Cross-Country Differences in the Effects of Oil Shocks*

Gert Peersman
Ghent University

Ine Van Robays
Ghent University

August 2009

Abstract

We compare the economic consequences of several types of oil shocks across a set of industrialized countries that are structurally very diverse with respect to the role of oil and other forms of energy in their economy. We find considerably different effects across countries, which crucially depend on the underlying source of the oil price shift. For oil demand shocks driven by global economic activity and oil-specific demand shocks, all countries experience respectively a temporary increase and transitory decline of real GDP following the oil price increase. The role of oil and other forms of energy seems not to matter to explain cross-country differences for the consequences of both shocks. This role, however, is very important to explain asymmetries in the effects of exogenous oil supply shocks. Whereas net oil and energy-importing countries all face a permanent fall in economic activity, the impact is insignificant or even positive in net energy-exporting countries. In addition, countries that improved their net energy-position the most over time, became less vulnerable to oil supply and oil-specific demand shocks, relative to other countries.

JEL classification: E31, E32, Q43
Keywords: Oil prices, vector autoregressions, cross-country differences

*We acknowledge financial support from the Interuniversity Attraction Poles Programme - Belgian Science Policy [Contract No. P6/7] and Belgian National Science Foundation. All remaining errors are ours.

1 Introduction

Since the seminal work of Hamilton (1983) for the United States, a growing number of studies have been analyzing the economic consequences of oil shocks across industrialized countries.[1] These studies mostly find that oil price increases are detrimental for economic growth and document some cross-country differences in the effects. In this paper, we also investigate systematic differences between industrialized countries, but we depart from the existing literature by exploring the cross-country dimension in several ways that enables us to provide additional insights on some unresolved issues in the oil literature.

First, we consider a set of countries that are very different with respect to the role of oil and energy in their economy. Some of them are purely depend on imports of oil and other energy products to provide their energy needs (Euro area, Japan and Switzerland) or are a net oil and energy importer despite having signficant domestic oil production (United States). Other countries are net oil and energy-exporters (Canada and Norway), whereas also an oil-exporting but energy-importing country (United Kingdom) and a net oil-importing but non-oil energy exporting country (Australia) are part of our country sample. This diversity of countries enables us to asses whether the role of oil and other forms of energy matters for the economic consequences of oil shocks. Due to the substitutability of crude oil, the worldwide prices of other sources of energy typically also rise at times of increasing oil prices. We therefore do not only take into account the oil intensity of the economies, but also the role of non-oil energy products.

Second, the existing literature compares the effects of oil price shocks across countries, relying on the implicit assumption that oil price changes exclusively originate from the exogenous supply side of the oil market.[2] However, it is now commonly accepted that oil prices are also driven by demand conditions, especially in more recent decades (see e.g. Barsky and Kilian 2004, Hamilton 2003 or Rotemberg 2007). Accordingly, the current cross-country estimates represent the economic effects of an average oil price shock determined by a combination of supply as well as demand factors, which could seriously bias

[1] For instance Darby (1982), Burbidge and Harrison (1984), Mork, Oslen and Mysen (1994), Cuñado and Pérez de Gracia (2003), Jiménez-Rodríguez and Sánchez (2005), and Kilian (2008).

[2] Kilian (2008a) is an exception. He compares the impact across countries by using a measure of exogenous oil supply shocks. The latter is constructed by comparing actual oil production in the wake of some political crises to a counterfactual path of how production would have evolved in the absence of the crises. This approach, however, depends on the selection of the events and no generic supply shocks are identified.

cross-country comparisons. In particular, recent studies by Kilian (2009) and Peersman and Van Robays (2009), henceforth PVR (2009), have shown for respectively the US and Euro area that the ultimate consequences of oil price rises are very different depending on the underlying source of oil price shift. It is very likely that the underlying source of oil price shift also matters for the other countries in our analysis. In addition, the role of oil and energy in the economy to explain cross-country asymmetries could also depend on the underlying type of oil shock. For instance, if the oil price shift is demand driven due to increased worldwide economic activity, some countries could be part of the global boom or differently gain from trade with the rest of the world, which might not be the case after a conventional oil supply shock. The recycling effects via increased trade to oil-exporting countries could also depend on the driving force, etc. As a consequence, considering all innovations to the oil price as exogenous oil supply shocks is problematic. To improve a cross-country analysis, we therefore estimate the economic consequences of oil shocks depending on its underlying source. More specifically, we make a distinction between exogenous disruptions in oil supply, oil demand shocks driven by global economic activity and oil-specific demand shocks which could be the result of speculative or precautionary motives in a structural VAR framework. To identify the shocks, we introduce a set of sign restrictions on a number of variables representing the global oil market.

Finally, our cross-country analysis also contributes to the literature that investigates how the dynamic effects of oil shocks have changed over time. Edelstein and Kilian (2009), Herrera and Pesavento (2007) and Blanchard and Gali (2007) find a reduced impact of oil price shocks on US macroeconomic aggregates over time. A prominent explanation for this time variation discussed in the literature is a changed role and share of oil in the economy (e.g. Bernanke 2006 or Blanchard and Gali 2007). In particular, a declined oil intensity could have made the economy less vulnerable to oil shocks in more recent periods. Baumeister and Peersman (2008 and 2009), henceforth BP (2008 and 2009), have however shown that such comparisons over time are seriously distorted since the global oil market is characterized by a remarkable structural change since the mid-eighties. Specifically, both the oil supply and oil demand curves became much steeper or less elastic over time. As a consequence, typical oil supply and demand shocks are currently characterized by a much smaller impact on world production and a greater effect on oil prices compared to the 1970s and early 1980s. Due to this structural change in the oil market, comparisons over time fundamentally depend on the way of normalization. For instance, BP (2008) show that when an oil supply shock is measured as a similar shift in oil prices (e.g. 10 percent rise), the impact on real GDP and inflation in the US indeed becomes smaller over time. However, when oil supply shocks are measured as a standardized change in oil production (e.g. a fall of 1 percent), the consequences are currently more severe. The latter can be explained by a much greater leverage of the same production disruption on oil prices because of a less elastic oil demand curve. Both experiments to analyze time variation are clearly misleading since they implicitly assume a constant elasticity of oil demand over time, which is strongly rejected by the data. Looking at a one standard deviation shock, BP (2008) actually find that the impact on the US macroeconomy is relatively constant over time. Whether the underlying magnitude of an average oil shock has changed over time, however, cannot be identified.

This normalization problem can be avoided by exploring the cross-country dimension of our analysis, and more about the sources of time variation can be learned. More specifically, whilst all countries experienced a fall in oil intensity over time, the magnitudes have been very different. Some countries even switched from being a net oil-importing country to a net oil-exporting country (e.g. Canada and United Kingdom). By estimating the dynamic effects for the sample periods 1970-1985 and 1986-2008, we can evaluate the importance of oil and other energy products for time-variation by comparing the relative change over time between countries. Since all countries have been subject to the same structural changes in the oil market, this exercise does not suffer from a normalization problem.

Several interesting results emerge from our analysis. First, we find considerably different consequences depending on the underlying source of the oil price shift. After an unfavorable oil supply shock, all net 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 less in the latter group, probably driven 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 of real GDP after a global activity shock, whereas output temporarily declines following an oil-specific demand shock. In contrast to an oil supply shock, cross-country differences of the magnitudes of the effects after both demand shocks are, however, not determined by the importance of oil or energy for the domestic economy. Finally, a changed role of oil and other forms of energy over time is important to explain time-variation of the dynamic effects. In particular, countries that improved their net oil and energy-position the most over time, became much less vulnerable to oil supply and oil-specific demand shocks relative to other countries.

The rest of the paper is structured as follows. In the next section, we analyze the economic effects of oil shocks across countries for the 1986Q1-2008Q1 sample period. We describe the cross-country differences with respect to the role of oil and other forms of energy, present our representative structural VAR model and show the estimation results. Section 3 investigates whether the impact has changed over time. We first describe and reproduce the normalization problem of Baumeister and Peersman, followed by a discussion of the cross-country changes in economic structures and the evidence. Finally, section 4 concludes.

2 The economic effects of oil shocks across countries

2.1 Country characteristics

Table 1 shows the cross-country differences with respect to the role of oil and other forms of energy in the economy. All figures are obtained from the International Energy Agency (IEA) and are calculated as averages per unit of GDP over the period 1986-2008, which will also be the sample period of our benchmark estimations. The role of oil is clearly very different across countries. The US, Euro area, Japan, Switzerland and Australia are net oil-importing countries, whereas the UK, Canada and Norway are net oil-exporters. Imports of oil are considerably higher in the Euro area, Japan and the US compared to Switzerland and Australia. The latter country, as well as the US, also has a domestic oil producing sector that cannot be ignored. On the other hand, average oil exports in Norway are about 35 times as high as in Canada and the UK. Overall, Norway, US and Canada are the most oil-intensive economies. The latter is reflected in final consumption of petroleum products per unit of GDP, which is also shown in Table 1. Canada and the US consume the most, whereas petroleum consumption is lowest in the UK.

