Another Look at Global Disinflation*

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Abstract

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

JEL Classification Number: E31, F02, F41

Keywords: markup model, open-economy New Keynesian Phillips curve, dynamic factor model, global disinflation

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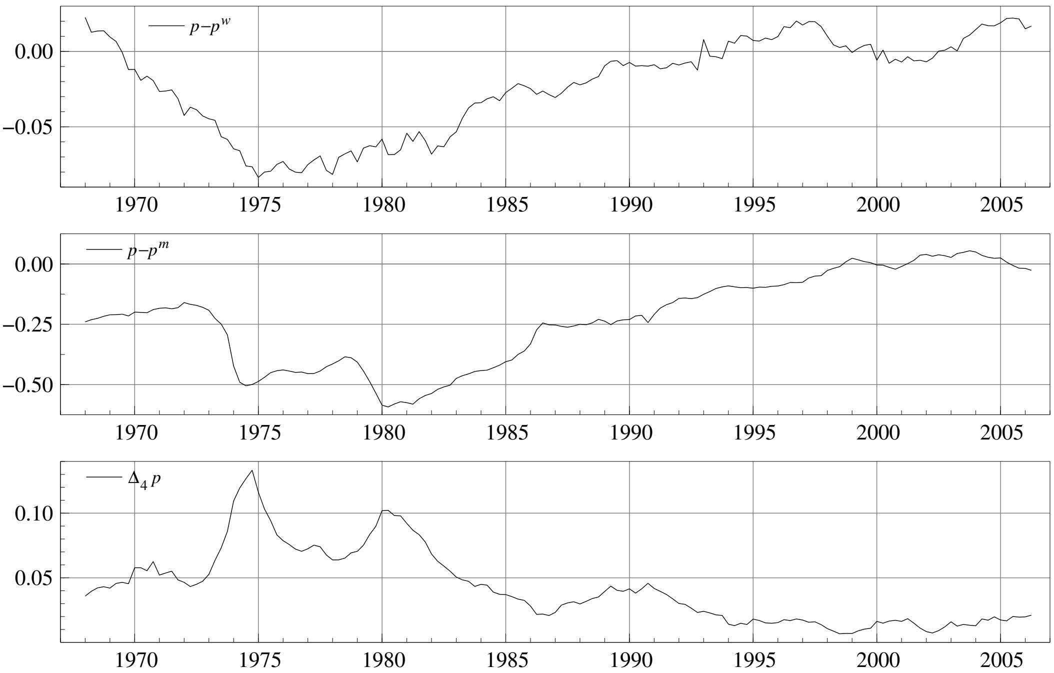
1 Introduction

The dramatic decline in both the rate and volatility of global inflation over the past decades can be seen as one of the greatest achievements in the global economy. Despite an extensive number of researches conducted both in central banks and academia, consensus has not emerged yet 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, recently, an issue regarding how and to what extent "globalisation" has affected this change in the inflation process has attracted particular attention of researchers—see Borio and Filardo (2007), IMF (2006), Pain, Koske, and Sollie (2006), Cecchetti et al (2007), Ihrig et al (2007), among others. While many observers refer globalisation, or the closer integration of labour abundant emerging market economies to the global economy, as one of the most important structural changes that the global economy has experienced, some are quite skeptical about its impact on inflation. These include Ball (2006) stating "[T]here is little reason to think that globalisation has influenced inflation significantly."

Against this backdrop, this paper focuses on impact 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 wages costs $(p^w-p)_t$ and real import prices $(p^m-p)_t$, have dropped as such. These adjustments in the relative prices, which are possibly associated with globalisation, appear strongly correlated with the past developments of the inflation rate (Figure 2).

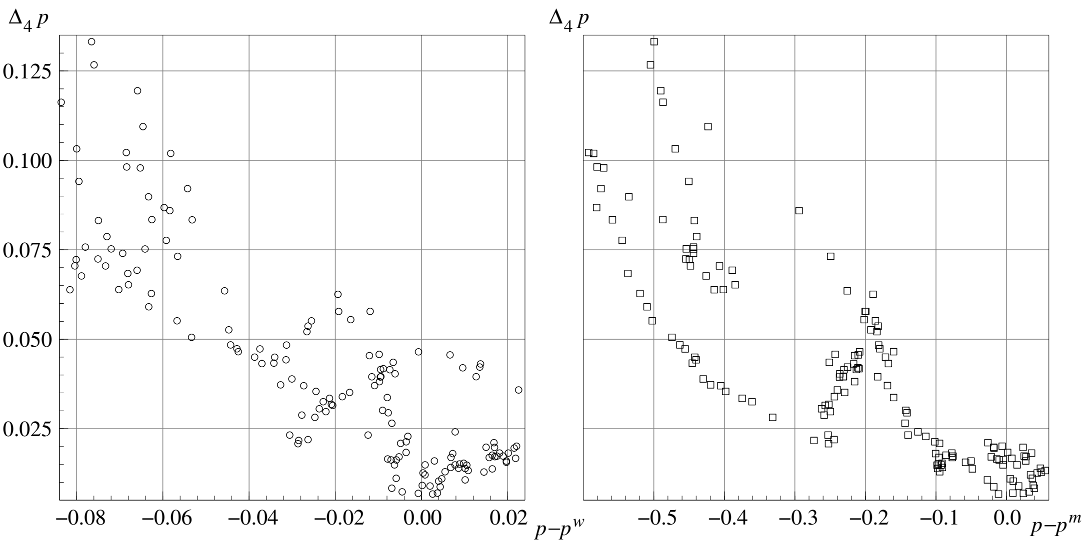
In this paper, the link between relative price adjustments and the level of inflation rates is established by a markup model. A markup model itself has a long history with a numerous number of empirical applications—see, for example, the survey of Bronfenbrenner and Holzman (1963) and Frisch (1983). 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), Heath, Roberts, and Bulman (2004) estimate a similar model for various countries, and more recently, Pain, Koske, and Sollie

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.

