Oil and the Euro Area Economy

Gert Peersman and Ine Van Robays

Universiteit Gent; Universiteit Gent

Paper prepared for the 49th Panel Meeting of ***Economic Policy*** in Prague, April 2009

We examine the macroeconomic effects of different types of oil shocks and the oil transmission mechanism in the Euro area. A comparison is made with the US and across individual member countries. First, we find that the underlying source of the oil price shift is crucial to determine the repercussions on the economy and the appropriate monetary policy reaction. Second, the transmission mechanism is considerably different compared to the US. In particular, inflationary effects in the US are mainly driven by a strong direct pass-through of rising energy prices and indirect effects of higher production costs. In contrast, Euro area inflation reacts sluggishly and is much more driven by second-round effects of increasing wages. Third, there are also substantial asymmetries across member countries. These differences are due to different labour market dynamics which are further aggravated by a common monetary policy stance which does not fit all.

1. INTRODUCTION

There has been considerable interest among policymakers and academics concerning the interaction between oil and macroeconomic performance since the 1970s. This period was characterised by serious disruptions in the oil market and macroeconomic

We are grateful to Philippe Martin (the editor), three anonymous referees, Christiane Baumeister, Michel Beine, Selien De Schryder, Reuben Jacob, Stefan Gerlach, Domenico Giannone, Freddy Heylen, Lutz Kilian, Vivien Lewis, Frank Smets, Arnoud Stevens and Rudi Vander Vennet as well as conference participants at CESifo Munich and seminar participants at the European Central Bank and National Bank of Belgium for useful comments and suggestions. We acknowledge financial support from the Interuniversity Attraction Poles Programme – Belgian Science Policy [Contract No. P6/07] and the Belgian National Science Foundation. All remaining errors are ours.

stagflation, and the possibility of its recurrence has been a major concern in more recent times. At the time of the introduction of the euro in 1999, the price of crude oil hovered around $16 a barrel. By the middle of 2008, oil prices reached a peak of $147 a barrel. This remarkably prolonged surge in oil prices seriously interfered with the primary objective of price stability of the newly established European Central Bank (ECB). For the Euro area, there is currently little evidence about the macroeconomic impact of oil shocks and little is known about the exact oil transmission mechanism which complicates the appropriate monetary policy reaction.[1]

Many factors contributed to the build-up of oil prices between 1999 and 2008, including the relentless growth of China and India, and widespread instability in oil-producing regions. It is very likely that the ultimate consequences of oil price rises and required interest rate reaction are different depending on the source of oil price shift. Production disruptions in oil-producing countries can be considered as unfavourable oil supply shocks and hence, result in a fall of oil production, rising oil prices, higher inflation and depressed global economic activity. Due to the opposite impact on output and inflation, central banks of oil-importing countries are confronted with a trade-off between output stabilisation and price stability. Alternatively, oil prices can also rise because of increased demand for oil, which could be the result of increased economic activity or precautionary motives. In response to higher crude oil prices, oil producing countries typically accommodate demand by raising oil production or exploring new oil resources that become profitable. In this case, central banks of oil-importing countries are also confronted with higher inflation, but the output situation can be different. In particular, in case of increased worldwide economic activity, the Euro area itself could be in a boom or indirectly gain from trade with the rest of the world. Even if the oil demand shock is of a purely speculative nature, part of the income transfers to oil-exporting countries could be recycled via increased trade, thereby reducing the negative impact on output. Consider Germany, although it is a pure oil-importing country, it has prospered considerably from extensive trade with booming regions like Russia and the Middle East between 2001 and 2008. As a result, monetary policymakers are not necessarily confronted with a trade-off between output and inflation and should not always react in the same way.

Figure 1 shows that movements in policy rates were indeed not always the same after similar oil price hikes and suggests that central banks take this into account. The figure displays the evolution of the (log) real crude oil price level in euro and dollar since 1999 and the interest rates set by the ECB and the Federal Reserve System (FED). We distinguish three periods of real oil price increases of more than 50 percent, i.e. 1999Q1-00Q3, 2003Q4-05Q3 and 2007Q1-08Q2. During the first episode, both central banks increased their interest rate by approximately 200 basis points. In the second period, however, the ECB kept the nominal interest rate constant at 2 percent, whilst the FED aggressively increased its policy rate with 2.5 percent. Conversely, the FED lowered its interest rate by more than 3 percent between 2007Q1 and 2008Q2 whereas the ECB even

[1] For recent overviews of US studies, see Hamilton (2008) or Kilian (2008b).

slightly tightened monetary policy. Accordingly, we do not only observe different policy behaviour across various oil episodes, but also differences between central banks.

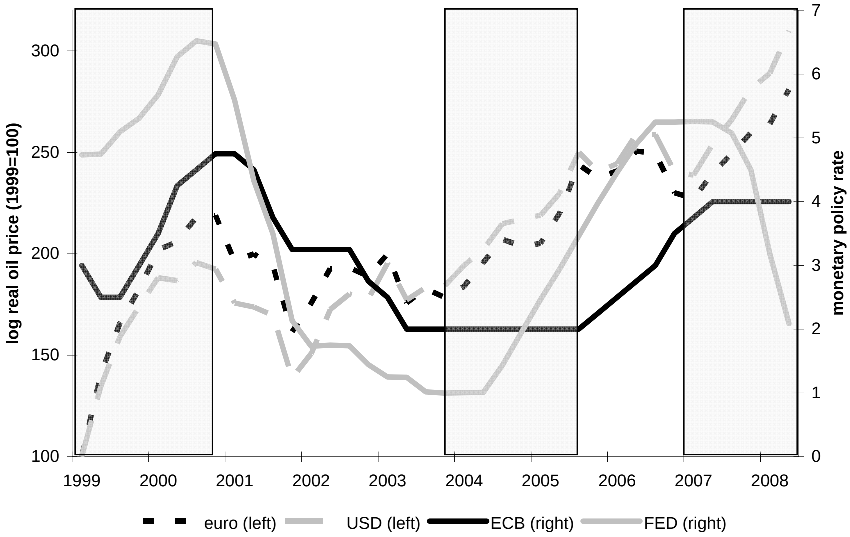

Figure 1. Evolution of real oil price and central bank interest rates since 1999

Not only the source of oil price shocks and the magnitude of the impact are relevant issues for monetary authorities, but also the timing and exact pass-through to inflation and economic activity are important. Since changes in monetary policy only affect inflation with a time lag, direct effects on the general price level through rising energy prices are inevitable over short horizons because energy prices are a component of the consumer price index. However, additional indirect inflationary effects may arise because higher energy input costs for the production process are passed on to consumer prices. These indirect effects are more delayed than the direct effects and can be influenced by monetary policy. Moreover, if the oil shock leads to higher inflation expectations, the danger exists that so-called second-round effects via higher wage demands are created which could result in a self-sustaining spiral of higher costs and prices. Whereas the direct and indirect effects only result in a permanent impact on the level of the consumer price index, second-round effects could trigger more harmful persistent effects on inflation. It is therefore important to have a clear view on the whole transmission mechanism of an oil price shock to inflation and the timing of the impact. This is even more the case in a currency union like the Euro area. Given dissimilarities in economic structures, openness, competition and the wage-setting process across countries, it is possible that individual member countries are differently influenced by shocks to oil prices which could create tensions within the ECB and complicate a common monetary policy stance.

In this paper, we analyse the exact impact of several types of oil shocks and the oil transmission mechanism for the Euro area economy and individual member countries in more detail. We also make a comparison with the United States (US). More specifically, we first demonstrate that the underlying source of oil price movements is crucial to determine the repercussions on the economy. We make a distinction between disruptions in oil supply, oil demand shocks driven by increased global economic activity and oil-specific demand shocks which could be the result of speculative or precautionary motives. While all three oil shocks have a positive impact on consumer prices, the impact on economic activity is considerably different. After an oil supply and oil-specific demand shock, there is respectively a permanent and temporary fall in the level of output, confronting monetary policymakers with a trade-off between output and inflation stabilisation. On the other hand, rising oil prices as a result of increased global economic activity are characterised by a transitory rise in domestic output. Hence, output and inflation drift in the same direction. The monetary policy reaction of the ECB to the three types of oil shocks is strikingly different compared to the FED. It turns out that the Euro area monetary authorities choose relatively more for their inflation objective while the FED seems to care more about output stabilisation.

We also examine the exact pass-through of oil supply shocks. The difference with the US is again striking. While the ultimate effects on consumer prices and output are of similar magnitude, the transmission mechanism is totally different. In particular, inflationary effects in the US are mainly driven by direct effects of rising energy prices in the consumption basket and indirect effects of increased production costs for non-energy goods and services. The latter is captured by significant higher import prices and core inflation whereas the price of domestic value added, i.e. the GDP deflator, remains constant. In contrast, Euro area inflation is much more driven by second-round effects of increasing wages resulting in a significant rise of the GDP deflator and a stronger impact on core inflation. Consequently, the transmission to consumer prices is also much more delayed in the Euro area than in the US. In particular, the pass-through to consumer prices is less than half after one year, while for the US almost half of the effect occurs contemporaneously and the process is complete after one year. Also the output reaction is very sluggish in the Euro area compared to an immediate response in the US.

Individual Euro area member countries also react very differently to oil supply shocks. The differences across countries, however, cannot be attributed to the oil intensity of the economies. The source of asymmetries should instead be explained by the labour market dynamics and monetary policy transmission mechanism. More specifically, strong second-round effects are only present in some individual countries, for example those with a formal wage indexation mechanism and high employment protection. On the other hand, nominal wages and prices hardly react in other countries. A common central bank, however, has to react to area-wide inflation to offset average second-round effects, which further exacerbates the cross-country differences. In particular, due to a limited wage and price effect, countries without second-round effects are confronted with higher real interest rates and a monetary policy stance which is very tight. The opposite is true for countries with strong second-round effects. Accordingly, output and inflation are further depressed in the former group of countries which in turn lead to higher real interest rates aggravating the differences even more. Asymmetric reactions in the Euro area countries to a symmetric shock such as an oil supply disruption lies at the heart of the optimum currency area literature and is a serious source of concern for policymakers. Similar movements of the business cycle and symmetric shocks are crucial conditions for a common monetary policy stance to be acceptable for all the individual countries. Our evidence suggests, however, that one size does not fit all. We even find that the single monetary policy stance eventually results in a greater fall of economic activity in member countries with a limited impact on prices which is at odds with the conventional view of an aggregate supply shock, i.e. a large price increase is expected to be accompanied by a strong fall in output. Conversely, in the absence of a single monetary policy reaction, we find that countries experiencing a strong wage and price reaction are indeed also confronted with more severe output consequences, which is consistent with the textbook aggregate supply view.

The rest of the paper is structured as follows. In the next section, we analyse the macroeconomic effects of different types of oil shocks depending on the underlying source of oil price shifts. We make a comparison between the Euro area and the US. Section 3 investigates the oil transmission mechanism in more detail. Specifically, we describe the channels of oil transmission and measure their relative importance in the total pass-through to inflation. The impact in individual member countries and an explanation for the cross-country differences are presented in section 4. Finally, some policy implications are discussed in section 5.

2. MACROECONOMIC EFFECTS OF OIL SHOCKS

2.1. The impact of different types of oil shocks in the Euro area

Not all oil shocks are alike. Eventually, each oil shock is associated with an increase in the price of crude oil, but the cause of the increase can be crucial for the economic consequences. Kilian (2008a) indeed shows that the economic effects in the US significantly differ depending on the driving force of the oil price shift. He also indicates that the relative importance of the different types of shocks varies a lot over time. In our analysis, we therefore make an explicit distinction between oil supply shocks, oil-specific demand shocks and oil demand shocks caused by global economic activity. To do so, we rely on a structural vector autoregression (SVAR) framework. This method allows us to capture the dynamic relationships between macroeconomic variables within a linear model. The value of each variable is expressed in terms of its own past values, past values of all other variables in the VAR and an error term. These error terms are serially uncorrelated but likely correlated with each other. In order to ensure identification, SVAR models are therefore explicit about the contemporaneous relationships between the variables. With this approach, it is therefore possible to disentangle oil price movements depending on the underlying driving force and the dynamic effects on the macroeconomy. A detailed discussion of the methodology and some robustness checks can be found in the technical appendix B.

Our benchmark SVAR-model for the Euro area contains seven variables, in particular global oil production (Q_{oil}), nominal crude oil prices (P_{oil}), an index of world economic activity (Y_{wd}), the euro-dollar exchange rate ($S_{€/\$}$), real GDP ($Y_{EA}$), consumer prices ($P_{EA}$) and the nominal interest rate (i_{EA}). All data used for the estimations are described in appendix A. The benchmark model is estimated for the sample period 1986Q1-08Q1. Baumeister and Peersman (2008a) find a considerable break in oil market dynamics and pass-through to the real economy in the first quarter of 1986, which remains stable thereafter. This date, often selected for sample breaks in the oil literature, is related to the collapse of the OPEC cartel or the start of the Great Moderation. The mid-1980s can also be considered as the hard-EMS period, with an aligned monetary policy stance for the whole Euro area, which closely resembles the current situation. To disentangle different types of oil shocks, we elaborate on Baumeister and Peersman (2008b) and rely on the following sign conditions, which are derived from a simple supply-demand model of the global oil market:

	Q_{oil}	P_{oil}	Y_{wd}	$S_{€/\$}$	Y_{EA}	P_{EA}	i_{EA}
Oil supply shock	< 0	> 0	≤ 0				
Oil-specific demand shock	> 0	> 0	≤ 0				
Global economic activity shock	> 0	> 0	> 0				

First, an *oil supply shock* is a traditional textbook shift of the supply of oil not driven by changes in the macroeconomic environment, for instance as a result of production disruptions created by military conflicts or changes in production quotas set by oil-exporting countries. Accordingly, after an unfavourable oil supply shock, there is a fall of global oil production, a rise in oil prices and world economic activity will not expand. Second, all shocks that lead to a positive co-movement between oil production and oil prices are considered as shocks on the demand side of the oil market. To disentangle oil-specific demand shocks from *demand shocks caused by increased global economic activity*, we identify the latter as a shock which is characterised by increased world economic activity. Rising oil demand due to continuous growth of China and India is a good example. Shocks to global economic activity could originate in the Euro area itself, but even if this shock comes from countries outside the Euro area, adverse output effects caused by the oil price increase could be subdued due to sustained strong exports to these countries. On the other hand, unfavourable o*il-specific demand shocks* that are not driven by economic activity, could be shifts in precautionary oil demand or speculative oil demand as a result of increased uncertainty about future supply. These shocks are therefore characterised not to have a positive impact on global economic activity. In contrast, the associated oil price hike is very likely to result in a negative effect on world economic activity. The consequences of oil-specific demand shocks for the Euro area could also be different from oil supply shocks, given the opposite movement of oil production and hence potentially different effects on income of oil-exporting countries. The sign restrictions on the global oil market are sufficient to uniquely disentangle the three types of oil shocks. Since all Euro area variables are not constrained in the estimations, the direction and magnitude of these responses are determined by the data.

