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Empirical analyses of impacts of oil price changes on macroeconomic activities

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博　士　論　文

平成２５年１１月

神戸大学大学院経済学研究科

経済学専攻

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博士論文

Empirical analyses of impacts of oil price changes on macroeconomic activities

（原油価格の変動がマクロ経済活動に与える影響についての実証分析）

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Doctoral Dissertation

Empirical analyses of impacts of oil price changes on macroeconomic activities

November 2013

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Contents

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.

In the end of the 2000s, Kilian (American Economic Review, vol. 99, 2009, pp. 1053-1069) indicated two more limitations found in most existing literature on the effects of changes in oil price on the global economy and prices. First, early studies on the relationship between oil price shocks and inflation assumed that oil price shocks were exogenous. In other words, these studies did not consider the possibility of reverse causality from the global economy through oil demand fluctuations. The second limitation is that previous analyses fail to distinguish the mechanisms underlying structural oil innovations. He states that it is impossible to accurately investigate the effects of higher oil prices on the economy without distinguishing what kind of structural shocks cause an increase in oil price in the first place. To solve these limitations, he proposed a two-step approach based on the structural vector autoregression (SVAR) model of the global oil market. Then he 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 SVAR model has become a major tool to investigate the effects of different types of oil shocks. However, much remains unknown about the effects of oil price changes in countries other than the U.S. economy because many research focus on the U.S. economy. Moreover, whether and how the degree of dependency on imported oil affects the response of economies to oil price changes is still open question. In addition, since most previous literature sheds light on the response of aggregate price to higher oil price, the effects of changes in oil price on the prices of the detailed category of goods and services are largely unknown.

Therefore, it is worth extending the existing studies on the effects of oil price shocks on economic activities in different way; major countries other than the United States, the degree of dependency on imported oil, and the prices of the detailed category of goods and services. This paper empirically analyzes impacts of oil price changes on macroeconomic activities from a variety of aspects as described above. An outline of the abovementioned research is presented as follows.

Chapter 1 investigates the effects of changes in oil price on three major economies, the United States, the United Kingdom, and Japan, using a two-step approach based on a structural VAR model of the global crude oil market proposed by Kilian (2009). I find oil–specific demand shocks as well as aggregate demand shocks played an important role in the rise in the real price of oil since early 2002 and the subsequent sharp drops after the failure of Lehman Brothers Holdings Inc.. Moreover I have found that oil–specific demand shocks increase real GDP in Japan, which is very different from the United States and the United Kingdom where oil -specific demand shocks lead to reduction in real GDP. This difference possibly comes from the oil efficiency of Japanese products.

Chapter 2 investigates the effects of oil price shocks on the production, price level, and exchange rate of eight important industrialized countries. The 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.

Chapter 3 investigates the dynamic effects of changes in oil price on the expenditure category consumer price index (CPI) in the United States and Japan. In this study, we apply a two-block structural vector autoregressive (VAR) model proposed by Kilian and Park (2009). Our results confirm that each expenditure category price index responded very differently to the same structural shock, and that whether changes in oil price function as a positive stimulus or a negative shock for the individual expenditure category prices also depends on the kind of underlying shock that drives the changes in oil price. Finally, our results also reveal that the manner in which changes in oil price affect each expenditure category price differ between the United States and Japan and these detailed-level differences may lead to aggregate-level differences in the price response of both countries to changes in oil price.

Chapter 1
Investigating effects of oil price changes on the US, the UK and Japan

1.1 Introduction

This paper investigates the causes for wild fluctuations in oil prices since the mid-2000s. It also assesses, empirically, the effects of oil price shocks on the real economic activity and price development of three industrialized countries; the US, the UK, and Japan. In order to pursue my study, I have used the structural VAR model of the global crude oil market proposed by Kilian (2008).

The price of oil is one of the most familiar economic indicators for many people as it is closely related to daily life. People are sensitive to changes in the price of gasoline or that of gas for example. Therefore, changes in the price of oil and their causes have been an interesting issue for economists. Early works reported that recessions in the US economy were related to exogenous political events in 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 increases in oil price[1]. The effect of the oil shock on the US economy has been studied by many economists from other aspects as well. For instance, Bernanke, Gertler, and Watson (1997) studied oil price shocks in terms of monetary policy. Finn (2000) investigated the role of exogenous oil price variation as a source of the US economic cycle.

However, the writers of early literatures generally assumed exogeneity of oil shocks in studying the response of macroeconomic aggregates, when there may be reverse causality from the global economy through oil demand prices. This may bring inappropriate implications to policy makers. For example, a central bank would unambiguously raise interest rates in response to an endogenous demand-driven increase in the price of oil, but may face a difficult tradeoff between inflation and output when deciding policy against an exogenous cost-push, oil supply-shock. This point is closely related to the ongoing debate over whether it was oil supply shocks or contractionary monetary policy that caused the US recession in the late 1970s and 1980s, e.g. Bernanke, Gertler and Watson (1997), Barsky and Kilian (2002, 2004)[2],

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1 Hamilton (1996) use "net oil price increase" as an oil price variables while Hooker (1996b), in his reply to Hamilton (1996), casts doubt on the theoretical and empirical validity of using "net oil price increase" to represent oil price shocks to the macro economy.

