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WORKING PAPER

The Economic Consequences of Oil Shocks: Differences Across Countries and Time

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The Economic Consequences of Oil Shocks: Differences Across Countries and Time*

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We examine the economic consequences of oil shocks across a set of industrialised countries over time. First, we show that knowing the underlying reason for a change in oil prices is crucial to determine the economic repercussions and the appropriate monetary policy reaction. For oil demand shocks driven by global economic activity, all countries experience a temporary increase in real GDP following an oil price increase, while for oil-specific demand shocks all countries experience a temporary decline in real GDP. The effects of exogenous oil supply shocks are, however, very different across countries when oil prices increase. Whereas net oil and energy-importing countries all face a permanent fall in economic activity following an adverse supply shock, the impact is insignificant or even positive for net-energy exporters. Second, the pass-through to inflation turns out to differ considerably across oil-importing countries and strongly depends on the existence of second-round effects via increasing wages. Third, we investigate how the dynamic effects have changed over time. We document a much less elastic oil demand curve since the mid-1980s, which seriously distorts intertemporal comparisons. However, we demonstrate that countries which improved their net-energy position the most over time became relatively less vulnerable to oil shocks compared to other countries.

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1. Introduction

The interaction between oil and macroeconomic performance has long attracted attention in the economic literature.[1] This interest dates back to the 1970s. As shown in Figure 1, the 1970s and early 1980s were characterised by large oil price spikes. Unfavourable oil supply shocks are frequently considered to have been the underlying source of worldwide macroeconomic volatility and stagflation during that period (see for example Blinder and Rudd 2008). The long-standing debate surrounding the relationship between oil and the macroeconomy has recently intensified in light of dramatic oil price fluctuations. Specifically, while the price of crude oil hovered around US$12 a barrel at the beginning of 1999, the price shot up to US$133 by the middle of 2008 and collapsed to US$39 in early 2009. In this paper, we examine the macroeconomic effects of oil shocks across a set of industrialised countries that are structurally diverse in terms of size, labour market characteristics, monetary policy regimes, and the role of oil and other forms of energy in the economy: Australia, Canada, the euro area, Japan, Norway, Switzerland, the United Kingdom and the United States. We analyse the interaction between oil and the macroeconomy from three different perspectives which can provide valuable insights for monetary policy.

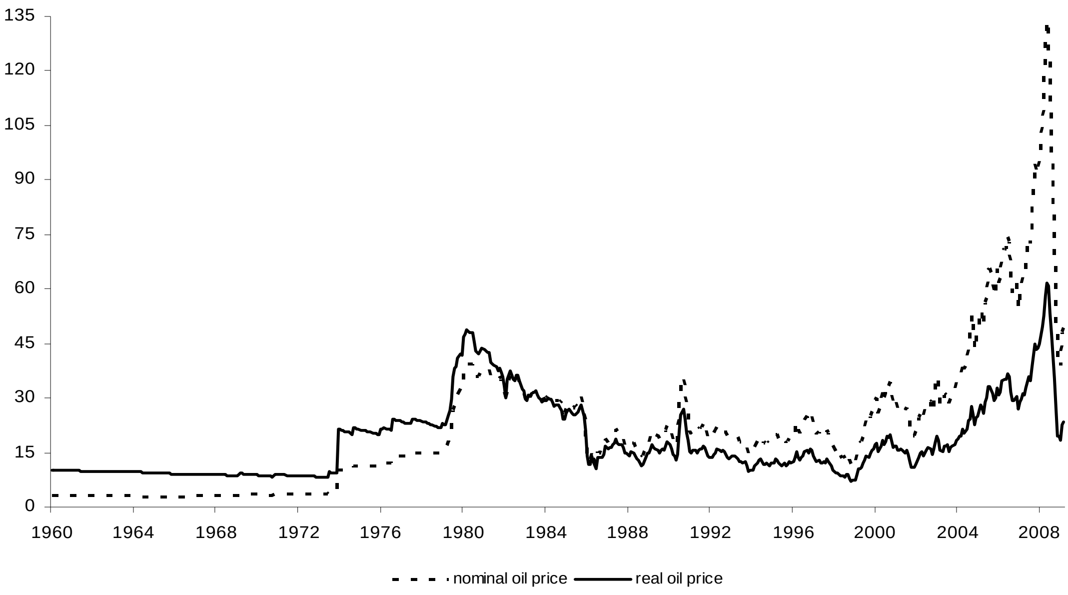


Figure 1. Evolution of the nominal and real price of crude oil
Notes: The oil price is the monthly average price of West Texas Intermediate in US dollars, real oil prices are deflated using US monthly CPI data.

[1] Hamilton (1983) is the seminal academic contribution. For recent overviews, see Hamilton (2009a) and Kilian (2008).

First, we assess the economic repercussions of several types of oil shocks. Understanding the consequences of different oil shocks is important for formulating an appropriate policy response. It is likely that these consequences depend on the source of the oil price shift and differ across countries. Indeed, recent studies by Kilian (2009) and Peersman and Van Robays (2009a) have shown that the effects on the US and the euro area economy vary considerably depending on the source of oil price movements. For example, exogenous disruptions in the supply of crude oil that lead to higher oil prices are expected to result in depressed economic activity and rising inflation in oil-importing countries. Alternatively, oil prices can rise because of increased demand for oil which could reflect worldwide economic expansion or precautionary motives, with potentially different effects on output.

The repercussions of oil shocks for oil-exporting countries are less clear since rising oil prices imply higher oil export revenues in an inelastic market. Further, countries that export non-oil forms of energy could be affected by oil disturbances in a different way. Since the prices of alternative sources of energy typically rise with the price of crude oil due to substitution, oil-importing countries that produce and export other forms of energy could potentially benefit from soaring oil prices through an increased demand for their oil substitutes (Peersman and Van Robays 2009b).

In Section 2 of the paper, we investigate the extent to which the cause of the oil price increase matters for the dynamic effects across countries. Within a structural VAR framework, a distinction is made between exogenous disruptions to oil supply, oil demand shocks driven by a thriving global economy and oil-specific demand shocks, which could be the result of speculative activities or precautionary buying. We demonstrate different consequences depending on the underlying source of oil price shifts. After an unfavourable oil supply shock, oil and energy-importing countries face a permanent fall in economic activity, while the impact is insignificant or even positive in net energy-exporting countries. Inflationary effects are also smaller in the latter group, which can be explained by an appreciation of their exchange rates. On the other hand, the dynamic effects of oil demand shocks driven by global economic activity and oil-specific demand shocks turn out to be much more similar across countries. In particular, for all countries, we find a transitory increase in real GDP after a global activity shock, whereas output temporarily declines following an oil-specific demand shock.

Second, we examine the transmission mechanism through which oil shocks affect inflation and economic activity. Direct effects on the general price level through rising energy prices are expected at short horizons because energy prices are a component of the consumer price index. However, additional inflationary effects may arise as higher energy input costs or higher wage demands feed through to consumer prices. These indirect effects are more delayed than the direct effects and can thus be influenced by the monetary policy reaction. For this reason it is crucial for a forward-looking central bank to understand the transmission of oil shocks to inflation so that it can implement appropriate policy.

Following Peersman and Van Robays (2009a), we assess the quantitative importance of individual channels for all the oil-importing countries in Section 3. Consistent with the results of Peersman and Van Robays (2009a), we find that the direct effects of rising energy prices on consumer prices are significant for all countries, whereas additional indirect effects vary substantially, in particular the second-round effects. The latter are sizeable in the euro area and Switzerland, mild in Japan and absent in the United States. As a consequence, the speed and magnitude of the pass-through to consumer prices is also very different for these countries.

Finally, we investigate whether the dynamic effects of oil shocks have changed over time. On the one hand, the evolution of the monetary policy framework could explain the weaker effect of recent oil price changes. Other leading explanations for this resilience include a declining share of oil in the economy, more flexible labour markets, changes in the composition of automobile production and the overall importance of the automobile sector (see for example Blanchard and Galí 2007, Bernanke 2006 and Edelstein and Kilian 2009). On the other hand, the oil market itself has gone through a series of structural changes that could affect macroeconomic interactions. Lee, Ni, and Ratti (1995) and Ferderer (1996) attribute the instability of the empirical relationship between oil prices and economic activity to the increased oil price volatility since the mid-1980s. Baumeister and Peersman (2008) provide evidence of a considerably less elastic global oil demand curve over time. Accordingly, more recent oil supply shocks are characterised by a much smaller impact on world oil production and a greater effect on oil prices compared to the 1970s and early 1980s, which can also bring about time-varying effects.

The steepening of the oil demand curve, as argued by Baumeister and Peersman (2008), distorts empirical comparisons of macroeconomic effects over time. By estimating the effect of exogenous oil supply shocks before and after the mid-1980s, in Section 4 we demonstrate that the choice of normalisation is crucial in concluding whether the economic consequences of oil shocks have changed. In particular, when an oil supply shock is measured as a similar shift in oil prices (for example a 10 per cent rise), the impact on real GDP and inflation becomes smaller over time, which is in line with the existing evidence comparing the impact of oil price shocks over time (for example Blanchard and Galí 2007, Edelstein and Kilian 2009 and Herrera and Pesavento 2009). However, normalising on a similar oil price increase implicitly assumes a constant elasticity of oil demand over time, which is rejected by the data. In particular, the shift of the oil supply curve needed to generate for example a ten per cent oil price increase is much smaller in more recent periods compared to the 1970s and early 1980s. When a typical one standard deviation oil supply shock is considered, the impact in many countries has not changed significantly over time. Whether the underlying magnitude of such an average oil shock has changed can unfortunately not be identified.

The cross-country dimension of our analysis, however, should allow us to explore the sources of time variation. Specifically, while all economies experienced a fall in oil intensity, the magnitudes have varied; some countries switched from being net-oil importers to net-oil exporters over time (for example Canada and the United Kingdom). Accordingly, we can evaluate the relevance of the dependence on oil and other forms of energy by comparing the relative changes between countries across time. This exercise does not suffer from a normalisation problem, since the structural changes in the global oil market are the same for all countries. We show that modifications in the role of oil and other forms of energy across sub-periods are important in explaining time variation in the dynamic effects of oil shocks. In particular, countries that had the greatest improvement in their net-oil and energy positions over time also became less vulnerable to oil supply shocks.

2. The dynamic effects of different types of oil shocks

2.1. Country characteristics

Table A1 contains some country-specific structural indicators of the role of oil and other forms of energy. All entries are calculated as averages per unit of GDP. The role of oil is very different across the countries considered. Australia, the euro area, Japan, Switzerland and the United States are net oil-importing countries, whereas Canada, Norway and the United Kingdom are net oil exporters. Imports of oil are considerably higher in the euro area, Japan and the United States compared to Australia and Switzerland. Australia and the United States also have a domestic oil-producing sector that cannot be ignored. On the other hand, average oil exports in Norway are about 35 times higher than in Canada and the United Kingdom.

The role of other forms of energy could also lead to cross-country differences in the dynamic effects of crude oil shocks. The prices of non-oil sources of energy, such as natural gas, typically move closely with oil prices. This is clearly the case when the oil price shift is driven by an expansion of worldwide economic activity which triggers a general surge in demand for commodities. For exogenous oil supply and oil-specific demand shocks, the magnitude of this effect will depend on the substitutability of oil with other sources of energy. Hence, an oil-importing country that produces and exports other forms of energy could therefore still benefit from an adverse oil shock via increased demand for alternative sources of energy. Australia is a good example of this (see Table A1). Conversely, while being an oil-exporting country, the United Kingdom is a net importer of non-oil energy. On the other hand, Canada and Norway are net exporters of both, and all other oil-importing countries (the euro area, Japan, Switzerland and the United States) also import other forms of energy. As shown in Peersman and Van Robays (2009b), the role of oil and energy can explain differences in the economic effects of oil shocks across countries. After discussing the model specification and identification in the following two sections, we reconsider their findings in light of the challenges they pose for monetary policy makers in Section 2.5.

2.2. A benchmark structural VAR Model

Not every oil price increase is alike because the underlying source can differ. The oil price shocks of the 1970s, for instance, are typically attributed to exogenous shortfalls in oil production, whereas the prolonged build-up in oil prices that started in 1999 is commonly said to be mainly driven by shifts in the demand for crude oil (for example Hamilton 2003, 2009b).[2] Knowing what drives an oil price increase is important for understanding the impact on the economy and for designing the appropriate monetary policy response. Indeed, Kilian (2009) and Peersman and Van Robays (2009a) show that the economic effects of oil shocks in the United States and the euro area differ significantly depending on the cause of the oil price shift. In our analysis, we make an explicit distinction between oil supply shocks, oil-specific demand shocks and oil demand shocks caused by global economic activity. Following Peersman and Van Robays (2009b), we rely on a structural vector autoregression (SVAR) framework that has the following general representation:

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

The vector of endogenous variables can be divided into two groups. The first group, X_t, captures the supply and demand conditions in the crude oil market and includes world oil production (Q_{oil}), the nominal refiner acquisition cost of imported crude oil expressed in US dollars (P_{oil}) and a measure of world economic activity (Y_w). The other block of variables, $Y_{j,t}$, is country-specific and contains real GDP (Y_j), consumer prices (P_j), the nominal short-term interest rate (i_j) and the nominal effective exchange rate (S_j) of country j. c is a matrix of constants and linear trends, A(L) is a matrix polynomial in the lag operator L, and B is the contemporaneous impact matrix of the vector of orthogonalised error terms ε_t^X and $\varepsilon_{j,t}^Y$; ε_t^X captures the structural shocks in the oil market and $\varepsilon_{j,t}^Y$ are shocks specific to country j. In this paper, we focus on shocks emanating from the crude oil market. This model is referred to as the benchmark VAR model. A separate VAR is estimated for each country j.

