What drives oil prices? Emerging versus developed economies.*

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Abstract

We analyze the importance of demand from emerging and developed economies as drivers of the real price of oil the last two decades. Using a FAVAR model that allows us to separate between different groups of countries, we find that demand from emerging economies (most notably from Asian countries) is more than twice as important as demand from developed countries in accounting for the fluctuations in the real price of oil and in oil production. Furthermore, we find that different geographical regions respond differently to oil supply shocks and oil-specific demand shocks that drive up oil prices, with Europe and North America being more negatively affected than emerging Asia and South America. We show that this heterogeneity in responses is not only attributable to differences in energy intensity in production across regions, but also to degree of openness and the investment share in GDP.

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1 Introduction

Since the seminal work of Hamilton (1983), a large literature has suggested that there is a significant negative link between oil price increases and economic activity in a series of different countries (see e.g. Burbidge and Harrison (1984), Gisser and Goodwin (1986), Bjørnland (2000) and Hamilton (1996, 2003, 2009) among many others). Higher energy prices typically lead to an increase in production costs and inflation, thereby reduced overall demand, output and trade in the economy.

Recent findings by Barsky and Kilian (2002, 2004), however, suggest that the negative effects of oil price changes may be exaggerated, as previous papers did not allow for a 'reverse causality' from macroeconomic variables to oil prices. Allowing for such a link, they find that oil price shocks have played a smaller role in the U.S. recessions than commonly thought.[1] Subsequently, Kilian (2009) has shown that if the increase in the oil price is driven by increased demand for oil associated with fluctuations in global activity and not disruptions of supply capacity, economic activity may even be positively affected, at least in the short run. Corroborate findings for the US and the Euro area have been documented by Kilian et al. (2009), Kilian and Park (2009), Lippi and Nobili (2012), Peersman and Van Robays (2012) and Aastveit (2012) among others.

The steady increase in oil prices without apparent severe negative effects on the global economy during the last decade, suggests that demand shocks have been important drivers of the price of oil. Consistent with this view, Kilian and Murphy (2012) finds that oil supply shocks have accounted for a smaller fraction of the variability of the real price of oil in more recent time, implying a greater role for demand shocks as a driver of the oil prices. But from where is the increased demand for oil initiated? From emerging economies, that are growing at a pace twice that of the developed economies? Or from the developed world, whose demand are the main drivers of export and thereby growth in emerging economies?

While it is commonly believed that growth in emerging markets (Asia in particular) is the main driver of the increased demand for oil (see e.g. the discussion in Kilian (2009), Baumeister and Peersman (2012b) and Hicks and Kilian (2012)[2]), no studies have analyzed this question explicitly using a structural model. Hence, very little is known about the effect the increased

[1] See also Kilian (2008b) and Edelstein and Kilian (2009) for corroborate findings using different methodology.

[2] Hicks and Kilian (2012) show that recent forecast surprises were associated with unexpected growth in emerging economies and that these forecast surprises were central in driving up the real price of oil during the mid 2000s.

growth in emerging economies has had on the real price of oil, and maybe equally importantly, how economic activity in different regions of the world are affected by changes in oil prices.

To answer these questions, we estimate a factor augmented vector autoregressive (FAVAR) model with separate activity factors for emerging and developed economies in addition to global oil production and the real price of oil. The advantage with this modeling strategy is that we can preserve the parsimonious data representation offered by factor modeling techniques, while also utilize a large cross section of countries in one single model.[3] Traditionally, empirical studies investigating the interaction between oil prices and the macro economy have employed one or many small scaled vector autoregressions (VAR), typically covering only one country in each model. This limits the cross sectional dimensions of the analysis.

To identify the structural shocks in the model, we build on the work of Kilian (2009), which separates between oil supply and demand shocks in a structural VAR model. Unique for our study is the identification of separate demand shocks in emerging and developed economies using the FAVAR approach. The structural shocks are identified using a mixture of sign and zero restrictions, which allow for a simultaneous reaction to demand shocks in emerging and developed countries.

To the best of our knowledge, this is the first paper to explicitly analyze the contribution of demand from developed and emerging countries on the real price of oil. Furthermore, the identification scheme adopted to isolate the various demand shocks is new in the oil literature. Finally, given the large number of countries included in the analysis, this is also the most comprehensive analysis to date of the relationship between oil prices and macroeconomic activity.

We have three main findings, robust to numerous robustness checks. First, we show that demand shocks in emerging and developed economies together account for 50-60 percent of the fluctuations in the real price of oil during the last two decades. This supports the finding in Kilian (2009) and others of a strong importance of global demand for explaining oil price fluctuations.

Second, demand shocks from emerging markets, from Asia in particular, are more than twice as important as demand shocks from developed economies for explaining the fluctuations in the real price of oil as well as in global oil production.

[3] The FAVAR model was first introduced by Bernanke et al. (2005) to study the transmission of monetary policy shocks. Other and more recent applications include e.g. Boivin et al. (2009), Eickmeier et al. (2011), Aastveit et al. (2011) and Thorsrud (2012).

Third, we find that countries respond differently to the adverse oil market shocks that drive up oil prices. In particular, while economic activity in Europe and the US fall back permanently following oil supply or oil-specific demand shocks, economic activity in emerging Asia and South America fall by much less, and in some cases actually increase temporarily (at least after oil supply shocks). While some of these results relate to the fact that many emerging countries are commodity exporters benefitting from a higher terms of trade, we find that other factors such as a high investment share in GDP and a high degree of openness may be important factors explaining the observed heterogeneity in the responses.

The remainder of the paper is structured as follows: Section 2 describes the model, the identification scheme and the estimation procedure. In Section 3 we report the results. We first describe the estimated factors and the contribution of those to the domestic variables. Then we give a detailed description of the impulse responses of the identified shocks and the contribution to the variation in the oil price in various historical periods. Section 4 discusses robustness while Section 5 concludes.

2 The Factor Augmented VAR model

The main purpose of this paper is to study the impact of demand from developed economies and emerging economies on fluctuations in the real price of oil. To do so we specify a model that includes separate measures for activity in developed economies and emerging economies, in addition to global oil production and the real price of oil. The activity measures are meant to capture shifts in demand for oil in respectively developed and emerging markets, and are constructed by applying factor modeling techniques. More precisely, our full model is a FAVAR building on the general setup of Bernanke et al. (2005) and Boivin et al. (2009).

It is instructive to represent the model in a state space form. Here the transition equation is specified as:

$$F_t = \beta(L)F_{t-1} + u_t, \tag{1}$$

where $F_t = \begin{bmatrix}\Delta prod_t & devAct_t & emeAct_t & \Delta rpo_t\end{bmatrix}'$ are respectively the first differences of the logarithm of global oil production, an unobserved developed economy activity factor, an unobserved emerging economy activity factor and the first difference of the logarithm of the real price of oil. $\beta(L)$ is a conformable lag polynomial of order p, and u_t is a 4×1 vector of reduced form residuals. The structural disturbances follow $u_t = \Omega^{1/2}\varepsilon_t$, with

$\varepsilon \sim N(0,1)$ and $\Omega = A_0(A_0)'$, where Ω is the covariance of the reduced form residuals.

The observation equation of the system is:

$$X_t = \Lambda F_t + e_t, \tag{2}$$

where $X_t = \begin{bmatrix} \Delta prod_t & X_t^{dev} & X_t^{eme} & \Delta rpo_t \end{bmatrix}'$ is a $N \times 1$ vector of observable variables, and X_t^{dev} and X_t^{eme} are respectively $N^{dev} \times 1$ and $N^{eme} \times 1$ vectors of developed and emerging activity variables. Λ is a $N \times 4$ matrix of factor loadings, and e_t is a $N \times 1$ vector of idiosyncratic, zero mean, disturbances.

2.1 Estimation and model specification

We estimate the reduced form model (equation 1 and 2) in a two step procedure: First the unobserved activity factors for developed and emerging economies are estimated and identified using the method of principal components. Prior to estimating the factors all variables are transformed to induce stationarity, by using the first difference of the logarithm of the respective variable, and standardized. The identified factors are then used as observed variables in a standard VAR framework. The lag length is set to 4, and the VAR residuals pass standard diagnostic tests.[4] In our baseline model, $N = 66$, and we estimate the model over the sample 1992:Q1 to 2009:Q4, yielding $T = 72$ observations.[5]

To construct distributions for the impulse response functions, and accurately take into account the problem of generated regressors in the second estimation step, we employ a residual bootstrap procedure of the whole system, with 5000 replications.[6]

[4] As shown in e.g. Hamilton and Herrera (2004), a too restrictive lag length can give misleading results regarding the effects of oil market shocks on the macro economy, while increasing the lag length to over one year have negligible effects.

[5] Bernanke et al. (2005) investigate two different methods for estimating the state space system in equation 1 and 2; a two step procedure and a joint estimation by likelihood-based Gibbs sampling techniques, and they show that the two procedures produce very similar results. The two step procedure is however simpler, and much less computational intensive.

[6] Bai and Ng (2006) show that the least squares estimates obtained from factor-augmented regressions are $\sqrt{T}$ consistent and asymptotically normal if $\sqrt{T}/N \to 0$. In our sample this is hardly the case, and bootstrap methods are thus a potential alternative to the normal approximation, see e.g. Goncalves and Perron (2011). Further, the confidence bands for the impulse response functions are biased adjusted in the sense that we use Hall's percentile intervals (see Hall (1992)).