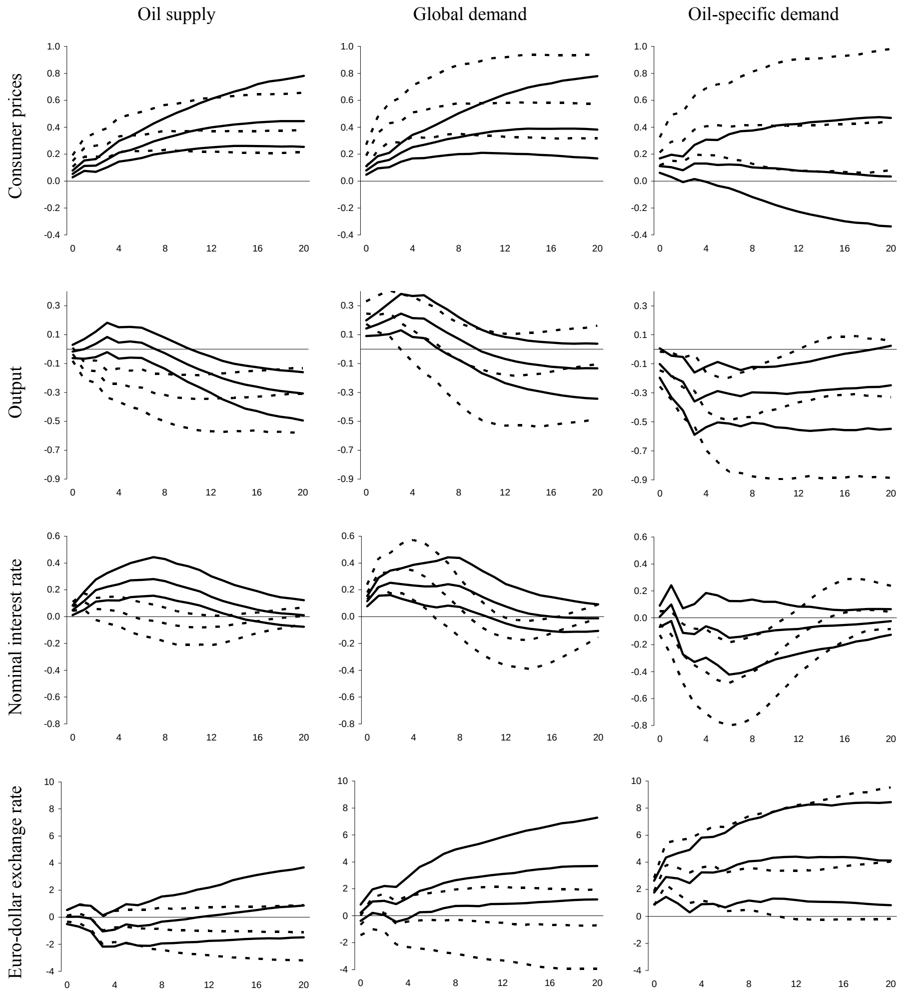

Figure 2. Impact of different types of oil shocks in the Euro area and the US

Notes: Figures are median impulse responses to a 10 percent contemporaneous rise in oil prices , together with the 16th and 84th percentile error bands, horizon is quarterly, Euro area: full lines, United States: dotted lines.

Figure 2 shows impulse responses for the benchmark Euro area variables (full lines) the first twenty quarters after each shock, together with 16^{th} and 84^{th} percentile error bands. All responses have been normalised to a 10 percent contemporaneous rise in crude oil prices, a value which is close to the observed average quarterly volatility over the sample period. The impact is strikingly different among the three types of oil shocks. A 10 percent unfavourable oil supply shock raises consumer prices in the Euro area by 0.44 percent in the long-run and leads to a permanent fall in the level of output by 0.31 percent. To offset the inflationary consequences, there is a significant tightening of monetary policy, whereas the euro-dollar exchange rate remains unaffected. In contrast, we observe an appreciation of the euro after an oil price shift due to increased global economic activity. Accordingly, the final impact on inflation is somewhat more subdued, being around 0.40 percent. The effect on output after this shock, however, is totally different. Economic activity even temporarily rises, which confirms our conjecture. Surprisingly, although no trade-off exists between output stabilisation and price stability after a global demand shock, European monetary authorities react in the same way as in the case of an oil supply shock. Also the macroeconomic impact of oil-specific demand shocks is different from the two other types of oil disturbances. This shock leads to a significant appreciation of the euro vis-à-vis the dollar. Possibly, this appreciation results from the tendency to invest in commodities as a means to protect against depreciations of the dollar. A depreciation of the dollar vis-à-vis the euro goes then hand in hand with increased demand for oil, which is exactly what the oil-specific demand shock should capture. The appreciation of the euro contributes to a negligible transmission to consumer prices, being hardly 0.10 percent in the long-run, but also to a significant transitory drop in output. Although the impact on inflation is limited and the fall in output significant, the monetary policy reaction turns out to be insignificant.

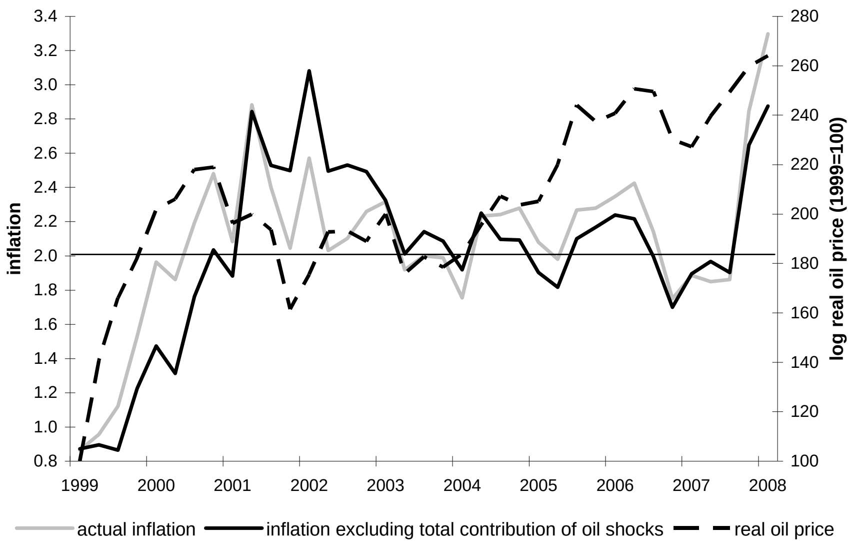

Figure 3. Contribution of oil shocks to Euro area HICP-inflation since 1999

Based on these estimates, we can calculate the cumulative effects of all three shocks on consumer price inflation since the establishment of the ECB and thereby determine the relative importance of these shocks to explain inflation fluctuations. For the whole sample period, relying on forecast error variance decompositions, 51 percent of contemporaneous oil price volatility is driven by oil supply shocks, 13 percent by oil-specific demand shocks and 36 percent by global activity shocks. The long-run contributions to Euro area inflation fluctuations are respectively 22, 2 and 15 percent. This implies that all three shocks together explain about 39 percent of total consumer price variability.[2] Figure 3 displays the real oil price evolution, actual HICP-inflation and the inflation rate that excludes the total contribution of oil shocks since the introduction of the euro. Not surprisingly, oil shocks made a significant contribution to consumer price inflation during various episodes. Specifically, actual inflation was consistently above the level of inflation without oil shocks for the periods 1999-01, 2004-07 and the end of our sample period. However, unfavourable oil shocks cannot be considered as the reason for missing the inflation target of ‘below but close to 2 percent’. Even without oil shocks, actual inflation would have been above target most of the time. In particular, the fall of oil prices at the end of 2000 actually lowered actual inflation towards the target between 2001 and 2003, which illustrates that the explanation of missing the target should be found elsewhere.

2.2. Comparison with the United States

In order to compare the macroeconomic impact of oil shocks and monetary policy reaction, we have also estimated the benchmark SVAR for the US. Impulse response functions (dotted lines) are also shown in Figure 2. There are not only similarities, but also some remarkable differences between both areas. Consider an oil supply shock. The final impact on consumer prices and output turns out to be more or less the same. The speed of transmission, however, is very different. While inflation effects are relatively persistent in the Euro area, we find a much faster pass-through to headline inflation in the US. The immediate impact on consumer prices is only $1/9^{th}$ of its long-run effect in the Euro area, while for the US almost half of the impact occurs contemporaneously. Even after one year, the pass-through is still less than half in Europe while almost complete in the US. The output reaction is also much more sluggish in the Euro area compared to an immediate fall in the US. In section 3, when we consider the oil transmission mechanism, we will analyse this difference in more detail.

Given the trade-off between output and inflation stabilisation after an oil supply disturbance, the FED keeps its policy rate more or less constant, which contrasts with the significant tightening in the Euro area. The difference in reaction is even more striking following an oil-specific demand shock. Despite strong inflationary effects, there is a significant loosening of policy to offset the negative output reaction in the US. Conversely, Euro area monetary authorities do not react despite the significant fall in output and negligible inflation effects. On the other hand, when monetary authorities are not confronted with a trade-off between output and inflation, which is the case for a global shock in economic activity, we observe a tightening in the US which is even larger than in the Euro area. Accordingly, we can conclude that the monetary policy reaction in the Euro area is more in line with its inflation objective while the FED cares relatively more about output stabilisation.

[2] The long-run contributions to output variability are respectively 11, 7 and 7 percent.

3. A CLOSER LOOK AT THE OIL TRANSMISSION MECHANISM

Knowing the channels through which oil price changes are transmitted to the economy is key to understanding the impact and to determining the appropriate policy reaction. In the previous section, we have found long-lasting inflationary effects for an oil supply shock in the Euro area and a speed of pass-through which is considerably different from the US. Also output reacts much more sluggish in the Euro area. The ultimate impact of an oil shock on inflation can be divided into several effects which we examine one by one. Since aggregate demand effects are part of the transmission mechanism to consumer prices, the pass-through to economic activity is also implicitly discussed. In particular, we consider a direct effect of oil shocks on the energy component of consumer prices, an indirect effect via rising production costs of non-energy goods and services, second-round effects and an impact due to a fall in aggregate demand. The former three channels have a positive impact on inflation whilst the latter channel should reduce inflationary consequences. However, all channels are expected to affect several price measures or output components in a very different way. By examining the reaction of those variables in more detail, it will be possible to determine the relevance of the different effects.

To disentangle the channels of oil transmission, we extend the benchmark SVAR model of section 2. Specifically, we re-estimate the benchmark SVAR for Euro area and US by adding each time an additional variable of interest which captures a specific channel (see appendix B for details). We focus on the impact of an oil supply shock that raises crude oil prices by 10 percent. As we have demonstrated, disruptions in the supply of oil are the most important driving force behind oil price fluctuations and inflationary consequences. Furthermore, it is not straightforward to determine the precise transmission channels of oil price shifts driven by global economic activity since they could be correlated with domestic shocks, such as shocks to productivity or trade, which might impair the interpretation of the different channels. This difficulty carries over to an oil-specific demand shock, because the accompanying appreciation of the euro could affect the relevance of the transmission channels. Moreover, the estimated impact of an oil-specific demand shock on Euro area inflation turned out to be insignificant.

3.1. Direct versus indirect effects of oil shocks

Since a consumer price index is calculated as a weighted average of prices of different types of goods and services of which energy goods is one, there will be a direct impact of an oil shock on inflation. The weight of energy goods in the consumption basket is currently almost 10 percent in the Euro area, of which more than half is related to oil, e.g. gasoline and heating fuels. The magnitude of these direct effects will depend on the share of oil in the energy basket and the substitutability of oil with other sources of energy. At times of rising oil prices, however, the worldwide price of other sources of energy, such as natural gas, typically also rises due to increased demand for these other forms of energy as well. Part of the pass-through of crude oil prices to final prices of oil-related products and other energy goods should also depend on competition and demand conditions in the energy sector. For commodities, this pass-through is mostly considered to be rapid and complete.

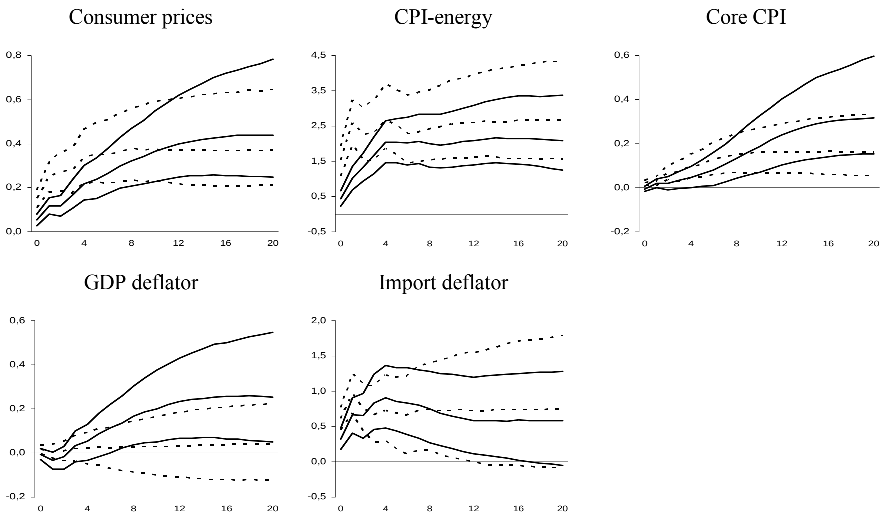

Figure 4. Direct versus indirect effects of oil supply shocks in the Euro area and US

Notes: Figures are median impulse response functions to a 10 percent contemporaneous rise in oil prices, together with 16th and 84th percentiles error bands, horizon is quarterly, Euro area: full lines, United States: dotted lines.

To evaluate the relevance of this direct effect on inflation and the existence of possible additional indirect effects, we consider the impact of an oil supply shock on respectively CPI-energy and core-CPI. The impulse response functions for a 10 percent oil price rise are displayed in the first row of Figure 4, together with the impact on headline inflation. Not surprisingly, there is a very strong reaction of CPI-energy to an oil supply shock. The long-run impact of a 10 percent rise in crude oil prices is estimated to be 2.09 and 2.68 percent for the Euro area and the US respectively. For the US, the impact is already complete after one quarter whilst it takes about one year in the Euro area. Given a share in consumer prices that is for both close to 10 percent, the rise in energy prices is almost fully responsible for the reaction of headline inflation in the very short-run, as can be seen in Figure 4.[3]

There are, however, also considerable indirect effects of oil shocks on inflation, especially over longer horizons. These indirect effects are fully captured by the reaction

[3] The average share of CPI-energy in total CPI between 1998 and 2007 was respectively 8.73 and 7.60 percent for the Euro area and US, and the shares of oil products (fuels) in CPI respectively 4.72 and 3.89 percent. However, the composition of the consumer price index is slightly different in the US and the Euro area. The main difference is the inclusion of owner-occupied housing in the US, which is considered as a capital good in the Euro area and thus not included in the consumer price index. A re-scaling would already result in a higher weight of oil and energy in US consumption compared to the Euro area. An additional important difference is that the US CPI only covers the price changes faced by the urban population and weights based on urban expenditure patterns, which can differ from those of the rural population. Also this limited coverage can further underestimate the energy expenditures in total private US expenditures.

of core inflation, which explicitly excludes food and energy prices. This measure is very popular among policymakers. Fluctuations in the price of food and energy are mostly only temporary and do not necessarily affect the persistent component of inflation. Due to a delay between monetary policy actions and its effects on the economy, this underlying trend in inflation is more relevant for interest rate decisions. Hooker (2002) found that oil shocks made a substantial contribution to US core inflation before 1981 but have made little contribution since. We find a statistically significant impact on core CPI for the US and the Euro area. The magnitude in the Euro area is, however, twice as large as the impact in the US, being respectively 0.32 and 0.16 percent. The speed of transmission is also totally different. Core inflation starts to rise relatively quickly in the US and the impact is complete after less than two years. In the Euro area, CPI excluding food and energy prices only starts to increase after more than one year up until four years after the initial oil price shift. This different pattern of core inflation is reflected in the sluggish pass-through of oil supply shocks to headline inflation in the Euro area compared to a fast transmission in the US. The exact sources of the indirect effects are further analysed in the next sections.

