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**Inflation Responses
to Recent Shocks: Do G7
Countries Behave
Differently?**

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ECONOMICS DEPARTMENT

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by

Lukas Vogel, Elena Rusticelli, Pete Richardson, Stéphanie Guichard and Christian Gianella

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ABSTRACT/RÉSUMÉ

Inflation Responses To Recent Shocks: Do G7 Countries Behave Differently?

This paper uses a variety of empirical methods to examine the apparent differences in monetary policy stances as between the United States and other G7 economies, notably those in the euro area, during the period of sharp increases in oil and other commodity prices in the first half of 2008. In particular it asks the question whether observed differences in policy stances could be attributed to differences in economic structures and the vulnerability of different regions to inflationary shocks coming from import prices as opposed to differences in monetary policy objectives. The main conclusion is that although there are a number of differences in the estimated impact and dynamics of commodities, import prices and exchange rates on domestic inflation, which may have contributed to differences in policy stances during the boom in commodity prices, they cannot explain them all.

JEL classification codes: E31; E52; J30

Keywords: inflation; Phillips curve; commodity prices; import prices; error-correction model; DSGE models

Réponse de l'inflation aux chocs récents : est ce que les pays du G7 diffèrent les uns des autres ?

Ce papier utilise plusieurs méthodes empiriques distinctes pour examiner les différences apparentes dans l'orientation des politiques monétaires aux États-Unis et d'autres économies du G7, notamment de la zone euro, pendant la période de fortes hausses des cours du pétrole et des matières premières au premier semestre de 2008. En particulier il pose la question de l'origine des différences observées dans l'orientation des politiques : peuvent-elles être attribuées aux différences de structures économiques et à la vulnérabilité de différentes régions aux chocs inflationnistes venant des prix à l'importation ou aux différences dans les objectifs de politique monétaire. La conclusion principale est que bien qu'il y ait un certain nombre de différences dans l'impact estimé des prix à l'importation des produits de base et des taux de change sur l'inflation domestique et dans leurs dynamiques, lesquels ont pu contribuer aux différences d'orientation des politiques monétaires durant la phase de boom des cours des matières premières, ces différences ne peuvent pas tout expliquer.

Classification JEL : E31 ; E52 ; J30

Mots clefs : Inflation ; courbe de Phillips ; prix des matières premières ; prix des importations ; modèles à correction d'erreurs ; modèles DSGE

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INFLATION RESPONSES TO RECENT SHOCKS; DO G7 COUNTRIES BEHAVE DIFFERENTLY

by

Lukas Vogel, Elena Rusticelli, Pete Richardson, Stéphanie Guichard and Christian Gianella¹

1. Introduction and main findings

1. After declining steadily since the early 1980s, domestic inflation picked up again in the early 2000s in most OECD countries and accelerated sharply over the first half 2008 before receding sharply towards the end of the year. These movements can to a large extent be related to import prices and, more specifically, the commodity components of imports. Between 2000 and July 2008, oil prices expressed in US dollars and yen increased fivefold, and non-energy commodity prices more than doubled. Since then, commodity prices have substantially eased, but remain above their levels in the first half of the decade (Figure 1). The monetary policy responses to higher inflationary pressures have differed across industrialised economies, even when looking at benchmarks that take into account the relative cyclical positions of the major economies. Some central banks appeared more “hawkish” on inflation while others, where the acceleration of commodity prices inflation coincided with the beginning of financial turmoil, have appeared more “dovish”.

2. These different reactions may have reflected a number of factors including: i) differences in the exposure to global price shocks as a result of different commodity intensities of production and consumption across countries; ii) differences in the propagation of shocks due to cross-country differences in inflation and wage dynamics; iii) differences in policy objectives and the channels of monetary policy transmission. This paper analyses and compares the exposure of the G7 economies to the global inflation shocks of 2000-08 and the impact of these shocks on domestic inflation in order to assess the role of factors (i) and (ii).²

1. At the time of preparation the authors were all members of the Macroeconomic Analysis and Systems Management Division of the OECD Economics Department. They would like to thank Jérôme Brezillon, Alain de Serres, Jørgen Elmeskov, David Haugh, Patrice Ollivaud, Nigel Pain, Jean-Luc Schneider and David Turner for helpful discussions, suggestions and support and to Diane Scott for assistance in preparing the document. The views expressed in this paper are those of the authors and do not necessarily reflect those of the OECD or its member governments.

2. A substantial body of research suggests policy objectives and transmission channels to be rather similar on both sides of the Atlantic. See Smets and Wouters (2005) as well as Sahuc and Smets (2008) for studies using estimated DSGE models of the euro area and the United States.

Figure 1. Oil and non-energy commodity prices in the G7 economies

2000=100

Brent crude oil

Non-energy commodities

HWWA index

Note: Commodity prices are expressed in domestic currency assuming full exchange rate pass-through.

Source: OECD Economic Outlook database.

3. The empirical research has mainly drawn on four different methods to analyse inflation dynamics:

- A simple accounting framework can be used to provide back-of-the-envelope calculations for the mechanical direct impact of commodity and import prices on domestic inflation (*e.g.* Kamin *et al.*, 2004; MacCoille, 2008). Changes in commodity and import prices are multiplied by the respective share of commodities and imports in total domestic demand to obtain a first estimate for the impact on consumer prices. The accounting framework is a useful benchmark as it gives an idea about the order of magnitude of the effects of price shocks on inflation. Such an approach is limited however to the extent that it concerns the direct mechanical effects and does not capture any indirect or dynamic effects coming from other price level influences, such as domestic labour costs, and monetary or fiscal policies.
- Single-equation estimates within a Phillips curve framework have been the dominant approach in the analysis of inflation dynamics for a long time. Such an approach typically looks at the separate influences of commodity or import prices on consumer price level and estimates the impact of these components on domestic inflation (*e.g.* Batini *et al.*, 2005; Pain *et al.*, 2006; Van den Noord and André, 2007). The approach accounts for both the direct and indirect impact of commodity and import prices on inflation but is limited to the extent that it does not fully account for other indirect effects coming via domestic production costs, domestic demand and exchange rate dynamics.
- Statistical vector autoregressive (VAR) estimation methods allow for feedbacks between the variables included in the analysis (*e.g.* Blanchard and Galí, 2007; Kilian, 2007, 2008) and also policy reactions to shocks. The VAR approach is however a-theoretical, exploiting the time series properties of the data, although parameter restrictions may be imposed to add more theory-informed structure and for hypothesis testing (*e.g.* using SVAR methods).
- DSGE models provide a further tool to analyse the transmission of shocks to inflation and other macroeconomic variables.³ These typically allow for the general equilibrium nature of economic adjustment to shocks and disentangle the different transmission channels. However, apart from their simplicity they also have other shortcomings, including that cross-country differences in calibrated models tend to be rather slight and that they assume stability and policy-independence of deep parameters.⁴

This paper employs a combination of these different methods as complementary tools to investigate the impact of commodity and import price dynamics on consumer price inflation in the G7 economies.

4. The main conclusion is that differences in exposure to global commodity price shocks and their propagation to prices and wages may have contributed to the differences in policy stances observed during the boom of commodity prices, but cannot explain them all. In particular, the analysis suggests that:

- The increase in commodity prices between 2000 and mid-2008 had a larger direct impact on domestic inflation in the United States than in the euro area, reflecting both dollar depreciation

3. See for example Adjemian and Darracq, 2008; Carlstrom and Fuerst, 2006; Duval and Vogel, 2008; Nakov and Pescatori, 2007; Roeger, 2005.

4. This assumption that has been challenged by recent research (Benati, 2008; Fernández-Villaverde and Rubio-Ramírez, 2007).

and the higher energy content of domestic demand in the US economy. The direct impact was even larger in Japan.

- The exchange rate pass-through in G7 economies is incomplete and displays substantial cross-country variations. Over the first half of 2008, limited pass-through had a dampening effect on the transmission of international price developments in those countries exposed to currency depreciation.
- Despite the higher oil intensity of the US economy, estimates for the period 1990-2007 suggest that, conditional on labour costs, the long-term impact of oil prices on domestic consumer prices in the euro area is stronger or of similar size as in the United States and stronger than in Japan, the United Kingdom and Canada.
- The long-term impact of non-energy commodity prices on consumer prices appears similar between the United States, the euro area and Canada, while it is considerably stronger in the United Kingdom and weak in Japan.
- The long-run elasticity of domestic consumer price levels to non-commodity import prices varies substantially across countries. It is high in Canada and the United States, but low in Japan, the euro area and the United Kingdom.
- Domestic labour costs remain the dominant long-run determinant of consumer price levels in G7 countries. In this context, there is no strong evidence for real wage resistance and wage-price feedback in G7 countries in recent years.
- VAR estimates suggest that short-run responses of domestic inflation to commodity and import price changes are broadly similar across G7 countries, although there is some evidence of a stronger initial inflation impact in the United States and the United Kingdom compared to the euro area and Japan.
- Finally, counterfactual simulations with a DSGE model illustrate that greater concern for output losses may have been an important factor behind the milder monetary response to commodity price shocks in the United States as compared with the euro area. Although the empirical evidence is weak, they also suggest that a flatter Philips curve, associated in some economies with larger price stickiness, might imply a more restrictive monetary policy even under similar objectives and confirm that higher real wage resistance to commodity price shocks would also increase the necessary degree of monetary tightening.