2.3. Identification of different types of oil shocks

Identification of the underlying structural shocks in an SVAR model requires a number of restrictions on the relationships between the endogenous variables. Kilian (2009) disentangles oil supply shocks from demand shocks by assuming a short-run vertical oil supply curve in a monthly VAR, so shifts in the demand for oil do not have contemporaneous effects on the level of oil production. In addition, he postulates that economic activity is not immediately

[2] Barsky and Kilian (2004) argue that even the oil shocks of the 1970s were mostly demand driven.

affected by oil-specific demand shocks. His recursive identification scheme is, however, less appropriate for estimations with quarterly data such as real GDP. He therefore averages the monthly structural disturbances over each quarter to estimate the impact on real GDP using a single-equation approach in a second step. Instead, we follow Baumeister and Peersman (2009) and Peersman and Van Robays (2009a) to recover the structural innovations by imposing the following more general sign restrictions:

Structural shocks	Q_{oil}	P_{oil}	Y_{wd}	Y_j	P_j	i_j	S_j
1. Oil supply shock	< 0	> 0	≤ 0				
2. Oil demand shock driven by economic activity	> 0	> 0	> 0				
3. Oil-specific demand shock	> 0	> 0	≤ 0				

The identification restrictions are derived from a simple supply and demand model of the oil market. First, an oil supply shock moves oil prices and oil production in opposite directions. Such shocks could, for instance, be the result of production disruptions caused by military conflicts or changes in the production quotas set by the Organisation of Petroleum Exporting Countries (OPEC). Following an unfavourable oil supply shock, world industrial production will either fall or not change.

Second, demand shocks result in a shift of oil production and oil prices in the same direction, as demand-driven rises in oil prices are typically accommodated by increasing oil production in oil-exporting countries. Demand for oil can increase because of changes in macroeconomic activity, which induces rising demand for commodities in general. Increasing demand from emerging economies like China is a good example. We define such a shock as an oil demand shock driven by economic activity. Accordingly, this shock is characterised by a positive co-movement between world economic activity, oil prices and oil production.

Finally, shifts in demand for oil that are not driven by economic activity are labelled oil-specific demand shocks. Fears concerning the availability of future supply of crude oil or an oil price increase based on speculative motives are obvious examples. In contrast to the demand shock driven by economic activity, oil-specific demand shocks do not have a positive effect on global economic activity since they emerge in a climate of uncertainty. Thus, the final impact on world activity could even be negative because of the associated oil price increase.

The sign conditions are imposed to hold for the first four quarters after the shocks to allow for sluggish responses. These conditions are sufficient to uniquely disentangle the three types of shocks, and no zero restrictions on the contemporaneous relationships among the oil market variables are needed. Since all individual country variables are left unconstrained in the estimations, the direction and magnitude of these responses are determined by the data. Except for the interest rate, all variables are transformed to quarterly growth rates by taking the first difference of the natural logarithm. A more detailed explanation of the data used and the estimation procedure is provided in the appendix.

2.4. Relevance of different types of oil shocks

Variance decompositions of the benchmark VARs indicate that disruptions in the supply of oil are the most important driving force behind oil price fluctuations over the period 1986-2008. The relative importance of the two types of oil demand shocks combined in explaining oil price volatility is approximately equal to that of oil supply shocks.[3] The importance of exogenous oil supply disruptions is also reflected in the historical decomposition of the oil price. As shown in Figure A1 of the appendix, oil supply shocks drove sizeable fluctuations in the oil price, including: the considerable fall in the oil price in 1986 when Saudi Arabia decided to raise oil production; the increase in oil prices after Iraq's invasion of Kuwait in 1990; and the significant rise in the oil price in 1999 driven by the joint decision of both OPEC and non-OPEC members to cut oil production. Although shocks to oil demand seem increasingly important in explaining the more recent run-up in oil prices since the early 2000s, oil production disruptions clearly remain a key factor for understanding fluctuations in the price of crude oil.

2.5. Economic consequences of oil shocks across countries

The results reported in this section are based on estimations of the benchmark VAR model over the sample period 1986Q1-2008Q1 with three lags. The choice of starting date is motivated by Baumeister and Peersman (2008) who find a considerable break in the oil market dynamics in the first quarter of 1986 in a time-varying VAR framework; the model

[3] More specifically, the contemporaneous contributions to oil price variability of an oil supply shock, an oil demand shock driven by global economic activity, and an oil-specific demand shock are 57, 27 and 16 per cent, respectively.

remains relatively stable thereafter (see also Section 4). This date, which coincides with the collapse of the OPEC cartel and the start of the Great Moderation, is also often selected for sample splits in the oil literature.

Figures 2 to 4 summarise the estimated median impulse response functions of the individual country macroeconomic variables to the different types of oil shocks which are discussed in Sections 2.5.1-2.5.3. [4,5] Apart from the interest rate, the responses have been cumulated and are shown in levels to aid interpretation. In order to evaluate their significance, the accompanying 16th and 84th percentiles of the posterior are shown in Figures A2 to A4 in the appendix.[6] For reasons of comparability, each oil shock has been normalised in such a way that it leads to a 10 per cent long-run increase in the nominal price of oil, which is close to the observed quarterly volatility of oil prices over the estimation period. The median responses for output and consumer prices at one relevant horizon after the shock can also be found in Table A1 in the appendix.

2.5.1. Oil supply shocks

Figure 2 illustrates that the economic consequences of an oil supply shock are very different for oil-importing and oil-exporting countries. Consider real GDP in the first column. All net oil and non-oil energy-importing countries (the euro area, Japan, Switzerland and the United States) experience a permanent fall in real economic activity. The long-run magnitude is somewhat greater in Japan compared to the other three countries (see also Table A1). Moreover, output falls very slowly in the euro area and Switzerland, whereas we observe an immediate decline in Japan and the United States.[7] This difference in timing will be further discussed in Section 3 when we examine the oil transmission mechanism. On the other hand, output permanently increases in countries that export both oil and other forms of energy, that is, Canada and Norway. Despite being a net oil-importing country, real GDP only falls in Australia temporarily. However, Australia is a significant non-oil energy-exporting country,

[4] The estimated impulse responses of the nominal effective exchange rates to the different types of shocks are shown in Figures A2 to A4 in the appendix, and the responses of oil production and oil prices are shown in Section 4.1, which presents the changes in the dynamics of the oil market over time.

[5] The presence of country-specific breaks in the data, for example because of changes in the monetary policy strategy, might affect some of the country-specific results. However, in order to not affect the cross-country comparability of the responses to oil shocks, no country-specific dummy variables are included in estimation.

[6] These bands are the 16th and 84th percentile responses of the joint draws that satisfy the imposed sign restrictions, see appendix. Therefore, the error bands represent model uncertainty rather than sampling uncertainty, see Fry and Pagan (2007).

[7] Economic activity in the euro area and Switzerland even temporarily rises, although these increases are not statistically different from zero.

which probably compensates for the negative oil price effect. Also the United Kingdom, which is an oil-exporting but non-oil energy-importing country, undergoes only a transitory decline in activity. Overall, not only the role of oil but also that of other forms of energy is likely to be important for the dynamic effects of oil supply shocks on the economy.

The dependence on oil and non-oil energy products also seems to matter for the inflationary consequences. The exact pass-through for net energy-importing countries will be analysed in Section 3, but the impulse responses reported in Figure 2 reveal a relatively strong impact on consumer prices for all of these countries (except for Japan) whereas inflationary pressures are negligible or even negative in energy-exporting countries. This different impact on consumer prices is probably driven by the response of exchange rates, which tend to appreciate in energy-exporting countries, exerting a downward effect on inflation (see Figure A2 in the appendix).

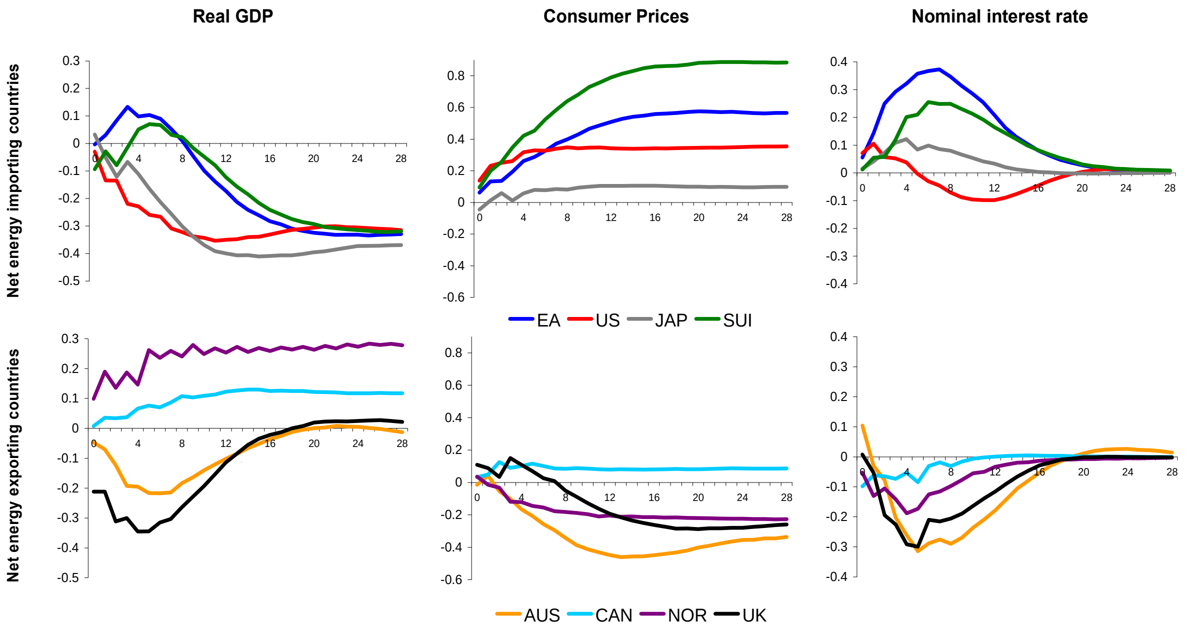


Figure 2. Impact of oil supply shock
Notes: Figures are median impulse responses to a 10 per cent long-run rise in oil prices. The frequency is quarterly.

As shown in the last column of Figure 2, all net energy-importing countries raise their interest rate substantially in order to fight the inflationary pressures the oil supply shock gives rise to. The tightening is much stronger in the euro area and Switzerland, compared to the slight increase in Japan and the United States. On the other hand, the monetary policy reaction is rather weaker in the net energy-exporting countries since the long-run effects on consumer prices are insignificant. In general, the reaction of monetary policy to an oil supply shock is thus consistent with the response of inflation.

2.5.2. Oil demand shock driven by global economic activity shocks

The effects of an oil demand shock driven by rising global economic activity are substantially different from oil supply shocks. Figure 3 shows that all countries face significant long-run inflationary effects and a transitory increase in real GDP due to this shock (see also Figure A3 in the appendix). Somewhat surprising is the result that output in Canada, Japan and the United Kingdom declines in the long run.

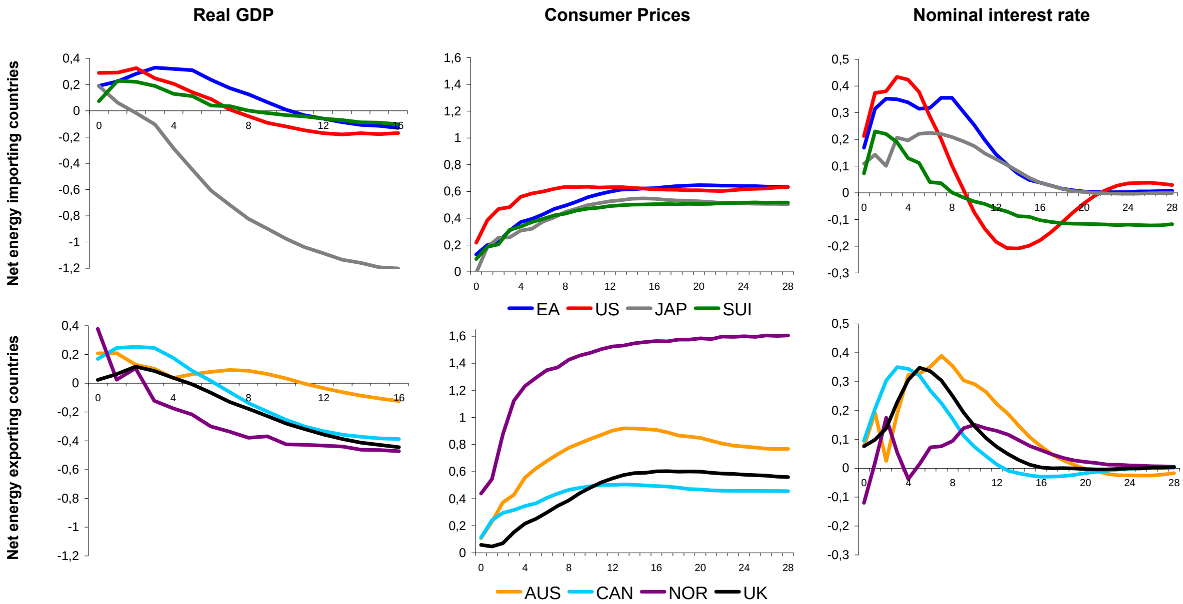


Figure 3. Impact of oil demand shock driven by economic activity
Notes: Figures are median impulse responses to a 10 per cent long-run rise in oil prices. The frequency is quarterly.

When we compare the magnitudes of the maximum impact across countries using Table A1, the temporary increase in output is rather similar, irrespective of the relevance of energy products. This is not a surprise since we are considering an oil price increase that is driven by an expansion of worldwide economic activity. Output can even rise in oil-importing countries because the country itself is in a boom, or because it indirectly gains from trade with the rest of the world. Accordingly, other structural features probably determine the size of the effects. In particular, shocks that affect global economic activity could, for instance, be technology or aggregate demand shocks. Also, the inflation differences are small between most countries. We only observe a stronger impact in Australia and Norway. Given the strong inflationary effects and the temporary increase in economic activity in all countries, no trade-off exists for monetary policy in the short run. Consequently, the interest rate is raised significantly in all countries with the exception of Norway.