2.2 Data and Identification

Our data set includes variables from 33 different countries, where for each country we use real GDP and industrial production as measures of economic activity, see Appendix A for details. In total our sample countries account for around 80 percent of world GDP, measured by purchasing-power-parities.[7]

We determine a priori which countries should be characterized as developed- and emerging economies. Countries that are members of the OECD at the beginning of our sample are characterized as developed economies. The remaining countries are referred to as emerging economies. Accordingly, the following 18 countries are characterized as developed economies: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the UK and the US. Likewise, the following 15 countries are characterized as emerging economies: Argentina, Brazil, Chile, China, Hong Kong, India, Indonesia, Korea, Malaysia, Mexico, Peru, Singapore, South Africa, Taiwan and Thailand.[8] Of these countries, four developed countries (Canada, Denmark, Norway and the UK) and four emerging countries (Argentina, Indonesia, Malaysia and Mexico) are net oil exporters over the period (1991-2009).[9] However, many other countries are commodity producers (i.e. Australia, New Zealand, Peru), whose export prices may have been highly correlated with oil prices over the period. See Table 3 in Appendix B for more information.

To measure oil production and the real price of oil we use respectively world crude oil production, in millions barrels per day, and the US real refiners acquisition cost of imported crude oil. The nominal oil price has been deflated by the US consumer price index. These are the same variables used in e.g. Kilian (2009).

Identification in this model is affected by two issues: First, we need to estimate the unobserved factors such that the developed economy and emerging economy factors are identified, and second, we need to identify the structural shocks. Below we discuss in detail how this is done.

2.2.1 Identifying the factors

As described above, two of the factors in our system are observable, namely $\Delta prod_t$ and Δrpo_t. Thus, we only need to estimate and identify the two unobserved activity factors, $devAct_t$ and $emeAct_t$. To get unique identification,

[7]Authors calculations based on 2009 estimates from IMF.

[8]Note that Chile, Korea and Mexico are now members of the OECD.

[9]Although Brazil is not a net oil exporter over the whole period, in recent years, Brazil has been a major producer and a net exporter.

we follow the method proposed by Bai and Ng (2011). Here, two unrestricted factors are first estimated by principal components based on the vector X_t, defined in equation 2.[10] Then, these factors are organized in the F_t vector described above, and rotated so that they can be identified as respectively a developed and an emerging activity factor. Especially, we implement the rotational identification restrictions, which Bai and Ng (2011) label PC3, such that $\Lambda^* = \begin{bmatrix} I_r & \Lambda_2 \end{bmatrix}'$, where I_r is a 4×4 identity matrix, and Λ_2 is a $(N-4) \times 4$ loading matrix.

Rewriting the observation equation as

$$X = F\Lambda' + e, \tag{3}$$

where $F = (F_1, F_2, ..., F_T)'$ is the $T \times r$ matrix of factors and $\Lambda = (\lambda_1, \lambda_2, ..., \lambda_N)'$ is the $N \times r$ matrix of factor loadings (with $\lambda_1 = (\lambda_{1,1}, \lambda_{1,2}, ..., \lambda_{1,r})'$, the identified factors (F^*) and loadings (Λ^*) are easily estimated based on the unrestricted estimates (F and Λ) as follows; $F^* = F\Lambda_r'$ and $\Lambda^* = \Lambda\Lambda_r^{-1}$.

The rotation of the initial factor estimates depends on Λ_r, the upper 4×4 part of Λ, and thus the ordering of the variables in X (in equation 3). Towards this end we let the first 4 variables in X be: $\Delta prod$, x^{US}, x^{China} and Δrpo, which implies that the identified Λ^* loads with one on respectively oil production, US and China GDP, and the price of oil (the observable factors loads with one on their respective variables also without the rotation). The identified factors and loadings can then be reordered so that they comply with the ordering given in equation 1 and 2.

Importantly, this identification scheme puts no restrictions on the correlation between the factors , but still gives $r^2 = 16$ restrictions, thus ensuring unique identification of the factors and loadings (see Bai and Ng (2011) for details).[11]

2.2.2 Identifying the shocks

To identify the structural shocks in the FAVAR model, we build on the work of Kilian (2009), which separates between oil supply and demand shocks in a structural VAR model. Unique for our study is the identification of separate demand shocks in emerging and developed economies.

[10] In our model the choice of estimating two activity factors is motivated by the economic question we ask. However, the different information criteria discussed in Bai and Ng (2002), also suggest that two factors are appropriate for our data set.

[11] We have experimented with using different (emerging and developed) variables to identify the activity factors. The conclusions reported in section 3 are not much affected by the choice of normalizing variables. Further, estimating the factors from different blocks of data, i.e. the two blocks described in section 2.2, and letting the loading matrix in equation 2 be block diagonal also yields very similar results.

Accordingly, to identify the structural innovations in the model as oil supply shocks, developed-country oil demand shocks, emerging-country oil demand shocks and other oil-specific demand shocks, we employ a mixture of sign and zero restrictions, which are novel in this literature. Especially we restrict A_0, defined in section 2 as:

$$\begin{bmatrix} u^{prod} \\ u^{devAct} \\ u^{emeAct} \\ u^{rpo} \end{bmatrix} = \begin{bmatrix} x & 0 & 0 & 0 \\ x & + & + & 0 \\ x & + & + & 0 \\ x & x & x & x \end{bmatrix} \begin{bmatrix} \varepsilon^{\text{oil supply}} \\ \varepsilon^{\text{developed demand}} \\ \varepsilon^{\text{emerging demand}} \\ \varepsilon^{\text{oil-specific demand}} \end{bmatrix} \tag{4}$$

where $+$ indicates that the effect of the shock must be positive, x leaves the effect unrestricted, and finally zero imposes contemporaneous exclusion restrictions.

The identification scheme imposes the following restrictions. First, crude oil supply shocks ($\varepsilon_t^{oilsupply}$) are defined as unpredictable innovations to global oil production. The supply shocks are allowed to affect oil production, all activity measures and the price of oil within the quarter, while oil production itself responds to all shocks but the oil supply shock with a lag. This implies a vertical short-run supply curve of crude oil. Given that adjusting oil production is costly and the state of the crude oil market is uncertain, these are plausible restrictions.[12]

Second, innovations to the activity factors for developed and emerging economies (that cannot be explained by global oil supply shocks) are referred to as respectively developed-country oil demand shocks ($\varepsilon^{\text{developed demand}}$ for short), and emerging-country oil demand shocks ($\varepsilon^{\text{emerging demand}}$ for short). The real price of oil, as well as the developed and the emerging activity factors, can be affected on impact by these demand shocks. As such, we allow for a simultaneous reaction to demand shocks in emerging and developed countries. This is plausible given the relative sizes of the economies (or block of countries)[13] and the potential interaction due to trade and financial integration. Moreover, compared to standard recursive identification, the advantage with our identification scheme is that it is insensitive to whether the developed factor is ordered above the emerging factor or vice versa in the VAR.[14] However, this makes column two and three of the sign restriction

[12] Baumeister and Peersman (2012a) estimate the price elasticity of oil supply to be very small in our estimation period, consistent with the view that the short-run supply curve is nearly vertical.

[13] At the end of 2009 the emerging and developed economies in our sample accounted for roughly 32 and 47 percent of world GDP based on purchasing-power-parity.

[14] In the robustness section we will see that using a recursive identification scheme will yield results that are not robust to the ordering of variables.

matrix equal, and to fully identify the structural shocks, we impose two additional sign restrictions on the short-run impulse responses: To identify $\varepsilon^{\text{developed demand}}$ we impose that the response of $devAct - emeAct > 0$, and to identify $\varepsilon^{\text{emerging demand}}$ we impose that the response of $emeAct - devAct > 0$. The restriction implies that after a emerging-country demand shock (that increases activity in emerging countries), activity in developed countries is restricted to increase as well, but by less than in the emerging countries (and vice versa for a developed-country demand shock). This type of restriction allows us to identify demand from different group of countries (regions).[15] All sign restrictions are set to hold for 2 quarters only.[16]

Finally, other innovations to the real price of oil that cannot be explained by $\varepsilon^{\text{oil supply}}$, $\varepsilon^{\text{developed demand}}$ or $\varepsilon^{\text{emerging demand}}$ are referred to as oil-specific demand shocks ($\varepsilon^{\text{oil-specific demand}}$). Although this shock captures all other oil market specific shocks not explained by the other shocks in the model, Kilian (2009) argues that such a shock mainly captures precautionary demand for oil driven by the uncertain availability (scarcity) of future oil supply.

With minor modifications, the sign restrictions are implemented following the procedure outlined in Rubio-Ramirez et al. (2010) and Mumtaz and Surico (2009), and is explained in detail in Appendix D.

As is now well known in the literature, the sign restrictions will not yield unique identification (see Fry and Pagan (2011)). That is, while the sign restrictions solve the structural identification problem by providing sufficient information to identify the structural parameters, there will be many models with identified parameters that provide the same fit to the data. Accordingly, the (median) estimated impulse response functions might potentially represent responses to shocks from different models, and analysis of variance decompositions might be meaningless because the structural shocks considered are not orthogonal.

To circumvent this problem we do the following: For each set of reduced form parameters, we draw 1000 accepted candidate impulse responses (based on A_0 above), and compute the median impulse response function among these accepted draws. We then compute the mean squared error between all the candidate functions and the median impulse response function. The impulse response function with the lowest score is stored. As such, for each set of parameter estimates the identified structural shocks are orthogonal.[17]

[15] Restrictions on one variable relative to another variable have been applied previously by among others Farrant and Peersman (2006) and Eickmeier and Ng (2011), but in a very different context.