Not only the role of crude oil, but also that of other forms of energy could be relevant to interpret cross-country differences of the dynamic effects of crude oil price shocks. At times of rising oil prices, the prices of other sources of energy, such as natural gas, typically also rise due to increased demand for these other forms of energy as well. This is clearly the case when the oil price shift is driven by increased worldwide economic activity since demand for commodities in general is likely to rise. For exogenous oil supply and oil-specific demand shocks, the magnitude of such an effect will obviously depend on the substitutability of oil to other sources of energy. Since prices of non-oil energy products tend to follow oil price movements, an oil-importing country that produces and exports other energy products could therefore still benefit from an unfavorable oil shock via increased demand for other sources of energy. Australia is a good example (see Table 1). Despite being an net importer of crude oil, Australia is a significant exporter of other energy goods. Conversely, whilst being an oil-exporting country, the UK 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 (US, Euro area, Japan and Switzerland) also import other forms of energy. In section 2.3, we will evaluate whether these structural differences matter for the impact of oil shocks.

2.2 A structural VAR Model

We estimate the dynamic effects of oil shocks using 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 oil market and includes world oil production (Q_{oil}), the nominal price of crude oil expressed in US dollars (P_{oil}) and a measure of world economic activity (Y_w). The other group of variables $Y_{j,t}$ is country-specific and contains real GDP (Y_j), consumer prices (P_j), 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 orthogonalized error terms ε_t^X and $\varepsilon_{j,t}^Y$. ε_t^X captures the structural shocks in the oil market and $\varepsilon_{j,t}^Y$ the shocks specific to country j.

In the existing literature, cross-country comparisons are based on the dynamic effects of an average oil price shock or a non-linear transformation of it. However, not every oil price increase is alike because the underlying source can differ. Rising oil prices could be the consequence of exogenous production disruptions in oil-producing countries, but oil prices can also rise because of increased demand for oil resulting from economic activity or precautionary motives. The final economic consequences are likely to be different and hence, knowing what drives the oil price increase can be important for understanding the impact on the economy. Indeed, Kilian (2009) and PVR (2009) show that the economic effects of oil shocks in the US and Euro area are significantly different depending on the cause of the oil price shift. We therefore distinguish three different types of oil shocks, i.e. an oil supply shock, an oil demand shock driven by global economic activity and an oil-specific demand shock.

To identify the structural innovations, we elaborate on BP (2008, 2009) and PVR (2009) by imposing sign restrictions on the estimated impulse responses of the oil market variables in X_t. 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 in ε_t^X, which corresponds to restricting B to be block lower triangular. To disentangle the three oil shocks, we implement the following sign conditions:

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

The sign restrictions are derived from a simple supply-demand scheme of the oil market. First, an oil supply shock is an exogenous shift of the oil supply curve and therefore 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 quota's set by oil-exporting countries. Following an unfavorable oil supply shock, world industrial production will not increase. Second, shocks on the demand side of the oil market will 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 endogenously increase because of changes in macroeconomic activity that induce rising demand for commodities in general. Increasing demand from emerging economies like China and India is a good example. We define such a shock as an oil demand shock driven by economic activity. Accordingly, this shock is characterized 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 labeled oil-specific demand shocks. Fears concerning the availability of future supply of crude oil or an oil price increase based on speculative motives are natural 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. The final impact could even be negative because of the associated oil price increase. We impose the sign conditions to hold the first four quarters after the shocks to allow for sluggish responses. These sign restrictions on the global oil market are sufficient to uniquely disentangle the three types of shocks.[3] Since all individual country variables are not constrained in the estimations, the direction and magnitude of these responses are determined by the data. We also do not further identify the individual country shocks in $\varepsilon^{Y}_{j,t}$ since only the oil shocks are of interest.

The VAR model is estimated using quarterly data over the sample period 1986Q1-2008Q1. Using a time-varying VAR framework, BP (2008) find a considerable break in the oil market dynamics in the first quarter of 1986, which remains stable thereafter. This date, related to the collapse of the OPEC cartel or the start of the Great Moderation, is often selected for sample breaks in the oil literature and explains the choice of the starting point of our sample. Except for the interest rate, all variables are transformed to quarterly growth rates by taking the first difference of the natural logarithm.[4] Based on the conventional lag-selection criteria, we include three lags of the endogenous variables in the model. The results are however robust to reasonable changes in the sample period, to different choices of lag length and to alternative oil price and global economic activity measures.[5] Since we allow for feedback from the country-specific variables to the variables of the oil market in the VAR model, the magnitude and the dynamics of the identified

[3] Kilian (2009) disentangles oil supply shocks from demand shocks by assuming a vertical short-run oil supply curve in a monthly VAR, according to which shifts in the demand for oil do not have contemporaneous effects on the level of oil production. In addition, he assumes that economic activity is not immediately affected by oil-specific demand shocks. His identifying assumptions are, however, less appropriate for estimations with quarterly data such as real GDP. He therefore averages the monthly structural innovations over each quarter to estimate the impact on real GDP based on a single-equation approach in a second step.

[4] In line with PVR (2009), we did not found plausible cointegration relationships between the variables. Qualitative consistent results are, however, found for a log-level specification which allows for cointegration.

[5] More specifically, the results are robust to using real crude oil prices deflated by the US GDP deflator or WTI spot oil prices as oil price measures, and the global industrial production index constructed by the OECD as index of global economic activity.

shocks could differ depending on the country included in $Y_{j,t}$, which could impair cross-country comparability of the effects. However, imposing strict exogeneity between the oil market and country variables by estimating a so-called near-VAR does not affect the results reported in the paper, which indicates that cross-country comparisons can be made by simply normalizing the oil shocks to a 10 percent oil price increase.[6]

Following Peersman (2005) and PVR (2009), a Bayesian approach is used for estimation and inference. The prior and posterior distributions belong to the Normal-Wishart family. Because there are an infinite number of possible contemporaneous impact matrices for each draw from the posterior when using sign restrictions, we use the following procedure. 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 draw of a possible contemporaneous impact matrix. We then construct impulse response functions. If all the conditions imposed on the impulse responses are satisfied, we keep the draw. 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, which should improve identification (see Paustian 2007). A total of 1000 'successful' joint draws are then used to generate the impulse responses, of which the medians, 16th and 84th percentile error bands are reported in the figures.

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 nominal refiner acquisition cost of imported crude oil, which is considered to be the best proxy for the free market global price of imported crude oil in the literature. The world economic activity indicator is taken from BP (2009) and PVR (2009), and is calculated as a weighted average of industrial production of a large set of individual countries, including for instance China and India. Euro area data is collected from the Area Wide Model (AWM) dataset, see Fagan et al. (2001), and US real GDP, consumer prices and the nominal interest rate are retrieved from respectively US Bureau of Economic Analysis (BEA), US Bureau of labor Statistics (BLS) and from the Federal Reserve Economic Data (FRED) dataset. Data of the other individual countries are obtained from the OECD Main Economic Indicators (OECD MEI) database and the exchange rate data of all countries included are the Bank for International Settlements (BIS) nominal effective exchange rate indices.

[6] These results are available upon request.

2.3 The impact of different types of oil shocks across countries

Figure 1 shows the estimated median impulse response functions of the macroeconomic variables of all individual countries to the three types of oil shocks for the 1986Q1-2008Q1 sample period.[7] The estimated responses have been accumulated and are shown in levels in the figures. Each oil shock has been normalized to a ten percent long-run increase in the nominal price of oil, which is close to the observed quarterly volatility of oil prices over the estimation period. In order to evaluate the significance of the responses, Figure A1-A3 in the appendix show the median responses together with the 16th and 84th percentile error bands. To facilitate comparisons, Table 1 also contains the median responses for output and consumer prices at relevant horizons for all countries grouped according to the role of oil and energy for the economy.