Figure 2: Correlation between two markups and inflation



Note: 8 OECD countries averaged by PPP GDP weights in 2000.

(2006) use it to analyse the global disinflation. This paper can be seen as a complement of the last paper, which does not calculate contribution of each factor.

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

The structure of the remaining of the paper is as follows. Section 2 introduces an open-economy version of markup model. Section 3 estimates it and shows large contributions coming from two markups. Section 4 extends the analysis to a multivariate dimension and quantifies the impacts of the global relative price shocks as well as the monetary policy shock. Section 5 concludes the paper.

2 Two Markups

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

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

where p_t is consumer prices at the time period t, p^w_t is unit labour costs (ULC), p^m_t is import prices, y_t is the output gap, and u_t is an error term. All variables except for y_t are in logarithm and Δ denotes the first difference operator. $(p - p^w)_t$ is a price markup over the labour costs and $(p - p^m)_t$ is that over the import costs. At the time of high markups, prices are likely to be cut subsequently through competitive pressures, and thus expected signs of α_1 and α_2 are negative.

Another way of interpreting these markups is that these terms represent relative prices: i.e., relative prices of wage costs p_t^w and import prices p_t^m vis-a-vis consumer prices p_t. The equation embeds the mechanism that inflation is adjusted by relative price movements. In the long run, once these relative prices 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).

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

$$\Delta p_t = \phi E_t \Delta p_{t+1} + \lambda rmc_t + const. + u_t, \tag{2}$$

where rmc_t is the real marginal cost and often represented by the labour share, which is nothing but $-(p-p^w)_t$ in equation (1).[1] In an open economy set up, Batini, Jackson, and Nickell (2005) show that it 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 other specifications of the open-economy NKPC. Although details of these specifications differ each other depending on the complexity of the model set up, they share a common feature that, on top of the labour share, the markup over imported materials prices $(p - p^m)_t$ is included in the equation.

There exist a number of fundamental differences between a reduced form (equation (1)) and a structural form (equation (2)), but as far as factor contributions are concerned, these two approaches may not differ much. One of key differences between them is a forward-looking

[1]

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

where W is nominal wage, L is labour inputs, P is output price and Y is real outputs. WL/PY is the labour share and WL/Y is the unit labour cost.

inflation expectation $E_t \Delta p_{t+1}$ in equation (2). 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

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

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 (2) may yield a very similar result to equation (1)—or more precisely its restricted versions (3) and (4) 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 prices inflation Δp_t^m. Over the past decade or so, imports—especially those of manufactured goods—from emerging market economies to industrial counties have swelled, which has been associated with lower import inflation. For instance, Kamin, Marazzi, and Schindler (2006) estimate Chinese exports alone lowered annual import inflation in major industrial countries by 0.25 percentage point 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 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. To the extent that import prices has risen at a slower rate than consumer prices, globalisation puts additional downward pressures 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 the lower labour share. 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 share in industrial countries. Indeed, Guscina (2006) and IMF (2007) show that globalisation, together with rapid technological change, has had a significant impact on a trend decline in the labour share.[2]

Some researchers further argue that globalisation has changed the parameters of the inflation process. These include greater sensitiveness of domestic inflation to import prices such as larger coefficients on Δp_t^m and $(p - p^m)_t$ (Ihrig et al (2007), IMF (2006), Pain, Koske, and Sollie (2006)).[3] Borio and Filardo (2007) show domestic inflation has become less sensitive to the domestic output gap y_t—in fact, this is a theoretical prediction of an open-economy NKPC such as 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.

3 Estimation Results

3.1 Data

All the data, otherwise noted, come from the OECD Economic Outlook database. p_t is log of private final consumption deflator; p_t^w is log of unit labour cost of the total economy; p_t^m is log of imports of goods and services deflator; and y_t is the output gap calculated by the HP filter on real GDP (the bandwidth is 1600). Figure 3 plots the annual inflation $\Delta_4 p_t$ together with two markups for each sample country.