5. Insofar as commodity price shocks of the recent orders of magnitude have not been observed for more than two decades, the available empirical evidence may of course be subject to important limitations when applied to a less stable economic environment. For example, wages may be more sensitive to larger shocks and the perceived risk of large second-round effects and an unanchoring of inflation expectations may have been a contributory factor to different policy stances. Nonetheless, with the large falls in oil and other commodity prices and the subsequent decline in economic activity since mid-2008, such risks and associated differences in policies have largely disappeared.

6. The remainder of this paper consists of four sections. Section 2 presents back-of-the-envelope estimates of the direct impact of commodity price and exchange rate developments on consumer price inflation in G7 countries. Section 3 then presents estimates of the short-run inflation dynamics and the long-run relationships between price level components in a consumer price Phillips curve framework with error-correction specification and estimates for second-round effects from a wage equation. Section 4

provides evidence from VAR estimates. Finally, Section 5 illustrates the impact of key structural parameters and policy objectives on optimal policy responses and inflation dynamics. A technical annex provides more specific details of the methods used.

2. Assessing the mechanical direct impact of recent international price shocks

7. The mechanical direct exposure of the G7 economies to the increase in international commodity prices over 2000-08 depends on the composition of imports and domestic demand and on the relative exchange rate developments. Figure 2 plots the change in commodity and non-commodity import prices weighted by their respective share in aggregate demand⁵ together with consumer price inflation, illustrating the pressure on domestic inflation associated with commodity price developments in the G7 countries.

The impact of higher commodity prices has been larger in the United States compared to the euro area

8. The accounting framework provides back-of-the-envelope calculations for the mechanical impact of recent commodity and exchange rate developments on inflation.⁶ The direct impact of commodity prices, *i.e.* the *first-round* effect, depends on the share of commodities in total domestic demand. According to the back-of-the-envelope calculations reported in Table 1, rising commodity prices had a substantially higher impact on inflation in the United States and Japan compared to the euro area during the period 2001-08. Since 2006, when prices of food and several other commodities, including metals, began to rise sharply, the mechanical contribution of commodity prices to inflation increased significantly, with the direct impact in the United States and Japan still exceeding the one in the euro area.

9. While the stronger direct exposure of the United States to commodity price shocks partly reflects the higher share of oil in US production and consumption, exchange rate dynamics in recent years have added to the cross-country differentials.⁷ The appreciation of the euro and the Canadian dollar relative to the US dollar significantly cushioned the inflationary pressure from commodity price shocks. Thus oil prices in local currency in the euro area rose by a factor of three between 2001 and mid-2008, compared with a factor of five for the United States.⁸

5. This differs from the subsequent analysis using total domestic demand for energy commodities. Figure 2 weighs commodity prices by the share of commodity imports in total demand, due to the lack of comparable data for the domestic supply of non-energy commodities.

6. More details on the approach are provided in the Annex.

7. The estimated effects of commodity prices are expressed in local currency terms, combining the direct effect of world market prices on import prices at constant exchange rates with the impact of exchange rate dynamics. In general, it appears realistic to assume an approximately complete pass-through of exchange rate dynamics into the price in domestic currency of imported commodities. The pass-through may however be more limited for commodities, such as gas, which are sold on more fragmented markets.

8. This abstracts from whether the weakening of the US dollar was itself a factor behind rising world commodity prices.

Figure 2. Import prices and CPI inflation in the G7 economies

Note: Import price inflation is weighted by the share of the respective import category in total domestic demand. Import prices are not corrected for changes in import composition. Euro area imports include intra-area trade. The harmonised CPI is used for European countries.

Source: OECD *Economic Outlook* database.

Table 1. **The direct impact of higher commodity prices on domestic inflation**

Annual average, percentage points (domestic currency terms)

	Energy	Food	Other commodities	Total	Headline – core inflation
2001-08¹					
United States	0.5	0.2	0.1	0.7	0.8
Japan	0.5	0.4	0.2	1.1	2.1
Euro 3 ²	0.2	0.1	0.0	0.4	0.5
Germany	0.3	0.1	0.0	0.4	0.7
France	0.2	0.1	0.0	0.3	0.4
Italy	0.2	0.1	0.0	0.3	0.3
United Kingdom	0.3	0.2	0.1	0.6	0.6
Canada	0.2	0.1	0.1	0.4	0.2
2006-08					
United States	0.7	0.4	0.1	1.2	0.7
Japan	0.7	0.9	0.3	2.0	2.0
Euro 3 ²	0.4	0.4	0.1	0.9	0.6
Germany	0.4	0.4	0.1	0.9	0.8
France	0.4	0.3	0.1	0.8	0.4
Italy	0.4	0.5	0.2	1.0	0.5
United Kingdom	0.6	0.7	0.2	1.4	0.9
Canada	0.4	0.4	0.2	1.0	0.0

Note: These estimates combine the movements in individual commodity prices and exchange rates, weighted by the relevant shares in total demand.

1. For the rest of 2008, commodity prices and domestic inflation are assumed to be in line with the projections presented in *OECD Economic Outlook No.84*.
2. GDP weighted average of France, Germany and Italy.

Source: IEA Energy Statistics of OECD countries, *OECD Economic Outlook 84* database. OECD STAN database and OECD calculations.

Given lower pass-through, exchange-rate dynamics have less affected non-commodity import prices

10. Movements in the exchange rate have contributed to cross-country inflation differentials also via their impact on non-commodity import prices. The pass-through of exchange rate dynamics into non-commodity import prices tends to be incomplete and significantly lower than the (almost) complete pass-through for commodity imports and displays notable differences across countries. Table 2 reports the estimated mechanical impact of recent changes in nominal effective exchange rate on non-commodity imports prices, based on recent estimates of exchange rate pass-through, reported in Figure 3 and further described in the Annex.⁹ The third column of Table 2 gives the mechanical impact of observed effective

9. These estimates are based on conventional pass-through equations using quarterly data on import prices, nominal effective exchange rates and production costs for the period 1993q1-2007q4. The results are in line with estimates in Ihrig *et al.* (2006) and Marazzi *et al.* (2005). Generally, pass-through to overall import and to non-commodity import prices in domestic currency is found to be incomplete (parameters less than one) in G7 economies, but heterogeneous across countries. Pass-through is found to be especially low in France and the United States, but high in Canada, Italy, Japan and the United Kingdom. Note, however, that for Canada the assumptions made in the construction of the official import price statistics imply an upward bias to the estimates.

nominal appreciations and depreciations on domestic inflation, taking into account the import content of total demand in the G7 economies.

Table 2. **The direct impact of exchange-rates on domestic prices via non-commodity import prices**

	Nominative effective exchange-rate variation	Impact on non-commodity import prices (in domestic currency terms)	Impact on domestic prices
	Per cent ¹	Per cent ²	Percentage points ³
2001-08⁴			
United States	-1.6	0.3	0.0
Japan	-0.2	0.1	0.0
Euro 3 ⁵	1.3	-0.5	-0.1
Germany	1.4	-0.5	-0.2
France	1.2	-0.1	0.0
Italy	1.3	-0.8	-0.2
United Kingdom	-1.5	0.9	0.2
Canada	2.8	-1.8	-0.6
2006-08⁴			
United States	-1.1	0.2	0.0
Japan	3.8	-2.1	-0.2
Euro 3 ⁵	0.8	-0.3	-0.1
Germany	0.8	-0.3	-0.1
France	0.8	-0.1	0.0
Italy	0.8	-0.5	-0.1
United Kingdom	-3.9	2.2	0.5
Canada	-1.0	0.7	0.2

1. An increase means an appreciation of the nominal effective exchange rate. Annual average rates.
2. The estimated impact is based on the pass-through estimates for non-commodity imports shown in the Figure 3.
3. Based on the share of non-commodity imports in total demand.
4. For the rest of 2008, nominal exchange rates are those assumed in *OECD Economic Outlook No 84*.
5. GDP weighted average of France, Germany and Italy.

Source: OECD calculations.

