On the Influence of Oil Price Shocks on Economic Activity, Inflation, and Exchange Rates

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Abstract

In this paper, we investigate the effects of oil price shocks on the production, price level, and exchange rate of eight important industrialized countries, using a two-step approach based on a structural VAR model of the global crude oil market proposed by Kilian (see American Economic Review, vol. 99, 2009, pp. 1053-1069). Our main finding is that the effect of oil price shocks on exchange rates also depends on where the changes fundamentally come from. We also conclude that the degree of dependency on imported oil is one of the important factors that affect the pattern of impulse responses.

Keywords: structural VAR, oil price, exchange rate, dependency on imported oil

1. Introduction

The price of oil is one of the most familiar economic indicators for many people as it is highly related to our daily life. People are sensitive to changes in the price of gasoline or gas, for example. Moreover, the relationships between oil prices and economic cycles have been firmly linked to public expectation since the oil shocks of the 1970s. Therefore, changes in the oil price and their causes have been an interesting issue for economists. Early works (Hamilton, 1983, 1996; Hooker, 1996) reported that recessions in the US economy were related to exogenous political events in Organization of the Petroleum Exporting Countries (OPEC) countries and subsequent rises in the price of oil. For example, Hamilton (1983, 1996) and Hooker (1996) show that most of the US recessions were preceded by oil price increases. The effects of oil shock on the US economy have also been studied from other viewpoints. For instance, Bernanke, Gertler, and Watson (1997) studied oil price shocks in terms of monetary policy. Other authors have intensively studied the effects of oil price shocks on the exchange rates. According to De Gregorio and Wolf (1994), the currencies of commodity exporters tend to move along with commodity prices. However, some authors (Habib & Kalamova, 2007) showed that such relationships are not always alike. Habib and Kalamova (2007), who analyze the exchange rate of three major oil exporters (Norway, Saudi Arabia, and Russia), find a robust relationship with oil prices only for Russia.

The problem with early studies (e.g., Hamilton, 1983, 1996; Hooker, 1996) is that they generally assumed exogeneity of oil shocks (when there may be reverse causality from the global economy through oil demand prices) while studying the response of macroeconomic aggregates. This may raise inappropriate implications for policy makers. For example, a central bank would unambiguously increase interest rates in response to an endogenous demand-driven increase in the price of oil, but may face a difficult trade-off between inflation and output when considering policies against an exogenous cost-push oil supply shock.

To solve the problem described above, Kilian (2009) established a two-step approach based on the structural vector autoregression (SVAR) model of the global oil market. He proposed a method to decompose shocks to the real price of oil into three components: (1) oil supply shocks, or shocks to the physical ability to produce oil; (2) aggregate demand shocks, or shocks to the current demand for oil determined by global macroeconomic conditions; and (3) oil-specific demand shocks, or shocks that may, for example, reflect precautionary demand, which stems from an uncertainty about possible future shortfalls of oil. Based on this identification of structural shocks, Kilian (2009) concludes that a rise in oil price may affect the real economy differently, depending on the underlying cause of the increase in the real price of oil. Following this contribution, the structural VAR model has become a major tool to investigate the effects of different types of oil shocks. For instance, Kilian and Park (2009) apply the structural VAR method to control for reverse causality between the price of oil and stock prices. They report that since the 1970s the price of oil has responded to some of the same economic forces that drove stock prices and cause and effect were not well defined in regressions of stock returns on oil price changes. They showed that the reaction of the US real stock return to an oil price shock differs greatly depending on whether the change in the price of oil is driven by demand or supply shocks in the oil market.

As stated above, a large body of empirical literature documents the effects of oil price changes on macroeconomic activity However, most studies focus on the U.S. economy. By and large, the effects of oil price changes in countries other than the U.S. remain unknown. Therefore, the dynamics of oil price shocks—their magnitudes, transmission mechanisms, and historical changes—in other important industrialized countries are worth empirical investigation. Furthermore, whether an economy responds to oil price changes according to the degree of its dependency on imported oil and how this relationship is structured are still open questions. Therefore, the relationship between oil price and the exchange rate is an important issue to be addressed.

