equation (8), $u_{k,t}^{w}$ or that of import price markup equation (9), $u_{k,t}^{m}$. In equation (12), this shock is represented as the sum of two orthogonal components, a common factor f_t and an idiosyncratic component $\xi_{k,t}$, both of which follow an AR(2) process in (13) and (14). We are interested in a common shock corresponding to $u_{k,t}^{w}$ and $u_{k,t}^{m}$, which is denoted as f_t^{w} and f_t^{m}, respectively. As seen above, both wage and import price markups are subject to individual country-specific factors such as business cycle conditions, the progress in labour market reform, exchange rate movements, etc. Common shocks, which can be interpreted as *global* shocks to relative prices, may arguably capture the effect of globalisation. This interpretation is subject to caveats, however, not only because markups are also influenced by other sources of global shocks such as oil supply shocks,[10] but also because equations (12)-(14) are a mere statistical decomposition. The identification of the global shocks is entirely based on simultaneity in the process of $u_{k,t}$, which may or may not have an origin in global factors. Even if shocks have an origin in global factors, they may not be captured by f_t, if they affect some countries with lags.

Estimation is carried out in two steps. In the first step, the system of equations (7)-(11) is estimated by Full Information Maximum Likelihood (FIML) by pooling all sample countries' data. This enables us to take into account cross-country correlations as we did in the SUR estimation above. In the second step, based on residuals $\hat{u}_{k,t}^{w}$ and $\hat{u}_{k,t}^{m}$ calculated in the FIML estimation, we estimate corresponding common factors f_t^{w} and f_t^{m} by applying a dynamic

[9] Sekine and Teranishi (2008) find that most of central banks investigated in this paper have increased the responsiveness of their policy interest rates to inflation.

[10] We will try to control for the effects of oil supply shocks later.

factor model (12)-(14) to each residual. The dynamic factor model is estimated by the Bayesian Markov chain Monte Carlo (MCMC).

Figure 5 shows the obtained global shocks. Two oil supply shocks in the 1970s have visible negative impacts on global import price markup shocks f_t^m. Then, they began to rise (ie, wider $(p - p^m)$ markup) from the middle of the 1980s when the import penetration ratio, often used as a proxy for trade integration, started to pick up in the sample industrial countries (Figure 6, left-hand panel). Foreign direct investment also began to expand rapidly in the middle of the 1980s. Although it is difficult to pin down what caused the global wage markup shocks f_t^w to reverse their course in the latter half of the 1970s, the timing broadly coincides with an increased degree of foreign competition measured by Borio and Filardo (2007) (Figure 6, right-hand panel). A relatively large positive shock is observed for the global wage markup shock around 1990, when China, India and the former Soviet bloc joined the global economy and the global labour supply increased sharply (Freeman (2005)). These observations lend themselves well to the view that global relative price shocks are broadly related to the process of globalisation.

The contribution of each shock to global disinflation is calculated by historical decomposition. The system equations (7)-(11) can be represented by

$$Z_{k,t} = C_k Z_{k,t-1} + V_{k,t},$$

where $Z_{k,t} = \begin{bmatrix} X_{k,t} \\ X_{k,t-1} \\ (p-p^w)_{k,t} \\ (p-p^m)_{k,t} \end{bmatrix}$, $V_{k,t} = \begin{bmatrix} U_{k,t} \\ 0 \\ \vdots \\ 0 \end{bmatrix}$ and $U_{k,t} = \begin{bmatrix} u_{k,t}^p \\ u_{k,t}^w \\ u_{k,t}^m \\ u_{k,t}^y \\ u_{k,t}^i \end{bmatrix}$.

C_k is an appropriately defined 12×12 matrix, which contains estimated coefficients of equations (7)-(11) as well as identity restrictions. $Z_{k,t}$ and $V_{k,t}$ are 12×1 vectors and $U_{k,t}$ is a 5×1 vector. Then, conditioning on $Z_{k,T}$, all the historical values thereafter can be expressed by