11. The estimates in Table 2 suggest that the impact of nominal effective exchange rate appreciation or depreciation on non-commodity import prices over the period might account for inflation differentials between the euro area and the United States of at most 0.2 percentage points. The lower US pass-through significantly moderated the inflationary pressure from the dollar depreciation. More generally, the estimates point to moderate inflationary pressure also in other countries with depreciating currencies and to disinflationary effects in economies with appreciating effective exchange rates. A notable exception is for the United Kingdom, where the sterling depreciation over the past year is estimated to have added a full percentage point to inflation *via* the impact on non-commodity import prices alone.¹⁰

10. In the case of the United Kingdom most of the contribution of depreciation shown in Table 2 for 2006-08 has occurred during the past year.

Figure 3. **Estimates of exchange rate pass-through into import prices across the G7 economies**

Elasticity of total import and non-commodity import prices to exchange rate variations

Note: The estimated pass-through measures the cumulative response of import prices in local currency in the first year after a change in the exchange rate. See the Annex for more details.

12. The calculations in Tables 1 and 2 account for the mechanical direct impact of commodity price and exchange rate developments on domestic inflation but do not capture the indirect effects of commodity prices and exchange rates on inflation, *i.e.* the second-round effects. Such effects depend on how the pricing behaviour of competitors, domestic production costs and monetary policy react to commodity and import price shocks and may go either way (Hampton, 2001):

- Higher commodity or import prices may be offset by lower prices for other goods and services if demand for the latter falls due to the declining purchasing power. Such expenditure switching effects might lead to a shift in relative prices without much effect on the aggregate price level.
- For net commodity exporters, rising commodity prices will generally increase overall demand, which exerts upward pressure on inflation, while import prices tend to decline with a related appreciation of the country's exchange rate.
- Relative price adjustments tend to create less inflationary pressure in an economy that has a credible inflation target. Higher price and wage flexibility in the domestic sector is also supportive to relative price adjustment without strong price level effects.
- If wages are implicitly or explicitly indexed to consumer price inflation, then higher commodity and import prices tend to lead to an increase in nominal wage claims in the domestic economy, with adverse second-round effects on domestic production costs, inflation and unemployment.

The subsequent sections extend the analysis to look at the observed relationship between commodity and import prices and domestic inflation, including both the direct first-round and indirect second-round effects.

3. Price and wage equation estimates

Estimates of consumer price Phillips curves...

13. The methodology used to assess the impact of commodity and import prices on domestic consumer price inflation in a Phillips curve framework follows Pain *et al.* (2006) and previous studies reported therein. An error-correction model (ECM) relating domestic consumer prices to unit labour costs, import prices and measures of output gaps is estimated to simultaneously assess the short-term dynamics and the long-run price level effects of non-commodity import and commodity price shifts. Batini *et al.* (2005) show that such a specification can be derived from theoretical models of price setting with price stickiness and monopolistic competition such as the New Keynesian Phillips curve.

14. An extension and innovation in this paper is to include separate energy commodity, non-energy commodity and non-commodity import prices as distinct sources of upward or downward pressure on domestic consumer prices. To account for potential changes over time in the composition of aggregate demand, commodity and non-commodity import prices in the error-correction term are interacted with the shares of energy commodities, non-energy commodity imports and non-commodity imports in total domestic demand. The estimated equation is:

$$\begin{aligned} \Delta \ln P_t = & c + A(L)\Delta \ln P_{t-1} + B(L)\Delta \ln P_t^{M,oil} + C(L)\Delta \ln P_t^{M,noil} + D(L)\Delta \ln P_t^{M,non-com} + E(L)\Delta \ln ULC_t \\ & - \lambda \left(\ln P_{t-1} - \alpha M_{t-1}^{SH,oil} \ln P_{t-1}^{M,oil} - \beta M_{t-1}^{SH,noil} \ln P_{t-1}^{M,noil} \right. \\ & \left. - \gamma M_{t-1}^{SH,non-com} \ln P_{t-1}^{M,non-com} - \delta [1 - M_{t-1}^{SH,oil} - M_{t-1}^{SH,noil} - M_{t-1}^{SH,non-com}] \ln ULC_{t-1} \right) + \xi GAP_t + \varepsilon_t \end{aligned} \quad (1)$$

where P represents the domestic price level measured by the private consumption expenditure deflator, $P^{M,oil}$ is the world-market oil price measured in local currency, $P^{M,noil}$ is the non-oil commodity import price in local currency, $P^{M,non-com}$ is the price of non-commodity imports in local currency, ULC are domestic unit labour costs and GAP is the domestic output gap.¹¹ $M^{SH,oil}$, $M^{SH,noil}$ and $M^{SH,non-com}$ are the shares of oil supply, non-energy commodity imports and non-commodity imports in total domestic demand, respectively.¹² $A(L)$, $B(L)$, $C(L)$, $D(L)$ and $E(L)$ are polynomial functions of the lag operator. The lag length is set to one. The equation is estimated on quarterly data for the period 1990q1-2007q4, with a dummy 1991q1 included for Germany to account for the immediate impact of reunification.¹³ All data

-
11. The foreign output gap, a trade-weighted average of foreign output gaps for each country, was also tested in the regression, but the respective coefficient was never significantly different from zero. Besides measurement problems, the insignificance of the foreign output gap may indicate that the inclusion of import prices already controls for foreign price and demand pressure so that it may be necessary to allow also for exchange rate dynamics. For example, foreign currency depreciation should offset foreign price increases associated with monetary expansion abroad (see Tanaka and Young, 2008).
12. To assess the aggregate inflationary pressure from commodity prices it would be preferable to include the total demand for non-energy commodities instead of non-energy commodity imports in the equation. This was not possible, however, given the lack of comparable data.
13. The estimation period 1990q1-2007q4 is chosen as the Chow tests of parameter stability over the period 1960q1-2007q4 suggested a significant structural break in the inflation dynamics in a number of countries around 1990.

come from the *OECD Economic Outlook* database, with the exception of oil supply taken from the IEA *World Energy Statistics and Balances* database.

15. Equation (1) is a special case of the Johansen co-integration procedure that restricts the vector error-correction model to a system in which the co-integrating vector enters only in the equation of interest, which in this case is the equation for consumer price inflation. All other variables, *i.e.* unit labour costs, commodity prices and non-commodity import prices, are considered weakly exogenous (Banerjee *et al.*, 1998). The corresponding price Phillips curves were estimated in two systems of equations using the seemingly unrelated regression method (SUR), which allows for heteroskedasticity and correlation of the residuals across countries. The first system includes the United States, Japan, the euro area, the United Kingdom and Canada, while the second includes Germany, France and Italy, the three euro area countries among the G7 members.

16. Static homogeneity of degree one was tested in the long-run relationship. Static homogeneity means that increasing all price level components in equation (1) by one percent raises domestic consumer prices by one percent in the long run (Hampton, 2001). If static homogeneity holds, monetary policy has no long-run effect on relative prices and the composition of real demand and production in the economy. The hypothesis of static homogeneity:

$$\alpha M_{t-1}^{SH,oil} + \beta M_{t-1}^{SH,noil} + \gamma M_{t-1}^{SH,non-com} + \delta(1 - M_{t-1}^{SH,oil} - M_{t-1}^{SH,noil} - M_{t-1}^{SH,non-com}) = 1 \quad (2)$$

is rejected only for Japan and Canada and has consequently been imposed as a restriction for the other countries.

17. The aggregate demand shares of energy commodities, non-energy commodity imports and non-commodity imports are included in equation (1) to account for the potential change over time in demand penetration. The elasticity of consumer price levels to prices of their individual components depends on the share of the latter in total demand. Not controlling for changes in these shares over time can lead to time-varying parameter estimates. As the aggregate demand shares M are value shares, which are increasing even at constant volume if relative prices increase, their inclusion risk biasing the estimates of α , β and γ downwards. Given this drawback of the demand share measures and as a means to assess the robustness of the results, the equation (1) was estimated with and without the value shares as a control variable.

18. The corresponding estimates of the error-correction term are reported in the Tables 3 and 4. Estimates in Table 3 do not allow for the value shares of the commodity and import components in aggregate demand, while the estimates in Table 4 also include these shares. The estimates of α , β , γ and δ in the regression including M are multiplied by the respective average shares in order to ensure the comparability of results in Tables 3 and 4. The coefficient λ in equation (1) corresponds to the rate of error correction and the half life of deviations from the long-run equilibrium can be measured as $\ln(0.5)/\ln(1+\lambda)$ quarters.