Panel A of Figure 1 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 energy-importing countries (US, Euro area, Japan and Switzerland) experience a permanent fall in economic activity in the long-run. In contrast, output permanently increases in the countries that export both oil and other forms of energy, i.e. Norway and Canada. Despite being a net oil-importing country, real GDP only temporarily falls in Australia. The latter, however, is a significant non-oil energy exporting country, which probably compensates for the negative oil price effect. Also the UK, who is an oil-exporting but non-oil energy-importing country, experiences only a transitory fall in economic activity. Overall, not only the role of oil but also other forms of energy in the economy are important to determine the dynamic effects of oil supply shocks on output across countries. This also seems to be the case for the inflationary consequences.[8] We find an impact on consumer prices which is relatively strong for all energy-importing countries except for Japan, whereas inflationary pressures are negligible or even negative in net energy-exporting countries (see also Figure A1 in the appendix). These different

[7] The estimated impulse responses of oil production and oil prices following the structural shocks are shown in Figure 2 in section 3.1 of the paper, when we discuss the changes in the dynamics of the oil market over time.

[8] This finding is rather surprising given that PVR (2009) show that asymmetries in labor market characteristics are crucial to explain differences of the impact of oil supply shocks on consumer prices in individual Euro area countries. However, they only consider a set of net oil-importing countries, while we show that differences in oil and energy import dependence do seem to matter when also oil and energy-exporting countries are included in the analysis.

consumer price responses are probably driven by the response of the exchange rate. The exchange rate tends to appreciate in oil-exporting countries, which likely limits the pass-through to inflation.[9] The interest rate response after oil supply shocks is generally in accordance with the effect on inflation, i.e. only in oil-importing countries, monetary policy is significantly tightened to stabilize inflation.

The economic effects of an oil demand shock driven by global economic activity are substantially different from the impact of exogenous oil supply shocks. Panel B of Figure 1 shows that all countries experience significant long-run inflationary effects and even a significant short-run increase of real GDP (see also Figure A2 in the appendix). When we compare the magnitudes across countries in Table 1, the temporary increase of output is similar for all countries, irrespective of the relevance of energy products. Although in contrast with the results after oil supply shocks, this finding is not surprising since we consider an oil price shift that is driven endogenously by a shift in worldwide economic activity. Accordingly, other factors are likely to determine the final effects on economic activity and inflation, rather than the oil and energy intensity of the economy. Output can rise because the country itself is in a boom, or because it indirectly gains from trade with the rest of the world. Also inflation differences are small between most countries. We only observe a stronger impact in Australia and Norway. Somewhat surprising, output in Japan, UK and Canada declines in the long run. In most countries, the interest rate temporarily increases.

The dynamic effects of oil-specific demand shocks are also considerably different compared to the two other sources of oil price shifts, as can be seen in Panel C of Figure 1. In all countries, this shock is characterized by a temporary, U-shaped, 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 US (see Figure A3 in the appendix). In the oil and energy-exporting countries, the exchange rate does not significantly respond, in contrast to the appreciations after an oil supply shock. Comparing cross-country differences of the magnitudes of the effects (see Table 1) indicates that oil-importing and oil-exporting countries react in a similar way, i.e. also after this type of oil demand shock, the role of oil and energy in

[9] For instance, when we add respectively the import and GDP deflator to the Norwegian VAR as an eighth variable, the import deflator considerably falls and the GDP deflator strongly increases after an oil supply shock, which confirms this conjecture.

the economy seems not to matter much. Except in the US, the interest rate response is generally in line with the reaction of consumer prices.

In sum, the underlying source of the oil price increase is crucial to determine the repercussions of oil shocks on the economy. In addition, the role of oil and other forms of energy in the economy, i.e. being a net energy-importing or energy-exporting country, is only important to understand the cross-country divergences after conventional exogenous oil supply shocks. These marked differences are absent for shocks at the demand side of the global oil market. Accordingly, making cross-country comparisons solely based on oil price shocks is misleading since oil prices are determined by a combination of supply and demand disturbances, with each shock affecting the economies differently. In the end, variance decompositions show that for the period 1986-2008, oil supply and demand shocks both explain approximately 50 percent of oil price volatility.[10]

3 Has the impact changed over time?

3.1 The normalization problem

The way the economy experiences oil shocks appears to have changed fundamentally over time. Variations in the share and role of oil in the economy are prominent arguments in the literature of time-varying effects of oil shocks (e.g. Bernanke 2006, Blanchard and Gali 2007 or Hamilton 2009).[11] For the US economy, Edelstein and Kilian (2009), Herrera and Pesavento (2007) and Blanchard and Gali (2007) indeed find a reduced impact of oil price shocks on real GDP and inflation over time, and refer to a decreased dependency on crude oil as a possible explanation. On the other hand, the oil market itself has undergone substantial changes, which can also bring about time-varying effects of oil shocks. Lee, Ni and Ratti (1995) and Ferderer (1996) argue that increased oil market volatility has led to a breakdown of the empirical relationship between oil prices and economic activity since the

[10] More specifically, oil supply shocks contribute 57 percent to oil price variability, whilst the contemporaneous contribution of oil demand shocks driven by economic activity and oil-specific demand shocks are respectively 27 and 16 percent.

[11] Other potential explanations for changing effects of oil shocks over time that have been put forward are improved monetary policy, more flexible labor markets, changes in the composition of automobile production and the overall importance of the automobile sector (see e.g. Blanchard and Gali 2007 or Edelstein and Kilian 2009). These explanations are out of the scope of this paper, but could be explored in future research.

mid-eighties. BP (2008) and BP (2009) document respectively a considerably less elastic or steeper oil demand and oil supply curve over time. These changes in the oil market, however, seriously complicate comparisons of the dynamic effects of oil shocks over time. For instance, if a comparison of the consequences of an oil supply shock is based on a similar change of crude oil prices (e.g. a 10 percent rise), BP (2008) find a more muted impact on the US economy in more recent periods, which is consistent with the above described evidence in the oil literature. Such a comparison, however, implicitly assumes a constant elasticity of the oil demand curve, which is exactly rejected by the data. Consequently, normalizing on a certain oil price increase assumes totally different associated oil supply shifts over time, i.e. large shifts in the 1970s and more limited ones in since th esecond part of the 1980s. Figure A4 in the appendix illustrates this graphically. On the other hand, if an exogenous oil supply shock is measured as a similar shift in world oil production (e.g. a production shortfall of 1 percent), BP (2008) find much stronger effects on real GDP and consumer prices in the US in more recent times compared to the 1970s and early 1980s. For exactly the same reason, however, normalizing on oil production is also biased. In particular, a similar shift in oil production currently has a greater impact on oil prices, which complicates the comparison over time. When they consider a typical one standard deviation oil supply shock, the impact has not dramatically changed. Whether the size of average oil shocks has changed, however, cannot be identified. This problem of comparability after oil supply shocks also carries over to shocks at the demand side of the oil market. BP (2009) show that also the short-run oil supply curve became much less elastic over time. As a consequence, also comparisons of normalized demand shocks are distorted since a constant slope of the oil supply curve is assumed.

In Figure 2, we demonstrate this normalization problem in the context of our analysis. BP (2009) model time variation by estimating a Bayesian VAR with time-varying parameters and stochastic volatility. We reproduce their results by estimating the effects using our benchmark SVAR model for two different sample periods, i.e. 1971Q1-1985Q4 (henceforth 'the seventies') and 1986Q1-2008Q1 (henceforth 'the nineties'). The latter period is also the one used for the estimations in section 2. The first two columns of the figure show the impulse responses for respectively global oil production and the oil price for one standard deviation shocks. A typical unfavorable oil supply shock is in the nineties characterized by a much smaller fall of world oil production and a greater effect on the price of crude oil relative to the seventies. The corresponding estimated oil demand elasticities can be found in the last column of Figure 2, and confirm the considerable steepening over time. To illustrate the implications for making comparisons over time, Figure 2 also shows the impact on US real GDP for an oil supply shock measured respectively as a one standard deviation shock, an oil price increase of 10 percent and an oil production shortfall of 1 percent.[12] An oil supply shock that raises oil prices by 10 percent indeed has a smaller impact on activity in the US in the more recent period. However, the effects of a 1 percent innovation in oil production are stronger in the nineties, whereas the impact is more or less constant over time for a one standard deviation shock, which is in line with BP (2008). Similar difficulties emerge for a comparison of both oil demand shocks over time. Whilst the impact of the one standard deviation shocks on oil prices did not change a lot over time, the underlying disturbances in oil production are very different, especially in the short run. Accordingly, the short-run supply curve became much steeper over time, which can also be seen by the elasticities in the last column of Figure 2. Whereas the steepening does not hold anymore in the long run, a normalized experiment is still biased, particularly since the economic consequences after oil demand shocks are only temporary. The bottom two rows of Figure 2 illustrate this for US real GDP.[13]

3.2 Structural changes and cross-country differences over time

In order to better understand time variation in the dynamic effects of oil shocks, we can explore the cross-country dimension of our analysis. More specifically, we can investigate whether a changing role of oil and energy matters for time variation by comparing the time-varying responses to changes in the oil and non-oil energy intensities over time. If a reduced dependency on crude oil and other forms of energy has resulted in a more subdued responsiveness to oil shocks, the change over time should be larger for countries that improved their net energy position or oil intensity the most. Hence, comparing relative changes between countries avoids the normalization problem.

