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Why has Core Inflation Remained so Muted in the Face of the Oil Shock?

Paul van den Noord,

Christophe André

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TABLE OF CONTENTS

ABSTRACT/RÉSUMÉ

Why has core inflation remained so muted in the face of the oil shock?

To help policymakers form a judgment on inflation risks and the required monetary policy stance the OECD has developed an analytical framework based on a set of "eclectic" Phillips curves estimated for the two largest OECD economies, the United States and the euro area, which is presented in this paper. This framework is used in the preparation of the *Economic Outlook* to explain recent developments in core inflation, excluding food and energy, based on developments in measures of economic slack (the output gap), spill-over effects from energy prices onto core inflation and lagged responses to past inflation *via* expectations formation. The fact that the knock-on effects from energy shocks onto core inflation appear small in comparison with the 1970s can be explained by the secular fall in energy intensity, a low and stable rate of "mean inflation" -- to which observed inflation reverts after a shock has worked its way through -- and persistent slack in the aftermath of the bursting of the dotcom bubble.

JEL codes:E31, E52, Q40.
Keywords: inflation, monetary policy, energy.

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Pourquoi l'inflation sous-jacente est elle restée si modérée en dépit du choc pétrolier ?

Afin d'aider les décideurs politiques à apprécier les risques inflationnistes et l'orientation requise pour la politique monétaire, l'OCDE a développé un cadre analytique fondé sur un ensemble de courbes de Phillips "éclectiques" estimées pour les deux plus grandes économies de l'OCDE, les États-unis et la zone euro, qui est présenté dans ce document. Ce cadre est utilisé dans la préparation des *Perspectives économiques* pour expliquer l'évolution récente de l'inflation sous-jacente, hors alimentation et énergie, en fonction de l'évolution de mesures de la robustesse de la conjoncture (l'écart de production), des effets de contagion des prix de l'énergie sur l'inflation sous-jacente et des réponses différées à l'inflation passée à travers la formation des anticipations. Le fait que les effets d'entraînement des prix de l'énergie sur l'inflation sous-jacente apparaissent faibles comparés aux années 1970 peut s'expliquer par la baisse séculaire de l'intensité énergétique, un taux d'inflation "moyen" faible et stable -- vers lequel l'inflation observée converge une fois qu'un choc a été absorbé -- et par une faiblesse persistante de l'économie à la suite de l'éclatement de la bulle "dotcom".

Classification JEL :E31, E52, Q40.
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WHY HAS CORE INFLATION REMAINED SO MUTED IN THE FACE OF THE OIL SHOCK?

by

Paul van den Noord and Christophe André[1]

1. Introduction

1. Most measures of core inflation -- which eliminate the most volatile price movements such as those of food and energy -- have remained well contained so far in major OECD economies such as the United States and the euro area despite the run-up in oil prices in recent years and the risk of spillovers into core inflation (Figure 1). Even so, monetary policy makers repeatedly express concern that the oil price hike may eventually feed into inflation expectations, potentially thus reducing the room to maintain, or revert to, an accommodative stance of monetary policy if needed. If the oil price shock does not spill over into core inflation (or expectations thereof), the dilemma for monetary policy may be less severe: central banks could then see through the oil price shock, letting the temporary increase in headline inflation do the work of transferring purchasing power from oil consumers to oil producers.

2. To help policymakers form a judgment on inflation risks and the required monetary policy stance the OECD routinely disentangles the various influences at work in its biannual *Economic Outlook*. For this purpose it has developed an analytical framework based on a set of "eclectic" Phillips curves estimated for the two largest OECD economies, the United States and the euro area.[2] These are used to explain recent developments in core inflation, excluding food and energy, based on developments in measures of economic slack (the output gap), spill-over effects from energy prices onto core inflation and lagged responses to past inflation via expectations formation. This paper presents this framework.

3. The first section of the paper will discuss the stylised developments in (core) inflation over the past three decades and what are considered to be their main determinants. This is followed by a brief discussion of the "state-of-the-art" findings as to the empirical significance of these determinants and changes therein over time. Next, empirical estimates of the determinants of core inflation for the United States and the euro area are presented.

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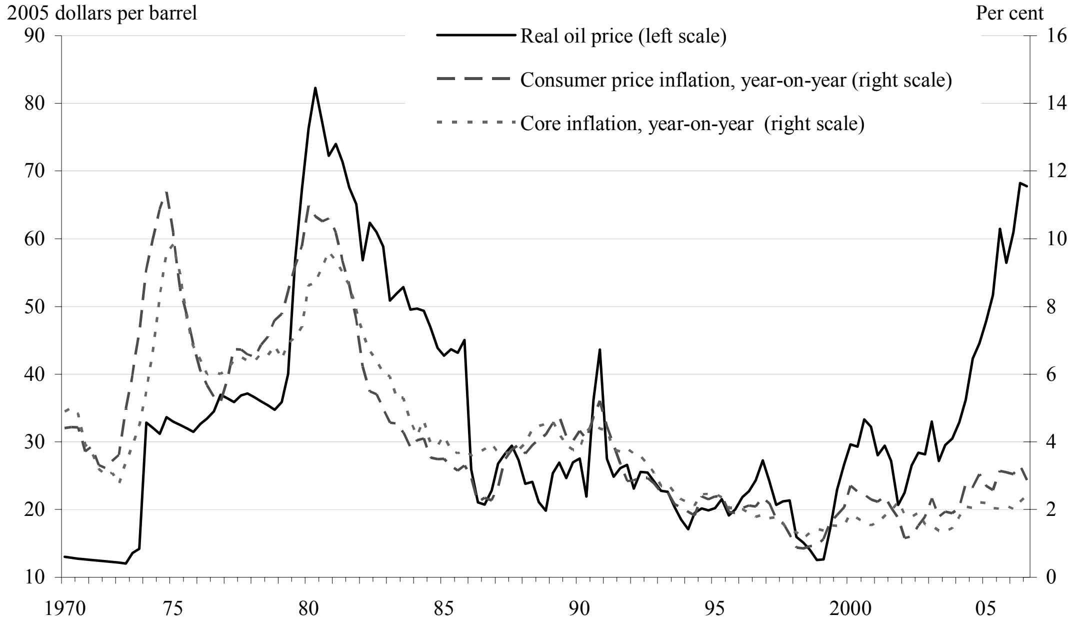
1. At the time of writing, the authors were members of the General Economic Analysis Division of the OECD Economics Department. They are grateful to Jean-Philippe Cotis, Romain Duval, Jorgen Elmeskov, Mike Feiner, Nathalie Girouard, Stéphanie Guichard, Mike Kennedy, Peter Jarrett, Vincent Koen, Annabelle Mourougane, Peter Tulip, Dave Turner and Lukas Vogel for helpful comments and suggestions, and to Anne Eggimann for excellent technical assistance. The views expressed in this paper are the authors' and are not necessarily those of the OECD or its member countries.

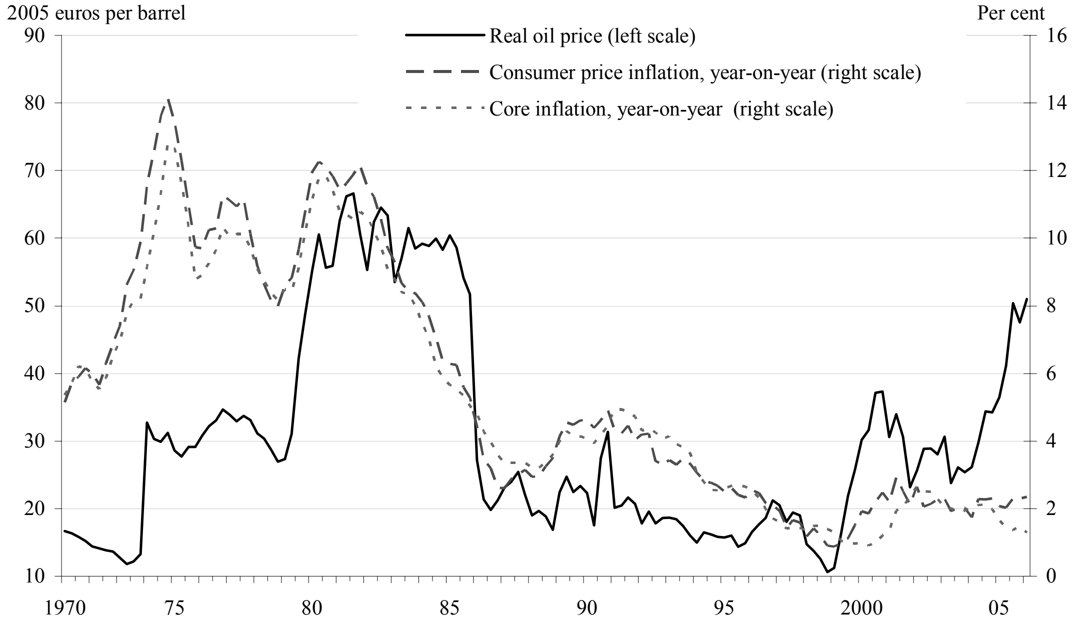
2. This framework was introduced in Box I.4 of OECD *Economic Outlook* No. 78, December 2005.

Figure 1. Inflation and oil prices

United States



Euro area



Note: Consumer price inflation is measured by the change in the private consumption expenditure (PCE) deflator for the United States and the Harmonised index of consumer prices (HICP) for the euro area. Core inflation is measured by the corresponding indices excluding food and energy for the United States and energy and unprocessed food for the euro area. Since HICP data start in 1991, prior to this date, the euro area headline and core inflation series are aggregates of national series for, respectively, the consumer price index (CPI) and the CPI excluding food and energy. Real oil prices refer to quarterly averages of Brent crude spot prices - prior to May 1987, prices for oil of a similar quality as Brent - deflated by core price indices as defined above.

Source: OECD Economic Outlook 80 database.

2. Stylised developments

4. In most major OECD economies the oil shocks in the mid and late 1970s were followed by an extended period of high inflation and sharp contractions in economic activity -- a combination of features that is commonly labelled "stagflation" (Figure 2). Oil prices soared by over 150% in the first oil shock and by slightly less in the second one. Headline consumer price inflation rose by 4 percentage points within four to six quarters after the first and second oil shock both in the United States and in what is now the euro area. Meanwhile the output gap fell by up to 6 percentage points on both sides of the Atlantic within about six quarters after the first shock. After the second shock, however, the negative output gap repercussions were much stronger (up to 10 percentage points) in the United States than in the euro area (up to 5 percentage points). This divergence is reflected also in core inflation (excluding food and energy, which is a better gauge of domestically-generated inflation; see below), which showed a pretty similar pattern in the two economies after the first oil shock, but diverged after the second one, with core inflation quickly reversing in the United States while being much more persistent in the euro area.

5. Developments during the most recent oil price shock have been quite different. First, the nature of the shock itself has been different. While totalling around 150% -- in the ballpark of the earlier shocks -- it has been a gradual, if persistent, rise spanning several years, rather than a sudden spike. Second, while headline inflation has shown some tendency to rise in the United States, core inflation has shown only a minute increase. In the euro area headline inflation hardly responded and core inflation even fell. So there has been a modest divergence between the two economies. This largely seems to reflect the divergence in the (negative) output gap, which has been narrowing in the United States while remaining broadly stable in the euro area.

