Responses of economic activity to global oil market shocks: a comparative study among net oil-consuming and producing countries

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ABSTRACT

This article aims to explore the influences of oil price shocks driven by several origins on industrial production of major net oil-producing and consuming countries during 1986M5–2013M1. The empirical findings rejected the existence of nonlinear relationship among structural oil price shocks and economic activity across majority of the sample countries. This finding strengthens the proposed linear model outcomes. The structural impulse-response analyses revealed that in total, the influences of structural oil price shocks on industrial production are statistically significant, but very country-specific. Furthermore, unexpected non-oil innovations in real exchange rate, which are driven by various macroeconomic factors, exert strong positive influences over economic activity in both groups of sample countries. These effects potentially offset the negative influences of other calculated structural shocks in the oil market on economic activity.

Keywords: structural oil price shocks, structural vector auto regression (SVAR), nonparametric nonlinear causality, impulse-response function, net oil-consuming and producing countries

JEL: F40, O14, Q43

1. Introduction

The literature on the macroeconomic effects of oil price changes shows mixed findings resulting from differences in estimation methods, the identification of shocks, sampling and the specification of variables and period. One point of distinction in this body of research is between oil-importing countries and oil-exporting countries, that is between countries that import large volumes of oil and those that export large volumes of oil. A simple argument is that depending on the structure of their economies, the

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macroeconomies of oil importers will suffer (benefit) from oil price increases (decreases), whereas those of oil exporters will benefit (suffer) from oil price increases.

The former includes countries like the US, China, Japan, India, Germany and South Korea and the latter like Saudi Arabia, Russia, the United Arab Emirates, Kuwait, Nigeria and Iran. However, this distinction does not accurately reflect the potential impact of oil price changes where there is chance of the mixture of oil production and exporting and oil consumption and importing. For example, only 11 out of the world’s 15 leading oil-producing countries are also leading oil-exporters, yet few would deny that oil prices would still affect their economies, and certainly in a different way for a country that exported with a relatively low level of domestic consumption or one that exported with a high level of domestic consumption. Likewise, despite being a leading oil-producer, the US is also the largest oil-importer. In fact, 5 out of the 15 leading oil-producing countries are also among the leading oil-consumers. Surely, the macroeconomies of these countries will react differently according to whether they are a large oil producer and a small oil consumer or a large oil consumer and a small oil producer.

Theoretically, a significant reduction in oil price benefits oil-importers and hurts oil-exporters. For the former countries, lower oil prices is similar to a tax cut, which increase consumer disposable income. This allows central banks to expand money aggregate. Due to upgrading cash flows, lower interest rates as well as lower inflation cause higher economic activity and higher share prices. Jumping industrial production finally leads economic growth. In contrast, higher oil prices are known to be common reasons for appearing recessions in these countries. This story is narrated adversely for the latter economies. While higher oil prices may cause recession in oil-importing countries, economic growth may appear in oil-exporters.

In this paper, I focus on net oil production and consumption instead of oil-exporting and importing, which are measured as a share of GDP. I also aim to correct the existing imbalance in findings given the usual focus on oil importers (here net consumers) and on oil exporters (here net producers), mainly because reliable and consistent data are usually more difficult to obtain for the latter. To compare the responses of economic activity of net oil-consuming and producing countries to the origin-driven oil price shocks, I first follow Kilian (2009) to measure structural oil market shocks. These shocks include oil supply shocks, aggregate demand shocks and precautionary (oil-specific) demand shocks. I also consider further shocks in my analysis to measure the effects of the non-oil shocks on industrial production. Then, utilizing a nonparametric nonlinear approach, I test the existence of any nonlinear causation among target variables. Finally, I imply the structural vector auto regressive (SVAR) approach to measure responses of industrial production to measured oil market shocks calculated in the last sections. The remainder of the paper is structured as follows. Section 2 covers the available research on the subject. Section 3 discusses the data, methods and the estimation results, respectively. Section 4 provides some brief concluding remarks.

2. Transmission of oil price shocks to economic activity

A large body of research suggests that oil price movements have significant effects on economic activity (Hamilton, 1983, 1996, 2003; Gisser and Goodwin, 1986; Mork , 1989; Hooker , 1996, Burbidge and Harrison, 1984; Mork et al., 1994; Jimenez -Rodriguez and Sanchez, 2005, 2009 and Kilian, 2008). Although there are several methods to measure economic activity, two proxies are considered to be the most popular among others: GDP and industrial production. As one of the frontier studies, which indexed GDP as a measurement of economic activity, Mork (1989) found that oil price falls do not exert statistically significant impacts on the US GDP. Later, he found evidence of asymmetry in an inverse relationship between oil price changes and aggregate economic activity for Norway and G7 countries (Mork, 1994). This finding introduced a new concept for empirical studies on oil price–GDP relationship since the mid-1980s.

In this regard, Lardic and Mignon (2008) showed that while standard cointegration is rejected, there is evidence for asymmetric cointegration between oil prices and GDP. In a similar research, He *et al.* (2010) investigated the cointegrating relationship between crude oil prices and global economic activity. They used Kilian's economic index as an indicator of global economic activity. Based on a supply–demand framework and the cointegration theory, they found that real future prices of crude oil are cointegrated with the Kilian economic index as well as a trade weighted US dollar index. They also Showed that crude oil prices are influenced significantly by fluctuations in the Kilian economic index through both long-run equilibrium conditions and short-run impacts. They developed an empirically stable, data-coherent and single-equation error-correction model (ECM), which has sensible economic properties. Their empirical results based on the ECM showed that the adjustment implied by a permanent change in the Kilian's economic index is a relatively drawn out process.

Although GDP is considered as one of the best available measurements for economic activity, it cannot fully satisfy the requirements of reflecting economic activity's reactions to the oil price shocks. For instance, the reaction of industrial production to the oil market shocks in an industrial country might be stronger than GDP's reaction. Such reactions might be different in less-industrialized economie. Furthermore, if the oil price increases, GDP reduces due to income effect; GDP is a domestic value added and the cost of imported oil should be deducted in national accounting. At the same time, labour supply and industrial production goes up in response to the oil price shock (Lee and Ni, 2002). However, input cost effect will decrease both GDP and industrial production.

When industrial production is used as a proxy for cash flows, the results are fitted with the theory of rational valuation. Jones and Kaul (1996) examined the stock market efficiency by using an arbitrage pricing theory (APT) model. The theory suggests that changes in expected future cash flows and future returns of underlying assets are exactly reflected in stock prices. They found that cash flows affect stock returns positively. Park and Ratti (2008) showed that when real US stock returns are allowed to affect real stock returns in European markets, oil price shocks have a statistically significant impact on real stock returns in all European countries at the same time or with a lag of one month.

When looking for the available researches conducted on industrial production reactions to economic shocks, I find very few authors who have paid attention to the impact of oil price shocks at the industry level (see Bohi, 1989; Lee and Ni, 2002; Kilian and Park, 2009; Herrera, 2011). Majority of these articles have focused on the US, with the only exception being Bohi (1989) who also explored such industry-level effects on economies other than the US (specifically, Germany, Japan and the UK). While Bohi (1989) and Lee and Ni (2002) analyzed the impact of oil price shocks on output in manufacturing industries, Kilian and Park (2007) and Herrera (2007) investigated such effects on industry-level stock returns and on industry-level inventory-sales, respectively.

In this regard, Jimenez-Rodriguez (2008) found diverse responses of industrial production to the oil price shocks among industrial countries. She assessed the dynamic effect of oil price shocks on the output of the main manufacturing industries in six OECD countries. She mentioned that the pattern of responses to an oil price shock by industrial output was diverse across the four European Monetary Union (EMU) countries under consideration (France, Germany, Italy, and Spain), but broadly similar in the UK and the US. Moreover, she evidenced cross-industry heterogeneity of oil shock effects within the EMU countries. Later, she found that the main reason of diverse responses of national economies to the oil price shocks is their different macroeconomic structure (Jimenez-Rodriguez, 2011). In this study, she analysed the role of the macroeconomic structure in response of industrial output to an oil price shock in six OECD countries. The cross-country differences she found in this research could be partially explained by differences in the transmission mechanisms of such shocks.

Finally, Lee and Ni (2002) used the demand-supply analysis to explain the macroeconomic effects of oil price shocks. They showed that in supply-side, the oil-intensive industries will reduce their production if an oil price shock appears. Nevertheless, in demand-side, industrial production movements are not clear due to responsibility of less-oil-intensive industries. One reason is that the production of less-oil-intensive industries moves down if the demand of more-oil-intensive industries reduces. However, an increase in demand of more-oil-intensive industries may raise demand and supply of less-oil-intensive industries (automobile and steel industries for instance).