Panel A of Table 2 lists several indicators of the country-specific role of oil, non-oil energy and total energy for the 1970-1985 and 1986-2008 period and shows the changes of these indicators over time. Whilst all countries experienced a noticeable fall in total

[12] The results for other countries and variables are available upon request, but the consequences are identical since all countries are subject to same changes in the global oil market.

[13] Note that, since the impact on production in the seventies is only transitory, we had to normalize the effects for a contemporaneous 1 percent decline in oil production.

energy intensity of the economy and an improvement in net oil and total energy import dependence, the cross-country differences are substantial (see respectively the first, third and last column of Panel A). Norway is the only country that has been a net exporter of crude oil over the entire sample. Its exports of crude oil increased to a level more than seven times as high compared to the seventies. In addition, exports of non-oil energy are also four times higher in the nineties. The oil and gas industry in Norway is currently even the largest contributor to GDP. Whereas Canada and the UK were on average oil-importing countries in the seventies, they switched to being net-exporters on average since the mid-1980s. Canada also succeeded in more than doubling its net exports of other forms of energy. This rise is even larger for Australia, which increased its net export ratio from 87 tonnes per unit of GDP in the seventies to 220 in the period covering the nineties. Even within the group of net energy-importing countries, the changes are very different over time. The Euro area and Japan significantly reduced their oil dependency to almost half the level of the seventies. Part of this improvement, however, is compensated by increased imports of other forms of energy. On the other hand, the US and Switzerland have hardly improved their reliance on oil imports. Both countries also experienced the smallest fall in net imports of total energy. Noticeable is the evolution of the US. The overall energy intensity of its economy has been reduced the most over time. However, this reduction can be fully attributed to a fall in domestic production. The net energy import dependence of the US has actually not really changed over time.

With a view to evaluate whether a changed role of oil and other forms of energy in the economy is important to explain varying effects of oil shocks, we compare the change in economic impact with the relative improvement in the net oil and energy position over time. Figure 3 depicts the impact on real GDP of the three types of oil shocks, normalized to a 10 percent increase of oil prices, for respectively the 1970-1985 and 1986-2008 periods.[14] The degree of reduced responsiveness between both periods, calculated as the difference between the maximum median response of GDP in the seventies and the nineties to each oil shock, are reported in Panel B of Table 2.[15] Table 2 shows that the

[14] As already mentioned, since we only compare the relative cross-country differences over time, it does not matter whether we normalize on oil prices or oil production.

[15] Note that if we would consider the change in the long-run impact on economic activity instead of the difference in the maximum effect, we would not take into account that in several countries also the shape of the response has changed considerably. This is clearly the case for Japan and Switzerland after an oil supply shock for example.

maximum fall in output after an oil supply shock, which is normalized to increase oil prices by 10 percent, has indeed reduced over time for all countries. The degree of improvement, however, is very different. First, consider the countries that are net exporters of energy on average since 1986 in Panel A of Figure 3, i.e. Norway, Canada, Australia and the UK. Whilst the output effects after oil supply shocks were more or less equally severe as in the net energy-importing countries in the seventies, the impact on economic activity became insignificant or even positive in more recent times. These net energy-exporting countries also made considerable advances in their net oil and total energy positions over time (see Panel A of Table 2). Second, even among the net energy-importing countries, we notice a reduction in the output effects after oil supply shocks which is somewhat lower in Switzerland and the US, two countries that hardly improved their net energy dependence. Accordingly, relative improvements in the oil and energy positions could explain the changed effects oil supply shocks.[16] Compared to the strongly time-varying effects of oil supply shocks, the responses of GDP after oil demand shocks driven by economic activity have changed much less over time, except for Switzerland (see Panel B of Figure 3 and Table 2). Considering the relative changes over time, the role of oil and energy seems not to matter for explaining the cross-country differences, which is not surprising given the nature of this type of shock as discussed in section 2.3. On the other hand, the net energy position can be of importance for understanding time-variation in the effects of oil-specific demand shocks. The last column of Table 2 indicates that the peak of the decline became somewhat more subdued for the countries that improved their net energy-position most over time, with the notable exception of the US. Specifically, in contrast to the net energy-importing countries, most net-energy exporting countries managed to reduce the maximum decline in economic activity following an oil-specific demand shock. In sum, these results support the hypothesis that the oil and non-oil energy intensities are important to explain cross-country differences over time after oil supply shocks and oil-specific demand shocks.

[16] Rank correlations of respectively 0.93 and 0.52 between the change in net oil and net energy imports and the change in economic impact over time confirm that the time-varying effects of oil supply shocks can be related to the changes in oil and energy dependence.

4 Conclusions

In this paper, we compared the dynamic effects of several types of oil shocks across a set of industrialized countries which are very diverse with respect to the role of oil and other forms of energy in their economy. Several important insights emerge from this analysis. First, the underlying source of the oil price shift is crucial to determine the economic consequences for all countries, which is in line with the results of Kilian (2009) and Peersman and Van Robays (2009) for the United States and Euro area respectively. More specifically, for oil demand shocks that are driven by shifts in global economic activity, all countries experience a temporary increase of economic activity and a significant rise of inflation. Conversely, oil-specific demand shocks are followed by a transitory decline of output and negligible inflationary effects. The role of oil and energy does not seem relevant for explaining the cross-country differences in the impact of both demand shocks. This role, however, is very important to determine the economic effects of exogenous oil supply shocks. In particular, all net oil and energy-importing countries are confronted with a permanent fall in economic activity and a rise of inflation. On the other hand, the long-run impact on real GDP is insignificant or even positive in countries that are net energy-exporters. In addition, also the impact on inflation is much more subdued, probably driven by an appreciation of the effective exchange rate in the latter group of countries. As a result, not disentangling oil price shocks based on their underlying source could seriously bias estimations of the cross-country effects of oil shocks.

Second, making a comparison of the dynamic effects of oil shocks over time implicitly poses a normalization problem, since both the oil demand curve and the short-run oil supply curve have steepened since the mid-1980s. Considering the time-varying impact of a certain oil price increase, or alternatively a specific fall in oil production, implies a bias since totally different associated oil shocks are assumed. We showed that by using the cross-country dimension and considering relative changes over time, however, we can avoid this normalization problem. In particular, if the role and share of oil and energy is important for understanding time variation, the change in the economic effects should be more favorable for countries that improved their oil and energy position the most over time. Our results show that the degree of improvement in oil and energy dependence is indeed important for time-variation in the effects of oil supply shocks and oil-specific demand shocks and for explaining the associated cross-country differences.

Our evidence obviously does not exclude that other factors are also relevant determinants for cross-country differences of the economic repercussions and time-varying effects of oil shocks. Whereas we have only analyzed the role of oil and energy, also monetary policy credibility, labor market characteristics or other structural features could matter to explain asymmetries. The relevance of other determinants is something which could be explored in future research, in particular for the effects on inflation. A first attempt for individual Euro area countries is made by Peersman and Van Robays (2009).

References

[1] Barsky, R.B. and L. Kilian (2004), "Oil and the Macroeconomy Since the 1970s", *Journal of Economic Perspectives*, 18(4), p 115-134.

[2] Baumeister, C. and G. Peersman (2008), "Time-Varying Effects of Oil Supply Shocks on the US Economy", *Ghent University Working Paper 2008/515.*

[3] Baumeister, C. and G. Peersman (2009), "Sources of the Volatility Puzzle in the Crude Oil Market", *mimeo*, Ghent University.

[4] Bernanke, B.S. (2006), "Energy and the Economy", *speech to the Economic Club of Chicago*, June 15.

[5] Blanchard, O.J. and J. Galí (2007), "The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so different from the 1970s?", *NBER Working Paper 13368*.

[6] Burbidge, J. and A. Harrison (1984), "Testing for the Effects of Oil-Price Rises Using Vector Autoregressions", *International Economic Review*, 25(2), p 459-484.

[7] Cuñado, J. and F. Péres de Gracia (2003), "Do Oil Price Shocks Matter? Evidence for some European Countries", *Energy Economics*, 25, p 137-154.

[8] Darby, M. (1982), "The Price of Oil and World Inflation and Recession", *American Economic Review*, 72, p 738-751.

[9] Edelstein, P. and L. Kilian (2009), "How Sensitive are Consumer Expenditures to Retail Energy Prices?", *Journal of Monetary Economics*, fortfcoming.