6. All considered, inflation and its core component responded strongly to the oil price shocks in the 1970s and early 1980s, but the response has been much more muted during the most recent run-up in energy prices. Why this may be the case is still not entirely settled and fears of a resurgence of inflation have not disappeared. The next section reviews the literature on this issue before we present our own findings.

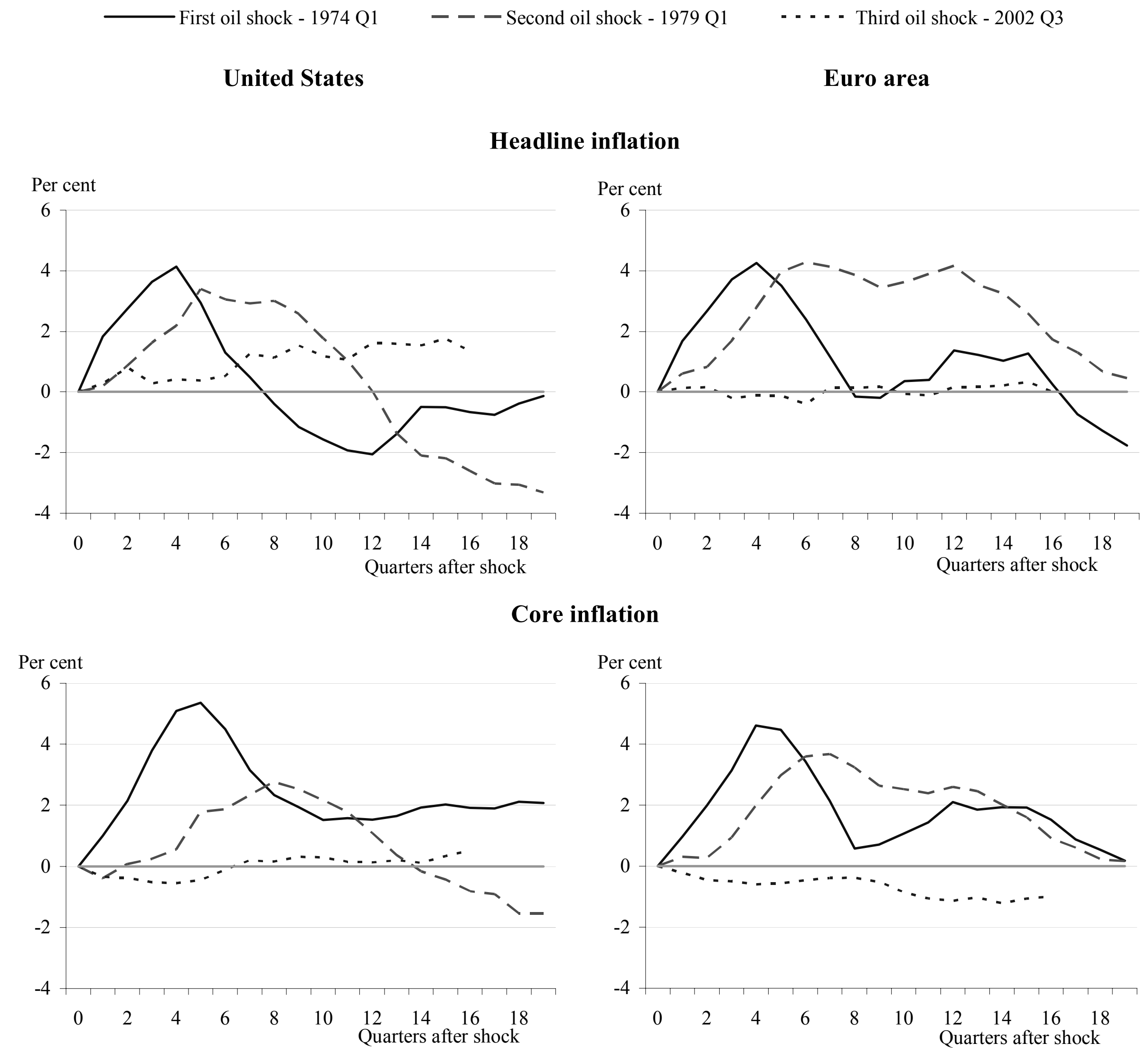
3. Mainstream explanations

7. Hypotheses as to why the recent oil price shock has not affected (core) inflation that much abound and can be grouped under five main headings:

- *The nature of the shock*. One factor is that the very sharp spikes in oil prices in the 1970s led to great uncertainty and therefore were rather disruptive, unlike the more gradual oil price increases in recent years (Hamilton, 2003). In this environment "non-linearities" may have prompted stronger reactions than normal.

Figure 2. Stylised responses to oil shocks

Year-on-year inflation rate relative to the inflation rate in the quarter preceding the oil shock



Source: OECD Economic Outlook 80 database and authors' calculations.

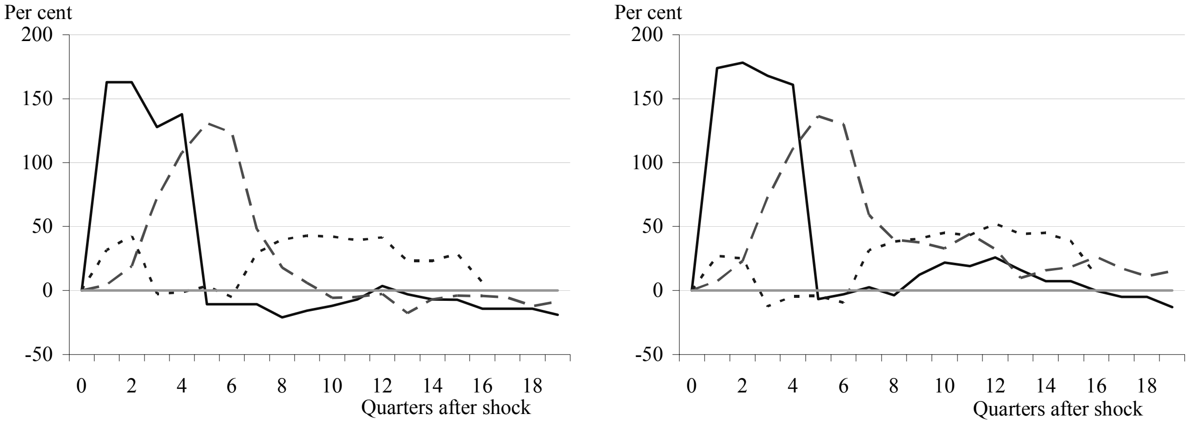
Figure 2. Stylised responses to oil shocks (cont.)

First oil shock - 1974 Q1 — Second oil shock - 1979 Q1 — Third oil shock - 2002 Q3

United States **Euro area**

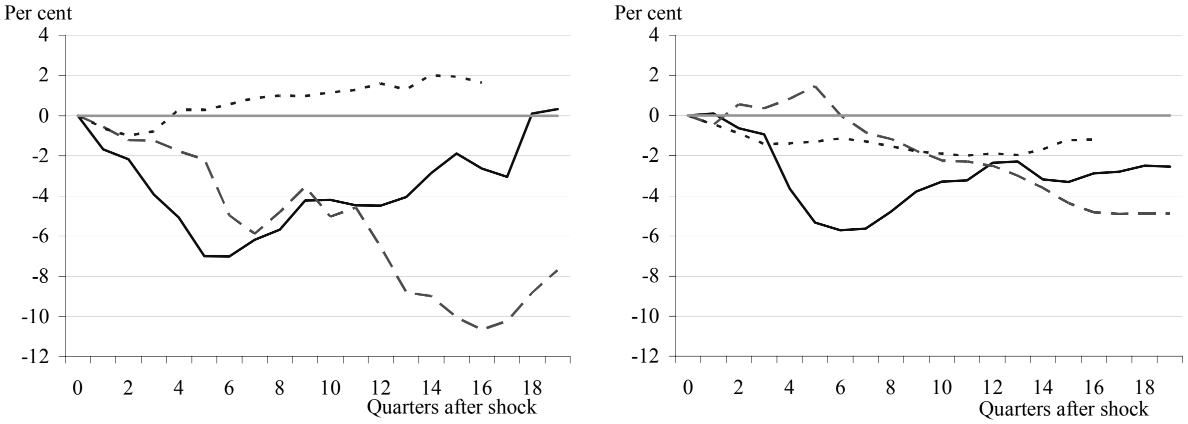
Oil price in local currency

Year-on-year change in nominal oil prices relative to their rate of change in the quarter preceding the oil shock



Output gap[1]

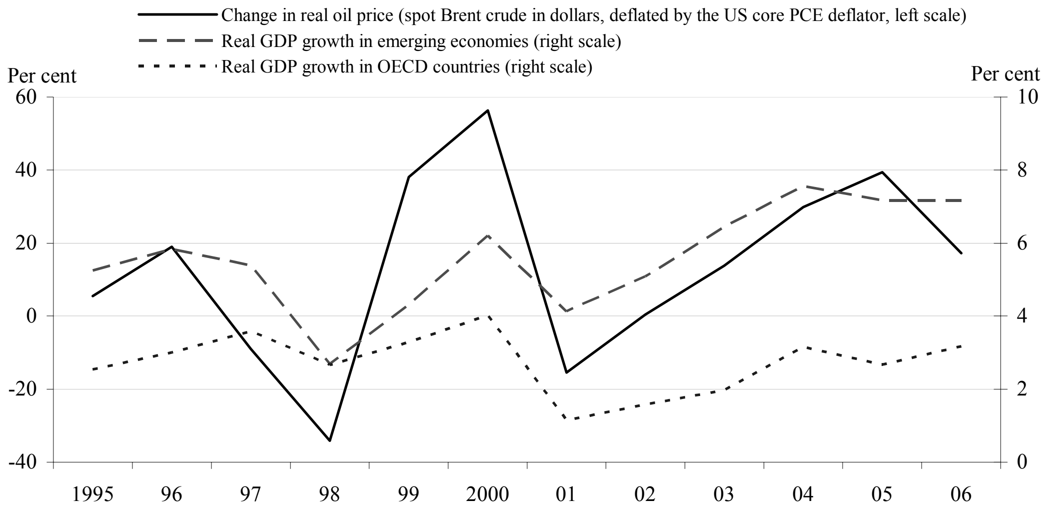
Difference from the level in the quarter preceding the oil shock



1. In the United States, the level of the gap in the quarter preceding the oil shock (t=0 in the charts) was 2.5, 3.4 and -1.4 for the first, second and third oil shock, respectively. For the euro area, the gap levels were 3.3, 1.6 and 0.1, respectively.
Source: OECD Economic Outlook 80 database and authors' calculations.

- *Cyclical conditions*. The earlier oil shocks occurred when major OECD economies were at a cyclical peak. As a result, oil demand in OECD economies was strong, which created the conditions for cartel behaviour among oil producers (*e.g.* Barsky and Kilian, 2004). By contrast, the recent oil shock stemmed from robust growth in emerging (non-OECD) economies and kicked in when major OECD economies were still struggling with the aftermath of the bursting of the dotcom bubble (Figure 3).

Figure 3. Global economic growth and oil prices



Source: OECD Economic Outlook 80 database and IMF World Economic Outlook (September 2006).

- *Globalisation*. Since the mid-1990s, globalisation sparked growing flows of cheap goods coming from emerging economies into the OECD area, which may have offset the inflationary impact from soaring oil prices (Pain *et al*., 2006, IMF, 2006). Moreover, due to stiff global competition the pricing power of firms and bargaining power of workers in developed countries may have declined, which should provide further offsets. The global trade boom, meanwhile, helped to stem the negative impact of high oil prices on activity in OECD economies.