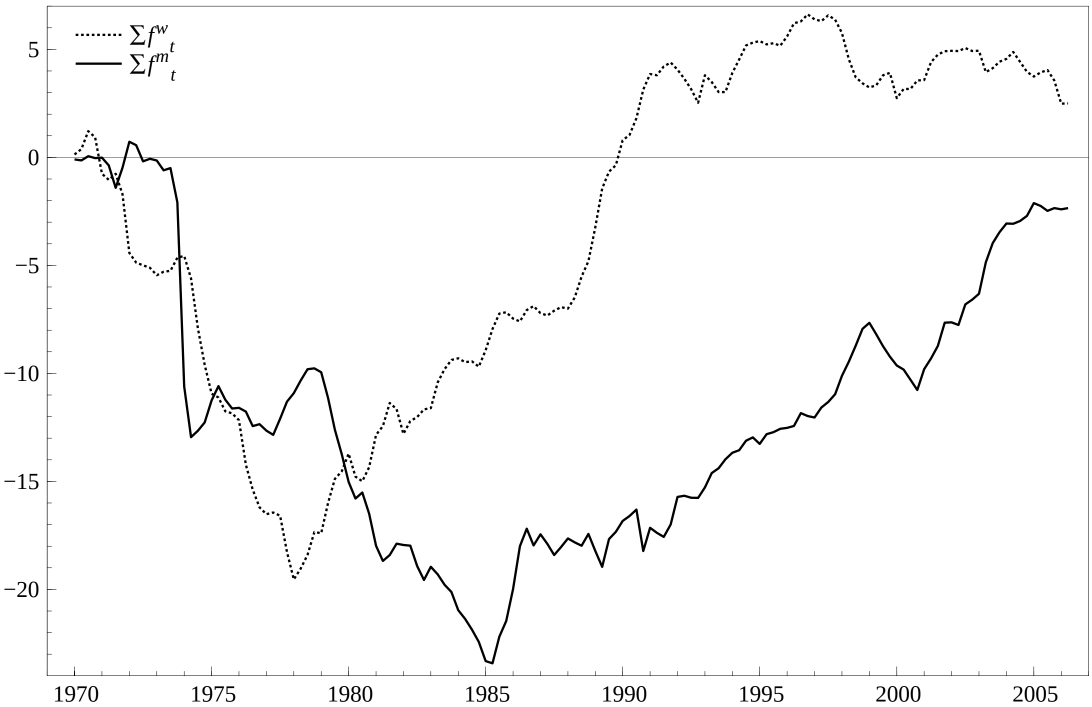
$$Z_{k,T+h} = C_k^h Z_{k,T} + \sum_{j=0}^{h-1} C_k^{h-j} V_{k,T+j} + V_{k,T+h}.$$

Setting T as 1969Q4, we can calculate what is attributable to a monetary policy shock $u_{k,t}^i$ for inflation $\Delta p_{k,t}$ during 1970Q1-2006Q2 and then taking the difference of those averaged during 1970Q1-1989Q4 and 1990Q1-2006Q2, we have the contributions of a policy shock to the disinflation observed before and after 1990. Similarly, we can calculate the contributions of relative price shocks $u_{k,t}^w$ and $u_{k,t}^m$. If we replace $u_{k,t}^w$ and $u_{k,t}^m$ with $\gamma_k^w f_t^w$ and $\gamma_k^m f_t^m$, we have the contributions of the global wage markup shock f_t^w and the global import price markup shock f_t^m.

Table 6 shows the contributions of the monetary policy shock and two global relative price shocks to a decline in inflation from 1970-1989 to 1990-2006. As an average of 8 OECD countries, the monetary policy shock accounts for about 1 percentage point out of a 5 percentage point decline in the inflation rate. Contributions of the monetary policy shock in Japan and Germany are small or slightly positive. This might be because central banks in these countries were already relatively hawkish against inflation in the former sample period compared to other central banks. For instance, some observers attribute the low inflation from 1975 onward in these countries to stronger discipline on the part of Japan’s and Germany’s monetary authorities. Compared to the Bundesbank, the interest rate setting by the ECB since 1999 may have been slightly more accommodative.