3.2. Cost effects

Since oil is an important input factor in the production process, increased oil prices imply higher production costs for firms. As a consequence, firms will attempt to pass these increased costs on to their selling prices, resulting in higher consumer prices of non-energy goods. In contrast to the direct effects, this indirect cost effect will affect core inflation. The impact on consumer price inflation is also expected to be more delayed. Specifically, higher input costs are only gradually transmitted via producer prices to consumer prices. The degree of competition at each stage of the production process will matter for the final impact on inflation, since variations in profit margins can partly offset the cost effects.

The reaction of the GDP and import deflators can shed more light on the relevance of cost effects. More specifically, since the Euro area is a pure importer of crude oil and the GDP deflator is the price of domestic value added, the direct effects and the cost effects of oil as an input factor in the Euro area production function will not be part of this indicator. [4] Accordingly, without domestic oil production, a higher cost of crude oil as an input factor in the aggregate gross output production function will only affect the import deflator. The latter contains not only crude oil prices, but also the prices of final goods or other foreign commodities which could be directly or indirectly affected by oil price shifts, which are also cost effects of oil shocks. When domestic producers decide not to pass on the increased input costs to the next step in the production chain, or to do this

[4] The only exceptions are other non-oil sources of energy which are *produced* in the Euro area, such as gas in the Netherlands. To the extent that the prices of these sources increase due to substitution effects, the GDP deflator could also rise as a consequence of cost effects. This proposition also relies on the standard assumption of separability between oil and other production factors in order to ensure the existence of a value-added production function (see Barsky and Kilian 2002 or Rotemberg and Woodford 1996 for a formal exposition of a production function with foreign commodity import and domestic value added).

more or less than proportionally, the GDP deflator will change. For instance, transport companies or firms producing oil-related products based on crude oil could react by changing their profit margins. Such a reaction, however, is not a pure input-cost effect, but can be considered as demand or second round effects, which will be discussed in the next sections. The situation is slightly different for the US, which produces oil but is still a net oil-importer. Hence, in the case of the US, the cost effects of rising crude oil prices could also affect the GDP deflator. Given the small share of domestic oil production, this influence is expected to be relatively small.

Impulse response functions for the GDP and import deflator can also be found in Figure 4. The response of the import deflator for the Euro area should be interpreted with caution. Since this series in the Area Wide Model (AWM) dataset is an aggregate of import of all individual countries, trade *between* member countries is also included. As a result, higher export prices of one member country, for instance due to second-round effects, will result in higher import prices for the other member countries.[5] The latter could bias the estimated effects for the Euro area upwards. The messages of the results, as discussed below, are nevertheless very clear.

Consider first the US. Despite being an oil-producing country, there is no reaction of the GDP deflator to an oil supply shock. In contrast, import prices increase significantly. Consequently, the rise of US core inflation can be fully attributed to a cost effect, and the reaction of headline inflation is a combination of this indirect cost effect and direct effects of rising energy prices. The situation in the Euro area is totally different. The GDP deflator rises significantly after an unfavourable oil supply shock. Given the estimated significant immediate rise of the import deflator, which combines direct and cost effects, the existence of a cost effect in the Euro area cannot be excluded. However, the shape and magnitudes of the responses reveal that the bulk of the reaction of core inflation should be explained by the reaction of the GDP deflator. The latter is a combination of second-round and demand effects and will be further decomposed in the next section.

3.3. Second-round versus demand effects

Oil supply shocks could increase the GDP deflator via positive second-round effects and decrease it via negative demand effects. Due to increased consumer prices via the direct and cost effects, employees are likely to demand higher nominal wages in subsequent wage bargaining rounds to maintain their purchasing power, which could trigger second-round effects of oil shocks. If there is a formal wage indexation mechanism in which nominal wages are indexed to consumer prices, this even happens automatically. Consequently, the costs of firms could further rise. If firms decide to pass on the higher wage costs to output prices, there is an additional increase in the prices of goods and

[5] Unfortunately, import (and export) data for the whole Euro area vis-à-vis the rest of the world are not available for our sample period. For the individual countries, analysed in section 4, this is not a problem. Higher import prices for an individual country imply a higher input price in the domestic production function, which can be considered as a cost effect for the country under consideration.

services contained in the non-energy component of CPI. In contrast to direct and cost effects, rising wages will affect the GDP deflator. Moreover, whilst direct and cost effects only result in a permanent shift of the *price level*, second-round effects could lead to a self-sustaining spiral of increasing wages and prices which results in a more persistent impact on *inflation*. The existence of second-round effects will depend on supply and demand conditions in the wage-negotiation process and the reaction of inflation expectations. The latter is in turn influenced by the credibility of monetary policy. Note that second-round effects could also be triggered when price-setters increase the mark-up of prices above costs because of higher inflation expectations.

On the other hand, the GDP deflator could be influenced by downward demand effects. The impact of an oil shock is typically represented by a textbook shift of the aggregate supply curve along a downward sloping aggregate demand curve. An unfavourable shock creates a rise in the price level and depresses economic activity. A negative slope of the aggregate demand curve already results in a more subdued impact on prices than would be the case if the aggregate demand curve were perfectly inelastic. The greater the elasticity of aggregate demand, the lower the impact on prices will be. Firms could for instance react to this supply disturbance by decreasing their profit margins to limit the price increase. The transmission of oil to output and inflation is also often considered through *additional* demand-side effects, which are mostly captured by an accompanying shift of the aggregate demand curve. For net oil-importing countries, an unfavourable oil supply shock could result in a reduced or a changed composition of aggregate demand because of an income, precautionary savings, uncertainty and monetary policy effect. The exact working and relevance of these sub-channels will be examined in the next section, but they all result in a further fall of economic activity. At least for some goods, these demand effects could reduce the final impact on prices, in particular on the GDP deflator.

We analyse the existence of second-round and demand effects by estimating the impact on (nominal) total labour costs per employee, unemployment, real consumer wages and the producer price-wage ratio. The latter variable can be considered as the inverse of real producer wages, or alternatively as the sum of profits and net indirect taxes, since it excludes both input and wage costs. Impulse response functions can be found in Figure 5.

In the US, second-round effects are not present since nominal wages do not rise and also the price-wage ratio remains constant. Consequently, there is no reaction of the GDP deflator and all inflationary effects can be attributed to direct and costs effects. The absence of a GDP deflator reaction to an oil supply shock in the US, however, does not imply that there are no demand effects. First, since the US is also an oil-producing country, the constant price-wage ratio could cover positive cost effects compensated by negative demand effects. Second, it is perfectly possible that a reduction in aggregate demand is transmitted to the labour market. A fall in labour demand and accompanying rise in unemployment reduces bargaining power of employees which could impede nominal wages to move up. This is exactly what we observe. As a result of constant nominal wages and a rise in headline inflation, employees face a significant reduction in purchasing power, i.e. real consumer wages drop by 0.5 percent.

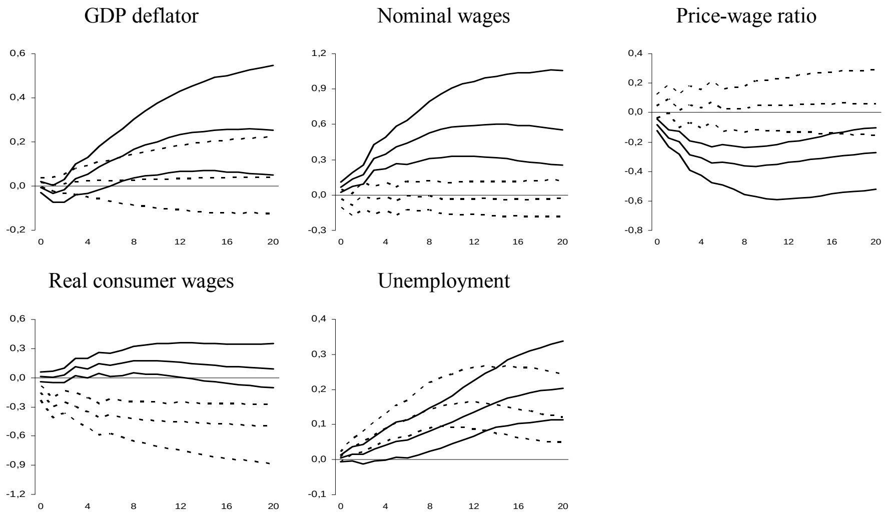

Figure 5. Second-round effects of oil supply shocks in the Euro area and the US

Notes: Figures are median impulse response functions to a 10 percent contemporaneous rise in oil prices, together with 16th and 84th percentiles error bands, horizon is quarterly, Euro area: full lines, United States: dotted lines.

This contrasts with the dynamics in the Euro area. Despite an increase in unemployment, European employees seem to be able to transfer the loss in purchasing power to producers, i.e. their long-run purchasing power remains constant.[6] We find a considerable rise of nominal wages after an oil supply shock which drives the GDP deflator reaction. Specifically, a 10 percent rise of crude oil prices results in an increase of total labour costs per employee of 0.6 percent. Rising labour costs are only partially transmitted to the GDP deflator, which is reflected in a permanent fall of the price-wage ratio. The latter indicates that also demand effects are present resulting in higher real wages for producers because their output prices increase less than labour costs do.[7] Surprisingly, we even find a transitory increase of real consumer wages, indicating that nominal wages rise more than consumer prices do in the short run. In sum, following an oil supply shock, we can fully attribute the source of second-round effects in the Euro area to a substantial rise in nominal wages.

The difference in labour market dynamics between Euro area and US is striking but in line with other research. Trade unions are considered to be very influential in most countries of the Euro area, whereas labour markets are more competitive in the US

[6] Some caution is required when interpreting the results for wages. First, these figures are for ‘total labour costs’, i.e. all costs producers face for employees. The magnitude for the ‘net wages’ reaction is therefore not necessarily the same. Second, labour costs are measured as ‘total labour costs per employee’, which could be different from a measure based on ‘average labour costs per hour’. For the latter, sufficient quarterly data for hours worked are unfortunately not available.

[7] Note that a reduction in profit margins of domestic suppliers of oil-related products will also be part of the estimated price-wage ratio response.

(Calmfors and Driffill 1988). A small elasticity of labour supply in a competitive labour market will result in a loss of purchasing power which is almost entirely borne by the worker. On the other hand, if employees are organised in strong monopolistic unions, they can succeed in shifting the income loss to firms. For instance, Daveri and Tabellini (1997) show that higher labour taxes lead to higher producer wages in European countries, whilst the labour tax burden in the US and other Anglo-Saxon countries is shifted to the workers. This finding is confirmed by our results for an oil supply shock. We find a significant rise of real producer wages, whilst real consumer wages are unaffected in the Euro area. In the US, producer wages remain constant and the wages received by employees decline significantly.

3.4. Demand effects and the impact on economic activity

A final factor which influences the transmission of crude oil price rises to inflation is the impact of a reduction in aggregate demand. On the one hand, an increase in prices will result in lower demand and economic activity, which is reflected in a move along a downward sloping aggregate demand curve. To limit the fall in production, firms could react by decreasing their profit margins or negotiate lower wages for its employees, which could be enforced by a reduction in labour demand. The pass-through of rising input costs and/or wages to inflation is then incomplete. This can happen at any stage of the production process, including for producers of oil-related and other energy products. On the other hand, an unfavourable oil supply shock can also trigger an independent reduction of aggregate demand, i.e. a shift of the aggregate demand curve. This independent demand-side channel, which reduces economic activity and inflation, can further be decomposed into a number of sub-channels.[8]

For oil-importing countries, higher energy prices erode the disposable income of domestic consumers that depresses the demand for other goods. This *income effect* depends on the elasticity of oil demand and should be bounded by the energy share in consumption. However, oil demand is considered to be very inelastic. Consumers have to drive to work and heat their houses and thus little choice remains besides paying higher prices (Kilian 2008b). In addition, consumers may decide to increase their overall savings. Such a *precautionary savings effect* could be the result of a greater perceived likelihood of future unemployment and income loss, and also results in reduced consumption.

Figure 6 shows the responses of real GDP and its main components. In the US, we find a considerable fall in private consumption which is consistent with both effects. The immediate fall and shape is also strongly correlated with the response of real GDP. For

[8] Oil shocks could also result in a changed *composition* of aggregate demand, for example a shift from energy-intensive to energy-efficient goods, which will also lower economic activity (Davis and Haltiwanger 2001). This change could cause a reallocation of capital and labour from the energy-intensive to the energy-efficient sector. In the presence of frictions in capital and labour markets, these reallocations will be costly in the short-run, and can lead to a substantial reduction in economic activity. In contrast to the other demand effects, this allocative effect is not necessarily accompanied by a shift in the aggregate demand curve, and the impact on inflation is less clear. For a more detailed exposition of the demand side effects and an overview of the empirical literature, we refer to Kilian (2008b).

the Euro area, however, we find a temporary rise in private consumption the first quarters after an oil supply shock. Real consumption only starts to decline two years after the oil shock. This is not surprising, given the estimated reaction of real consumer wages reported in section 3.3, i.e. a slight increase in the short-run and an insignificant reaction in the long-run. This evidence suggests that income and precautionary savings effects are probably not relevant in the Euro area.

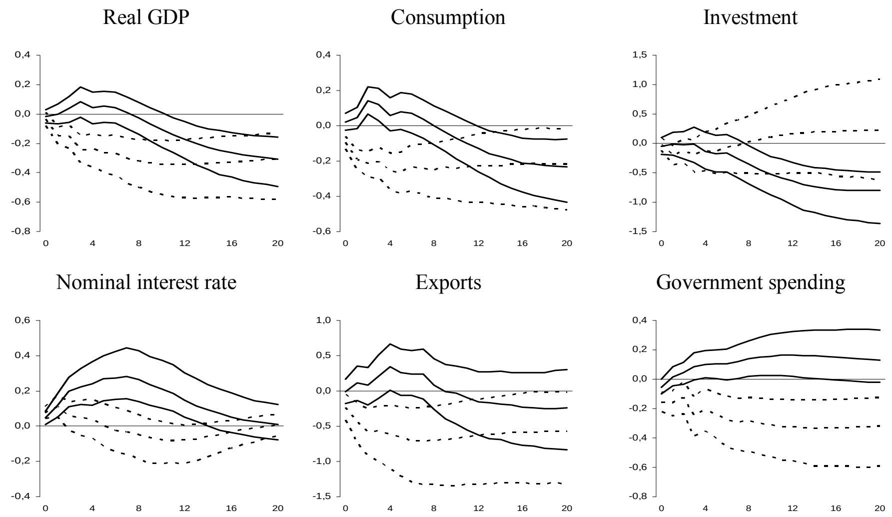

Figure 6. Demand effects of oil supply shocks in the Euro area and the US

Notes: Figures are median impulse response functions to a 10 percent contemporaneous rise in oil prices, together with 16th and 84th percentiles error bands, horizon is quarterly, Euro area: full lines, United States: dotted lines.