19. The existence of significant long-run co-integration relationships in the ECM was accepted in all cases. The speed of adjustment appears highest in Japan and strong in France, the United Kingdom and Canada, with half-life times of 4-5 quarters, while being lower in Germany and Italy. Estimates for the United States and the euro area are in the range of 6-8 quarters. The difference in the estimated speed of adjustment is small and statistically insignificant, even though prices are generally considered more flexible in the US economy.¹⁴

14. For a survey on price flexibility in the United States and the euro area see Altissimo *et al.* (2006).

Table 3. **Error-correction terms from consumer price Phillips curve estimates for the G7 economies**

Estimates not controlling for changes in import and oil supply shares

	ECM term	Non-commodity imports (-1)	Non-oil commodity imports (-1)	Oil (-1)	Unit labour cost (-1)	adj. R ²	Half life (quarters)
United States	-0.09 (0.00)	-0.13 (0.01)	-0.04 (0.02)	-0.04 (0.02)	-0.79	0.66	7.5
Japan	-0.17 (0.01)	-0.08 (0.18)	-0.01 (0.69)	0.01 (0.55)	-0.20 (0.19)	0.45	3.7
Euro area	-0.11 (0.00)	0.00	-0.04 (0.03)	-0.05 (0.00)	-0.91	0.68	6.1
Germany	-0.06 (0.00)	0.00	-0.07 (0.37)	-0.07 (0.00)	-0.86	0.98	11.1
France	-0.13 (0.00)	-0.15 (0.00)	-0.04 (0.03)	-0.03 (0.03)	-0.78	0.60	5.1
Italy	-0.09 (0.00)	-0.40 (0.00)	-0.08 (0.02)	0.07 (0.00)	-0.59	0.64	7.4
United Kingdom	-0.11 (0.00)	-0.09 (0.16)	-0.16 (0.00)	0.00 (0.90)	-0.75	0.63	5.8
Canada	-0.14 (0.00)	-0.30 (0.00)	-0.03 (0.20)	0.00 (0.95)	-0.91 (0.00)	0.31	4.7

Note: These estimates correspond to the estimated long-run error correction mechanism (ECM) relationships for the period 1990q1-2007q4. P-values of a t-test on the significance of estimated coefficients are provided in brackets.

... illustrate that domestic costs still dominate consumer price levels

20. A consistent feature of the estimates is the dominant influence of unit labour costs across the G7 countries so that in the long run, consumer price levels still remain largely driven by the domestic cost component. The euro area aggregate, Germany and Canada appear at the top of the range, while Japan, Italy and to some extent the United States, France and the United Kingdom exhibit lower elasticities. These estimates suggest that the risk of a wage-price feedback loop might be slightly higher in the euro area, Germany and Canada compared to the other G7 economies.

Table 4. **Error-correction terms from consumer price Phillips curve estimates for the G7 economies**

Estimates controlling for changes in import and oil supply shares

	ECM term	Non-commodity imports (-1)	Non-oil commodity imports (-1)	Oil (-1)	Unit labour cost (-1)	adj. R ²	Half life (quarters)
United States	-0.11 (0.00)	-0.08 (0.04)	-0.05 (0.00)	-0.01 (0.13)	-0.85	0.63	5.9
Japan	-0.16 (0.01)	-0.08 (0.21)	-0.01 (0.58)	0.01 (0.41)	-0.21 (0.07)	0.46	3.9
Euro area	-0.08 (0.00)	0.00	-0.03 (0.26)	-0.05 (0.00)	-0.92	0.63	8.2
Germany	-0.05 (0.00)	0.00	-0.05 (0.65)	-0.05 (0.03)	-0.90	0.98	13.8
France	-0.15 (0.00)	-0.10 (0.00)	-0.05 (0.00)	-0.01 (0.15)	-0.84	0.56	4.2
Italy	-0.08 (0.00)	-0.52 (0.00)	-0.08 (0.05)	0.10 (0.00)	-0.50	0.68	8.5
United Kingdom	-0.11 (0.00)	-0.09 (0.28)	-0.14 (0.00)	0.00 (0.84)	-0.76	0.63	5.9
Canada	-0.12 (0.00)	-0.29 (0.00)	-0.05 (0.06)	0.03 (0.29)	-1.02 (0.00)	0.30	5.5

Note: These estimates correspond to the estimated long-run error correction mechanism (ECM) relationships for the period 1990q1-2007q4. P-values of a t-test on the significance of estimated coefficients are provided in brackets.

21. The import price effects appear to be quite heterogeneous across individual economies. Nevertheless, the estimated coefficients on import prices are of comparable magnitude across the main economic regions, especially when contrasted with the stronger weight of unit labour costs. Prices of non-commodity imports, by far accounting for most of total imports, are found to have a robust long-run effect on consumer price levels in the United States, France, Italy and Canada, while the coefficient estimates are smaller in value and statistically insignificant for Japan, the euro area aggregate, Germany and the United Kingdom.¹⁵

15. For the euro area aggregate and Germany the insignificant coefficient for non-commodity imports has been restricted to zero.

22. The non-oil commodity import prices appear to have a sizeable impact on long-term consumer price levels in the United States, France, Italy and the United Kingdom. Similar estimates are found for the euro area and Canada, but in these cases the results are sensitive to the specifications in Tables 3 and 4.¹⁶ Finally, the long-run parameter estimates for Japan and Germany are insignificant.

23. Oil prices are found to have significant long-run impacts on consumer prices in the euro area and Germany in both Tables 3 and 4. The difference between the euro area and the United States is small in Table 3 and more pronounced in Table 4, though in a direction that contrasts the priors related to the higher oil intensity of the US production and consumption.¹⁷ The estimates for the United States and France are not significant in the regression including value shares (Table 4) and generally insignificant for Japan, the United Kingdom and Canada. The coefficient estimates for Italy are highly significant but have a counterintuitive sign.

24. Besides the long-run impact on consumer prices, commodity and non-commodity imports also affect consumer price inflation in the short run (Table 5). The changes in non-commodity import prices appear to have similar effects on consumer price inflation in the United States, the euro area, the United Kingdom and Canada over a two-quarter horizon, although the point estimates are lower than the share of non-commodity imports in total demand. Estimated effects are somewhat higher for France and Italy, while the significant coefficient estimate for Germany has counterintuitive sign.

Table 5. **Short-term dynamics from consumer price Phillips curve estimates for the G7 economies**

	Constant	PCP (-1)	Non- commodity imports (0)	Non- commodity imports (-1)	Oil (0)	Oil (-1)	Non-oil commodity imports (0)	Non-oil commodity imports (-1)	Unit labour cost (0)	Unit labour cost (-1)	Output gap (0)	Output gap (-1)
United States	0.00 0.00	0.16 0.13	0.09 0.00	-0.06 0.02	0.01 0.00	0.00 0.53	0.01 0.14	0.00 0.37	0.06 0.02	0.01 0.58	0.05 0.22	-0.03 0.45
Japan	0.00 0.00	-0.14 0.23	0.01 0.68	0.01 0.44	0.00 1.00	0.00 0.33	0.00 0.56	-0.01 0.19	-0.13 0.31	0.02 0.69	-0.13 0.26	0.27 0.06
Euro area	0.00 0.00	0.17 0.13	0.03 0.30	0.02 0.35	0.01 0.00	0.00 0.11	0.01 0.11	0.01 0.09	0.08 0.21	-0.12 0.03	-0.09 0.14	0.13 0.07
Germany	0.01 0.00	0.00 0.83	0.00 0.90	-0.08 0.05	0.00 0.38	-0.01 0.21	0.00 0.84	0.00 0.81	0.08 0.17	0.00 0.98	0.08 0.23	0.01 0.92
France	0.00 0.00	0.28 0.01	0.08 0.00	0.02 0.38	0.01 0.00	0.00 0.10	0.02 0.00	0.00 0.86	0.01 0.94	-0.07 0.22	-0.08 0.33	0.11 0.25
Italy	0.00 0.00	0.15 0.13	0.07 0.00	0.00 0.88	0.01 0.01	0.01 0.04	0.01 0.11	0.00 0.81	0.04 0.20	0.01 0.85	0.11 0.16	-0.06 0.47
United Kingdom	0.00 0.18	-0.17 0.11	0.06 0.03	-0.01 0.68	0.00 0.81	-0.01 0.08	0.01 0.16	-0.01 0.38	0.17 0.05	0.10 0.12	-0.25 0.07	0.26 0.08
Canada	0.00 0.09	0.04 0.70	0.03 0.25	0.02 0.48	0.01 0.03	0.01 0.03	0.01 0.45	-0.01 0.52	0.23 0.01	0.13 0.07	-0.04 0.64	0.07 0.49

Note: These estimates correspond to the Phillips curve specification providing the ECM estimates in Table 3. P-values of a t-test on the significance of estimated coefficients are provided in brackets.

16. However, a test for equality of the United States and euro area coefficient estimates would not be rejected.

17. In recent years this difference may have been more than compensated by the fact that the United States has faced a much stronger oil-price increase due to the depreciation of the dollar *vis-à-vis* the euro.

25. Point estimates for the short-term impact of non-oil commodity prices on domestic inflation are similar across countries: small, but significant only for the euro area and France. The short-run inflationary impact of oil price dynamics is similar for the United States, the euro area, France, Italy and Canada, insignificant for Japan and Germany and negative in the United Kingdom. The point estimates suggest that a doubling of oil prices would raise annualised consumer price inflation by about four percent in the United States and the euro area.