- *Propagation mechanisms and the role of monetary policy*. Rapid propagation of the oil price shocks was at least in part responsible for the stagflation in the 1970s, and the mechanism may have changed, if not disappeared, at the current juncture (Hooker, 1999). Hunt (2005) provides evidence that the persistence of high inflation observed in the 1970s can be explained by the combination of resistance by workers to the erosion of their real wages and accommodative monetary policies, resulting from an over-estimation of potential output by the monetary authorities. The accommodative role of monetary policy in this episode has also been emphasised by Bernanke *et al.* (1997) and Trehan (2005).

- *Inflation is better anchored.* A priori it is not obvious what weights should be attached to each of the above explanations, but it is clear that the occurrence of an oil shock on its own cannot suffice to produce a long-term inflationary effect, unless inflation expectations are weakly anchored. Since the 1970s, monetary policy has regained credibility in the pursuit of price stability objectives, thus helping to anchor inflation expectations. Labonte (2004), after reviewing the literature on the effects of oil shocks on the US economy concludes that "every study that explored the issue found that oil's broad effects on the economy were waning, and more recent studies tended to find oil to have smaller effects".

8. In order to disentangle the possible sources of inflation persistence in the wake of an adverse oil price shock (or any other price shock) two sources of inflation persistence are distinguished: inflation persistence inherent to the inflation process itself and inflation persistence stemming from rigidities in product and labour markets and an associated poor matching of supply and demand after an adverse shock.[3] Inherent inflations persistence may reflect for example the dependence of the wage-price setting process on past inflation due to indexation. It may also arise when inflation expectations adapt to past observed inflation rather than being rooted in a credible and fixed inflation target.

9. It is hard to distinguish empirically between inherent and other forms of inflation persistence, but both are likely to have become lower since the 1970s. Indexation mechanisms have become less prevalent in wage-price setting processes, notably in the euro area, and inflation expectations are better anchored owing to more credible monetary policy. Even so, demonstrating the fall in inherent persistence empirically proves to be rather challenging. The conventional starting point is the expectations-augmented Phillips curve introduced by Friedman (1968) and Phelps (1967); see *e.g.* Stock and Watson (1999):

$$\pi_t = \mathrm{E}_{t-1}(\pi_t) + \beta_1 \,\mathrm{GAP}_{t-1} + \beta_2 \mathrm{G(L)}\, \mathrm{Z}_\mathrm{t} + \varepsilon_t \tag{1}$$

where π_t is the inflation rate, $E_{t-1}(\pi_t)$ the expected rate of inflation for period t conditional on information available at time $t-1$, GAP_{t-1} the lagged output or unemployment gap, Z_t a variable summarising the influence of supply shocks and ε_t a random disturbance. G(L) is a polynomial in the lag operator L.

10. If expectations are adaptive, *i.e.* inflation expectations are driven by past inflation, Equation (1) can be rewritten as:

$$\pi_t = \beta_0 + \sum_{\mathrm{i=1}}^{\mathrm{n}} \alpha_i \,\pi_{t-i} + \beta_1 \,\mathrm{GAP}_{t-1} + \beta_2 \mathrm{G(L)}\, \mathrm{Z}_\mathrm{t} + \varepsilon_t \tag{2}$$

This model has been found to fit the data quite well in general (Stock and Watson, 1999). Typically the unit root condition $\Sigma_i \alpha_i = 1$ cannot be rejected and as a result "many macroeconomists have concluded that high inflation persistence is a 'stylised fact' " (Levin and Piger, 2002). If the unit root condition holds, the long-run Phillips curve is vertical and inflation is a random walk process.[4] To illustrate this, Equation (2) can be rewritten in an error-correction form (to simplify, the inflation process is assumed to be AR(1) and there is assumed to be only one lag on the shock variable):[5]

$$\pi_t = \beta_0 + \alpha_1 \,\pi_{t-1} + \beta_1 \,\mathrm{GAP}_{t-1} + \beta_2 \,\mathrm{Z}_{\mathrm{t\text{-}1}} + \varepsilon_t \tag{2.1}$$

This is equivalent to:

$$\Delta\pi_t = \beta_0 + (\alpha_1 - 1)\; \pi_{t-1} + \beta_1 \,\mathrm{GAP}_{t-1} + \beta_2 \,\mathrm{Z}_{\mathrm{t\text{-}1}} + \varepsilon_t \tag{2.2}$$

3. See for example Angeloni *et al*. (2004).

4. Assuming that there is no persistence in exogenous shocks.

5. The result can be generalised to more general autoregressive processes, see Marques (2004).

or

$$\Delta\pi_t = (\alpha_1 - 1)(\pi_{t-1} - \frac{\beta_0}{1-\alpha_1} - \frac{\beta_1}{1-\alpha_1}\text{GAP}_{t-1} - \frac{\beta_2}{1-\alpha_1}\text{Z}_{t-1}) + \varepsilon_t = (\alpha_1 - 1)(\pi_{t-1} - \pi_t^l) + \varepsilon_t$$

(2.3)

11. In Equation (2.3), inflation adjusts to its long-run level π^l at a speed $(\alpha_1 - 1)$. The closer to unity α_1 is, the slower the convergence to equilibrium will be and in the extreme case where $\alpha_1 = 1$ inflation is a random walk. Moreover, as Equation (2.2) demonstrates, if $\alpha_1 = 1$ any inflationary shock will have a permanent effect on inflation.

12. A shortcoming of the above approach to persistence is the implicit assumption that inflation is stationary around a constant mean which according to Equation (2.3) is equal to $\beta_0/(1-\alpha_1)$ (assuming that both the gap and the supply shock variable are stationary with zero mean). However, as can be seen from Figure 4, which plots quarter-on-quarter core inflation rates along with a trend computed using a Hodrick-Prescott filter (λ=1600), there has been a marked downward trend in this variable over the past two decades, although it has been broadly stable since the mid-1990s. In statistical terms, this translates into non-stationarity for important sub-periods, as evidenced by the unit root tests in Table 1. Several methods have been tried to disentangle the downward trend component and "pure" inertia. Some studies have allowed for breaks in mean inflation that coincide with major changes in monetary regimes (Corvoisier and Mojon, 2005, Levin and Piger, 2002). Others have approximated mean inflation with the help of Hodrick-Prescott (Marques, 2004) or Kalman filters (Dossche and Everaert, 2005). Importantly, all these studies obtain lower estimates of inflation persistence than those that assume a constant mean inflation.

Table 1. Unit root tests for core inflation

Augmented Dickey Fuller test

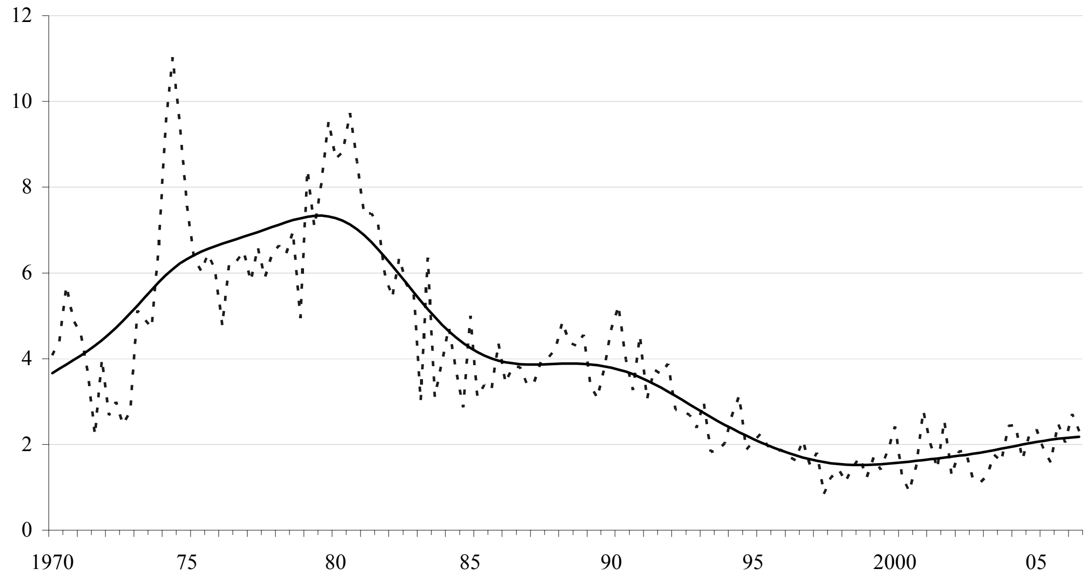
	1970-2006	1970-1985	1986-2006	1995-2006
United States				
Level	-1.90	-2.63 *	-1.49	-4.94 ***
First difference	-16.69 ***	-10.64 ***	-8.43 ***	-8.72 ***
Euro area				
Level	-1.36	-1.92	-1.81	-2.29
First difference	-13.25 ***	-7.38 ***	-14.47 ***	-12.22 ***

Note: *, **, *** indicate stationarity at the 10%, 5% and 1% level respectively. The lag structures for the ADF equations are chosen using the Schwarz Information Criterion. The critical values are from MacKinnon (1996).

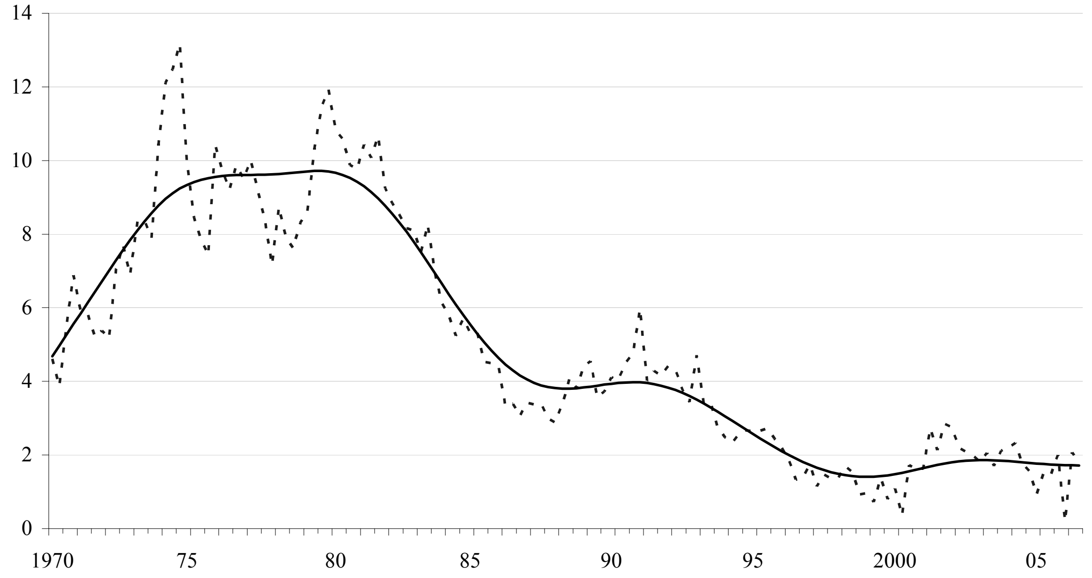
Source: Authors calculations.

Figure 4. Inflation trends

United States



Euro area



Note: annualised quarter-on-quarter change in the private consumption deflator excluding food and energy for the United States and in the HICP excluding energy and unprocessed food for the euro area. The trend is calculated using a Hodrick-Prescott filter (λ=1600).
Source: OECD Economic Outlook database 80.