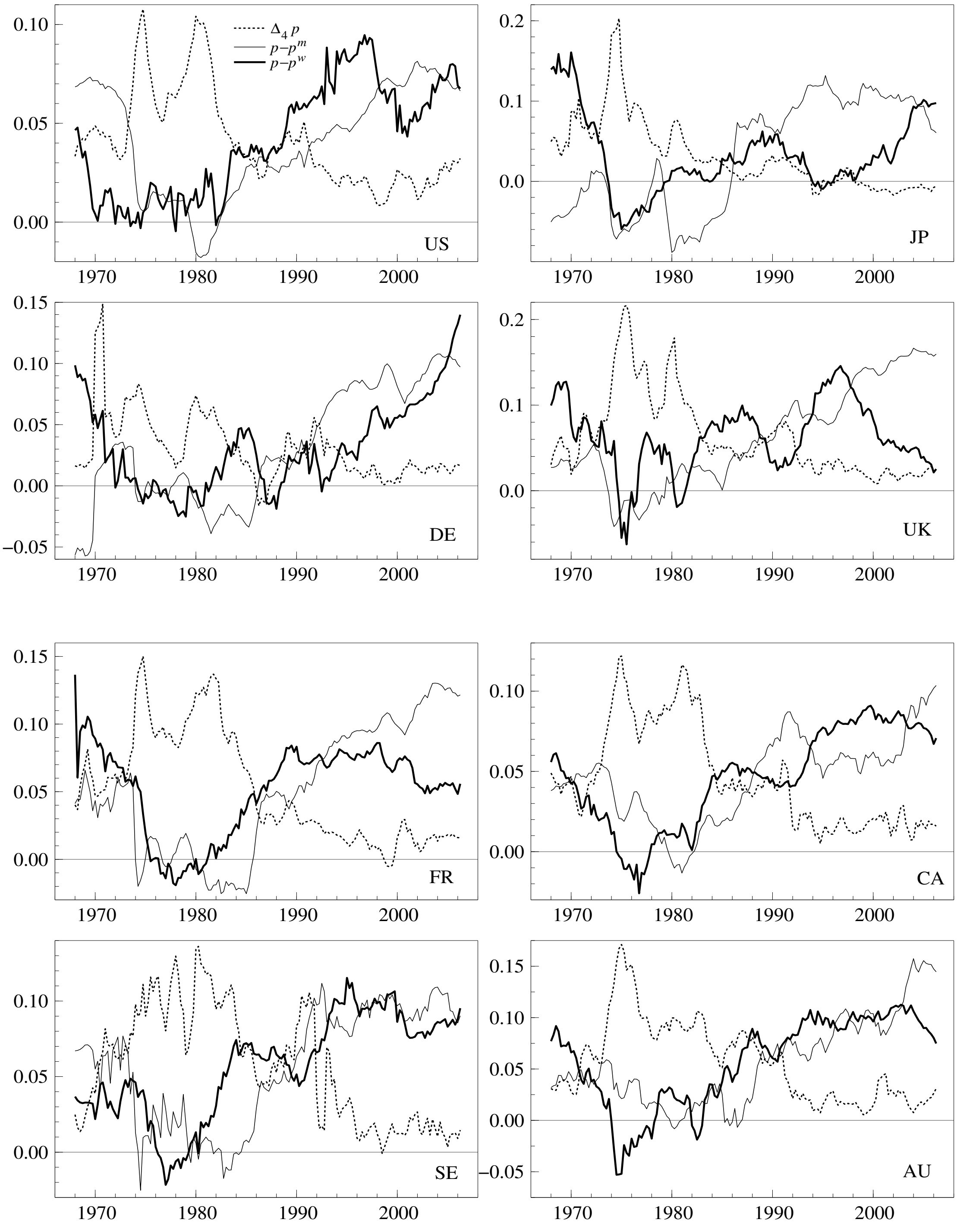
Although short- to medium-term fluctuations differ considerably, all countries show a clear trend increase in the wage markup. To a certain extent, this can be seen as a rebound from the sharp drop in the wage markup in the early 1970s. Recently, the wage markup seems to begin dropping in cyclically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

[2] See Ellis and Smith (2007) as an alternative view. Global competitive pressures 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 two markups appear inconsistent with the view (Kohn, 2006).

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

Figure 3: Two markups and inflation



Note: Two markups, $p - p^w$ and $p - p^m$, are adjusted so that their means and ranges fit those of annual inflation rate $\Delta_4 p$ in 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 test

	no time trend			with time trend		
	Fisher	1% CV	5% CV	Fisher	1% CV	5% CV
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	77.5
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
y	233.5	65.3	55.7	234.4	91.4	79.5

Notes:

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.

stronger over the past three decades (Japan, Germany), but also in weaker currency countries (Australia, Sweden) imply 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 stop rising especially in countries whose currencies depreciated at the same time (the United States, Japan).

There is ambiguity regarding stationarity of 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, presence of a unit root in the consumer prices inflation rate Δp_t cannot be rejected at the 1% critical level. These observations are consistent with Banerjee and Russell (2001), Banerjee, Cockerell, and Russell (2001), who show that the inflation rate and 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), Peseran 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 know to have low power in the case of breaks in trends. Indeed, rolling test statistics of Banerjee, Lumsdaine, and Stock (1992), which allows for a break at an unknown point in the sample period, rejects the unit-root null for $(p - p^w)_t$ in Japan and France and $(p - p^m)_t$ in Germany and France at the 5% critical level.