2 Barsky and Kilian (2004) reports five recessions of the US which followed surges in

and Hamilton and Herrera (2004). Developing the works of Barsky and Kilian (2002, 2004), Kilian (2008) established the structural VAR model of the global oil market in order to identify three underlying shocks in the global oil market: (1) oil supply shocks; shocks to the physical ability to produce oil, (2) aggregate demand shocks; shocks to the current demand for all industrial commodities which are determined by global macroeconomic conditions and (3) oil-specific demand shocks; shocks which cannot be explained based on oil supply shocks or aggregate demand shocks. Oil-specific demand shocks may for example, reflect precautionary demand[3], which stems from an uncertainty about possible future shortfalls of oil. Based on this identification of structural shocks, Kilian 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. Today, it is widely understood that the price of oil has been endogenous to global macroeconomic conditions and cannot be treated as exogenous.

As seen in the previous studies above, most empirical literatures have mainly focused on the effects of changes in oil price on the US economy. In contrast, a relatively small number of studies have been done for other major economies, such as Japan. Much remains unknown about the response of those economies associated with oil price fluctuations. To my best knowledge, this article is the first study to make a comparison of the effects of changes in oil price on three major economies, the US, the UK, and Japan, taking the endogeneity of oil price into consideration. The main findings of this paper are as follows: First, the historical decomposition analysis allows me to conclude that oil-specific demand shocks as well as aggregate demand shocks played an important role in the rise in the real price of oil since early 2002 and the subsequent sharp drops after the failure of Lehman Brothers Holdings Inc.. Second, Kilian's finding, the way oil price changes affect economy is different depending on where the changes fundamentally come from, is found not to be specific to US economy. It is also true for two other big industrialized economies; Japan and the UK. Third, I have found that oil-specific demand shocks increase real GDP in Japan, which is very different from the US and the UK where oil-specific demand shocks lead to reduction in real GDP. This difference possibly comes from the oil efficiency of

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the price of oil: the recessions of November 1973, January 1980, July 1981, July 1990 and March 2001.

[3] Alquist and Kilian (2007) conduct formal analysis on precautionary shocks. It is stated that precautionary demand varies depending on whether there is good access to inventory holdings of oil that may act like an insurance against a disturbance in oil supplies.

Japanese products.

The remainder of the paper is organized as follows: Section 1.2 provides a detailed description of the data. Section 1.3 describes the econometric models used in this paper. Section 1.4 summarizes the empirical results, such as historical decomposition and measures the impact of the shocks on three economies by regressing three structural shocks on the growth of real GDP and CPI. Section 1.5 proposes a conclusion.

1.2. Data Description

Following Kilian (2008), I will consider the following three shocks as structural innovations to the global oil market; oil supply shocks, aggregate demand shocks and oil-specific demand shocks. Correspondingly, the variables which I will use are as follows: world crude oil production; world industrial production[4]; and West Texas Intermediate spot crude oil prices[5]. Details about the data such as its sources are described in the Table 1.1.

The major differences described by Kilian (2008) are a choice of variable which represents global real economic activity and the length of the sample period. For the index of global real economic activity, Kilian (2008) constructs his original series based on dry cargo freight rates. To some extent, the fluctuations in freight rates captures the cycle of macroeconomic conditions. However, it possibly reflects some irrelevant information to real economic activity which is specific to the ship-freight market, such as weather condition and a demurrage. Therefore, I will use the index of world industrial production instead, taking the difference from its time trend to capture the development of global real economic activity well. As for the sample period, this paper covers 1973.1-2010.12[6] which is the updated series of Kilian (2008), 1973.1-2006.10. This allows me to reveal the underlying cause of the hike in oil price in summer 2008 and the subsequent sharp drop.

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4 The index of world industrial production is weighted sum of the industrial production of each OECD countries plus major six non-member economies; Brazil, China, India, Indonesia, the Russian Federation, and South Africa. The weight is calculated based on purchasing-power-parity valuation of each country.

5 As for the oil price, the US refiner acquisition cost of imported crude oil deflated by the US CPI is used in Kilian (2008). Instead of this series, I use WTI because besides the fact that WTI is considered one of the most popular international oil price index.

6 The starting and ending date is dictated by the availability of the oil production data which is subscribed from the Oil and Gas Journal.

1.3. Methodology

Similar to Kilian (2008), I will take the following two steps in my analytical framework. As a first step, the structural VAR model of the global crude oil market will be estimated in order to obtain a series of identified shocks. Secondly, by using these structural shocks obtained from the SVAR model, regression models will be estimated to assess the macroeconomic implication of the identified shocks for each country.

1.3.1. The Structural VAR model: Decomposing the Real Price of Oil

Consider a restricted VAR model with 24 lags[7] based on monthly data described in the previous section. The restricted VAR is represented as

$$X_t = \alpha + \sum_{i=1}^{24} \beta_i X_{t-i} + e_t \tag{1.1}$$

where $X_t = (\Delta prod_t, IIP_t, P_t)'$ and $e_t = (e_t\Delta^{prod}{}_t, e_t^{IIP}, e_t^{P})'$. $\Delta prod_t$ is the percentage change in global crude oil production and all variables are expressed in the natural log[8].