A shift in aggregate demand and output could also be the consequence of *uncertainty effects*. Significant disruptions in oil supply raise uncertainty about future availability of oil and its price, which could lead to the postponement of irreversible purchases of investment and consumption goods that are complementary to energy. Bernanke (1983) shows that increased uncertainty about the future price of irreversible investments raises the option value associated with waiting to invest, which will lead to less investment expenditures. Accordingly, also the substitution of energy-intensive for more energy-efficient durable consumption goods can be postponed. As a result, there is a fall in aggregate demand. For the US, we find little support for the existence of such a channel for investment goods, since the latter does not significantly react to an oil supply shock. Also Edelstein and Kilian (2008) find no evidence in favour of an uncertainty effect for US consumer expenditures.

In contrast to the US, we find a considerable fall in Euro area investment. Given the absence of an investment response in the US and the fact that the decline only starts after about one to two years, it is very likely that another effect is at work on the demand side in the Euro area. In particular, the effects on demand and output could be aggravated if the central bank tightens policy in response to the inflation induced by the oil price shock, which is called *a monetary policy effect*. Bernanke, Gertler and Watson (1997) argue that the monetary contractions to control the inflationary effects of an oil shock were the principal cause for the US downturns in the 1970s, rather than the oil price spikes themselves. For the post-1986 period, we hardly find an increase of the nominal interest rate in the US and, given a rise in inflation, certainly not of the real interest rate. Consequently, monetary policy effects in the US can be ignored, which is confirmed by the insignificant reaction of investment. However, it is much more likely that there is a strong monetary policy effect in the Euro area, which dominates at the demand side and explains the output reaction. First, there is a significant monetary tightening. The interest rate increases by 30 basis points after a 10 percent oil price shock. Second, also the timing is in line with a monetary policy effect. The interest rate only rises step-by-step reaching a maximum after about 6 to 7 quarters. Given lags in the monetary transmission mechanism, consumption, investment and therefore also real GDP start to fall with a delay. Especially the much stronger decline in investment, which amounts to 0.8 percent in the long-run is a feature which characterises the influence of monetary policy effects. In sum, monetary policy is very likely to significantly subdue the impact of oil supply shocks on inflation in the Euro area, and explains why there is a very sluggish output reaction compared to the US.

Finally, Figure 6 also shows some differences for the impact on exports and government spending. Whereas reduced government spending and a fall of exports contribute significantly to the overall decline in US real GDP, we do not find a significant response of exports and a countercyclical reaction of government spending to an oil supply shock in the Euro area. The insignificant reaction of Euro area exports is notably a combined result of a rise in Germany and a fall in many other member countries as shown in appendix B.

4. THE PASS-THROUGH TO INDIVIDUAL EURO AREA MEMBER COUNTRIES

In the context of a single currency, the resemblance of output and inflation fluctuations of the participating countries is a major concern. A very important issue for the Eurosystem is therefore the possibility of different effects of oil shocks in individual member countries. Although all members are oil-importing countries, asymmetries could arise because of dissimilarities in oil intensity, economic structure, competition, the monetary transmission mechanism or the wage-bargaining process. Hence, if output and inflation react differently to an oil shock in the member countries, a single monetary policy stance could not be appropriate. In this section, we investigate the pass-through of oil supply shocks for respectively Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain. We first quantify the cross-country differences of the impact on output and inflation. In the rest of the paper, we will try to explain these differences relying on the different channels of oil transmission.

Table 1. Long-run impact of oil supply shocks and characteristics of individual Euro area countries

	Real GDP[1]	CPI[1]	CPI Energy[1]	Core CPI[1]	Import deflator[1]	GDP deflator[1]	Nom. wages[1]	Real wages[1]	Oil demand[2]	Cons. petrol. prod.[3]	Share in CPI		Labour market	
											Energy[4]	Oil(fuels)[5]	AIM[6]	OECD EPL[7]
Euro area	**-0.31**	**0.44**	**2.09**	**0.32**	0.58	**0.25**	**0.55**	0.09	73.2	60.0	8.73	4.72		
United States	**-0.31**	**0.37**	**2.68**	**0.16**	0.75	0.04	-0.03	**-0.50**	99.5	91.5	7.60	3.89	no	0.20
Austria	**-0.21**	**0.44**	**1.24**	**0.37**		**0.29**	0.07	-0.23	57.6	52.7	7.89	4.77	no	2.10
Belgium	**-0.23**	**0.44**	**2.49**	**0.23**	-0.23	**0.25**	**1.04**	**0.57**	106.4	81.0	10.39	5.54	strong	2.53
Finland	**-0.98**	-0.02	**1.10**	-0.11	**1.35**	**-0.47**	**-0.40**	-0.36	89.5	77.0	8.60	5.44	weak	2.13
France	**-0.39**	0.14	**1.30**	0.01	-0.07	**0.18**	0.12	-0.04	66.5	60.3	8.70	5.00	weak	2.90
Germany	0.13	**0.72**	**2.44**	**0.63**	**0.75**	**0.58**	**0.97**	0.18	67.8	62.9	9.92	4.87	no	2.63
Greece	**-0.26**	**1.06**				**1.00**			94.6	65.0	7.17	5.51	weak	3.30
Ireland	**-1.35**	**0.26**	0.66	**0.29**	-0.06	-0.50	-0.04	-0.29	79.4	69.3	8.61	6.09	no	0.97
Italy	**-0.36**	**0.39**	**1.73**	**0.29**	**1.08**	**0.34**	**0.84**	**0.40**	67.6	47.8	6.84	3.60	strong	2.73
Netherlands	**-0.29**	**0.27**	**2.04**	**0.26**	0.30	**0.39**	0.02	**-0.25**	95.8	55.9	9.03	3.82	no	2.30
Portugal	**-0.70**	0.19			-0.38	**0.51**			90.0	70.0	8.56	4.76	no	3.77
Spain	**-0.49**	**0.55**	**2.28**	**0.49**	1.04	**0.40**	**1.22**	**0.64**	78.6	62.8	8.62	5.32	strong	3.27
Correlation CPI	0.57	1.00	0.69	0.95	0.13	0.76	0.82	0.63	0.03	-0.17	-0.17	0.10		0.31
Correlation GDP	1.00	0.57	0.76	0.48	0.08	0.77	0.56	0.44	-0.16	-0.38	0.15	-0.46		0.46

Notes: [1] impact after 20 quarters of a 10% rise in oil prices, bold figures are significant based on the confidence bands; [2] oil demand (in metric ton) / GDP (million USD, PPP weighted), average for period 1986-2007; [3] consumption of petroleum products (tonne of oil equivalent) / GDP (million USD, PPP weighted), average for period 1986-2006; [4] share of CPI-energy in total CPI, average for period 1998-2007; [5] share of oil products (fuels) in CPI, average for period 1998-2007; [6] degree of automatic wage indexation (ECB, 2008a); [7] OECD indicator of the strictness of employment protection legislation

4.1. Impact in individual Euro area countries

To measure the impact of oil shocks on consumer prices and output, we estimate an extended SVAR for each individual country. More specifically, both individual country aggregates are added to the benchmark Euro area SVAR, which is then re-estimated for each country (see appendix B for the details). The long-run effects of a 10 percent oil price rise on real GDP and consumer prices are reported in Table 1 and Figure 7. All graphs of the impulse responses can be found in the appendix, including the difference of the individual country with the area-wide response, to measure the significance.

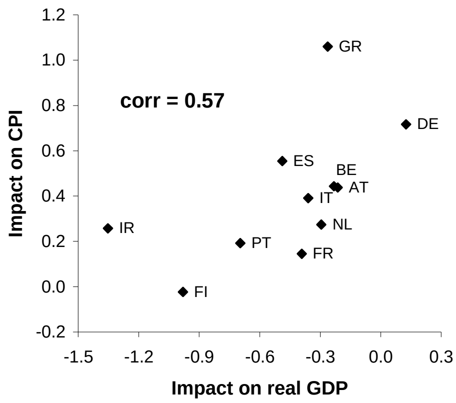

Figure 7. Long-run impact of oil supply shock in individual Euro area countries

Notes: Figures are median impact after 20 quarters of a 10 percent rise in oil prices

There are substantial differences across individual countries. For consumer prices, we find a very strong impact for Greece, Germany and Spain, being respectively 1.06, 0.72 and 0.55 percent. On the other hand, the impact on inflation is insignificant in Finland, France and Portugal. The output effects are also considerably different. Ireland, Finland and Portugal suffer severe losses in output, while there is no fall in economic activity for Germany and a relatively subdued impact for Austria, Belgium and Greece. As shown in the appendix, the cross-country differences are statistically significant. Surprisingly, the CPI and GDP reactions do not seem to be strongly correlated with the oil intensity of the economies. Table 1 also contains the average oil demand and consumption of petroleum products for each economy. Whereas the correlation of oil demand and petroleum consumption with the long-run effects on real GDP tends to be slightly negative, none of the indicators are correlated with the estimated impact on consumer prices. Even more striking is that the correlation between the ultimate impact on output and consumer prices is significantly positive at 0.57, as also shown in Figure 7. This implies that countries experiencing little inflationary effects are confronted with a larger fall in economic activity, which is at odds with the conventional view of unfavourable oil shocks. Specifically, oil supply disturbances are assumed to shift a country's aggregate supply curve. A strong fall in output is then expected to be accompanied by a significant rise of prices. The magnitude of this impact should mainly depend on the relevance of oil for the economy. Apparently, a significant positive correlation between the reaction of output and prices across countries indicates that also demand effects are at play. To investigate this more carefully, we need to decompose the different channels of oil transmission, which is done in the next sections.

4.2. The direct versus indirect effects in individual countries

To analyse the direct and indirect effects at the country level, we estimate the impact of an oil supply shock on the energy component of CPI, core CPI, the import and GDP deflator for all individual countries in the same way as we did for the Euro area and the US. Specifically, these variables are one-by-one added to the extended SVAR model for each individual country, which is then re-estimated. The long-run responses to a 10 percent rise in crude oil prices are shown in Table 1 and Figure 8. Full impulse responses can also be found in appendix B. Due to lack of data, the responses of some country-specific variables are missing.

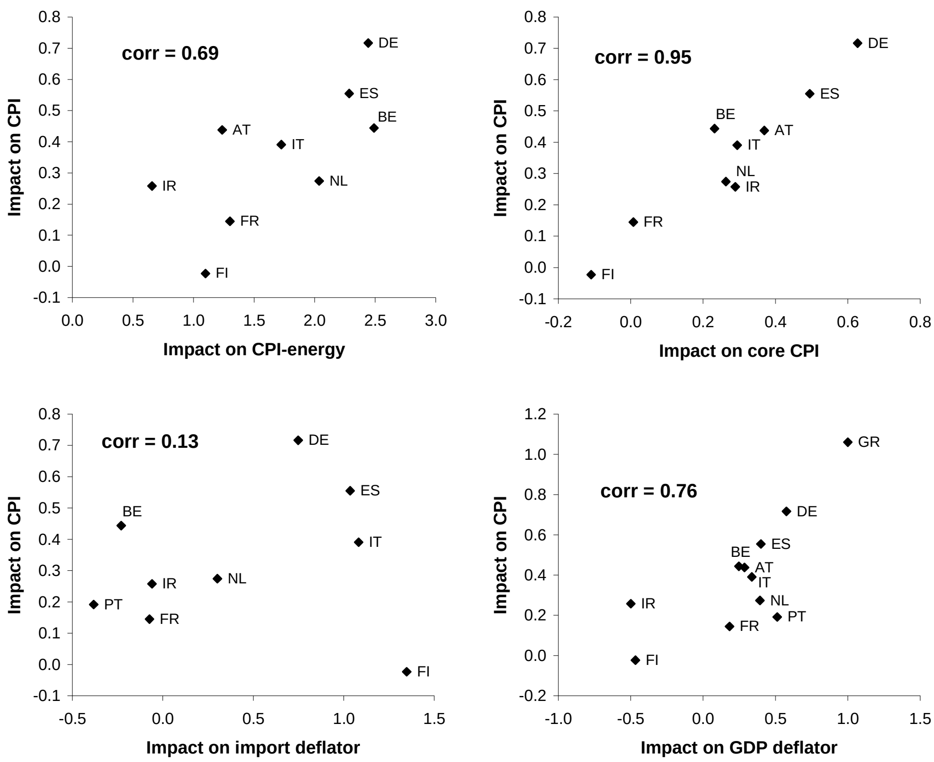

Figure 8. Direct versus indirect long-run effects in Euro area countries

Notes: Figures are median impact after 20 quarters of a 10 percent rise in oil prices

For all countries, with the exception of Ireland, we find a substantial rise of CPI-energy. The *shares* of energy prices in the consumption baskets, however, do not explain the estimated cross-country differences of the long-run reaction of headline inflation.

Specifically, there is no correlation between the long-run reaction of CPI and the energy share in CPI, not even with the share of oil-related products (see Table 1). Cross-country differences in direct effects of oil shocks on headline inflation are rather driven by the *magnitude* of movements in energy prices. In particular, as shown in Figure 8, the correlation between the long-run responses of CPI-energy and headline inflation is 0.69. As a consequence, the domestic reaction of energy prices contributes to the asymmetries between member countries. A detailed analysis of the determinants of energy price reaction is beyond the scope of this paper, but Table 1 reports a strong positive correlation between the size of energy-price shift and output effects across countries, indicating that demand conditions are probably important. A greater fall in economic activity is likely to have a downward impact on profit margins of the energy sector, thereby weakening the rise in the price of energy goods.

The reaction of core inflation is, however, more important to explain cross-country differences in the total consumer price response, i.e. we find a correlation of 0.95 between both. We notice no reaction of core inflation in Finland and France, and a significant impact in all other countries. Consequently, indirect effects are crucial to determine the asymmetric effects on inflation in individual Euro area member countries. All of them experience a significant rise of import prices in the short-run (see Figure A1 in the appendix). For many countries, however, this rise becomes insignificant in the long-run. A low correlation indicates that the impact of import prices cannot explain differences in headline inflation. Asymmetric cost effects are therefore probably not important for cross-country differences in the long run. On the other hand, the correlation between the impact on the GDP deflator and CPI is very high, being 0.76. Accordingly, cross-country differences of indirect effects are rather determined by second-round and/or demand effects. The GDP deflator rises considerably in Greece, Germany and Portugal. For Finland and Ireland, there is even a fall in the deflator.

4.3. Second-round effects as a source of cross-country differences

For the Euro area as a whole, we found a crucial role for second-round effects as a driving force of headline inflation following oil supply shocks. Poor central bank credibility could be a source of second-round effects. When inflation expectations are not well anchored, an oil shock that raises inflation could trigger higher inflation expectations resulting in increased wage demands by employees which are then passed on to higher prices. If central bank credibility is the main explanation of second-round effects in the Euro area, given a common monetary policy framework, wage and price dynamics should be very similar for individual members. However, this is clearly not the case. Table 1 also contains the effects of an oil supply shock on nominal wages, which are substantially different across countries. Nominal wages in Austria, France, Ireland and the Netherlands do not react to an oil supply shock. There is even a significant fall in Finland. On the other hand, there is a considerable rise of nominal wages in Belgium, Germany, Italy and Spain. The long-run reaction of these countries to a 10 percent oil supply shock fluctuates around 1 percent. Accordingly, it is not very likely that central bank credibility is the driving force of second-round effects. In contrast, Figure 9 suggests that different wage responses are the driving force of inflationary differences. In particular, the correlation of the long-run reaction of wages with the impact on consumer prices and GDP deflator is respectively 0.82 and 0.68. In the rest of this section, we explain why specific labour market characteristics are likely to be a *source* of the second-round effects and the asymmetric impact of oil supply shocks on inflation in individual Euro area countries. As we will demonstrate in the next section, a single monetary policy stance will aggravate the divergence across countries, which will result in a positive correlation between the ultimate impact on inflation and economic activity. In section 4.5, we will provide additional evidence for this proposition by excluding alternative hypotheses such as reversed causality.