13. If inflation expectations are purely forward looking, by definition there can be no inherent inflation persistence because lagged inflation drops out of the equation. The new Keynesian Phillips curve (NKPC) literature argues in favour of such forward-looking behaviour and provides some microeconomic underpinnings for it (Gali *et al*., 1999, 2001). However, purely forward looking Phillips curves fit the data poorly (see *e.g.* Roberts, 1998).[6] As a result, backward-looking terms have been introduced into the NKPC, dubbed the "hybrid NKPC". Estimating a hybrid NKPC, Gali *et al*. (2001) improve the fit and find statistically significant backward-looking behaviour. They estimate the proportion of backward-looking price setters at between ¼ and ½ for the United States and between ¼ and ⅓ for the euro area.[7] While the actual split between forward and backward looking behaviour may be questionable, this approach does show that taking forward-looking expectations into account can lower significantly the weight of autoregressive terms and therefore measured inflation persistence -- *i.e.* a qualitatively similar result to that obtained using models allowing for shifts or continuous adjustments in mean inflation.

14. As noted, persistence may also occur if excess supply conditions persist due to rigidities in product and labour markets. One way to capture this form of persistence in a Phillips curve equation is by assuming a speed limit to growth, which implies that inflation could rise even if the level of the output gap may still be negative. This could stem from hysteresis in unemployment -- resulting in a weakening of competitive mechanisms on the labour market -- and/or if under-investment in downturns constrains the productive potential of the economy.[8] Speed limits translate into inflation being not only sensitive to the level but also to the change in the output gap:

$$\pi_t = \mathrm{E}_{t-1}(\pi_t) + \beta_1 \,\mathrm{GAP}_{t-1} + \mu\, \Delta\mathrm{GAP}_t + \beta_2 \mathrm{G(L)}\, \mathrm{Z_t} + \varepsilon_t \qquad (3)$$

If $\mu=0$, there is no speed limit. High growth will generate inflation only if no slack remains in the economy.

15. Another way of capturing persistence stemming from market rigidities is to assume asymmetry in the inflation response during downturns and upturns. A linear Phillips curve, as in Equation (1) implies a symmetric response when output falls below potential. However, if rigidities prevent prices or wages from falling when the economy is operating below potential, the Phillips curve will be kinked. A negative output gap will cause little disinflation (*i.e.* there will be a high degree of persistence stemming

6. The NKPC has been criticised on other grounds as well. Rudd and Whelan (2005) argue that the GMM estimates used in the NKPC literature "do not really allow us to distinguish between forward and backward looking models of inflation". Tavlas and Swamy (2006) argue that the hybrid NKPC is mis-specified, and Roberts (1998), using survey measures of inflation expectations, finds that expectations "are neither perfectly rational nor as unsophisticated as simple autoregressive models would suggest".

7 . Paloviita (2002) estimates NKPCs for the euro area and individual euro area countries using OECD projections as a gauge for inflation expectations. She finds that "the output gap based new Keynesian Phillips curve with the currently expected future inflation tracks inflation variation plausibly".

8. Hysteresis refers to a situation where protracted deviations of employment from its equilibrium level cause part of the cyclical employment to become structural. People who are out-of-work for a long time tend to see an erosion of their skills and employers may be reluctant to hire them when the economy recovers. In addition, if the wage-bargaining process only involves employed workers (insiders), wages will be less responsive to the level of unemployment than in the case of competitive markets, thus increasing unemployment persistence (for a more complete description of the mechanisms causing hysteresis, see Elmeskov and Mc Farlan, 1993).

from market rigidities), but inflation could rise steeply when output comes to exceed potential. This assumption can be tested by replacing the GAP variable in Equation (1) by two separate variables, respectively, for positive and negative output gaps (see Turner, 1995):

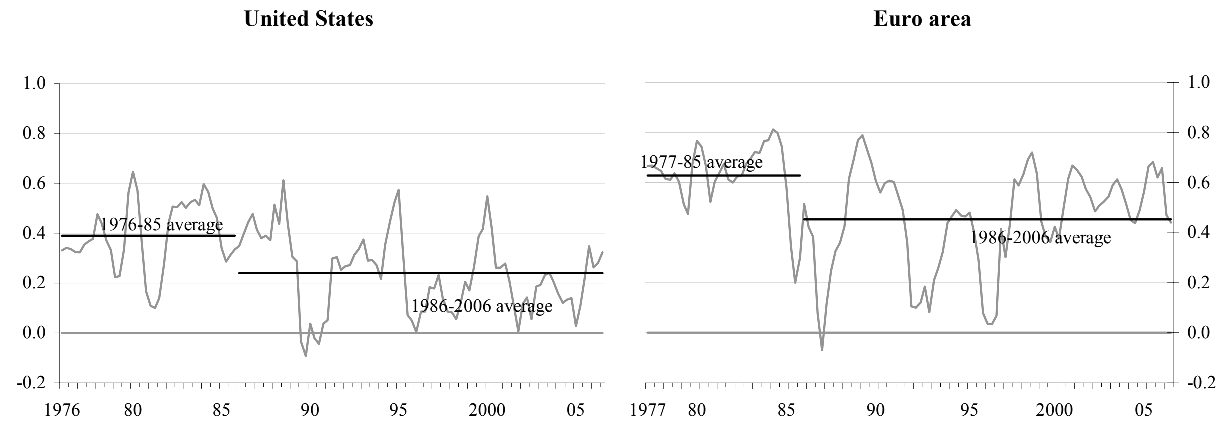
$$\pi_t = \mathrm{E}_{t-1}(\pi_t) + \theta_1\ \mathrm{GAP}^{+}_{t-1} + \theta_2\ \mathrm{GAP}^{-}_{t-1} + \beta_2 \mathrm{G(L)}\ \mathrm{Z}_\mathrm{t} + \varepsilon_t \qquad (4)$$

where GAP^{+} and GAP^{-} denote positive and negative output gaps, respectively. If $\theta_1 > \theta_2$ the response of inflation to the gap is asymmetric. Cournède *et al*. (2005) in a cross-country panel study cannot reject this hypothesis on statistical grounds (see also Baghli *et al*., 2006).

16. A key question is if inflation persistence stemming from market rigidities has increased or decreased since the 1970s. Interestingly, the association between inflation and output gaps has become weaker in major economies, which would suggest greater inflation persistence in the face of cyclical conditions (Figure 5).[9] This phenomenon could be linked to enhanced economic integration, to the extent that supply constraints have become less prominent and inflation less sensitive to local demand conditions (see Pain *et al.*, 2006). Another notable phenomenon is the lower volatility in gap and inflation series, which may be the fruit of stability-oriented monetary policies and better-anchored inflation expectations (see Blanchard and Simon, 2001, Cotis and Coppel, 2005 and Gordon, 2005).[10] But some authors have stressed that here too globalisation has played its part by producing incentives for stability-oriented monetary policies (Romer, 1991, and Rogoff, 2003). The OECD's structural indicators do provide evidence that governments have been aiming for more flexible labour and product markets -- in part induced by globalisation. But globalisation also implies that prices reflect global rather than local demand conditions, which should of course not be confused with inflation persistence.

Figure 5. The falling association between inflation and the output gap

Five-year rolling correlations between the change in core inflation and the output gap



Source: OECD Economic Outlook 80 database and authors' estimates.

9. Regression analysis for a panel of countries comprising the local and global output gaps as explanatory variables for different estimation periods suggests that the former may have become less significant and the latter more so (see Borio and Filardo, 2006).

10. From a forecasting point of view, Stock and Watson (2006) note that "one reason for the deterioration in the relative performance of the ADL (autoregressive distributed lag) activity-based forecasts is that the variance of the activity measures has decreased since the mid-1980s (this is the "Great Moderation"), so in a sum-of-squares sense their predictive content, assuming no changes in coefficients, has declined."

4. Some new empirical evidence

17. The econometric work for the United States and the euro area reported in this paper serves two purposes: *i)* to enhance our understanding as to how the inflation process has changed since the previous episodes of major oil price shocks in the 1970s and early 1980s; and *ii)* to come up with a set of equations for core inflation that exhibit the best possible fit for the most recent period. Accordingly, the analysis seeks to answer the following questions:

- Has the mean (or "equilibrium") rate of inflation -- to which observed inflation reverts after a shock has worked its way through -- fallen over time, *i.e.* is it lower at the current juncture than it was during the 1970s and early 1980s?

- Have spill-over effects of energy price hikes onto core inflation become smaller over time, even when correcting for a fall in energy intensity of consumption?

- Is there any evidence that inflation persistence due to a slow response of disinflation to economic slack associated with rigidities in product and labour markets has fallen over time?

18. With a view to addressing these questions, a series of regressions was run based on the above specifications (2), (3) and (4) for the United States and the euro area. All data is extracted from the OECD Economic Outlook 80 database. The output gap is the difference between actual and potential GDP based on a Cobb-Douglas production function, in per cent of potential output (see Cotis *et al*., 2005 for details).

19. It is important to note that the regressions were run on core inflation, which excludes energy and food, rather than headline inflation. This choice has a two-pronged rationale:

- Energy and food prices are notoriously volatile, while accounting for a sizeable share of consumer spending.[11] Therefore, consumer price indices excluding these items tend to be a more accurate gauge of the underlying inflationary pressures.

- More fundamentally, energy prices are largely exogenous from the point of view of energy-importing economies and should therefore not appear on the left-hand side of any inflation equation (as would be the case if headline inflation was the dependent variable). Similarly, food prices are strongly affected by external factors such as weather conditions and bear little relationship with local demand conditions.

20. It is also worth emphasising that exclusion-based measures of core inflation have been criticised on a number of grounds (*e.g.* Marques, 2002, 2003). In particular, rather than being a leading indicator of headline inflation, exclusion-based core inflation tends to lag it, which makes it less useful for forward-looking policy. Another shortcoming is that the exclusion of food and energy may be somewhat arbitrary and could lead to a downward bias in the assessment of inflation pressure at times of

11. Their combined weight is 20% of the US Private Consumption Expenditure deflator (PCE) and 17% in the euro area Harmonised index of consumer prices (HICP). In the latter case, aside from energy only unprocessed food is taken into account, as opposed to total food in the US case.

strong growth in emerging economies, the latter putting downward pressure on manufacturing prices whereas energy prices are boosted. However the correlation between alternative ("statistical") indicators of core inflation based on smoothing procedures or that exclude any goods and services whose prices are volatile in any month appears to be generally high (Catte and Sløk, 2005).

21. By way of a benchmark first a version of Equation (2) is estimated which only contains the autoregressive term and the output gap as sole explanatory variables. Subsequently a variety of oil-price shock variables are included, notably the rate of change in the oil import price (over and above core inflation) and a range of other gauges of imported inflation. The overall strategy is to estimate each version of the equation for three sample periods: 1971Q2-2006Q3, 1971Q2-1985Q4 and 1986Q1-2006Q3. For the euro area, moreover, a shortening of the second sub-sample to 1992Q1-2006Q3 led to further improvements in robustness, possibly owing to the reduction of aggregation bias as business cycles got more synchronised across countries with the creation of the European Economic and Monetary Union (EMU). The results are reported in Tables A1 to A7. Their interpretation is as follows.

