BANK OF CANADA
BANQUE DU CANADA

Working Paper/Document de travail
2015-23

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Bank of Canada Working Paper 2015-23

June 2015

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Juncal Cunado,[1] Soojin Jo[2] and Fernando Perez de Gracia[1]

[1]Department of Economics
Universidad de Navarra
31080 Pamplona, Spain
jcunado@unav.es
fgracia@unav.es

[2]Canadian Economic Analysis Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
sjo@bankofcanada.ca

ISSN 1701-9397

Acknowledgements

We especially thank James Hamilton for comments and suggestions on a preliminary version of the paper. All remaining errors are ours.

Abstract

This paper analyzes the macroeconomic impact of oil shocks in four of the largest oil-consuming Asian economies, using a structural vector autoregressive model. We identify three different types of oil shocks via sign restrictions: an oil supply shock, an oil demand shock driven by global economic activity and an oil-specific demand shock. The main results suggest that economic activity and prices respond very differently to oil price shocks depending on their type. In addition, a country's oil-importing and -exporting status in the world oil market affects the transmission of shocks. Finally, subsample analysis shows a possible structural break in Japan and South Korea for all three types of oil shocks.

JEL classification: E32, Q43, O53
Bank classification: Econometric and statistical methods; International topics

Résumé

À l'aide d'un modèle vectoriel autorégressif structurel, les auteurs analysent l'incidence macroéconomique des chocs pétroliers dans quatre des économies asiatiques les plus consommatrices de pétrole. S'appuyant sur des restrictions de signe, ils distinguent trois types de chocs, à savoir un choc d'offre, un choc de demande créé par l'activité économique mondiale et un choc spécifique de demande. Les principaux résultats indiquent que l'activité économique et les prix réagissent de manière très différente aux variations des cours du pétrole selon le type de choc en cause. Par ailleurs, le statut d'importateur ou d'exportateur de pétrole d'un pays au sein du marché mondial des produits pétroliers influe sur la transmission des chocs. Enfin, l'analyse par sous-échantillons montre un possible changement structurel au Japon et en Corée du Sud relativement aux trois classes de chocs recensées.

Classification JEL : E32, Q43, O53
Classification de la Banque : Méthodes économétriques et statistiques; Questions internationales

Non-Technical Summary

Since the seminal paper by Hamilton (1983), a great number of studies analyzed the relationship between oil prices and real economic activity, focusing on the recessionary effect of unexpected oil price increases. However, most previous studies focused on developed countries such as the United States and/or European countries, and relatively less attention has been paid to Asian economies despite their increasing importance in the global oil market.

This paper analyzes the economic impact of oil price shocks in four of the largest oil-consuming Asian economies: Japan, Korea, India and Indonesia. The main contribution of this paper is to examine Asian countries, while differentiating the effects of oil shocks caused by 1) exogenous disruptions in the oil supply, 2) an increase in oil demand due to strong global economic activity, and 3) higher demand due to speculative or precautionary motives. We examine the effects of each shock on economic activity and the price level of each country.

We find that depending on the type of shock, an unexpected increase in the oil price results in distinct responses of economic activity and consumer price indexes. More specifically, an oil demand shock driven by global economic activity increases economic activity of all four countries, while the other two shocks overall do not show such positive impacts. In addition, the analyzed countries' oil-importing or -exporting status in the world oil market also matters for the direction and magnitude of the responses, especially for those of an oil supply shock. Finally, for the case of Japan and Korea, we also find evidence of a structural break in the way both countries respond to oil price shocks before and after the Asian financial crisis.

1. Introduction

A great number of studies have analyzed the relationship between oil prices and real economic activity since the seminal paper by Hamilton (1983), focusing on the recessionary effect of unexpected oil price increases (see Brown and Yücel (2002), Kilian (2008) and Hamilton (2008) for detailed surveys). More recently, for example, Elder and Serletis (2010) and Jo (2014) analyzed the role of oil price uncertainty, exploring a non-linear oil price-economic activity relationship. One common feature in most previous studies is a focus on developed countries such as the United States and/or European countries, and relatively less attention has been paid to Asian economies despite their increasing importance in the oil market.

Hence, this paper analyzes the economic impact of oil price shocks in four of the largest oil-consuming Asian economies: Japan, Korea, India and Indonesia. [1] The main contribution of this paper is to examine Asian countries while distinguishing the effects of oil shocks according to their type, compared to the previous studies on Asian countries (e.g., Abeysinghe (2001), Cunado and Perez de Gracia (2005), Ran and Voon (2012) and Le and Chang (2013)). More precisely, we estimate a structural vector autoregressive (SVAR) model while differentiating the effects of oil shocks caused by 1) exogenous disruptions in the oil supply, 2) an increase in oil demand due to strong global economic activity, and 3) higher demand specifically for oil due to speculative or precautionary motives. In particular, to identify the underlying shocks, we introduce sign restrictions on variables representing the global oil market and examine their effects on economic activity and the price level of each country, as in Peersman and Van Robays (2009).