3. Data, Methodology and results

3.1. Data

My sample data consist of global oil prices, industrial production and real exchange rate for seven net oil-consuming and three net oil-producing countries. My sample selection criterion is the share of net oil production (consumption) in GDP. As illustrated in Figure 1, I calculate this index for a wide range of oil-producing and consuming countries. Finally, data availability let us to select the US, Brazil, Denmark, Italy, Germany, the Netherlands and Sweden as net oil consumers and Canada, Mexico and Norway as net oil producers. Table 1 provides a summary of oil production and consumption share of GDP in the sample countries.

<FIGURE 1 ABOUT HERE>

<TABLE 1 ABOUT HERE>

I use monthly data covering the period 1986M5–2013M1. Data for industrial production (IP) and nominal exchange rate (ER) are collected from the Organisation for Economic Co-operation and Development (OECD). I also use the monthly West Texas Intermediate (WTI) oil price index, available in the World Bank website. All data are indexed to the 2010 monthly-average.

3.2. Methods

In this section, I explain the econometric methods have been utilized in this article. These methods include SVAR model to measure oil price shocks as well as shocks in real exchange rate, nonparametric nonlinear approach to test nonlinear causation and impulse-response analysis to measure responses of industrial production to the structural shocks.

3.2.1. Structural shocks

In this paper, I measure crude oil market shocks using a two block structural shocks presented by Kilian (2009). The standard SVAR model is specified as below:

$$\boldsymbol{AY_t} = \alpha + \sum_{i=1}^{j} \boldsymbol{B_i Y_{t-i}} + \varepsilon_t \qquad 1$$

In this Equation, $\boldsymbol{Y} = (\Delta OS, \Delta RA, \Delta OP, \Delta ER)'$ indicates log-differences of global oil supply, Kilian index of global real economic activity, global oil price and country-specific real exchange rate variables, respectively. The exogenous error terms (ε_t) are assumed to be serially and mutually structural innovations. The lag length j is selected to be 24. $\boldsymbol{A}$ is a full rank matrix such that $\boldsymbol{A^{-1}}$ is a recursive structure defining the reduced form $e_t = \boldsymbol{A^{-1}}\varepsilon_t$. Such decomposition is presented as follows:

$$e \equiv \begin{pmatrix} e_t^{\Delta OS} \\ e_t^{\Delta RA} \\ e_t^{\Delta OP} \\ e_t^{\Delta ER} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{Oil\, supply\, shock} \\ \varepsilon_t^{Aggregate\, demand\, shock} \\ \varepsilon_t^{Other\, oil-specific\, shock} \\ \varepsilon_t^{Other\, exchange-specific\, shock} \end{pmatrix} \quad 2$$

Consequently, the structural innovations define oil market shocks as follows: crude oil supply shocks are unpredictable innovations to global crude oil production. Shocks to the global demand for industrial commodities (aggregate demand shocks) are those innovations to global real economic activity, which are not explained by crude oil supply shocks. Oil-specific demand shocks, which are interpreted as precautionary demand shocks, are innovations to the real price of oil that cannot be explained by oil supply shocks or aggregate demand shocks. Finally, other exchange-specific shocks are innovations in real exchange rate, which are not explained by oil supply shocks, aggregate demand shocks and other oil-specific shocks.

There are some restrictive assumptions behind the above decomposition. First, oil supply innovations do not respond to shocks in aggregate demand, other oil-specific and other exchange-specific shocks in the short-term. This lets the oil supply shocks to be considered exogenously. The oil-producers control over global oil production, which induces their no response or less response to the short-term changes in oil market, confirms the reliability of such assumption.

Second, global economic activity responds to global oil price shocks immediately, while oil-specific shocks or country-specific exchange shocks have no effects on global economic activity in the short-term. As discussed in Kilian (2009), oil-specific shocks may influence global economic activity after a month. Moreover, if any influences of shocks in country-specific exchange rate are existent, it may take more than a month to change global economic activity.

Finally, as Kilian (2009) and Kilian and Park (2009) discuss, other oil-specific shocks are interpreted as precautionary demand shocks, which are induced by the expected shortfalls in oil supply. These shocks do not respond to the exchange rate innovations in a country within one month as they are mainly caused by uncertainty in future global oil supply. Furthermore, other shocks to the country-specific exchange rates are caused by many other economic and non-economic factors. Thus, other factors which are affecting real exchange rate and hence, affect industrial production are separated from those influencing crude oil market and affect industrial production.

3.2.2. Parametric nonlinear test

The first step to study the effects of structural shocks on industrial production is exploring the existence of any nonlinear causation of these shocks over industrial production through applying parametric nonlinear test. This test, when some nonlinear causation is found, can also properly determine whether the causation is asymmetric or not. The test is similar to the linear Granger causality test; however, it follows the Mackey–Glass (1977) process with special parameters being estimated by conducting ordinary least squares method. To start with, suppose we have the following country-specific two models:

$$DL\varsigma_{it} = \alpha_{11}\frac{DL\hat{\varsigma}_{it-\tau_1}}{1+DL\hat{\varsigma}_{it-\tau_1}^{c_1}} - \delta_{11}DL\hat{\varsigma}_{it-1} + \alpha_{12}\frac{DLIP_{t-\tau_2}}{1+DLIP_{t-\tau_2}^{c_2}} - \delta_{12}DLIP_{t-1} + z_t$$

$$i = 1,2,3,4 \qquad (3)$$

$$DLIP_t = \alpha_{21}\frac{DL\hat{\varsigma}_{it-\tau_1}}{1+DL\hat{\varsigma}_{it-\tau_1}^{c_1}} - \delta_{21}DL\hat{\varsigma}_{it-1} + \alpha_{22}\frac{DLIP_{t-\tau_2}}{1+DLIP_{t-\tau_2}^{c_2}} - \delta_{22}DLIP_{t-1} + u_t$$

$$i = 1,2,3,4 \qquad (4)$$

where $DLIP_t$ and $DL\varsigma_{it}$ indicate the log-differences of the industrial production and the oil market shocks estimated by Equations 1 and 2, respectively. D is the first difference operator, L shows the logarithm and $\hat{\varsigma}$ indicates the relevant estimated shock. Also, i refers to each of four shocks I calculate in this paper, $\tau = max(\tau_1, \tau_2)$ is the calculated integer delays, c is the constant and $t = \tau, \tau+1, \dots, N$. The parameters α and δ, indicate the linear and nonlinear effects of the cause variable, respectively. Finally, the two error terms z_t and u_t are assumed to be N(0,1). To select the integer delays τ_i and constants c_i, I use the Schwarz and Akaike information criterion (AIC) prior to the model estimation. If the estimated shocks in this paper are defined to be nonlinear Granger cause of industrial production, α_{11} should significantly differ from zero (the null hypothesis). Consequently, we need to estimate each equation once with no constraint and once with the constraint of a zero value for α_{11} (and α_{22}). Assuming $\hat{\vartheta}$ and $\hat{\mu}$ are the residuals of the unconstrained and constrained Mackey–Glass models, respectively. We calculate the Fisher-distributed statistic of the test as below:

$$S_F = \frac{(S_c - S_u)/n_c}{S_u/(T - n_u - 1)} \sim F(n_c, T - n_u - 1) \qquad (5)$$

where $S_u = \sum_{t=1}^{T}\hat{\vartheta}^2$, $S_c = \sum_{t=1}^{T}\hat{\mu}^2$, n_u=4 due to existence of four parameters in the Mackey–Glass model and $n_c = 1$ as there is one parameter needed to be zero when estimating constrained model. Such statistic gives enough support to consider the coefficients statistical confidence.

3.2.3. Linear regression model

To consider the linear responses of industrial production to the estimated shocks in crude oil market obtained from Equations 1 and 2, I follow Kilian (2009) linear approach to measure such impulse-responses. I also decompose country-specific forecast error variances of each shock to determine the contribution of each shock in variations of industrial production. To calculate the impulse-responses, consider the following country-specific Equation:

$$DLIP_t = \delta_j + \sum_{i=0}^{24} \varphi_{ji} \hat{\varsigma}_{jt-i} + \omega_{jt} \qquad j = 1, 2, 3, 4 \qquad 6$$

Where $DLIP$ and $\hat{\varsigma}$ are log-difference of industrial production and estimated shocks using Equations 1 and 2, respectively. Also, δ is the constant term and ω is the error term. The purpose of estimating Equation 6 is to find the model coefficients (φ). Such coefficients are reporting industrial production responses to each shock impulses during a 24-month horizon (Kilian, 2009). Consequently, the number of lags is determined by the maximum horizon of the impulse-response function. More importantly, the error terms are potentially serially correlated. This provides biased estimations of the standard errors. In order to solve the problem, I employ bootstrapping methods to extract the standard errors.

3.3. Results

Here we first need to consider the existence of any nonlinear effects of calculated structural shocks on country-specific industrial productions. The results of applying modified nonlinear parametric M–G model are presented in Table 2. The Table presents the lag order and the power of each shock affecting industrial production separately as well as the relevant test statistic with F distribution.

<TABLE 2 ABOUT HERE>

Table 2 indicates that first, the power of cause variable (e.g. shocks) is reported to be unit in all of the cases. This reduces the chance of nonlinear causal effects of such shocks on industrial production. Second, oil shocks generally influence industrial productions in less than 4 months in almost all cases.