Table 2: Static long-run coefficients (Baseline)

	$p - p^w$	$p - p^m$	Δp^w	Δp^m	y	const.	σ
US	-0.033^{**}	-0.011^{**}	0.212^{**}	0.145^{**}	0.011	0.004^{**}	0.002
	(0.011)	(0.002)	(0.060)	(0.016)	(0.018)	(0.001)	
JP	-0.036^{**}	-0.005^{**}	0.567^{**}	0.044^{**}	0.020	0.001	0.006
	(0.013)	(0.002)	(0.040)	(0.013)	(0.044)	(0.001)	
DE	0.006	-0.009	0.415^{**}	0.080^{*}	0.149^{**}	0.004^{**}	0.008
	(0.018)	(0.006)	(0.066)	(0.039)	(0.053)	(0.001)	
GB	-0.095^{**}	-0.021^{**}	0.344^{**}	0.067^{*}	0.116^{*}	-0.005^{**}	0.006
	(0.022)	(0.004)	(0.059)	(0.033)	(0.051)	(0.002)	
FR	-0.055^{**}	-0.016^{**}	0.338^{**}	0.135^{**}	0.076	0.002^{**}	0.003
	(0.012)	(0.003)	(0.053)	(0.020)	(0.045)	(0.001)	
CA	-0.037^{**}	-0.017^{**}	0.321^{**}	0.130^{**}	0.026	0.004^{**}	0.004
	(0.011)	(0.004)	(0.061)	(0.031)	(0.030)	(0.001)	
SE	-0.047^{**}	-0.022^{**}	0.104	0.126^{**}	0.043	0.004^{**}	0.008
	(0.011)	(0.006)	(0.070)	(0.031)	(0.047)	(0.001)	
AU	-0.063^{**}	-0.010^{*}	0.264^{**}	0.055	-0.003	-0.005^{**}	0.005
	(0.014)	(0.005)	(0.057)	(0.030)	(0.038)	(0.002)	
8 OECD	-0.039^{**}	-0.014^{**}	0.336^{**}	0.099^{**}	0.061^{*}	0.001	0.007
	(0.015)	(0.003)	(0.071)	(0.017)	(0.025)	(0.001)	

Notes:

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 prices inflation Δp^m; $\theta/(1-\sum\beta_j)$ for output gap y; 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.

3.2 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 Untied 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 average are obtained by Generalised Least Square (GLS) proposed by Swamy (1970).[4]

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

[4] All the estimation is conducted by Ox (Doornik, 2006).

Table 3: Contribution of each factor (Baseline)

	Avearge 1970-1989	Average 1990-2006	Actual	Difference between 1970-1989 and 1990-2006					
				Explained by					
				$\sum \Delta p_{-j}$	$(p-p^w)_{-1}$	$(p-p^m)_{-1}$	$\sum \Delta p^w_{-j}$	$\sum \Delta p^m_{-j}$	y_{-1}
US	5.5	2.3	−3.2	−1.0	−0.5	−0.8	−0.4	−0.6	0.0
JP	5.6	0.0	−5.6	−0.4	−0.2	−1.1	−3.3	−0.1	0.0
DE	4.3	1.8	−2.5	0.0	0.1	−0.8	−1.5	−0.2	0.2
GB	9.1	2.9	−6.1	−0.9	−0.8	−2.8	−1.9	−0.5	−0.1
FR	8.0	1.6	−6.4	−1.1	−0.9	−1.5	−1.7	−0.9	0.0
CA	6.7	1.9	−4.8	−1.2	−1.1	−0.8	−1.2	−0.5	0.0
SE	8.3	2.8	−5.6	0.6	−2.7	−2.5	−0.7	−1.0	0.0
AU	8.7	2.4	−6.3	−1.6	−2.3	−0.8	−1.3	−0.3	0.0
Avg.	7.0	2.0	−5.1	−0.7	−1.0	−1.4	−1.5	−0.5	0.0

Notes:

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

hand, the output gap y is significant only in the case of Germany and the United Kingdom (and also 8 OECD countries average). We might be able to interpret this as an indication that the labour share is a better representation of real marginal cost than the output gap as discussed by advocates of the New Keynesian Phillips curve (Galí and Gertler (1999) and Woodford (2003)).

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

However, this argument omits the level effect. The wider wedge between import and domestics prices ($(p-p^m)_{-1}$ in the table) as well as the falling labour share ($(p-p^w)_{-1}$ 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 a decline in inflation. More interestingly, either or both of these effects tend to be larger for small open economies compared to the

Table 4: Static long-run coefficients (8 OECD)

	Baseline	Simple	Repara.	Sample-split	
specification	Eq. (1)	Eq. (2)	Eq. (3)	Eq. (1)	Eq. (1)
sample period	70Q1-06Q2	70Q1-06Q2	70Q1-06Q2	70Q1-89Q4	90Q1-06Q2
$p - p^w$	-0.039^{**}	-0.041^{*}	-0.059^{*}	-0.064^{**}	-0.057^{**}
	(0.015)	(0.019)	(0.025)	(0.024)	(0.020)
$p - p^m$	-0.014^{**}	-0.015^{**}	-0.022^{**}	-0.018^{**}	-0.029^{**}
	(0.003)	(0.003)	(0.004)	(0.006)	(0.011)
Δp^w	0.336^{**}	0.238^{**}	...	0.308^{**}	0.187^{*}
	(0.071)	(0.062)	...	(0.092)	(0.091)
Δp^m	0.099^{**}	0.076^{**}	...	0.088^{**}	0.081^{**}
	(0.017)	(0.015)	...	(0.021)	(0.024)
$\Delta(p - p^w)$	...	...	-0.347^{**}	...	...
	...	...	(0.122)	...	...
$\Delta(p - p^m)$	...	...	-0.112^{**}	...	...
	...	...	(0.025)	...	...
y	0.061^{*}	...	...	0.086^{*}	0.019
	(0.025)	...	...	(0.039)	(0.029)
const.	0.001	0.002	0.003	−0.001	0.002
	(0.001)	(0.002)	(0.002)	(0.004)	(0.001)
σ	0.007	0.007	0.007	0.009	0.007

Notes:

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

G3 economies (the United States, Japan and Germany). This may point to some global force behind these factors.