[10] Fagan, G., J. Henry and R. Mestre (2001), "An Area-Wide Model (AWM) for the Euro Area", *ECB Working Paper 42*.

[11] Ferderer, J.P. (1996), "Oil Price Volatility and the Macroeconomy", *Journal of Macroeconomics*, 18(1), p 1-26.

[12] Hamilton, J.D. (1983), "Oil and the Macroeconomy Since World War II", *Journal of Political Economy*, 91(2), p 228-248.

[13] Hamilton, J.D. (2003), "What is an Oil Shock?", *Journal of Econometrics*, 113, p 363-398.

[14] Hamilton, J.D. (2009), "Causes and Consequences of the Oil Shock of 2007-2008", *Brookings Papers,* forthcoming.

[15] Herrera, A.M. and E. Pesavento (2007), "Oil Price Shocks, Systematic Monetary Policy and the 'Great Moderation'", *Macroeconomic Dynamics*, 13(1), p 107-137.

[16] Jiménez-Rodríguez, R. and M. Sánchez (2005), "Oil Price Shocks and Real GDP Growth: Empirical Evidence for Some OECD Countries", *Applied Economics*, 37(2), p 201-228.

[17] Kilian, L. (2008), "A Comparison of the Effects of Exogenous Oil Supply Shocks on Output and Inflation in the G7 Countries", *Journal of the European Economic Association*, 6(1), p 78-121.

[18] Kilian, L. (2009), "Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market", *American Economic Review*, 99(3), June 2009.

[19] Lee, K., S. Ni, and R.A. Ratti (1995), "Oil Shocks and the Macroeconomy: The Role of Price Variability", *The Energy Journal*, 16(4), p 39-56.

[20] Mork, P., O. Oslen and H. Mysen (1994), "Macroeconomic Responses to Oil Price Increases and Decreases in Seven OECD Countries", *Energy Journal*, 15, p 15-38.

[21] Paustian, M. (2007), "Assessing Sign Restrictions", *The B.E. Journal of Macroeconomics*, 7(issue 1) (Topics), Article 23.

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

[23] Peersman, G. and I. Van Robays (2009), "Oil and the Euro Area Economy", *Economic Policy*, forthcoming.

[24] Rotemberg, J.J. (2007), "Comment on Blanchard-Galí: The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so different from the 1970s", *NBER book "International Dimensions of Monetary Policy",* forthcoming.

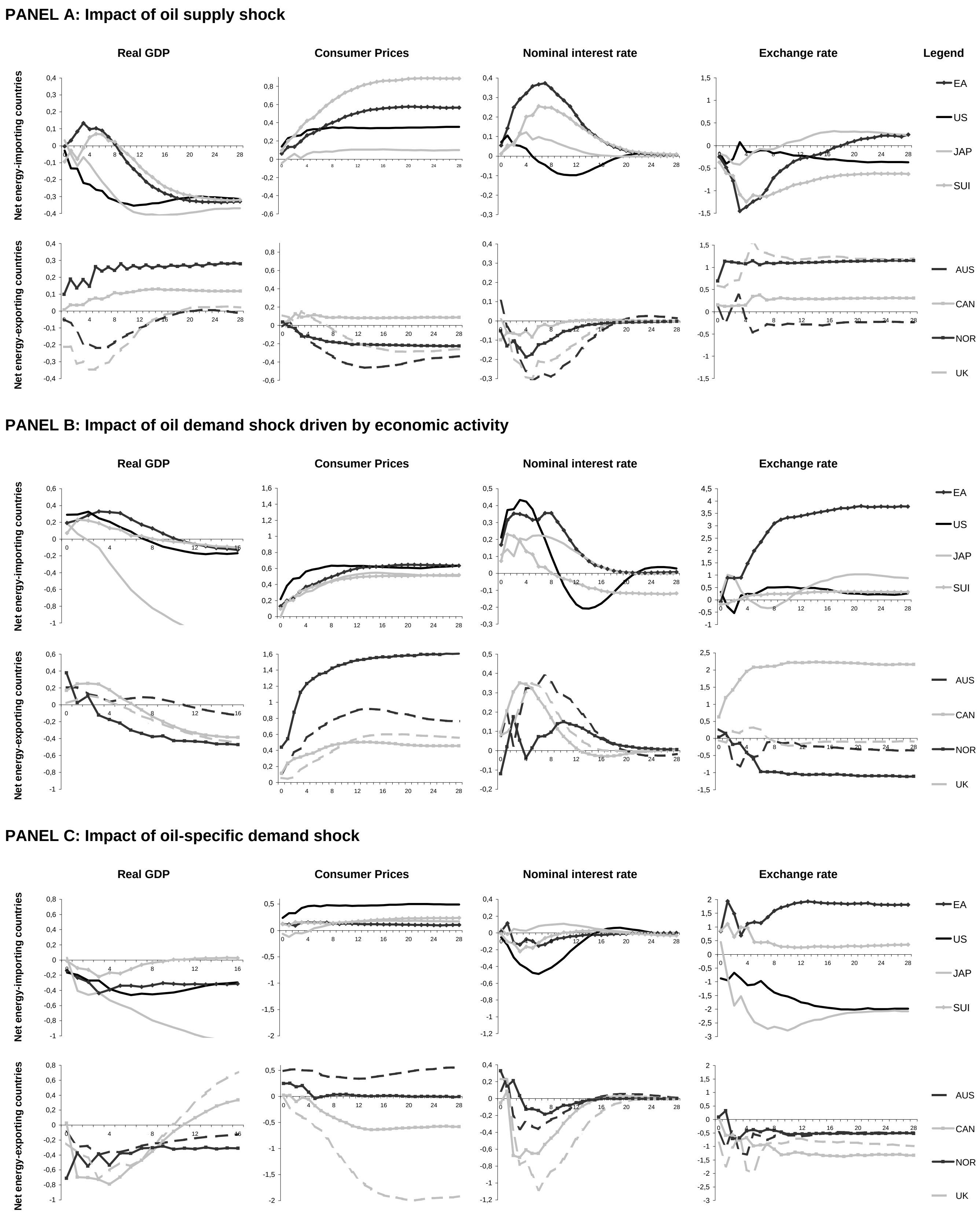


Figure 1. Impact of different types of oil shocks

Notes: Figures are median impulse responses to a 10 percent long-run rise in oil prices, horizon is quarterly.