Then, the structural VAR is represented as

$$A_0 X_t = A_0 \alpha + \sum_{i=1}^{24} A_i \beta_i X_{t-i} + u_t \tag{1.2}$$

In order to identify the structural shocks u_t, it is assumed that A_0^{-1} takes a specific form so that the reduced form errors e_t and the structural errors u_t have the relationship as below.

$$e_t = \begin{pmatrix} e_t^{\Delta prod} \\ e_t^{IIP} \\ e_t^{P} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} u_t^{\text{oil supply shock}} \\ u_t^{\text{aggregate demand shock}} \\ u_t^{\text{oil-specific demand shock}} \end{pmatrix} = A_0^{-1} u_t \tag{1.3}$$

The assumptions on A_0^{-1} are motivated as follows: First, oil supply shocks are innovations to oil production that are assumed not to respond to innovations to the demand for oil within the same month. i.e., the model postulates a vertical short-run

7 Although the lag length indicated by AIC is 7, based on the fact that I use monthly series in model, I have decided to take 24 lags as Kilian (2008) does. We can avoid the problem of dynamic misspecification by taking 24 lags. The results based on 7 lags and 12 lags are very similar to the result based on 24 lags.

8 The first difference of world production of oil, the level of index of economic activity and the level of real price of oil are used in Kilian (2008)'s original model. Stability test for the estimated VAR is also conducted.

supply curve of crude oil. Second, aggregate demand shocks are innovations to world industrial production that oil supply shocks cannot explain. With aggregate demand shocks, it is assumed that a rise in oil price, driven by shocks which are specific to the oil market, will not lower global world industrial production with a delay of at least a month. Lastly oil-specific demand shocks are innovations to the oil price that can be accounted for by neither the oil supply shocks nor aggregate demand shocks. Oil-specific demand shocks are, for example, supposed to reflect changes in precautionary demand, which come from uncertainty about future oil supply shortage. They are also supposed to reflect changes caused by speculative demand for oil.

1.3.2. Regression Model

Next I will explain how the structural innovations in model (1.3) affect the CPI and real GDP growth in the US, the UK, and Japan. One complication that must be addressed is caused by the fact that real GDP is not available at monthly frequency. In addition, the series other than real GDP which are given at a monthly frequency cannot be aggregated to a quarterly frequency because at that frequency, the identifying assumptions used in estimating model (1.3) would no longer be credible[9]. In order to deal with the frequency not being consistent, I firstly average the monthly structural innovation for each quarter:

$$\hat{\zeta}_{jt} = \frac{1}{3}\sum_{i=1}^{3}\hat{u}_{j,t,i}, j = 1,2,3, \qquad (1.4)$$

where $\hat{u}_{j,t,i}$ is the estimated disturbance for the *j*th structural innovation in the *i*th month of the *t*th quarter of the sample. Then by regressing the first difference of real GDP and the CPI on the averaged structural innovations with lags of innovations and constant respectively, I make it possible to investigate the impact of the shocks on each economy[10]:

$$\Delta y_t = \alpha_j + \sum_{i=0}^{12}\phi_{ji}\hat{\zeta}_{jt-i} + r_{jt}, j = 1,2,3, \qquad (1.5)$$

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9 The use of IIP for Japan is a possible clue to deal with the frequency problem because IIP is monthly data which is compatible with the short-run restrictions on my structural VAR models. However, I would rather see an effect of changes in oil price on whole economy which includes nonmanufacturing industries instead than manufacturing industries only. Thus quarterly real GDP data is used instead.

10 Note that regressions (1.5) and (1.6) rely on the assumption that within a given quarter there is no feedback from Δy_t and π_t to $\hat{\zeta}$ i.e., these shocks can be treated as predetermined with respect to the growth of real GDP and the CPI.

$$\pi_t = \beta_j + \sum_{i=0}^{12} \psi_{ji} \hat{\zeta}_{jt-i} + v_{jt}, j = 1,2,3, \quad (1.6)$$

where Δy_t and π_t refers to the first difference of real GDP and that of the CPI respectively and r_{jt} and v_{jt} are errors[11]. In this regression model, because ϕ_{jh} and ψ_{jh} are interpreted as an impulse response coefficients at horizon *h*, the number of lags is given by the maximum horizon of the impulse response function, which is defined as 12 quarters.

1.4. Empirical Results

Although I used different data for all three variables in the SVAR from those used by Kilian (2008), the results of the estimation are similar to his. Figure 1.1 plots the historical evolution (expressed as annual averages for readability) of the structural shocks obtained from the model. As shown by Kilian (2008), there was no evidence of unanticipated global oil supply disruptions in 1978 or 1979 but there were large negative shocks to crude oil supply in 1980 and 1981, associated with the outbreak of the Iran–Iraq War. As for oil-specific demand shocks, there was also a large positive shock in 1979. This is consistent with the fact that there was growing uncertainty about future oil supply at that time because of successive political events such as the Iranian Revolution, the Iranian hostage crisis and the Soviet invasion of Afghanistan.

Looking at the movements in the period from 2007 to the present, which is out of Kilian's sample period, there is a huge negative shock to aggregate demand in 2008. It clearly reflects the worldwide economic depression that started with the failure of Lehman Brothers Holdings Inc. on 15 September 2008. Another interesting point is that there is also a large negative disturbance to oil-specific demand. This is consistent with the view of market watchers[12] that there was large outflow of speculative funds from the oil market which had increased the oil price more than fundamentally determined. The disturbance to the oil-specific demand can also be interpreted, if it is understood that with the sharp drop in demand for oil, the expectations of investors for future oil demand also decreased.

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[11] Those errors are potentially serially correlated. For right inference on the response estimates obtained by model (1.5) and (1.6), serial correlation problem is dealt with by using block bootstrap methods. Following Kilian(2008), block size 4 and 20,000 bootstrap replications are used.

[12] In 2008, the writer worked as a market-watcher in the Bank of Japan.