The first objective of this paper is to assess both the differences and similarities in the selected industrialized economies' response to structural oil price shocks. The second is to find out whether oil shocks matter for exchange rates. In other words, we are particularly interested in how each shock has a different impact on oil exporters and importers. For our analysis, we follow the two-step approach proposed by Kilian (2009).

We extend the existing studies in two ways. First, we assess the effects of oil price shocks not only on real economic activity, as reflected in the GDP and CPI, for example, but also on the exchange rate. In particular, we are interested in whether the effects of oil price shocks on exchange rates depend on the fundamental source of shocks, as real economic activity does. Second, unlike most previous studies (Hamilton, 1983, 1996; Hooker, 1996; Kilian, 2009; Kilian & Park, 2009), which focus on the US economy, we compare the effects of oil price shocks across other important industrial countries, both exporters and importers of oil. As far as our knowledge goes, this is the first study to consider whether the degree of dependency on imported oil affects response patterns.

The remainder of the paper is organized as follows. Section 2 provides a detailed description of the data. Section 3 describes the econometric models used in this paper. Section 4 summarizes the empirical results. Section 5 concludes the study.

2. Data Description

Table 1 presents an overview of the data set and its sources. This includes monthly index of industrial production (IIP), consumer price index (CPI), and real effective exchange rate (REER) data of eight countries (Canada, France, Germany, Italy, Japan, Norway, the United Kingdom, and the United States). The sample period extends from December 1974 to December 2010. For the oil market, we use world crude oil production, world industrial production (Note 1), and West Texas Intermediate spot crude oil prices (Note 2) to identify structural shocks. The major difference from Kilian's (2009) original work is in regard to the choice of a variable to represent global real economic activity. Kilian (2009) constructs his original series based on dry cargo freight rates as the index of global real economic activity. However, these may reflect some irrelevant information on real economic activity that is specific to the ship-freight market, such as weather condition and demurrage. Therefore, we use the index of world industrial production, instead, to appropriately capture the development of global real economic activity.

Table 1. Data sources

Variable	Data source
Industrial Production(IIP)	Organization for Economic Co-operation and Development(OECD)
Consumer Price Index (CPI)	
World Industrial Production	
Real effective exchange rate	Bank for International Settlements(BIS)
World Production of Oil	Oil and Gas Journal
WTI crude oil price	Federal Reserve Bank

Table 2 presents the oil production-to-consumption ratios for each country over the period 1980 to 2010. The table indicates that the less the ratio, the more dependent the country is on imported oil. Canada, the United Kingdom, and Norway are considered oil-abundant countries as they produce more oil than they consume, whereas Italy, France, Germany, and Japan are oil-deficient countries. The United States also imports foreign oil, but the degree of its dependency on oil imports is relatively low.

Table 2. Dependency on imported-oil

Norway	UK	Canada	US	Italy	France	Germany	Japan
10.215	1.309	1.302	0.543	0.066	0.050	0.048	0.017

Notes: Average ratio of oil production to consumption during the 1980 to 2010.

Source: U.S. Energy Information Administration

3. Methodology

Following Kilian (2009), we adopt a two-step approach described as follows. First, we estimate the structural VAR model of the global crude oil market to obtain a series of identified shocks. Second, we estimate regression models, using these structural shocks, to assess the macroeconomic implication of the identified shocks for each country.

3.1 The Structural VAR Model: Identifying Structural Shocks

Consider a restricted VAR model with 24 lags (Note 3) represented as

$$X_t = \alpha + \sum_{i=1}^{24} \beta_i X_{t-i} + e_t \tag{1}$$

where X_t includes the percentage change in global crude oil production, a detrended series of world industrial production, and the real oil price in dollars, deflated using the US CPI.

Next, the structured VAR model is represented as follows:

$$A_0 X_t = A_0 \alpha + \sum_{i=1}^{24} A_i \beta_i X_{t-i} + u_t \tag{2}$$

The structural shock u_t includes oil supply shocks, aggregate demand shocks, and oil-specific demand shocks, identified under the Cholesky recursive scheme.