26. The short-run impact of unit labour costs on inflation is positive and robust in the United States, the United Kingdom and Canada, but insignificant for Japan, Germany, France and Italy. In the euro area the effect over two quarters is also close to zero.

27. The coefficients for the output gap in Table 5 support previous evidence (IMF, 2006; Pain *et al.*, 2006) that the link between domestic output gaps and inflation, over and above their impact on unit labour costs, has weakened over the past decades. The joint impact at lags zero and one is not significant, except for the positive effect in the euro area and Japan. This finding suggests that higher capacity utilisation does not affect the profit margins of producers and implies that economic slack mitigates inflationary pressure only to the extent that it dampens labour costs and that downward pressure on prices will occur only when labour costs decline in response to economic slack. With the exception of France, the coefficient estimates for lagged consumer price inflation do not suggest significant intrinsic inflation persistence in the G7 economies.

The impact of terms-of-trade shocks on unit labour costs and nominal wages has declined

28. The price Phillips curve conditions the impact of commodity and non-commodity import prices on additional determinants of consumer price inflation, such as domestic labour costs. Such a specification may encounter a problem of collinearity or endogeneity among regressors. Higher energy prices constitute a negative supply shock, which raises production costs and reduces labour productivity. The coefficient estimates for commodity prices in a regression that controls for unit labour costs indicate a partial elasticity if commodity prices affect wage and labour cost dynamics.¹⁸

29. Much of the inflation risk emanating from commodity price increases until mid-2008 has been associated with second-round effects via wages and the risk of a wage-price spiral, which is often considered to be more likely in Europe. Europe may indeed have a lower ability to absorb adverse terms-of-trade shocks because of the persistence of automatic wage indexation in a few countries and collective bargaining institutions that may promote real wage resistance whereby workers resist the loss of purchasing power that might be associated with an adverse terms-of-trade shock.

30. Empirical estimates do not however provide compelling evidence for significant real wage persistence in the G7 economies in recent years. An equation assessing the degree of real wage was estimated to investigate the strength of second-round effects of commodity and non-commodity import prices on wages and the potential endogeneity of unit labour costs to the terms of trade. The following simple autoregressive-distributed lag equation has been estimated for the G7 economies in a rolling ten-year window:

18. Furthermore, the estimated coefficients are not strictly structural in the sense of being independent of macroeconomic policy. A long-run elasticity of less than one for import prices may for example be consistent with credible inflation targeting, where relative price adjustment may occur via declining prices of domestically produced goods to offset rising import prices. This would weaken the correlation between import and total consumer prices in the data when domestic goods prices are not properly controlled for. In addition, the role of inflation expectations may not be properly incorporated, although lagged inflation is included as a proxy.

$$\begin{aligned} \Delta \ln ULC_t = & c + \sum_{i=1}^m \alpha_i \Delta \ln ULC_{t-i} + \sum_{i=0}^n \beta_i \Delta \ln WEDGE_{t-i} \\ & + \lambda (\Delta \ln ULC_{t-1} - \gamma \Delta \ln WEDGE_{t-1}) + \sum_{i=0}^q \delta_i UNEMP GAP_{t-i} + \varepsilon_t \end{aligned} \quad (3)$$

where *ULC* are total economy unit labour cost, *WEDGE* is the ratio of the private consumption deflator to the GDP deflator and *UNEMP GAP* is the unemployment gap, which is defined as the difference between the actual unemployment rate and the NAIRU. The estimation uses the lag lengths $m=1$, $n=3$ and $q=2$. The *WEDGE* term is inserted to capture commodity price and terms-of-trade shocks as the consumption deflator is expected to increase by a greater amount than the GDP deflator in response to an increase in commodity and import prices. An increasing wedge drives the real consumption wage below the real production wage. In case of real wage resistance the initial fall in the real consumption wage will provoke a compensating increase in nominal wage claims, which raises wage costs in the economy. The magnitude of real wage resistance is captured by the long-run elasticity γ .

31. The results from the rolling estimation of equation (3) in Figure 4 suggest that real wage resistance as captured by the parameter γ has declined after the oil price shocks of the 1970s, with some renewed increase in the United States and Canada following the strong dollar depreciation in the second part of the 1980s. Robustness checks that use the growth of compensations per employee instead of unit labour cost growth as the dependent variable (Figure 5) confirm the absence of real wage resistance to terms-of-trade shocks in recent years.¹⁹

32. The lack of real wage resistance to terms-of-trade shocks since the mid-1990s may be associated with labour market reform and the improved credibility of monetary policy, but it may also reflect the absence of large and persistent adverse shocks until more recent years. The increase in commodity prices in the first half of 2008 were of a magnitude not experienced since the two major previous oil price spikes.

4. Vector-autoregression estimates

33. Although the absence of significant second-round effects via wage costs supports the single-equation Phillips curve estimates, allowing for feedback among the regressors in the empirical framework is a worthwhile robustness check. In this sense VAR estimates are presented here as a complementary approach to analyse the feedback between drivers of inflation. The VAR approach requires only weak exogeneity of the regressors and allows the determinants of inflation to depend themselves on lagged values of domestic inflation.²⁰ The approach imposes little theoretical restrictions and primarily aims at fitting the data. Its structure captures the direct (first-round) and indirect (second-round) effects of the shocks and provides impulse responses for the aggregate impact.

19. Using a more complete wage equation along the lines of Blanchard and Katz (1999) and De Serres *et al.* (2002), for which results are not reproduced here, also corroborates the lack of real wage resistance to losses in purchasing power.

20. Besides the possible feedback of inflation on unit labour costs, inflation may also affect commodity and non-commodity import prices as the latter are measured in domestic currency terms and are thus affected by exchange rate dynamics. Cyclical conditions in large open economies may furthermore affect world commodity prices.

Figure 4. **The evolution of real labour cost resistance over time in G7 economies**

Long-run elasticity of labour cost growth to increases in relative import prices

Note: Long-run coefficient for the wedge between the private consumption and the GDP deflator. The error bands show the 95% confidence intervals. Years on the horizontal axis correspond to the start of the 10-year estimation window.

Figure 5. **The evolution of real wage resistance over time in G7 economies**

Long-run elasticity of nominal wage growth to increases in relative import prices

Note: Long-run coefficient for the wedge between the private consumption and the GDP deflator. The error bands show the 95% confidence intervals. Years on the horizontal axis correspond to the start of the 10-year estimation window.

34. VAR models for the G7 countries and the aggregate euro area have been estimated including the same variables²¹ as in the consumer price Phillips curve (1):

$$\begin{bmatrix} \Delta \ln P_t \\ \Delta \ln ULC_t \\ \Delta \ln P_t^{M, non-com} \\ \Delta \ln P_t^{M, noil} \\ \Delta \ln P_t^{M, oil} \end{bmatrix} = \sum_{i=1}^n A_i \begin{bmatrix} \Delta \ln P_{t-i} \\ \Delta \ln UCL_{t-i} \\ \Delta \ln P_{t-i}^{M, non-com} \\ \Delta \ln P_{t-i}^{M, noil} \\ \Delta \ln P_{t-i}^{M, oil} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^p \\ \varepsilon_t^{ulc} \\ \varepsilon_t^{non-com} \\ \varepsilon_t^{noil} \\ \varepsilon_t^{oil} \end{bmatrix} \quad (4)$$

The VARs are estimated on quarterly data over the period 1990q1-2007q4 (with a dummy 1991q1 for Germany). Based on the AIC criterion the lag length n is one for Japan, France and Italy, two for the euro area, Germany and Canada, three for the United States and six for the United Kingdom.

Short-term inflation responses vary across shocks, while being similar across G7 countries

35. On this basis, inflation responses to a unit shock are found to be lowest for oil price shocks, larger for non-energy commodity prices and strongest for non-commodity import prices (Figures 6-8).²² The differences across shocks correspond to the higher share of non-commodity imports and the relatively moderate share of energy commodities in total domestic demand.²³ The point estimates suggest initial inflation responses to commodity and non-commodity import price shocks in the United States and the United Kingdom to be moderately stronger than in the euro area and very limited in Japan, while the short-term dynamics from the Phillips curve estimates in Table 5 suggested a similar pattern for the United States, the euro area and France, and a stronger response in Italy.²⁴ The negative response for Germany is counterintuitive, but it coincides with the short-run dynamics in Table 5 and which may result from not controlling for monetary policy and output dynamics in post-unification years. The error bands for the impulse responses are sufficiently wide to not reject the hypotheses of zero responses most of the time.