1.4.1. Historical Decomposition of the Price of Oil

Figure 1.2 plots a historical decomposition of the real price of oil into the contribution of the structural shocks. The cumulative effects of each structural shock on the real price of crude oil are indicated by the solid line in each panel. This historical decomposition obtained from my model is consistent with the findings of Kilian (2008) in that oil supply shocks made a small contribution to oil price movements, and that shocks due to aggregate demand and oil-specific shocks made far bigger contributions to the real price of oil.

By taking a closer look at the recent developments to the cumulative effect of aggregate demand shock, we can see that the recent increase was driven largely by aggregate demand shocks. A large part of the surge in the real price of oil from the end of 2006 to the middle of 2008 in particular can be explained by this. It is also obvious that the level of the cumulative effect of aggregate demand shock on real price of oil in 2010 has recovered close to pre-Lefman shock level and it has helped maintain oil price at a historically high level. Meanwhile, oil-specific demand shocks played an important role in the recent surge as well. It is obvious that oil-specific demand shocks also contributed largely to the surge in oil price in early 2008 and the subsequent sharp fall at the end of 2008. This is corresponding to the views that crude oil prices became high in the early part of 2008 partly due to the speculative inflow of funds, and partly due to the tightening of supply and demand conditions (see Bank of Japan 2008a) and that the price of oil fell rapidly at the end of 2008 due to increased risk aversion among investors reflecting disruptions in global financial markets (see Bank of Japan 2008b).

1.4.2. The effect of Oil Price Shocks on the Economic Activity and Price Development

Figures 1.3-1.5 summarize the responses of the level of real GDP and CPI to each of the three structural shocks. Both real GDP and CPI respond very differently to each of the three structural shocks in all three countries. This clearly shows that Kilian's findings, the way oil price changes affect the US economy is very different depending on where the changes fundamentally come from, is also true for Japan and the UK.

Oil supply disruptions cause a small decline in the US and Japan's real GDP with some delays, whereas it leads to a small increase in the UK real GDP, but the one-standard error bands imply statistical insignificance. The corresponding effect on the level of the CPI is similar between the three economies. It is mostly flat and statistically insignificant for the first 6 quarters and then becomes negative afterwards. Regarding an aggregate demand expansion, there is a similar pattern in the response of the US, the UK and Japan's real GDP within first two years. After the second year, real GDP in the US and the UK become largely flat afterwards whereas Japan's real GDP keeps its level above initial state. At the end of the third year, the response of the US and the UK turns to be negative, which is statistically significant. Meanwhile, this shock causes a statistically significant increase in the price level of the US and the UK. In contrast, interestingly, it causes neither a statistically significant increase nor a decrease in the price level of Japan. A positive oil-market specific demand shock leads to a slight decline in the US and the UK real GDP. On the other hand, in Japan, this shock leads to a sustained increase in real GDP that reaches its maximum at the 10th quarter. This increase is statistically significant in the first three and a half years but becomes statistically insignificant after that. The corresponding effect on the level of the CPI is similar between the three economies. It results in a sustained and highly statistically significant increase.

The result suggests a fair degree of similarity in the real GDP and CPI responses between the US and the UK. The biggest difference between those two economies and the Japanese economy is that oil-specific demand shocks have a positive impact on Japanese GDP, while it results in reduction in the US and the UK real GDP. This result seems to confirm the findings of recent studies, stating that the impact of oil price increases on Japan's economy are relatively small or even positive and very different from other oil-importing countries. For example, Fukunaga, Hirakata and Sudo (2009) compared industry-level effects of oil price change in the US and Japan and found that the increase in the price of oil caused a global demand shift, especially in automobiles, towards more oil-efficent products made in Japan and thus it increases production in Japan. In this sense, the positive response of real GDP in Japan to the oil-specific demand shock can be explained in part by the result of a global demand shift towards oil efficient products made in Japan.

1.5. Conclusion

The main results can be summarized as below: First, by extending the sample period from Kilian (2008), I have found that oil-specific demand shocks as well as aggregate demand shocks played an important role in the wild fluctuations in oil prices since the mid-2000s. Second, I investigated the impact of changes in the price of oil on three industrialized economies. I have shown that the statement that the way oil price changes affect economy is very different depending on where the changes fundamentally come from is also true for Japan and the UK. The most interesting finding is that oil-specific demand shocks increase real GDP in Japan, which is very different from the US and the UK where oil-specific demand shocks lead to reduction in real GDP. This difference possibly comes from the oil efficiency of Japanese products. In this sense, a rise in the price of oil does not necessarily have a negative impact on Japan’s economy, which is in contrast to the public belief that an increase in oil price has negative consequences for the lives of Japanese people.

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Table 1.1 Data description and sources

Variable	Description	Data source
World Production of Oil (prod)	Original Series.	Oil and Gas Journal[13]
World Industrial Production (IIP)	Seasonally adjusted. Gap from linear trend.	Organisation for Economic Co-operation and Development
Real oil price (p)	Original Series of WTI deflated by the US CPI.	Federal Reserve Bank
Japanese Real GDP	Seasonally adjusted.	Cabinet Office of Japan
The US Real GDP		Bureau of Economic Analysis
The UK Real GDP		Office for National Statistics
Japanese CPI		Organisation for Economic Co-operation and Development
The UK CPI		
The US CPI		

[13] I have subscribed this data from Oil and Gas Journal.