Figure 5

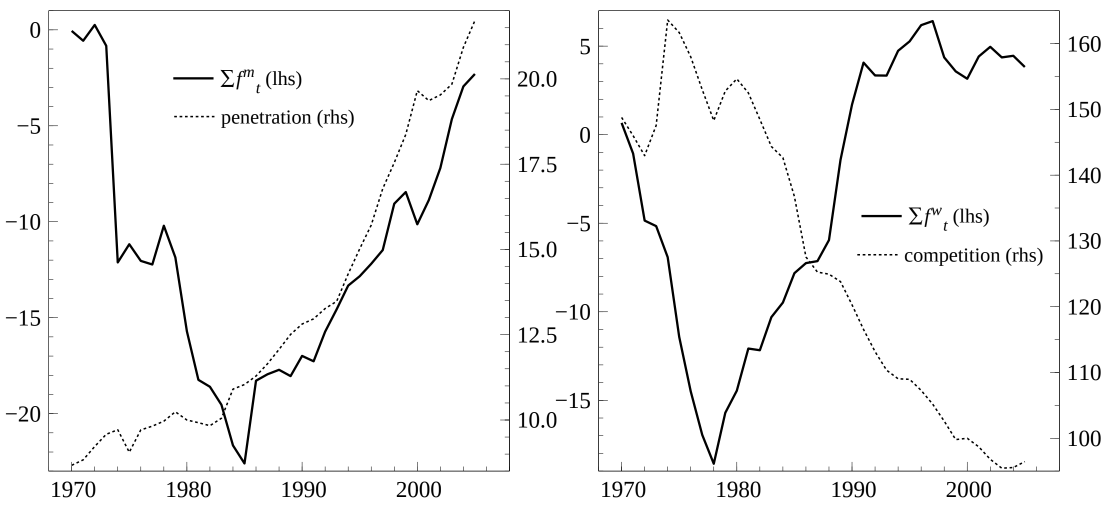
Two global relative price shocks



Note: Cumulative shocks of common factors of wage markup $\sum f_t^w$ and import price markup $\sum f_t^m$ calculated by equations (12)-(14). 1970Q1 is normalised at zero.

Figure 6

Global relative price shocks and globalisation



Note: See note for Figure 5 for two global relative price shocks. “Penetration” is measured by imports as a percentage of domestic demand. “Competition” is export prices divided by GDP deflator. Both indicators are the averages of the sample OECD countries based on PPP GDP weights in 2000.

Table 6

Historical decomposition[1]

	Contributions of shocks in						**memo.**
	Monetary policy $u^i_{k,t}$		**global wage markup** f^w_t		**global import price markup** f^m_t		**Disinflation from 70-89 to 90-06**
US	−0.5	(−0.4)	−1.2	(−1.0)	−0.2	(−0.1)	−3.2
JP	0.0	(−0.1)	−0.1	(0.0)	−1.2	(−1.1)	−5.6
DE	0.2	(−0.1)	0.6	(1.0)	0.8	(0.6)	−2.5
UK	−0.1	(−0.1)	−0.8	(−0.6)	−2.5	(−2.2)	−6.1
FR	−1.2	(−1.3)	−1.7	(−1.3)	−0.9	(−1.1)	−6.4
CA	−1.9	(−1.4)	−0.9	(−0.8)	−0.3	(−0.3)	−4.8
SE	−3.5	(−4.7)	−0.5	(−0.6)	−1.9	(−2.0)	−5.6
AU	−0.3	(0.0)	−1.5	(−0.9)	−0.1	(−0.1)	−6.3
Avg	−0.9	(−1.0)	−0.8	(−0.5)	−0.8	(−0.8)	−5.1

1. Historical decomposition based on a system of equations (7)-(11) and a dynamic factor model (12)-(14). Figures in parentheses are based on a system of equations (15)-(19) that incorporate the oil supply shock dummies and a dynamic factor model (12)-(14).

Two global relative price shocks account for about another 1 percentage point of decline respectively. Combined, the contributions of these two shocks amount to about a third of a 5 percentage point decline in the average inflation rates. These are smaller than those found in the single equation analysis (Table 5 above), but remain substantial. The observation is consistent with Ciccarelli and Mojon (2005) and Mumtaz and Surico (2006), who find that an international common factor of inflation explains the historical decline in the levels of national inflation rates, as the large contributions of global relative price shocks lead to a higher share of a common factor in national inflation rates. Either of these effects is relatively large in small open economies such as the United Kingdom, France and Sweden. The impact of the global wage markup is small in Japan and works in the opposite direction in Germany. This might be because these countries began to feel the effect of wage contraction later than other countries.