We find that conditional on the type of shock, an unexpected increase in the oil price results in distinct responses of economic activity and consumer price indexes (CPIs), extending the findings in Kilian (2009) to Asian economies. In addition, the analyzed countries' oil-importing or -exporting status in the world oil

[1] We do not include China in our study owing to the lack of reliable and long time-series data, as well as its potential effects on the world oil market. It is well known that China's rapidly increasing oil demand is greatly affecting the world oil price (see, for example, Hamilton, 2008).

market also matters for the direction and magnitude of the responses. This is consistent with the results for the G-7 countries in Baumeister et al. (2010). We also find evidence supporting the existence of the structural break before and after the Asian financial crisis for Japan and Korea. The subsample analysis presents differential responses of both countries' economic activity to an oil supply shock, and that of Korean real GDP to a globally driven oil demand shock. In the case of an oil-specific demand shock, the break shows up as changes in the transmission channel, since critical responses to the shock are observed from the CPIs prior to 1997 and in economic activity after 1997 for both economies.

The remainder of the paper is organized as follows. In section 2, we review the economic literature on the macroeconomy and oil price relationship for Asian economies. Section 3 outlines the econometric methodology and describes the identification strategy. Section 4 covers the data set used in the empirical analysis. Section 5 describes the effects of oil shocks on Asian economies. Finally, section 6 concludes.

2. Literature review on oil shocks in Asian countries

Among Asian economies, Japan is the country that has been most extensively studied. Burbidge and Harrison (1984) estimate a VAR model for five Organisation for Economic Co-operation and Development (OECD) economies including Japan, using monthly data from 1961M1 to 1982M6. In Japan's case, they find that the price of oil exerts a smaller influence both on the price level and the industrial production index than it does in the U.S. economy. Zhang (2008) studies Japan using data from 1957Q1 to 2006Q4, and finds that oil price changes and macroeconomic activity appear to have a non-linear relationship. More recently, Jimenez-Rodriguez and Sanchez (2012) show that oil price shocks generate a decrease in industrial production in Japan during the period 1976Q1–2008Q2, while resulting in higher inflation rates. Most other papers conduct a case study of

Japan as included in the panel of the G-7 countries or in comparison with the United States, rather than focusing on the Asian countries alone.[2]

Few studies focus on Asian economies. For example, Abeysinghe (2001) studies ten Asian economies (Indonesia, Malaysia, Philippines, Thailand, Hong Kong, South Korea, Singapore, Taiwan, China, Japan) and the United States, and finds that even the net oil exporters such as Indonesia and Malaysia cannot escape from the negative influence of high oil prices. In another paper, Cunado and Perez de Gracia (2005) analyze six Asian economies (Japan, Malaysia, Philippines, Singapore, South Korea and Thailand) between 1975Q1 and 2002Q2. They find that oil prices have a significant effect on economic activity and CPI, although the impact is limited to the short run and more significant when oil price shocks are defined in local currencies. Ran and Voon (2012), using quarterly data over 1984Q1–2007Q3 for Hong Kong, Singapore, South Korea and Taiwan, show that oil prices do not have a significant impact on real economic activity. However, they detect positive significant effects on unemployment rates and significant contemporaneous effects on CPIs. In a more recent paper, Le and Chang (2013) focus on the role of oil price shocks in trade balances, as well as their oil and non-oil components. They use monthly data from 1999M1 to 2011M11 for three East Asian economies (Malaysia, Singapore and Japan), and find that oil price shocks cause improvements in the trade balance in Malaysia, although not in Singapore, suggesting that the effect of oil price shocks can differ according to a country's degree of oil dependence.

3. SVAR framework with oil shocks

An SVAR framework has been favored to analyze the impact of oil price shocks in previous studies, since it can better reflect the structure of the global oil market (see, for example, Bernanke et al., 1997; Lee and Ni, 2002; Peersman, 2005; Kilian, 2009; and Peersman and Van Robays, 2009). In particular, the SVAR framework can be used to group oil price innovations into three different types, as in

[2] See, for example, Hutchison (1993), Engemann et al. (2011), Baumeister et al. (2010), and Peersman and Van Robays (2012). Other Asian economies that have also received some attention are South Korea (Lee and Song, 2009; An and Kang, 2011) and India (Ratti and Vespignani, 2013). Studies that cover the macroeconomic impact of oil shocks in China are Du et al. (2010) and Tang et al. (2010), among others.

Baumeister and Peersman (2013), Kilian (2009) and Peersman and Van Robays (2009). While Kilian uses a more conventional identification methodology of the triangular decomposition with the help of a global real economic activity index based on freight rates, the identification scheme of the other two papers imposes sign restrictions, which were implemented in many subsequent studies. Following this line of the literature, we identify three types of oil price shocks (i.e., oil supply shocks, oil demand shocks driven by global economic activity, and oil-specific demand shocks), in order to quantify the impact of each on relevant macroeconomic variables.

Following Baumeister et al. (2010) and Peersman and Van Robays (2009, 2012), we consider the following SVAR model:

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

where the vector of endogenous variables can be divided into two larger groups. In the first group, the 3-by-1 vector X_t captures the dynamics in the world oil market, with world oil production (Q_{oil}), the real price of crude oil expressed in U.S. dollars (P_{oil}), and a proxy variable of world economic activity (Y_w). In the second group of variables, $Y_{j,t}$ is a 2-by-1 vector containing country variables such as real GDP (G_j) and consumer prices (P_j) for each country j = {India, Indonesia, Japan and South Korea}. For Japan, the industrial production (IP) series is used for G_j instead of GDP. Finally, c is a vector of constants, and $A(L)$ is a matrix polynomial with the lag operator L, which is set to be four.

In order to proceed with the identification of different types of oil shocks, we use sign restrictions that are imposed on the first group of endogenous variables, as in Baumeister et al. (2010) and Peersman and Van Robays (2009). Table 1 illustrates the sign restrictions for the SVAR model.