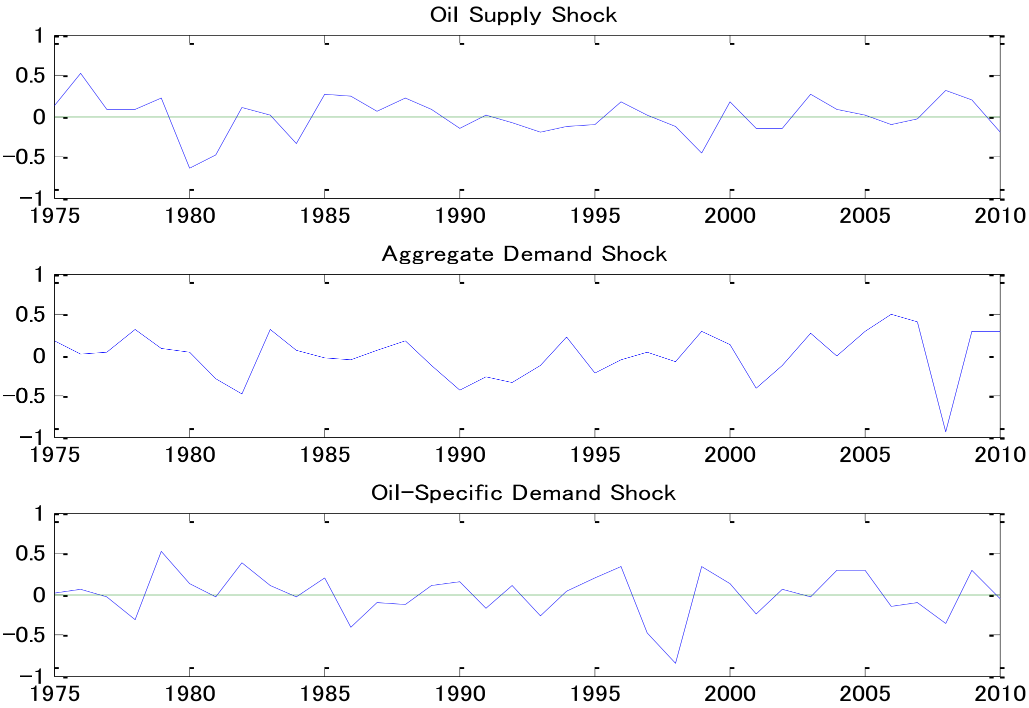

Figure 1.1: Historical evolution of the structural shocks (1973-2010)

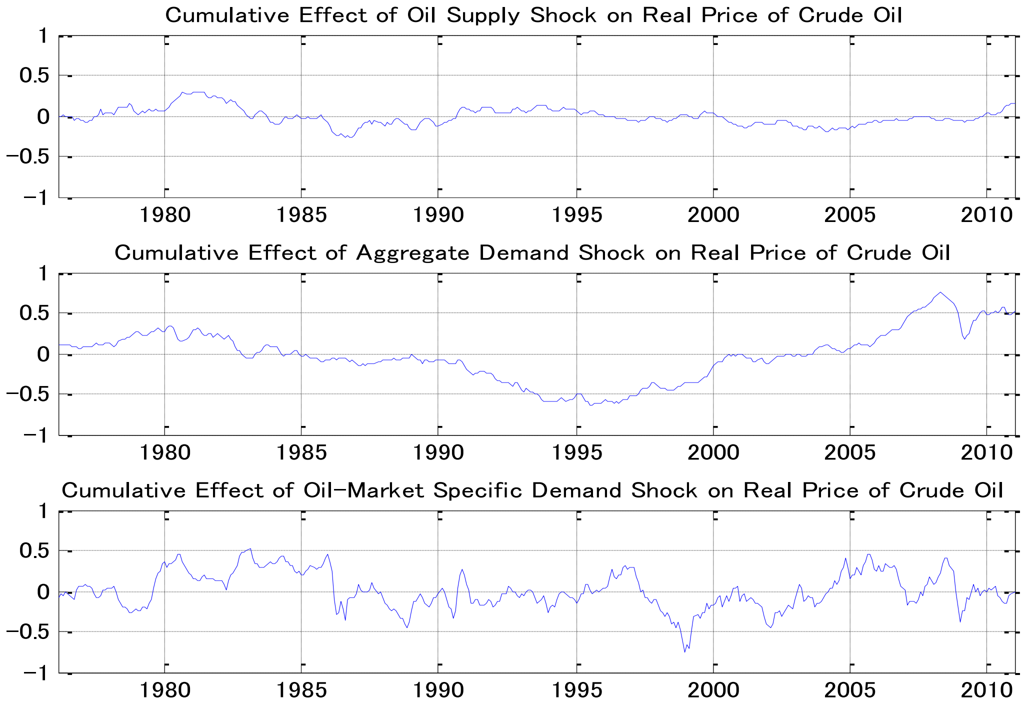

Figure 1.2: Historical decomposition of real oil price s (1973-2010)

Notes: Estimation based on model (1.2).