2.5.3. Oil-specific demand shocks

The dynamic effects of oil-specific demand shocks are very different from the two other shocks, as shown in Figure 4. In all countries except Japan, this shock is followed by a temporary fall in real GDP with the peak mostly within the first year after the shock. The effects on consumer prices are on average much smaller compared to other types of oil shocks and only significantly positive in Australia and the United States (see Figure A4 in the appendix). In the oil and energy-exporting countries, the exchange rate does not respond significantly, in contrast to the appreciation after an oil supply shock. Comparing cross-country differences in the magnitudes of the effects of this shock on GDP indicates that oil-importing and oil-exporting countries react in a similar way (Table A1). That is, the role of oil and energy in the economy again seems not to matter much for this shock. Figure 4 also shows that no clear distinction can be made between the inflationary effects in the net energy-importing and exporting countries.

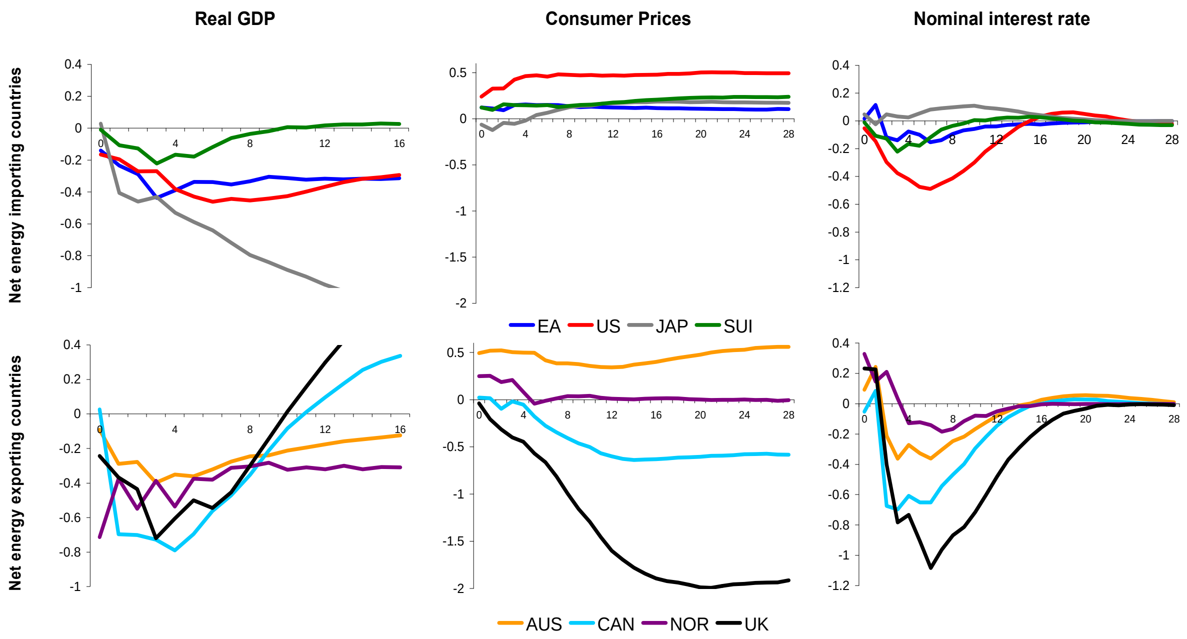


Figure 4. Impact of oil-specific demand shock
Notes: Figures are median impulse responses to a 10 per cent long-run rise in oil prices. The frequency is quarterly.

The temporary fall in economic activity in combination with the rise of consumer prices in most countries creates a trade-off for monetary policy makers. The negligible reaction of consumer prices, however, should give more room to stabilise declines in output. Indeed, the interest rate tends to decrease in the aftermath of an oil-specific demand shock, although this response is mostly insignificant. In line with the other oil shocks, the monetary authorities generally change their interest rate in accordance with the effect on inflation. Only the United States accommodates the fall in economic activity despite the significant increase in consumer prices.

In summary, the economic effects of an oil price change critically depend on the cause of the price change. As a result, monetary policy implications differ depending on the nature of the oil shock. In addition, the role of oil and other forms of energy in the economy (that is, being an energy-importing or energy-exporting country) is only important for understanding cross-country differences in the case of conventional oil supply shocks.

3. The pass-through to inflation and economic activity

Knowledge of how oil market developments are transmitted to the macroeconomy is key to determining the appropriate policy reaction in response to oil shocks. First, the magnitude of the final effects on inflation and output depends on which channels are operative as well as on their relative strengths. Second, the timing of the impact is also important for policy decisions. Given that monetary policy actions affect headline inflation only with a lag, direct effects of rising energy prices are unavoidable. However, if the initial shock to relative energy prices also creates indirect effects by feeding into the price of non-energy goods and services over longer horizons, there is a stabilisation role for central banks. In what follows, we focus on the pass-through after oil supply shocks in oil-importing countries for two reasons.

First, as shown in the historical decompositions in Section 2.4, oil supply shocks are the single most important driving force behind oil price fluctuations. 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 makes the interpretation difficult. This carries over to oil-specific demand shocks, after which the inflationary consequences are only significantly positive in Australia and the United States.

Second, as already documented in the previous section, there exist significant differences in the inflationary consequences between oil-importing and oil-exporting countries after an exogenous oil supply shock. The latter group is actually not confronted with rising consumer prices, which can be explained by an appreciation of the nominal and real effective exchange rates. Therefore, we investigate the relative importance of different transmission channels in oil-importing countries by applying a procedure proposed in Peersman and Van Robays (2009a) that estimates the transmission mechanism of oil shocks by disentangling the effect on consumer prices and economic activity into several sub-effects that are approximated by different price measures and GDP components. This should help in understanding the cross-country differences of the monetary policy responses.

More specifically, we consider the direct effect of oil shocks on the energy component of consumer prices, the indirect effect via rising production costs of non-energy goods and services, second-round effects of rising wages and an impact due to a fall in aggregate demand. The first three channels have a positive effect on inflation, whereas the latter channel should reduce inflationary pressures. Adverse aggregate demand effects are also reflected in the response of economic activity and its components. In order to evaluate the relevance of the individual transmission channels, we extend our benchmark SVAR model of Section 2.2 and re-estimate the benchmark SVARs for all countries by adding one additional variable at a time that captures a specific channel (see the appendix for details). The results of the median estimates are summarised in Figures 5 and 6; Figures A5 and A6 in the appendix show the impulse response functions separately along with the 16^{th} and 84^{th} percentiles confidence bands.

The upper-left panel of Figure 5 shows that the ultimate effect on consumer prices and the speed of pass-through is very different across oil-importing countries. The first graph displays the estimated median oil price responses for the different countries that is normalised to a 10 per cent long-run increase.[8] The impact of this oil price increase on consumer prices is strong in the euro area (0.58 per cent), insignificant in Japan (0.10 per cent), very strong in

[8] The cross-country results are robust when the oil price increases are normalised to a short-run increase in oil prices. These results are available upon request.

Switzerland (0.88 per cent) and subdued in the United States (0.35 per cent), see also Table A1. Even more striking is the difference in the speed of adjustment. While the pass-through is still less than half after one year in the euro area and Switzerland, the process is almost complete in Japan and the United States over the same horizon. As already mentioned, also the shapes of the output responses after an oil supply shock are different (see section 2.5.1). The response of economic activity is very sluggish in the euro area and Switzerland, compared to a much quicker decline in Japan and the United States. These remarkable differences are explained in the next sections.

3.1. Direct effects

To measure the direct effect of an oil price shock on inflation, we consider the impact of an oil supply disturbance on the energy component of CPI. The impulse response functions for a long-run 10 per cent oil price rise are displayed in the first row of Figure 5. Not surprisingly, there is a significant reaction of the energy component of the CPI in all countries. The magnitude is 3.0, 1.4, 4.1 and 2.7 per cent for the euro area, Japan, Switzerland and the United States, respectively. The stronger response in Switzerland is partly driven by a significant exchange rate depreciation. For Japan and the United States, the impact on the energy component of the CPI is already complete after 1-2 quarters, while it takes about one year in the euro area and Switzerland.

If only direct effects are relevant, then prices of non-energy goods and services should not be influenced by the oil shock and the final effect on inflation is determined by the increase in relative prices. This can be examined by looking at the impact on core-CPI, which explicitly excludes energy prices. These estimated responses (the second row of Figure 5) reveal that significant indirect inflationary effects are present in the euro area, Switzerland and the United States. The long-run magnitudes of these indirect effects are respectively, 0.36, 0.53 and 0.14 per cent. In addition, the speed of transmission to core inflation is very different. Core inflation starts to rise relatively quickly in the United States, while the pass-through is very sluggish in the euro area and Switzerland. These differences in speed and magnitude carry over to headline inflation. For Japan, we do not find additional indirect effects – the response of core CPI is insignificant (Figure A5). In turn, the magnitude and timing of the indirect inflationary effects depend on the presence and relative strength of its components: the cost effects, second-round effects and demand effects.

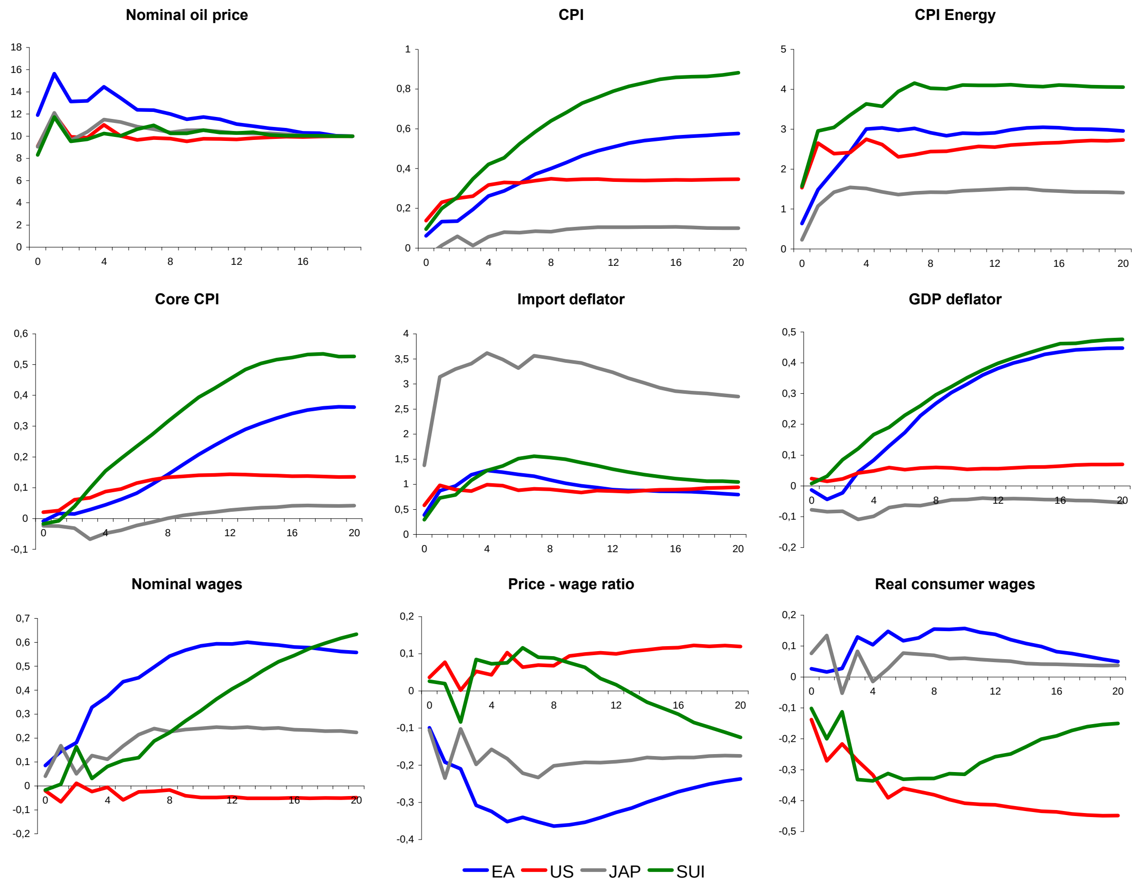


Figure 5. The pass-through of oil supply shocks to consumer prices in oil and energy-importing countries
Notes: Figures are median impulse responses to a 10 per cent long-run rise in oil prices. The frequency is quarterly.

3.2. Cost effects

Increased oil prices imply higher production costs for firms, which will attempt to pass these onto consumers by raising their prices. In contrast to the direct effects, this cost effect has an influence on core inflation. To evaluate the role of cost pressures on core inflation, we estimate the effect on both the GDP deflator and the import deflator. Since only net oil-importing countries are considered, the cost effect should only affect the import deflator and not the GDP deflator, since the latter is the price of domestic value added that explicitly excludes foreign inputs. Both the direct and the cost effect are thus only reflected in a shift of the import deflator, and the response of the GDP deflator captures the remaining indirect effects.[9] The import deflator not only incorporates the price of imports of crude oil, but also the price of imported final goods and other foreign commodities that could be directly or indirectly influenced by oil price shifts. For Switzerland, this effect is aggravated by an estimated significant depreciation of the exchange rate.

Impulse responses for the GDP and import deflators are presented in the second row of Figure 5 and in Figure A5. Whereas import prices increase significantly, there is no reaction of the US GDP deflator to an oil supply shock, despite being an oil-producing country. Consequently, the rise of US core inflation can be fully attributed to the cost effect. Similarly in Japan, an oil supply shock does not affect the GDP deflator in the long run. We even find a fall in the short run. Given the insignificant reaction of core inflation, the latter implies only a limited transitory cost effect in Japan.

The situation in the euro area and Switzerland is completely different. These economies experience a significant rise in the GDP deflator after an unfavourable oil supply shock. Given the reaction of the import deflator, which combines direct and cost effects, the existence of a cost effect in both economies cannot be excluded.[10] However, the speed and magnitude of the responses reveal that the bulk of the reaction of core inflation can be explained by the reaction of the GDP deflator. This striking contrast with Japan and the United States will be further examined in the next section.

3.3. Second-round effects

An unfavourable oil supply shock could increase the GDP deflator via positive second-round effects and decrease it via negative demand effects. The demand channel is analysed in the next section. Second-round effects are triggered if employees successfully raise nominal wages to maintain their purchasing power after a rise in energy prices. As a result, the costs to

[9] This proposition 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 2004 or Rotemberg and Woodford 1996 for a formal exposition of a production function with foreign commodity imports and domestic value added). The situation is slightly different for the United States, which is also a significant oil producer. In addition, the GDP deflator could also rise due to price increases of non-oil energy products that are produced within the country.