The oil supply shocks affect industrial production of net oil-consuming countries between 1–3 months. This period, however, seems to be longer in net oil-producing countries when it takes 7 months in Canada, 6 months in Mexico and only one month in Norway. The lag length for the effects of aggregate demand shocks is not too much different between two panels; where it varies between 1–4 months in net oil-consuming countries, it lasts 2–3 months in net oil-producing countries. The lag lengths for the effects of other oil-specific shocks varies significantly, particularly across net oil-consuming countries; it is reported to be one month in Brazil, Sweden and the US, 3 months in the Netherlands, 4 months in Denmark and Germany and 8 months in Italy. Such lags varies between one month in Norway and Mexico and 4 months in Canada. Finally, other shocks in real exchange rates seem to affect industrial production constantly, which takes 2–3 months with exceptions of Brazil, Norway and Mexico with 1 month lag length.

The modified nonlinear parametric M–G tests are then performed for each sample country, based on the predetermined parameters. Recall that this test allows detecting the nonlinear causality running from my estimated shocks to industrial production without distinguishing the signs of their changes. The findings indicate that there is no evidence confirming the existence of such nonlinear causation, except in case of oil supply shocks in Mexico, aggregate demand shocks in Norway and oil-specific shocks in Italy.

The nonlinearity tests show that there is little evidence of nonlinearity across sample net oil-consuming and producing countries. This finding suggests that a linear specification may well capture the linkage between crude oil shocks and industrial production movements in the context of this study. The absence of such nonlinearity reduces the likelihood of model misspecification in this paper and increases the reliability of our results.

3.3.1. Country-specific responses to global oil supply shocks

Using the structural VAR model presented in Equation 6, we now consider the country-specific responses of economic activity to global oil price shocks. Fig. 2 illustrates such responses from individual net oil-consuming and producing countries. The Figure shows that unexpected increase in global oil production exerts significant positive effects on economic activity of both net oil-consuming and producing countries. This is intuitive since higher oil supply reduces oil prices and afterward industry costs. Thus, expansion in industrial production is expected. The minor exceptions in net oil-consuming countries include the responses in Brazil and the Netherlands, which are reported to be statistically negative and zero, respectively.

<FIGURE 2 ABOUT HERE>

Fig. 2 also shows that economic activity responses to oil supply shocks in net oil-consuming countries appears a few months later than net oil-producing countries. Rather than the US, which responds immediately and Brazil, which negatively responds after 2 months, other net oil-consuming countries exhibit significant positive responses within 2–12 months. On the other hand, where Canada and Mexico as net oil-producing countries respond immediately, Norway starts responding in the second half of the second year. Altogether, I find that there is no significant difference between our two sample panels in magnitude and direction of responses to global oil supply shocks. Furthermore, the industrial production across net oil-consuming countries responds to the oil supply shocks very similarly, while such similarity is not evident across net oil-producing countries (see Table 3).

<TABLE 3 ABOUT HERE>

3.3.2. Country-specific responses to global oil demand shocks

The effects of unanticipated shocks in global aggregate demand on country-specific industrial production are illustrated in Fig. 3. The Figure shows that the responses of economic activity to shocks in aggregate demand are statistically significant in most of the countries, although its pattern seems to be different by country. These effects are reported to vary within a wider range in net oil-producing countries than net oil-consuming. In the latter panel, where global aggregate demand has significant substantial positive influences on industrial production in Brazil, Germany, Italy and Sweden, it exerts zero and significantly negative effects in the Netherlands and Denmark, Respectively. The US, however, uniquely responds positively during the first year while the response trend turns negative at the second year. In net oil-producing countries, on the other hand, Norway and Mexico exhibit very late significant negative response to global aggregate demand shocks where Canada's industrial production responses follow the US pattern.

<FGURE 3 ABOUT HERE>

It seems that structural differences between our sample economies, which have been known as the major reason for diverse country-specific responses of industrial production to global oil price shocks by Jimenez-Rodriguez (2011), is evident mostly by unanticipated shocks to global aggregate demand. Such differences in macroeconmic structures shed light on assumed diversities, which may come from net oil consumption and production. Thus, I cannot extend my results illustrated in Fig. 3 to all net oil-consuming and producing countries. Furthermore, it is intuitive that shocks in global economic activity index, presented by Kilian (2009) induces the increases in crude oil prices (He et al, 2011). An increase in oil price will result in higher industry costs (Jung and Park, 2011), which can be more sensible across oil-intensive industries as well as those productions which are oil intensive in use (such as transportation equipment). As time elapses, these negative effects may gradually offset the positive effects of increasing demand on the markets, which require production expansion (Kilian and Park, 2009). Thus, two opposite powers make diverse trends of responses to global demand shocks. This could be a reason for a very country-specific responses of industrial production to the aggregate demand shocks. Table 4 confirms this country-specific reaction. Fig. 3 also shows that the influences of increasing oil prices due to shocks in global aggregate demand in net oil-producing countries are less substantial than in net oil-consuming countries. This finding is in conjunction with Sotoudeh and Worthington (2014), which proved the existence of cointegrating relationship between oil price changes and industrial production only across net oil-consuming countries.

<TABLE 4 ABOUT HERE>

3.3.3. Country-specific responses to other global oil price shocks

Fig. 4 depicts the cumulative responses of country-specific industrial production to other oil-specific shocks. These shocks are associated to global oil price shocks and cannot be explained by oil demand and supply shocks. The impulse-responses indicate that the influences of other oil-specific shocks on industrial production are substantially negative across net oil-producing and most of the net oil-consuming countries. Furthermore, the negative responses are followed by positive reaction during the first year in net oil-producing and consuming countries except Brazil and Denmark. The pattern and the variation seem to be very similar between both panels of countries.

<FIGURE 4 ABOUT HERE>

Kilian (2009) and Alquist and Kilian (2010) define the other oil-specific shocks as precautionary demand induced by the expectation of a shortfall in oil supply. Kilian (2009) shows that unanticipated oil-specific demand increases have an immediate, large and persistent positive effect on the real oil prices. Thus, we can expect the negative responses of industrial production to the oil market shortfalls in the long-term. In short-term, however, oil-specific demand shocks induce temporary increase in global economic activity (Kilian, 2009). Additionally, such oil market shortfalls may be considered as temporary for the first few months. These can explain initial increase in industrial production within sample countries. Overall, rather than being net oil consumer or producer, industrial production oof all countries respond to the oil-specific shocks very similarly (see Table 5).

<TABLE 5 ABOUT HERE>

3.3.4. Country-specific responses to other shocks to real exchange rate

Fig. 5 illustrates the country-specific responses of industrial production to unanticipated domestic currency depreciation due to all other shocks rather than shocks in supply, demand and precautionary demand of oil. Given that exchange rate delivers domestic value of one unit foreign currency, the sources of these shocks may include shocks in the government expenditures, imports, exports, inflation, money supply or any other factor affecting real exchange rate. Fig. 5 provide evidences indicating that mentioned shocks exert statistically significant and large influences on real exchange rate of country-specific industrial production across net oil-consuming and producing countries. The first important implication of this finding is that any change in industrial production where an oil supply, demand or precautionary demand shock appears does not indicate the industrial production reaction to such oil shocks. Where all estimated oil shocks may affect country-specific industrial productions, either directly or indirectly, other shocks to real exchange rates at the same time may affect industrial production diversely. As the Figure illustrates, the industrial production responses to non-oil shocks in real exchange rate are mostly negative during the first year in both panels. Thus, this reaction can mitigate the initial positive effects of other oil shocks on industrial production presented in previous figures.

<FIGURE 5 ABOUT HERE>

Fig 5 also shows that the duration and magnitude of negative effects in net oil-producing countries seem to be more than that in net oil-consuming countries. In net oil-producing countries, industrial production responds negatively to other shocks in real exchange rate within all three countries, substantially in Norway and preceded by significant increase in Canada and Mexico. In net oil-consuming countries, however, 4 out of 7 net oil-consuming countries exhibit initial negative responses to other shocks in real exchange rate. In Germany, Italy and the Netherlands, the industrial production reduction is either not significant or less than other net oil-consuming due to beneficial effects that joining to European Union common currency provides for them (Jamil et al., 2012). In Brazil and Sweden, I find significant large decrease in industrial production. In the US, the responses grow up to 600 percent at the end of the second year.

There are two opposite flows, which specify the current direction of responses to non-oil shocks in real exchange rate within both panels. The domestic currency depreciation increases the price of intermediate goods including crude oil. The afterward increase in cost of production, particularly in net oil-consuming countries, reduces industrial production. On the other hand, the currency depreciation will increase net exports and aggregate demand. This motivates industrial production to grow up. Consequently, the combination of above flows forms the movement direction of industrial production responding to shocks in real exchange rate. The results indicate that the long-term effects of non-oil shocks in real exchange rate are mostly positive within both panels, with stronger negative effects across net oil-producing countries. Furthermore, industrial production in net oil-consuming countries reacts to these shocks similarly, while such reactions are heterogeneous across net oil-producing countries (see Table 6).