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21. More complex specifications, such as VAR models including output and the interest rate, could have been used instead to illustrate monetary policy and output responses. But given the focus on prices and inflation the more parsimonious five-variable structure has been preferred. The results from equation (4) are insensitive to the ordering of the variables in the VAR.
22. Impulse responses have also been analysed for shocks to unit labour costs to test the plausibility of the estimated models. The impulse responses for shocks to unit labour costs are found very plausible, but they are not reproduced here given the focus of the analysis on commodity and import price shocks.
23. The lower share of commodities in demand has to be contrasted with the fact that commodity price shocks tend to be larger than the changes in non-commodity import prices. To account for this difference shocks may be expressed in standard errors rather than as unit shocks. The latter facilitates comparison of the responses across scenarios and across countries, however.
24. The results are in line with the impulse responses to oil price shocks in Blanchard and Galí (2007). The latter find a stronger inflation response to oil price shocks in the United States compared to European countries and Japan and a moderation of the inflationary impact in a post-1984 compared to a pre-1984 sample. As Blanchard and Galí (2007) consider a 10% shock to oil prices and annualise quarterly inflation, the numerical size of their inflation responses is correspondingly larger than the size of the impulse responses in Figure 6.

Figure 6. Inflation response to oil price shocks

Consumer price inflation after a one percent oil price shock, in per cent

Note: Impulse responses are for percentage changes in the private consumption deflator. The estimation period is 1990q1-2007q4. All data are from the OECD *Economic Outlook* database. Dotted red lines give the 95% confidence interval. The displayed impulse responses are for non-annualised quarter-on-quarter inflation.

Figure 7. Inflation response to non-energy commodity price shocks

Consumer price inflation after a one percent non-oil commodity price shock, in per cent

Note: Impulse responses are for percentage changes in the private consumption deflator. The estimation period is 1990q1-2007q4. All data are from the OECD *Economic Outlook* database. Dotted red lines give the 95% confidence interval. The displayed impulse responses are for non-annualised quarter-on-quarter inflation.

Figure 8. Inflation response to non-commodity import price shocks

Consumer price inflation after a one percent non-commodity import price shock, in per cent

Note: Impulse responses are for percentage changes in the private consumption deflator. The estimation period is 1990q1-2007q4. All data are from the OECD *Economic Outlook* database. Dotted red lines give the 95% confidence interval. The displayed impulse responses are for non-annualised quarter-on-quarter inflation.

5. The role of policy objectives

36. The previous discussion points to a number of differences in the short-run and long-run impact of commodity and import prices on inflation in G7 economies. The calculation of the mechanical direct impact illustrates that the US economy has been exposed to larger price shocks than the euro area due to the dollar depreciation and the somewhat larger share of commodities in US aggregate demand. By contrast, price Phillips curves point to similar short-run but somewhat lower long-run impact of oil on consumer prices for comparable shocks in the United States. Consequently, the differences in the inflation dynamics alone do not seem to justify major differences in policy stance between the two regions. The different sizes of shock may justify a stronger monetary policy reaction in the United States, but as the supply effect of a commodity price shock generates a trade-off between stabilising inflation and stabilising the output gap, the direction and strength of the interest rate reaction also depends on the policy objectives of the monetary authorities.

37. To illustrate the relevant issues, counterfactual simulations have been run using a small dynamic macroeconomic model which attempts to disentangle the importance of policy objectives and economic structure on the monetary response to commodity price shocks. The model is that described in Duval and Vogel (2008) and summarised in the Annex of this paper. It comprises a small open economy with an open economy demand equation, a forward-looking price Phillips curve, intertemporal consumption smoothing and a flexible exchange rate. Households consume manufactured goods and commodities, and output is produced with commodities and labour. Output and inflation are assumed to depend on domestic and foreign demand and production costs, while commodity price shocks are allowed to hit both the small economy and the rest of the world.

38. As an illustration of the importance of economic structure and policy objectives on a simple optimised policy rule, two model variants are compared for two different objective functions. The first uses estimated US values for the share of energy in consumption (6.9%) and production (2.0%) and for the average speed of price adjustment (two quarters), while the second uses typical euro area values for the share of energy in consumption (6.0%) and production (1.6%) along with a lower average speed of price adjustment (five quarters).²⁵ Central bank preferences are described by an objective function with respect to inflation and output $\text{var}(\pi^{CPI}) + \gamma \text{var}(\hat{y})$. The policy maker is assumed to focus mainly on headline inflation ($\gamma=0.1$) in the first scenario and puts equal weight on the variance of headline inflation and the variance of the output gap ($\gamma=1$) in the second scenario.

39. The impact of the basic structural assumptions and the policy objectives on the optimal policy response is analysed assuming a simple interest rate rule:

$$i_t = 1.5\pi_t^{CPI} + \alpha(\pi_t^{core} - \pi_t^{CPI}) \quad (5)$$

40. The central bank is assumed to react to headline inflation and the gap between core and headline, where core is lower than headline inflation in the case of rising commodity prices.²⁶ Table 6 presents the

25. The energy shares are taken from De Fiore *et al.* (2006) and the estimates of price stickiness from Altissimo *et al.* (2006). Note that for simplicity the model excludes feedback from domestic dynamics on world market commodity prices and global output and inflation.

26. The omission of the output gap in rule (5) can be justified by the emphasis on inflation targeting across the Atlantic and the fact that the uncertainty around real time measures of the output gap may be especially pronounced in times of major commodity price shocks. Nevertheless, Taylor rules including the output gap could be analysed along the same lines. One should be aware that the rules are optimised just for a

optimal value for α under the two alternative calibrations and objective weights and Figure 9 the resulting dynamics for a 50% increase in the world market price of energy commodities which decays at a speed of $AR(1)=0.95$.²⁷

Table 6. **Optimised simple rules for alternative model calibrations and loss functions**

	United States	Euro area
$\gamma=0.1$	-0.17	0.19
$\gamma=1.0$	0.41	1.46

41. The corresponding results show that for both loss functions, the optimal rules would place lower weight on the gap between core and headline inflation in the US economy, *i.e.* be more restrictive than in the euro area.²⁸ The reason is the higher share of oil in US aggregate demand which translates into a higher initial impact of the energy price shock in the US economy. The optimised rules indicate that the empirically-observed difference between the oil share and price stickiness parameters cannot alone account for a more accommodative stance of US monetary policy, but that a higher weight on output in the US loss function is sufficient to rationalise a more accommodative rule. However, even though α is larger in the euro area compared to the US scenario, the euro area rule may lead to a stronger actual increase in interest rates. The stronger increase in rates is due to the fact that somewhat lower speeds of adjustment assumed for the euro area reduces the slope of the Phillips curve. Core prices are less sensitive to the monetary contraction and headline inflation is therefore higher, calling for a stronger interest rate response.

42. Since the estimates in Section 3 indicated the absence of significant real wage resistance to terms-of-trade shocks in both the euro area and the United States in recent years, real wage rigidity was set to zero in the above simulations. To illustrate the possible implications of a potential resurgence of real wage resistance in reaction to strongly increasing commodity prices, the simulations were repeated keeping real wage rigidity at zero in the United States, while setting the parameter to 0.5 in the euro area. The corresponding optimal values of α are shown in Table 7. Compared to the previous case, these show a reduced weight on core relative to headline inflation in the euro area if output has little weight in the loss function, while under a loss function giving equal weight to output and inflation, α is moderately higher than in Table 6. Under both loss functions the actual degree of tightening, *i.e.* the initial increase in the nominal interest rate, in the euro is stronger than in the United States due to the flatter Phillips curve (Figure 10).

43. A broad conclusion is that differences in policy objectives and structural characteristics in wage price setting behaviour, such as the degrees of price stickiness and real wage rigidity might have potentially important effects on observed policy stances, although the empirical support for such structural differences is comparatively weak.

commodity price shock and the trade-offs that the latter creates. Rules that are optimal under an extended set of exogenous shocks may exhibit different values of α .

27. The optimal value of α is determined with the optimisation algorithm in Dynare 4. The values on the y-axis denote deviations from the steady state. Note that the model assumes rational expectations with perfect foresight once the shock has occurred, and that models with learning may require a more restrictive policy reaction to keep inflation expectations anchored.

28. For $\gamma=1$ the optimal value of α is even negative, indication that the monetary response to headline should be more aggressive than the 1.5 in the classical Taylor rule. For $\gamma=1$ in the euro area α is close to 1.5, which means that monetary policy should almost exclusively react to core instead of headline inflation.

Table 7. Optimised simple rules with and without real wage rigidity

	United States		Euro area	
	$\rho=0.0$		$\rho=0.0$	$\rho=0.5$
$\gamma=0.1$	-0.17		0.19	0.14
$\gamma=1.0$	0.41		1.46	1.48

Figure 9. Impulse responses for alternative calibrations and loss functions

Figure 10. Impulse responses with real wage rigidity in the euro area model

TECHNICAL ANNEX

Calculations of mechanical impact

44. This annex describes the general methods and more detailed empirical estimates underlying the analysis of inflation responses to price shocks discussed in the main paper. It describes the calculation of the direct impact of higher commodity prices on domestic inflation, presents background information on the price Phillips curve and wage equation estimates and presents the structural model used for counterfactual experiments.