Table 2. Mean inflation, shock responsiveness and persistence

Sample period	*1971Q2-2006Q3*	*1971Q2-1985Q4*	*1986Q1-2006Q3*	*1992Q1-2006Q3*
United States				
Mean inflation (%)	3 – 4	4 – 6	2 – 3	..
Half life of shock (quarters)	8 – 12	3 – 6	3 – 8	..
Coefficient on output gap	0.1	0 – 0.2	0.1	..
Coefficient on oil price[1]	0.2 – 0.3	0.3 – 0.6	0.1 - 0.2	..
Euro area				
Mean inflation (%)	5 – 6½	7 – 8½	3 – 3½	2 – 2½
Half life of shock (quarters)	13- 17	3 - 5	6 – 11	4 - 6
Coefficient on output gap	0.1 – 0.2	0.2 – 0.3	0.1	0.1
Coefficient on oil price[1]	0.1 – 0.2	0.1 – 0.4	0.1	0.1 – 0.2

1. Real oil price weighted by the oil intensity of production.

22. Table 2 shows for each of the two economies and the three (four) sample periods the mean inflation rate and the regression coefficients on the output gap and oil price shock variables. The results are reported as ranges, rather than point estimates, that emerge from a set of regressions using different gauges for the energy price shocks (see Annex for further details). As discussed above, mean inflation can be approximated by computing the ratio between the constant term and one minus the sum of the coefficients in the autoregressive term:

$$\beta_0 \Big/ (1-\sum_{i=1}^{n}\alpha_i) \qquad (5)$$

23. The degree of inherent persistence can be gauged by the half-life, which is defined as the period required for the impact of a shock on an exogenous variable to be reduced by half.[12]

24. The main findings that emerge from Table 2 can be summarised as follows:

- As expected, the regressions on the whole sample period yield an overblown estimate of inherent inflation persistence, with the move from high to a low mean inflation being picked up by the AR term. Splitting the sample period into two suggests considerably less inherent inflation persistence.

- Inherent inflation persistence is rather similar in the two economies, with the half life of shocks in the range of three to eight quarters. Even so, it is somewhat higher in the euro area in the second sub-period, which may, however, be due to the move towards a low inflation regime in the run-up to the single currency being picked up by the AR term. This is confirmed by the estimate for a shorter sub-sample starting in 1992, with inherent persistence again being similar to that in the United States.

- The fall in mean inflation over time is rather pronounced in both economies, but especially in the euro area. In the United States mean inflation falls from the 4-6% range in the first sub-period to the 2-3% range in the second sub-period. In the euro area it falls from the 7-8½ per cent range in the first sub-period to the 2-2½ per cent range in the EMU period from 1992 onward.

- There is no tangible evidence that the degree of persistence stemming from market frictions would have moved a lot over time. Speed limits could not be detected, *i.e.* the change in the output gap was not significant in any of the specifications estimated. There is some evidence of positive output gaps exerting a stronger impact than negative output gaps on core inflation in both economies, but the difference is not statistically significant (see Annex).

- The responsiveness of core inflation to energy price shocks is again rather similar in the two economies, albeit it was stronger in the United States in the first sub-period. This is a stylised finding, possibly reflecting the greater variability of (and hence a greater visibility of variations in) US retail energy prices than in the euro area where indirect taxes act as a cushion.

25. Spill-over effects of energy price hikes may be magnified via higher inflation expectations and informal or formal indexation mechanisms (second-round effect). The latter effect is picked-up by the autoregressive term and the former one by the coefficient on the relevant shock term. Either way, if confirmed, the inflationary impact of adverse price shocks has fallen, and this is indeed confirmed by a dynamic simulation of standardised oil shocks (Figure 6). A combination of lower shock sensitivity and lower mean inflation is consistent with the stylised finding that inflation has become lower and less volatile.

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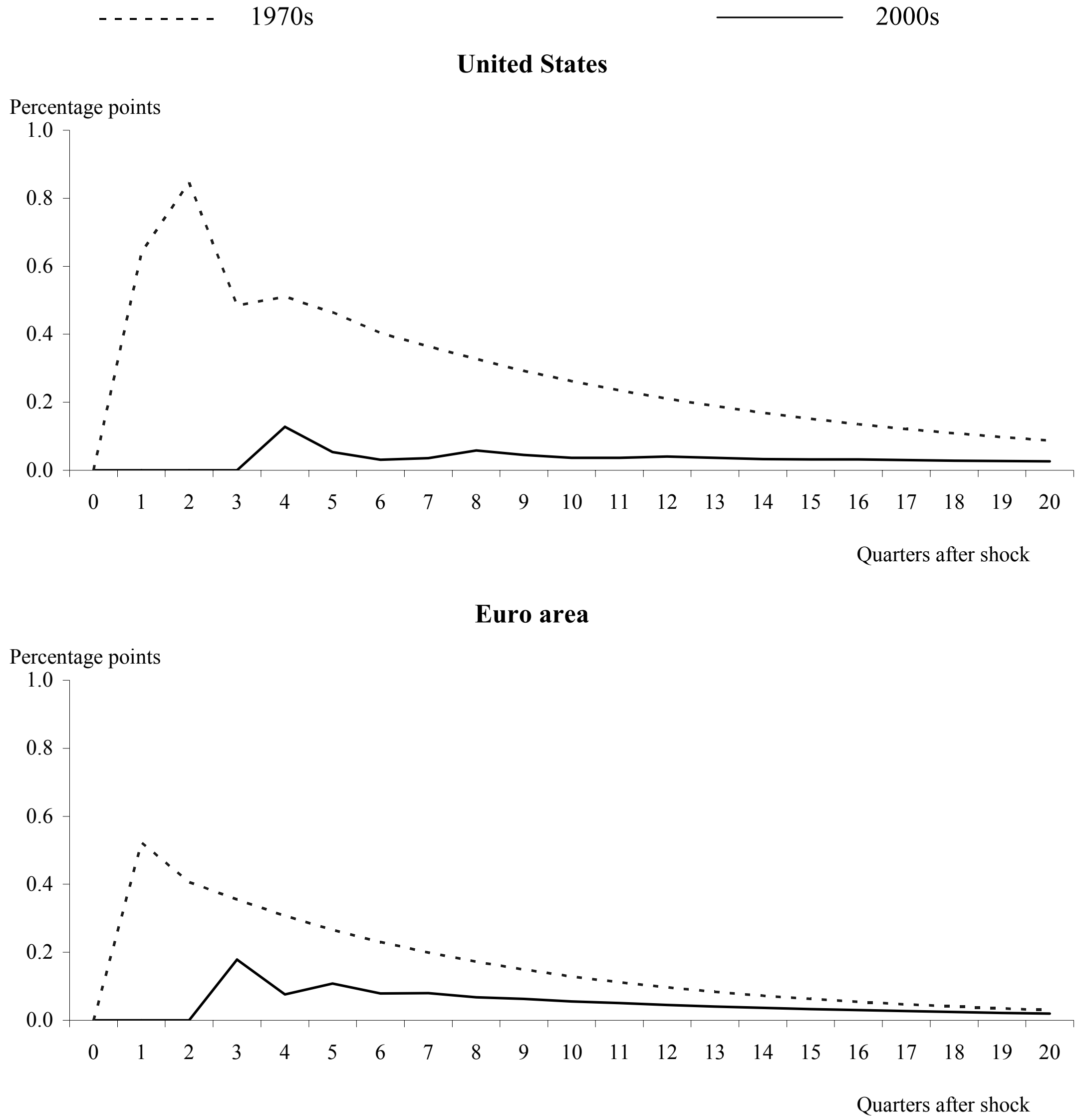
12. In an AR(1) process of the form $y_t = \rho\, y_{t-1} + \varepsilon_t$, the half-life h is such that $\rho^h = ½$, or $h = \ln(½) / \ln \rho$. In higher order AR processes, the computation of the half-life is more complex, but it is standard practice to use the AR(1) formula with ρ equal to the sum of autoregressive coefficients as an approximation (Marques, 2004, Corvoisier and Mojon, 2005).

Figure 6. Simulation of oil shocks

Impact of a 100% oil shock on core inflation



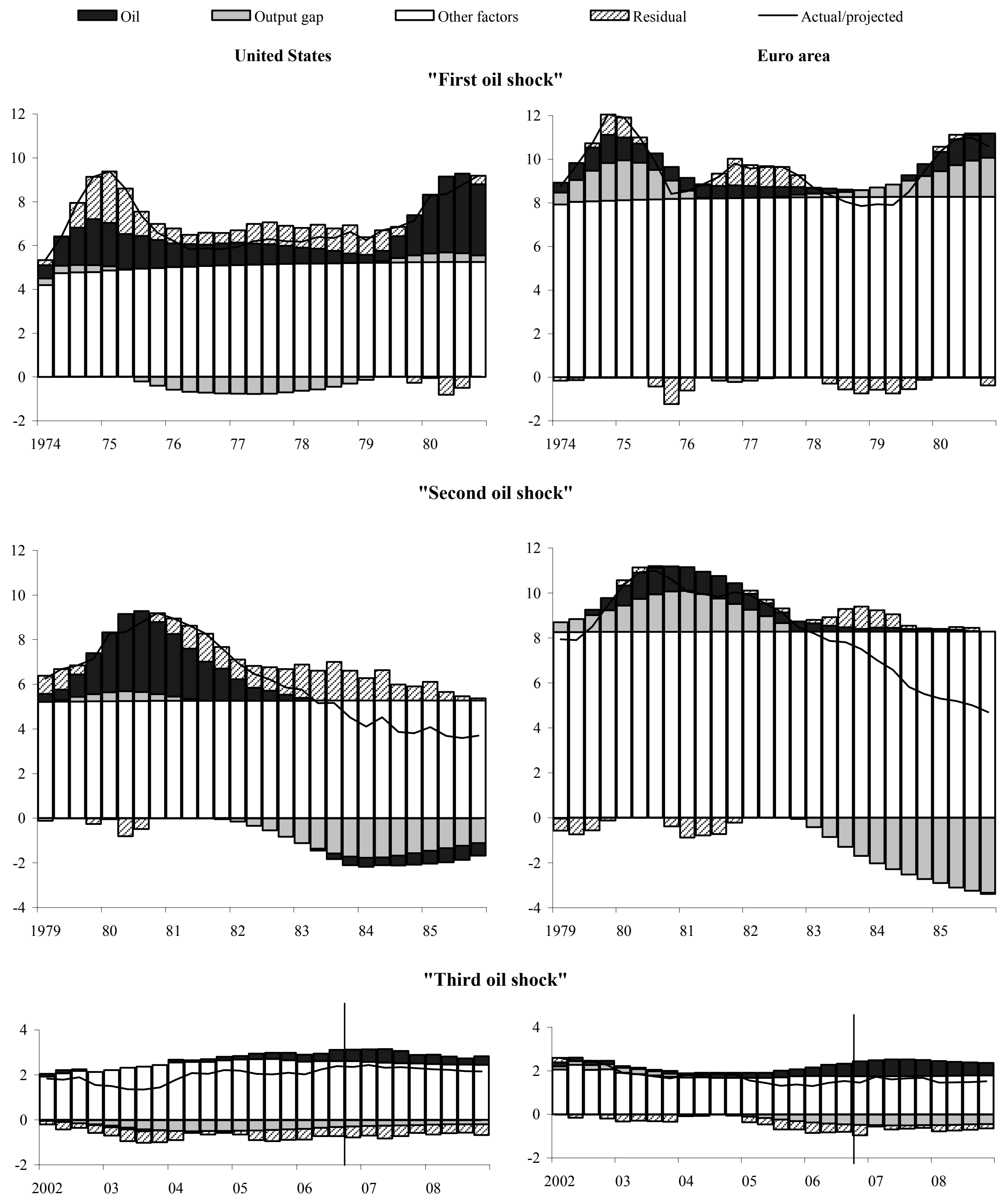
Note: The equations used for these simulations are described in the Annex.