Meanwhile, the contribution of the output gap y_{-1} is zero for almost all the cases, the result of which is not surprising in the light of insignificance of the coefficient on it in Table 2. Moreover, since the output gap is calculated by the HP filter, more than a decade long average in Table 3 should smooth out these cyclical effects.

3.3 Alternative specifications

As a part of robustness checks, we drop the output gap y_{t-1} from equation (1), which has a negligible effect in Table 3. Furthermore, in order to address possible endogeneity, we further drop contemporaneous terms of ULC growth Δp_t^w and import prices inflation Δp_t^m. The simplified

Table 5: Contribution of each factor (8 OECD average)

specification	Baseline Eq. (1)	Simple Eq. (2)	Repara. Eq. (3)	Sample-split Eq. (1)
$\sum \Delta p_{-j}$	−0.7	−1.3	−2.2	−0.3
$(p-p^w)_{-1}$	−1.0	−1.0	−1.0	−1.3
$(p-p^m)_{-1}$	−1.4	−1.7	−1.7	−1.8
$\sum \Delta p^w_{-j}$	−1.5	−0.8	...	−1.6
$\sum \Delta p^m_{-j}$	−0.5	−0.3	...	−0.5
$\sum \Delta(p-p^w)_{-j}$	...	...	−0.1	...
$\sum \Delta(p-p^m)_{-j}$	...	...	−0.1	...
y_{-1}	0.0	...	...	0.0
const.	0.0	0.0	0.0	0.5

Notes:

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 column of "Baseline" is same as the last row of Table 3.

model becomes

$$\Delta p_t = \alpha_0 + \alpha_1(p-p^w)_{t-1} + \alpha_2(p-p^m)_{t-1} + \sum_{j=1}^{2}\beta_j \Delta p_{t-j} + \sum_{j=1}^{2}\gamma_j \Delta p^w_{t-j} + \sum_{j=1}^{2}\delta_j \Delta p^m_{t-j} + u_t. \quad (3)$$

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 A.1 and A.2 in the Appendix. 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 same as those in the baseline case.

Without loss of generality, equation (3) can be reparameterised as

$$\begin{aligned}\Delta p_t = {} & \alpha_0 + \alpha_1(p-p^w)_{t-1} + \alpha_2(p-p^m)_{t-1} \\ & + \sum_{j=1}^{2}\beta_j \Delta p_{t-j} + \sum_{j=1}^{2}\gamma_j \Delta(p-p^w)_{t-j} + \sum_{j=1}^{2}\delta_j \Delta(p-p^m)_{t-j} + u_t. \end{aligned} \quad (4)$$

The equation expresses that the current inflation is determined by the level and the change in two markups as well as its own lags. This enables us to calculate overall contributions of two markups (both levels and changes). These effects may arguably be able to 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 the third columns of Tables 4 and 5 and corresponding results of individual countries are in Tables A.3 and A.4 in the Appendix. Although coefficients on changes in two markups are statistically significant, since they are mean reverting, contributions of those variables are small, -0.1 percentage points respectively. Meanwhile, the contributions of the level of two markups remain same as the simplified case (3).

3.4 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 fourth and fifth columns of Table 4; individual countries are Tables A.5 and A.6 in the Appendix).

There are several interesting observations. First, static long-run coefficients on import price inflation Δp_t^m do not show a parameter shift: 0.088 in the former sample period and 0.081 in the latter sample period (the difference between these two coefficients are not statistically significant from zero). This differs not only from what some observers expect (a greater impact of import prices inflation), but also a declining second-stage pass-through reported by Sekine (2006).[5] Second, in line with IMF (2006) and Pain, Koske, and Sollie (2006), coefficients on $(p - p^m)$ tends to take somewhat larger negative values—from -0.018 to -0.029. Finally, coefficients on the output gap y decline from 0.086 to 0.019, which is consistent with the growing evidence of the flatter Phillips curve.

Contributions calculated from coefficients of these split-sample estimations again confirm the above observation: i.e., two markup terms account for a substantial part of the global disinflation (the fourth column of Table 5).

[5] In fact, estimation of the same specification used by Sekine (2006)

$$\Delta p_t = \alpha_0 + \sum_{j=1}^{2} \beta_j \Delta p_{t-j} + \sum_{j=0}^{2} \delta_j \Delta p_{t-j}^m + \theta y_{t-1} + u_t,$$

confirms his result. Static long-run coefficients on Δp^m declines from 0.21 in the former sample period to 0.13 in the latter sample period. From this, we may conclude that there is little evidence of parameter instability once we take into account the effects of widening two markups as well as contained ULC growth.