[16] The results are robust to altering the horizon with (+/-) one quarter.

[17] The uncertainly bands presented around the impulse response functions below represent mainly parameter uncertainty, and not uncertainty originating from the sign restriction

3 Results

In the following, we first present the oil variables and the identified activity factors for developed and emerging economies. Thereafter we investigate what drives the real price of oil as well as oil production, and finally we examine how the different regions and countries are affected by oil supply and oil-specific demand shocks.

3.1 Factors

Figure 1, Panel (a) and (b), displays the two observable series; global oil production and the real price of oil. The figure (Panel (a)) shows high growth in the real price of oil during the economic booms in 1999/2000 and 2006/2007, as well as a decrease in the real price of oil during the Asian crisis and the recent financial crisis. The economic booms and busts are also evident in global oil production (Panel (b)), where there is a slowdown in production during the two recessions and an increase during the two expansions. Further, there is also evidence of a slowdown in global oil production during 2002/2003. The dates coincides with the Venezuelan unrest (strike) and U.S. attack on Iraq (second Persian Gulf War).

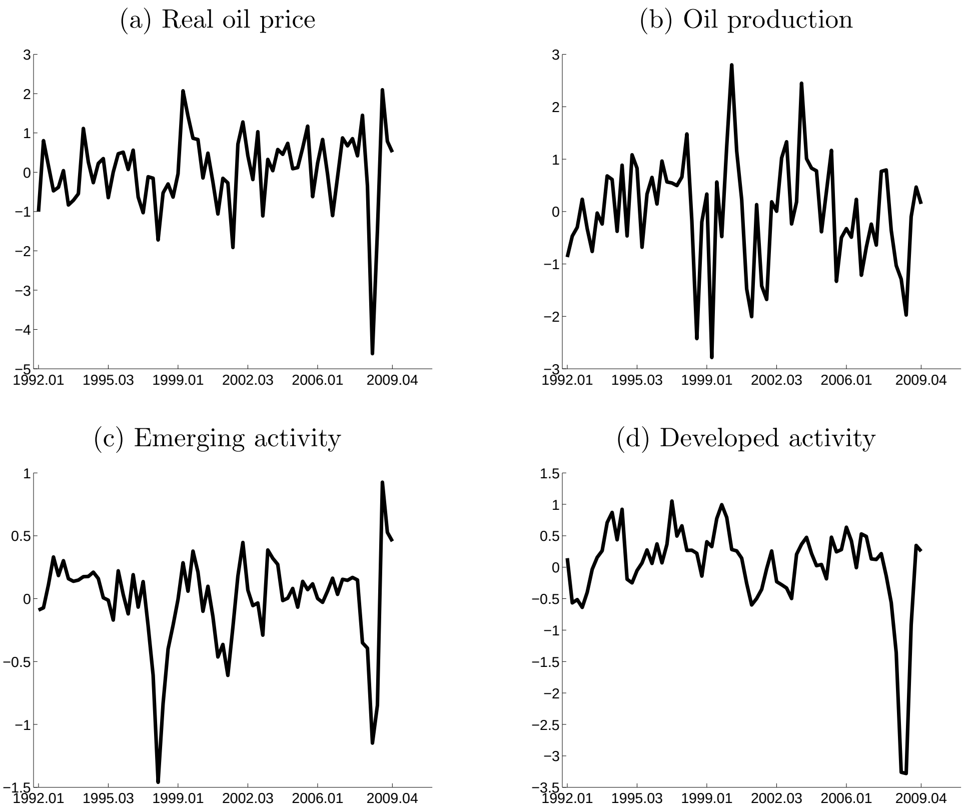
Figure 1, Panel (c) and (d), displays the two key activity variables used in the analysis; Emerging and developed economy factors. As can be seen in the figure, the two factors capture features commonly associated with the business cycles in the each respective region the last 20 years. Both the booms and busts predating and following the Asian crisis towards the end of the 1990's, and the dot com bubble around 2001 are evident in the emerging and the developed factors respectively.

There is, however, a notable difference in how the recent financial crisis has affected the two factors. The decline in the activity factor representing the developed economies is much larger than any other earlier decline in that factor. For the emerging activity factor, the recent financial crisis also caused large negative movements. However, compared to earlier downturns, the recent crisis does not stand out as very special. Also, the recovery in the emerging activity factor has been stronger than in the developed economy factor.

Although the factors should capture common movements among the countries in each respective group, the various countries may still contribute dif-

draws. Here it should be noted that the identification restrictions we employ are very informative, i.e. the differences between the different sign restriction draws are not large. This is due to the fact that we employ a mixture of sign and short run restrictions. Further results can be given by request.

Figure 1: **Observable variables and estimated factors**



Note: The figure shows the standardized values of the first differences of the logs of each observable variable, i.e. the real price of oil and global oil production, and the estimated activity factors (the median). The sample used in the VAR is 1992:Q1 to 2009:Q4, while we use information from 1991:Q1 to 2009:Q4 to estimate the unobserved factors.

ferently to the factors. In particular, some countries may be more correlated with its respective factor than others. To illustrate this (and to interpret the factors somewhat more), Table 3 in Appendix B displays the correlation between activity variables in each country and the developed and emerging factors. Focusing on the correlation with the developed factor first, the table indicates that with the exception of Australia, Japan, New Zealand and Norway, all the developed countries are highly correlated with the developed factor (as expected). For Japan and New Zealand, however, the correlation with the emerging factor (that contains many Asian countries) is slightly higher than with the developed factors. Clearly, location matter. For Norway, and to some extent Australia, the correlation (for GDP) between both the developed and the emerging factor is low, suggesting a more idiosyncratic pattern in these countries.

For the emerging factor, the picture is more diverse between the Asian and the South American countries. While the Asian countries are highly correlated with the emerging factor, three of the South American countries (Argentina, Chile, Mexico) and South Africa, are slightly more correlated with the developed factor than with its emerging factor. This indicates that the Asian countries dominate the emerging factor.

3.2 What drives oil prices?

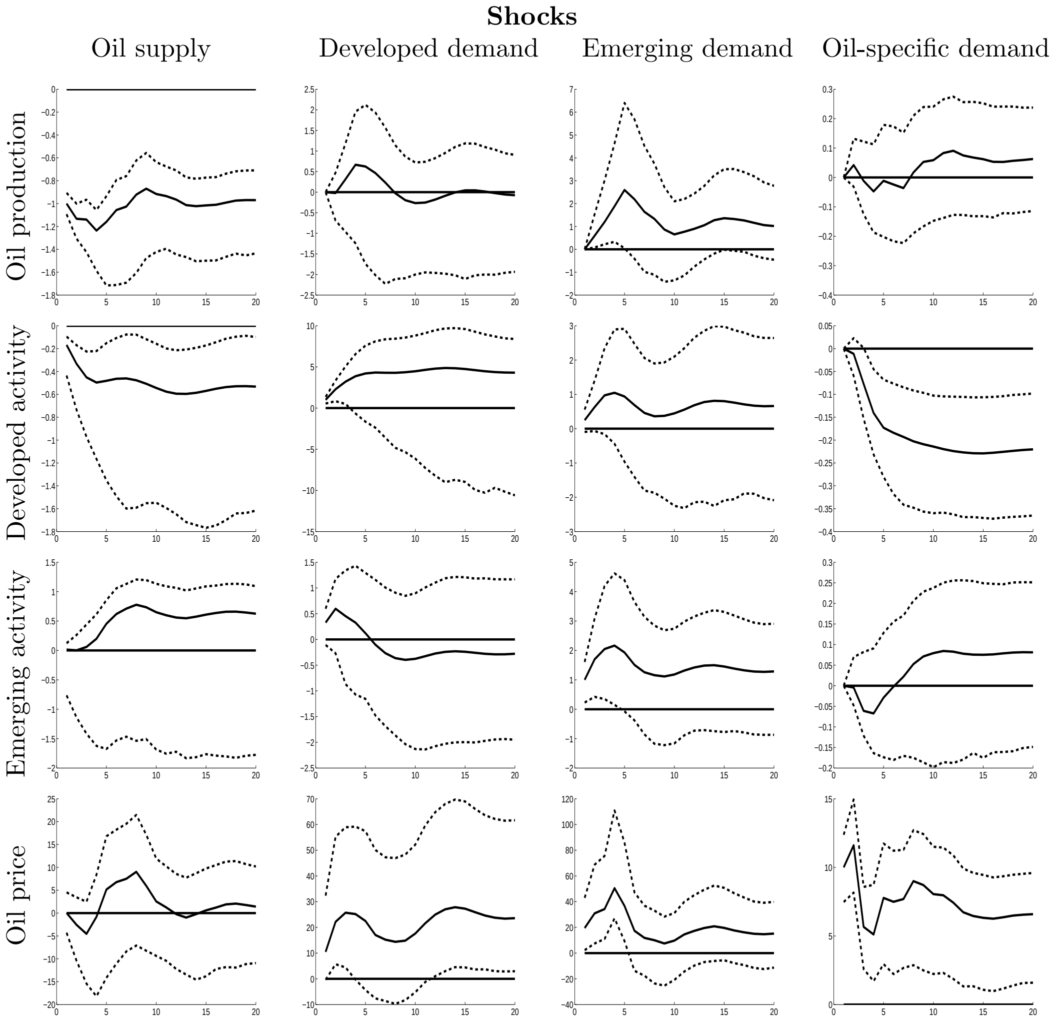
Figure 2 reports the impulse responses in the model. Each row contains the responses in a specific variable to the four different shocks. To compare the developed-country and the emerging-country demand shock, we normalize both shocks to increase activity in each respective region with one percent. The oil supply shock is normalized to decrease oil production with one percent, while the oil-specific demand shock is normalized to increase the real oil price by an initial 10 percent. While the normalization of the two demand shocks allows us to compare the contribution of developed and emerging countries, the normalization of the two 'oil market' shocks is chosen to facilitate comparison with previous studies.