[10] The response of the import deflator in the Euro area should be interpreted with caution. This series, which is obtained from the Area Wide Model dataset, is an aggregate of import prices of all individual member countries. As a result, higher export prices of one member country, (due to second-round effects) will result in higher import prices for the other member countries and hence an increase in the aggregate import deflator.

firms increase. If firms pass on higher wage costs to output prices, there is upward pressure on prices of goods and services contained in the non-energy component of CPI. In contrast to direct and cost effects, rising wages also affect the GDP deflator. Moreover, while 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 could depend on the response of inflation expectations and the supply and demand conditions in the labour market. Note that second-round effects could also be triggered if price-setters increase their mark-ups because of higher inflation expectations.

The relevance of second-round effects in oil-importing countries can be evaluated by examining the reaction of (nominal) total labour costs per employee, 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. The median impulse responses of these variables can be found in the last row of Figure 5. Strikingly, the existence of second-round effects is very different across countries and seems to be the key explanation of cross-country differences in the ultimate impact of an oil supply shock on inflation. For the United States, since nominal wages do not rise and the price-wage ratio remains constant, second-round effects are not present. Given the rise in overall consumer prices, this implies that the loss of purchasing power is entirely borne by employees, with a significant fall in the real consumer wage.

The situation is different in Japan. While the GDP deflator remains constant in the long run, nominal wages do rise slightly after an unfavourable oil supply shock and workers succeed more or less in maintaining their purchasing power. In contrast to the United States, producers suffer via a significant fall in the price-wage ratio that offsets the wage increase, which signals the presence of significant adverse demand effects.[11]

In the euro area, real consumer wages remain constant in the long run and there is a significant fall in the price-wage ratio. The latter indicates that demand effects are also present

[11] The absence of a reaction of the GDP deflator to an oil supply shock in the United States does not imply that there are no (negative) demand effects. First, since the United States is also an oil-producing country, the constant price-wage ratio could imply that positive cost effects are offset by negative demand effects. Second, it is possible that a reduction in aggregate demand is transmitted to the labour market. A fall in labour demand and accompanying rise in unemployment reduces the bargaining power of workers, helping to contain nominal wages. Peersman and Van Robays (2009a) show that this is what happens.

in the euro area, thereby limiting the transmission to headline inflation. However, in contrast to Japan, the fall in the price-wage ratio only partially offsets rising labour costs. Accordingly, rising labour costs and second-round effects also result in higher producer and consumer prices. The second round effects are reflected in the significant rise of the GDP deflator. As is the case in the euro area, a significant increase in nominal wages in Switzerland triggers second-round effects that explain the rise in the GDP deflator. Although in the short run the loss in purchasing power is borne by the employees in Switzerland, they manage to keep their real wages constant in the long run (Figure A5).[12]

These cross-country differences in the pass-through to inflation have different implications for monetary policy. More specifically, the main channel through which an oil supply shock passes through to inflation in the euro area and Switzerland is via second-round effects. In order to stabilise inflation, a strong monetary policy response is needed since such a wage-price spiral could otherwise trigger persistent inflationary effects. Conversely, the final impact on consumer prices in the United States is mainly determined by direct and cost effects, and in Japan by direct effects since nominal wage increases are not passed on to consumer prices. Accordingly, oil supply shocks in these latter two countries do not have a persistent effect on inflation, and a strong monetary policy response is not needed. This is exactly the monetary policy behaviour that we observe after an oil supply shock (Figure 2).

3.4. Demand effects

A reduction in aggregate demand is the final transmission channel of an adverse oil supply shock to inflation we need to consider that also influences the GDP deflator. On the one hand, an increase in costs and prices will lower demand and economic activity with the aggregate supply curve shifting along a downward-sloping aggregate demand curve. To limit the fall in production, firms could react by decreasing profit margins or negotiate lower wages for their employees. The pass-through to inflation will depend, among other things, on the elasticity of aggregate demand. An oil shock could also trigger an independent reduction of aggregate

[12] Since quarterly data on nominal total labour costs are not available for Switzerland, the data used is interpolated annual nominal wages based on variations in unit labour costs corrected for changes in GDP .

demand – a shift of the aggregate demand curve. These additional demand-side effects further reduce economic activity but have a tempering impact on inflation.[13]
For oil-importing countries, an increase in oil and energy prices erodes disposable income. Given a relatively small elasticity of oil and energy demand, this income effect depresses the demand for other domestically produced goods. In addition, consumers may decide to increase their overall precautionary savings because of a greater perceived likelihood of future income loss, which also results in a reduction of private spending. Furthermore, if uncertainty increases about future availability of oil and its price, it may be optimal to postpone 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 and durable consumption expenditure. Finally, aggregate demand could also fall if the central bank tightens policy in response to the inflation induced by the oil shock. These independent demand side effects should reduce the ultimate pass-through of an oil supply shock to consumer prices.

To learn more about the existence of demand effects, Figure 6 shows the median impulse responses of real GDP, private consumption, investment and the nominal interest rate. The impulse response functions with the confidence bands and the estimated reaction of exports and government consumption are shown in Figure A6 in the appendix. The results are again very different across countries. In the United States, there is an immediate fall in private consumption in line with the response of real GDP. This pattern is consistent with the existence of an income and precautionary savings effect. It is not very likely that a monetary policy effect is present in the United States: we hardly find an increase of the nominal interest rate and certainly not the real interest rate, and the investment reaction, which should capture the main channel of monetary transmission, is only marginally significant. The rather insignificant response of investment also indicates that the uncertainty effect, and the associated postponement of irreversible investment, is negligible.

[13] 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 energy-intensive to energy-efficient sectors. 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 see Kilian (2008b).

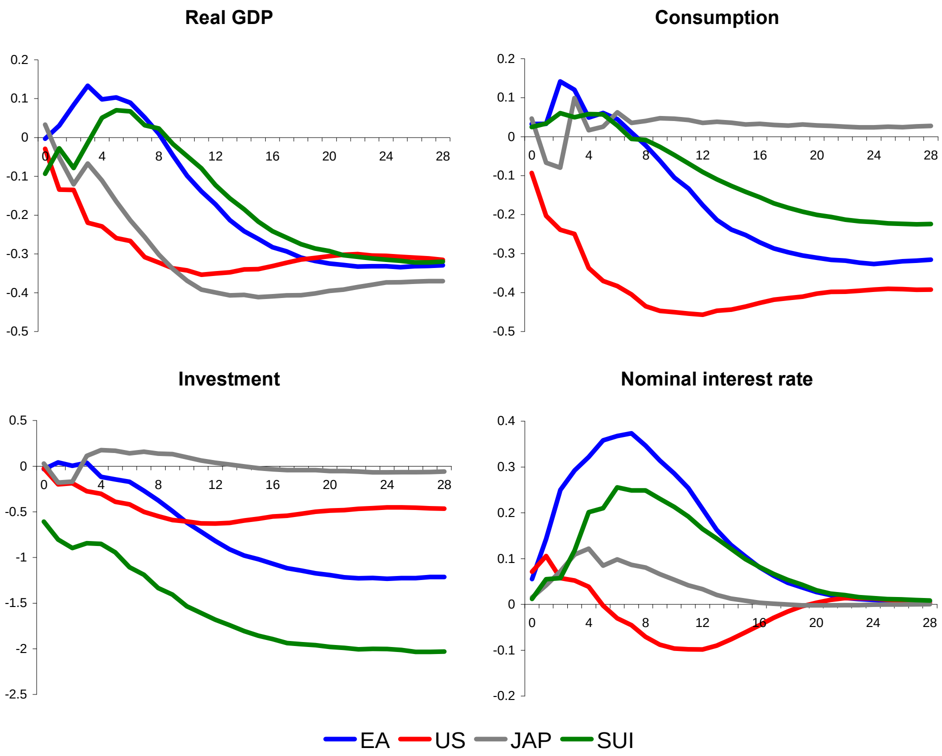


Figure 6. Demand effects and the pass-through to economic activity in oil and energy-importing countries
Notes: Figures are median impulse responses to a 10 per cent long-run rise in oil prices. The frequency is quarterly.

The nature of the demand-side effects in the euro area and Switzerland is completely different to that in Japan and the US. Private consumption declines very sluggishly, which is not in line with an income or precautionary savings effect for which a relatively quick response is expected. For the euro area, this is not surprising given the insignificant reaction of real consumer wages. In Switzerland, purchasing power remains constant in the long run. In addition, there is a considerable decline of investment in the euro area and Switzerland that also only starts accelerating with a delay. This pattern of consumption and investment responses indicates that another effect is at play. The inflationary effects caused by the oil shock and the existence of harmful second-round effects in these two economies, results in a monetary tightening as captured by the significant estimated interest rate increase in both economies. This monetary policy effect is likely to be responsible for the fall in economic activity and can also explain the different speed of pass-through to real GDP. Given lags in the monetary transmission mechanism, consumption, investment and real GDP only start to fall with a delay. The much stronger decline in investment is a feature that confirms the presence of monetary policy effects. The lack of an interest rate reaction in Japan, combined with the absence of a loss in purchasing power for consumers, results in an insignificant reaction of private consumption and investment. Hence, demand effects in Japan are only reflected in a significant fall of the price-wage ratio reported in Section 3.3.

4. Time-varying effects of oil supply shocks

There is reason to believe that the economic effects of oil shocks has changed fundamentally over time. The two large oil price shocks of the 1970s were associated with higher inflation and lower economic growth. In contrast, the latest, sustained run-up in oil prices appears to have had a relatively modest impact on real economic activity and consumer prices. Instabilities over time in the relationship between oil and the macroeconomy are widely documented in the literature.[14] On the one hand, the macroeconomic structure has evolved considerably over time. Prominent features of this change are improved monetary policy (Bernanke *et al* 1997 and Blanchard and Galí 2007), more flexible labour markets (Blanchard and Galí 2007), changes in the composition of automobile production and the overall importance of the US automobile sector (Edelstein and Kilian 2009), and modifications in the role and share of oil in the economy (Bernanke 2006 and Blanchard and Galí 2007).[15] On the other hand, the oil market itself has undergone substantial changes. For instance, institutional transformations such as the transition from a regime of administered oil prices to direct trading in the spot market, and the collapse of the OPEC cartel in late 1985 were accompanied by a dramatic rise in oil price volatility. Lee, Ni, and Ratti (1995) and Ferderer (1996) make the case that this increased oil market volatility led to the breakdown of the relationship between oil prices and economic activity.

For the US economy, Blanchard and Galí (2007), Edelstein and Kilian (2009), and Herrera and Pesavento (2009) find a reduced impact of oil price shocks on real GDP and inflation over time. Baumeister and Peersman (2008), however, have shown that such intertemporal comparisons are seriously distorted since the global oil market has been characterised by further structural change since the mid-eighties. In what follows, we further document this structural change and the consequences for our analysis.

[14] Structural breaks in the relationship between oil prices and the macroeconomy were first documented by Mork (1989) and Hooker (1996, 2002).

[15] Other arguments for the changing (but not necessarily reduced) macroeconomic effects of oil shocks that have been put forward are time-varying mark-ups of firms (Rotemberg and Woodford 1996) and changes in firms' capacity utilisation (Finn 2000).

4.1. Structural change in the oil market

In order to explore how the interaction between oil shocks and the macroeconomy has evolved over time, Baumeister and Peersman (2008) estimate a multivariate Bayesian VAR that features time-varying coefficients and stochastic volatilities in the innovation processes for the period 1970:Q1-2008:Q1. The time-varying coefficients are meant to capture gradual transition in the propagation mechanism of oil shocks, while the stochastic volatility component models changes in the magnitude of structural shocks and their immediate impact.[16] Using this time-varying VAR model, they document that the crude oil market is characterised by a considerably less elastic, hence steeper oil demand curve since the mid-1980s. Figure 7 shows the estimated slope of the oil demand curve at each point in time with 16th and 84th percentiles of the posterior distribution.[17] While the price elasticity fluctuates between -5 per cent and -15 per cent during the 1970s and early 1980s, the contraction in oil demand after a 10 per cent increase in oil prices is as small as 1 per cent to 2 per cent since the mid-1980s.

Figure 7. Estimated elasticity of oil demand over time (Baumeister and Peersman 2008)
Notes: Median effect four quarters after the shock with 16th and 84th percentiles confidence bands.

This steepening of the oil demand curve seriously complicates comparisons of the dynamic effects of oil supply disturbances over time. For instance, a comparison that is based on a similar change in crude oil prices (for example a 10 per cent rise) implicitly assumes a

[16] This approach has frequently been used in the so-called "Great Moderation" literature, see for example Cogley and Sargent (2002) or Primiceri (2005).

[17] The figure displays the elasticity of oil demand to a 10 per cent increase in the real price of crude oil $\left(\frac{\Delta Q}{Q} \Big/ \frac{\Delta P}{P}\right)$ measured four quarters after the initial shock. The exact horizon of the elasticity does not matter for the conclusions.

constant price elasticity of oil demand over time, which is obviously rejected by the data. Consequently, this experiment compares the impact of a totally different underlying oil supply shock. Figure A7 illustrates that the shift of the oil supply curve needed to generate a similar oil price increase clearly differs for a steep as opposed to a flat oil demand curve. For exactly the same reason, measuring an exogenous oil supply shock as a similar shift in world oil production over time (for example a drop in production of 1 per cent) is a biased experiment since the resulting oil price increase will be very different. However, the impact of a "typical" (for example one standard deviation) oil supply shock can be compared. Even so, the magnitude of a representative oil supply disturbance could have changed over time, which could also influence the outcome. Whether the size of a typical oil supply shocks has changed unfortunately cannot be determined.[18] This problem of comparability also carries over to shocks originating on the demand side of the oil market. Baumeister and Peersman (2009) show that also the short-run oil supply curve became highly inelastic over time. Accordingly, comparisons of normalised demand shocks are biased since a constant slope of the oil supply curve is assumed. In the next section, we demonstrate the consequences of this structural change for drawing conclusions about time variation.