<Insert Table 1 about here>

There are three scenarios for identification, based on a basic supply-demand model for the oil market. First, an *oil supply shock* represents an exogenous disruption of the supply curve caused by geopolitical turmoil such as military conflicts or changes in production quotas of the Organization of Petroleum Exporting Countries. Therefore, the oil supply shock tends to move oil production and oil prices in opposite directions, with no potential gain in global economic activity. In the second scenario, a *demand shock driven by global economic activity* generates a shift of oil production and oil prices in the same positive direction, accompanied by an unexpected boost in economic activity; higher global economic activity would lead subsequent increases in oil prices and oil production. However, some increases in the oil price may not be directly related to a current increase in fundamental economic activity, but are rather due to heightened concerns regarding the availability of oil in the future. This third scenario is identified as an *oil-specific demand shock* with no positive changes in world economic activity, although oil production and oil prices are expected to go up.[3]

Each restriction is imposed for four subsequent periods after the impact period. This allows sufficient time for the shock to propagate. In addition, we impose zero restrictions on the impact matrix for the local variables, while shocks arising from the dynamic changes in the world oil market are free to affect an individual country during the same period. Hence, the direction of responses of the local variables will be purely determined by the data. In sum, the shocks are identified in the world crude oil market.

We estimate the above VAR for each Asian economy in the sample, via Bayesian estimation with uninformative natural conjugate priors. Appendix A contains more details on the estimation method and the estimation of the impulse-response function (IRF) using the sign restrictions.

[3] The three structural shocks can have different names across studies. In particular, the third shock, i.e. the oil-specific demand shock, is called the "other demand shock" in Baumeister and Peersman (2013) or "speculative demand shock" in Kilian and Murphy (2014). Here, the key is to consider them as not driven by the current fundamental economic demand. Rather, these shocks arise from changes in perception or economic sentiment (i.e., forward-looking behaviors of agents) that further result in an increased demand for oil. In addition, the implemented sign restrictions are practically identical across studies.

4. Data

Our selected economies, as per the BP Statistical Review of World Energy (2012), are the largest Asian oil-consuming economies (excluding China due to data limitations): Japan, Korea, India and Indonesia. The BP Statistical Review shows that in 2011 Japan consumed 4.4 million barrels per day (5.0%); India, 3.5 million (4.0%); South Korea, 2.4 million (2.6%) and Indonesia, 1.4 million (1.6%). The data series for four Asian economies in our sample have different starting dates, determined by the availability of quarterly data for each country. The sample period (for Korea and Japan) runs from the 1970s, including most of the oil price increases in that decade, until the most recent increases in 2008. We analyze the period between 1974Q2 and 2013Q2 for Japan and South Korea; the sample period of India starts in 1997Q2, and that of Indonesia in 1983Q2, while both end in 2013Q2. The definitions of the relevant variables and their source for each country (i.e., GDP or IP and CPI) as well as the oil price, oil production and world production index are provided in Appendix B.

In our baseline VAR with five variables, we use the real world oil price, defined as the U.S. crude oil composite acquisition cost by refiners, deflated by the U.S. CPI. The oil production series is obtained from the U.S. Energy Information Administration (EIA). The world economic activity is proxied by the seasonally adjusted total IP index of OECD member countries. This series is originally available from 1975Q1, and we extrapolate the observations in 1974 based on the G-7's total IP index provided also by the OECD. All variables in the VAR are in non-annualized quarterly growth rates (i.e., first-differenced logs).

5. The effects of oil shocks on Asian economies

5.1 Full sample analysis

5.1.1. Oil supply shock

Figure 1 shows the cumulative median impulse responses of GDP and CPI in the Asian economies to an oil supply shock, with the 68% posterior credible set. We find that the supply shocks in Japan and Korea have negative effects on the local economic activity variables, although the effects are not entirely significant. India's GDP does not seem to respond much. Interestingly, real GDP in Indonesia, which was an oil-exporting country until 2008, responds positively to the oil supply shock. This is consistent with our prior belief: as an oil-producing and -exporting country, an increase in oil price due to a supply disruption in another area would make oil production more profitable for a fixed amount of oil exports. This would increase net exports, and thus, GDP.[4]

With regards to CPI, Japan and India respond positively in the short run, while Korea has a slightly more persistent effect. Indonesia's CPI shows a different response again, with CPI decreasing significantly for a prolonged period.

<Insert Figure 1 about here>

5.1.2. Oil demand shock driven by economic activity

Figure 2 illustrates the impulse-response function to an oil demand shock driven by global economic activity. As the figure shows, economic activities in each of our selected Asian economies respond positively to the shock, although the effect on the Korean GDP is relatively short-lived. The CPIs of Japan and Korea are expected to rise substantially, while this is not as clear for India and Indonesia. Since all countries in the sample are heavily dependent upon exports for economic growth, it is possible that stronger world economic activity can dominate unexpected increases in oil prices, and hence, real GDP grows.[5] Indonesia additionally benefits from the higher demand for oil directly with crude oil exports.

<Insert Figure 2 about here>

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[4] The results for Indonesia remain unchanged when we restrict the sample to the period when Indonesia was a net oil-exporting country (i.e., 1983Q2-2007Q4).