Starting with our focal question; what drives oil prices, we examine the bottom row. While demand from both the developed and the emerging countries increase the real oil price significantly for 1-2 years, the effect of the normalized emerging-country demand shock is by far strongest of the two demand shocks (increasing oil prices with an initial 20 percent versus 10 percent for the developed-country demand shock). Interestingly, a shock to the emerging activity factor also has the strongest effect on oil production (upper row), which increases significantly for a year. While demand from developed economies also increases oil production, the effect is not significant.

What about the explanatory power of the two oil market (oil supply and oil-specific demand) shocks? A one percent disruption in oil production due to an oil supply shock eventually increases the oil price with 5-10 percent. The delayed response may suggest that oil consuming countries have built up inventories of oil which they can draw upon on production shortfalls, delaying the oil price response. Also, if oil deliveries are based on future contracts, it might take some time before supply disruptions work their way into prices.[18]

[18] However, the response is not really significant.

Figure 2: **Impulse responses**



Note: The developed-country and emerging-country demand shocks are normalized to increase respectively developed activity and emerging activity by one percent. To facilitate comparison with earlier studies, the oil supply shock is normalized to decrease oil production by one percent, while the oil demand shock is normalized to increase the real oil price by 10 percent. The normalization has been done after adjusting the size of the shocks such that they reflect the standard deviation of observable variables. Thus, for oil supply and demand shocks we have used the sample standard deviations for the quarterly growth rates in oil production and oil prices (roughly 0.9 and 16). For developed and emerging demand shocks we have used respectively the sample standard deviation of US and China GDP growth (approximately 0.7 and 1.3). The dotted lines display 90 percent confidence intervals, while the solid lines are the point estimates.

The last shock, interpreted in Kilian (2009) as a precautionary oil-specific demand shock (ultimately driven by expectations about future oil supply shortfalls), trigger an immediate and sharp increase in the real price of oil (normalized to increase by 10 percent). Such expectations can change almost immediately in response to e.g. exogenous political events, and therefore tend to increase prices without any subsequent effects on oil production.

Turning to the reverse causality; what are the effects of the two oil market shocks on the macro economy? First, an disruption in oil production that eventually increases the real oil price with 5-10 percent, lowers activity in developed economies by approximately 0.5 percent permanently (second row). However, the same shock causes activity in emerging countries to actually increase, although the standard error bands are wide (third row).

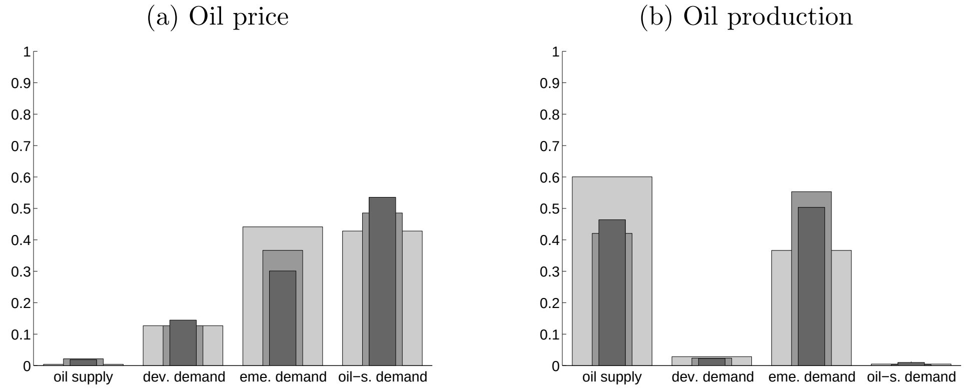
A shock to oil-specific demand, normalized to increase the real price of oil with an initial 10 percent, lowers GDP in the developed countries slightly (0.2 percent), while GDP in emerging countries falls at first, but then increases marginally.[19]

Variance decompositions for the real price of oil and oil production, displayed respectively in panel (a) and (b) in Figure 3 allows us to compare the relative contribution of all shocks. The Figure confirms the results found above. The emerging activity factor is by far more important than the developed activity factor in explaining the variance in the oil price and in oil production. In fact, for 1-2 years, approximately 40 percent of the variation in the oil price is explained by emerging demand shocks, while developed demand shocks explain close to 15 percent. Turning to oil production, 40-50 percent of the variation is explained by emerging demand shocks, while less than 10 percent is due to developed demand shocks. Hence, we conclude that demand from emerging countries is more than twice as important as demand from developed economies in explaining the variance in the oil price, and, up to five times more important in explaining the variance in oil production.

Our results suggests that the emerging countries have an income elasticity that is higher than in the developed countries. Typically, as a country becomes more developed (richer), the growth of petroleum use declines (as the country produces less manufacturing goods and more services), and hence also the income elasticity. Indeed, in our sample, rough measures of income elasticities show that emerging Asia and South America have income elasticities close to unity, while the average across developed countries is around 0.5. Consistent with this, Hamilton (2009) has suggested that while the in-

[19] Following both an oil supply and an oil demand shock, the uncertainty bands around the responses in the emerging activity factor are in particular large. This probably reflects the fact that the emerging market economies are less homogenous than the developed economies, as seen in the correlation numbers reported in Table 3 in Appendix B.

Figure 3: **Variance decomposition**



Note: The bars display the variance decomposition with respect to the shocks for horizons 4, 8 and 12 quarters. The widest bars correspond to the shorter horizon.

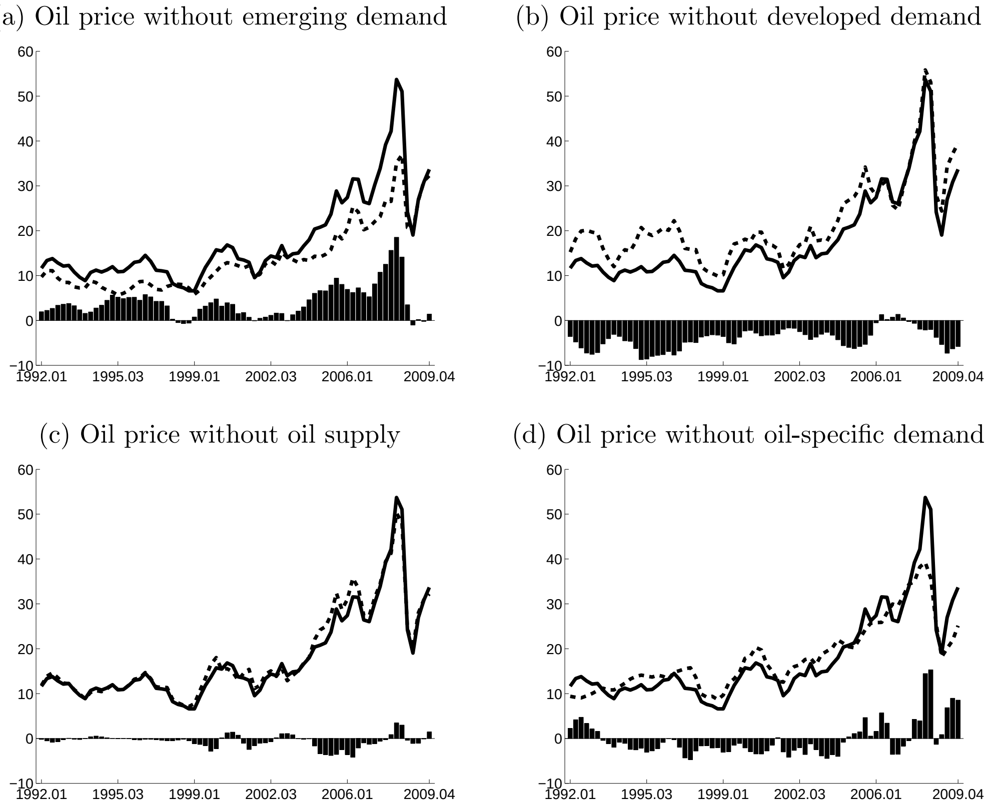
come elasticity of oil consumption in the US has declined over time (to 0.5), the income elasticity in newly industrialized countries may (still) be closer to unity.

Turning to the Oil supply shocks, Figure 3, Panel (b), shows that these shocks explain a small share of the variation in the real price of oil. This is consistent with findings in Baumeister and Peersman (2012b), who using a time-varying SVAR approach show that oil supply shocks have become a less important source of oil price movements in recent years. That oil supply shocks explain a small variation of the real price of oil in our sample is therefore not unique, and as expected.

Finally, the oil (specific) demand shocks explain the remaining 40-50 percent of the variation of the real price of oil after 1-2 years, but a negligible part of oil production at all horizons.