<TABLE 6 ABOUT HERE>

3.3.5. Forecast error variance decomposition

To quantify the contribution of oil price shocks to variations in merchandise trade variables, I employ the variance decomposition analysis. Figures 6 and 7 show the variance decomposition results of forecasting errors in industrial production of net oil-consuming and producing countries at the forecast lengths of 1, 6, 12 and 24 months, respectively.

<FIGURE 6 ABOUT HERE>

The first interpretation of the results illustrates the difference in absolute contribution of each shock in changes in industrial production between two sample panels of countries. First, in net oil-consuming countries, the contribution of oil supply shocks in industrial production gradually decreases (Brazil, Denmark, the US), increases (Germany, Sweden) or fluctuates (Italy, the Netherlands) where such trend is reported to be only decreasing across net oil-producing countries. The average contribution of oil supply shocks in industrial production variation across net oil-consuming countries is 23 per cent with exceptions of Denmark and the US (with much higher contribution) and Germany (with lower contribution). Such contributions, however, seem to be significantly higher across net oil-producing countries where explain 45 per cent of changes in industrial production in average. Second, the role of aggregate demand shocks in explaining the industrial production variations seems to fluctuate during the time across net oil-consuming countries and to decrease across net oil-producing countries. In net oil-consuming countries excepted Sweden, the contribution of aggregate demand shocks at the first month is less than all other times and stands on 4.8 per cent. This ratio reaches to maximum of 39 per cent of industrial production variation at the first month in Sweden and varies within these two bands across net oil-consuming countries. There is no big difference between net oil-consuming and producing countries in terms of the maximum and minimum variation in the role of aggregate demand shocks in industrial production changes during the time.

Third, the contribution of other oil price shocks in industrial production variation differs significantly across sample countries. In net oil-consuming countries, such contribution gradually drops in Brazil, Germany, the Netherlands and the US while it does not follow a particular pattern in Denmark, Italy and Sweden. Similarly, the contribution of other oil price shocks in industrial production variation of net oil-producing countries fluctuates during the time. However, these shocks are reported to explain less variations of industrial production in net oil-producing countries than net oil consumers, particularly during the first six months. Finally, the contribution of other shocks in real exchange rate seems to be increasing during the first year in most of the sample countries. In Brazil, Germany, the Netherlands and Sweden among net oil-consuming panel and in Canada and Mexico among net oil-producing panel, other shocks in real exchange has fairly no power at the first month in explaining industrial production variation. Such power increases within all sample net oil-consuming and producing countries during 6 months and then, it varies differently across countries with no special pattern.

<FIGURE 7 ABOUT HERE>

The second interpretation of the results presented by the Fig. 6 and Fig. 7 explains the difference in comparative contribution of each shock between sample panels of countries. During the first month, oil supply shocks (in Denmark and the US) and other oil price shocks (in the rest of the net oil-consuming countries) explain major variations in industrial production where in net oil-producing countries, only oil supply shocks explain more than 60 per cent of changes in industrial production. As time elapses, the contribution of each estimated shock in net oil-consuming countries become equal with exception of Germany and the US. In Germany, other oil price shocks always perform the highest role in explaining the variations of industrial production. In the US, industrial production variations are better explained during the time. In net oil-producing countries, however, oil supply shocks are still the most significant source of variations in industrial production during the first year, which are gradually replaced with other shocks to real exchange rate. Finally, where aggregate demand shocks across net oil-consuming countries make the least contribution to industrial production variations in average, other oil price shocks perform similar role in net oil-producing countries.

4. Conclusion

Oil as a strategic commodity can affect national economic activity not only when it is considered as a source of energy and demand, but also when it injects income to national economy through supply side. A significant reduction in oil price benefits oil-importers and hurts oil-exporters. For the oil-importing countries, lower oil prices are similar to a tax cut, which increase consumer disposable income. This allows central banks to expand money aggregate. Due to upgrading cash flows, lower interest rates as well as lower inflation cause higher economic activity and higher share prices. Jumping industrial production finally leads economic growth. In contrast, higher oil prices are common reasons for appearing recessions in oil-importing countries. This story is narrated for the oil-exporters adversely. While higher oil prices may cause recession in oil-importing countries, economic growth may appear in oil-exporters.

Due to possible adverse effects of an oil price shock on oil-importing and oil-exporting economies, I conducted further comparative research on country-specific reactions of such economies to oil price shocks driven by different origins. Thus, using a two block structural shocks model, we first measured oil supply shocks, aggregate demand shocks, oil-specific demand shocks and other shocks appeared in exchange rate. Oil supply shocks are unpredictable innovations to global crude oil production. Shocks to the global demand for industrial commodities (aggregate demand shocks) are those innovations to global real economic activity, which are not explained by crude oil supply shocks. Oil-specific demand shocks, which are interpreted as precautionary demand shocks, are innovations to the real price of oil that cannot be explained by oil supply shocks or aggregate demand shocks. Finally, other exchange-specific shocks are innovations in real exchange rate, which are not explained by oil supply shocks, aggregate demand shocks and other oil-specific shocks.

A comprehensive investigation includes testing for the existence of both linear and nonlinear influences of oil price shocks on economic activity. Consequently, we initially explored the nonlinear causation of oil price shocks to industrial production, which is used as proxy for economic activity. The nonparametric nonlinear tests show that there is little evidence of nonlinearity across sample net oil-consuming and producing countries. This finding suggests that a linear specification may well capture the linkage between crude oil shocks and industrial production movements in the context of this study. The absence of such nonlinearity reduces the likelihood of model misspecification in this paper and increases the reliability of the results.

At the next step, I considered the linear responses of economic activity to the estimated shocks in crude oil market. The results of my linear country specific impulse-response estimations are summarized as follows: first, the oil supply shocks affect economic activity in net oil-consuming countries after 1–3 months. This period, however, seems to be longer in net oil-producing countries, varied from 1–7 months. Aggregate demand shocks influence economic activity after 1–4 months in net oil-consuming countries and 2–3 months in net oil-producing countries. The lag lengths for the effects of other oil-specific shocks vary significantly across two panels of countries. The lag length is generally varied from 1–8 months within net oil-consuming countries and 1–4 months across net oil-producing countries. Other shocks in real exchange rates seem to affect economic activity constantly, which takes 2–3 months within all countries in average.

Second, unexpected increase in global oil production exerts significant positive effects on economic activity of both net oil-consuming and producing countries. The estimations indicate that there is no significant difference in responses of two groups of countries to the oil price shocks driven by oil production. Nevertheless, net oil-consuming countries generally respond to the oil-production-driven shocks slower than net oil-producing countries.

Third, the oil price shocks driven by aggregate demand shocks affect majority of net oil-consuming and producing countries, however, diversely across sample countries and less substantial across net oil-producing countries. Such diversity among net oil-producing countries seems to be greater than net oil-consuming countries. This finding reveals that the structural differences in national economies, which are known as major reason for diverse reactions of countries to the oil price shocks, are considerable only when the oil price shocks are driven by aggregate demand shocks.

Forth, oil-specific demand shocks, which are associated to global oil price shocks and cannot be explained by oil demand and supply shocks, influence economic activity of net oil-producing countries substantially negatively. Such effects are evident in most of the sample net oil-consuming countries. The pattern and the variation of industrial production responses seem to be very similar across all sample countries. Furthermore, I found that in addition to initial temporary increase in industrial production due to an oil-specific demand shock, which has also been found in other studies, these shocks affect industrial production negatively in the long-term.

Fifth, while I define real exchange rate as domestic value of one unit foreign currency, the sources of these shocks in real exchange rate may include shocks in the government expenditures, imports, exports, inflation, money supply or any other factor affecting real exchange rate. I found that shocks in real exchange rate exert statistically significant and large influences on country-specific industrial production across all sample countries. The industrial production responses to non-oil shocks in real exchange rate are mostly negative during the first year in all countries. This reaction can mitigate the initial positive effects of oil price shocks on industrial production calculated in previous sections. Also, the duration and magnitude of negative effects in net oil-producing countries seem to be higher than that in net oil-consuming countries.

Finally, while the contribution of oil supply shocks in industrial production variation of net oil-producing countries is decreasing over a two-year horizon, it is variable across net oil-consuming countries. Such contribution is equivalent to 23 percent in net oil-consuming countries and 45 percent in net oil-producing countries in average. The contribution of oil price shocks driven by aggregate demand shocks in industrial production variation during a two-year horizon is the same as contribution of oil supply shocks. Oil-specific demand shocks make variable country-specific contributions across all countries. The contribution of other shocks in real exchange rate seems to be increasing during the first year in most of the sample oil-importing and oil-exporting countries. The shocks in real exchange rate at the first month have fairly no power in explaining industrial production variation in these countries. Such power increases within all sample net oil-consuming and producing countries during 6 months and then, it varies differently across countries with no special pattern.