4.2. Has the economic impact of oil shocks changed over time?

The results of Baumeister and Peersman (2008) presented in Figure 7 clearly show a break in the slope of the oil demand curve in the first quarter of 1986. To compare the dynamic effects of oil supply shocks, we use our benchmark SVAR model of Section 2.2 for the United States, estimated for two different sample periods: 1970:Q1-1985:Q4 (the '1970s') and 1986:Q1-2008:Q1 (the '1990s'). The latter period corresponds to the model reported in the previous sections. The top row of Figure A8 contains the impulse responses of world oil production and the oil price following a typical one standard deviation oil supply shock. Dotted black lines and full red lines are the estimates for the 1970s and the 1990s, respectively. An unfavourable oil supply shock in the 1990s is characterised by a much smaller fall in oil production in combination with a larger increase in the price of crude oil relative to the seventies. The corresponding estimated slope of the oil demand curve, which is depicted in the last column of the first row, confirms the considerable steepening over time.

[18] This is a standard problem when VAR results are compared across different sample periods. Only the contemporaneous impact of a shock on a number of variables can be measured. Consequently, it is not possible to know exactly whether the shock itself (volatility) has changed or if the immediate reaction to this shock has changed (economic structure).

The consequences of this structural change in the crude oil market for US real GDP and consumer prices is shown in the second and third rows of Figure A8.[19] Clearly the choice of normalisation becomes very important. Consider, for instance, the effect of an oil supply shock which raises the price of crude oil by 10 per cent. Such a shock has a more muted impact on economic activity and inflation in more recent times compared to the 1970s. This finding complies with the general perception and the empirical evidence on time-varying effects of oil price shocks discussed above. This experiment, however, is biased since it implicitly assumes a constant slope of the oil demand curve across both sample periods, which is clearly not the case. More specifically, a 10 per cent rise in oil prices corresponds to an oil production shortfall of less than 1 per cent in the more recent sample period. To elicit the same oil price movement in the 1970s, a decline in oil supply of around 3 per cent was required. Despite the assertion by Blanchard and Galí (2007) that "what matters [] to any given country is not the level of global oil production, but the price at which firms and households can purchase oil" (p17), it is the volume of oil which matters for the production process. For instance, the impact on revenues for oil-exporting countries and corresponding income recycling effects via trade depend on both the amount of oil production and its price.[20]

Alternatively, we could consider a 1 per cent reduction in oil production. Oil supply shocks have often been associated with physical disruptions in the production of crude oil due to deliberate decisions by OPEC aimed at imposing a certain price level, or as a result of the destruction of oil facilities in the wake of military conflicts. Figure A8 shows that the accumulated loss in US real GDP growth is about twice as large in the 1990s compared to earlier times and the response of consumer prices is much more pronounced in the more recent period. This finding is not surprising since a similar reduction in oil quantities triggers a substantially larger oil price increase in the recent period due to the much lower elasticity of the oil demand curve. More specifically, oil prices are estimated to have increased by 23.9 per cent in response to a 1 per cent shortfall in world oil production in the 1990s, while they only rose by 3.2 per cent in the 1970s. Normalising on the quantity variable to make intertemporal comparisons is therefore also problematic, because a typical (one standard deviation) shift of oil supply in the 1990s is characterised by a change in world oil production that is only one

[19] Results for other countries and variables are available upon request. However, since the structural change in the oil market is the same for all countries, the general message of a distorted comparison over time is not altered.

[20] The issue of whether oil prices or quantities matter in a world production function can be compared with employment and wages. In this case the amount of employment is more relevant for economic activity than the wage level, since the latter is only a transfer from employers to employees.

fifth of an average shift in the 1970s. Given the indistinguishability of volatility and the immediate impact of a structural shock in an SVAR, it is not possible to identify whether these smaller variations in oil production are just the result of a steeper oil demand curve, or also the consequence of smaller shifts in the underlying supply curve over time.[21]

When we consider the dynamic effects of a typical one standard deviation oil supply shock, the lower right-hand-side panels of Figure A8 show that the impact on US macroeconomic aggregates is rather similar across the two sample periods. This is consistent with the evidence provided in Baumeister and Peersman (2008).[22] If the effects of average oil supply disturbances on the US economy have not dramatically changed over time, it is surprising that the perceived consequences of current oil shocks are so different now from those in the 1970s. To explain this, Baumeister and Peersman (2008) demonstrate that oil supply shocks made only a limited contribution to the Great Inflation. Alternative factors, such as loose monetary policy, were much more important explanators of excessive inflation experienced during this period, in line with the propositions made by Barsky and Kilian (2004). Oil supply shocks contributed to varying degrees to the recessions of 1974/75, the early 1980s and 1990s, but also other shocks were at play. Unfavourable oil supply disturbances substantially dampened real activity around 1999, which made the ongoing boom more subdued. As a consequence, the timing of oil shocks could have shaped the general perception that adverse oil supply shocks were more detrimental to the economy in the 1970s compared to more recent times.[23] Baumeister and Peersman (2008) show that the most recent oil price surges were more demand-driven, consistent with our findings concerning the historical decomposition of the oil price (see Section 2.4). Since economic consequences are very different for demand-side induced oil shocks, the fact that they currently dominate oil price movements could have altered the way that their effects are perceived.

4.3. Cross-country differences over time

The previous section documented that comparisons of the dynamic effects of oil supply shocks over time are problematic because of the problem of how to normalise the shocks.

[21] Note that, in case the of a vertical oil supply curve, the observed decline in oil production responses would be fully driven by decreased oil supply volatility.
[22] However, this is not the case for all countries in our analysis, in particular the energy-exporting countries.
[23] Hamilton (2009b) argues, for instance, that oil price changes also made a significant contribution to the US recession between 2007:Q4 and 2008:Q3.

However, Peersman and Van Robays (2009b) show that the cross-country dimension of the analysis can be exploited to learn more about time variation while circumventing this normalisation problem.[24] Specifically, they argue that if reduced reliance on crude oil and other forms of energy is at the origin of a more subdued response to oil shocks, the change over time should be greater for countries that improved their net-energy position or reduced the oil intensity of economic activity the most. Table A2 reports several indicators of the average shares of oil and energy for all individual countries for 1970-1985 and 1986-2008. While all countries experience a noticeable fall in total energy intensity and an improvement in net-oil and energy dependence, the cross-country differences are substantial. Canada and the United Kingdom even switched from being oil importers in the 1970s to net exporters more recently. Even within the group of oil and energy-importing countries, the changes over time vary across countries. Unlike the euro area and Japan which significantly lowered their reliance on oil imports, Switzerland and the United States hardly improved their oil dependence.

To evaluate whether a change in the importance of oil and other forms of energy in the economy is important in explaining time variation, we examine the impact of an oil supply shock, normalised to a 10 per cent long-run oil price rise, for all countries for the periods 1970-1985 and 1986-2008 (Figure A9).[25] The differences between both periods based on the maximum median responses over the horizon are also reported in Table A2. Normalising on oil prices, the ultimate output consequences have indeed reduced over time for all countries, in line with the evidence for the United States reported above. However, the degree of improvement is very different across countries. Figure 8 provides a better sense of the link between oil and energy dependence and macroeconomic performance. It shows the rank correlations between changes in the net oil and energy imports per unit of GDP and changes in output effects measured by the difference in maximum median impact of an oil supply shock on real GDP across subsamples.

[24] Since the structural changes in the global oil market are the same for all countries, comparing relative changes between countries does not suffer from a normalisation problem.

[25] Since we only compare the relative cross-country differences over time, it does not matter whether we normalise on oil prices or oil production.

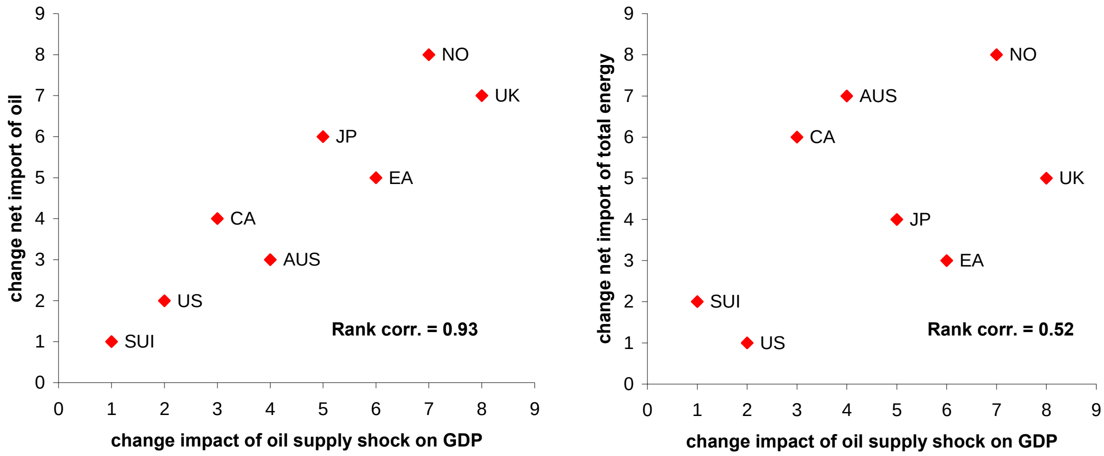


Figure 8. Rank correlation of the change in the net oil and energy position and impact on GDP over time

Notes: The rankings of the change in the oil and energy position over time are based on the results in Table 2 and the change in the impact on real GDP is calculated as the difference between the maximum negative median impact after an oil supply shock in the 1990s versus the 1970s.

The resulting scatter plots reveal a strongly positive relationship between improvements in the net oil and net energy positions and the moderation of consequences for economic activity. The relationship is more significant based on net oil imports. More specifically, countries that made the greatest advancements in either reducing their oil dependence, the euro area and Japan, or extending their net-oil positions, Norway and the United Kingdom, experienced the greatest mitigation of output effects. Switzerland and the United States, which made only little progress in lowering net oil imports, face smaller reductions in economic activity over time. With regard to changes in net energy imports, all countries that are currently net exporters of energy, Australia, Canada, Norway and the United Kingdom, made the largest improvement in their net-energy position over time. While their output effects were more or less equally severe as in the other countries in the 1970s, the impact in these four countries became insignificant or even positive in more recent times. Both developments are reflected in the scatter plot with these countries being concentrated in the upper-right corner of the right-hand panel of Figure 8. Even among the energy-importing countries, we notice a reduction in the output effects in combination with lower net imports of energy; again this is more modest in Switzerland and the United States since these economies hardly improved their net-energy dependence over time.[26] Overall, these results support the hypothesis that the importance of

[26] Note that, if we would only consider the long-run impact on economic activity, Japan is the country with the smallest improvement (see Figure A9). However, this result would be mainly driven by a changed speed of the effects. Considering the difference between the maximum impact on economic activity in both the 1970s and the 1990s takes this into account.

oil and other forms of energy help to explain different output effects of oil supply shocks over time. For inflation, we also find a stronger reduction in the effects for countries that improved their net-energy position the most over time (see Figure A9, panel B).

5. Conclusions

This paper investigates the dynamic effects of oil shocks on a set of industrialised economies that are very diverse with respect to the role of oil and energy in the economy. By approaching this cross-country analysis from three different perspectives, we can provide useful guidance regarding how monetary policy can best deal with oil price movements. Several results stand out.

First, the consequences of an oil price increase depend crucially on the underlying source of the oil price shift in all countries, in line with the results of Kilian (2009) and Peersman and Van Robays (2009a). More specifically, after an oil demand shock driven by a global economic upswing, output temporarily increases and consumer prices rise strongly. This is in contrast to an oil-specific demand shock, after which economic activity temporarily declines and inflationary effects are mostly insignificant. For both types of oil demand shocks, the degree of dependence on oil and energy is not important for explaining cross-country differences in the economic effects. Conversely, being a net-oil or energy-exporting country does matter for exogenous oil supply shocks. We find that all the net-oil and energy-importing countries (the euro area, Japan, Switzerland and the United States) experience a permanent contraction in economic activity and a significant boost in inflation, whereas the long-run output response in the oil and energy-exporting countries (Australia, Canada, Norway and the United Kingdom) is insignificant or even positive. The inflationary consequences for these oil exporters are limited, probably because of the appreciation of the effective exchange rates in the aftermath of an oil supply shock.

Second, the pass-through of an oil supply shock to consumer prices differs considerably among oil-importing countries. While the direct effects of oil supply disturbances to inflation are strong and significant in all of these countries, cross-country differences in inflationary pressures are due to indirect effects, which are mainly determined by the existence of second-round effects. In the euro area and Switzerland, the GDP deflator as well as nominal wages increase notably, which explains the relatively pronounced and sluggish responses of consumer prices. In contrast, in Japan and the United States the GDP deflator does not react in the long run. Second-round effects are not present in the United States since nominal wages and mark-ups do not adjust, whereas the slight increase in the wage rate in Japan is completely offset by a decrease in producers' profit margins. Also demand and output effects are different across countries. In the United States, the income and precautionary savings effects help to account for the immediate fall in real GDP, while a delayed decrease in economic activity in the euro area and Switzerland can be attributed to monetary policy that tightens to halt second-round effects.

Finally, we find that countries that have improved their net-energy position the most over time became relatively less susceptible to oil supply shocks. By exploring the cross-country dimension, we have avoided the normalisation problem that is inherent in comparing macroeconomic effects of oil supply shocks across time periods. This problem arises because the oil demand curve has become much less elastic since the mid-1980s. Accordingly, a similar oil price increase over time, or a similar oil production disruption, imply totally different underlying shifts of the oil supply curve.

It is likely that in addition to the dependence on oil and other energy products, changes in monetary policy credibility and labour market characteristics could play an important role in explaining time variation in the effect of oil supply shocks. Analysing the relative importance of these structural changes is left for future research. Another interesting question is whether the inflationary effects of oil shocks are symmetric. We have assumed symmetry in all our estimations, which is not necessarily true in the case of downward rigidity of nominal wages, for example.