Controlling for the oil supply shocks yields broadly similar results. In an attempt to remove the effects of these shocks, we add dummy variables D_h, which take one at the time of the corresponding periods, otherwise nil. Following Hamilton (2003) and Kilian (2005), six episodes are considered: the Arab-Israel war (1973Q4); the Iranian revolution (1978Q4); the Iran-Iraq war (1980Q4); the Persian Gulf war (1990Q3); civil unrest in Venezuela (2002Q4); and the Iraq war (2003Q1). Figures in parentheses in Table 6 are calculated based on the system equations that incorporates these dummies

$$\Delta p_{k,t} = a_{0k} + a_{1k}(p - p^w)_{k,t-1} + a_{2k}(p - p^m)_{k,t-1} + a_{3k}(L)X_{k,t-1} + a_{4h}D_h + u^p_{k,t}, \quad (15)$$

$$\Delta(p - p^w)_{k,t} = b_{0k} + b_{1k}(p - p^w)_{k,t-1} + b_{2k}(p - p^m)_{k,t-1} + b_{3k}(L)X_{k,t-1} + b_{4h}D_h + u^w_{k,t}, \quad (16)$$

$$\Delta(p - p^m)_{k,t} = c_{0k} + c_{1k}(p - p^w)_{k,t-1} + c_{2k}(p - p^m)_{k,t-1} + c_{3k}(L)X_{k,t-1} + c_{4h}D_h + u^m_{k,t}, \quad (17)$$

$$y_{k,t} = d_{0k} + d_{1k}(p - p^w)_{k,t-1} + d_{2k}(p - p^m)_{k,t-1} + d_{3k}(L)X_{k,t-1} + d_{4h}D_h + u^y_{k,t}, \quad (18)$$

$$i_{k,t} = e_{0k} + e_{1k}\Delta p_{k,t} + e_{2k} y_{k,t} + e_{3k}(L) i_{k,t-1} + e_{4h} D_h + u^i_{k,t}, \tag{19}$$

and a dynamic factor model (12)-(14). On average, the contributions of global wage markup shocks become somewhat smaller in negative, but remain substantial. Those of global import price markup shocks are the same as before.

4. Conclusion

The global economy has experienced substantial relative price adjustments over the past decades. Both wage costs and import prices have declined relative to consumer prices, which has led to higher markups in consumer prices over wage costs and import prices. This paper links these relative price adjustments with the global disinflation using an open-economy markup model and extends the analysis to a multivariate setup so that two global relative price shocks and the monetary policy shock are identified. Out of a 5 percentage point decline in the inflation rates in eight OECD countries, two global shocks account for more than 1.5 percentage points, while the monetary policy shock accounts for another 1 percentage point.

Even if one accepts this paper's view that the tailwind from relative price adjustments has acted to reduce the inflation rate, this does not guarantee that policy organisers can continue to rely on it in the future. The global wage markup shock seems to have ceased to rise and the labour share has already begun to increase in cyclically advanced countries. Given the recent increases in energy and base metal prices as well as food prices, the import price markup may seem to peak. The tailwind may well turn into a headwind once the global economy reaches its capacity limit. After all, it may be the case that "The apparent excess in savings, combined with globalization, technology-driven increases in productivity, and the shift of workforces from centrally planned economies to competitive markets, has helped suppress... rates of inflation for all developed and virtually all developing nations. Yet... none of these forces is likely to be permanent. Inflation in a fiat money world is difficult to suppress" (Greenspan (2007, pp 13-14)).

Appendix: Derivation of the long-run solution

The long-run solution of (2) can be derived from marginal cost pricing. Suppose a CES production function, which includes imported intermediate goods as a factor of production.[11]

$$Y = \left[\alpha_L L^{\rho} + \alpha_M M^{\rho}\right]^{1/\rho},$$

where Y is outputs, L is labour inputs and M is imported intermediate goods. The cost minimisation problem yields the following cost function also represented as a CES form.

$$C = Y\left[a_L (P^w)^r + a_M (P^M)^r\right]^{1/r},$$

where $r = \rho/(\rho - 1)$ and $a_L = (\alpha_L)^{-r/\rho}$, $a_M = (\alpha_M)^{-r/\rho}$. Differentiation of this relationship with respect to output Y and linear approximation give the following marginal cost.

$$\hat{c} = \bar{b}\hat{p}^w + (1 - \bar{b})\hat{p}^m, \tag{20}$$

where a hat indicates the log-deviations from steady-state values.

$$\bar{b} = \frac{a_L (\bar{P}^w)^r}{a_L (\bar{P}^w)^r + a_M (\bar{P}^m)^r},$$

where $\bar{P}^w$ and $\bar{P}^m$ are steady-state values of P^w and P^m. Equation (2) may be interpreted as an empirical correspondence of equation (20), which implies that in the long run output prices are determined by marginal costs.