The mechanical direct impact of commodity prices on domestic inflation

45. Consistent with previous OECD work (see Pain *et al.*, 2006) the analysis of the direct impact of commodity import prices was done within a simple accounting framework, where the impact of energy, food and other commodity prices has been considered separately. The direct inflationary pressure from commodity prices is determined multiplying commodity price inflation (relative to domestic inflation) by the share of the corresponding commodity category in total demand.

46. The shares of the various commodities in total demand were based on the share of net imports plus domestic value added using the OECD Structural Analysis (STAN) Database. The prices of energy commodities were proxied by the international (Brent) price of crude oil, and the price of food by the Hamburg Institute of International Economics (HWWA) food index. Non-food non-energy commodity import prices were computed as the import-weighted average of three HWWA international prices (tropical beverages, agricultural raw materials and minerals, ores and metals). All commodity import prices were expressed in local currency terms, so that the direct measure of inflationary pressures combines the direct effect on import prices at constant exchange rates and the impact of exchange rate fluctuations.

The mechanical direct impact of exchange rate fluctuations on domestic inflation

47. The estimates in Table 2 of Section 3 combine the direct impact of world-market commodity price changes and exchange rate fluctuations on commodity prices in domestic currency and on domestic inflation. Table 3 in the main text adds estimates for the effect of exchange rate movements on non-commodity import prices in domestic currency and on domestic inflation. The strength of the impact of nominal exchange rate appreciation or depreciation on domestic currency prices is called the *exchange rate pass-through*, and it may differ across time horizons depending on price setting behaviour.

48. Empirical pass-through estimates are commonly obtained from a single-equation approach regressing the percentage change of import prices in domestic currency P^m on the percentage change of the nominal effective exchange rate E^e and a the percentage change of foreign production costs P^f :²⁹

29. Sekine (2006) distinguishes between *first-stage* pass-through as the impact of foreign price and exchange rate movements on import prices in domestic currency and *second-stage* pass-through from import prices in domestic currency to domestic consumer prices. Equation (A1) only captures the first-stage pass-

$$\Delta \ln P_t^m = \alpha + \sum_{j=1}^n \beta_j \Delta \ln P_{t-j}^m + \sum_{j=0}^n \gamma_j \Delta \ln E_{t-j}^e + \sum_{j=0}^n \delta_j \Delta \ln P_{t-j}^f + \varepsilon_t \quad (A1)$$

The inclusion of lagged values of the dependent and explanatory variables allows for a delayed adjustment of import prices to changes in the effective exchange rate and in foreign production cost. The discussion of pass-through typically focuses on the cumulative long-run effect (Ihrig *et al.*, 2006):

$$\gamma = \frac{\sum_{j=0}^n \gamma_j}{1 - \sum_{j=1}^n \beta_j} \quad (A2)$$

49. The exchange rate pass-through is complete if $\gamma = -1$ in (A2) and incomplete in the case of $\gamma > -1$. The strength of the pass-through depends on the production and market structure in the sector of traded goods and can vary across countries and branches (Goldberg and Hellerstein, 2008; Mishkin, 2008):³⁰

- Incomplete pass-through may result from mark-ups and marginal production costs varying with exchange rate appreciation or depreciation:
- Mark-up fluctuations occur when the price elasticity of demand depends on the sales price and of competitors' sales prices. If the industry is competitive, exporting firms may absorb a proportion of the exchange rate change so as not to lose market share.
- Situations where marginal production costs depend on the exchange rate are: 1) the presence of non-traded local costs in the destination market; 2) the use of imported inputs in the production of export goods; and 3) decreasing returns to scale, where marginal costs depend on the quantity of goods produced.
- Nominal price stickiness due to menu costs or contract duration leads prices to respond less to current changes in the economic environment. It may also reduce pass-through if changes in the exchange rate are expected to be short-lived, so that exporters chose not to adjust sales prices in the country of destination.

Recent empirical research summarized in Goldberg and Hellerstein (2008) finds a large role for non-traded local costs in the destination country and for imported inputs in explaining incomplete pass-through of exchange rate changes to import prices. Nominal price stickiness, on the other hand, is primarily found to delay the transmission of exchange rate fluctuations into import prices. In addition, estimates of imperfect pass-through may also be due to cross-country differences in price level definitions and to the imprecise measurement of international goods prices and production costs.³¹

50. Equation (A1) has been estimated for a system of 30 OECD countries based on quarterly data for the period 1993q1-2007q4 applying the seemingly unrelated regression (SUR) method. The data all come

through, while Table 2 in Section 3 adds mechanical calculations for the second stage based on the share of non-commodity imports in total domestic demand.

30. Campa and Goldberg (2005a) as well as Marazzi *et al.* (2005) provide formal expositions of possible links between market structure, price setting behaviour and exchange rate pass-through.
31. Indeed, comparing the prices of goods with common barcode classification Broda and Weinstein (2008) find higher pass-through estimates for US-Canadian trade than estimates with aggregate trade price indices would suggest. They conclude the extent of cross-border price differentiation between Canada and the United States to be similar to the price differentiation in Canadian and US domestic markets.

from the OECD *Economic Outlook* database. Both total import price inflation and non-commodity import price inflation have been tested as dependent variables. The effective exchange rate is a trade-weighted exchange rate index for each country. Trade-weighted foreign unit labour costs are included to proxy foreign production costs.³² The baseline specification includes each variable with four lags, *i.e.* $n=4$.

51. Table A1 presents the long-run exchange rate pass-through estimates for the G7 economies.³³ The left part of the table presents the estimates for total import prices, while the right part excludes commodity import prices.³⁴ For both import price aggregates, the first column reports the pass-through γ from (A2) including all estimated coefficients up to $n=4$, while values in the second (10%) and third (5%) columns include only coefficients significant at the 10% and 5% levels. Column 4 of each block reports the pass-through estimates from reduced models. The latter are obtained by iteratively eliminating coefficients that are not significant at the 10% level until all retained coefficients are significant at 10%. The final column to the right for comparison reports the estimates for core import price pass-through from Ihrig *et al.* (2006). The exchange rate pass-through to total import and on non-commodity import prices displayed in Table 2 and Figure 2 in Section 3 refer to the estimates including all coefficients that are significant at the 5% level in the baseline $n=4$ specification.

Table A1. **Estimates of exchange-rate pass-through to import prices in G7 economies**

Country	Import prices				Non-commodity import prices				
	All	10%	5%	Reduced	All	10%	5%	Reduced	Ihrig <i>et al.</i> (2006)
Canada	-0.77	-0.59	-0.59	-0.74	-0.78	-0.78	-0.64	-0.62	-0.89
Germany	-0.48	-0.50	-0.50	-0.70	-0.43	-0.37	-0.37	-0.53	-0.29
France	-0.32	-0.15	-0.31	-0.59	-0.07	-0.10	-0.10	-0.09	-0.16
United Kingdom	-0.67	-0.70	-0.70	-0.61	-0.63	-0.78	-0.56	-0.42	-0.59
Italy	-0.82	-0.80	-0.80	-0.86	-0.73	-0.64	-0.64	-0.89	-0.47
Japan	-0.67	-0.60	-0.73	-0.64	-0.70	-0.54	-0.54	-0.49	-0.61
United States	-0.43	-0.29	-0.29	-0.41	-0.29	-0.26	-0.21	-0.21	-0.32

Note: Columns 10% (5%) take into account only coefficients significant at 10% (5%) levels. The estimates of Ihrig *et al.* (2006) use trade-weighted CPI data to proxy foreign production costs and cover the period 1990q1-2004q4.

52. The estimates in Table A1 are broadly in line with previous empirical work providing evidence for limited exchange rate pass-through and for considerable heterogeneity across countries (*e.g.* Campa and Goldberg, 2005; Campa and Gonzalez-Minguez, 2005; Dees *et al.*, 2008; Ihrig *et al.*, 2006; Marazzi *et al.*, 2005; Sekine, 2006). Generally, pass-through is found to be incomplete for all G7 economies. Consistent with other studies, pass-through estimates for France and for the United States are particularly low. Due to the higher pass-through on commodity prices, non-commodity import prices tend to be less responsive to

32. Existing empirical studies use different foreign production cost measures. Ihrig *et al.* (2006) and Marazzi *et al.* (2005) employ trade-weighted foreign CPI data, and Sekine (2006) uses foreign core CPI as a proxy for costs. In making the current estimates, models were tested across a variety of cost measures, including: trade-weighted measures of foreign CPIs, foreign GDP prices, foreign output gaps, foreign wage shares, and foreign unit labour costs. Finally, the latter has been preferred to the alternative measures based on its superior empirical fit.