[5] The World Bank and OECD National Accounts data indicate that the four countries in our sample indeed have higher shares of goods-and-services exports relative to GDP. More specifically, Japanese exports of goods and services took 15% of GDP in 2012; Korea, 56%; India, 24%; and Indonesia, 24%.

5.1.3. Oil-specific demand shock

Figure 3 shows the VAR response to an oil-specific demand shock. As we can see, both Japan's and Korea's economic activities experience a significant and persistent decrease, while both countries' CPIs increase. This may be again due to the industry structures of the two countries, which rely heavily upon exports; hence, a rise in oil prices without a clear boost in global demand can easily lead to a slump, since it will only increase the input factor price. India and Indonesia's responses are less pronounced for both variables.

<Insert Figure 3 about here>

Together, the results indicate that an oil price innovation can lead to differential responses depending on its type, extending the findings in Kilian (2009) to Asian economies.

5.2. The structural breaks in Japan and Korea: subsample period analysis

We re-estimate the model for Japan and Korea using subsamples based on a potential structural break in 1997, as we have longer series for the two countries. We select 1997 as the year of the break since the Asian financial crisis in that year brought drastic turbulence that spilled over to many aspects of the Asian economies. In fact, Pahlavani and Harvie (2008) find that several economic series in Korea, such as GDP, CPI, and exchange rates, exhibit a break in 1997. Andreou and Ghysels (2002) also find 1997 to be a break point for the Japanese financial market.[6]

Figures 4-6 show the impulse responses to the three shocks in different periods. First, the response of Korean GDP shows a dramatic change to an oil

[6] Related to this point, Blanchard and Galí (2010) show different effects of oil price shocks before and after 1984 for the G-7 countries, reflecting the approximate beginning of the Great Moderation in the United States. More discussions on a structural break in the mid-80s can be found in Blanchard and Galí (2010), Edelstein and Kilian (2009) and Herrera and Pesavento (2009).

supply shock in Figure 4: the shock had strong detrimental effects to Korean GDP growth prior to 1997, but the significance disappears in the post-1997 period. Interestingly, the responses of Japanese IP change in the opposite way: the negative effects of the supply shock were much more pronounced and persistent in the later period. This structural change contributed to the less-significant responses of the two countries to the supply shock for the overall period, shown in Figure 1. For CPI, a break is less clearly observed for both economies.

<Insert Figures 4-6 about here>

In the case of an oil demand shock driven by global economic activity (Figure 5), it is again the responses of the real GDP of Korea that show a dramatic change: while the Korean GDP responded with a persistent decrease over time prior to 1997, the GDP increases significantly for the first three quarters after the initial impact in the later period. The share of the manufacturing industry in Korea increased rapidly throughout the 1990s, with the overall economy opening up for international investors. The Asian crisis further strengthened the trend of integration into, and the co-movement with, the global economy (see Pahlavani and Harvie (2008) for more details). Hence, Korean GDP after 1997 would grow along with an increase in world economic activity, despite increases in oil prices, rather than decline as in the earlier period.

Finally, the transmission of an oil-specific demand shock (Figure 6) also presents evidence of a structural break, although not as strong as for the previous two shocks. While the effect of the oil-specific demand shock can be seen in persistent increases in CPIs both in Japan and Korea in the earlier period, the shock propagates rather through economic activity after 1997: the economic activity of both countries retracts significantly throughout the impulse-response horizon. This indicates that the channel through which oil-specific demand shocks mainly propagate may have changed.

6. Conclusion

We examine the impact of structural oil price shocks on the largest four Asian oil-consuming economies (excluding China) between 1974Q2 and 2013Q2. We follow Kilian (2009) and Peersman and Van Robays (2009) in categorizing oil shocks by type (i.e., oil supply shocks, oil demand shocks driven by economic activity, and oil-specific demand shocks), applying sign restrictions.

We derive three main insights. First, the supply shock in Japan and Korea has negative but weakly significant effects on the economic activity variables, while India's GDP does not respond much. However, real GDP in Indonesia, an oil-exporting country until 2008, responds positively to the same shock. Second, each of our selected Asian economies responds positively to an oil demand shock driven by global economic activity. Third, Japan and Korea's economic activities experience significant and persistent decreases after an oil-specific demand shock, while India and Indonesia's responses are less pronounced. In sum, the responses depend both on the type of oil price shock and the analyzed countries' oil-importing or -exporting status in the world oil market.

Furthermore, we find evidence supporting a structural break before and after the Asian financial crisis in Japan and Korea for all three shocks. An oil supply shock had much more detrimental effects on Korean real GDP growth pre-1997 than after 1997, while the opposite was the case for Japanese IP. In addition, the responses of Korean GDP to an oil demand shock driven by economic activity again changed notably, implying a closer correlation between Korea and the rest of the world after 1997. Finally, while the transmission of an oil-specific demand shock was mainly observed from persistent increases in the CPI in both Japan and Korea prior to 1997, the shock propagated afterwards for both countries through economic activity.

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Appendix A. Bayesian estimation of the SVAR model and IRFs

We estimate the VAR model via a Bayesian estimation method with the Normal-Wishart prior, since the Bayesian approach has advantages in imposing sign restrictions and computing error bands for impulse responses.