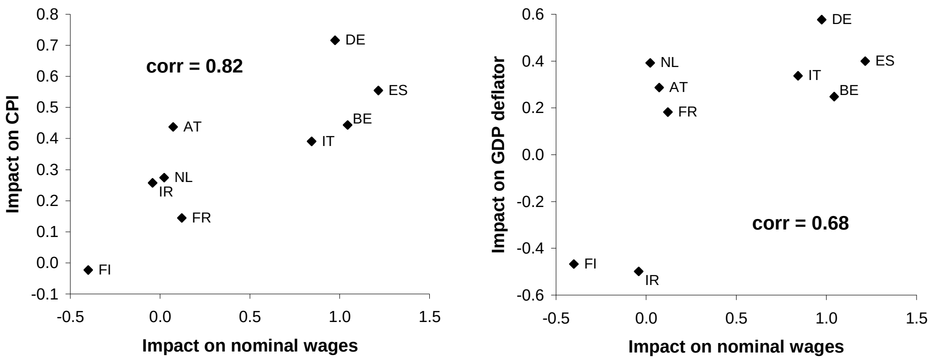

Figure 9. Second-round effects as a source of cross-country inflation differences

Notes: Figures are median impact after 20 quarters of a 10 percent rise in oil prices

An important labour market feature which could trigger or strengthen second-round effects is the existence of an automatic wage indexation mechanism. A system in which wages are automatically indexed to past inflation could exist by law, could be part of a collective wage agreement or individual worker contracts. Such a mechanism automatically leads to wage increases after a shock to oil or energy prices. The speed and magnitude of the wage reaction will depend on, among other things, the inflation measure, reference period, frequency and the coverage of employment in the mechanism. When such a mechanism exists, firms will have no alternative apart from increasing prices, reducing their profit margins or implementing a combination of both. A brief summary of formal automatic wage indexation in the Euro area countries, obtained from ECB (2008a), can be found in Table 1. Many countries have no or hardly any automatic wage indexation system, in particular Austria, Germany, Ireland, the Netherlands and Portugal. With the exception of Germany, all these countries are characterised by an insignificant reaction of nominal wages after an oil supply shock. Some form of wage indexation exists in Finland, France and Greece. Finland has a contractual, non-automatic system, in which wage increases are possible if inflation exceeds an agreed threshold. This mechanism has, however, only been triggered once.

France has an automatic indexation mechanism, but only for the minimum wage which only covers 13% of private sector employment. A similar (non-automatic) system existed in Greece up to 2003, in which the minimum wage and some other private sector agreements sometimes included a clause to compensate for inflation above a certain threshold. Also these countries experience only a moderate increase in wages after an oil supply shock.

On the other hand, a strong automatic wage indexation mechanism exists in Belgium and Spain.[9] Both countries experience a significant reaction of nominal wages following an oil shock. Belgium has a system which covers almost 100% of private sector employment, and also public wages are fully indexed to inflation.[10] Whenever the four-month moving average of past inflation exceeds a threshold of 2%, there is an indexation of wages, limited by a wage norm and adjusted with some delay. The reference indicator is a health index which excludes alcohol, tobacco and petrol, but still contains heating fuel, gas and electricity. For Belgium, we find a considerable response of nominal wages to an oil supply shock which accumulates to 1.04 percent in the long-run. Also Spain has an automatic wage indexation mechanism, which covers around 68% of private sector employment. The mechanism adjusts for inflation that is higher than the expected inflation rate embedded in wage agreements. Spain is the country with the strongest reaction of nominal wages to an oil supply shock, which is estimated to be 1.22 percent. Before 1993, wages in Italy were automatically indexed to inflation on a quarterly basis for all employees according to a mechanism known as the 'scala mobile'. Although indexation is not automatic anymore since 1993, a wage guideline continued to exist in national collective agreements, covering 100% of private sector employment. This clause compensates for the difference between expected inflation under the previous contract and actual inflation. Also for Italy we find a significant reaction of nominal wages. Remarkably, the countries with strong wage indexation even experience real wage increases in the long-run. A possible explanation could be that, due to the automatic indexation, firms have no choice but laying off employees with lower productivity to remain competitive when confronted with an unfavourable oil supply shock. As a result, the average real wage could rise in the long-run.

The absence of automatic indexation does not mean that second-round effects are not possible. Countries without a formal mechanism could still have a strong de facto indexation of wages to prices in the wage bargaining process. Du Caju et al. (2008) report that price developments are the most important factor entering wage negotiations in Euro area countries. Second-round effects, or real wage rigidity, could then arise because unions may want to maintain employees' purchasing power. The probability of success and actual wage change will depend on labour market conditions and bargaining power of employees. For example, unions might be more successful to maintain purchasing power under a tight labour market. Consider Germany, in which nominal

[9] Note that also Cyprus, Luxembourg, Malta and Slovenia have automatic wage indexation mechanisms, countries which are not included in the cross-country comparisons due to lack of data.

[10] Belgium is also a country in which the government consumption deflator reacts strongly to an oil supply shock, a result which is not reported in the paper.

wages rise significantly after an unfavourable oil shock and real consumer wages remain relatively constant. Germany is also a country which does not experience a fall in real GDP, which could give more power to unions to negotiate higher wages. A positive correlation between the cross-country responses of output and wages and our sectoral evidence in section 4.5 support this hypothesis, i.e. sectors and countries experiencing a smaller fall in activity are characterised by a stronger increase in nominal wages. So, also demand conditions might matter for triggering second-round effects on the labour market in case there is no formal automatic wage indexation.

Another important determinant of employees' bargaining power is the degree of employment protection. When employment protection is strict, the likelihood of de facto indexation and real wage rigidity is higher. Figure 10 shows the correlation of the OECD (2004) indicator of the strictness of employment protection legislation (EPL) with the impact of an oil supply shock on nominal wages and the GDP deflator. This index is constructed based on the legal protection of permanent workers against (individual) dismissal, regulations on temporary forms of employment and specific requirements for collective dismissal. This index can more generally be considered as a measure of labour market rigidity. Employment protection is high in the Southern European countries Portugal, Greece, Spain, France and Italy. Conversely, protection is fairly low in Ireland, Austria and Finland. With the exception of France, the former group are also the countries with a very strong pass-through to nominal wages and inflation, whilst the latter group only has a limited reaction of wages and prices. The correlation of the EPL indicator and the estimated responses of nominal wages and the GDP deflator is respectively 0.75 and 0.63, indicating that the strength of the wage reaction is related to the degree of labour market rigidity.

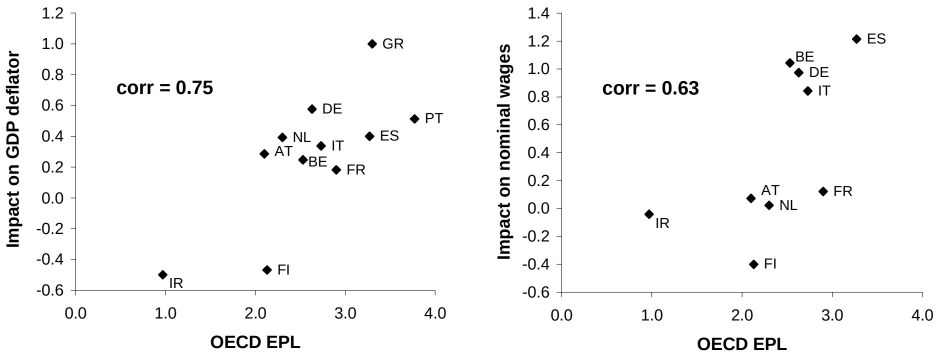

Figure 10. Strictness of employment protection legislation and second-round effects

Notes: Figures are median impact after 20 quarters of a 10 percent rise in oil prices, EPL is the OECD (2004) indicator of the strictness of employment protection legislation.

Calmfors and Driffill (1988) argue that the degree of coordination and centralisation of wage bargaining is crucial for real wage rigidity. Countries with wage setting at the level of individual firms are characterised by very limited power for unions and more flexible real wages. Also in highly centralised systems with national bargaining, the reaction of nominal wages is expected to be more moderate since strong unions will care more about the macroeconomic implications of their demands. On the other hand, when wage agreements are made at an intermediate level of centralisation, e.g. the sector level, unions typically ignore the macroeconomic consequences of their actions. Accordingly, second-round effects are more likely to occur. Berger and Everaert (2007) show that only in the latter group of countries, a labour tax increase results in increased unemployment, which indicates that exactly those countries succeed in shifting the burden of the tax increase to the producers, which is supported by the results found in Daveri and Tabellini (1997). The fact that all countries for which we find a significant reaction of nominal wages belong to this group, is certainly not at odds with this theory.

4.4. Single monetary policy stance and individual country divergence

Until now, we have found strong support for differences in labour market dynamics as a source of second-round effects and the asymmetric inflationary effects across individual Euro area countries. However, this still does not explain why we find a positive cross-country correlation between the impact on output and inflation. In order to explore this counterintuitive positive correlation, it is useful to compare the aggregate demand effects across member countries. Figure 11 presents the correlations for real GDP and its two most relevant components, real private consumption and real investment, which are also the ones that drive the area-wide output effects.

Despite a much smaller ratio of investment compared to consumption to total GDP (on average respectively 21% and 57%), the cross-country differences can be better explained by the responses of investment. Specifically, the correlation with the impact on real GDP is respectively 0.70 and 0.79 for private consumption and investment, and respectively 0.51 and 0.84 for the corresponding deflators with the GDP deflator. For the reaction of both GDP components, we find a positive correlation with their own deflator. However, also this correlation is much higher for investment compared to consumption, i.e. respectively 0.87 versus 0.36. These positive correlations indicate that the demand effects dominate the effects of rising wages and prices on the supply side.

But why do we find such different demand effects in individual Euro area countries? An important determinant should be asymmetric monetary policy effects. The latter already dominates the area-wide output response to an oil supply shock. This does not necessarily mean that the monetary transmission mechanism is different, for instance due to different financial structures. In particular, our estimated cross-country asymmetries do not correspond with the existing empirical literature on the impact of monetary policy shocks in Euro area countries. For example, we find the weakest output response in Germany whilst Peersman (2004) finds the strongest impact for a common monetary policy shock in Germany.

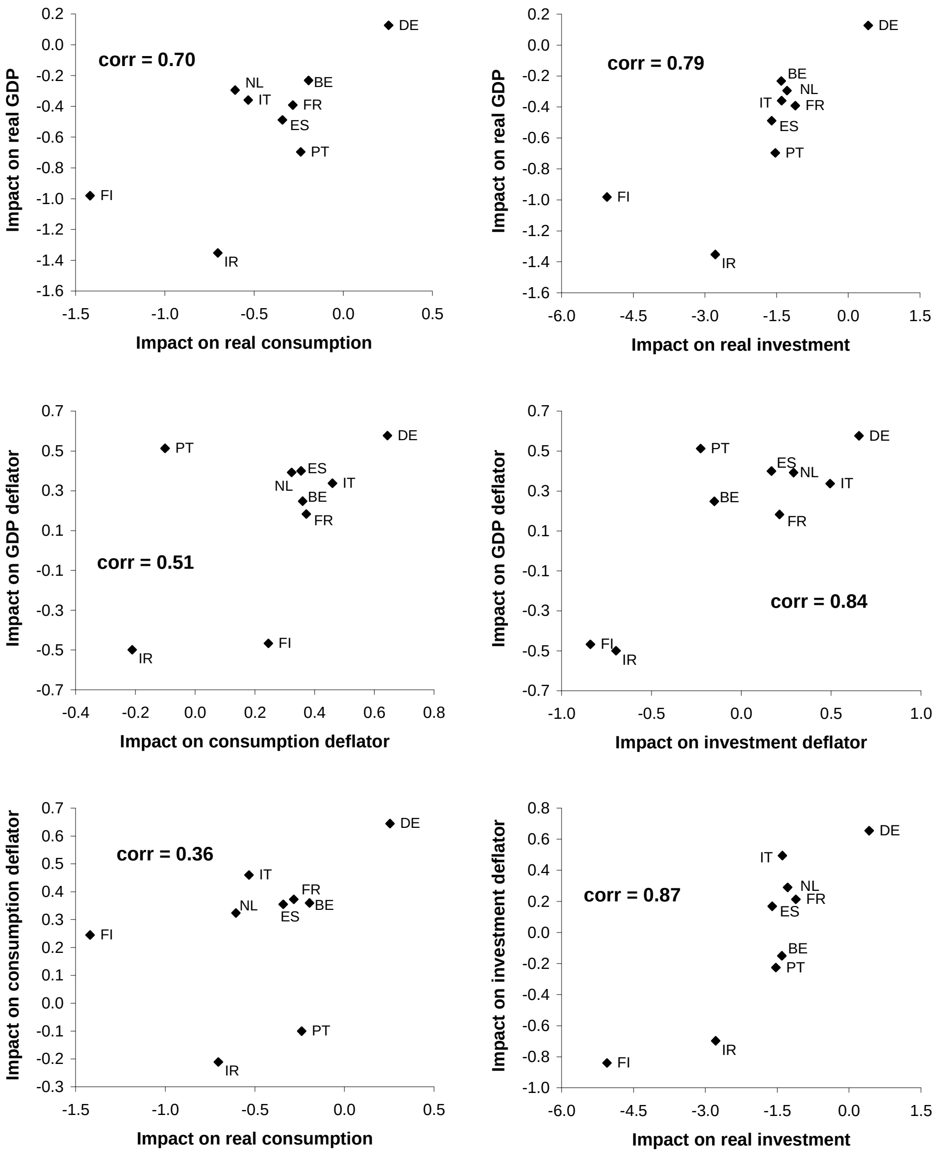

Figure 11. Demand effects in individual Euro area countries

Notes: Figures are median impact after 20 quarters of a 10 percent rise in oil prices

It is much more likely that the source of a different impact of a single monetary policy stance is exactly the cross-country asymmetric labour market reaction to an oil supply shock and the corresponding different effects on inflation, which we found in section 4.3. More specifically, since average inflation starts to rise in the Euro area and second-round effects are triggered, the ECB has no choice but to increase the interest rate. However, the magnitude of second-round effects and level of inflation are considerably different across individual member countries because of different labour market dynamics. Prices in some countries, for instance Finland and Ireland, do not react at all.