33. Pass-through estimates for other OECD economies are available upon request.

34. Standard tests on the residuals indicate that the null hypotheses of normality and lack of serial correlation of the error terms is supported at conventional significance levels (10%) for the results in Table A1.

exchange rate dynamics than total import price levels.³⁵ Except for overall import prices in Italy, which display a p-value of 0.17, the hypothesis of complete pass-through, *i.e.* $\gamma=-1$, is rejected at the 5% level across the G7 economies.

A New Keynesian small open economy model

53. The small open economy DSGE model in Duval and Vogel (2008) can be used to illustrate the inflation and output responses to oil price shocks under alternative monetary policy rules and differentials in economic structure. The linearised version of the model consists of ten equations:

$$\hat{y}_t = E_t \hat{y}_{t+1} - \omega(i_t - E_t \hat{\pi}_{H,t+1} + \ln \beta) + \frac{\gamma}{1-\gamma}(\omega - \varepsilon)(E_t \hat{\pi}_{O,t+1}^* - E_t \hat{\pi}_{C,t+1}^*) + (\omega - 1)E_t \Delta \hat{c}_{t+1}^* \quad (\text{A3})$$

$$\tilde{y}_t = -\frac{(1-\theta)\gamma\omega + (1+\varphi)\theta\omega - \gamma\varepsilon(1+\varphi\theta)}{1-\gamma}(\hat{p}_{O,t}^* - \hat{p}_{C,t}^*) + \frac{(1+\varphi\theta) - (1-\theta)\omega}{1+(\theta+\omega)\varphi}\hat{c}_t^* \quad (\text{A4})$$

$$\hat{x}_t \equiv \hat{y}_t - \tilde{y}_t \quad (\text{A5})$$

$$\begin{aligned} \hat{\pi}_{H,t} = & \beta E_t \hat{\pi}_{H,t+1} + \lambda \left[\theta + \frac{\gamma}{1-\gamma} \left(1 - \frac{\theta + (1-\theta)(\gamma + [1-\gamma]\alpha)}{\omega} \varepsilon \right) \right] (\hat{p}_{O,t}^* - \hat{p}_{C,t}^*) \\ & + \lambda(1-\theta)(\hat{w}_t - \hat{p}_{C,t}) + \lambda \frac{\theta + (1-\theta)(\gamma + [1-\gamma]\alpha)}{\omega} (\hat{y}_t - \hat{c}_t^*) \end{aligned} \quad (\text{A6})$$

$$\hat{p}_{C,t} = \hat{p}_{H,t} + (\gamma + [1-\gamma]\alpha)(\hat{p}_{F,t} - \hat{p}_{H,t}) + \frac{\gamma}{1-\gamma}(\hat{p}_{O,t}^* - \hat{p}_{C,t}^*) \quad (\text{A7})$$

$$\hat{p}_{M,t} = \frac{1}{1-\gamma}(\hat{p}_{C,t} - \hat{p}_{O,t}) \quad (\text{A8})$$

$$\begin{aligned} \hat{w}_t - \hat{p}_{C,t} = & \frac{\rho_w}{1+(1-\rho_w)\varphi\theta}(\hat{w}_{t-1} - \hat{p}_{C,t-1}) + \frac{1-\rho_w}{1+(1-\rho_w)\varphi\theta} \left[\varphi\theta - \frac{(1-\alpha)(1+\varphi\theta)\gamma\varepsilon}{\omega} \right] (\hat{p}_{O,t}^* - \hat{p}_{C,t}^*) \\ & + \frac{1-\rho_w}{1+(1-\rho_w)\varphi\theta} \left[\varphi + \frac{(1-\alpha)(1-\gamma)(1+\varphi\theta)}{\omega} \right] \hat{y}_t + \frac{1-\rho_w}{1+(1-\rho_w)\varphi\theta} \left[1 - \frac{(1-\alpha)(1-\gamma)(1+\varphi\theta)}{\omega} \right] \hat{c}_t^* \end{aligned} \quad (\text{A9})$$

$$\hat{c}_t^* = -\frac{(1-\theta)\gamma + (1+\varphi)\theta + (1-\theta)\gamma\varepsilon\varphi}{(1-\gamma)(1-\theta)(1+\varphi)}(\hat{p}_{O,t}^* - \hat{p}_{C,t}^*) \quad (\text{A10})$$

35. High pass-through is even already assumed during the construction of series for non-commodity import prices. The high estimate for pass-through to non-commodity import prices in Canada is at least partly the result of the assumption of high exchange rate pass-through also to non-commodity import prices in the Canadian case.

$$\hat{p}_{F,t}^* = \frac{(1-\gamma)(1+\varphi)\theta + (1-\theta)\gamma\epsilon\varphi}{(1-\gamma)(1+\varphi\theta)} (\hat{p}_{O,t}^* - \hat{p}_{C,t}^*) + \hat{p}_{C,t}^* + \frac{(1-\theta)(1+\varphi)}{1+\varphi\theta} \hat{c}_t^* \quad (\text{A11})$$

$$\hat{p}_{C,t}^* = (1-\gamma)\hat{p}_{F,t}^* + \hat{p}_{O,t}^* \quad (\text{A12})$$

$$\hat{p}_{O,t}^* - \hat{p}_{C,t}^* = \rho(\hat{p}_{O,t-1}^* - \hat{p}_{C,t-1}^*) + \mu_t \quad (\text{A13})$$

where the variables (in logs) and the parameters are defined as follows:

$\hat{y}$	Output
$\hat{\bar{y}}$	Potential output
$\hat{x}$	Output gap
$\hat{\pi}_H$	GDP price inflation
$\hat{p}_C$	Consumer price index (CPI)
$\hat{p}_M$	Core CPI
$\hat{w}$	Nominal wage
$\hat{c}^*$	Foreign consumption
$\hat{p}_F^*$	Foreign core CPI
$\hat{p}_C^*$	Foreign CPI
i	Nominal interest rate
$\hat{p}_O^*$	World market oil price
α	Trade openness
β	Discount rate
ϵ	Substitution elasticity in consumption between oil and manufactured products
φ	Inverse of labour supply elasticity
γ	Steady-state share of oil in consumption
θ	Steady-state share of oil in production
ρ_w	Real wage inertia
ξ	Probability of price non-adjustment
ρ	Shock persistence
$\lambda \equiv (1-\beta\xi)(1-\xi)\xi^{-1}$	
$\omega \equiv 1+(1-\alpha)^2\gamma(\epsilon-1)$	

54. The equations (A3) and (A4) respectively determine actual and potential output in the economy, both expressed as percentage deviations from the steady state. The output gap (A5) is the difference between actual and potential production is defined in equation. The New Keynesian Phillips curve (A6), which derives from the assumption of staggered price setting, characterises the dynamics of GDP prices, while the equations (A7) and (A8) define domestic CPI and core prices, respectively. Real wages in the domestic economy are determined by equation (A9).

55. Regarding the rest of the world, equation (A10) gives foreign consumption, while core and consumer prices follow the equations (A11) and (A12). For simplicity abstracting from nominal and real rigidities in the rest of the world, foreign actual and potential output levels coincide. This simplification allows separating the effects of domestic policy and structural settings on adjustment dynamics in the small economy. Finally, the monetary policy rule (5) from the main text closes the model. The oil price path is specified Table A2. Estimates of exchange-rate pass-through to import prices in G7 economies by equation (A13).

Table A2. **Parameter assumptions**

Parameter	Symbol	Value
Steady-state trade openness in manufactured goods	α	0.15
Discount rate	β	0.99
Substitution elasticity between oil and manufactured goods	ε	0.09
Elasticity of labour supply	φ	0.40
Consumption share of oil in the steady state	γ	0.069; 0.060
Input share of oil in steady state	θ	0.020; 0.016
Real wage inertia	ρ_w	0.00 (0.5)
Price inertia	ξ	0.50; 0.80
Oil price shock persistence	ρ	0.95

56. The model calibration in Table A2 relies on standard parameter choices taken from the literature. The US and euro area shares of energy in consumption (6.9% and 6.0%) and production (2.0% and 1.6%) are averages shares of fuel, car fuel and gas in consumption and production and taken from De Fiore *et al.* (2006). The elasticity of substitution between oil and manufactured consumer goods is set to 0.09 and the elasticity of labour supply to 0.40. The value of 0.80 for the probability of price adjustment replicates the average frequency of price adjustment in the euro area (five quarters) reported in Altissimo *et al.* (2006). In line with the estimates in Section 3, real wage inertia is set to zero in the benchmark scenario. The oil price shock has an autoregressive component of 0.99. The impulse responses in the text are for an initial doubling of the world real oil price. For a more detailed discussion of those choices and the related empirical evidence see Duval and Vogel (2008).

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