Source: Authors' calculations.

26. Figure 7 presents a decomposition of core inflation after the three main oil shocks starting at, respectively, 1974Q1, 1979Q1 and 2002Q3 into the contributions of the respective explanatory variables. The methodology is to run the equation on the basis of the known values of the exogenous variables and the residual term. The contribution of each of the explanatory variables, including that of the residual term, incorporates their impact via the lagged dependent variable. For each of the contributions the four-quarter averages are shown, which corresponds to the year-on-year (as opposed to the annualised quarter-on-quarter) contributions to core inflation. For each of the sub-periods the version of the equation is used which gives the best fit for that period (see Annex). From the simulations the following findings emerge.

Figure 7. Factors shaping core inflation

Contributions to year-on-year percentage changes in core inflation



Note: The equations used for these simulations are described in the Annex.
Source: OECD Economic Outlook 80 database and authors' calculations.

- At the time of the first two oil shocks in the 1970s and 1980s, the contribution of spill-over effects of energy prices onto core inflation was much more prominent in the United States than in the euro area. This is due to a combination of two factors: the greater energy intensity of the US economy and the stronger sensitivity of energy retail prices to oil shocks in the United States.

- The relatively strong persistence of high core inflation after the first oil shock in both economies appears to be due to buoyant demand conditions, with the contribution of the output gap turning quickly positive after initial slack. By contrast, the disinflation that followed the second oil shock coincided with a protracted period of negative output gap contributions.

- The contribution of energy spillovers in the latest period of oil price increases is comparatively small in both economies, and if anything slightly larger in the euro area than in the United States. There has been an offsetting negative contribution of output gap developments in both economies, although this has been shrinking in the United States.

5. Conclusions

27. In the two largest OECD economies, the United States and the euro area, the knock-on effects from energy shocks onto core inflation have clearly diminished in comparison with the 1970s. To some extent this can be explained by the secular fall in energy intensity -- for any given oil price hike the shock onto energy user prices is smaller and for a given rise in energy user prices the indirect impact on other retail prices is also smaller.

28. Another major reason why core inflation is less affected now than several decades ago is that the mean (or “equilibrium”) rate of inflation -- to which observed inflation reverts after a shock has worked its way through -- has fallen towards official inflation objectives and, importantly, so far proves to be stable at this low level. This suggests that inflation expectations are well-anchored -- indeed an important monetary policy achievement.

29. There has also been a dose of luck involved, however, in the sense that the latest oil shock kicked in when the major OECD economies were still grappling with slack in the aftermath of the bursting of the dotcom bubble -- unlike the situation in the 1970s when the shocks occurred at, or close to, cyclical peaks. Had the latest oil price shock hit during the upswing in the second half of the 1990s, its inflationary impact would have been heightened rather than offset by cyclical forces. The upshot is that monetary authorities should continue to take out insurance against the risk of a departure of inflation expectations from the official targets, especially if, and when, the absorption of residual slack nears its completion.

ANNEX
ESTIMATION AND SIMULATION RESULTS

30. Within the framework outlined in Section 3, a set of alternative equations have been estimated for the periods 1971Q2-2006Q3, 1971Q2-1985Q4, 1986Q1-2006Q3 and, for the euro area only, the second period 1992Q1-2006Q3 (see Annex Tables A1-A7):

- A benchmark equation in which an autoregressive process on core inflation supplemented by the output gap were included. The number of lags on core inflation, evaluated using the Akaike and Schwarz information criteria, has been set to four for the United States and two for the euro area (the same number of lags has been chosen for every period to ensure comparability). Dummy variables have been introduced to remove major outliers.

- In a next step, we introduced alternative measures of oil price shocks: the change in the price of oil relative to core inflation, weighted by the oil intensity of production in each economy, and the wedge between headline and core inflation.

- The third step was to introduce non-oil import prices, in addition to oil prices or the wedge.

- Fourth, in order to capture the effect of global competition on inflation we added the real effective exchange rate (in terms of unit labour costs in the manufacturing sector)[13] to oil prices or the wedge.

- Finally, a version of the equation was estimated in which total real import prices were included.

31. Simulation results shown in Figure 6 of the main text are based on the equation which incorporates (intensity-weighted) real oil prices as the only shock variable. For the 1970s, the equation estimated over the period 1971-1985 was used and for the 2000s the one estimated over the period 1986-2006 was used.

32. The equations used in the simulations for the first two oil shocks in Figure 7 of the main text include, in addition to autoregressive terms on core inflation and the output gap, relative oil prices and are estimated on the first sub-sample (1971-85). This equation is not the one with the lowest standard error, but has the advantage of containing less correlated explanatory variables than other specifications, making it more suitable for the calculation of contributions. For the recent oil shock, the equation used includes the wedge and the real effective exchange rate. This equation has the lowest standard error both for the United States and the euro area over the sample (1986-2006 for the United States and 1992-2006 for the euro area).

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13. Competitiveness-weighted relative unit labour costs in the manufacturing sector in dollar terms. Competitiveness weights take into account the structure of competition in both export and import markets of the manufacturing sector of 42 countries. An increase in the index indicates a real effective appreciation and a corresponding deterioration of the competitive position. For details on the method of calculation, see Durand *et al.* (1998).

Table A.1. Regressions on the full sample (1971Q2-2006Q3) for the United States

Dependant variable: Private consumption deflator excluding food and energy (Π)

	Benchmark		Oil prices		Oil and non-oil import prices		Oil prices and REER		Wedge		Wedge and non-oil import prices		Wedge and REER		Total import prices	
Constant	0.26	*	0.24		0.34	**	0.21		0.18		0.26	*	0.16		0.31	
Π_{-1}	0.37	***	0.47	***	0.38	***	0.46	***	0.53	***	0.44	***	0.52	***	0.42	***
Π_{-2}	0.30	***	0.26	***	0.31	***	0.25	***	0.24	***	0.29	***	0.24	***	0.29	***
Π_{-3}	0.20	**	0.13		0.12		0.13		0.10		0.10		0.10		0.12	
Π_{-4}	0.06		0.08		0.11		0.09		0.07		0.10		0.08		0.11	
Sum of autoregressive terms	0.93		0.94		0.92		0.94		0.94		0.93		0.94		0.93	
Half-life of a shock (quarters)	10.3		10.6		8.3		10.9		11.7		9.6		12.1		9.1	
Mean of inflation	4.0		3.7		4.2		3.5		3.1		3.8		2.8		4.2	
GAP_{-1}	0.14	***	0.10	**	0.07	*	0.10	**	0.06		0.05		0.06		0.07	*
OIL_{-1}			0.15	***	0.19	***	0.15	***								
OIL_{-2}			0.13	**			0.14	***								
$WEDGE_{-1}$									0.33	***	0.26	***	0.34	***		
$PMGSR_{-1}$															0.45	***
$PMGSXR_{-1}$					0.51	***					0.30	**				
REER							-0.01						-0.01			
Dummy 1974 (Q2 and Q3)	3.93	***														
Adjusted R^2	0.87		0.86		0.87		0.86		0.86		0.86		0.86		0.86	
Standard error of regression	0.81		0.87		0.83		0.87		0.86		0.84		0.86		0.85	
Diagnostic tests: p-values																
Ljung-Box Q-Statistic (4 lags)	0.93		0.93		0.60		0.88		0.66		0.58		0.62		0.69	
ARCH LM test (4 lags)	0.00		0.00		0.12		0.00		0.05		0.03		0.05		0.01	
White Heteroskedasticity	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
Ramsey RESET test	0.75		0.70		0.28		0.61		0.02		0.14		0.02		0.25	
Jarque-Bera Normality test	0.21		0.00		0.32		0.00		0.02		0.22		0.01		0.14	
Chow breakpoint test	0.07	1986:1	0.07	1986:1	0.03	1986:1	0.06	1986:1	0.00	1986:1	0.01	1986:1	0.00	1986:1	0.00	1986:1
Chow forecast test (3 years)	0.99	2003:4	0.98	2003:4	0.88	2003:4	0.98	2003:4	0.96	2003:4	0.88	2003:4	0.97	2003:4	0.89	2003:4

Definition of variables:

GAP: Output gap in percent of potential output.

OIL: Relative oil price change (Brent crude, in local currency, relative to core inflation, weighted by the oil intensity of production).

WEDGE: Difference between the change in the PCE deflator and the change in the PCE deflator excluding food and energy.

PMGSR: Relative import price change (Goods and services, in local currency, relative to core inflation, weighted by the share of imports in GDP).

PMGSXR: Relative non-oil import price change (Goods and services excluding oil, in local currency, relative to core inflation, weighted by the share of non-oil imports in GDP).

REER: Real effective exchange rate, adjusted for unit labour costs in the manufacturing sector.

All variables except GAP are defined as quarter-on-quarter percentage change (s.a.a.r).

*, **, *** indicate statistical significance of coefficients at the 10%, 5% and 1% level respectively.

Source of data: OECD Economic Outlook 80 database and authors' estimates.

Table A.2. Regressions on the first sub-sample (1971Q2-1985Q4) for the United States

Dependant variable: Private consumption deflator excluding food and energy (Π)

	Benchmark		Oil prices		Oil and non-oil import prices		Oil prices and REER		Wedge		Wedge and non-oil import prices		Wedge and REER		Total import prices	
Constant	0.68		1.00	*	0.80		1.08	*	0.68		0.67		0.81		0.83	
Π_{-1}	0.32	**	0.36	***	0.25	*	0.37	***	0.46	***	0.38	***	0.47		0.24	*
Π_{-2}	0.36	***	0.28	***	0.33	**	0.28	**	0.28	**	0.30	**	0.28		0.31	**
Π_{-3}	0.20		0.15		0.17		0.15		0.11		0.12		0.11		0.19	
Π_{-4}	0.00		0.02		0.08		0.01		-0.02		0.03		-0.04		0.09	
Sum of autoregressive terms	0.88		0.82		0.84		0.81		0.83		0.84		0.82		0.83	
Half-life of a shock (quarters)	5.6		3.4		3.9		3.2		3.8		3.9		3.4		3.6	
Mean of inflation	5.8		5.5		4.9		5.6		4.1		4.1		4.4		4.8	
GAP_{-1}	0.17	***	0.10		0.02		0.10		-0.04		-0.05		-0.04		0.01	
OIL_{-1}			0.21	**	0.29	***	0.21	**								
OIL_{-2}			0.21	**			0.20	**								
$WEDGE_{-1}$									0.62	***	0.54	***	0.62			
$PMGSR_{-1}$															0.88	***
$PMGSXR_{-1}$					0.82	***					0.36					
REER							0.01						0.01			
Dummy 1974 (Q2 and Q3)	3.88	***														
Adjusted R^2	0.74		0.70		0.74		0.70		0.74		0.74		0.74		0.74	
Standard error of regression	1.08		1.14		1.07		1.15		1.08		1.06		1.08		1.07	
Diagnostic tests: p-values																
Ljung-Box Q-Statistic (4 lags)	0.92		0.99		0.86		0.98		0.67		0.85		0.51		0.92	
ARCH LM test (4 lags)	0.25		0.17		0.94		0.12		0.66		0.63		0.63		0.94	
White Heteroskedasticity	0.02		0.21		0.10		0.16		0.68		0.05		0.81		0.34	
Ramsey RESET test	0.81		0.17		0.24		0.17		0.04		0.31		0.01		0.20	
Jarque-Bera Normality test	0.82		0.51		0.68		0.45		0.84		0.74		0.78		0.62	
Chow breakpoint test	0.33	1978:3	0.00	1978:3	0.02	1978:3	0.00	1978:3	0.02	1978:3	0.03	1978:3	0.04	1978:3	0.01	1978:3
Chow forecast test (3 years)	0.20	1983:1	0.14	1983:1	0.36	1983:1	0.11	1983:1	0.53	1983:1	0.57	1983:1	0.51	1983:1	0.34	1983:1

Definition of variables:

GAP: Output gap in percent of potential output.