3.2 Regression Model

Second, by regressing the log change in the IIP, CPI, and REER on the average structural innovations, with their respective lags and constants, we allow an investigation into how the structural shocks in model (2) affect each economy:

$$\Delta IIP_t = \alpha_j + \sum_{i=0}^{12} \phi_{ji} \hat{\zeta}_{jt-i} + r_{jt}, \; j = 1,2,3, \tag{3}$$

$$\Delta CPI_t = \beta_j + \sum_{i=0}^{12} \psi_{ji} \hat{\zeta}_{jt-i} + v_{jt}, \; j = 1,2,3, \tag{4}$$

$$\Delta REER_t = \gamma_j + \sum_{i=0}^{12} \lambda_{ji} \hat{\zeta}_{jt-i} + s_{jt}, \; j = 1,2,3, \tag{5}$$

$$\hat{\zeta}_{jt} = \frac{1}{3} \sum_{i=1}^{3} \hat{u}_{j,t,i}, \; j = 1,2,3, \tag{6}$$

where $\hat{u}_{j,t,i}$ refers to the estimated residual for the *j*th structural shock in the *i*th month of the *t*th quarter of the sample period and r_{jt}, v_{jt}, and s_{jt} are errors. To obtain correct inferences from the response estimates, we deal with the serial correlation problem using the block bootstrap method with block size 4 and 20,000 bootstrap replications. In this regression model, because ϕ_{jh}, ψ_{jh}, and λ_{jh} are interpreted as impulse response coefficients at horizon h, the number of lags is determined by the maximum horizon of the impulse response function, which is set to 12 quarters.

4. Empirical Results

Figures 1–8 summarize each country's IIP, CPI, and REER responses to each of the three structural shocks.

4.1 The United States

Unanticipated oil supply disruptions cause a statistically significant appreciation in REER. The corresponding effects on IIP and CPI are largely flat and mostly statistically insignificant. Aggregate demand increase leads to a temporary rise in IIP in the first year and a half, followed by a decline below the starting point. This IIP response pattern is consistent with that of most other oil-abundant countries. Unanticipated oil-specific demand expansion results in a persistent CPI increase, and the REER also appreciates as a result. The appreciation in REER is statistically significant between the fourth and the eleventh quarter.

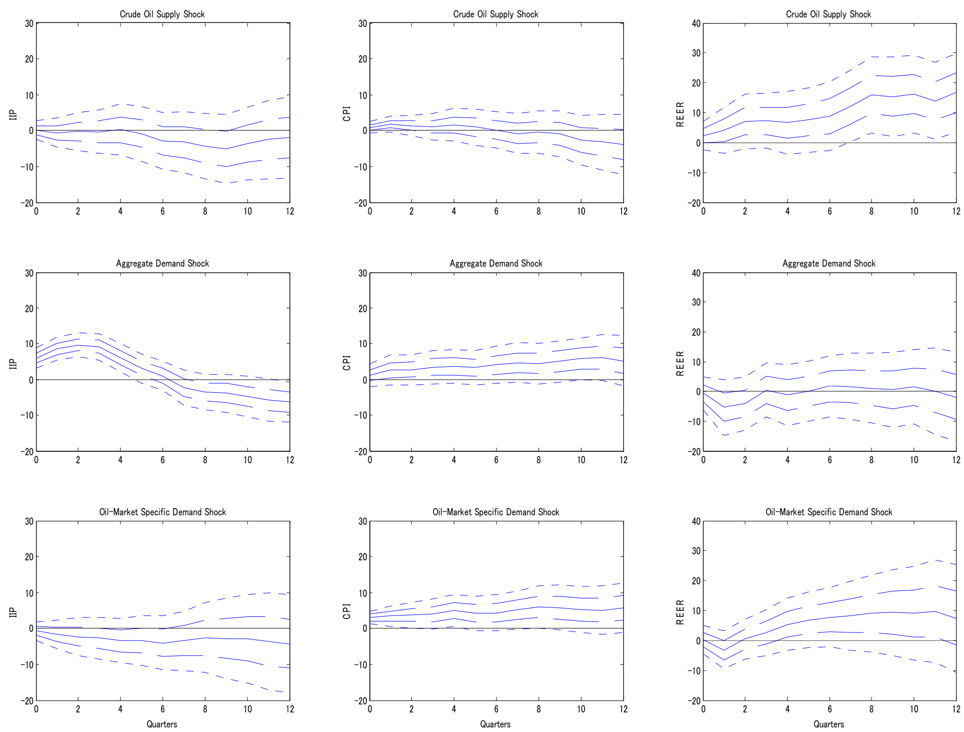

Figure 1. Cumulative responses of IIP, CPI and REER to each structural shock, the United States

Notes: Estimation based on model (2) - (4). One and two-standard error bands are shown by dashed line and dotted line respectively.