References

Alquist, R., and Kilian, L. (2010). What do we learn from the price of crude oil futures? *Journal of Applied Econometrics*, *25*,539–73.

Bohi, D.R. (1989). *Energy price shocks and macroeconomic performance*: Resources for the Future.

Burbidge, J., and Harrison, A. (1984). Testing for the effects of oil-price rises using vector autoregressions. *International Economic Review, 25*(2), 459–484.

Gisser, M., and Goodwin, T.H. (1986). Crude oil and the macroeconomy: Tests of some popular notions: Note. *Journal of Money, Credit and Banking, 18*(1), 95–103.

Hamilton, J.D. (1983). Oil and the macroeconomy since world war II. *Journal of Political Economy, 91*(2), 228–248.

Hamilton, J.D. (1996). This is what happened to the oil price-macroeconomy relationship. *Journal of Monetary Economics, 38*(2), 215–220.

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

He, Y., Wang, S., and Lai, K.K. (2010). Global economic activity and crude oil prices: a cointegration analysis. *Energy Economics, 32*(4), 868–876.

Herrera, A.M., Lagalo, L.G., and Wada, T. (2011). Oil price shocks and industrial production: Is the relationship linear? *Macroeconomic Dynamics, 15*(SUPPL. 3), 472–497.

Hooker, M.A. (1996). What happened to the oil price-macroeconomy relationship? *Journal of Monetary Economics, 38*(2), 195–213.
Jamil, M., Streissler, E.W., and Kunst, R.M. (2012). Exchange rate volatility and its impact on industrial production, before and after the introduction of common currency in Europe. *International Journal of Economics and Financial Issues, 2*(2), 85–109.
Jimenez-Rodriguez, R. (2008). The impact of oil price shocks: Evidence from the industries of six OECD countries. *Energy Economics, 30*(6), 3095–3108.
Jimenez-Rodriguez, R. (2011). Macroeconomic structure and oil price shocks at the industrial level. *International Economic Journal, 25*(1), 173–189.
Jimenez-Rodriguez, R., and Sanchez, M. (2009). Oil shocks and the macro-economy: a comparison across high oil price periods. *Applied Economics Letters, 16*(16), 1633–1638.
Jimenez-Rodriguez, R., and Sánchez, M. (2005). Oil price shocks and real GDP growth: empirical evidence for some OECD countries. *Applied Economics*, *37*(2), 201–228.
Jones, C.M., and Kaul, G. (1996). Oil and the stock markets. *The Journal of Finance, 51*(2), 463–491.
Jung, H., and Park, C. (2011). Stock market reaction to oil price shocks: A comparison between an oil-exporting economy and an oil-importing economy. *Journal of Economic Theory and Econometrics, 22*(3), 1–29.
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), 78–121.
Kilian, L. (2009). Not all oil price shocks are alike: disentangling demand and supply shocks in the crude oil market. *The American Economic Review, 99*(3), 1053–1069.
Kilian, L., and Park, C. (2009). The impact of oil price shocks on the U.S. stock market. *International Economic Review, 50*(4), 1267–1287.
Lardic, S., and Mignon, V. (2008). Oil prices and economic activity: an asymmetric cointegration approach. *Energy Economics, 30*(3), 847–855.
Lee, K., and Ni, S. (2002). On the dynamic effects of oil price shocks: a study using industry level data. *Journal of Monetary Economics*, *49*(4), 823n852.
Mackey, M. C. and Glass, L. (1977) Oscillation and chaos in physiological control systems, *Science*, *197*, 287–9.
Mork, K.A. (1989). Oil and the macroeconomy when prices go up and down: An extension of hamilton's results. *Journal of Political Economy, 97*(3), 740–744.
Mork, K.A., Olsen, O., and Mysen, H.T. (1994). Macroeconomic responses to oil price increases and decreases in seven OECD countries. *Energy Journal, 15*(4), 19–35.
Park, J., and Ratti, R.A. (2008). Oil price shocks and stock markets in the U.S. and 13 European countries. *Energy Economics, 30*(5), 2587–2608.
Sotoudeh, M.A., and Worthington, A.C. Nonlinear interest rate effects of global oil price changes: comparison of net oil consuming and net oil producing countries. *Applied Economics Letters, 22*(9), 693-699.

Tables

Table 1. *Oil consumption and production share of GDP in sample countries (1976–2011)*

Country	Oil consumption variation*	Oil production variation*	Net oil consumption share of GDP (%)**	Net oil production share of GDP (%)**
Brazil	984–2629	173–2193	1.89	…
Denmark	176–326	4–390	0.80	…
Germany	2362–3341	NA	2.10	…
Italy	1532–1976	27–127	2.42	…
Netherlands	610–1122	NA	3.09	…
Sweden	305–564	NA	2.21	…
USA	15235–20802	6734–10580	1.66	…
Canada	1540–2298	1598–3522	…	0.72
Norway	176–235	279–3418	…	11.57
Mexico	730–2030	894–3766	…	4.55

Notes: * indicates thousand barrels daily. ** denotes the average of annual index.
Source: IEA and World Bank websites.

Table 2. *Parametric nonlinear M–G causality test*

	OS shocks −/→ IP				AD shocks −/→ IP		
Country	lag	power	test statistic	Country	lag	power	test statistic
Brazil	1	1	0.0580	Brazil	2	1	1.7226
Denmark	3	1	0.3739	Denmark	5	1	1.0709
Germany	3	1	0.2054	Germany	4	1	1.4068
Italy	3	1	1.0613	Italy	3	1	2.1621
Netherlands	2	1	0.9562	Netherlands	2	1	0.6241
Sweden	1	1	0.3065	Sweden	1	1	0.3291
US	1	1	0.3783	US	3	1	1.0546
Canada	7	1	0.0108	Canada	3	1	0.8103
Norway	1	1	0.5472	Norway	3	1	10.7032***
Mexico	6	1	3.8841**	Mexico	2	1	0.6295
	OD shocks −/→ IP				ER shocks −/→ IP		
Country	lag	power	test statistic	Country	lag	power	test statistic
Brazil	1	1	2.7195	Brazil	1	1	1.2148
Denmark	4	1	1.2757	Denmark	3	1	1.2619
Germany	4	1	0.9665	Germany	3	1	0.1046
Italy	8	1	13.4698***	Italy	3	1	1.3657
Netherlands	3	1	0.3266	Netherlands	2	1	0.3918
Sweden	1	1	0.5672	Sweden	2	1	0.5703
US	1	1	0.2231	US	3	1	1.3986
Canada	4	1	0.5016	Canada	3	1	0.4226
Norway	1	1	1.5530	Norway	1	1	0.4730
Mexico	1	1	0.1025	Mexico	1	1	2.4478

Notes: Lag and power of cause variables affecting dlip and have selected using SBIC and ACI. ** and *** indicate 5% and 1% significance level. OS stands on oil supply shocks, AD stands on aggregate demand shocks, OD stands on oi-specific demand shocks and ER stands on other shocks to real exchange rate.

Table 3. *Correlation coefficients of impulse-responses to oil supply shocks*

	Brazil	Denmark	Germany	Italy	Netherlands	Sweden	US	Canada	Norway	Mexico
Brazil	1									
Denmark	0.66	1								
Germany	0.83	0.77	1							
Italy	0.82	0.79	0.93	1						
Netherlands	0.30	–0.04	0.26	0.25	1					
Sweden	0.89	0.70	0.85	0.88	0.19	1				
US	0.40	0.59	0.65	0.62	0.16	0.60	1			
Canada	–0.54	–0.16	–0.28	–0.29	–0.01	–0.35	0.47	1		
Norway	0.79	0.47	0.63	0.63	0.13	0.75	0.18	–0.63	1	
Mexico	0.14	0.28	0.23	0.23	–0.03	0.37	0.76	0.58	0.01	1

Table 4. *Correlation coefficients of impulse-responses to aggregate demand shocks*

	Brazil	Denmark	Germany	Italy	Netherlands	Sweden	US	Canada	Norway	Mexico
Brazil	1									
Denmark	–0.30	1								
Germany	0.78	0.13	1							
Italy	0.34	0.61	0.77	1						
Netherlands	0.25	0.08	0.49	0.49	1					
Sweden	0.88	–0.20	0.82	0.47	0.23	1				
US	–0.83	0.61	–0.43	0.14	0.03	–0.67	1			
Canada	–0.85	0.55	–0.48	0.07	0.01	–0.70	0.98	1		
Norway	–0.26	0.30	0.11	0.30	0.41	–0.06	0.47	0.45	1	
Mexico	–0.37	0.76	–0.15	0.36	0.10	–0.38	0.60	0.56	0.06	1

Table 5. *Correlation coefficients of impulse-responses to other shocks in oil price*