Appendix: Structural VAR model and identification

The economic consequences of oil shocks are analysed using a structural VAR model, of which the general representation is given in Section2.2. Since no significant cointegration relation is found, 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. Based on standard likelihood ratio tests and the usual lag-length selection criteria, we include three lags of the endogenous variables. The model is estimated using quarterly data for the sample period 1986:Q1-2008:Q1. Data on all oil-related variables are obtained from the Energy Information Administration (EIA) and the International Energy Agency (IEA). The oil price variable is the nominal refiner acquisition cost of imported crude oil, which is considered as the best proxy for the free market global price of imported crude oil in the literature. The indicator of global economic activity is obtained from the United Nations Monthly Bulletin of Statistics and is calculated as a weighted average of industrial production of a large set of individual countries, including for instance China and India. Refer to Baumeister and Peersman (2009) for further explanation of how this index is constructed. All euro area data are collected from an updated version of the Area Wide Model (AWM) dataset, see Fagan *et al* (2001). US data is from the Bureau of Labor Statistics (BLS), the Bureau of Economic Analysis (BEA) and the Federal Reserve Economic Data (FRED) database. For the remaining countries, GDP, consumer prices and nominal interest rates are obtained from the OECD Main Economic Indicators database (OECD MEI), OECD Economic Outlook database (OECD EO) or the IMF International Financial Statistics database (IFS). Finally, the exchange rate data are the nominal effective exchange rate indices from the Bank for International Settlements (BIS). The results are robust to different choices of lag length, 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 of the OECD.

The shocks in the VAR model are identified by relying on a limited set of sign restrictions which are explained in Section 2.3. Since the structural shocks are mutually orthogonal, the variance-covariance matrix of a reduced form estimation of the VAR is $\Omega = BB'$, for an infinite number of possible B (see Equation (A1) below). We consider the set of possible B that fulfil the sign conditions imposed. Peersman (2005) shows how to generate all possible decompositions. To uniquely disentangle the three types of shocks in ε_t^X, we implement the sign restrictions on the oil market variables. These are assumed to hold for the first four quarters after the shocks, which is standard in the literature. The responses of all country-specific variables are left unconstrained in the estimations and their responses are fully determined by the data. For more details on the implementation of sign restrictions for identification see Peersman (2005).

Similar to Peersman (2005) and Peersman and Van Robays (2009), a Bayesian approach is used for estimation and inference, for which the prior and the posterior distribution belong to the Normal-Wishart family. In order to draw the 'candidate truths' from the posterior, a joint draw is taken from the unrestricted Normal-Wishart posterior for the VAR parameters as well a draw of a possible contemporaneous impact matrix, which allows us to construct impulse response functions. If the imposed sign restrictions on the impulse response functions of the global oil market variables are satisfied, 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 oil shocks simultaneously. A total of 1000 'successful' joint draws are then used to generate the median responses, together with the 84th and 16th percentile error bands.

To evaluate the channels of transmission in Section 3, the benchmark SVAR model is extended as follows:

$$\begin{bmatrix} X_t \\ Y_{j,t} \\ Z_{j,t} \end{bmatrix} = c + A(L) \begin{bmatrix} X_{t-1} \\ Y_{j,t-1} \\ Z_{j,t-1} \end{bmatrix} + B \begin{bmatrix} \varepsilon_t^X \\ \varepsilon_{j,t}^Y \\ \varepsilon_{j,t}^Z \end{bmatrix} \qquad \text{(A1)}$$

where: X_t and $Y_{j,t}$ still contain the seven endogenous variables listed in Section 2.2, and the vector $Z_{j,t}$ consists of one variable intended to capture a specific channel or effect. Estimation and inference are exactly the same as for the initial model. Note that feedback is allowed from the variable in $Z_{j,t}$ to the benchmark variables in X_t and $Y_{j,t}$. As a result, the estimated magnitude and dynamics of the oil shock might slightly change across different specifications, which could affect comparability. However, imposing strict exogeneity between the oil market and the country variables, by estimating a so-called near-VAR, does not affect the results. Therefore, comparisons can be made by normalising the oil shocks to a 10 per cent long-run oil price increase, which is done throughout the paper. The cross-country differences reported are also robust to normalising the oil shocks on a short-run oil price increase of 10 per cent. Data on the variables used to measure the pass-through are collected from the OECD MEI database, except for the Euro area data which is from the AWM.

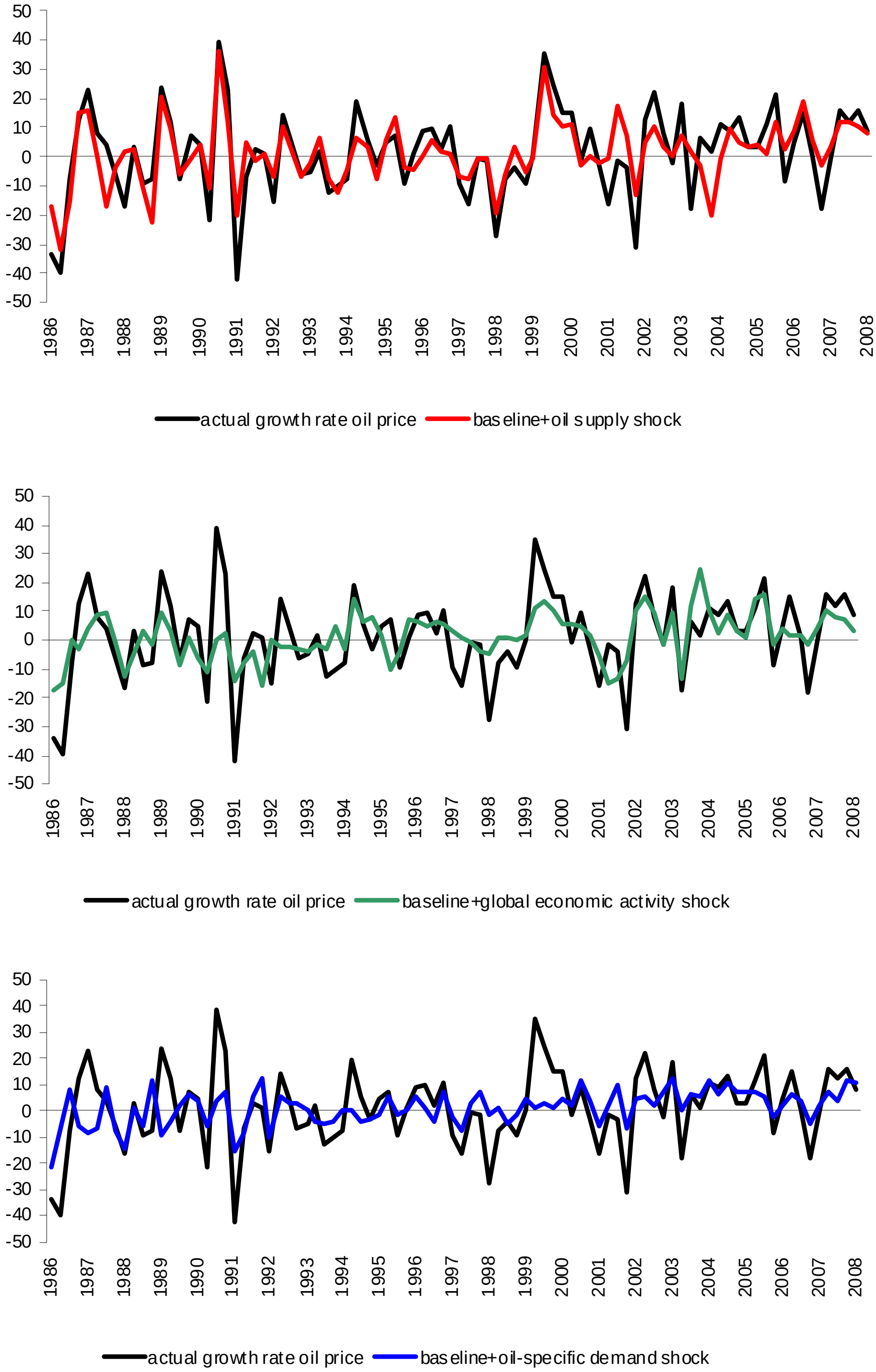


Figure A - 1. Historical contribution of different types of oil shocks to changes in the nominal oil price

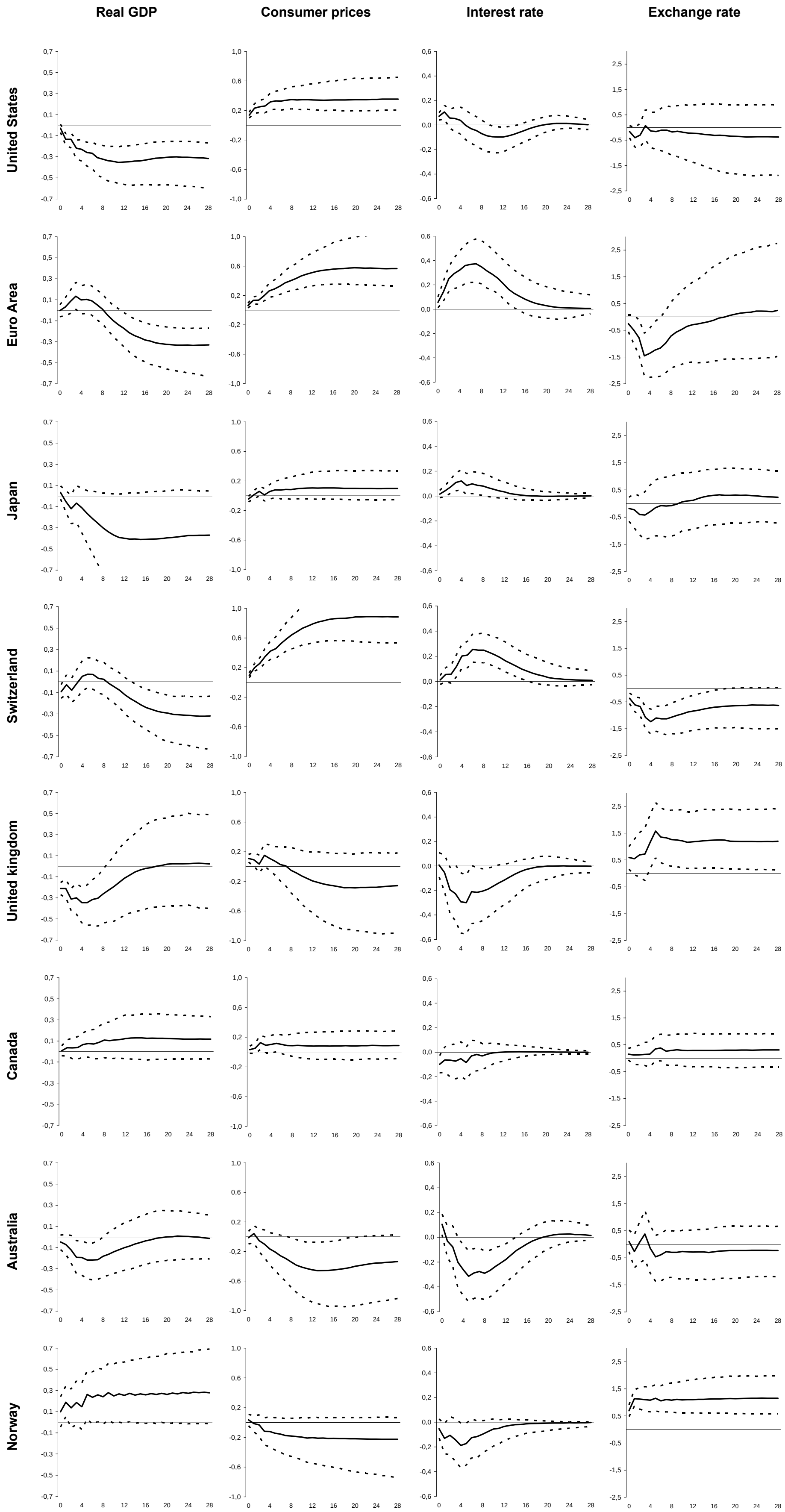


Figure A - 2. Impact of oil supply shock

Notes: Figures are median impulse responses to a 10 per cent long-run rise in oil prices, together with the 16th and 84th percentile error bands. The frequency is quarterly.

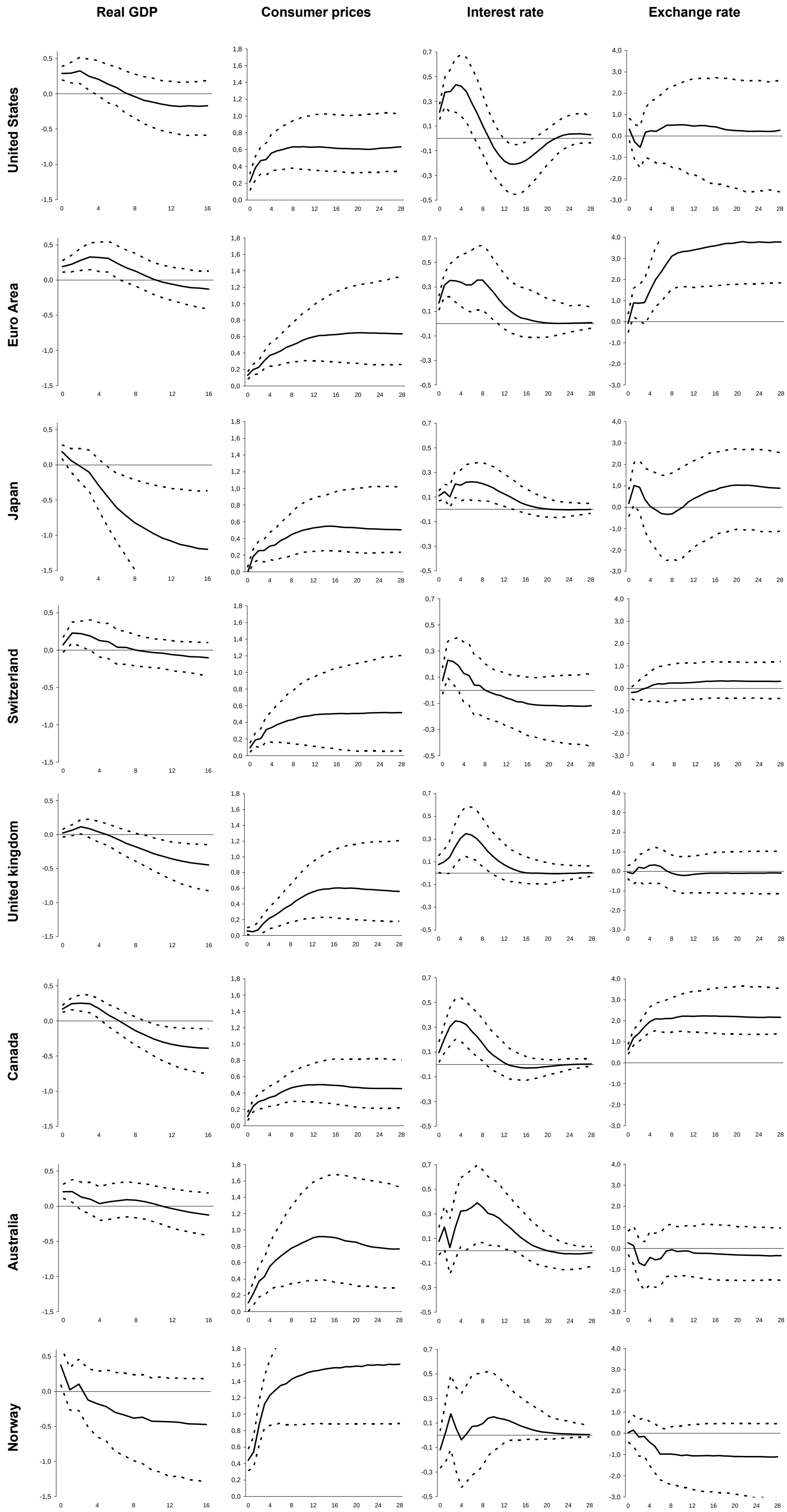


Figure A - 3. Impact of oil demand shock driven by economic activity
Notes: Figures are median impulse responses to a 10 per cent long-run rise in oil prices, together with the 16th and 84th percentile error bands. The frequency is quarterly.