4 Multivariate Extension

So far, our discussion has proceeded as if 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 $(p - p^w)_t$ through reducing the unit labour cost. The absence of large negative supply shocks as experienced in the 1970s, which might be considered as a good luck or the absence of a bad luck in the above discussion, may also account for wider import price markup $(p - p^m)_t$ as well as slower import prices inflation Δp_t^m. Identification of these effects requires a model, in which 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 two markups and the interest rate in the following system equations.

$$\Delta p_{k,t} = a_{0k} + a_{1k}(p - p^w)_{k,t-1} + a_{2k}(p - p^m)_{k,t-1} + a_{3k}(L)X_{k,t-1} + u^p_{k,t}, \quad (5)$$

$$\Delta(p - p^w)_{k,t} = b_{0k} + b_{1k}(p - p^w)_{k,t-1} + b_{2k}(p - p^m)_{k,t-1} + b_{3k}(L)X_{k,t-1} + u^w_{k,t}, \quad (6)$$

$$\Delta(p - p^m)_{k,t} = c_{0k} + c_{1k}(p - p^w)_{k,t-1} + c_{2k}(p - p^m)_{k,t-1} + c_{3k}(L)X_{k,t-1} + u^m_{k,t}, \quad (7)$$

$$y_{k,t} = d_{0k} + d_{1k}(p - p^w)_{k,t-1} + d_{2k}(p - p^m)_{k,t-1} + d_{3k}(L)X_{k,t-1} + u^y_{k,t}, \quad (8)$$

$$i_{k,t} = e_{0k} + e_{1k}\Delta p_{k,t} + e_{2k}y_{k,t} + e_{3k}(L)i_{k,t-1} + u^i_{k,t}, \quad (9)$$

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. Subscript k represents country k. Equation (5) corresponds to equation (4) augmented by the output gap $y_{k,t}$ and the policy interest rate $i_{k,t}$.[6]

Equations (5)-(9) can be seen as an identified VAR, in which relative price adjustments are embedded as an error correction mechanism in equation (5)-(8) and an identification restriction of the policy reaction function and policy shocks is imposed in the manner of Boivin and Giannoni (2006) in equation (9). 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 more aggressive response to inflation may be captured by a residual $u^i_{k,t}$ in equation (9).[7] However, this approach cannot capture the effect that does not reveal itself in the central bank's interest rate setting behaviour. For instance, if an introduction of the inflation targeting monetary policy framework coupled with greater degree of transparency and accountability has better anchored inflation expectations even without changing the policy reaction of the interest rate setting, the estimated monetary shock understates the true effect of the monetary policy.

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

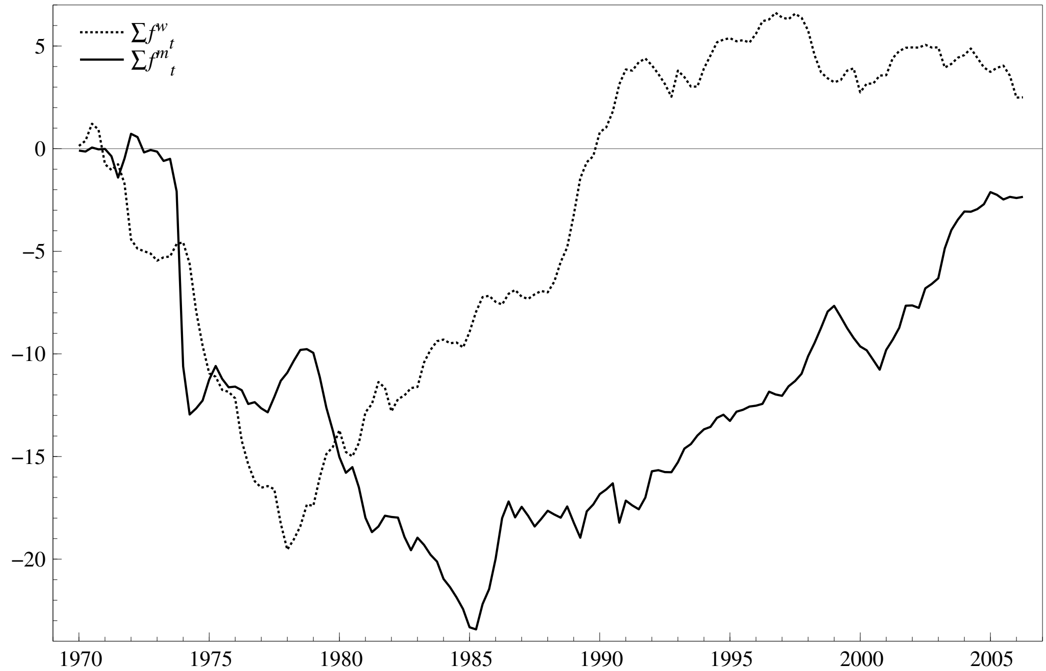
$$u_{k,t} = \gamma_k f_t + \xi_{k,t}, \tag{10}$$

$$f_t = \phi_1 f_{t-1} + \phi_2 f_{t-2} + w_t, \;\; w_t \sim \text{i.i.d.} N(0,1), \tag{11}$$

[6]In empirical analysis below, $i_{k,t}$ 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 provided through the BIS Databank service.

[7]Sekine and Teranishi (2007) find that most of central banks investigated in this paper have increased responsiveness of their policy interest rates to inflation.