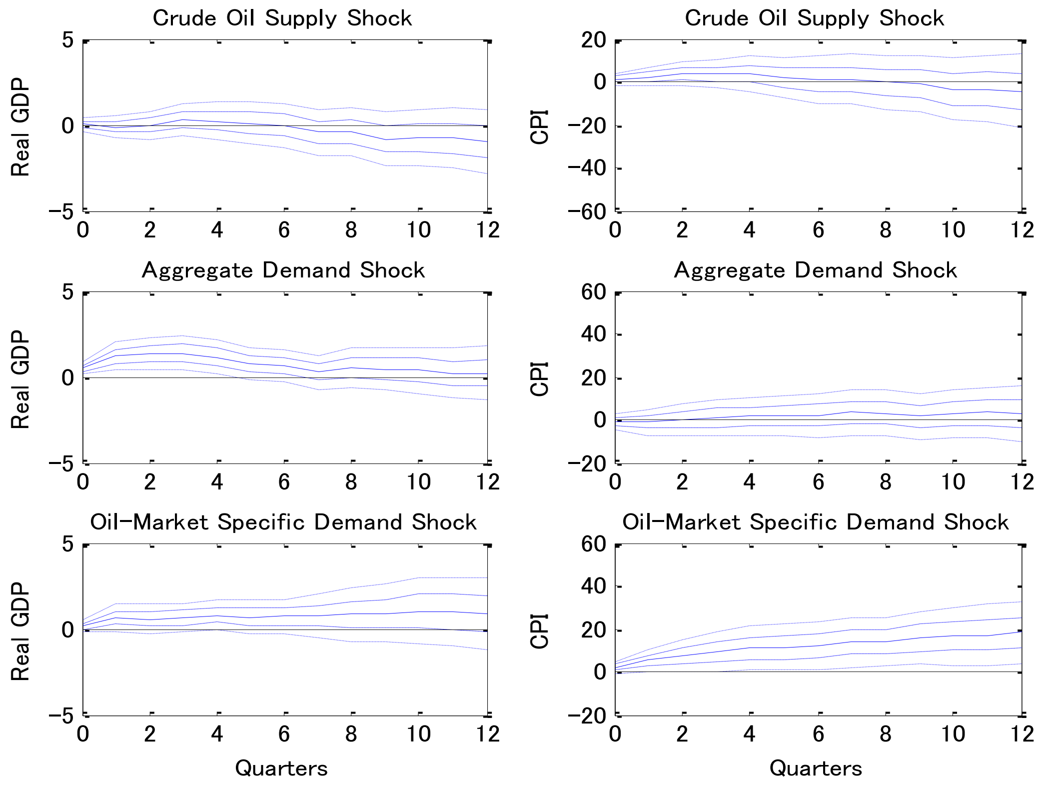

Figure 1.3: Cumulative responses of Japan's real GDP and CPI to each structural shock

Notes: Estimation based on model (1.5) and (1.6). One and two-standard error bands are shown by dashed line and dotted line respectively.

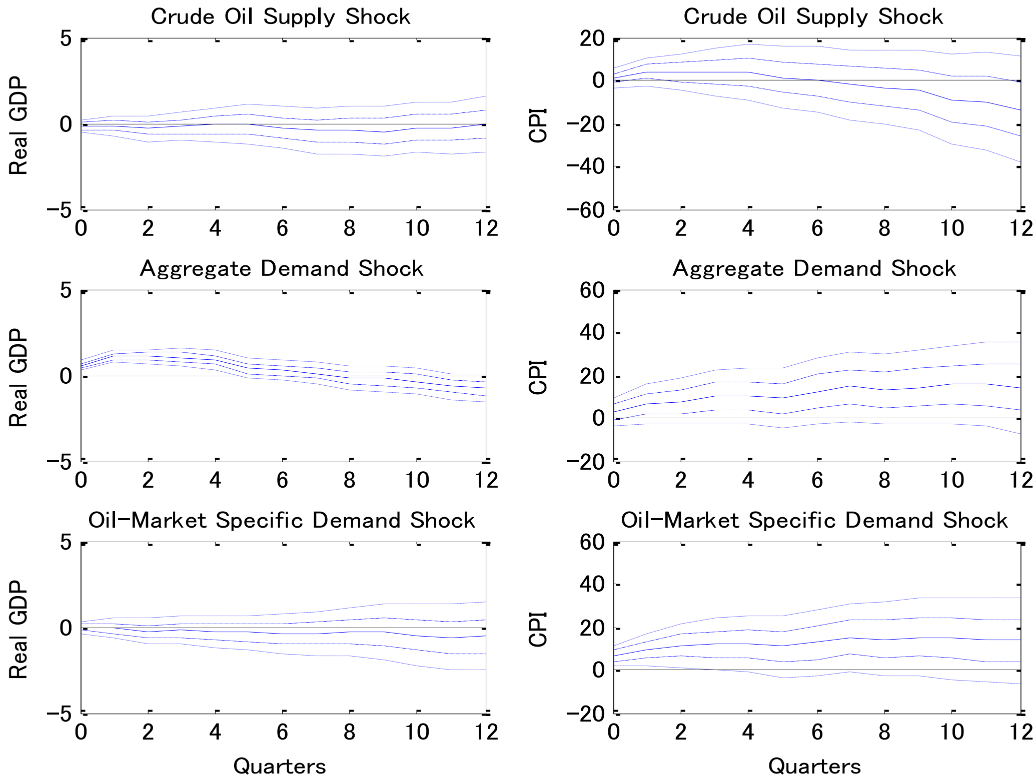

Figure 1.4: Cumulative responses of the US real GDP and CPI to each structural shock

Notes: Estimation based on model (1.5) and (1.6). One and two-standard error bands are shown by dashed line and dotted line respectively.