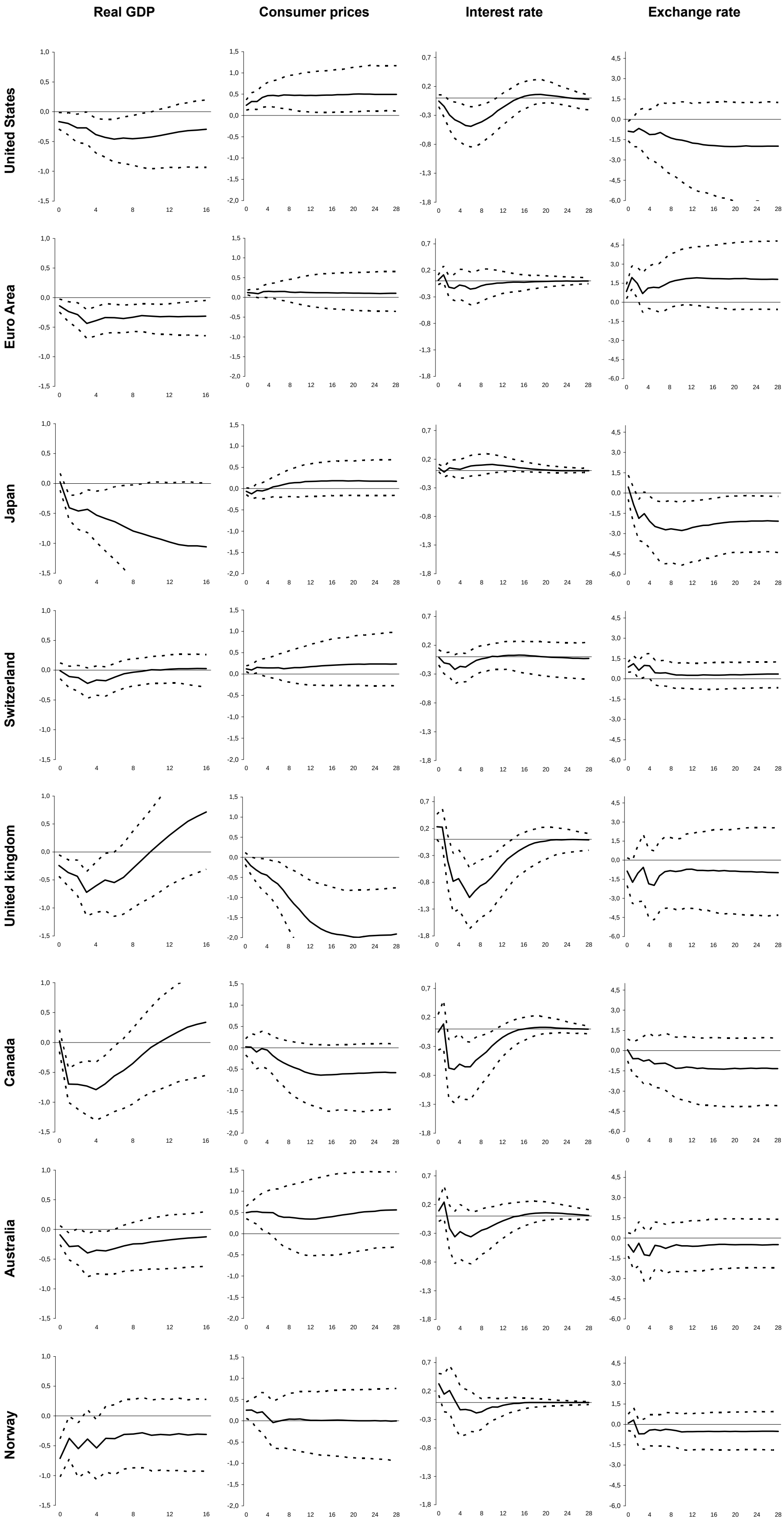


Figure A - 4. Impact of oil-specific demand shock

Notes: Figures are median impulse responses to a 10 per cent long-run rise in oil prices, together with the 16th and 84th percentile error bands. The frequency is quarterly.

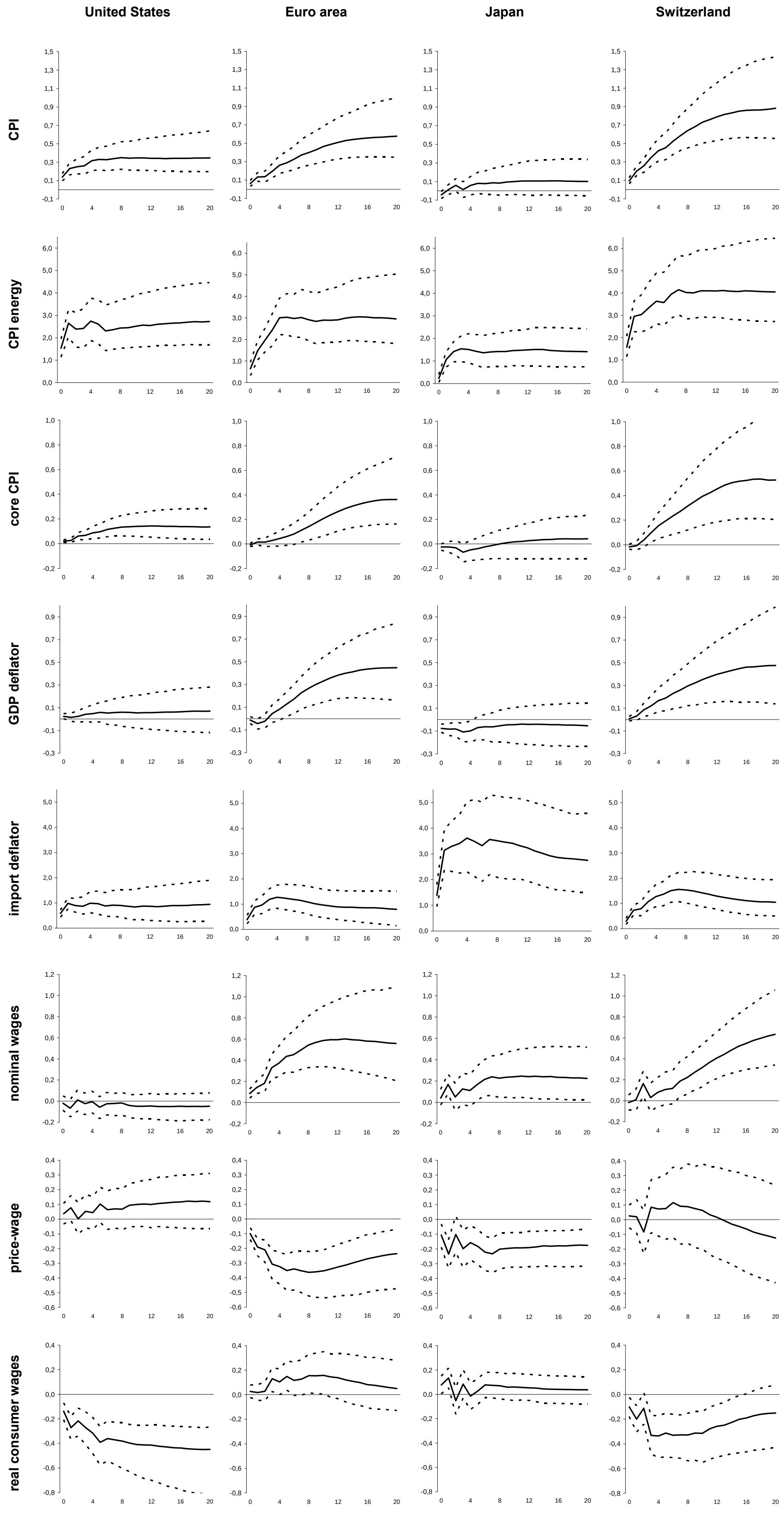


Figure A - 5. Pass-through of oil supply shocks to consumer prices in oil and energy-importing countries
Notes: Figures are median impulse responses to a 10 per cent long-run rise in oil prices, together with the 16th and 84th percentile error bands. The frequency is quarterly.

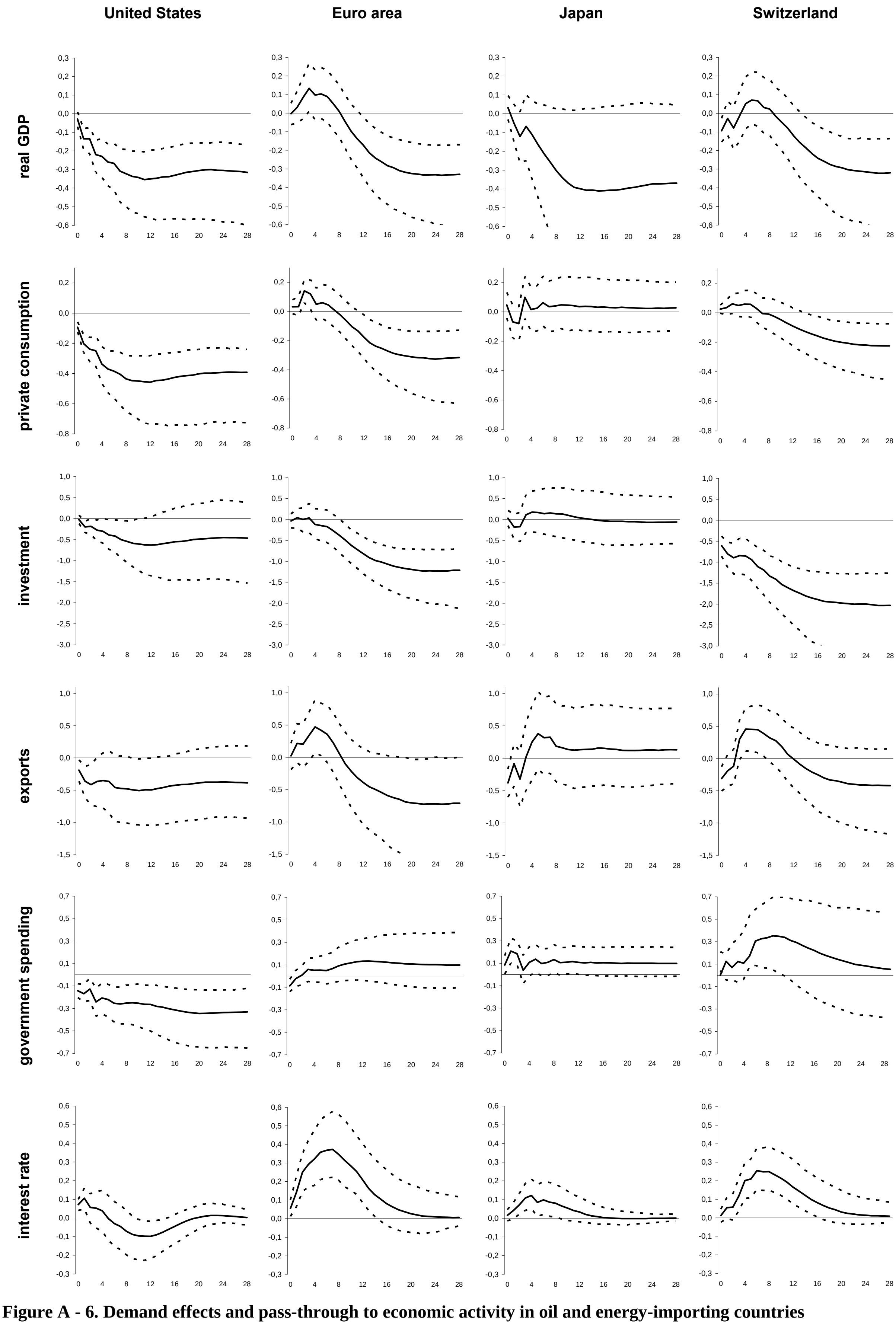


Figure A - 6. Demand effects and pass-through to economic activity in oil and energy-importing countries
Notes: Figures are median impulse responses to a 10 per cent long-run rise in oil prices, together with the 16th and 84th percentile error bands. The frequency is quarterly.