[11] For simplicity, a stock of capital is assumed to be fixed and omitted from the production function.

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Supplement

Table S.1

Static long-run coefficients (simplified)[1]

	$p-p^w$	$p-p^m$	Δp^w	Δp^m	**const**	**σ**	**adj R^2**
US	−0.057** (0.016)	−0.012** (0.002)	0.108 (0.073)	0.066** (0.021)	0.005** (0.001)	0.003	0.78
JP	−0.021 (0.018)	−0.012** (0.003)	0.294** (0.074)	0.042* (0.019)	0.000 (0.001)	0.008	0.62
DE	0.022 (0.021)	−0.020** (0.007)	0.167* (0.079)	0.123** (0.043)	0.005** (0.001)	0.010	0.13
UK	−0.067** (0.022)	−0.023** (0.004)	0.322** (0.060)	0.057 (0.033)	−0.003 (0.002)	0.007	0.74
FR	−0.087** (0.027)	−0.013 (0.007)	0.291** (0.106)	0.084* (0.034)	0.003* (0.001)	0.004	0.84
CA	−0.046** (0.011)	−0.021** (0.005)	0.234** (0.061)	0.082** (0.031)	0.005** (0.001)	0.004	0.79
SE	−0.046** (0.011)	−0.029** (0.006)	0.043 (0.063)	0.073* (0.028)	0.005** (0.001)	0.009	0.51
AU	−0.073** (0.014)	−0.014* (0.005)	0.135* (0.053)	0.021 (0.029)	−0.006** (0.002)	0.006	0.72
8 OECD	−0.041* (0.019)	−0.015** (0.003)	0.238** (0.062)	0.076** (0.015)	0.002 (0.002)	0.007	0.54

1. Coefficients obtained by SUR and GLS estimation of equation (4). See notes for Table 2.

Table S.2

Contribution of each factor (simplified)[1]

	Difference between 1970-1989 and 1990-2006					
	Actual	**Explained by**				
		$\sum \Delta p_{-j}$	$(p - p^w)_{-1}$	$(p - p^m)_{-1}$	$\sum \Delta p^w_{-j}$	$\sum \Delta p^m_{-j}$
US	−3.2	−1.3	−0.8	−0.7	−0.2	−0.2
JP	−5.6	−1.6	−0.1	−2.0	−1.3	−0.1
DE	−2.5	−0.1	0.5	−1.9	−0.6	−0.4
UK	−6.1	−0.9	−0.5	−3.0	−1.7	−0.4
FR	−6.4	−3.6	−0.7	−0.7	−0.8	−0.3
CA	−4.8	−1.5	−1.3	−1.0	−0.8	−0.3
SE	−5.6	0.6	−2.6	−3.3	−0.3	−0.6
AU	−6.3	−1.7	−2.6	−1.1	−0.6	−0.1
Avg	−5.1	−1.3	−1.0	−1.7	−0.8	−0.3

1. Contributions are calculated using regression coefficients of equation (4). See notes for Table 3.

Table S.3

Static long-run coefficients (further simplified)[1]

	$p - p^w$	$p - p^m$	const	σ	adj R^2
US	−0.082** (0.015)	−0.016** (0.002)	0.006** (0.001)	0.003	0.74
JP	−0.032 (0.026)	−0.021** (0.004)	−0.001 (0.002)	0.008	0.58
DE	0.026 (0.024)	−0.033** (0.008)	0.005** (0.001)	0.010	0.11
UK	−0.138** (0.025)	−0.036** (0.004)	−0.006 (0.002)	0.007	0.70
FR	−0.143** (0.035)	−0.026 (0.009)	0.004* (0.002)	0.004	0.83
CA	−0.076** (0.011)	−0.031** (0.007)	0.007** (0.001)	0.004	0.76
SE	−0.051** (0.011)	−0.035** (0.006)	0.005** (0.001)	0.009	0.48
AU	−0.095** (0.012)	−0.014* (0.005)	−0.008** (0.002)	0.006	0.70
8 OECD	−0.077** (0.027)	−0.022** (0.006)	0.002 (0.003)	0.008	0.48

1. Coefficients obtained by SUR and GLS estimation of equation (5). See notes for Table 2.

Table S.4

Contribution of each factor (further simplified)[1]