Consequently, these countries are confronted with a significant tightening of policy, reflected by a high real interest rate level, without having the need to reduce inflation. Restrictive monetary policy depresses economic activity which further reduces the inflation rate, leading to even higher real interest rates for these countries, which results in an amplification of the monetary policy effects. Conversely, for those countries that experience significant rises in wages and prices, such as Belgium, Germany, Italy and Spain, the monetary policy reaction is not very restrictive. The shift of the real interest rate is subdued, and consequently the output and inflation effects are moderate. This mechanism further aggravates the initial cross-country differences, resulting in a considerable divergence in the individual Euro area member countries. As a consequence, it is not surprising that the ultimate output and inflation effects across countries are positively correlated in contrast to the expected negative correlation. Improved competitiveness because of lower relative prices for the former group of countries does not compensate the monetary policy effects by increased exports, which is only logical given the worldwide fall in economic activity.

The magnitudes of the real interest rate shifts should not be underestimated. Between the second and eighth quarter after a 10 percent oil supply shock, the common nominal interest rate is continuously 20-30 basis points higher. The real interest rate based on the GDP deflator rises in a range of 10-15 basis points in countries like Germany, Italy and Spain (even a fall of the real rate in Greece). On the other hand, the real rate increases by 30-40 basis points in France, Finland and Ireland. A good rule of thumb for monetary policy effects is that a typical monetary policy shock which raises the real interest rate with on average 15 basis points the first four quarters after the shock, leads to a fall in economic activity by 0.2 percent in most Euro area countries (Peersman 2004). Given that the real interest rate reaction of some of the member countries is twice the size of a typical monetary policy shock and the increase itself is much more persistent, the estimated cross-country asymmetries do not come as a surprise.

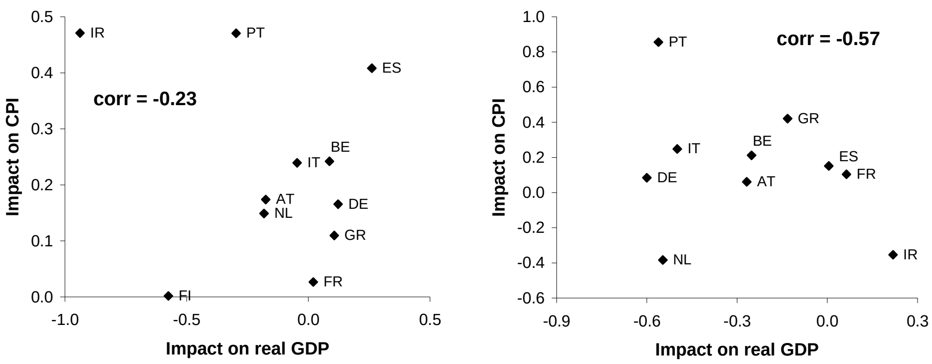

Figure 12. Impact in Euro area countries without a monetary policy reaction

Notes: Figures are median impact after 20 quarters of a 10 percent rise in oil prices, left panel contains impact when monetary policy is switched off in country-specific SVAR, right panel contains impact for an oil-specific demand shock.

As an alternative exercise to confirm our conjecture, we simulate the impact on output and inflation for all individual member countries by switching off the interest rate reaction, i.e. without a monetary policy response to the oil supply shock. The correlation between the effects on output and consumer prices across countries indeed becomes slightly negative, which is shown in the left panel of Figure 12. Whilst this experiment suffers from the Lucas critique, it nevertheless provides some support for our conclusions. Specifically, in the absence of a monetary policy reaction, the demand effects are not dominating the cross-country differences anymore. Another check we performed is an estimation of the individual country effects following an oil-specific demand shock. Also this test should be interpreted with caution. In particular, such a shock is not only hard to interpret, it is also accompanied by an appreciation of the euro which could influence individual countries differently, for example because of a different degree of openness. In addition, the responses of Euro area prices and wages are insignificant, which is also the case for most member countries. An oil-specific demand shock is, however, also characterised by a nominal interest rate which remains more or less constant (see section 2), i.e. there is no monetary policy reaction. For this shock, we find a correlation between the output and price reactions which is -0.57 (see panel B of Figure 12), implying that the dominance of the demand effect again disappears.

From this analysis, we can conclude that cross-country differences for the impact of oil supply shocks on output are driven by a common monetary policy stance which does not fit all. The source of these differences is an asymmetric reaction of wages and prices originating in the labour market. The different reaction of wages further aggravates the divergence of inflation and output across individual Euro area member countries. This finding is very robust and does not depend on our method or assumptions. First, when we take a slightly different approach by estimating all SVARs for the individual countries using a near-VAR system, as reported in the appendix, we find exactly the same conclusions. Second, our results do also not depend on the fact that part of our sample period is pre-EMU data. Specifically, we have also checked the robustness by adding the interest rate differential between the individual countries and the area-wide interest rate to the country-specific SVARs, which becomes zero from 1999 onwards. To measure the cross-country impact of oil supply shocks in the current monetary policy setting, we generated impulse responses without a reaction of this interest rate differential. Also this experiment does not affect the conclusion that one common monetary policy stance is suboptimal for many individual countries and creates considerable asymmetric reactions to an oil supply shock. Indeed, we observe that individual policy for some countries did deviate from the common policy response before 1999 to limit the divergence, i.e. there was a significant reaction of the interest rate differential.

4.5. A causal link between wages and prices - additional evidence

The high correlation between the reaction of nominal wages, GDP deflator and consumer prices across the member countries is still no guarantee that different labour market dynamics are the underlying source of the observed inflation differences. The causality could also run in the other direction. For example, countries confronted with higher inflationary effects due to a stronger direct impact of energy prices, could have a stronger wage reaction even when the labour market dynamics are the same, i.e. even if wages are indexed to increased prices in a similar proportion across countries. Moreover, both variables could be driven by a common third factor, for instance economic activity. A stronger fall in output for an individual country could constrain the price increase and also moderate wage growth because of reduced labour demand. In that case, asymmetric demand effects are the underlying source of cross-country differences and the different wage and price reactions a consequence of these effects. It is therefore important to illustrate the existence of a causal link going from wages to prices as a source of asymmetry. In section 4.3, we have already shown that specific labour market characteristics are consistent with the observed cross-country differences in wages and prices and a causal link from wages to prices.

To provide more formal evidence for the causality, we analyse the differences across sectors *within* countries, relying on the assumption that, for instance, inflation expectations are formed at the country level and labour market dynamics such as de facto indexation and bargaining power might be sector-specific in each country. More specifically, using data from the Eurosystem Wage Dynamic Network, we estimate the impact of an oil supply shock on output (real value added), prices (value added deflator) and wages (compensation per employee) for six different sectors in Belgium, Finland, France, Germany, Spain and Italy.[11] The estimation method is explained in appendix B. Figure 13 shows some revealing correlations, which provide additional support for a causal impact of wages on prices. The scatter plots show the estimated long-run effects of a 10 percent oil supply shock for all individual sectors, in which the impact is orthogonalised for country and sector-specific effects. In particular, we first regress the estimated effects on country and sector dummies. The residuals of this regression can be considered as the sectoral impact corrected for country and sector-specific effects.

Even after controlling for country-specific inflation effects or sector-specific demand effects, the correlation between the impact on wages and prices of the individual sector is very high at 0.70, as shown in the top-left panel of Figure 13. The absolute correlation, without a correction, is even 0.89 (not shown in the figures). Those sectors that experience a strong reaction of wages are also confronted with a larger impact on prices. Since this correlation is adjusted for country-specific effects such as inflation, the possibility of reversed causality is excluded. In other words, the positive correlation can not originate from the possibility that wages respond to inflationary pressures at the

[11] These sectors are respectively (i) agricultural, hunting, forestry and fishing products, (ii) total industry, (iii) construction, (iv) trade, repairs, hotels, restaurants, transport and communication, (v) financial intermediation and real estate, and (vi) other services. Since we use the value added deflator, cost effects are not part of it. There are 36 observations in total.

country level. Also demand effects which are country or sector-specific are corrected for. Hence, there must be a causal link going from wages to prices.

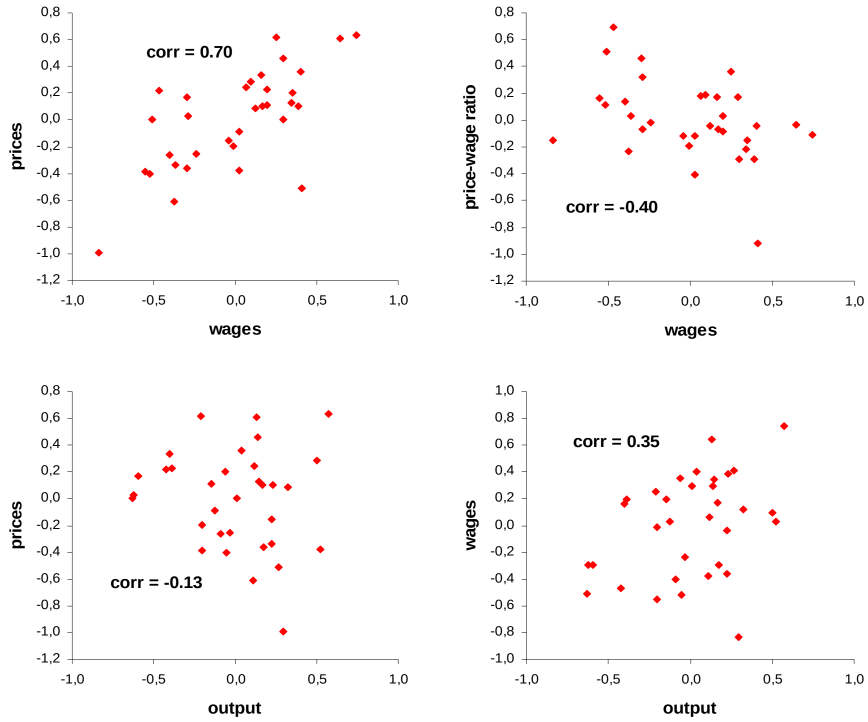

Figure 13. Impact of an oil supply shock in individual sectors of the Euro area

Notes: Impact after 20 quarters of a 10 percent rise in oil prices for 6 sectors in Belgium, Finland, France, Germany, Spain and Italy. The impact is orthogonalised for country-specific and sector-specific effects.

One can still argue that reversed causality or demand effects exist at the individual sector level within a country. For instance, some sectors might succeed to increase their prices more easily. Part of this rise might then be taken by employees via higher wages. Conversely, sectors which cannot increase their prices could partly transfer the fall in profit margins to their employees. If so, we should find a positive correlation between wages and the price-wage ratio at the sector level, which is clearly rejected by the data. The opposite is true: sectors with a greater reaction of wages are characterised by a fall in the price-wage ratio, as shown in the top-right panel of Figure 13. Particularly, sectors confronted with rising wages rather reduce their profit margins to limit the price change. Alternatively, some sectors might suffer a stronger fall in demand relative to other sectors within the country or similar sectors abroad, which could also lead to lower prices for firms and accompanying lower wages due to reduced labour demand. The positive correlation between wages and prices is then driven by the demand effect, without a causal link from wages to prices. After correcting for country and sector-specific effects, we indeed find a positive correlation between the responses of output and wages, i.e. sectors confronted with a stronger reduction in production also have a more subdued reaction of wages. However, the correlation is not very strong (0.35), which means that only part of the fall in demand is transmitted to the labour market. Furthermore, when demand effects determine both the reaction of wages and prices, also the correlation with prices should be significantly positive. The correlation between output and price responses, however, is insignificant and even slightly negative (bottom-left panel). As a consequence, also demand effects cannot explain why sectoral wages and prices move so strongly in the same direction after filtering for country and sector-specific effects. In sum, the significantly positive correlation between wages and prices must be the consequence of a causal link going from wages to prices. In particular, specific labour market dynamics can be considered as a source of asymmetric wage and price reactions to oil supply shocks.

5. CONCLUSIONS

In this paper, we have analysed the impact of different types of oil shocks on the Euro area economy and the exact pass-through to consumer price inflation. The oil transmission mechanism is compared with the US and differences across individual member countries are evaluated. Several policy implications are worth mentioning. First, the underlying source of the oil price shift is crucial to determine the economic consequences and appropriate monetary policy reaction. Conventional oil supply disturbances result in a fall of economic activity and persistent rise in consumer prices, confronting monetary authorities with a trade-off between price stability and output stabilisation. Also oil-specific demand shocks temporarily depress economic activity, but the impact on inflation is very limited due to an accompanying appreciation of the euro exchange rate vis-à-vis the US dollar. The limited impact on inflation, however, should give the ECB more room to stabilise economic activity. On the other hand, oil price shifts due to increased worldwide economic activity have a strong positive impact on Euro area inflation, but also output rises temporarily. Accordingly, policymakers do not face a trade-off, which allows for a strong interest rate reaction.

The transmission mechanism of oil shocks to headline inflation in the Euro area is worrisome. In contrast to the US, the most important channel turns out to be second-round effects of rising wages which are partly passed on by firms to higher prices. Such a wage-price spiral triggers very persistent inflationary effects, which can only be halted by a significant tightening of policy. Consider the recent financial crisis. Whereas the FED started to decline the interest rate from August 2007 onwards, the ECB waited until October 2008 due to remaining second-round effects of surges in energy and food prices, despite weakening of economic activity (ECB 2008b). During this period, the Governing Council frequently expressed its concern about the existence of schemes in which nominal wages are indexed to consumer prices in some countries and even called for these to be abolished. Indeed, we showed that such schemes involve the risk that upward shocks in inflation lead to harmful second-round effects, which can be avoided. In the absence of second-round effects, there will still be an impact of oil shocks on inflation due to direct and cost effects. However, both effects only result in a permanent shift of the consumer price level. Since there is no persistent rise in inflation, inflation expectations are well anchored, and a monetary tightening would not be required.

The direct and indirect effects of unfavourable oil supply shocks, however, cannot be considered as the only reason for frequently missing the inflation objective since the introduction of the euro. Our evidence shows that, at times, inflation would even have been more above the target in the absence of favourable oil price shocks. Looking ahead, the estimations also suggest that the considerable fall in oil prices since mid-2008 should contribute to a long-lasting significant reduction in inflation, which increases the risk of falling in a deflation zone. A relevant question in this context is whether inflationary effects of oil shocks are symmetric. In particular, we have assumed symmetry in all our estimations, i.e. the effects of rising and falling oil prices are of a similar magnitude. Especially when downward rigidity of nominal wages exists, this is not necessarily the case for second-round effects, which is something to be explored in future research.

The pass-through of oil prices is also very different across individual Euro area countries. In particular, due to different labour market dynamics, the reaction of wages, inflation and consequently also the role of second-round effects is substantially different. This asymmetric impact of oil shocks lies at the heart of the optimum currency area literature and is a serious concern for policymakers. It is very likely that similar cross-country differences will also appear when the Euro area is confronted with other common shocks on the supply side of the economy. A single monetary policy stance is only acceptable if countries react in a similar way to macroeconomic disturbances. For the ECB, there is no alternative, they have to increase the interest rate to stabilise area-wide inflation because of second-round effects. This common monetary policy reaction clearly does not fit all individual member countries and leads to considerable divergence, which justifies the concern of the ECB about the existence of automatic wage indexation mechanisms. This also applies for the enlargement of EMU. Some countries that recently joined, e.g. Cyprus, Malta and Slovenia also have a high degree of automatic wage indexation that could even lead to more divergences.