The results in Figure 3 reflect the average contributions of the various shocks over the last two decades. To examine the different periods in more detail, Figure 4 graphs the accumulated contribution of each structural shock to the real price of oil based on a historical decomposition of the data. In particular, Panel (a) shows for each quarter from 1992 to 2009 the actual real price of oil in levels (solid line) and the actual price minus the contribution from the emerging market shocks, i.e. what the real price of oil would have been had there been no demand shocks from emerging countries (dotted line). In Panel (b), (c) and (d), the dotted line displays the real price of oil minus the contribution of respectively demand from developed countries, oil supply

Figure 4: **Historical shock decompositions**



Note: The solid lines display the actual oil price. The dotted lines display what the oil price would have been if we exclude one of the structural shocks. The bars show the difference between the solid and dotted lines. A positive value indicates that the structural shock contributed to increase the price of oil.

shocks and oil-specific demand shocks.[20]

Panel (a) in the figure emphasizes an important role of emerging markets as drivers of the real oil price. This was especially pronounced in the middle of the 1990s and from 2002/2003 and onwards. In fact, demand from emerging markets added roughly 20 dollars to the oil peak (of around 55 dollars in real terms) in 2008. Thus, in our sample, the strong positive contribution from emerging economies has been steadily rising, only interrupted by the East Asian crisis (1997/1998), and the broader global economic downturn around

[20]We scale the starting values such that the total variance explained by each structural shock (the bars in Figure 4) are in accordance with the variance decompositions reported in Table 3.

2001.

On the other hand, demand from developed countries has contributed negatively to the real oil price throughout much of the sample period (Panel (b)). Only during the period leading up to the onset of the global financial crisis did developed economies contribute to push up the oil price. Interestingly, the negative contribution from the developed countries resembles the results for the aggregate global demand shocks identified in Kilian (2009), especially during the 1990s. However, from 2005 and onwards, Kilians' aggregate demand shocks contribute to increase the price of oil significantly. As our results show, when we separate between developed and emerging countries, most of the increased demand is attributed to emerging economies. The contrasting results for emerging and developed economies has not been documented before, but are well in line with the changes in world oil consumption patterns, where e.g. non-OECD countries share of total world oil consumption has grown by roughly 40 percent since the beginning of the 1990s.

The results in Panel (c) reiterate the discussion above; Oil supply shocks have not contributed much in explaining oil price fluctuations the last two decades, a finding supported in many recent studies. On the other hand, as described in e.g. Hamilton (2011), the only geopolitical events that potentially could have affected world oil production since 1992, were the Venezuelan unrest and the second Persian Gulf War, which both happened around 2003. Although the results in Panel (c) suggest that oil supply shocks indeed added extra dollars to the price of oil during this period, the effects are tiny. This confirms findings in Kilian (2008a,b, 2009), that geopolitical events do not matter so much through their effect on global oil production. As Kilian and Murphy (2012) show, such events seem to matter more through their effect on speculative demand.

Finally, Panel (d), which graphs the historical contribution of oil-specific demand shocks, shows a more erratic pattern than any of the other shocks. This is consistent with the interpretation that the shock mainly captures precautionary demand for oil, driven by uncertainty of future oil supply, as described in Kilian (2009). It has been a huge debate in the literature about the role of speculative trading in the oil market, and particularly about speculation's role in driving up the price of oil since 2005. We can not rule out that speculation is part of our identified oil-specific demand shock, but the results presented in Panel (d) do in any case not give this shock a large role in driving up oil prices compared to the emerging demand shock. Furthermore, the timing of the two largest contributions towards the end of the sample (2008:Q2 and 2008:Q3) does not suggest that this should be a speculative shock, since the world economy was clearly heading for (or already in) a severe downturn at this point in time.

To sum up so far, we find that while increased activity in both developed and emerging economies drive up the real price of oil, a demand shock initiated in the emerging countries has a far stronger effect on the oil price and production than a similar sized demand shock initiated in the developed world. This is a new finding in the literature. Furthermore, historical shock decompositions show that emerging economies contributed to increase the oil price particularly in the mid 1990s and from 2002/2003 and onwards. Looking at the reverse relationship, we have shown that while developed economies are affected negatively by the two oil market shocks that drive up the real oil price (oil supply and oil demand shock), emerging countries are much less negatively affected, and in periods, even positively affected. We turn to these issues in the next section, where we examine in more detail how the different geographical regions/countries within the emerging and the developed blocks respond to the various shocks.

3.3 Region and Country details

Most recent empirical studies of the interaction between the oil market and the macro economy concentrate on the impact on either one or a few developed (OECD) countries, e.g. the US in Kilian (2009) or France, Germany, Italy, Japan, the UK and the US in Blanchard and Galí (2010). In addition, many studies that do asses the impact of oil prices on economic activity across countries only consider net oil importing countries.[21] Both of these features might limit the generality of the findings.

An advantage with our FAVAR methodology is that we can analyze the responses of various oil and macro economic shocks across a large panel of countries simultaneously within the same model. Thus, we add a dimension to the earlier studies analyzing various countries separately. Below we investigate the individual country impulse responses provided by the FAVAR framework, which we average up to different geographical regions for ease of interpretation. That is, Figure 5, Panel (a) and (b), displays the average responses in the level of GDP in Asia, Europe, North America (NA) and South America (SA)[22] to emerging and developed demand shocks respectively, while Figure 5, Panel (c) and (d), displays the average responses in the level of GDP in the same regions to oil supply and oil (specific) demand

[21] The empirical studies by Peersman and Van Robays (2012), Bjørnland (1998) and Bjørnland (2000) are notable exceptions. Kilian et al. (2009) also quantify responses to oil price changes in oil exporting countries, but focuses on external balances and not aggregate activity.

[22] SA also includes South Africa.

shocks. The responses are graphed after two years and all shocks are normalized to increase the real price of oil. Note that the impulse responses graphing the effect of oil supply and oil-specific demand shocks on individual countries GDP are displayed in Figures 9 and 10 in Appendix C.[23]

A shock to either developed-country or emerging-country demand (normalized to increase activity in each group by one percent initially), has a positive effect on GDP across all geographical regions, see Figure 5. Interestingly, the emerging-country demand shock has by far the strongest effect on Asia, confirming again that the Asian countries are the main drivers in the emerging block. Following a developed-country demand shock, the positive response in Europe is the strongest, followed closely by North America. Of the emerging countries, the ones in South America are the most positively affected by the developed market shock. This is consistent with observed trade patterns, where South America has a larger share of their trade with developed countries than Asia has.

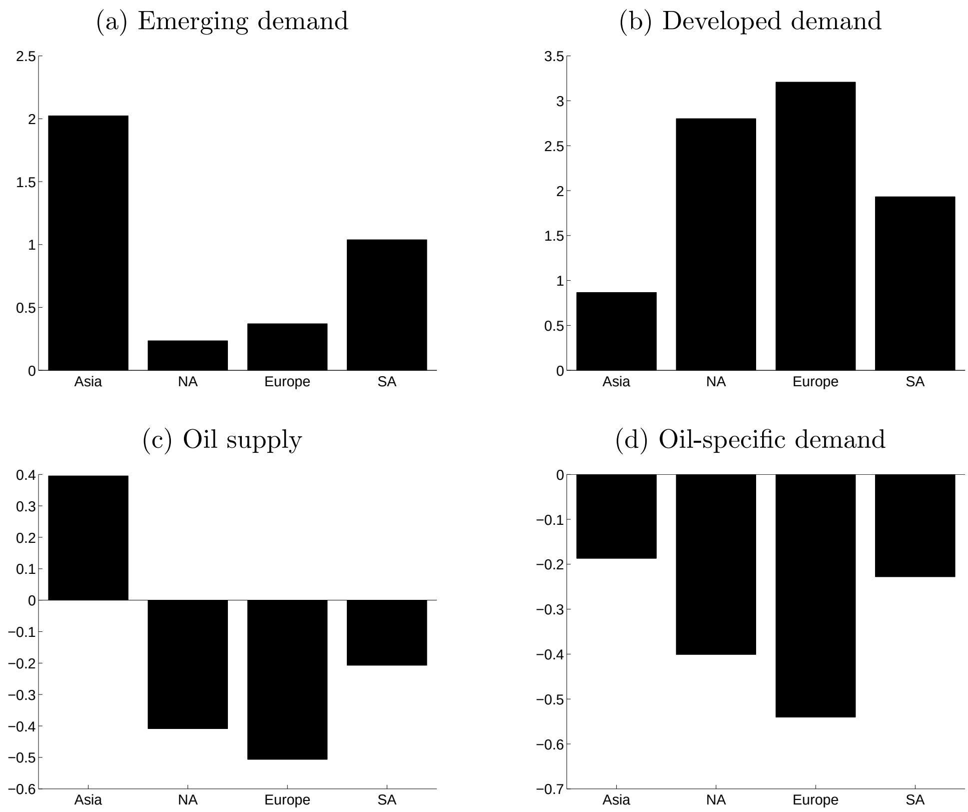
More diverse are the responses to the oil supply and the oil-specific demand shocks. Figure 5 shows in Panel (c) that while economic activity in North America and Europe are affected negatively following an adverse oil supply shock (that increase the real oil price), activity in emerging Asia and South America is much less affected, in fact, activity in Asia even increases. Although the average response in Asia is substantial, the response is in particular strong in Indonesia and Malaysia, two energy rich countries (see Figure 9 in Appendix C). In South America, only Brazil and Peru respond positively (again, see Figure 9 in Appendix C), explaining why the the overall response in South America is negative in Figure 5.

The same divergence between the regions can also be found following the oil-specific demand shocks, see Panel (d). While all countries are now affected negatively following such an oil shock, the effect is again less severe for the emerging Asian and South American countries than for Europe and the US (again, see the individual country impulse responses in Figure 10 in Appendix C for more details on the countries).

Hence, we have shown a divergence between the different regions, with emerging countries in Asia and South America being more important drivers of the real oil price, yet responding less severely to the adverse oil market shocks. Although the overall results are significant, one concern could still be that the factors might explain very different proportions of the variance in each individual country's activity measure. For example, the correlation between Norwegian GDP and the developed activity factor is only 0.3, while

[23] Additional graphs, including the impulse responses to the macro-economic shocks, can be given at request.