	Difference between 1970-1989 and 1990-2006			
	Actual	**Explained by**		
		$\sum \Delta p_{-j}$	$(p - p^w)_{-1}$	$(p - p^m)_{-1}$
US	−3.2	−1.5	−1.0	−0.9
JP	−5.6	−2.8	−0.1	−2.4
DE	−2.5	−0.4	0.5	−2.7
UK	−6.1	−2.2	−0.8	−3.6
FR	−6.4	−4.4	−0.8	−0.9
CA	−4.8	−2.2	−1.6	−1.1
SE	−5.6	0.3	−2.8	−3.8
AU	−6.3	−1.9	−3.3	−1.1
Avg	−5.1	−1.9	−1.3	−2.1

1. Contributions are calculated using regression coefficients of equation (5). See notes for Table 3.

Table S.5

Static long-run coefficients (reparameterised)[1]

	$p - p^w$	$p - p^m$	$\Delta(p - p^w)$	$\Delta(p - p^m)$	const	σ	adj R^2
US	−0.069** (0.017)	−0.015** (0.003)	−0.130 (0.099)	−0.080** (0.025)	0.007** (0.001)	0.003	0.78
JP	−0.031 (0.027)	−0.019** (0.004)	−0.444** (0.157)	−0.064* (0.029)	0.001 (0.002)	0.008	0.62
DE	0.030 (0.031)	−0.028** (0.010)	−0.235 (0.139)	−0.173* (0.074)	0.006** (0.002)	0.010	0.13
UK	−0.108** (0.030)	−0.037** (0.005)	−0.518** (0.149)	−0.092 (0.059)	−0.005* (0.002)	0.007	0.74
FR	−0.139** (0.039)	−0.021* (0.010)	−0.466 (0.241)	−0.135* (0.058)	0.005** (0.002)	0.004	0.84
CA	−0.067** (0.013)	−0.031** (0.008)	−0.342** (0.121)	−0.120* (0.051)	0.008** (0.001)	0.004	0.79
SE	−0.052** (0.011)	−0.033** (0.007)	−0.049 (0.075)	−0.082* (0.036)	0.006** (0.001)	0.009	0.51
AU	−0.086** (0.014)	−0.016* (0.006)	−0.160* (0.073)	−0.024 (0.035)	−0.007** (0.002)	0.006	0.72
8 OECD	−0.059* (0.025)	−0.022** (0.004)	−0.347** (0.122)	−0.112** (0.025)	0.003 (0.002)	0.007	0.54

1. Coefficients obtained by SUR and GLS estimation of equation (6). See notes for Table 2.

Table S.6

Contribution of each factor (reparameterised)[1]

	Difference between 1970-1989 and 1990-2006					
	Actual	**Explained by**				
		$\sum \Delta p_{-j}$	$(p-p^w)_{-1}$	$(p-p^m)_{-1}$	$\sum \Delta(p-p^w)_{-j}$	$\sum \Delta(p-p^m)_{-j}$
US	−3.2	−1.6	−0.8	−0.7	0.0	−0.1
JP	−5.6	−3.0	−0.1	−2.0	−0.2	0.1
DE	−2.5	−0.8	0.5	−1.9	−0.2	−0.1
UK	−6.1	−2.9	−0.5	−3.0	0.0	−0.1
FR	−6.4	−4.6	−0.7	−0.7	0.0	−0.1
CA	−4.8	−2.5	−1.3	−1.0	0.0	0.0
SE	−5.6	−0.1	−2.6	−3.3	0.0	−0.1
AU	−6.3	−2.4	−2.6	−1.1	0.0	0.0
Avg	−5.1	−2.2	−1.0	−1.7	−0.1	−0.1

1. Contributions are calculated using regression coefficients of equation (6). See notes for Table 3.

Table S.7

Static long-run coefficients (split sample)[1]