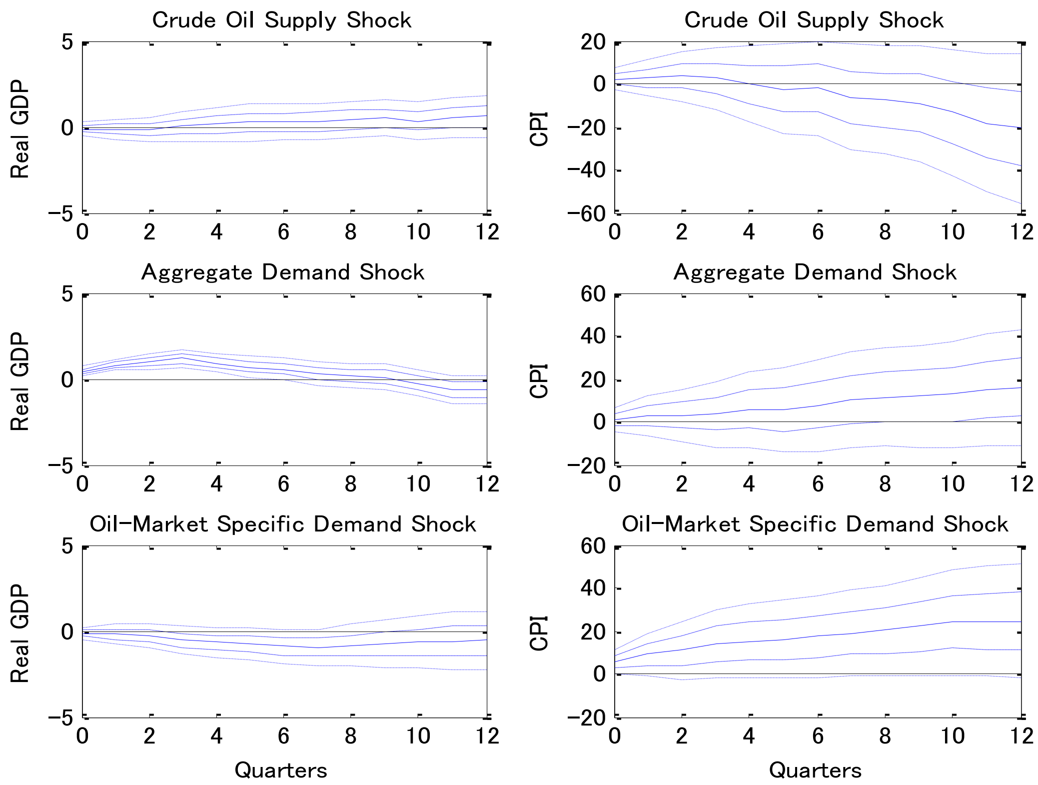

Figure 1.5: Cumulative responses of the UK real GDP and CPI to each structural shock

Notes: Estimation based on model (1.5) and (1.6). One and two-standard error bands are shown by dashed line and dotted line respectively.

Chapter 2
On the Influence of Oil Price Shocks on Economic Activity, Inflation, and Exchange Rates

2.1. 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, there is a large empirical literature on the effects of changes in oil price on macroeconomic activity However, much of those papers focus on the U.S. economy. Much remains unknown about the effects of oil price changes in countries other than the U.S. economy. Therefore, it is worth assessing empirically the effects of oil price shocks on important industrialized countries; their magnitudes, transmission mechanisms, and historical changes. In addition to this, whether and how the degree of dependency on imported oil affects the response of economies to oil price changes is still open question. Therefore, it is also important to think about the relationship between oil price and the exchange rate at this timing.

The first objective of this paper is to assess the differences as well as similarities in the response of the selected industrialized economies to structural oil price shocks. The second purpose of the present paper is to find out whether oil shocks matter for exchange rates. In other words, we are particularly interested in how the impact of each shock is different for oil exporters and importers. In order to pursue our study, we carry out 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 rest of this study is organized as following. Section 2.2 provides a detailed description of the data. Section 2.3 describes the econometric models used in this paper. Section 2.4 summarizes the empirical results. Section 2.5 concludes the study.

2.2. Data Description

Table 2.1 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[14], and West Texas Intermediate spot crude oil prices[15] 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 2.2 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,

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[14] 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.

[15] 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.

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.

2.3. 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.

2.3.1. The Structural VAR Model: Identifying Structural Shocks

Consider a restricted VAR model with 24 lags[16] represented as

$$X_t = \alpha + \sum_{i=1}^{24} \beta_i X_{t-i} + e_t \tag{2.1}$$

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:

$$A_0 X_t = A_0 \alpha + \sum_{i=1}^{24} A_i \beta_i X_{t-i} + u_t \tag{2.2}$$

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

2.3.2. 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 (2.2) affect each economy:

$$\Delta IIP_t = \alpha_j + \sum_{i=0}^{12} \phi_{ji} \hat{\zeta}_{jt-i} + r_{jt}, \; j = 1,2,3, \tag{2.3}$$

16 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.

$$\Delta CPI_t = \beta_j + \sum_{i=0}^{12} \psi_{ji} \hat{\zeta}_{jt-i} + v_{jt}, j = 1,2,3, \tag{2.4}$$

$$\Delta REER_t = \gamma_j + \sum_{i=0}^{12} \lambda_{ji} \hat{\zeta}_{jt-i} + s_{jt}, j = 1,2,3, \tag{2.5}$$

$$\hat{\zeta}_{jt} = \frac{1}{3} \sum_{i=1}^{3} \hat{u}_{j,t,i}, j = 1,2,3, \tag{2.6}$$

where $\hat{u}_{j,t,i}$ is the estimated disturbance for the jth structural innovation in the ith month of the tth 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.