Figure 5: **Effect of macro-economic and oil market shocks on GDP in different regions (median)**



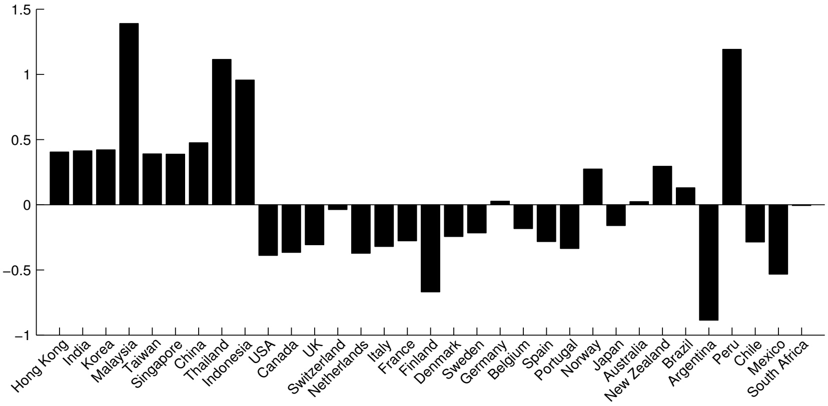
Note: y-axis (vertical axis) measures impulse responses after eight quarters. All shocks are normalized to increase the oil price. See Figure 2 for further details.

the correlation between US GDP and the developed activity factor is as high as 0.7 (see Table 3 in Appendix B). To avoid the direct dependence on the factor loading structure imposed in the FAVAR, we do one final exercise where we regress the structural oil supply and oil-specific demand shocks estimated in the model on the individual countries' GDP growth using standard OLS. This then also serves as a robustness check to the results plotted in Figure 5 that are based on the regional average of the individual country's impulse responses. The results are plotted in Figure 6.[24]

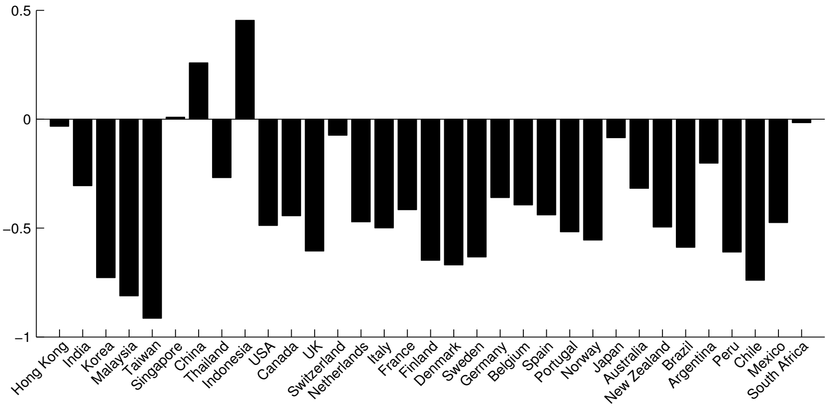
[24] A similar OLS regression was conducted in Kilian (2009) on the US only.

Figure 6: **Regression of oil shocks on observable GDP**

(a) Oil supply



(b) Oil-specific demand



Note: The bars show for each country the accumulated regression coefficients from the following regressions:

$$\Delta X_{t,i} = \alpha_i + \sum_{p=1}^{4} \beta_{p,i} s_{t-p} + e_{t,i}$$

where $\Delta X_{t,i}$ is the observable GDP growth in country i at time t, α and β are coefficients, and s_{t-p} are lags of the structural shocks (oil supply or oil demand) identified in our model.

The findings confirm the baseline results that oil supply shocks (that increase the oil price temporarily) stimulate GDP in all countries in emerging Asia (again, most notably in the two oil producing countries Indonesia and Malaysia), while in emerging South America and the developed countries, GDP falls, see Figure 6, Panel (a).[25] There are however a few exceptions to this picture; In Australia, Brazil, Germany, New Zealand, Norway and Peru, GDP picks up temporarily (like in Asia). While all countries but Germany are resource rich economies that may actually benefit from a higher oil price (that is highly correlated with the price of other commodities), we need to find other causes for why economic activity in the remaining Asian countries (and Germany) respond as they do. We will turn to this issue in Section 3.5.

Regarding the oil specific demand shock (Figure 6, Panel (b)), most countries respond negatively as expected. Exceptions are, again, some Asian countries (most notably Indonesia), which respond positively, implying that the average response in Asia is less severe than in the other countries, a feature we saw already in panel (d) in Figure 5.

3.4 Comparison with previous studies

We are not aware of other studies that estimate the effects of oil supply and oil-specific demand shocks on such a large panel of countries including emerging countries, as we do. It is still interesting to compare our results to recent studies which analyze the response in the US or a few other countries.

First, regarding the size of the responses to an oil supply shock that decreases oil production by one percent, our results (of an eventual increase in the oil price of 5-10 percent and a reduction in GDP by 0.5 percent), are slightly stronger than e.g. Kilian and Murphy (2012) and Kilian (2009) find,[26] but more in line with Baumeister and Peersman (2012b), which by applying a time-varying SVAR model finds that for the period we examine, oil supply shocks increase the real price of oil with close to 10 percent, while GDP falls by 0.5 percent.

Second, the responses to an oil-specific demand shock that is normalized to increase the real price of oil by 10 percent (causing a decline in US GDP of about 0.5 percent), are well in line with real output responses in Peersman and Van Robays (2009) and Aastveit (2012), while it is somewhat smaller than findings in Kilian (2009). More interestingly, note that in Kilian (2009) global real economic activity increases after an oil-specific demand shock. On the contrary, we show that such a shock has a significant negative effect on developed countries, while the effect on emerging countries are in periods positive, although not significant.

[25] Note that Japan is affected negatively by the oil supply shocks like the other developed countries.

[26] For instance, Kilian and Murphy (2012) finds that for the sample 1973-2009, a 1 percent shortfall in global oil production, increases the real price of oil by about 4 percent and reduces GDP in the US. by 0.2-0.5 percent.

Regarding the few studies that separate between oil exporting and importing countries, Peersman and Van Robays (2012), analyzing 11 developed countries, find that following an adverse oil supply shock, economic activity in energy exporting countries such as Norway and Canada respond positively temporarily. Corroborate results are also found in Bjørnland (2000) and Bjørnland (1998). However, while these studies typically attribute this to the fact that countries that respond positively are energy producing countries, we have shown here that there are many energy-importing countries (in Asia in particular) that also behave in this way. Hence, this is not just a story of energy intensity in production. We turn to this now.

3.5 The Asian puzzle - country characteristics

The heterogeneity in activity responses across countries and regions to disturbances in the oil market needs further examination. In particular, how is it possible that the emerging activity factor is the main driver of the oil price, yet, emerging countries (in Asia in particular) are the least negatively affected by adverse oil supply and oil specific demand shocks? And why do countries such as Australia, Brazil, Germany, New Zealand, Norway and Peru respond so similar to the Asian countries?

First, as already mentioned, some of the countries in the sample are commodity exporters, whose terms of trade increases with higher commodity prices (all of which are in periods highly correlated with the oil price). Australia, Brazil, New Zealand, Norway and Peru are all important exporters of energy, minerals or other raw materials. Some of the Asian countries (Indonesia and Malaysia) also have a high share of net commodity exports in total export. However, this can not explain the response in the majority of Asian countries, nor in Germany. Also, as there are other energy exporters that do not respond favorably to the oil market shocks (e.g. Argentina and Mexico), there must be other reasons for the observed heterogeneity.

A second hypothesis, (yet, related to the first) is that when oil prices increase, there is a net transfer of income from oil exporting countries to oil importing countries, since the net exporters demand import of goods and services. This may have benefitted Asian countries in particular, as well as Germany, which is the major exporter in EU.

Third, country structure matters. According to Hamilton (2009), a key parameter for determining the consequences of an oil price increase is the share of energy purchases in total expenditure. In particular, a low expenditure share combined with a low price elasticity of demand, will imply very small negative effects (if any) of an oil price increase. While the oil consumption share in the United States and other industrial economies has

Table 1: **Characteristics and correlations**

(a) Correlations between country structure and IRF levels

	Cons	**Inv**	**Open**
Oil supply	-0.44	0.58	0.43
	(0.01)	(0.00)	(0.01)
Oil demand	-0.28	0.46	0.19
	(0.12)	(0.01)	(0.28)

(b) Regional structure

	Cons	**Inv**	**Open**
Emerging Asia	55	33	145
Developed countries	66	23	60
Emerging South America	70	22	50

*Note: **Cons** = consumption, **Inv** = investment, **Open** = export+import, all as share of PPP Converted GDP Per Capita at 2005 constant prices. Results are based on the mean of the indicators (over the sample period 1992 - 2009). In Panel (a), the second row for each shock are p-values.*

been broadly flat since the 1980s, it has risen rapidly in emerging countries such as China. However, since China starts out from a much lower level, per capita oil consumption in the US is still 10 times larger than in China (cf. IMF WEO 2011). This may suggests that the negative price elasticity in the US is larger (in absolute terms) than in China, so that GDP in the US and other industrial countries respond more negatively to the adverse oil market shocks than the emerging countries.