4.2 The United Kingdom

In the United Kingdom, oil supply shocks cause a statistically significant decline in REER below the initial level from the sixth quarter onward, resulting in a gradual decline in CPI as well. The reduction in CPI becomes statistically significant in the tenth quarter. Unanticipated aggregate demand expansion causes a significant increase in IIP during the first five quarters, followed by a decline below the initial level. At the same time, this shock also significantly appreciates REER, but the lower one-standard error band implies statistical significance for the first six quarters only. Oil-specific demand shocks lead to a statistically significant decrease in IIP between the second and the ninth quarter. The shocks also provide a sustained level of shifts in CPI.

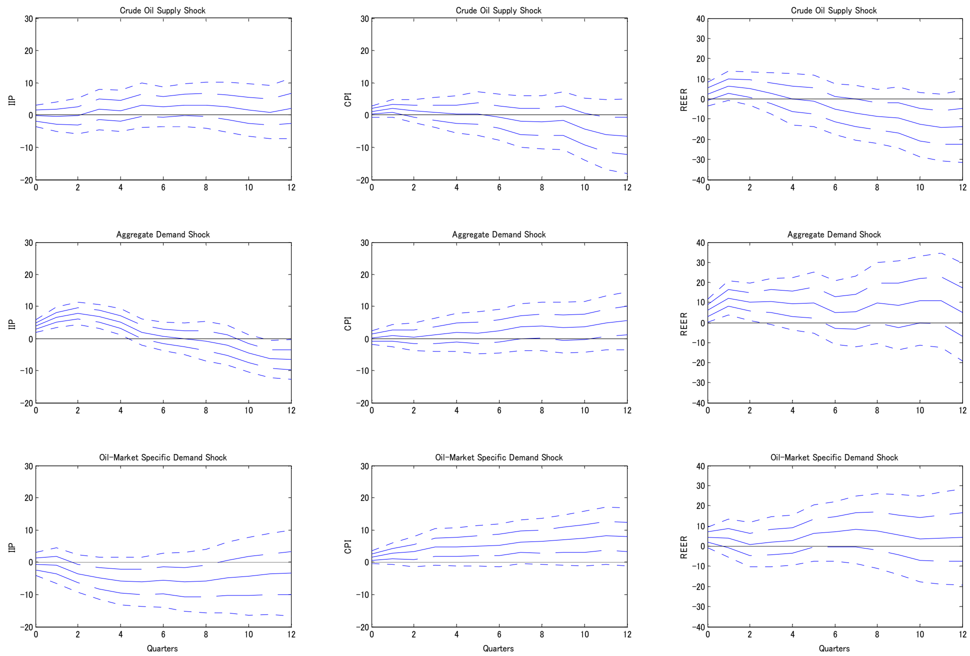

Figure 2. Cumulative responses of IIP, CPI and REER to each structural shock, the United Kingdom

Notes: Estimation based on model (2) - (4). One and two-standard error bands are shown by dashed line and dotted line respectively.

4.3 Canada

The response patterns look quite similar to those of the United States. The major difference is that aggregate as well as oil-specific demand shocks cause statistically significant appreciation in REER in the first year. In addition, unlike in the United States, unanticipated supply shocks have no statistically significant impact on REER.