Enhanced credibility could help to improve discipline on labour markets and reduce second-round effects, but it is clear that more labour market convergence and coordination between the member countries is a crucial condition to limit the losses of a common currency. Only when wages respond similarly to the common shock, one monetary policy stance is appropriate. A sufficiently high degree of labour market convergence requires more than institutional changes with respect to automatic wage indexation schemes. De facto indexation or real wage rigidity also depends on labour market conditions such as the level of bargaining coordination, the degree of employment protection or tightness of the market. We have found support that such characteristics matter for the existence of second-round effects. Also product market integration could enhance labour market integration, in particular wage convergence (Andersen et al., 2000). Firms have more power when they can relocate production costs across borders and increased competition should enforce labour market flexibility and wage moderation following unfavourable oil shocks.

APPENDIX A: DATA SOURCES AND DEFINITIONS

Data on all oil-related variables are obtained from the Energy Information Administration (EIA) and the International Energy Agency (IEA). The oil price variable we use is the refiner acquisition cost of imported crude oil, which is in the literature considered as the best proxy for the free market global price of imported crude oil. The world industrial production index is taken from Baumeister and Peersman (2008b) and is calculated as a weighted average of industrial production of a large set of individual countries, including for instance China and India.

All Euro area data are collected from an updated version of the Area Wide Model (AWM) dataset, see Fagan et al. (2001). The most recent two data points of the AWM dataset were updated using Eurostat data. Prices are captured by the HICP. Only the Euro area HICP components were retrieved from the OECD Main Economic Indicators (OECD MEI) database, which were backdated from 1990Q1 to 1985Q1 using individual country data. The OECD MEI database also provided data on CPI, CPI components and real GDP at individual country level. US CPI, CPI components and their weights in total CPI were collected from the Bureau of Labor Statistics (BLS), real GDP and the GDP deflator from the Bureau of Economic Analysis (BEA) and the federal funds rate from Federal Reserve Economic Data (FRED). The euro-dollar bilateral exchange rate was obtained from Eurostat, as well as the countries' CPI component weights. The GDP components and their deflators were retrieved from the OECD Economic Outlook (OECD EO) dataset for the individual Euro area countries as well as for the US. The series for Germany from this dataset were backdated from 1991Q1 to 1985Q1 using the growth rate of the series for West-Germany and Italian real investment had to be proxied by the growth rate of the difference between real GDP and the remaining GDP components. In addition, the OECD EO dataset supplied data on interest rates, employment and compensation of employees. For countries for which compensation data is missing in that dataset, series were taken from OECD MEI. The Eurosystem Wage Dynamic Network (WDN) database provided the EMU countries' GDP deflators, except for Austria which was taken from International Financial Statistics IMF data. The sector analysis data used in the paper was also collected from the WDN. Throughout the data collection process, data at monthly frequency were transformed to quarterly data by taking monthly averages. Except for the interest rate and the exchange rate, all data have been seasonally adjusted.

APPENDIX B – SVAR MODELS AND IMPLEMENTATION

Benchmark SVAR model

The economic effects of oil shocks reported in this paper are analysed using a structural VAR model. The benchmark VAR for the Euro area has the following representation:

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = c + A(L) \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + B \begin{bmatrix} \varepsilon_t^X \\ \varepsilon_t^Y \end{bmatrix}$$

The endogenous variables of the benchmark VAR can be divided into two groups. The first group of variables, X_t, contains world oil production (Q_{oil}), nominal crude oil prices expressed in US dollars (P_{oil}) and world industrial production (Y_{wd}). These variables are included to capture supply and demand conditions in the global oil market. The other group of variables, Y_t, are specific for the Euro area, i.e. real GDP (Y_{EA}), consumer prices (P_{EA}), the nominal short-term interest rate (i_{EA}) and the euro-dollar exchange rate ($S_{€/\$}$). c is a matrix of constants and linear trends, *A(L)* is matrix polynomial in the lag operator *L*, and *B* the contemporaneous impact matrix of the vectors of mutually uncorrelated disturbances ε_t^X and ε_t^Y. Specifically, ε_t^X is a vector which contains the three types of oil shocks described in the main text, i.e. oil supply shocks, oil-specific demand shocks and shocks to global economic activity, and ε_t^Y are four shocks specific to the Euro area.

For the US, exactly the same VAR is estimated by replacing Euro area real GDP, consumer prices and the nominal interest rate by the US equivalents. Since no significant cointegration relation was found in the benchmark model, all variables are transformed to growth rates by taking the first difference of the natural logarithms, except for the interest rate which remains in levels. Throughout the paper, the impulse response functions of the variables estimated in first differences are accumulated and shown in levels. Based on standard likelihood ratio tests and the usual lag-length selection criteria, we include three lags of the endogenous variables, which appears to be sufficient to capture the dynamics of oil shocks on the macro variables. The benchmark VAR model is estimated using quarterly data for the sample period 1986Q1-08Q1. The results are however robust to different choices of lag length, to reasonable changes in the sample period, alternative oil price measures such as real crude oil prices (deflated by US GDP deflator) or WTI spot oil prices, and different indicators of worldwide economic activity such as the global industrial production index produced by the OECD.

It is not possible to estimate the contemporaneous impact matrix *B* and therefore identify the structural innovations ε_t^X and ε_t^Y without further assumptions. In particular, since the structural shocks are mutually orthogonal, the variance-covariance matrix of a reduced form estimation of the VAR is $\Omega = BB'$. Given Ω, there are an infinite number of possible *B*. In the traditional SVAR literature, some conventional 'zero' restrictions are introduced to exactly estimate *B*. In the more recent literature, also sign restrictions are used for identification. In this case, only a set of possible *B* are considered conditional on fulfilling a number of sign conditions. This is the approach we follow in this paper. Peersman (2005) shows how to generate all possible decompositions. We first assume that contemporaneous fluctuations in oil production, oil prices and global economic activity are only driven by the three different types of shocks, which corresponds to restricting *B* to be block lower triangular. Since we are only interested in the impact of ε_t^X, we do not need to further identify the components of the lower block ε_t^Y. To uniquely disentangle the three types of shocks in the upper block ε_t^X , we implement the sign restrictions which are explained in section 2.1. We impose the sign restrictions to hold the first four quarters after the shocks, which is standard in the literature. More specifically, as in Peersman (2005), we use a Bayesian approach for estimation and inference. Our prior and posterior distributions of the reduced form VAR belong to the Normal-Wishart family. To draw the 'candidate truths' from the posterior, we take a joint draw from the unrestricted Normal-Wishart posterior for the VAR parameters as well as a random possible block lower triangular decomposition *B* of the variance-covariance matrix, which allows us to construct impulse response functions. If the impulse response functions from a particular draw satisfy the imposed sign conditions, the draw is kept. Otherwise, the draw is rejected by giving it a zero prior weight. We require each draw to satisfy the restrictions of all three shocks simultaneously. Note that the restrictions are only imposed on the impulse responses of the global oil market variables X_t, the responses of all other variables are fully determined by the data. Finally, a total of 1000 'successful' draws from the posterior are used to show the median, 84th and 16th percentiles in the figures. For ease of comparison, the identified shocks are normalised to increase the price of oil contemporaneously by 10 percent. The results can be found in Figure 2.

Extensions of the benchmark SVAR model

For all other estimations in the paper, for instance for the estimation of the impact on several price measures or the individual country estimates, the benchmark VAR is extended as follows:

$$\begin{bmatrix} X_t \\ Y_t \\ Z_t \end{bmatrix} = c + A(L) \begin{bmatrix} X_{t-1} \\ Y_{t-1} \\ Z_{t-1} \end{bmatrix} + B \begin{bmatrix} \varepsilon_t^X \\ \varepsilon_t^Y \\ \varepsilon_t^Z \end{bmatrix}$$

X_t and Y_t always contain the seven benchmark variables as described above. The only exceptions are the estimations for the GDP deflator, the deflators of the GDP-components and the price-wage ratio. In these cases, the consumer price index is simply replaced by the deflator. Z_t is a vector containing one or more variables to capture a specific channel or the country-specific effects. Estimation and inference are exactly the same as for the benchmark model. We still assume a block recursive structure for *B*, i.e. the global oil market variables are contemporaneously only influenced by the three types of shocks. Note that the extended SVAR model allows for a feedback from the variables in the additional block Z_t to the benchmark variables in X_t and Y_t via the coefficient matrix *A(L)*. As a result of this feedback, the estimated magnitude and dynamics of the oil supply shock might slightly change across different specifications, which could affect comparability. That is why we always show the impact of an oil supply shock which raises the oil price by 10 percent. However, imposing strict exogeneity, by restricting the feedback of Z_t on the benchmark variables X_t and Y_t to be zero, and estimating a so-called near-VAR, does not affect the results and story of the paper. Comparing the estimation results between different model specifications after a normalised 10 percent oil price increase can therefore easily be done.

For the extended SVAR-models for the Euro area and US, estimated in section 3, Z_t each time includes one variable of interest which should capture a specific channel. Estimations are done for respectively CPI-energy, core CPI, the import deflator, nominal wages, real wages, unemployment, the price-wage ratio, and all GDP components. The resulting impulse responses are shown in figures 4, 5 and 6.

For the individual Euro area countries, inflationary and output effects are each time estimated by including both country CPI (or GDP deflator) and real GDP in Z_t. All estimated responses of additional country variables, e.g. wages and GDP components, are obtained by adding the specific variable each time as a third variable to Z_t. The impulse response functions of CPI, the price components and wages of the EMU member countries are shown in Figure A1, and the estimated responses of real GDP and its components are displayed in Figure A2. In these figures, for respectively CPI and real GDP, we also include the difference of the country-specific response with the area-wide response and the accompanying error bands. We also generated responses for bilateral differences between all countries, not reported in the paper. These turn out to be significant for many country pairs. The long-run effects for all individual country variables, i.e. after twenty quarters, are reported in Table 1 and Figures 7-12.

Since our sample period includes pre-EMU data, we performed an additional robustness check by also including the difference of the country-specific interest rate with the common interest rate in Z_t for the individual country estimations. This difference should capture individual country monetary policy deviations from the common stance before 1999, which could otherwise bias the estimated interest rate coefficients. This deviation automatically becomes zero from 1999 onwards. To replicate the current single monetary policy framework, impulse responses are then generated by switching-off the reaction of this differential. This exercise does also not affect our conclusions, in particular the finding that one single monetary policy stance does not fit all. For some countries, the reaction of this differential to an oil supply shock turns out to be significant. This means that policy in some countries indeed deviated from the common interest rate reaction before 1999 to limit the divergence.

Finally, also the individual sector estimations of section 4.5 are done in a similar way. In particular, value added, nominal wages and the value added deflator of the specific sector under consideration are included in Z_t. Due to data availability, the sector models are estimated over a shorter sample period, i.e. 1987Q1-05Q4, and the number of lags is reduced to two. The sector correlations shown in Figure 13 are filtered for country and sector-specific characteristics by regressing the long-run response resulting from these sector-VAR estimations on a set of country and sector-specific dummies, and using the orthogonalised residuals for the correlations.

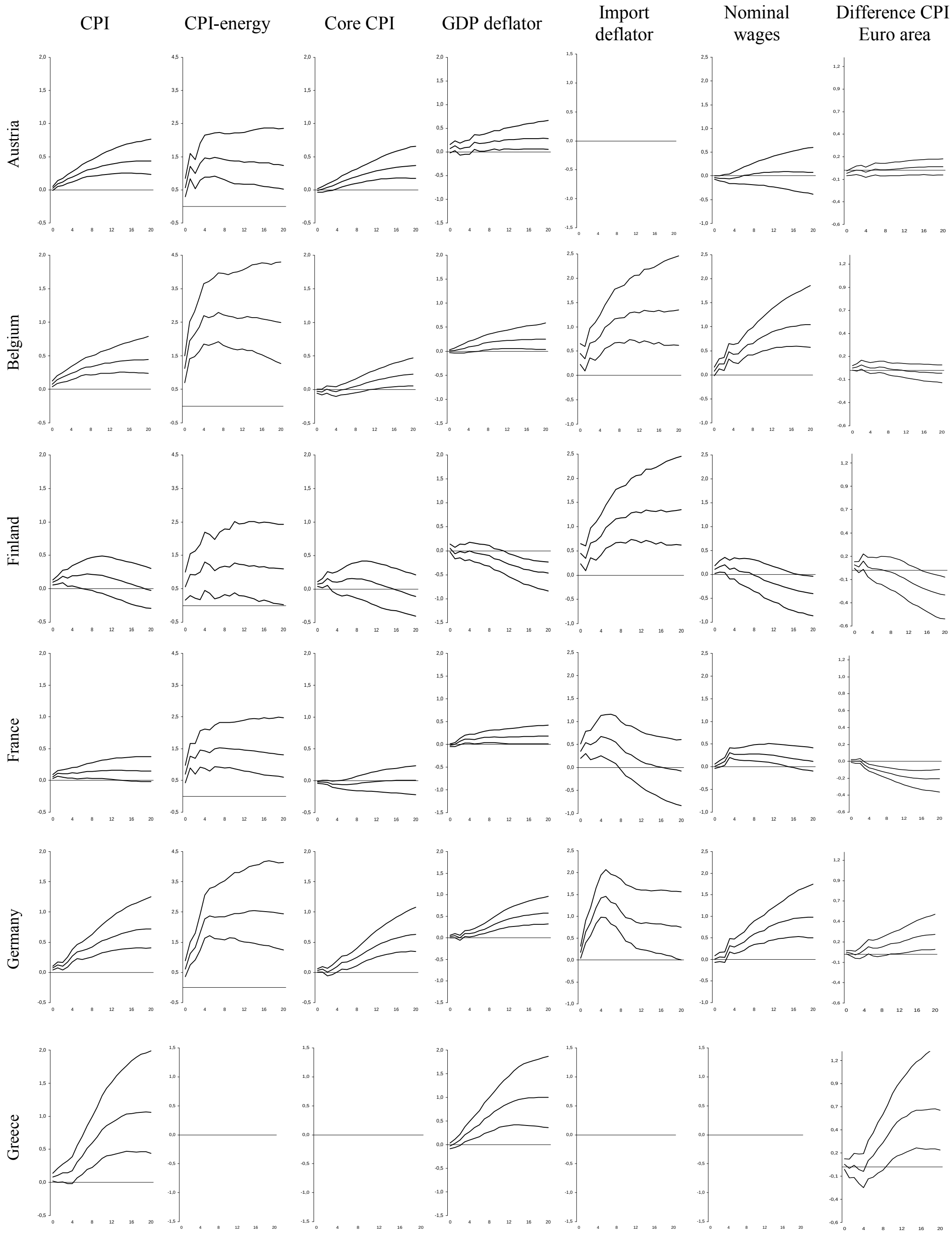

Figure A - 1. Impact of oil supply shock on price components and wages

Notes: Figures are median impulse responses to a 10 percent contemporaneous rise in oil prices, together with 16th and 84th percentiles error bands, horizon is quarterly.