In Table 1, we dig deeper into this issue, and analyze to what extent the composition of output matters. In particular, we examine if countries with a low consumption share and high investment share are less negatively affected by higher oil prices, as investments are less reversible (due to long-term plans), than overall consumption. We also examine if degree of openness matters. Countries that has tied most of its capital to the export sector, may be able to export some of the higher oil prices to the importers, whose price elasticity may be small.

Panel (a) in Table 1 shows the correlation between the impulse responses from the two oil market shocks; oil supply shock and oil (specific) demand shock with the mean of the three relevant indicators; consumption share, investment share and degree of openness, over the sample period 1992 - 2009. The table confirms that countries with a high consumption share are negatively correlated with the two oil shocks, while countries with high investment share and degree of openness will be positively correlated with the oil shocks (oil supply shocks in particular).

Which regions match these features? Table 1, Panel (b), shows that Emerging Asia stands out with low consumption share, high investment share and a high degree of openness. For South American countries, though, the picture is reverse (high consumption share, low investment share and a low degree of openness), which may explain why despite being positively affected by increased terms of trade, not all countries respond positively overall.[27]

Finally, subsidies may also play a role. Price controls prevent the full cost of a higher imported oil price from being passed through to the end user, thereby dampening the responsiveness of consumption to increases in prices. Studies in IMFs' World Economic Outlook 1999 and 2009, show that pervasive under-pricing of energy resources occurs in several non-OECD countries, including China, India, Indonesia and South Africa. This may also help explain the small (and sometimes positive) effects of oil supply and oil demand shocks in these countries. We leave this issue to be explored further in another study.

4 Robustness

We have many times argued that the main drivers of the emerging economies factor are the emerging Asian countries. This could be seen in the correlation numbers in Table 3 in Appendix B, where the individual Asian countries are more correlated with the emerging economies factor than emerging countries in South America, and also in Figure 5, where emerging demand shocks affect the Asian countries strongly.

In this section we do one more exercise which examines the robustness of this finding, and which also checks wether it is Asia or South America (or a mixture of both) that drives the oil-market macro-economy relationships presented in Section 3. To do so we split the sample of emerging countries in two blocks, and estimate two different factors; one consisting of emerging Asian countries and one consisting of emerging South American countries (including South Africa). Then we sequentially use these new factor estimates in our main model, as a replacement for the original emerging economies

[27]Note that Norway is an example of an oil producer whose consumption share is much smaller than the average share in the developed countries. This may explain why Norway may benefit from higher oil prices, at least temporarily.

factor. The results using the emerging Asian factor is very similar to the baseline results presented in Section 3, while the results change when we use the emerging South American factor, see Figure 7 and 8 in Appendix C. Especially, the emerging South American factor explains slightly less of the variance in oil pries and almost half of the variance in oil production compared to the results in Figure 3. Hence, we confirm again that Asia is the main driver of the results presented for the emerging factor, but the role of South America is far from negligible.

As described in Section 2.2.2, an advantage with our identification scheme is that we can identify distinct demand shocks which affect both the developed and the emerging factors simultaneously. If simultaneity was not important, however, then the FAVAR model could be identified using a standard recursive identification scheme; ordering the developed factor above the emerging factor, or vice versa. Identifying exactly such a recursive model, however, yields very different results from our baseline model. In particular, now the activity factor ordered first will always explain more of the variation of the oil price than the activity factor ordered second. Thus, simultaneity matters, which a standard recursive identification scheme does not adequately capture. Despite this, the recursive identifications schemes still reveal an important role for the emerging factor. First, the emerging activity factor will always explain relatively more of the oil price variation than the developed factor, irrespective on where it is ordered.[28] Second, emerging countries always explain more of the variance in oil production than developed economies, independent of the ordering of the emerging and the developed factor.

Further, our main results are not very sensitive to the number of lags used in the transition equation. In fact, when we estimate the model with two lags instead of four, the results are slightly stronger, implying that the emerging factor explains an even larger share of oil prices and oil production. Also, as mentioned already in Section 2.2.1, the factor estimates are not significantly affected by the choice of normalizing variables, nor to the estimation method.[29]

[28]When the emerging factor is ordered first, it explains almost twice as much of the variation in oil prices than when the developed factor is ordered first. Similarly, when the emerging factor is ordered last, it explains more than twice as much of the variation in oil prices than the developed factor does when ordered last.

[29]The results from the robustness section can be obtained if requested.

5 Conclusion

We estimate a FAVAR model with separate activity factors for emerging- and developed economies in addition to the global oil production and the real price of oil. We study two main questions: 1) How demand shocks in emerging and developed economies affect the real price of oil and global oil production, and 2) the effects of oil supply and oil-specific demand shocks on emerging and developed economies. To our knowledge, this is the first paper to explicitly analyze the contribution of developed and emerging countries on oil market variables using a structural model. We have three main findings which are robust to numerous robustness checks.

First, we show that demand shocks to emerging and developed economies account for 50-60 percent of the fluctuations in the real price of oil during the last two decades, supporting the finding in Kilian (2009) and others of a strong importance of demand for oil price fluctuations.

Second, demand shocks to emerging markets, and from Asia in particular, are by far more important than demand shocks from developed economies for fluctuations in the real price of oil as well as in global oil production.

Finally, we find that different regions respond differently to the adverse oil markets shocks. While economic activity in Europe and the US fall back permanently after oil supply and oil-specific demand shocks, economic activity in emerging Asia and South America fall by much less, and in some cases actually increase temporarily (at least due to the oil supply shocks). While some of these results relate to the fact that many emerging countries are commodity exporters benefitting from a higher terms of trade, we also find that countries with high investment share in GDP and a high degree of openness are less negatively affected by higher oil prices.

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Appendices

Appendix A Data and Sources

Most of the data series are collected from Ecowin. The few series we did not find there, were taken from the following sources: Gross Domestic Product (GDP) in China and Indonesia were found in the GVAR data set constructed by Pesaran et al. (2009). The series for industrial production (IP) in Argentina, Indonesia, Mexico and the Netherlands were collected from Datastream. The industrial production series in Denmark and Portugal were taken from OECD, while industrial production in Norway was collected from Statistics Norway.

All GDP series are at constant prices. The industrial production series are volume indexes, and refer, with few exceptions, to the manufacturing industry. For Argentina, China, Indonesia, Italy, Norway, Peru and Portugal, we only found series for overall industrial production.

Lastly, some of the activity series do not span the whole time period used in the analysis (1991:Q1 to 2009:Q4). To avoid excluding these variables from the sample, we have applied the EM algorithm, as described in Stock and Watson (2002), to construct the missing observations. However, experiments conducted on a reduced sample, i.e. excluding the series with missing observations, do not change our main conclusions.

Appendix B Tables

Table 2: **Oil production and consumption by countries**

	Country	Production	Consumption	Net exporter
Developed	*Australia*	0.64	0.87	No
	Belgium	0.01	0.61	No
	Canada	2.83	2.03	Yes
	Denmark	0.29	0.20	Yes
	Finland	0.01	0.21	No
	France	0.09	1.97	No
	Germany	0.13	2.74	No
	Italy	0.14	1.83	No
	Japan	0.11	5.36	No
	Netherlands	0.06	0.89	No
	New Zealand	0.05	0.14	No
	Norway	2.93	0.22	Yes
	Portugal	0.00	0.31	No
	Spain	0.03	1.39	No
	Sweden	0.00	0.37	No
	Switzerland	0.00	0.27	No
	United Kingdom	2.32	1.78	Yes
	United States	9.04	19.19	No
Emerging	*Argentina*	0.80	0.50	Yes
	Brazil	1.59	2.06	No
	Chile	0.02	0.23	No
	China	3.45	5.17	No
	Hong Kong	0.00	0.25	No
	India	0.77	2.12	No
	Indonesia	1.38	1.04	Yes
	Korea, South	0.01	2.06	No
	Malaysia	0.75	0.46	Yes
	Mexico	3.42	2.00	Yes
	Peru	0.11	0.15	No
	Singapore	0.01	0.69	No
	South Africa	0.20	0.47	No
	Taiwan	0.00	0.83	No
	Thailand	0.21	0.77	No

Note: Column three to five reports oil production and oil consumption in millions of barrels per day, measured as averages for the period 1992-2009 (Source: EIA).