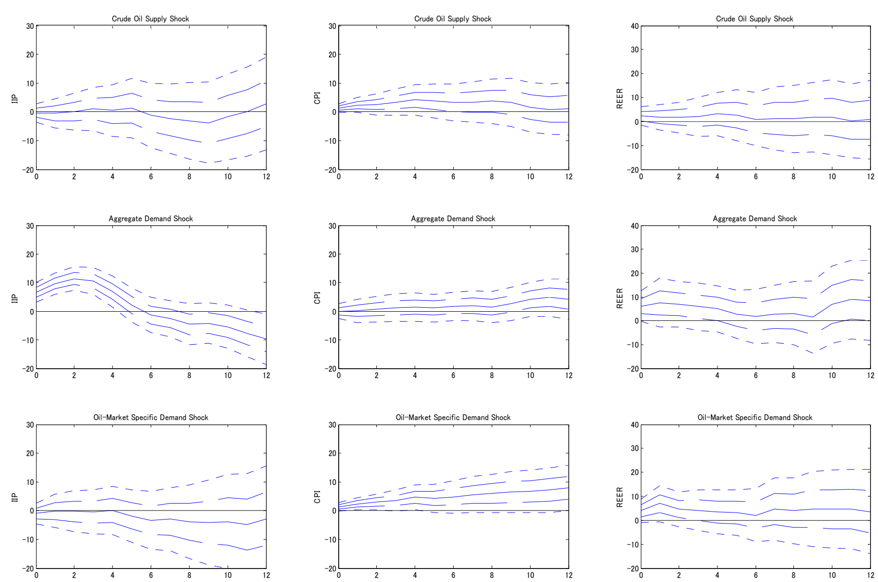

Figure 3. Cumulative responses of IIP, CPI and REER to each structural shock, Canada

Notes: Estimation based on model (2) - (4). One and two-standard error bands are shown by dashed line and dotted line respectively.

4.4 Norway

The impact of oil supply shocks causes a significant increase in REER, while IIP experienced a temporary reduction in the first year after a supply shock. These shocks also shift the CPI upward, although the effects are statistically insignificant. Aggregate demand shocks cause the REER to increase significantly in the first year and after the eighth quarter. Oil-specific demand shocks create a statistically significant impact only on CPI.

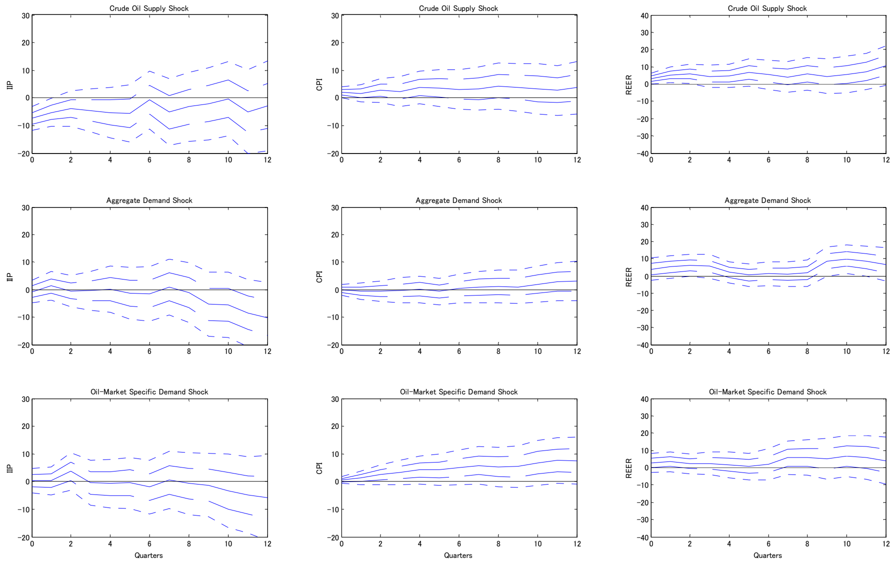

Figure 4. Cumulative responses of IIP, CPI and REER to each structural shock, Norway

Notes: Estimation based on model (2) - (4). One and two-standard error bands are shown by dashed line and dotted line respectively.

4.5 France

The responses of France differ from those of oil-abundant countries in that oil supply shocks lead to a sustained reduction in France’s IIP and REER. Most responses are statistically significant. The second major difference is that unanticipated aggregate demand expansion results in a sustained increase in IIP. Although the stimulus effect wears out gradually, IIP does not go under the initial level unlike in oil-abundant countries.