OIL: Relative oil price change (Brent crude, in local currency, relative to core inflation, weighted by the oil intensity of production).

WEDGE: Difference between the change in the PCE deflator and the change in the PCE deflator excluding food and energy.

PMGSR: Relative import price change (Goods and services, in local currency, relative to core inflation, weighted by the share of imports in GDP).

PMGSXR: Relative non-oil import price change (Goods and services excluding oil, in local currency, relative to core inflation, weighted by the share of non-oil imports in GDP).

All variables except GAP are defined as quarter-on-quarter percentage change (s.a.a.r).

*, **, *** indicate statistical significance of coefficients at the 10%, 5% and 1% level respectively.

Source of data: OECD Economic Outlook 80 database and authors' estimates.

Table A.3. Regressions on the second sub-sample (1986Q1-2006Q3) for the United States

Dependant variable: Private consumption deflator excluding food and energy (Π)

	Benchmark		Oil prices		Oil and non-oil import prices		Oil prices and REER		Wedge		Wedge and non-oil import prices		Wedge and REER		Total import prices	
Constant	0.31	*	0.26		0.39	*	0.41	**	0.23		0.36	*	0.37	**	0.32	
Π_{-1}	0.39	***	0.42	***	0.40	***	0.36	***	0.38	***	0.39	***	0.32	***	0.39	***
Π_{-2}	0.09		0.07		0.08		0.04		0.10		0.08		0.08		0.11	
Π_{-3}	0.17		0.15		0.09		0.13		0.17		0.09		0.14		0.13	
Π_{-4}	0.23	**	0.26	**	0.30	**	0.29	***	0.26	**	0.32	***	0.29	***	0.25	**
Sum of autoregressive terms	0.88		0.90		0.87		0.81		0.91		0.88		0.83		0.89	
Half-life of a shock (quarters)	5.5		6.4		5.1		3.4		7.5		5.6		3.7		5.7	
Mean of inflation	2.6		2.6		3.1		2.2		2.6		3.1		2.1		2.8	
GAP_{-1}	0.10	**	0.09	*	0.09	*	0.12	***	0.09	*	0.09	*	0.11	**	0.09	*
OIL_{-4}			0.09		0.04		0.11	*								
$WEDGE_{-4}$									0.12		0.07		0.16	**		
$PMGSR_{-4}$															0.15	*
$PMGSXR_{-3}$					0.19						0.21	*				
$PMGSXR_{-4}$					0.14						0.10					
REER							-0.02	**					-0.02	***		
$REER_{-1}$							-0.01	**					-0.01	**		
Adjusted R^2	0.75		0.75		0.76		0.78		0.75		0.76		0.78		0.75	
Standard error of regression	0.55		0.55		0.54		0.51		0.54		0.54		0.51		0.54	
Diagnostic tests: p-values																
Ljung-Box Q-Statistic (4 lags)	0.29		0.39		0.13		0.04		0.50		0.18		0.06		0.18	
ARCH LM test (4 lags)	0.12		0.18		0.05		0.29		0.30		0.07		0.67		0.08	
White Heteroskedasticity	0.02		0.05		0.01		0.12		0.02		0.00		0.07		0.02	
Ramsey RESET test	0.04		0.03		0.05		0.05		0.07		0.07		0.37		0.03	
Jarque-Bera Normality test	0.76		0.75		0.81		0.85		0.57		0.70		0.63		0.77	
Chow breakpoint test	0.31	1996:2	0.26	1996:2	0.14	1996:2	0.32	1996:2	0.23	1996:2	0.15	1996:2	0.25	1996:2	0.21	1996:2
Chow forecast test (3 years)	0.75	2003:4	0.66	2003:4	0.75	2003:4	0.78	2003:4	0.78	2003:4	0.73	2003:4	0.85	2003:4	0.80	2003:4

Definition of variables:

GAP: Output gap in percent of potential output.

OIL: Relative oil price change (Brent crude, in local currency, relative to core inflation, weighted by the oil intensity of production).

WEDGE: Difference between the change in the PCE deflator and the change in the PCE deflator excluding food and energy.

PMGSR: Relative import price change (Goods and services, in local currency, relative to core inflation, weighted by the share of imports in GDP).

PMGSXR: Relative non-oil import price change (Goods and services excluding oil, in local currency, relative to core inflation, weighted by the share of non-oil imports in GDP).

REER: Real effective exchange rate, adjusted for unit labour costs in the manufacturing sector.

All variables except GAP are defined as quarter-on-quarter percentage change (s.a.a.r).

*, **, *** indicate statistical significance of coefficients at the 10%, 5% and 1% level respectively.

Source of data: OECD Economic Outlook 80 database and authors' estimates.

Table A.4. Regressions on the full sample (1971Q3-2006Q3) for the euro area

Dependant variable: HICP excluding food and energy (Π)

	Benchmark		Oil prices		Oil and non-oil import prices		Oil prices and REER		Wedge		Wedge and non-oil import prices		Wedge and REER		Total import prices	
Constant	0.24	**	0.23	**	0.27	***	0.24	**	0.27	**	0.30	***	0.29	***	0.29	***
Π_{-1}	0.85	***	0.76	***	0.72	***	0.76	***	0.83	***	0.79	***	0.83	***	0.73	***
Π_{-2}	0.11		0.19	***	0.23	***	0.19	***	0.11		0.16	**	0.12	*	0.22	***
Sum of autoregressive terms	0.96		0.96		0.95		0.95		0.95		0.95		0.94		0.95	
Half-life of a shock (quarters)	17.4		15.6		14.7		14.7		12.7		12.5		11.8		14.6	
Mean of inflation	6.3		5.3		5.8		5.3		5.0		5.6		5.1		6.2	
GAP_{-1}	0.16	***	0.15	***	0.14	***	0.15	***	0.15	***	0.14	***	0.16	***	0.14	***
OIL_{-1}			0.16	***	0.14	***	0.16	***								
$WEDGE_{-3}$									0.17	**	0.14	**	0.16	**		
$PMGSR_{-1}$															0.11	***
$PMGSXR_{-1}$					0.08	**					0.08	**				
REER							0.00						0.00			
$REER_{-1}$													-0.01			
Dummy 1975:1	-2.84	***	-2.82	***	-2.66	***	-2.75	***	-2.86	***	-2.69	***	-2.79	***	-2.61	***
Dummy 1976:1	3.24	***	3.23	***	3.10	***	3.15	***	3.18	***	3.05	***	3.13	***	3.05	***
Dummy 1991:2	-2.10	***	-1.60	**	-1.59	**	-1.71	***	-2.05	***	-1.99	***	-2.15	***	-1.69	***
Dummy 2006:1	-1.60	**	-1.48	**	-1.61	***	-1.49	**	-1.81	***	-1.89	***	-1.83	***	-1.68	***
Adjusted R^2	0.96		0.97		0.97		0.97		0.96		0.96		0.96		0.97	
Standard error of regression	0.64		0.61		0.61		0.61		0.63		0.62		0.63		0.61	
Diagnostic tests: p-values																
Ljung-Box Q-Statistic (4 lags)	0.21		0.19		0.23		0.19		0.35		0.48		0.49		0.27	
ARCH LM test (4 lags)	0.15		0.26		0.30		0.13		0.24		0.19		0.29		0.29	
White Heteroskedasticity	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
Ramsey RESET test	0.14		0.35		0.59		0.30		0.38		0.54		0.46		0.63	
Jarque-Bera Normality test	0.00		0.01		0.08		0.03		0.01		0.05		0.04		0.12	
Chow breakpoint test	0.01	1986:1	0.01	1986:1	0.02	1986:1	0.01	1986:1	0.00	1986:1	0.02	1986:1	0.00	1986:1	0.01	1986:1
Chow forecast test (3 years)	0.47	2003:4	0.65	2003:4	0.75	2003:4	0.33	2003:4	0.64	2003:4	0.75	2003:4	0.66	2003:4	0.75	2003:4

GAP: Output gap in percent of potential output.

OIL: Relative oil price change (Brent crude, in local currency, relative to core inflation, weighted by the oil intensity of production).

WEDGE: Difference between the change in the HICP and the change in the HICP excluding energy and unprocessed food.

PMGSR: Relative import price change (Goods and services, in local currency, relative to core inflation, weighted by the share of imports in GDP).

PMGSXR: Relative non-oil import price change (Goods and services excluding oil, in local currency, relative to core inflation, weighted by the share of non-oil imports in GDP).

All variables except GAP are defined as quarter-on-quarter percentage change (s.a.a.r).

*, **, *** indicate statistical significance of coefficients at the 10%, 5% and 1% level respectively.

Source of data: OECD Economic Outlook 80 database and authors' estimates.

Table A.5. Regressions on the first sub-sample (1971Q3-1985Q4) for the euro area

Dependant variable: HICP excluding food and energy (Π)

	Benchmark		Oil prices		Oil and non-oil import prices		Oil prices and REER		Wedge		Wedge and non-oil import prices		Wedge and REER		Total import prices	
Constant	1.06	**	1.16	**	1.26	***	1.33	***	1.35	***	1.38	***	1.72	***	1.27	***
Π_{-1}	0.90	***	0.78	***	0.69	***	0.79	***	0.82	***	0.77	***	0.76	***	0.70	***
Π_{-2}	-0.02		0.08		0.15		0.04		-0.01		0.05		0.00		0.15	
Sum of autoregressive terms	0.87		0.85		0.84		0.83		0.82		0.82		0.76		0.84	
Half-life of a shock (quarters)	5.1		4.4		4.0		3.8		3.4		3.4		2.5		4.0	
Mean of inflation	8.3		7.9		8.0		7.9		7.4		7.5		7.2		8.0	
GAP_{-1}	0.21	***	0.19	***	0.17	***	0.22	***	0.23	***	0.21	***	0.27	***	0.17	***
OIL_{-1}			0.17	**	0.17	**	0.11									
$WEDGE_{-3}$									0.31	**	0.25		0.38	***		
$PMGSR_{-1}$															0.14	***
$PMGSXR_{-1}$					0.12	*					0.10					
$REER_{-1}$							-0.02	*					-0.03	***		
Dummy 1975:1	-2.57	***	-2.46	***	-2.16	***	-2.28	***	-2.42	***	-2.21	***	-2.04	***	-2.12	***
Dummy 1976:1	3.20	***	3.18	***	2.98	***	3.12	***	3.12	***	2.98	***	3.00	***	2.94	***
Adjusted R^2	0.86		0.87		0.88		0.88		0.87		0.87		0.89		0.88	
Standard error of regression	0.79		0.75		0.73		0.73		0.76		0.76		0.69		0.72	
Diagnostic tests: p-values																
Ljung-Box Q-Statistic (4 lags)	0.25		0.15		0.21		0.25		0.42		0.50		0.27		0.24	
ARCH LM test (4 lags)	0.70		0.50		0.31		0.43		0.89		0.62		0.15		0.35	
White Heteroskedasticity	0.02		0.01		0.08		0.02		0.07		0.18		0.06		0.07	
Ramsey RESET test	0.99		0.87		0.77		0.82		0.87		0.63		0.55		0.89	
Jarque-Bera Normality test	0.55		0.66		0.62		0.71		0.39		0.39		0.57		0.59	
Chow breakpoint test	0.69	1978:3	0.74	1978:3	0.92	1978:3	0.18	1978:3	0.82	1978:3	0.95	1978:3	0.66	1978:3	0.99	1978:3
Chow forecast test (3 years)	0.91	1983:1	0.92	1983:1	0.82	1983:1	0.83	1983:1	0.93	1983:1	0.92	1983:1	0.87	1983:1	0.80	1983:1

GAP: Output gap in percent of potential output.