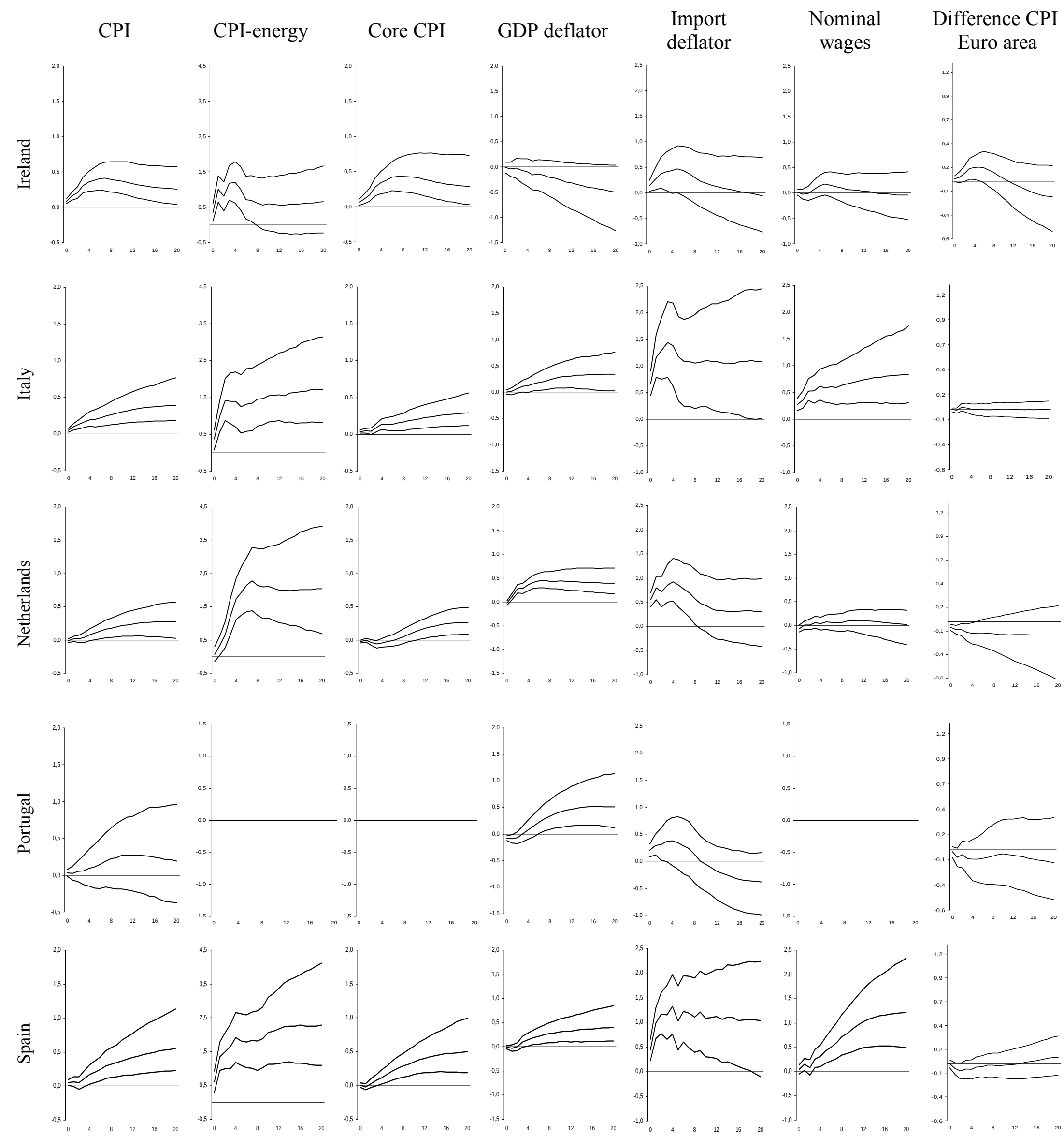

Figure A – 1(continued). Impact of oil supply shock on price components and wages

Notes: Figures are median impulse responses to a 10 percent contemporaneous rise in oil prices, together with 16th and 84th percentiles error bands, horizon is quarterly.

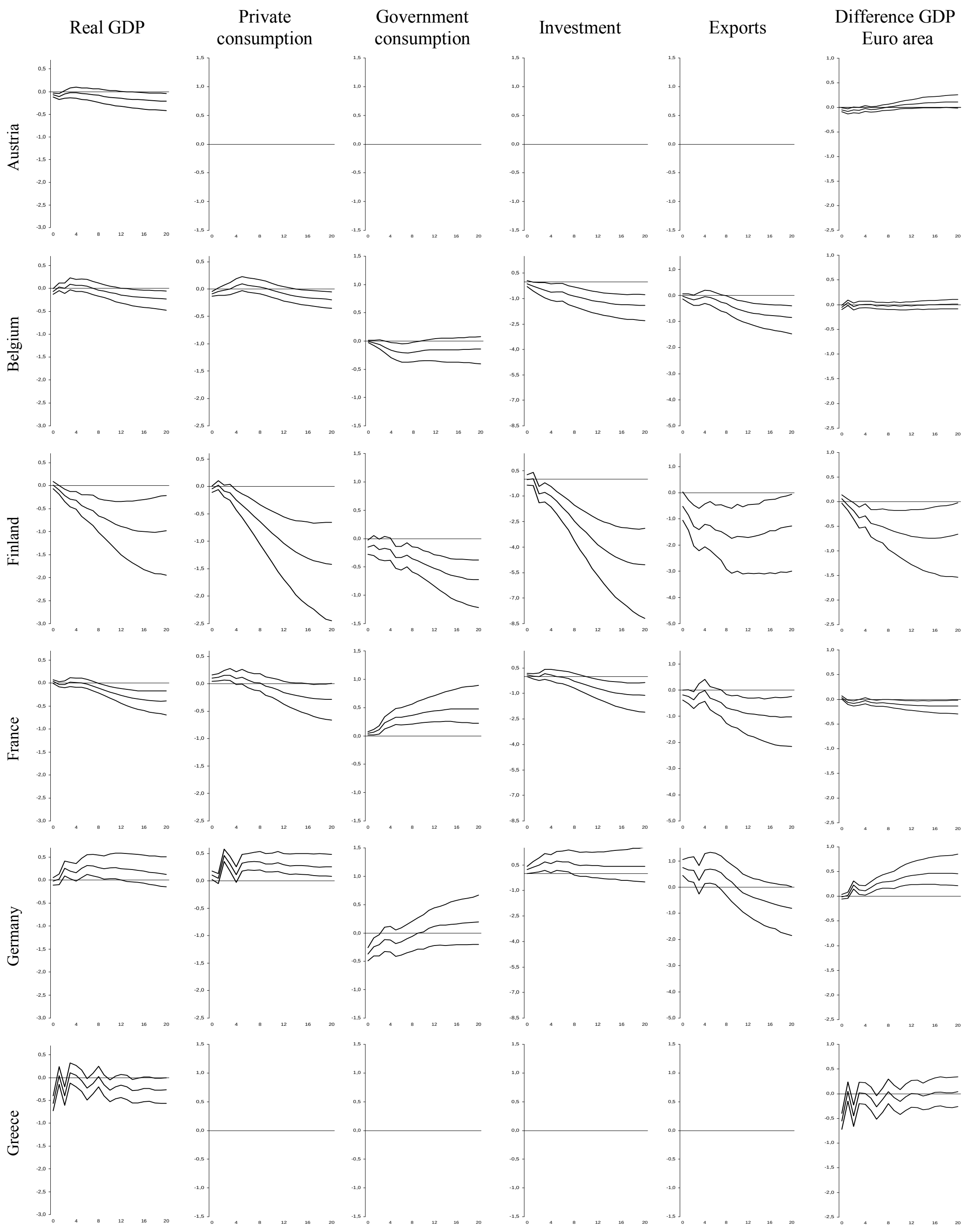

Figure A - 2. Impact of oil supply shock on the real GDP components

Notes: Figures are median impulse responses to a 10 percent contemporaneous rise in oil prices, together with 16th and 84th percentiles error bands, horizon is quarterly.

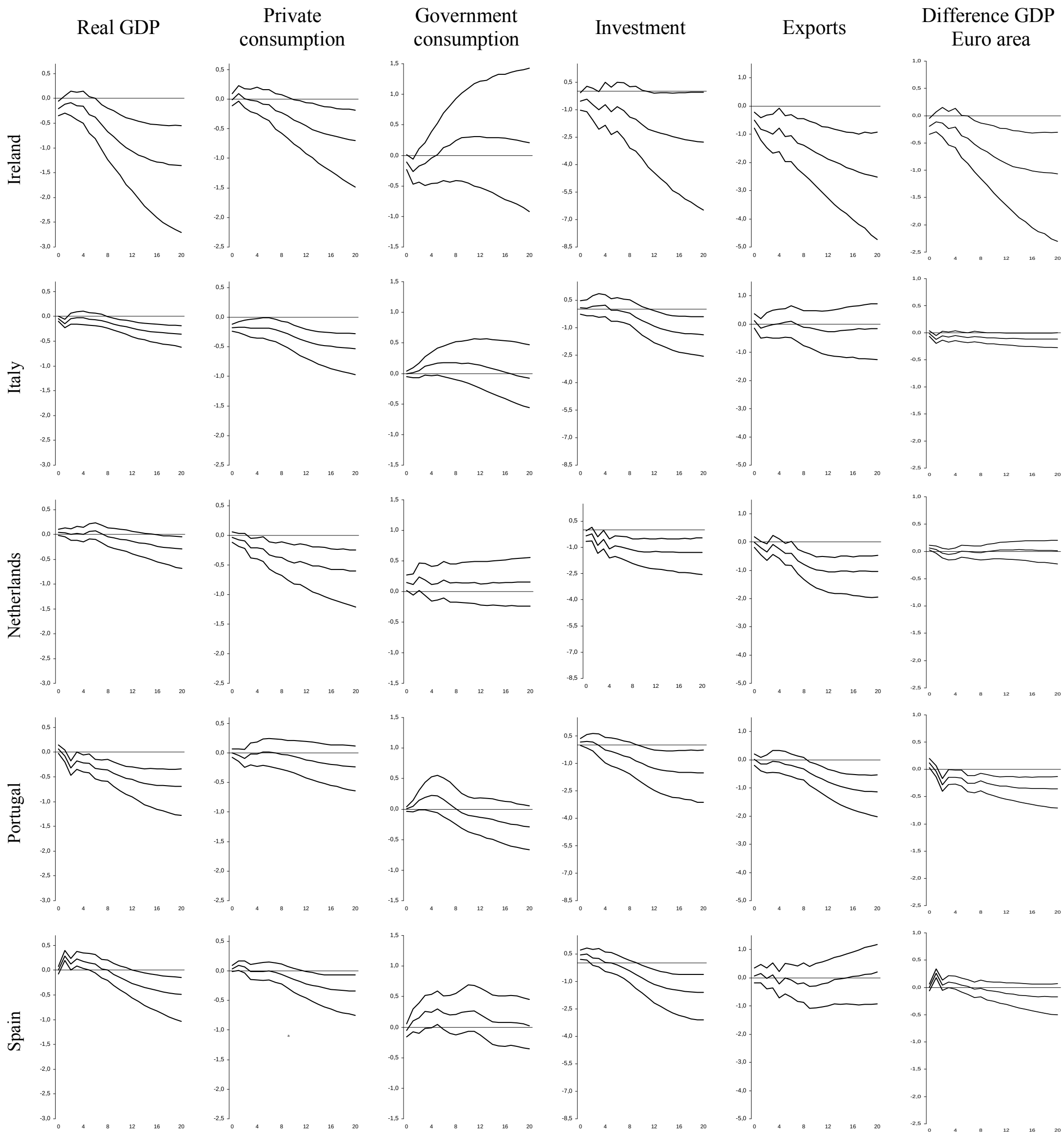

Figure A – 2(continued). Impact of oil supply shock on the real GDP components

Notes: Figures are median impulse responses to a 10 percent contemporaneous rise in oil prices, together with 16^{th} and 84^{th} percentiles error bands, horizon is quarterly.

REFERENCES

Andersen, T., N. Haldrup and J. Sorensen (2000), 'Labour market implications of EU product market integration', *Economic Policy*, 15(30), 106-133.

Barsky, R.B. and L. Kilian (2002), 'Do We Really Know that Oil Caused the Great Stagflation? A Monetary Alternative', *NBER Macroeconomics Annual 2001*, B.S. Bernanke and K. Rogoff (eds.), MIT Press, Cambridge, MA, 137-183.

Baumeister, C. and G. Peersman (2008a), 'Time-Varying Effects of Oil Supply Shocks on the US Economy', *mimeo*, Ghent University.

Baumeister, C. and G. Peersman (2008b), 'Sources of Oil Price Fluctuations in a Time-Varying Framework', *mimeo*, Ghent University.

Berger, T. and G. Everaert (2007), 'Labour Taxes and Unemployment Evidence from a Panel Unobserved Component Model', *Ghent University Working Paper No. 478.*

Bernanke, B. (1983), 'Irreversibility, Uncertainty and Cyclical Investment', *Quarterly Journal of Economics*, 97(1), 86-106.

Bernanke, B.S., M. Gertler and M. Watson (1997), 'Systematic Monetary Policy and the Effect of Oil Price Shocks', *Brooking Papers on Economic Activity*, 1, 91-157

Calmfors, F. and J. Driffill (1988), 'Bargaining Structure, Corporatism and Macroeconomic Performance', *Economic Policy*, 3(6), 13-61.

Daveri, F. and G. Tabellini (1997), 'Unemployment, Growth and Taxation in Industrial Countries', *Economic Policy*, 15(30), 47-104.

Davis, S.J. and J. Haltiwanger (2001), 'Sectoral Job Creation and Destruction Responses to Oil Price Changes", *Journal of Monetary Economics*, 48(3), 465-512.

Du Caju, P., E. Gautier, D. Momferatou and M. Ward-Warmedinger (2008), 'Institutional Features of Wage Bargaining in 22 EU Countries, the US and Japan', *European Central Bank*

ECB (2004), 'The Monetary Policy of the ECB', *European Central Bank*.

ECB (2008a), 'Wage Indexation Mechanisms in Euro Area Countries', *Monthly Bulletin*, May, 51-52.

ECB (2008b), 'Editorial', *Monthly Bulletin*, October, 5-7.

Edelstein, P. and L. Kilian (2008), 'How Sensitive are Consumer Expenditures to Retail Energy Prices?', *mimeo*, University of Michigan.

Fagan, G., J. Henry and R. Mestre (2001), 'An Area-Wide Model (AWM) for the Euro Area', *ECB Working Paper No. 42.*

Hamilton, J.D. (2003), 'What is an Oil Shock?', *Journal of Econometrics*, 113(2), 363-398.

Hamilton, J.D. (2008), 'Oil and the Macroeconomy', in S. Durlauf and L. Blume (eds.), *The New Palgrave Dictionary of Economics*, 2nd edition, Palgrave Macmillan.

Hooker, M.A. (2002), 'Are Oil Shocks Inflationary? Asymmetric and Nonlinear Specifications versus Changes in Regime', *Journal of Money, Credit, and Banking*, 34(2), 540-561.

Kilian, L. (2008a), 'Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market', *American Economic Review*, forthcoming.

Kilian, L. (2008b), 'The Economic Effects of Energy Price Shocks', *Journal of Economic Literature,* forthcoming.

OECD (2004), 'OECD Employment Outlook', *OECD*

Peersman, G. (2004), 'The Transmission of Monetary Policy in the Euro Area: Are the Effects Different Across Countries?', *Oxford Bulletin of Economics and Statistics,* 66(3), 285-308.

Peersman, G. (2005), 'What Caused the Early Millennium Slowdown? Evidence Based on Vector Autoregressions', *Journal of Applied Econometrics*, 20, 185-207.

Rotemberg, J.J. and M. Woodford (1996), 'Imperfect Competition and the Effects of Energy Price Increases on Economic Activity', *Journal of Money, Credit, and Banking*, 28(4), Part 1, 549-577.