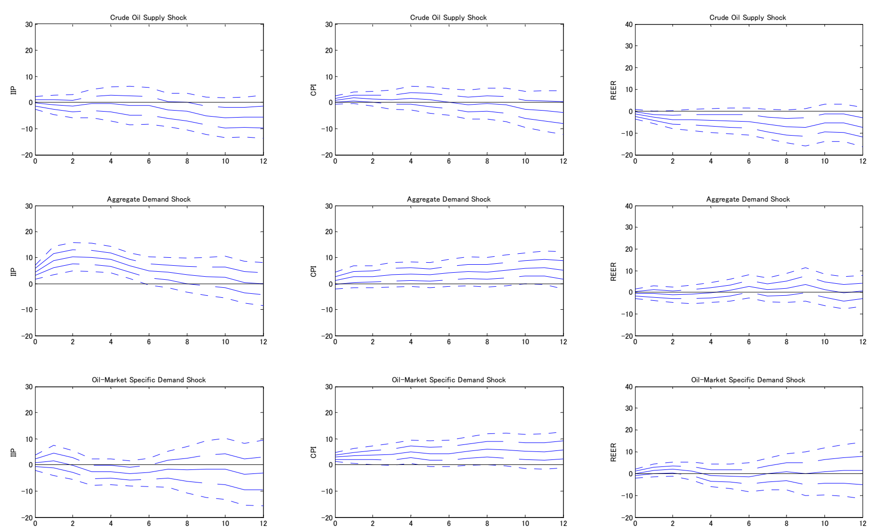

Figure 5. Cumulative responses of IIP, CPI and REER to each structural shock, France

Notes: Estimation based on model (2) - (4). One and two-standard error bands are shown by dashed line and dotted line respectively.

4.6 Italy

Italy's response patterns are quite similar to those of France. Unexpected oil supply shocks shift Italy's IIP and REER downward. At the same time, aggregate demand shocks lead to a sustained IIP increase as in the French case. A unique feature in Italy is that oil supply disruptions lower IIP and increase CPI much more than in France.

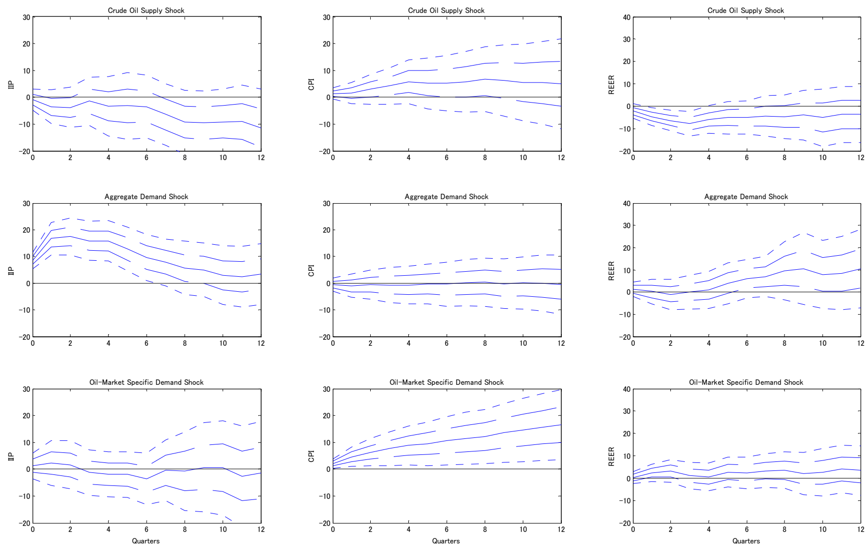

Figure 6. Cumulative responses of IIP, CPI and REER to each structural shock, Italy

Notes: Estimation based on model (2) - (4). One and two-standard error bands are shown by dashed line and dotted line respectively.

4.7 Germany

Oil supply disruptions cause a temporary depreciation in REER in the first year. At the same time, the disruptions also result in an IIP reduction two years after the initial shock. The impact of unanticipated aggregate demand expansion causes a significant increase in IIP. The response of IIP is positive in all horizons, which is unique among the eight countries. On the other hand, the impact on CPI and REER is not statistically significant. Oil-specific demand shocks lead to a statistically significant increase in CPI as in other countries. However, the increase is much lower than in other countries.