Once the VAR is estimated, we calculate impulse responses, based on the sign restrictions introduced in section 3. Denote by Ω the variance-covariance matrix of a reduced form of the SVAR (Equation (1)). We decompose the matrix Ω with the eigenvalue-eigenvector decomposition $\Omega = \mathrm{PDP}'$. We then draw a matrix W from the Standard Normal distribution, and decompose W using the QR method, where R is a diagonal matrix and Q is a matrix with orthonormal columns. With Q, the impact matrix becomes $\mathrm{P}\sqrt{\mathrm{D}}\mathrm{Q}'$; impulse responses of each country are generated by iterating over the impulse-response horizon of 24 quarters and then cumulated. It is worthwhile to note again that there is no restriction imposed on the responses of each country, and hence the responses at the country level are purely determined by data. We iterate over W until 500 draws matching all three sign restrictions are collected, with which we find a median and 68% posterior credible sets. For more details regarding the Bayesian estimation of a SVAR and IRFs using sign restrictions, see Baumeister and Peersman (2013), Baumeister et al. (2010) and references therein.

Appendix B. Data set: variables, definition and source

	Variable	Definition	Source
Country			
India	Exchange rate	National Currency per U.S. Dollar, period average	International Financial Statistics (International Monetary Fund)
	GDP	Real GDP	Central Statistical Organization, India/Haver Analytics
	CPI	Wholesale Price Index: All Items (SA, FY, 2004=100)	Haver Analytics
Indonesia	Exchange rate	Exchange Rate: U.S. (EOP, Rupiah/US$)	Bank Indonesia
	GDP	Real GDP	Biro Pusat Statistik/Haver Analytics
	CPI	CPI: Total (SA, 2007=100)	Biro Pusat Statistik/Haver Analytics
Japan	Exchange rate	Spot Exchange Rate: U.S. Dollar (AVG, Yen/US$)	Bank of Japan
	IP	Production of total industry (sa, 2005=100)	OECD
	CPI	CPI: General (NSA, 2010=100)	Ministry of Internal Affairs and Communications
South Korea	Exchange rate	Korea: Exchange Rate: Basic U.S. Dollar Rate (Avg, Won/$)	Bank of Korea
	GDP	Real GDP (SA, Billion Won)	Bank of Korea
	CPI	Korea: CPI: All Items (SA, 2010=100)	National Statistics Office/Haver Analytics
World variables			
Oil	Oil price	U.S. Crude Oil Imported Acquisition Cost by Refiners (Dollars per Barrel)	U.S. Energy Information Administration
	Oil production	Oil production (Thousand Barrels per Day)	U.S. Energy Information Administration
Global economic activity	Industrial production	Total OECD industrial production index (sa, 2005=100)	OECD

Table 1. Sign restrictions for the structural shocks

Structural shocks	Q_{oil}	P_{oil}	Y_w	G_j	P_j
Oil supply shock	<0	>0	≤0		
Oil demand shock driven by economic activity	>0	>0	>0		
Oil-specific demand shock	>0	>0	≤0		

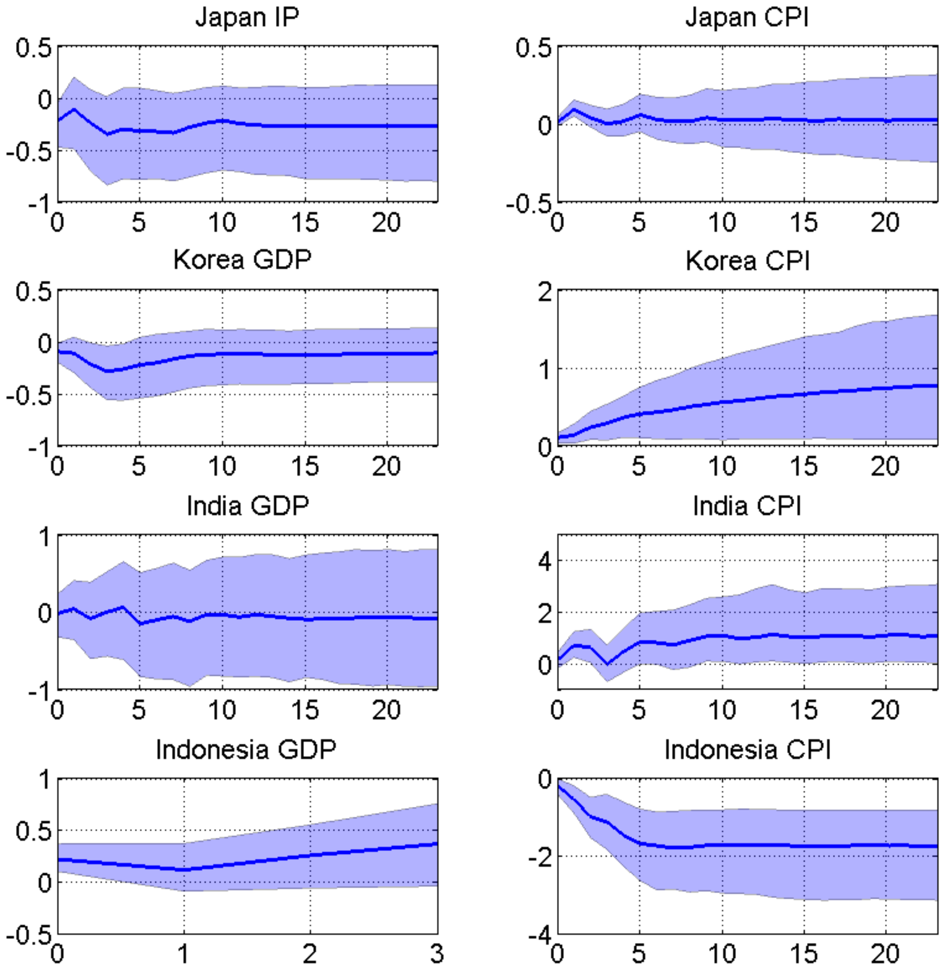

Figure 1. Impulse-response functions to an oil supply shock. The solid blue line is the median response, and the shaded area represents the 68% posterior credible set.