	Brazil	Denmark	Germany	Italy	Netherlands	Sweden	US	Canada	Norway	Mexico
Brazil	1									
Denmark	0.76	1								
Germany	0.82	0.68	1							
Italy	0.86	0.86	0.90	1						
Netherlands	0.85	0.69	0.87	0.91	1					
Sweden	0.82	0.81	0.91	0.96	0.86	1				
US	0.86	0.87	0.85	0.98	0.87	0.96	1			
Canada	0.82	0.82	0.90	0.94	0.85	0.97	0.95	1		
Norway	0.73	0.75	0.64	0.85	0.75	0.75	0.82	0.69	1	
Mexico	0.76	0.82	0.71	0.85	0.72	0.74	0.84	0.71	0.74	1

Table 6. *Correlation coefficients of impulse-responses to other shocks in real exchange rate*

	Brazil	Denmark	Germany	Italy	Netherlands	Sweden	US	Canada	Norway	Mexico
Brazil	1									
Denmark	0.46	1								
Germany	0.89	0.68	1							
Italy	0.80	0.79	0.94	1						
Netherlands	0.54	0.02	0.53	0.42	1					
Sweden	0.93	0.48	0.85	0.81	0.42	1				
US	0.81	0.77	0.93	0.96	0.38	0.85	1			
Canada	0.73	0.18	0.49	0.49	0.26	0.79	0.50	1		
Norway	–0.71	–0.50	–0.65	–0.62	–0.24	–0.65	–0.69	–0.47	1	
Mexico	0.90	0.39	0.81	0.75	0.45	0.90	0.74	0.79	–0.57	1

Figures

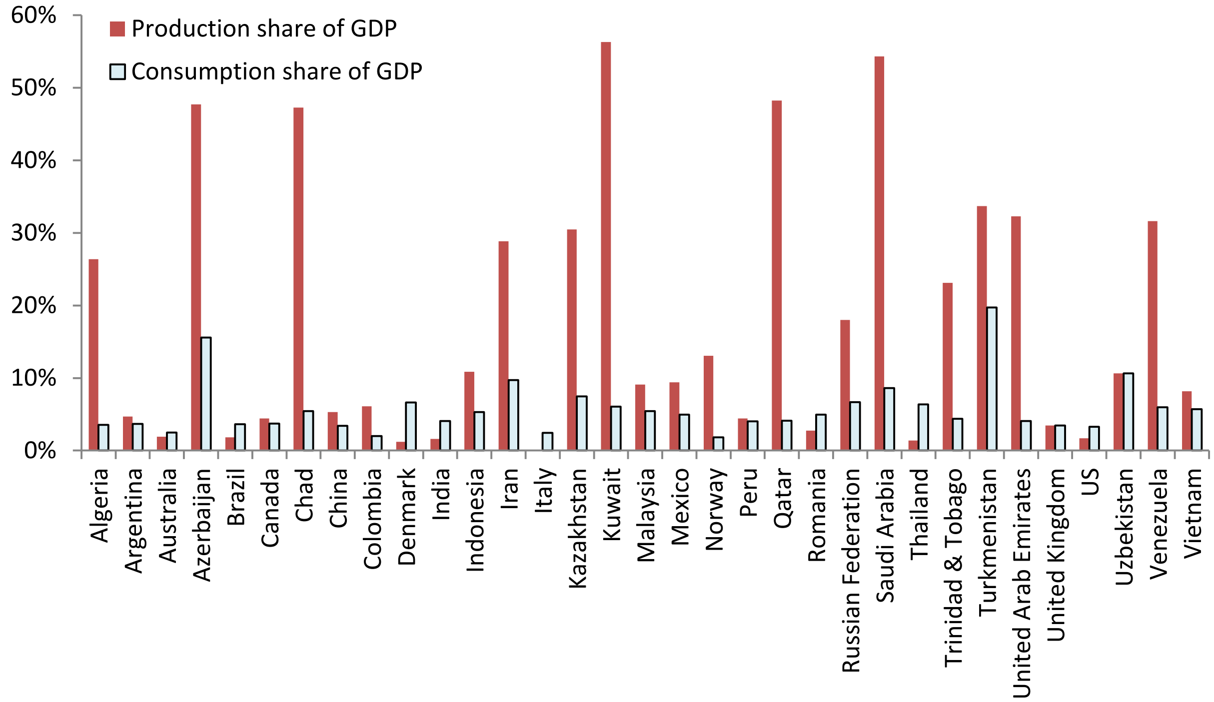
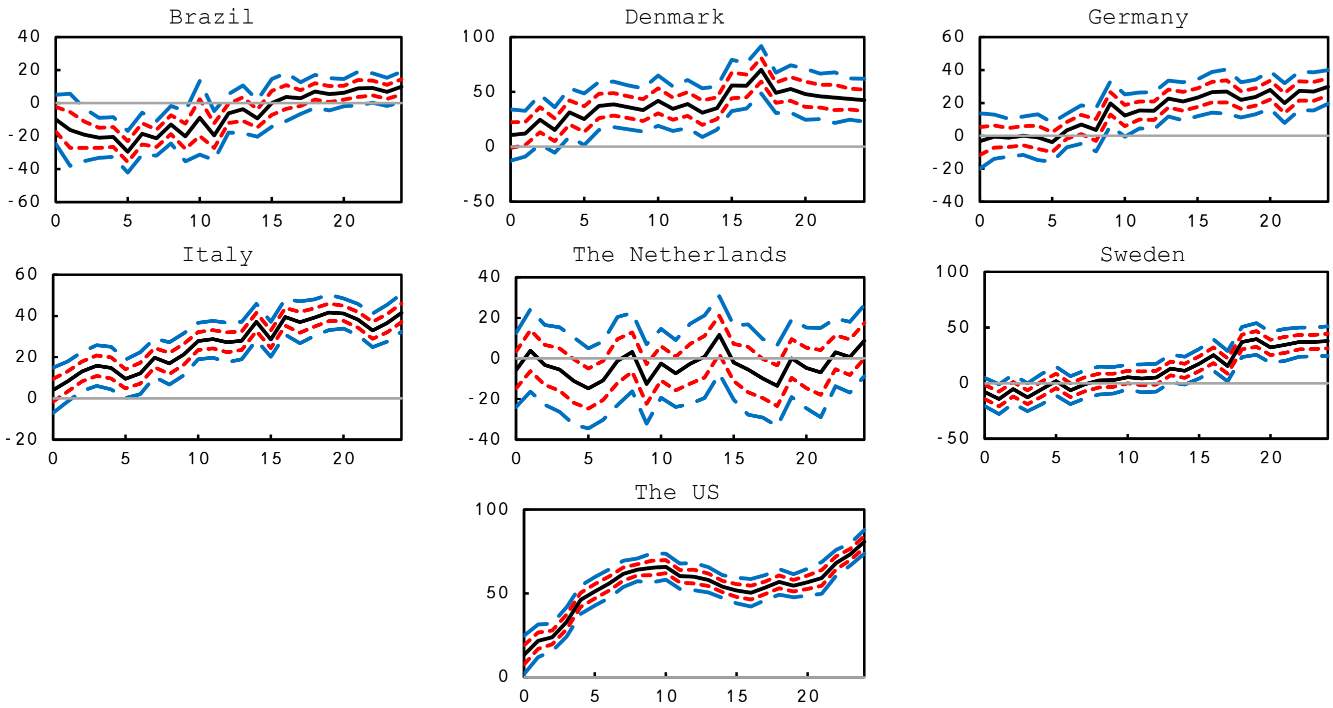


Fig 1. Production/consumption share of GDP for major oil consumer and producer countries.