OIL: Relative oil price change (Brent crude, in local currency, relative to core inflation, weighted by the oil intensity of production).

WEDGE: Difference between the change in the HICP and the change in the HICP excluding energy and unprocessed food.

PMGSR: Relative import price change (Goods and services, in local currency, relative to core inflation, weighted by the share of imports in GDP).

PMGSXR: Relative non-oil import price change (Goods and services excluding oil, in local currency, relative to core inflation, weighted by the share of non-oil imports in GDP).

All variables except GAP are defined as quarter-on-quarter percentage change (s.a.a.r).

*, **, *** indicate statistical significance of coefficients at the 10%, 5% and 1% level respectively.

Source of data: OECD Economic Outlook 80 database and authors' estimates.

Table A.6. Regressions on the second sub-sample (1986Q1-2006Q3) for the euro area

Dependant variable: HICP excluding food and energy (Π)

	Benchmark		Oil prices		Oil and non-oil import prices		Oil prices and REER		Wedge		Wedge and non-oil import prices		Wedge and REER		Total import prices	
Constant	0.35	**	0.30	**	0.29	*	0.24	*	0.26	*	0.22		0.22		0.30	**
Π_{-1}	0.53	***	0.53	***	0.53	***	0.55	***	0.57	***	0.57	***	0.58	***	0.53	***
Π_{-2}	0.35	***	0.38	***	0.38	***	0.39	***	0.35	***	0.36	***	0.36	***	0.38	***
Sum of autoregressive terms	0.89		0.90		0.91		0.93		0.92		0.94		0.94		0.91	
Half-life of a shock (quarters)	5.8		6.9		7.7		9.9		8.2		10.7		11.1		7.7	
Mean of inflation	3.1		3.1		3.3		3.6		3.2		3.6		3.7		3.5	
GAP_{-1}	0.13	***	0.12	***	0.12	***	0.12	***	0.10	**	0.10	**	0.11	***	0.12	***
OIL_{-1}			0.07		0.07		0.08									
$WEDGE_{-3}$									0.12	*	0.13		0.11			
$PMGSR_{-1}$																
$PMGSXR_{-1}$					0.02						0.03	*			0.04	
REER							-0.01	***					-0.01	**		
Dummy 1991:2	-1.41	***	-1.27	**	-1.31	**	-1.63	***	-1.49	***	-1.54	***	-1.82	***	-1.39	***
Dummy 2006:1	-1.50	***	-1.45	***	-1.48	***	-1.44	***	-1.66	***	-1.70	***	-1.63	***	-1.52	***
Adjusted R^2	0.85		0.86		0.85		0.87		0.86		0.86		0.87		0.86	
Standard error of regression	0.46		0.46		0.46		0.44		0.45		0.46		0.44		0.46	
Diagnostic tests: p-values																
Ljung-Box Q-Statistic (4 lags)	0.96		0.92		0.91		0.71		0.93		0.90		0.91		0.92	
ARCH LM test (4 lags)	0.76		0.59		0.58		0.45		0.89		0.91		0.91		0.68	
White Heteroskedasticity	0.18		0.26		0.02		0.09		0.33		0.02		0.10		0.01	
Ramsey RESET test	0.04		0.10		0.14		0.02		0.22		0.29		0.06		0.13	
Jarque-Bera Normality test	0.25		0.38		0.55		0.82		0.17		0.44		0.78		0.65	
Chow breakpoint test	0.02	1996:2	0.03	1996:2	0.07	1996:2	0.03	1996:2	0.02	1996:2	0.04	1996:2	0.01	1996:2	0.05	1996:2
Chow forecast test (3 years)	0.25	2003:4	0.31	2003:4	0.33	2003:4	0.15	2003:4	0.31	2003:4	0.35	2003:4	0.15	2003:4	0.31	2003:4

Definition of variables:

GAP: Output gap in percent of potential output.

WEDGE: Difference between the change in the PCE deflator and the change in the PCE deflator excluding food and energy.

REER: Real effective exchange rate, adjusted for unit labour costs in the manufacturing sector.

All variables except GAP are defined as quarter-on-quarter percentage change (s.a.a.r).

*, **, *** indicate statistical significance of coefficients at the 10%, 5% and 1% level respectively.

Source of data: OECD Economic Outlook 80 database and authors' estimates.

Table A.7. Regressions on the period 1992Q1- 2006Q3 for the euro area

Dependant variable: HICP excluding food and energy (∏)

	Benchmark		Oil prices		Oil and non-oil import prices		Oil prices and REER		Wedge		Wedge and non-oil import prices		Wedge and REER		Total import prices	
Constant	0.41	***	0.33	*	0.33	**	0.34	**	0.25		0.23		0.23		0.35	**
Π_{-1}	0.38	***	0.43	***	0.43	***	0.43	***	0.42	***	0.43	***	0.44	***	0.40	***
Π_{-2}	0.44	***	0.42	***	0.43	***	0.43	***	0.46	***	0.47	***	0.46	***	0.46	***
Sum of autoregressive terms	0.83		0.85		0.86		0.86		0.88		0.90		0.89		0.86	
Half-life of a shock (quarters)	3.6		4.4		4.5		4.5		5.4		6.4		6.1		4.5	
Mean of inflation	2.4		2.3		2.3		2.4		2.1		2.2		2.2		2.5	
GAP_{-1}	0.11	**	0.09	*	0.09	*	0.11	**	0.07		0.07		0.08		0.09	*
OIL_{-3}			0.14		0.13		0.09									
$WEDGE_{-3}$									0.20	**	0.20	**	0.19	**		
$PMGSR_{-3}$															0.06	
$PMGSXR_{-1}$					0.02						0.03					
REER							-0.01						-0.01			
Dummy 2006:1	-1.43	***	-1.57	***	-1.57	***	-1.52	***	-1.67	***	-1.70	***	-1.65	***	-1.48	***
Adjusted R^2	0.78		0.79		0.78		0.79		0.80		0.80		0.80		0.79	
Standard error of regression	0.44		0.43		0.44		0.43		0.42		0.42		0.41		0.43	
Diagnostic tests: p-values																
Ljung-Box Q-Statistic (4 lags)	0.91		0.78		0.78		0.72		0.75		0.72		0.77		0.78	
ARCH LM test (4 lags)	0.96		0.98		0.99		0.98		0.96		0.97		0.96		0.97	
White Heteroskedasticity	0.72		0.35		0.13		0.05		0.94		0.44		0.31		0.74	
Ramsey RESET test	0.66		0.69		0.73		0.46		0.80		0.83		0.88		0.76	
Jarque-Bera Normality test	0.17		0.36		0.42		0.74		0.01		0.04		0.24		0.21	
Chow breakpoint test	0.72	1999:1	0.47	1999:1	0.29	1999:1	0.43	1999:1	0.76	1999:1	0.26	1999:1	0.33	1999:1	0.64	1999:1
Chow forecast test (3 years)	0.23	2003:4	0.24	2003:4	0.26	2003:4	0.17	2003:4	0.23	2003:4	0.25	2003:4	0.16	2003:4	0.21	2003:4

Definition of variables:

GAP: Output gap in percent of potential output.

WEDGE: Difference between the change in the PCE deflator and the change in the PCE deflator excluding food and energy.

REER: Real effective exchange rate, adjusted for unit labour costs in the manufacturing sector.

All variables except GAP are defined as quarter-on-quarter percentage change (s.a.a.r).

*, **, *** indicate statistical significance of coefficients at the 10%, 5% and 1% level respectively.

Source of data: OECD Economic Outlook 80 database and authors' estimates.

Table A.8. Asymmetric Phillips curves

Coefficient of positive and negative output gaps

Full sample (1971Q2-2006Q3)

	Benchmark	Oil prices	Oil and non-oil import prices	Oil prices and REER	Wedge	Wedge and non-oil import prices	Wedge and REER	Total import prices
United States								
Positive gaps	0.25 ***	0.18 *	0.13	0.19 *	0.04	0.05	0.05	0.13
Negative gaps	0.09	0.06	0.03	0.05	0.07	0.05	0.06	0.04
Euro area								
Positive gaps	0.32 ***	0.26 ***	0.24 ***	0.27 ***	0.27 ***	0.25 ***	0.29 ***	0.24 ***
Negative gaps	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.06

First sub-sample (1971Q2-1985Q4)

	Benchmark	Oil prices	Oil and non-oil import prices	Oil prices and REER	Wedge	Wedge and non-oil import prices	Wedge and REER	Total import prices
United States								
Positive gaps	0.38 **	0.21	0.10	0.24	-0.13	-0.12	-0.14	0.07
Negative gaps	0.07	0.05	-0.02	0.04	-0.01	-0.02	-0.01	-0.02
Euro area								
Positive gaps	0.36 *	0.25 *	0.16	0.36 ***	0.31 **	0.25 *	0.38 ***	0.16
Negative gaps	0.11	0.15	0.18 *	0.13	0.16	0.17	0.17 *	0.18 *

Second sub-sample (1986Q1-2006Q3)

	Benchmark	Oil prices	Oil and non-oil import prices	Oil prices and REER	Wedge	Wedge and non-oil import prices	Wedge and REER	Total import prices
United States								
Positive gaps	-0.01	-0.03	-0.02	0.10	0.00	-0.02	0.08	-0.03
Negative gaps	0.18 **	0.18 **	0.17 **	0.13	0.18 **	0.17 *	0.14 *	0.18 **
Euro area								
Positive gaps	0.24 **	0.23 **	0.23 **	0.21 **	0.16	0.16	0.16	0.23 **
Negative gaps	0.06	0.03	0.03	0.05	0.06	0.05	0.07	0.03

Sample 1992Q1-2006Q3

	Benchmark	Oil prices	Oil and non-oil import prices	Oil prices and REER	Wedge	Wedge and non-oil import prices	Wedge and REER	Total import prices
Euro area								
Positive gaps	0.26 *	0.18	0.21	0.17	0.06	0.04	0.07	0.15
Negative gaps	0.04	0.04	0.04	0.06	0.07	0.08	0.07	0.06

Note: The specifications of the equations are the same as in table A2, except for the output gap, which is split between positive and negative values.

Source: Authors' calculations.

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