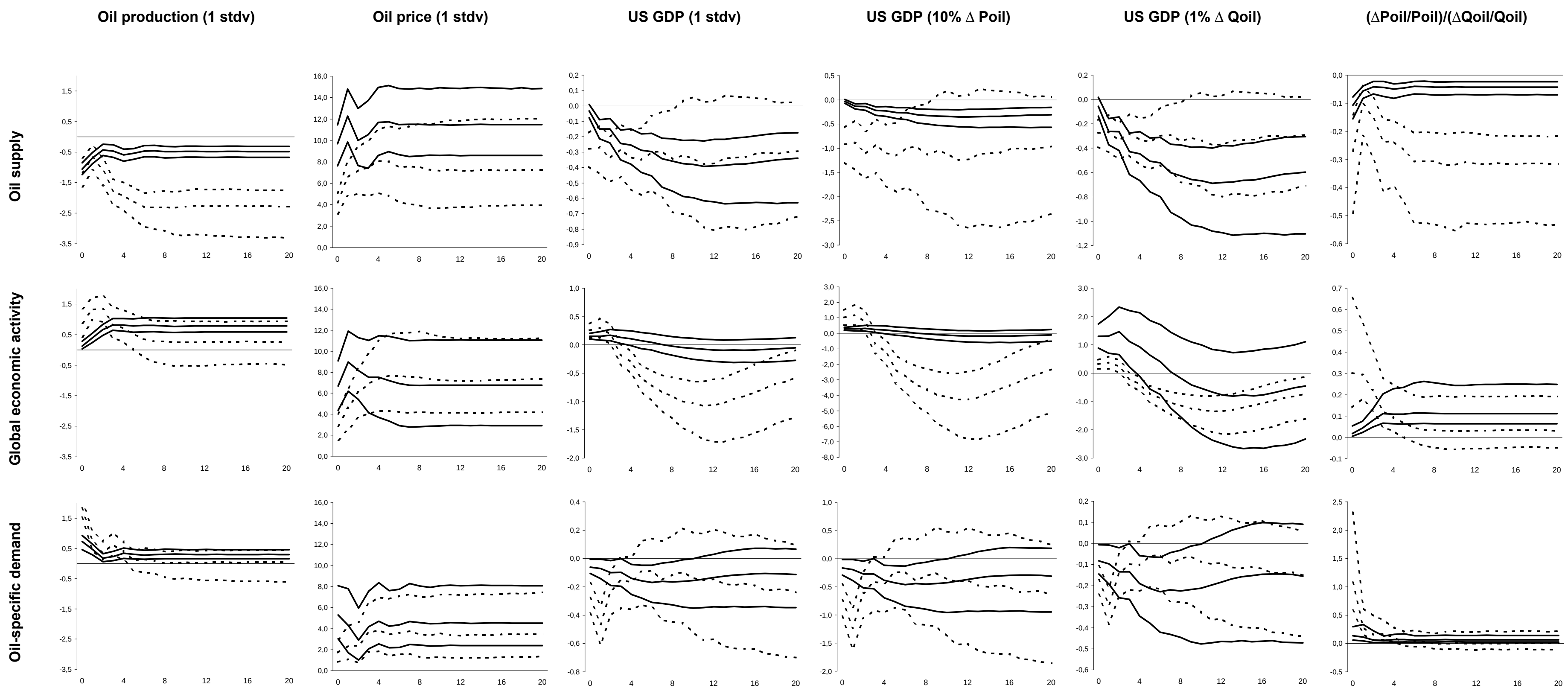
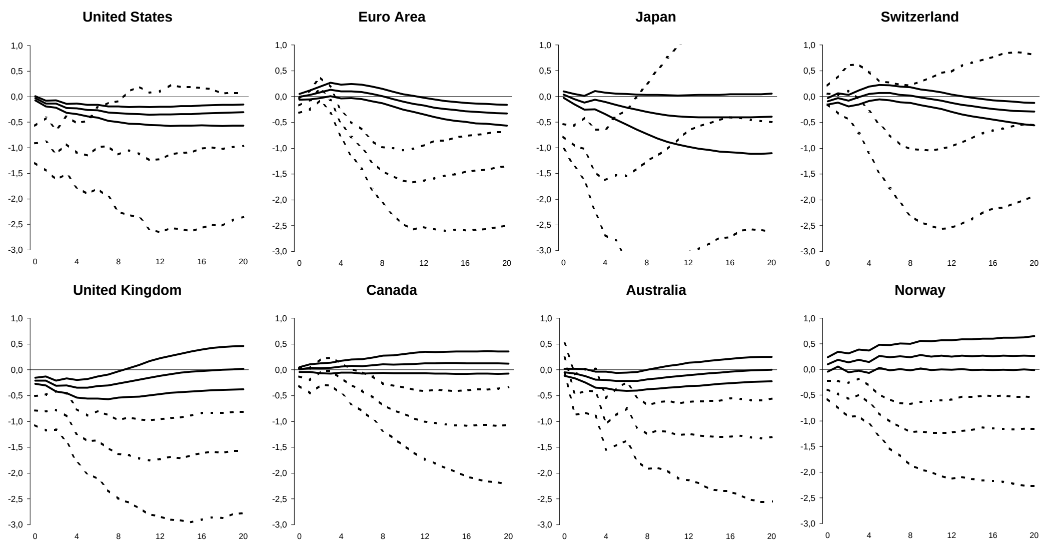


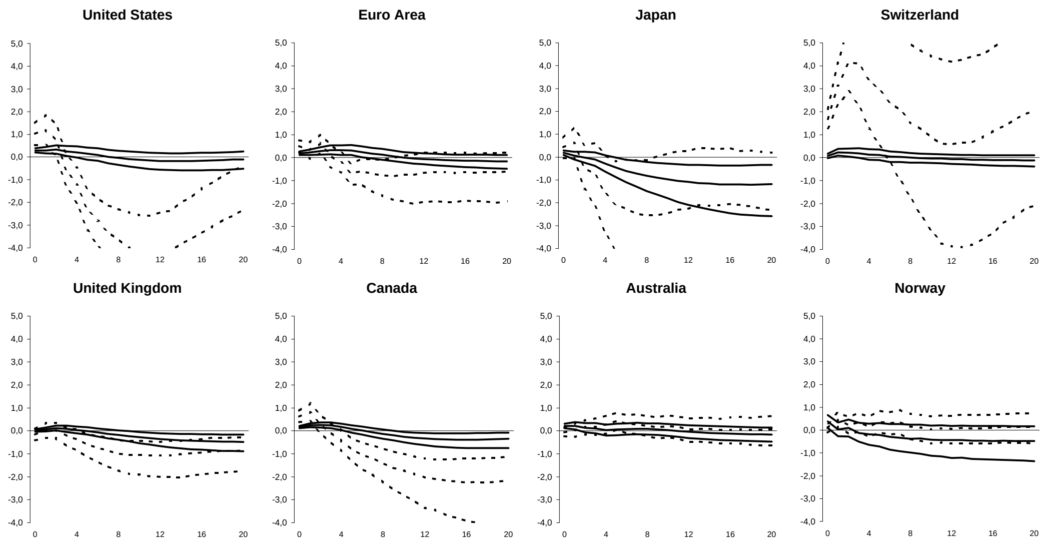
Figure 2. Oil market dynamics over time and the normalisation problem for the US

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

PANEL A: Effect of oil supply shock on GDP over time



PANEL B: Effect of oil demand shock driven by economic activity on GDP over time



PANEL C: Effect of oil-specific demand shock on GDP over time

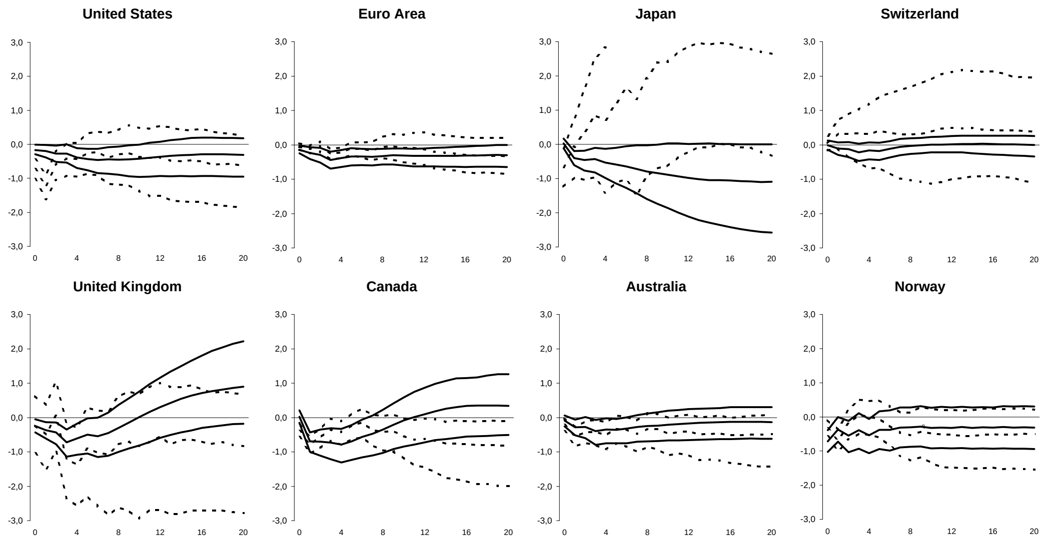


Figure 3. The effects of different types of oil shocks on GDP over time

Notes: The figures are median impulse response function to a 10 percent long-run increase in oil prices, horizon is in quarters, 1971-1985: dotted lines, 1986-2008: full lines.

Table 1 - Structural differences across countries and the impact of oil shocks

1986-2008	Oil[1]			Non-oil energy[1]			Total energy[1]			Energy Intensity[2]			Oil supply[3]		Global activity[3]		Oil-specific dem[3]	
	net import	production	total	net import	production	total	net import	production	total	petrol	other	total	GDP	CPI	GDP	CPI	GDP	CPI
United States	55	41	96	2	156	158	57	197	254	91	81	172	-0,31	0,35	0,33	0,61	-0,46	0,50
Euro Area	71	2	73	30	65	95	101	67	168	60	57	117	-0,32	0,58	0,33	0,65	-0,44	0,11
Japan	67	0	67	62	29	91	129	29	158	65	41	106	-0,40	0,10	0,19	0,53	-1,10	0,18
Switzerland	22	0	22	47	50	97	69	50	119	60	36	96	-0,29	0,88	0,23	0,51	-0,22	0,23
United Kingdom	-21	79	58	11	95	106	-10	174	164	52	61	113	0,02	-0,29	0,12	0,60	-0,72	-1,99
Canada	-16	109	93	-116	329	213	-132	438	306	101	132	233	0,12	0,08	0,25	0,47	-0,79	-0,60
Australia	7	53	60	-220	375	155	-213	428	215	73	69	142	0,00	-0,40	0,21	0,85	-0,40	0,48
Norway	-704	815	111	-331	398	67	-1035	1213	178	59	79	138	0,26	-0,22	0,38	1,58	-0,71	0,00

Notes:

[1]: Averages for the period 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]: Averages for the period 1986-2008 based on International Energy Agency (IEA) data measured as (tonnes of oil equivalent) / GDP (million USD, PPP weighted) of respectively total final consumption of petroleum products, total final consumption of total energy excluding petroleum products and sum of both.