	$p - p^w$	$p - p^m$	Δp^w	Δp^m	const	σ	adj R^2
$US_{70\text{-}89}$	−0.069* (0.029)	−0.014** (0.003)	0.219* (0.085)	0.145** (0.020)	0.001 (0.001)	0.003	0.84
$US_{90\text{-}06}$	−0.051* (0.019)	−0.012** (0.003)	0.087 (0.073)	0.119** (0.025)	0.005* (0.001)	0.002	0.66
$JP_{70\text{-}89}$	−0.052** (0.014)	0.002 (0.003)	0.601** (0.043)	0.038** (0.014)	0.005** (0.002)	0.007	0.74
$JP_{90\text{-}06}$	−0.084** (0.022)	−0.043** (0.009)	−0.010 (0.107)	−0.014 (0.026)	−0.002** (0.001)	0.004	0.41
$DE_{70\text{-}89}$	−0.037 (0.042)	−0.011 (0.017)	0.425** (0.096)	0.097 (0.054)	0.000 (0.006)	0.011	0.28
$DE_{90\text{-}06}$	0.031 (0.016)	−0.038** (0.010)	0.141 (0.086)	0.068 (0.052)	0.005** (0.001)	0.004	0.36
$UK_{70\text{-}89}$	−0.131** (0.033)	−0.035** (0.010)	0.331** (0.062)	0.047 (0.037)	−0.015** (0.005)	0.008	0.71
$UK_{90\text{-}06}$	−0.046** (0.012)	−0.025** (0.003)	0.369** (0.060)	0.037 (0.036)	−0.002 (0.001)	0.004	0.62
$FR_{70\text{-}89}$	−0.058** (0.017)	−0.004 (0.008)	0.356** (0.058)	0.137** (0.023)	0.006** (0.002)	0.005	0.77
$FR_{90\text{-}06}$	−0.121** (0.026)	−0.032** (0.005)	−0.195* (0.096)	0.167** (0.030)	0.004** (0.000)	0.002	0.54
$CA_{70\text{-}89}$	−0.036* (0.018)	−0.021* (0.008)	0.332** (0.085)	0.157** (0.050)	0.003* (0.002)	0.004	0.77
$CA_{90\text{-}06}$	−0.024 (0.019)	−0.007 (0.010)	0.363** (0.118)	0.136* (0.053)	0.004** (0.001)	0.004	0.17
$SE_{70\text{-}89}$	−0.041** (0.010)	−0.028** (0.007)	0.090 (0.058)	0.119** (0.028)	0.003 (0.002)	0.008	0.45
$SE_{90\text{-}06}$	−0.081** (0.020)	−0.065** (0.019)	0.201* (0.098)	0.064 (0.052)	0.004** (0.001)	0.008	0.36
$AU_{70\text{-}89}$	−0.070** (0.019)	−0.014 (0.013)	0.240** (0.069)	0.039 (0.046)	−0.008 (0.007)	0.006	0.56
$AU_{90\text{-}06}$	−0.070** (0.025)	−0.006 (0.005)	0.316** (0.090)	0.042 (0.026)	−0.005* (0.003)	0.004	0.39
8 $OECD_{70\text{-}89}$	−0.051** (0.017)	−0.017** (0.005)	0.340** (0.095)	0.104** (0.019)	−0.000 (0.003)	0.008	0.64
8 $OECD_{90\text{-}06}$	−0.058** (0.020)	−0.028** (0.010)	0.210* (0.087)	0.083** (0.024)	0.002 (0.001)	0.007	0.28

1. Coefficients obtained by SUR and GLS estimation of equation (1). See notes for Table 2. Subscripts indicate sample periods.

Table S.8

Contribution of each factor (split sample)[1]

	Difference between 1970-1989 and 1990-2006						
	Actual	**Explained by**					
		$\sum \Delta p_{-j}$	$(p-p^{w})_{-1}$	$(p-p^{m})_{-1}$	$\sum \Delta p^{w}_{-j}$	$\sum \Delta p^{m}_{-j}$	const
US	−3.2	−0.8	−1.0	−1.1	−0.7	−0.7	1.0
JP	−5.6	0.2	−0.4	1.6	−3.7	−0.1	−3.1
DE	−2.5	0.3	−1.0	−1.1	−1.8	−0.3	1.5
UK	−6.1	−1.1	−2.7	−5.4	−1.6	−0.4	5.0
FR	−6.4	0.2	−1.0	−0.5	−3.2	−1.1	−0.8
CA	−4.8	−2.0	−0.9	−0.8	−1.0	−0.5	0.3
SE	−5.6	2.0	−2.6	−3.7	−0.5	−1.2	0.4
AU	−6.3	−2.2	−1.9	−1.5	−0.9	−0.2	0.4
Avg	−5.1	−0.4	−1.4	−1.6	−1.7	−0.6	0.6

1. Contributions are calculated using regression coefficients of equation (1). See notes for Table 3.