Figure 4: Two global relative prices 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 (10)-(12). 1970Q1 is normalised at zero.

$$\xi_{k,t} \quad = \quad \psi_{k1}\xi_{k,t-1} + \psi_{k2}\xi_{k,t-2} + \epsilon_{k,t}, \;\; \epsilon_{k,t} \sim \text{i.i.d.} N(0, h_k^{-1}), \tag{12}$$

where $u_{k,t}$ is either residual of the wage markup equation (6), $u_{k,t}^w$ or that of the import price markup equation (7), $u_{k,t}^m$. In equation (10), 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 (11) and (12). 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 the labour market reform, the exchange rate movements, and so on so forth. Common shocks, which can be interpreted as *global* shocks to relative prices, may well capture the effect of globalisation, although they are also influenced by other sources of the global shock such as the oil supply shock.

Estimation is carried out in two steps. In the first step, a system equations of (5)-(9) 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 $\hat{u}^w_{k,t}$ and $\hat{u}^m_{k,t}$ calculated in the first step FIML estimation, we estimate corresponding common factors f^w_t and f^m_t by applying a dynamic factor model (10)-(12) to each residual. The dynamic factor model is estimated by the Bayesian Markov chain Monte Carlo (MCMC).

Figure 4 shows thus obtained global shocks. The global import price markup shocks f^m_t began to rise (i.e., wider $(p - p^m)$ markup) since the middle of the 1980s when the import penetration ratio, which is often used as a proxy for trade integration, started to pick up in the sample industrial countries. 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 the global relative price shocks are broadly related with the process of globalisation.

Contribution of each shock to the global disinflation is calculated by the historical decomposition. A system equations (5)-(9) can be represented by

$$\mathcal{X}_{k,t} = C_k \mathcal{X}_{k,t-1} + V_{k,t},$$

where

$$\mathcal{X}_{k,t} = \begin{bmatrix} X_{k,t} \\ X_{k,t-1} \\ (p-p^w)_{k,t} \\ (p-p^m)_{k,t} \end{bmatrix}, \quad V_{k,t} = \begin{bmatrix} U_{k,t} \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad \text{and} \quad U_{k,t} = \begin{bmatrix} u^p_{k,t} \\ u^w_{k,t} \\ u^m_{k,t} \\ u^y_{k,t} \\ u^i_{k,t} \end{bmatrix},$$

and C_k is an appropriately defined matrix, which contains estimated coefficients of equations (5)-(9) as well as identity restrictions. Then, conditioning on $\mathcal{X}_{k,T}$, all the historical values

Table 6: Historical decomposition

	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	-1.2	-0.2	-3.2
JP	0.0	-0.1	-1.2	-5.6
DE	0.2	0.6	0.8	-2.5
GB	-0.1	-0.8	-2.5	-6.1
FR	-1.2	-1.7	-0.9	-6.4
CA	-1.9	-0.9	-0.3	-4.8
SE	-3.5	-0.5	-1.9	-5.6
AU	-0.3	-1.5	-0.1	-6.3
Avg.	-0.9	-0.8	-0.8	-5.1

Note: Historical decomposition based on a system equation (5)-(9) and a dynamic factor model (10)-(12).

thereafter can be expressed by

$$\mathcal{X}_{k,T+h} = C_k^h \mathcal{X}_{k,T} + \sum_{j=0}^{h-1} C_k^{h-j} V_{k,T+j} + V_{k,T+h},$$

Setting T as 1969Q4, we can calculate what is attributable to a monetary policy shock $u^i_{k,t}$ for inflation $\Delta p_{k,t}$ during 1970Q1-2006Q2 and then taking difference of those averaged during 1970Q1-1989Q4 and 1990Q1-2006Q2, we have contributions of a policy shock to the disinflation observed before and after 1990. Similarly, we can calculate contributions of relative price shocks $u^w_{k,t}$ and $u^m_{k,t}$. If we replace $u^w_{k,t}$ and $u^m_{k,t}$ with $\gamma^w_k f^w_t$ and $\gamma^m_k f^m_t$, we have contributions of the global wage markup shock f^w_t and the global import price markup shock f^m_t.

Table 6 shows 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 account for about 1 percentage point decline out of a 5 percentage points 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 low inflation from 1975 onward in these countries to a stronger discipline on the part of Japan and Germany's monetary authorities. Compared to the Bundesbank, the interest rate setting by the ECB since 1999 may have been slightly more accommodative.

Two global relative price shocks account for about another one percentage point of decline respectively. Combined together, contributions of there 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 level of national inflation rates, as the large contributions of the 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 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 relatively later compared to other countries.

5 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 lead 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 points 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 one percentage point.

Even if one accepts this paper's view that the tailwind coming from relative price adjustments have 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 began to increase in cyclically advanced countries. Given the recent increases in energy and base metal prices as well as food prices, import price markup may seem to peak. The tailwind may well turn into the headwind once the global economy reaches its capacity limit, although it is very difficult to foresee when it occurs in advance.

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Table A.1: Static long-run coefficients (Simplified)

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

Note: Coefficients obtained by SUR and GLS estimation of equation (3). See notes for Table 2.