[3]: 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 for oil demand shock driven by global economic activity and maximum impact for an oil-specific demand shock; long-run (20 quarters) effect on CPI for all three shocks.

Table 2 - The role of oil and energy and impact of oil shocks over time

PANEL A: Oil and energy indicators over time

	Net import of oil[1]			Net import of non-oil energy[1]			Net import of total energy[1]			Total energy production[1]			Energy intensity[1]		
	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	-4	2	6	59	57	-2	315	197	-118	374	254	-120
Euro Area	112	71	-41	15	30	15	127	101	-26	83	67	-16	210	168	-42
Japan	122	67	-55	52	62	10	174	129	-45	23	29	6	197	158	-39
Switzerland	28	22	-6	58	47	-11	86	69	-17	36	50	14	122	119	-3
United Kingdom	44	-21	-65	15	11	-4	59	-10	-69	180	174	-6	239	164	-75
Canada	12	-16	-28	-57	-116	-59	-45	-132	-87	434	438	4	389	306	-83
Australia	31	7	-24	-87	-220	-133	-56	-213	-157	316	428	112	260	215	-45
Norway	-96	-704	-608	-82	-331	-249	-178	-1035	-857	397	1213	816	219	178	-41

PANEL B: Effects of oil shocks over time

	Oil supply shock Max impact on GDP[2]			Global activity shock Max impact on GDP[2]			Oil-specific demand shock Max impact on GDP[2]		
	1971-1985	1986-2008	change	1971-1985	1986-2008	change	1971-1985	1986-2008	change
United States	-1,24	-0,35	*0,89*	1,19	0,33	*-0,86*	-1,23	-0,46	*0,77*
Euro Area	-1,66	-0,33	*1,33*	0,61	0,33	*-0,28*	-0,33	-0,44	*-0,11*
Japan	-1,63	-0,41	*1,22*	0,63	0,19	*-0,44*	-0,66	-1,10	*-0,44*
Switzerland	-1,04	-0,32	*0,72*	4,13	0,23	*-3,90*	0,05	-0,22	*-0,27*
United Kingdom	-1,75	-0,35	*1,40*	0,02	0,12	*0,10*	-1,37	-0,72	*0,65*
Canada	-1,09	0,01	*1,10*	0,80	0,25	*-0,55*	-0,82	-0,79	*0,03*
Australia	-1,37	-0,22	*1,15*	0,44	0,21	*-0,23*	-0,55	-0,40	*0,15*
Norway	-1,23	0,1	*1,33*	0,47	0,38	*-0,09*	-0,68	-0,71	*-0,04*

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 imports of crude oil, net imports of total energy excluding crude oil, net imports of total energy, total domestic energy production and total domestic energy consumption.

[2]: Estimated maximum negative median response of GDP to oil supply shock and oil-specific demand shock and maximum positive median response of GDP to global economic activity shock. All oil shocks are normalised to increase oil prices by 10% in the long run.