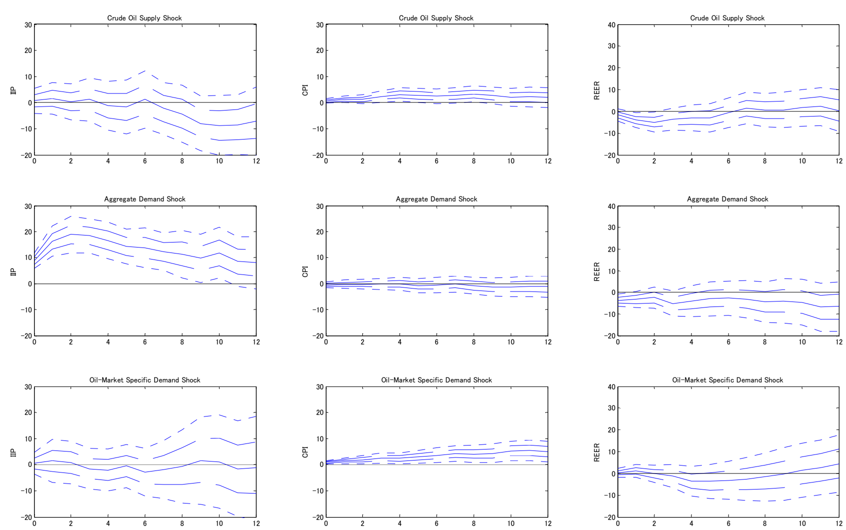

Figure 7. Cumulative responses of IIP, CPI and REER to each structural shock, Germany

Notes: Estimation based on model (2) - (4). One and two-standard error bands are shown by dashed line and dotted line respectively.

4.8 Japan

Oil supply shocks cause no significant effects on Japan's IIP, CPI, and REER. Aggregate demand shocks lead to a sharp increase in IIP, which reaches its maximum two quarters later. The increase is the largest among the sample countries. On the other hand, CPI does not show a significant rise in all horizons. These results are similar to the German case. Unanticipated oil-specific increase results in a statistically significant increase in CPI, but the amount of increase is relatively low. This pattern is also similar to the German case. Unlike in other countries, the shocks have a positive impact on IIP, which is a clear anomaly in Japan.

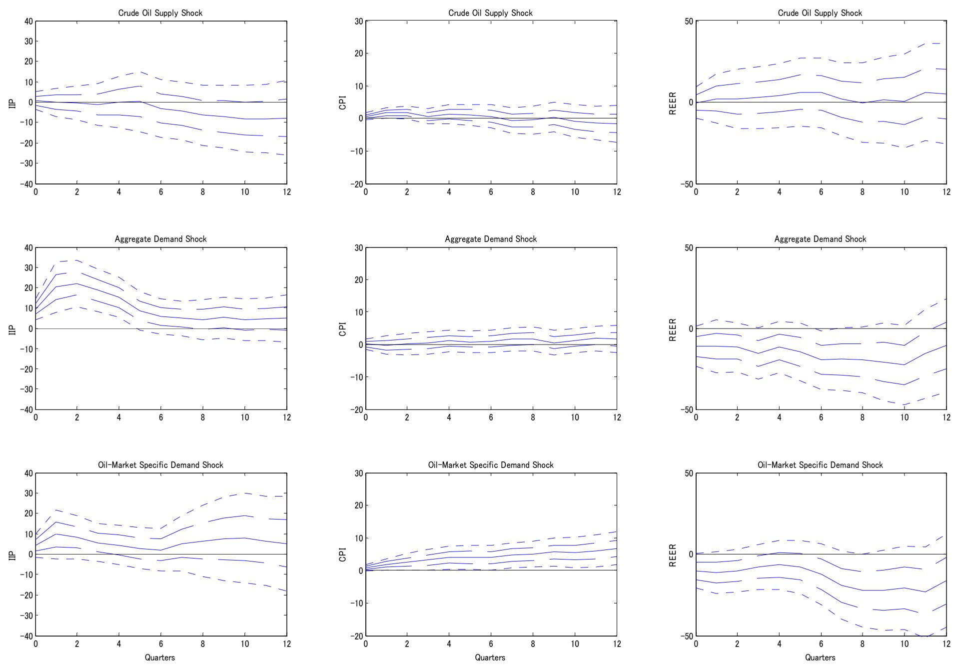

Figure 8. Cumulative responses of IIP, CPI and REER to each structural shock, Japan

Notes: Estimation based on model (2) - (4). One and two-standard error bands are shown by dashed line and dotted line respectively.