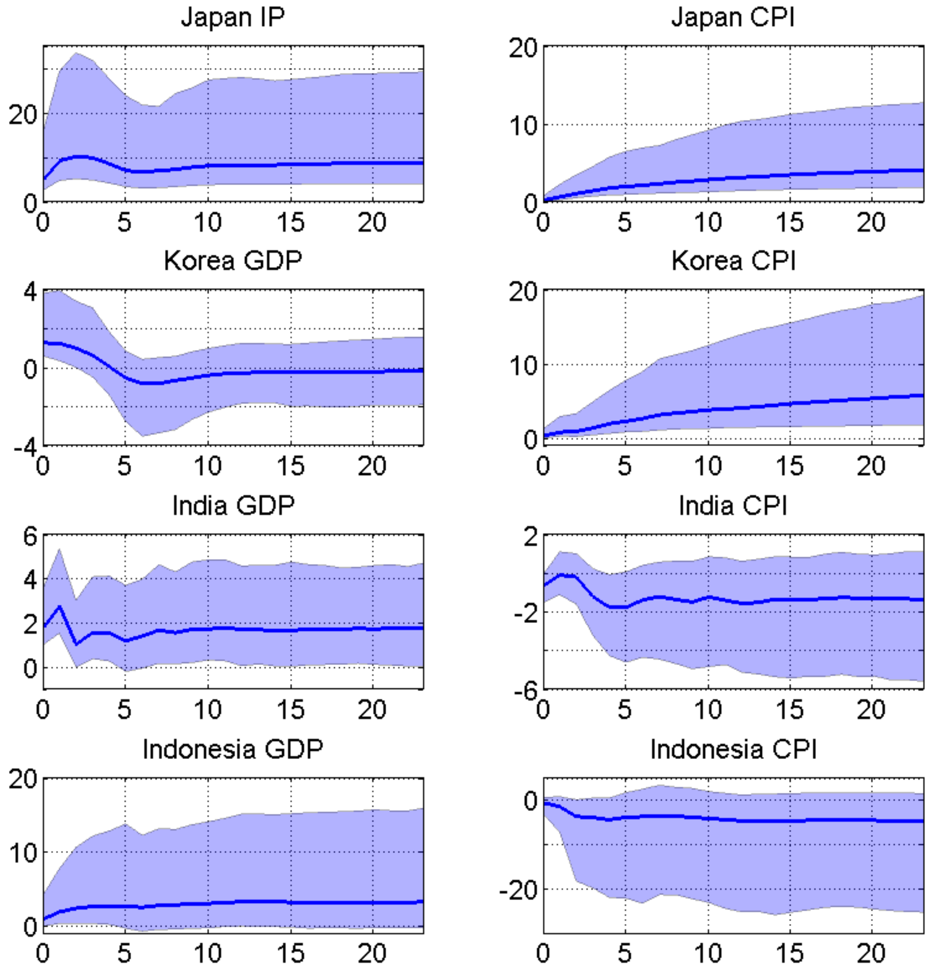

Figure 2. Impulse-response functions to an oil demand shock driven by global economic activity. The solid blue line is the median response, and the shaded area represents the 68% posterior credible set.