Net oil-consuming countries



Net oil-producing countries

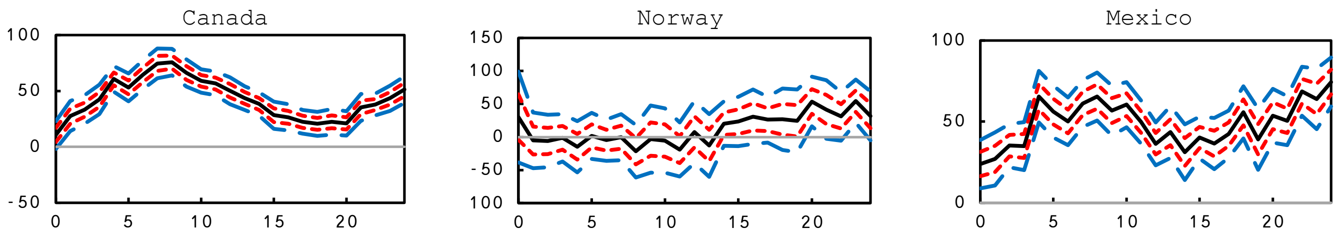
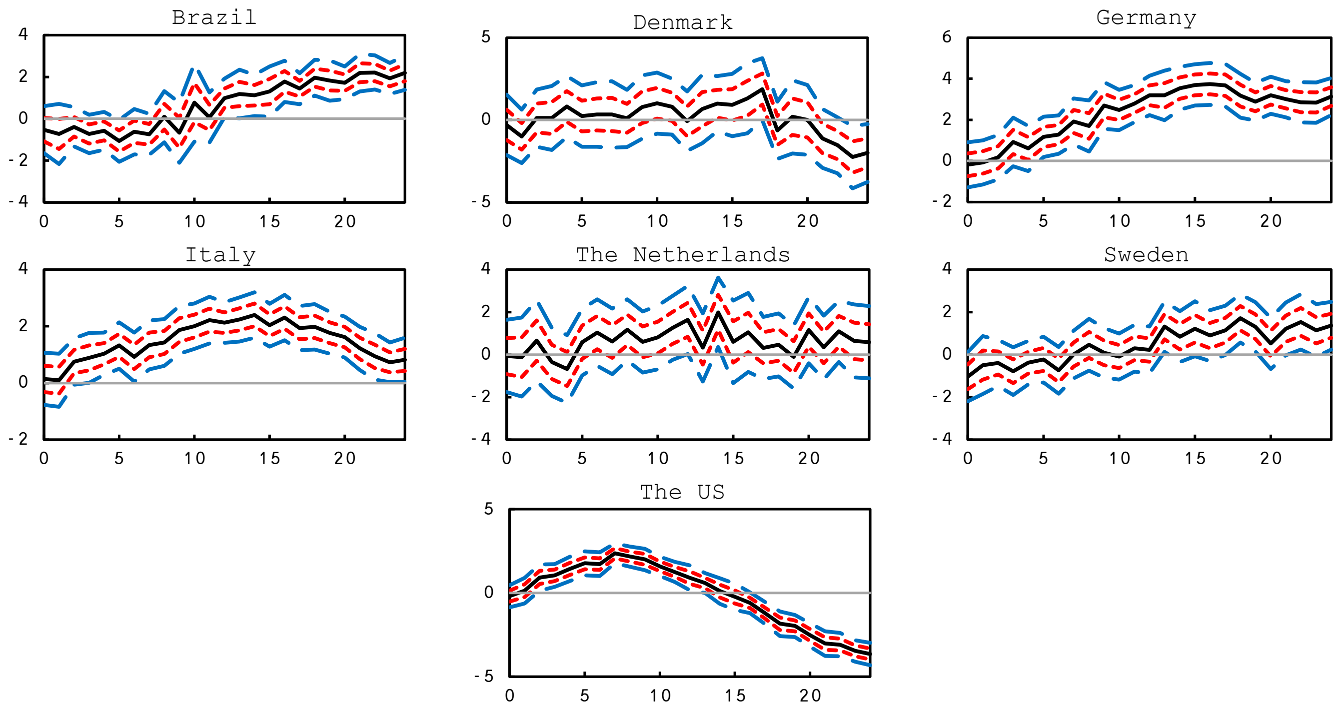


Fig. 2. Industrial production responses to the oil supply shocks. Horizontal axis indicates time (in months) and vertical axis indicates variation (in percent).

Net oil-consuming countries



Net oil-producing countries

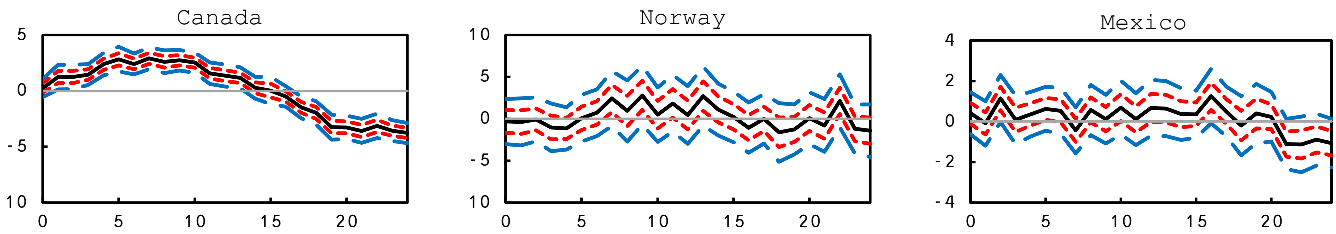
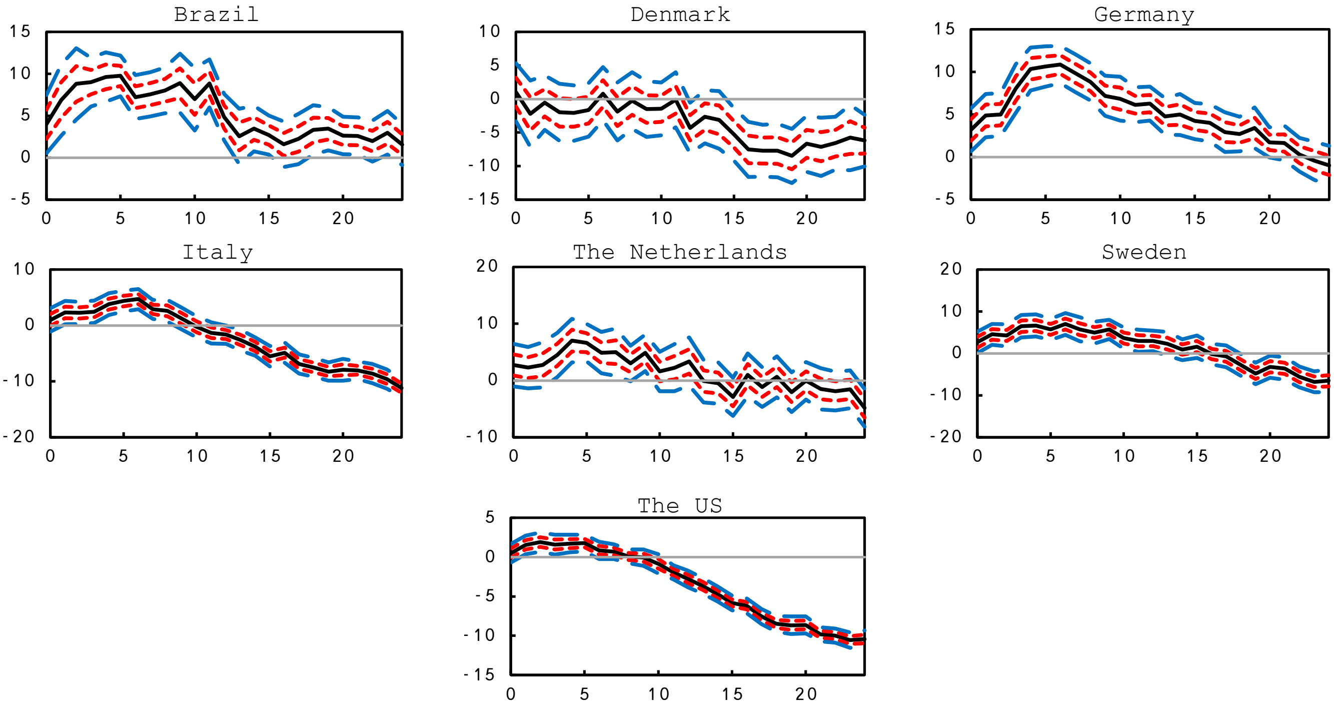


Fig. 3. Industrial production responses to the aggregate demand shocks. Horizontal axis indicates time (in months) and vertical axis indicates variation (in percent).