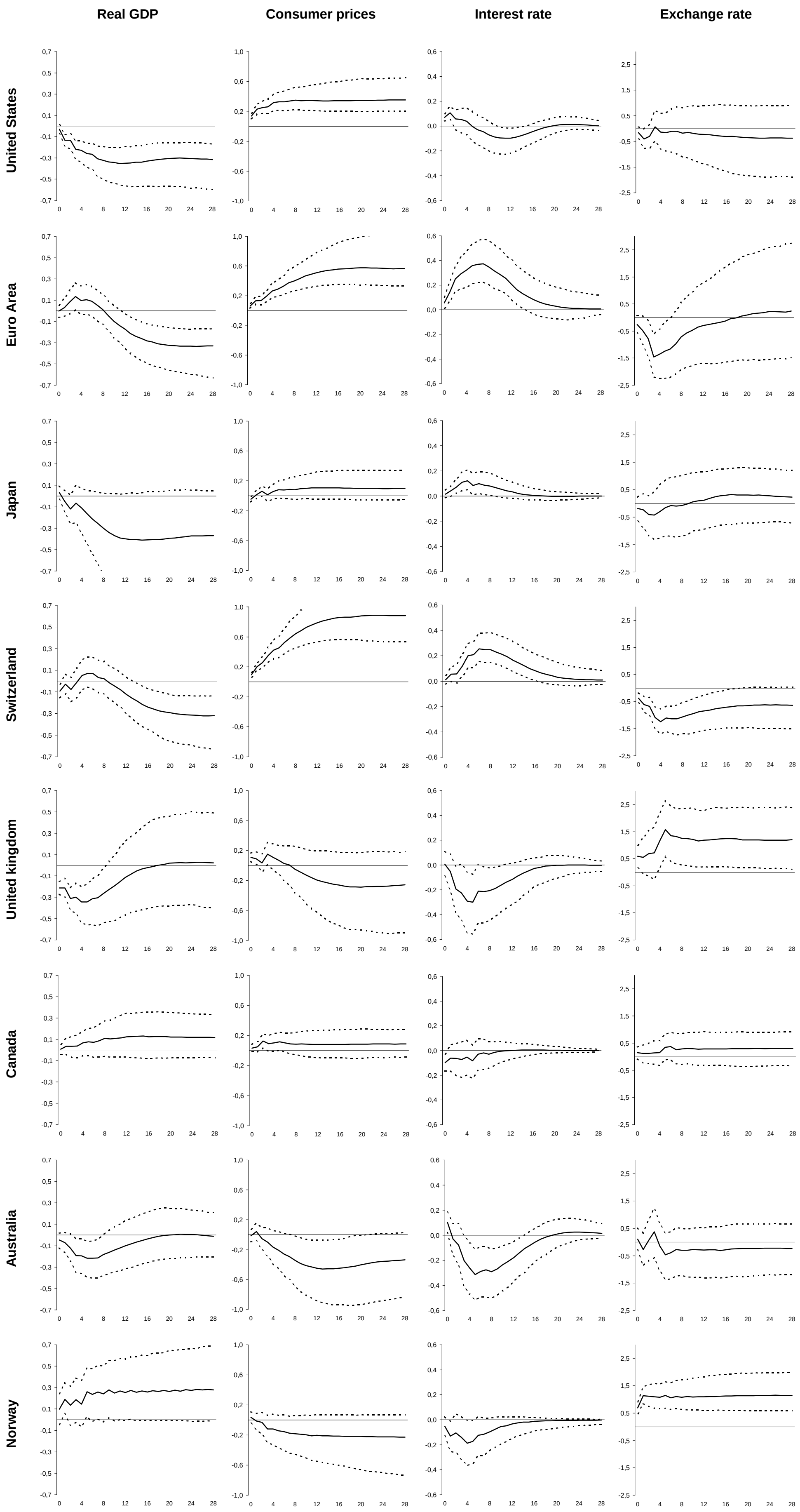


Figure A1. Impact of oil supply shock

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

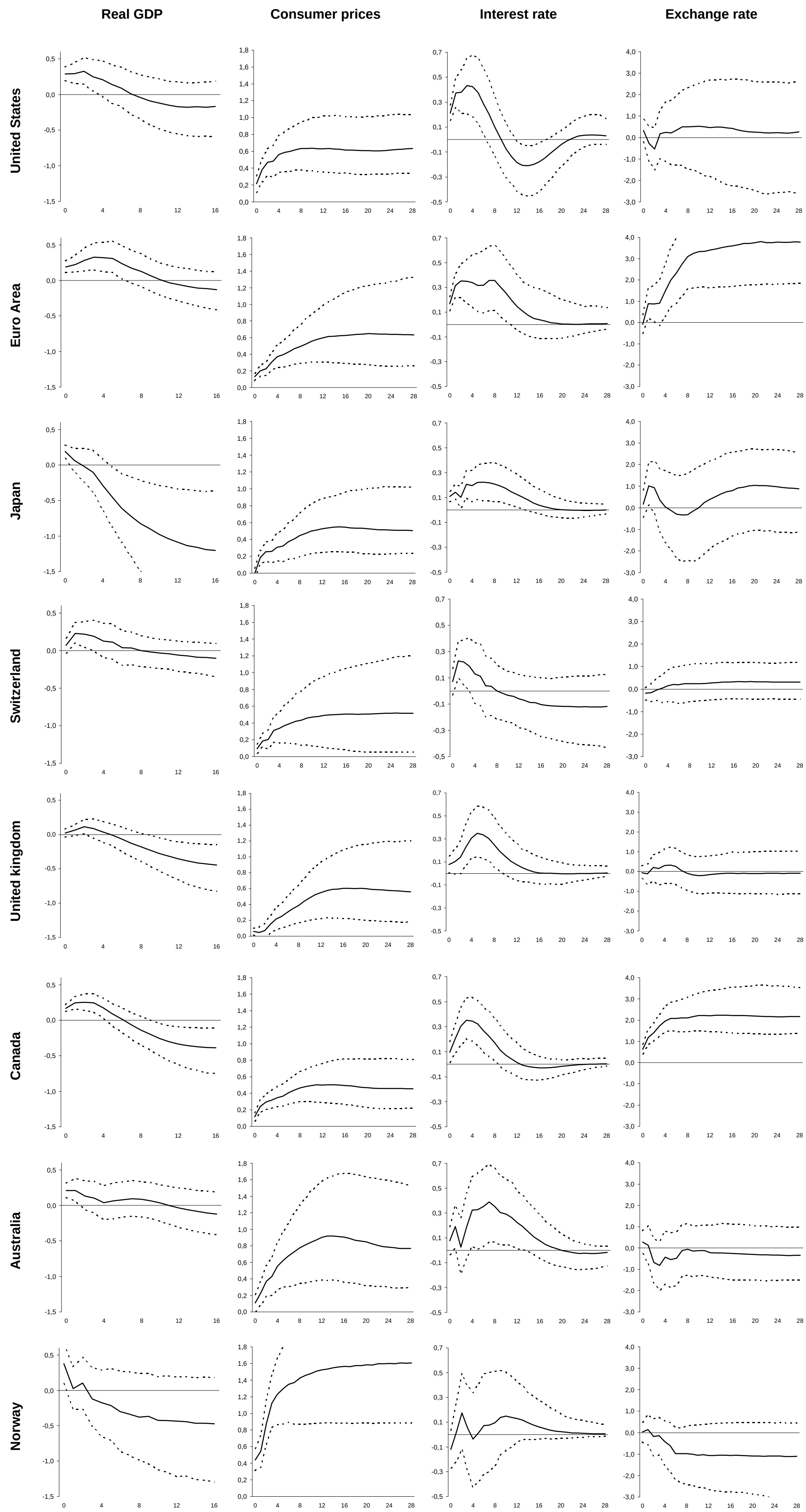


Figure A2. Impact of oil demand shock driven by economic activity

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

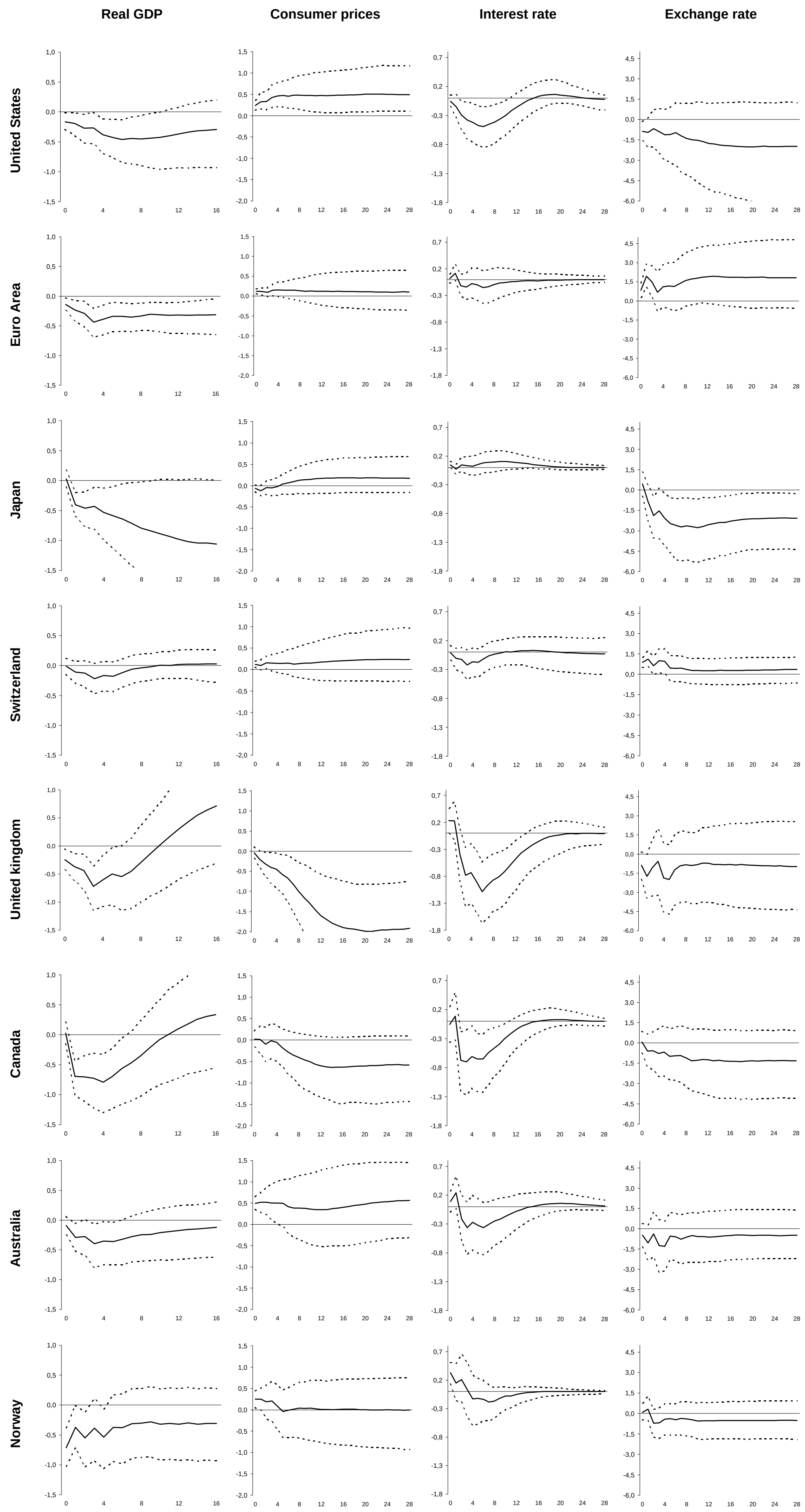


Figure A3. Impact of oil-specific demand shock

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

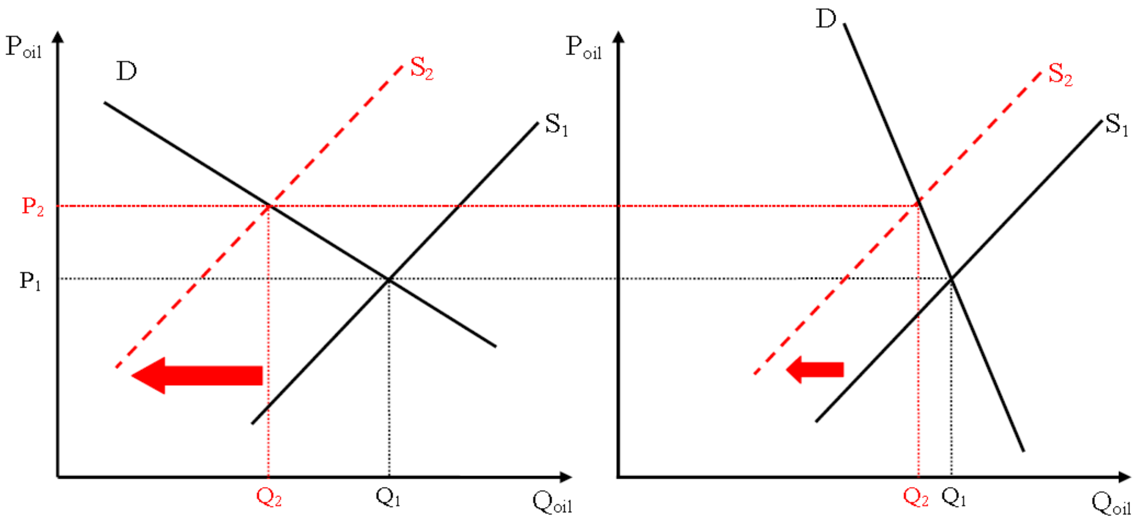


Figure A4. Steepening of the oil demand curve - oil supply shock with same oil price increase