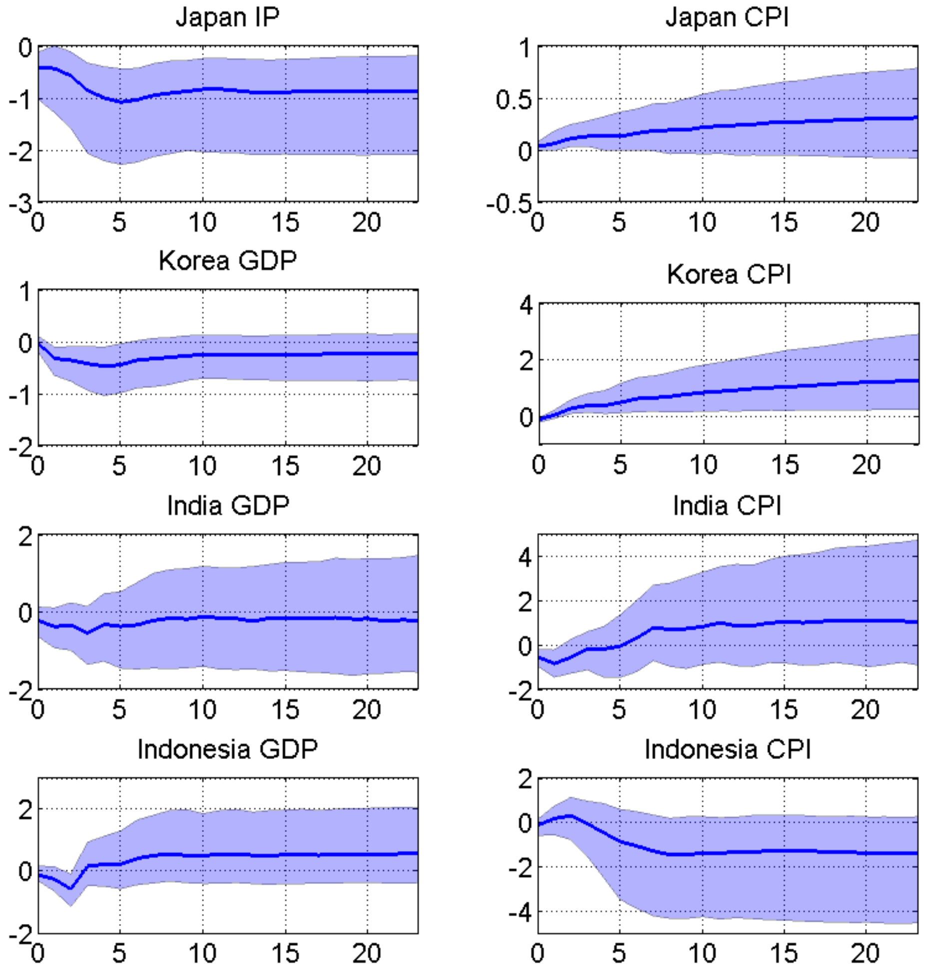

Figure 3. Impulse-response functions to an oil-specific demand shock. The solid blue line is the median response, and the shaded area represents the 68% posterior credible set.

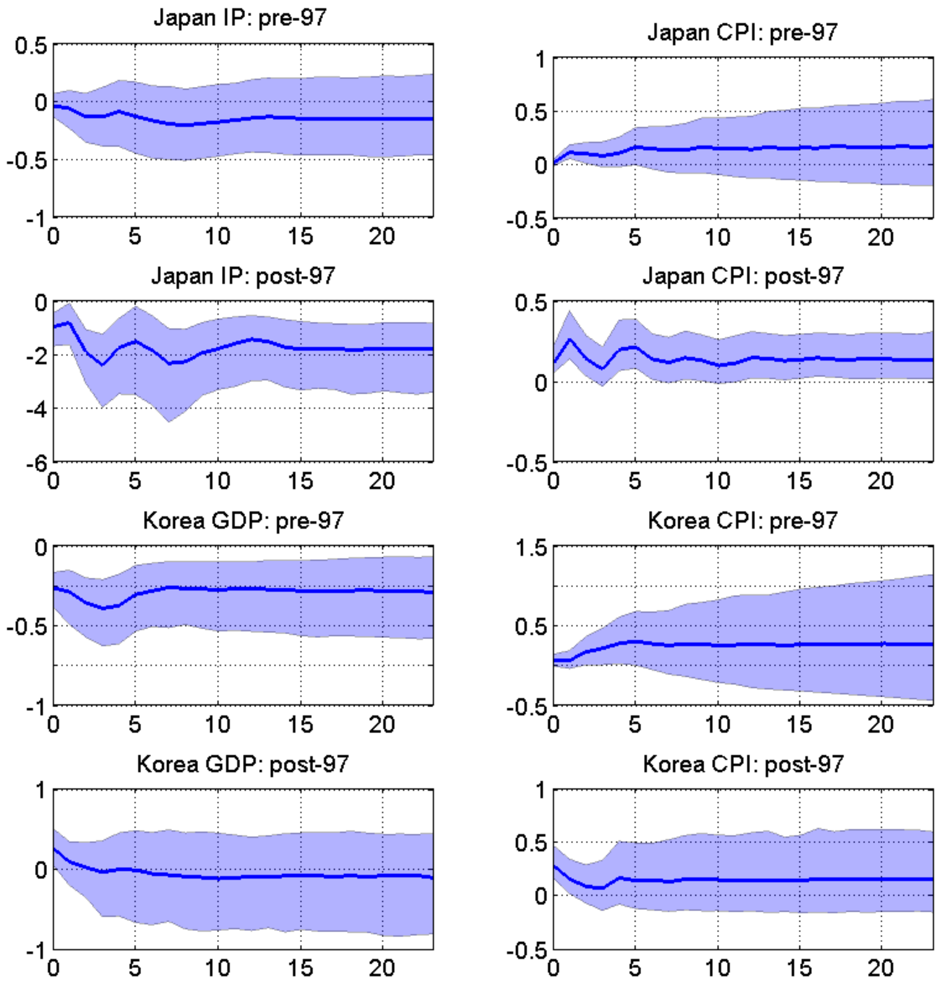

Figure 4. Impulse-response functions to an oil supply shock in Japan and Korea pre- and post-1997. The solid blue line is the median response, and the shaded area represents the 68% posterior credible set.