5. Conclusion

We investigate the effects of oil price shocks on the exchange rate and real economic activity of the important industrialized countries using Kilian's (2009) method. The main results can be summarized as follows: First, we showed that the effect of oil price shocks on exchange rates also depends on where the changes fundamentally come from. We extend Kilian's (2009) method, which focuses on the effect of oil price shocks on the real GDP and CPI of the United States, to shed light on the transmission effects of oil price shocks on the exchange rate. Second, we reveal that the degree of dependency on imported oil is one of the important factors that affect the impulse response pattern. For instance, we find no evidence that oil supply shocks cause no long-run effect on IIP in oil-abundant countries (Canada, Norway, the United Kingdom, and the United States) and that the shocks lead to a statistically significant decline in IIP in countries with high dependency on imported oil (France, Italy, and Germany) in the long run. These results can be interpreted to mean that, when facing unanticipated oil supply shocks, oil-deficient countries intentionally lower production levels to save oil, realizing that it would be difficult to import oil whatever the price demanded. In addition, positive aggregate demand expansion initially increases production in all countries but Norway. Over time, the stimulus effect wears out gradually, but producers in countries with high dependency on imported oil maintain their production levels above the initial state. On the contrary, production in oil-abundant countries turns out to be negative in around two years after the shock. To the best of our knowledge, this study is the first attempt to show, using the two-step SVAR method, how the degree of dependency on imported oil affects response patterns.

How the effects of oil price shocks differ in emerging countries is a topic worth investigating in a future research study. Moreover, time-varying-VAR models that incorporate possible structural breaks in the global oil market are also promising methods to deepen our understanding of the transmission mechanisms of oil price shocks.

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References

Bernanke, B. S., Gertler, M., & Watson, M. W. (1997). Systematic monetary policy and the effects of oil price shocks. *Brookings Papers on Economic Activity, 1,* 91-142. http://dx.doi.org/10.2307/2534702

De Gregorio, J., & Wolf, H. (1994). Terms of trade, productivity, and the real exchange rate. *NBER Working Paper No. 4807.* Retrieved from http://www.nber.org/papers/w4807.pdf?new_window=1

Habib, M., & Kalamova, M. M. (2007). Are there oil currencies? The real exchange rate of oil exporting countries. *ECB Working Paper Series No.839.* Retrieved from http://www.ecb.int/pub/pdf/scpwps/ecbwp839.pdf

Hamilton, J. D. (1983). Oil and the macroeconomy since World War II. *Journal of Political Economy, 91,* 228-248. http://dx.doi.org/10.1086/261140

Hamilton, J. D. (1996). This is what happened to the oil-macroeconomy relationship. *Journal of Monetary Economics, 38,* 215-220. http://dx.doi.org/10.1016/S0304-3932(96)01282-2

Hooker, M. A. (1996). What happened to the oil price-macroeconomy relationship? *Journal of Monetary Economics, 38,* 195-213. http://dx.doi.org/10.1016/S0304-3932(96)01281-0

Kilian, L. (2009). Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. *American Economic Review, 99,* 1053-1069. http://dx.doi.org/10.1257/aer.99.3.1053

Kilian, L., & Park, C. (2009). The impact of oil price shocks on the U.S. stock market. *International Economic Review, 50,* 1267-1287. http://dx.doi.org/10.1111/j.1468-2354.2009.00568.x

Notes

Note 1. The index of world industrial production is the weighted sum of the industrial production of all OECD countries, plus six non-member economies: Brazil, China, India, Indonesia, Russia, and South Africa.

Note 2. As for the oil price, the U.S. refiner acquisition cost of imported crude oil is used in Kilian (2009). Instead, we use the WTI, which is one of the most popular international oil price indices.

Note 3. Although the lag length indicated by the Akaike's Information Criterion (AIC) is 7, we decided to use 24 lags as Kilian (2009) did, considering the fact that we use monthly series in the model. We can avoid the dynamic misspecification problem by using 24 lags. The results based on 7 and 12 lags are very similar to those based on 24 lags.