Table A.2: Contribution of each factor (Simplified)

	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

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

Table A.3: Static long-run coefficients (Reparameterised)

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

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

Table A.4: Contribution of each factor (Reparameterised)

	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

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

Table A.5: Static long-run coefficients (Split sample)

	$p-p^w$	$p-p^m$	Δp^w	Δp^m	y	const.	σ
US_{70-89}	−0.079*	−0.014**	0.214*	0.137**	0.038	0.001	0.003
	(0.036)	(0.003)	(0.094)	(0.021)	(0.026)	(0.001)	
US_{90-06}	−0.050**	−0.012**	−0.010	0.095**	0.007*	0.006*	0.002
	(0.018)	(0.003)	(0.076)	(0.024)	(0.031)	(0.001)	
JP_{70-89}	−0.052**	0.003	0.602**	0.038*	0.019	0.006**	0.007
	(0.018)	(0.003)	(0.043)	(0.014)	(0.061)	(0.002)	
JP_{90-06}	−0.069**	−0.031**	0.004	−0.026	0.084	−0.002**	0.004
	(0.020)	(0.009)	(0.090)	(0.023)	(0.045)	(0.001)	
DE_{70-89}	−0.027	−0.003	0.397**	0.036	0.208*	0.004	0.010
	(0.045)	(0.019)	(0.108)	(0.065)	(0.099)	(0.006)	
DE_{90-06}	0.033*	−0.046**	0.156	0.093	−0.086	0.005**	0.004
	(0.016)	(0.011)	(0.087)	(0.051)	(0.053)	(0.001)	
GB_{70-89}	−0.174**	−0.045**	0.225**	0.022	0.188**	−0.020**	0.007
	(0.035)	(0.010)	(0.069)	(0.037)	(0.060)	(0.005)	
GB_{90-06}	−0.049**	−0.025**	0.339**	0.031	0.034	−0.002	0.004
	(0.013)	(0.003)	(0.071)	(0.036)	(0.044)	(0.001)	
FR_{70-89}	−0.059**	−0.010	0.365**	0.097**	0.203**	0.005**	0.004
	(0.014)	(0.006)	(0.048)	(0.019)	(0.056)	(0.002)	
FR_{90-06}	−0.091**	−0.027**	−0.203*	0.169**	0.035	0.004**	0.002
	(0.023)	(0.005)	(0.089)	(0.026)	(0.029)	(0.000)	
CA_{70-89}	−0.038*	−0.023**	0.333**	0.141**	0.053	0.003	0.004
	(0.018)	(0.008)	(0.086)	(0.048)	(0.040)	(0.002)	
CA_{90-06}	−0.009	−0.014**	0.482**	0.181**	−0.060	0.003*	0.004
	(0.020)	(0.010)	(0.133)	(0.053)	(0.050)	(0.001)	
SE_{70-89}	−0.046**	−0.029**	0.054	0.116**	0.050	0.003	0.008
	(0.010)	(0.007)	(0.058)	(0.027)	(0.046)	(0.002)	
SE_{90-06}	−0.083**	−0.075**	0.210	0.042	−0.040	0.004**	0.008
	(0.021)	(0.021)	(0.106)	(0.058)	(0.067)	(0.001)	
AU_{70-89}	−0.053*	−0.008	0.262**	0.057	−0.080	−0.001	0.006
	(0.020)	(0.012)	(0.067)	(0.043)	(0.051)	(0.007)	
AU_{90-06}	−0.103**	−0.002	0.074	0.058*	0.181**	−0.006*	0.004
	(0.024)	(0.005)	(0.093)	(0.024)	(0.049)	(0.003)	
8 $OECD_{70-89}$	−0.064**	−0.018**	0.308**	0.088**	0.086*	−0.001	0.009
	(0.024)	(0.006)	(0.092)	(0.021)	(0.039)	(0.004)	
8 $OECD_{90-06}$	−0.057**	−0.029**	0.187*	0.081**	0.019	0.002	0.007
	(0.020)	(0.011)	(0.091)	(0.024)	(0.029)	(0.001)	

Note: Coefficients obtained by SUR and GLS estimation of equation (4). See notes for Table 2. Subscript attached with countries corresponds to sample periods.

Table A.6: Contribution of each factor (Split sample)

	Difference between 1970-1989 and 1990-2006							
	Actual	Explained by						
		$\sum \Delta p_{-j}$	$(p-p^w)_{-1}$	$(p-p^m)_{-1}$	$\sum \Delta p^w_{-j}$	$\sum \Delta p^m_{-j}$	y_{-1}	*cont.*
US	−3.2	−0.9	−1.1	−1.1	−0.8	−0.6	0.0	1.3
JP	−5.6	0.3	−0.4	1.5	−3.8	−0.1	0.0	−3.1
DE	−2.5	−0.3	−0.7	−0.4	−1.5	−0.1	0.2	0.3
UK	−6.1	−1.3	−3.7	−7.1	−0.7	−0.2	−0.1	7.0
FR	−6.4	1.2	−1.2	−1.3	−3.7	−0.9	0.0	−0.5
CA	−4.8	−1.9	−0.8	−0.9	−0.9	−0.4	0.0	0.2
SE	−5.6	2.1	−3.0	−3.8	−0.1	−1.2	0.0	0.5
AU	−6.3	−1.8	0.4	−1.0	−1.6	−0.4	0.0	−2.0
Avg.	−5.1	−0.3	−1.3	−1.8	−1.6	−0.5	0.0	0.5

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