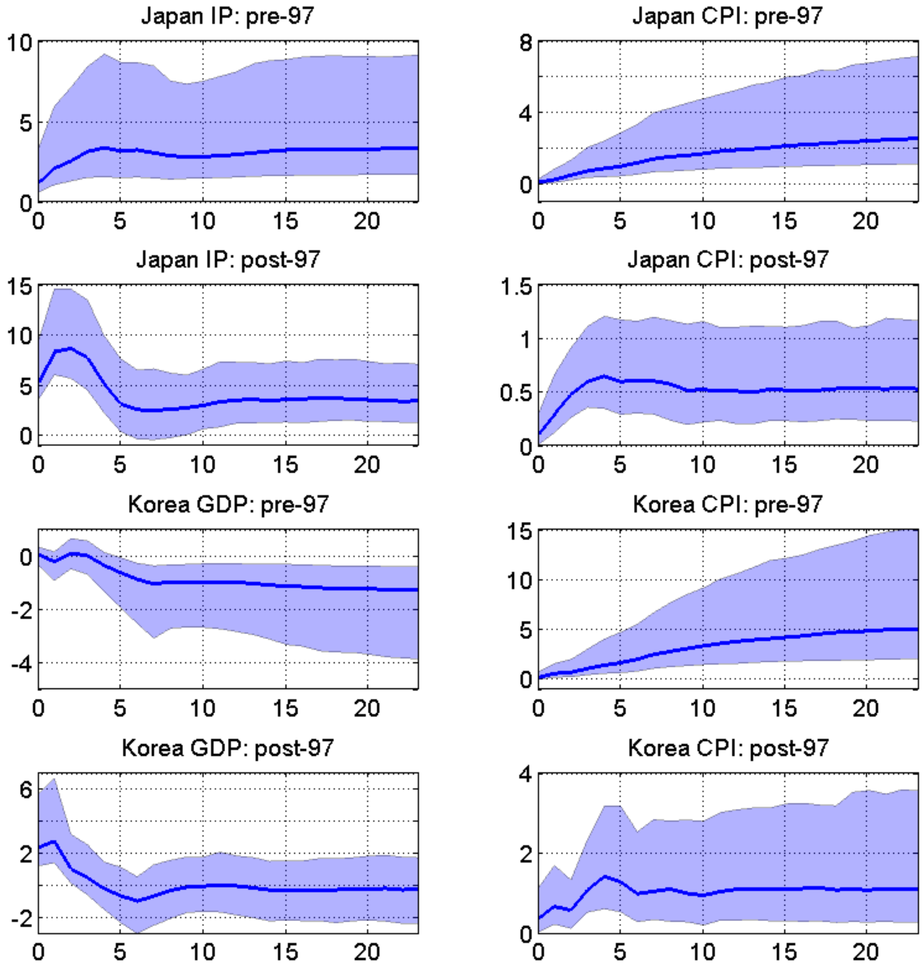

Figure 5. Impulse-response functions to an oil demand shock driven by global economic activity in Japan and Korea pre- and post-1997. The solid blue line is the median response, and the shaded area represents the 68% posterior credible set.

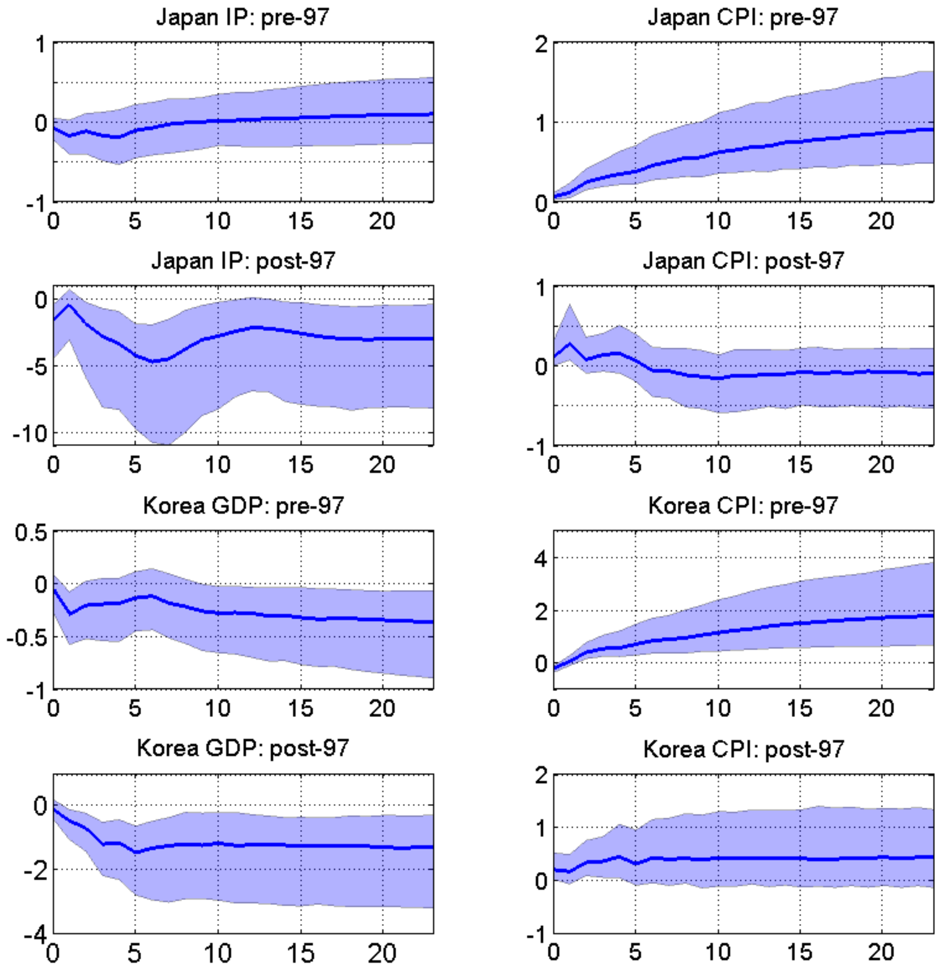

Figure 6. Impulse-response functions to an oil-specific demand shock in Japan and Korea pre- and post-1997. The solid blue line is the median response, and the shaded area represents the 68% posterior credible set.