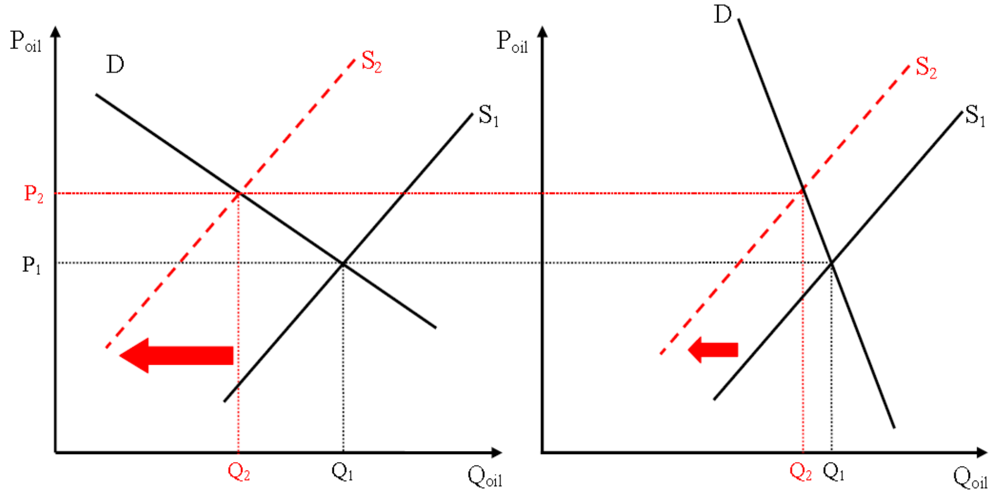


Figure A - 7. Oil supply shock with same oil price increase but flat versus steep slope of oil demand curve

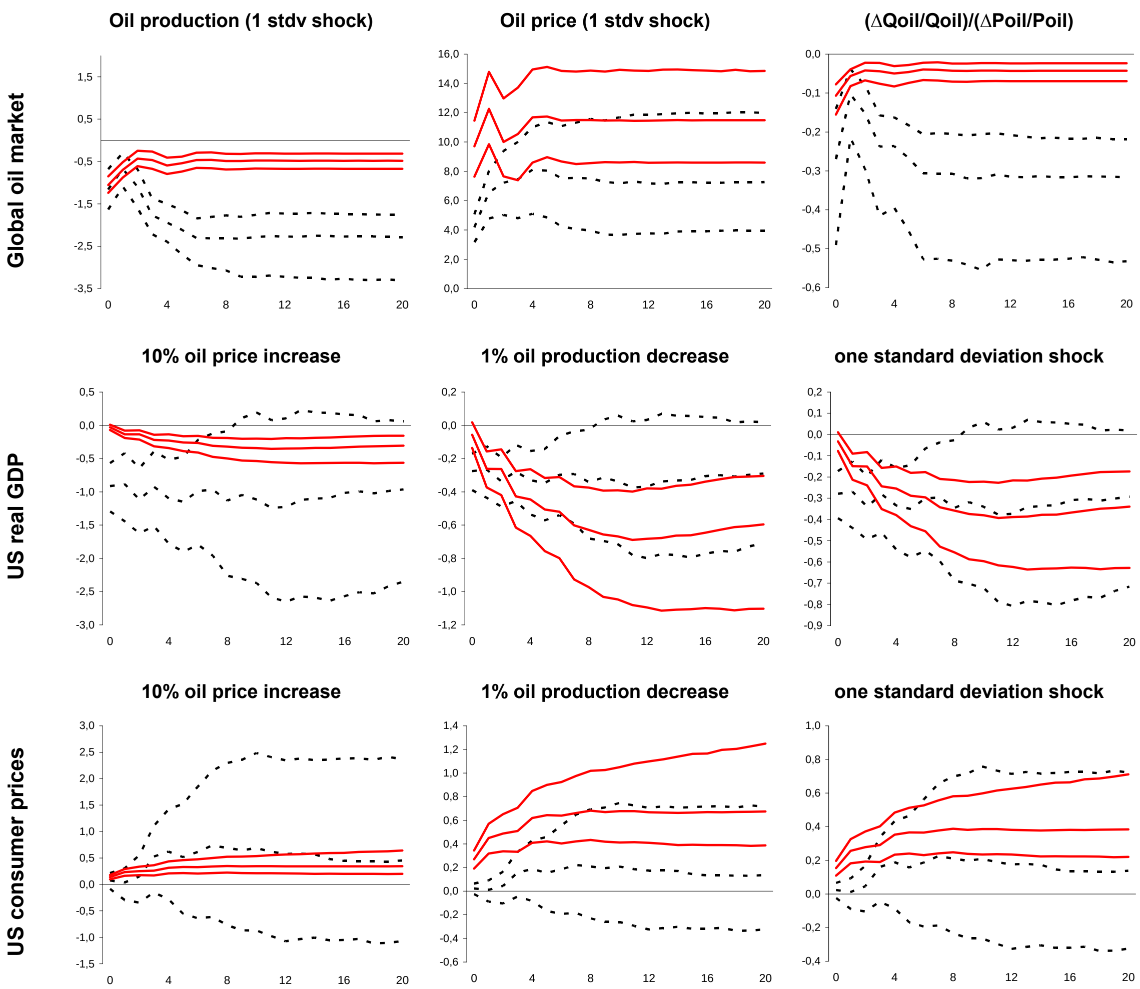
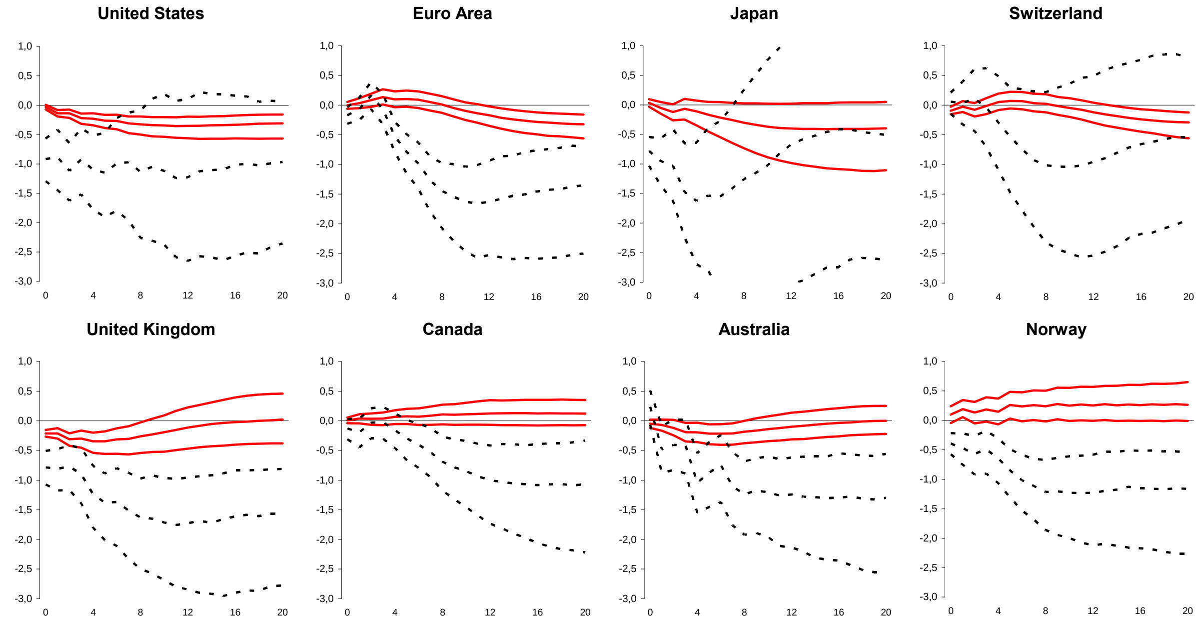


Figure A - 8. Impulse response functions after an oil supply shock over time

Notes: Figures are median impulse responses, together with the 16th and 84th percentile error bands. The frequency is quarterly. 1971-1985: dotted lines, 1986-2008: full lines.

PANEL A: Effects on real GDP



PANEL B: Effects on consumer prices

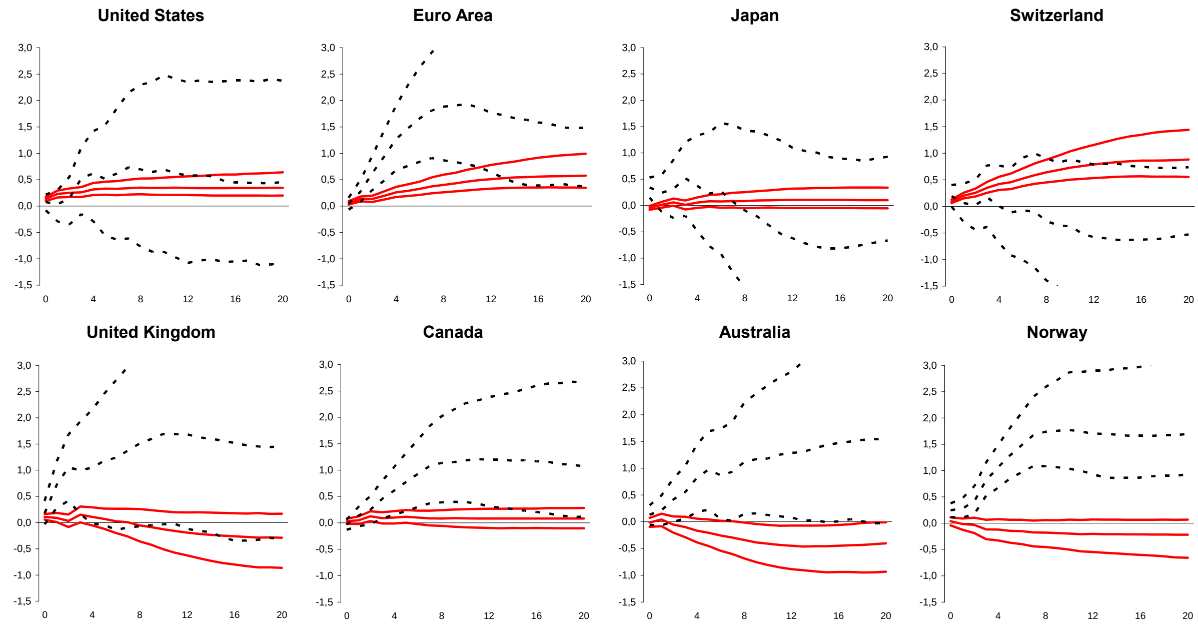


Figure A - 9. The effects of an oil supply shocks over time
Notes: The figures are median impulse response function to a 10 per cent long-run increase in oil prices. The frequency is quarterly. 1971-1985: dotted lines, 1986-2008: full lines.

Table A1. Structural differences across countries and the impact of oil shocks: 1986-2008

	Oil[1]			Non-oil energy[1]			Total energy[1]			oil supply[2]		global activity[2]		oil-specific dem[2]	
	net import	production	total	net import	production	total	net import	production	total	GDP	CPI	GDP	CPI	GDP	CPI
United States	55	41	96	2	156	158	57	197	254	-0,31	0,35	0,33	0,61	-0,46	0,50
Euro Area	71	2	73	30	65	95	101	67	168	-0,32	0,58	0,33	0,65	-0,44	0,11
Japan	67	0	67	62	29	91	129	29	158	-0,40	0,10	0,19	0,53	-1,10	0,18
Switzerland	22	0	22	47	50	97	69	50	119	-0,29	0,88	0,23	0,51	-0,22	0,23
United Kingdom	-21	79	58	11	95	106	-10	174	164	0,02	-0,29	0,12	0,60	-0,72	-1,99
Canada	-16	109	93	-116	329	213	-132	438	306	0,12	0,08	0,25	0,47	-0,79	-0,60
Australia	7	53	60	-220	375	155	-213	428	215	0,00	-0,40	0,21	0,85	-0,40	0,48
Norway	-704	815	111	-331	398	67	-1035	1213	178	0,26	-0,22	0,38	1,58	-0,71	0,00

Notes: [1]: Averages for 1986-2008 based on International Energy Agency (IEA) data measured as (tonnes of oil equivalent) / GDP (million USD, PPP weighted) of respectively crude oil, total energy excluding crude oil and total energy

[2]: Estimated median impulse responses of GDP in the long-run (20 quarters) to a 10% oil price rise for an oil supply shock, maximum impact over the horizon for oil demand shock driven by global economic activity and maximum impact over the horizon for an oil-specific demand shock; long-run (20 quarters) effect on CPI for all three shocks

Table A2. The role of oil and energy and the impact of oil supply shocks over time

	Net import of oil[1]			Net import of energy[1]			Energy intensity[1]			Maximum impact on GDP[2]			Maximum Impact on CPI[2]		
	1970-1985	1986-2008	change	1970-1985	1986-2008	change	1970-1985	1986-2008	change	1970-1985	1986-2008	change	1970-1985	1986-2008	change
United States	63	55	*-8*	59	57	*-2*	374	254	*-120*	-1,24	-0,35	*0,89*	0,74	0,35	*-0,38*
Euro Area	112	71	*-41*	127	101	*-26*	210	168	*-42*	-1,66	-0,33	*1,33*	1,93	0,58	*-1,35*
Japan	122	67	*-55*	174	129	*-45*	197	158	*-39*	-1,63	-0,41	*1,22*	0,52	0,11	*-0,41*
Switzerland	28	22	*-6*	86	69	*-17*	122	119	*-3*	-1,04	-0,32	*0,72*	0,19	0,89	*0,70*
United Kingdom	44	-21	*-65*	59	-10	*-69*	239	164	*-75*	-1,75	-0,35	*1,40*	1,69	0,15	*-1,54*
Canada	12	-16	*-28*	-45	-132	*-87*	389	306	*-83*	-1,09	0,01	*1,10*	1,21	0,13	*-1,08*
Australia	31	7	*-24*	-56	-213	*-157*	260	215	*-45*	-1,37	-0,22	*1,15*	1,65	0,04	*-1,61*
Norway	-96	-704	*-608*	-178	-1035	*-857*	219	178	*-41*	-1,23	0,1	*1,33*	1,77	0,04	*-1,74*

Notes: [1]: Averages for period based on International Energy Agency (IEA) data measured as (tonnes of oil equivalent) / GDP (million USD, PPP weighted) of respectively net import of crude oil, net import of total energy and total domestic energy consumption

[2]: Estimated maximum negative median impulse response over the horizon to an oil supply shock that raises oil prices by 10%

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