Net oil-consuming countries



Net oil-producing countries

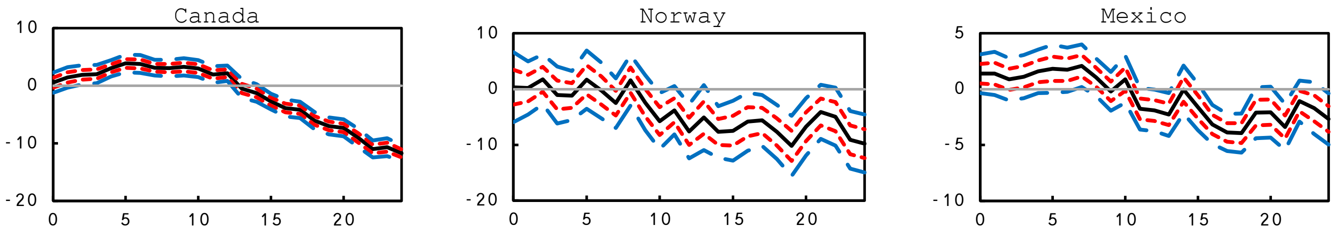
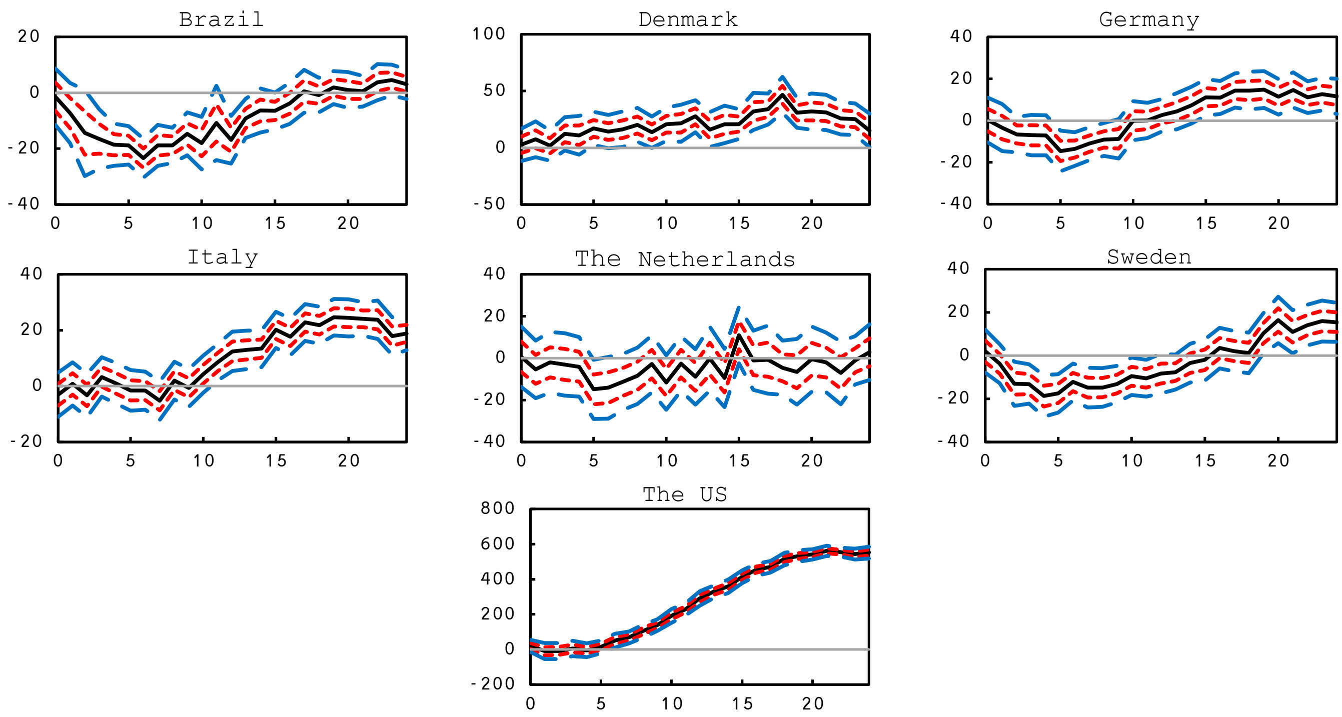


Fig. 4. Industrial production responses to other oil price shocks. Horizontal axis indicates time (in months) and vertical axis indicates variation (in percent).

Net oil-consuming countries



Net oil-producing countries

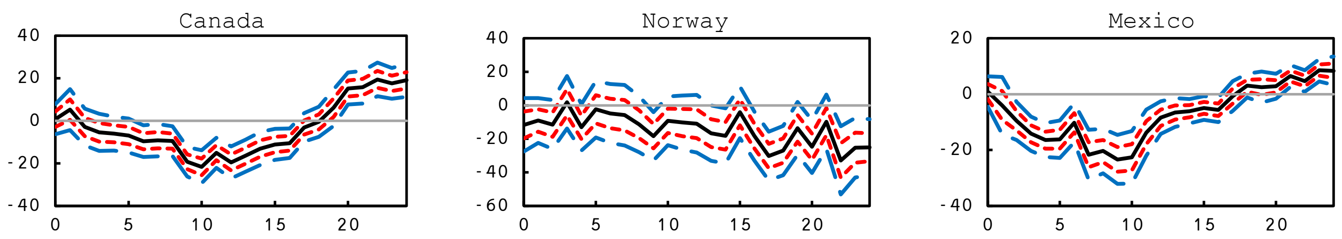


Fig. 5. Industrial production responses to non-oil shocks in real exchange rate. Horizontal axis indicates time (in months) and vertical axis indicates variation (in percent).

Net oil-consuming countries

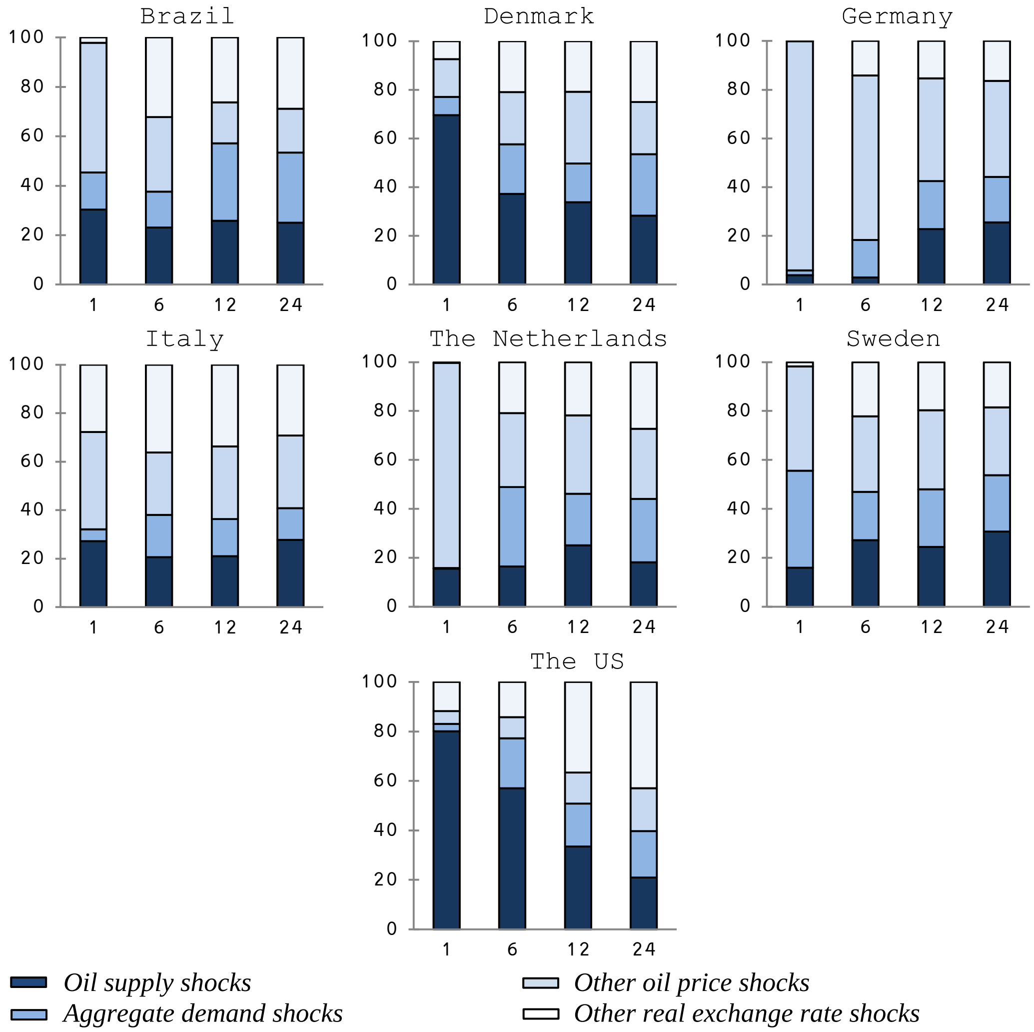


Fig 6. Forecast error variance decomposition of economic activity responses to global oil price shocks. The horizontal axis indicates time horizon for 1, 6, 12 and 24 months and the vertical axis indicates cumulative percentage.

Net oil-producing countries

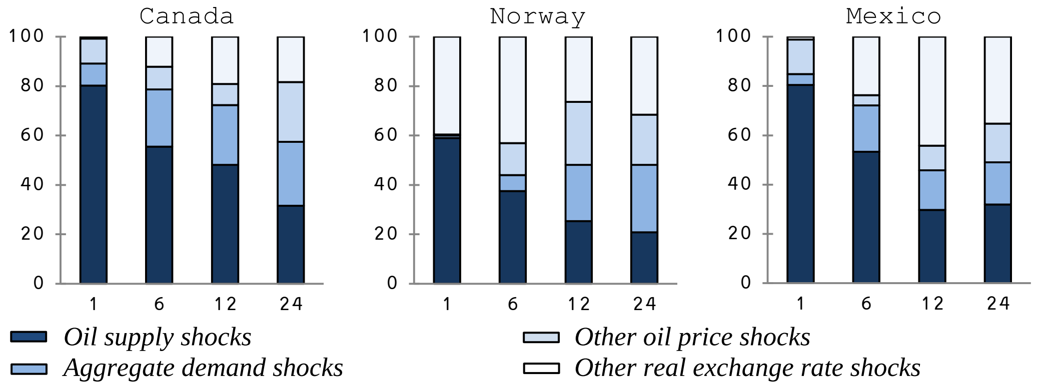


Fig 7. Forecast error variance decomposition of economic activity responses to global oil price shocks. The horizontal axis indicates time horizon for 1, 6, 12 and 24 months and the vertical axis indicates cumulative percentage.