Table 3: **Correlation with factors**

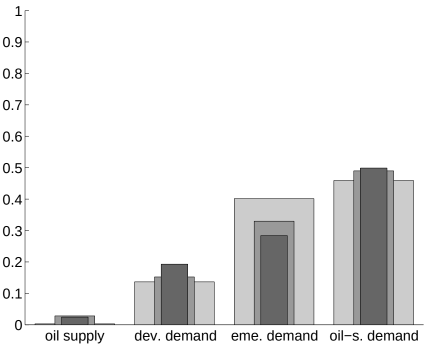
Developed				**Emerging**			
Country	**Variable**	*emeAct*	*devAct*	**Country**	**Variable**	*emeAct*	*devAct*
Australia	*GDP*	0.09	0.35	*Argentina*	*GDP*	0.20	0.25
	IP	0.34	0.48		*IP*	0.36	0.38
Belgium	*GDP*	0.41	0.78	*Brazil*	*GDP*	0.44	0.41
	IP	0.32	0.63		*IP*	0.51	0.41
Canada	*GDP*	0.16	0.75	*Chile*	*GDP*	0.24	0.32
	IP	0.32	0.70		*IP*	0.37	0.41
Denmark	*GDP*	0.19	0.56	*China*	*GDP*	0.36	0.14
	IP	0.04	0.43		*IP*	0.27	0.10
Finland	*GDP*	0.26	0.80	*Hong Kong*	*GDP*	0.78	0.47
	IP	0.15	0.62		*IP*	0.43	0.33
France	*GDP*	0.25	0.83	*India*	*GDP*	*N/A*	*N/A*
	IP	0.35	0.75		*IP*	0.19	0.24
Germany	*GDP*	0.29	0.74	*Indonesia*	*GDP*	0.54	-0.02
	IP	0.20	0.68		*IP*	0.58	0.01
Italy	*GDP*	0.42	0.80	*Korea*	*GDP*	0.59	0.49
	IP	0.43	0.83		*IP*	0.70	0.45
Japan	*GDP*	0.63	0.52	*Malaysia*	*GDP*	0.49	0.27
	IP	0.66	0.46		*IP*	0.69	0.48
Netherlands	*GDP*	0.17	0.78	*Mexico*	*GDP*	0.26	0.67
	IP	0.29	0.56		*IP*	0.16	0.61
New Zealand	*GDP*	0.47	0.43	*Peru*	*GDP*	0.31	0.08
	IP	*N/A*	*N/A*		*IP*	0.45	0.33
Norway	*GDP*	0.08	0.33	*Singapore*	*GDP*	0.75	0.43
	IP	0.17	0.51		*IP*	0.54	0.32
Portugal	*GDP*	0.10	0.66	*South Africa*	*GDP*	0.24	0.56
	IP	-0.07	0.24		*IP*	0.40	0.61
Spain	*GDP*	-0.02	0.75	*Taiwan*	*GDP*	0.56	0.52
	IP	0.31	0.76		*IP*	0.61	0.27
Sweden	*GDP*	0.32	0.83	*Thailand*	*GDP*	0.48	0.22
	IP	0.32	0.78		*IP*	0.63	0.42
Switzerland	*GDP*	0.17	0.69				
	IP	0.33	0.62				
United Kingdom	*GDP*	0.23	0.84				
	IP	0.37	0.80				
United States	*GDP*	0.27	0.71				
	IP	0.36	0.81				
	Mean	***0.27***	***0.65***		***Mean***	***0.45***	***0.35***

Note: Column three to four, and seven to eight report the correlation between observable activity variables and the identified emerging and developed activity factors. IP is an abbreviation for industrial production. N/A are missing values.

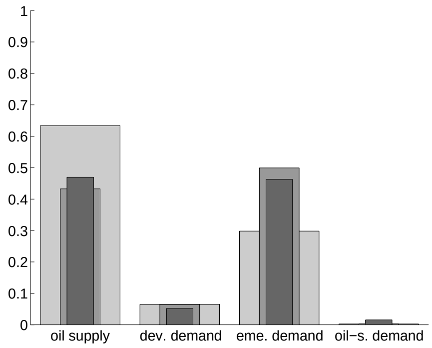
Appendix C Figures

Figure 7: **Variance decomposition: Asia only**

(a) Oil price



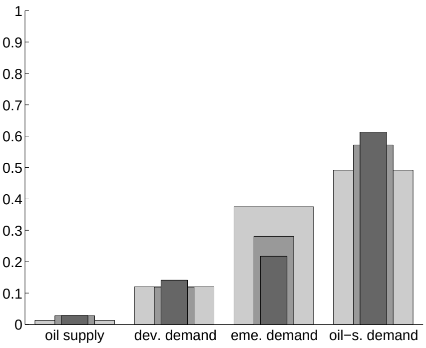
(b) Oil production



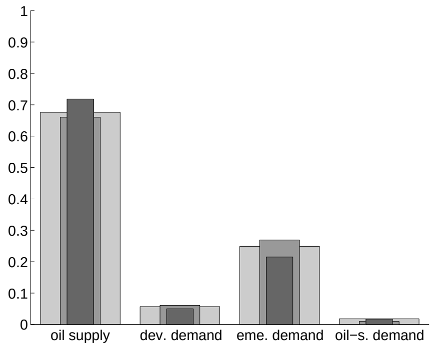
Note: The bars display the variance decomposition with respect to the shocks for horizons 4, 8 and 12 quarters. The widest bars correspond to the shorter horizon.

Figure 8: **Variance decomposition: South America only**

(a) Oil price

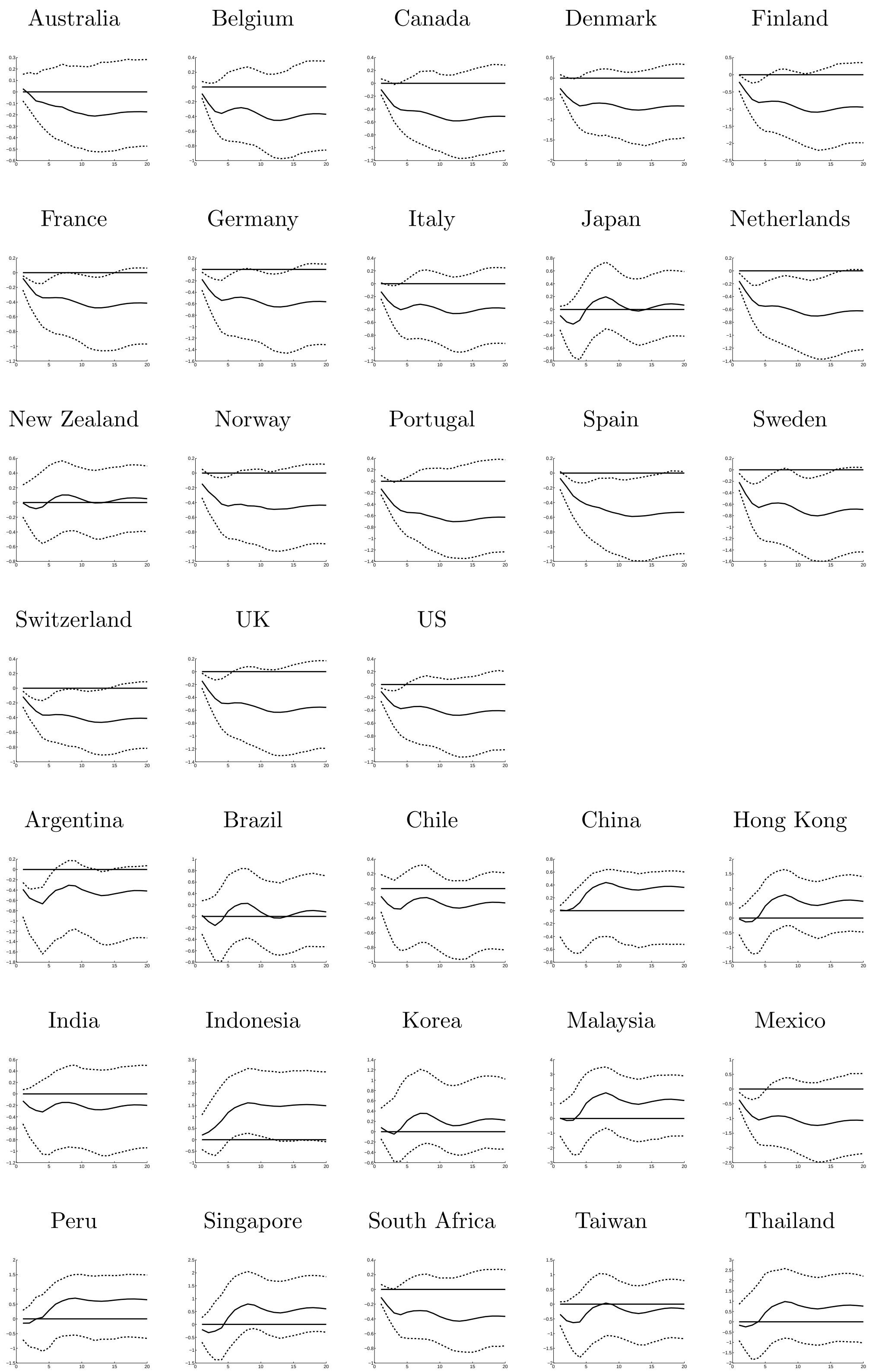


(b) Oil production



Note: The bars display the variance decomposition with respect to the shocks for horizons 4, 8 and 12 quarters. The widest bars correspond to the shorter horizon.

Figure 9: **Impulse responses: Oil supply shock**



Note: The figures show the responses of GDP (in percent) in a given country after a normalized oil supply shock (see Notes to Figure 2 for further details).

Figure 10: **Impulse responses: Oil-specific demand shock**

Note: The figures show the responses of GDP (in percent) in a given country after a oil demand shock that increases oil prices with 10 percent (see Notes to Figure 2 for further details).

Appendix D Implementation of sign restrictions

We implement the following algorithm for each draw of the reduced form covariance matrix Ω:

1. Let $\Omega = PP'$ be the Cholesky decomposition of the VAR covariance matrix Ω, and $\tilde{A}_0 = P$.

2. Draw an independent standard normal n x k matrix J, where n is the size of the block (e.g. developed and emerging) and k is the number of shocks affecting that block according to the block exogenous structure outlined in section 2.2 and equation 4. Let $J = QR$ be the "economy size" QR decomposition of J with the diagonal of R normalized to be positive.

3. Compute a candidate structural impact matrix $A_0 = \tilde{A}_0 \cdot \tilde{Q}$, where $\tilde{Q}$ is a N x N identity matrix with Q' in the n x k block associated with the developed and emerging block in equation 4.

4. Redo step 1-3 for the next block of data.

If the candidate matrix satisfies the sign restrictions, we keep it. Otherwise the procedure above is repeated. The imposed signs can also be restricted to hold for many periods, in which case the candidate matrix must be past into the impulse response function before validation.