2.4. Empirical Results

Figures 2.1–2.8 summarize each country's IIP, CPI, and REER responses to each of the three structural shocks.

2.4.1. 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.

2.4.2. 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.

2.4.3. 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.

2.4.4. 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.

2.4.5. 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.

2.4.6. 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.

2.4.7. 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.

2.4.8. 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.

2.5. 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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Table 2.1: Data sources

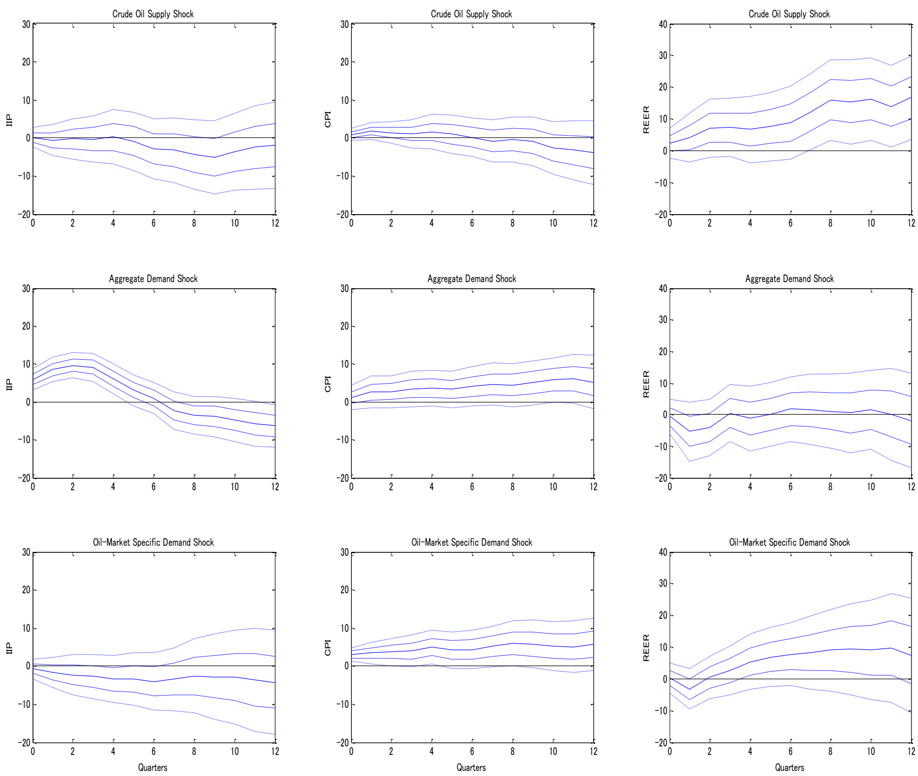
Variable	Data source
Industrial Production(IIP) **Consumer Price Index (CPI)** **World Industrial Production**	Organization for Economic Co-operation and Development(OECD)
Real effective exchange rate	Bank for International Settlements(BIS)
World Production of Oil	Oil and Gas Journal
WTI crude oil price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

Table 2.2: 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

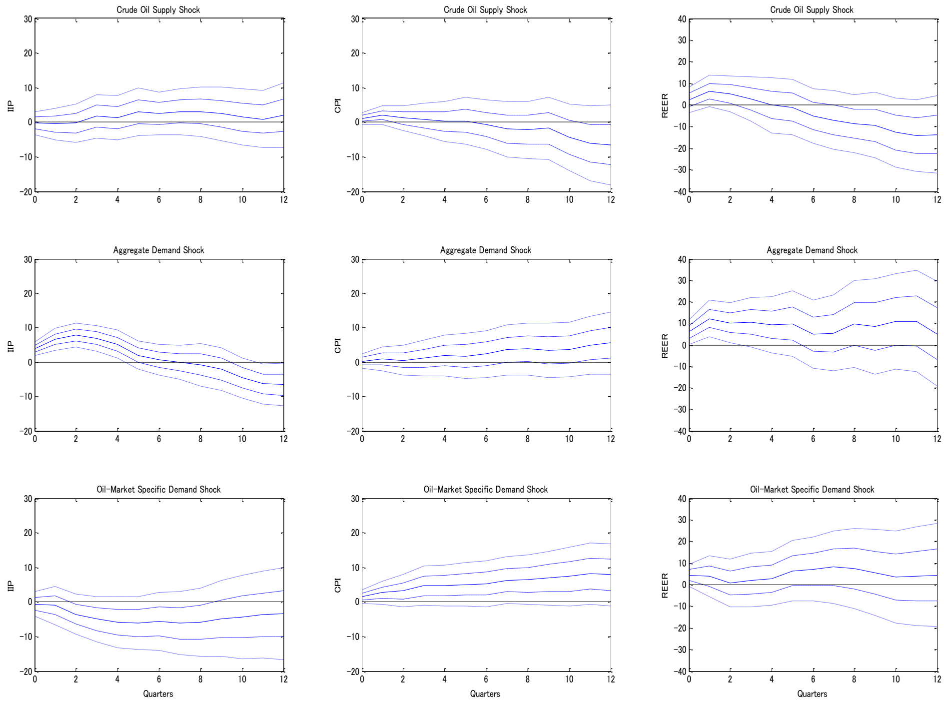
Notes: Average ratio of oil production to consumption during the 1980 to 2010.

Source: U.S. Energy Information Administration



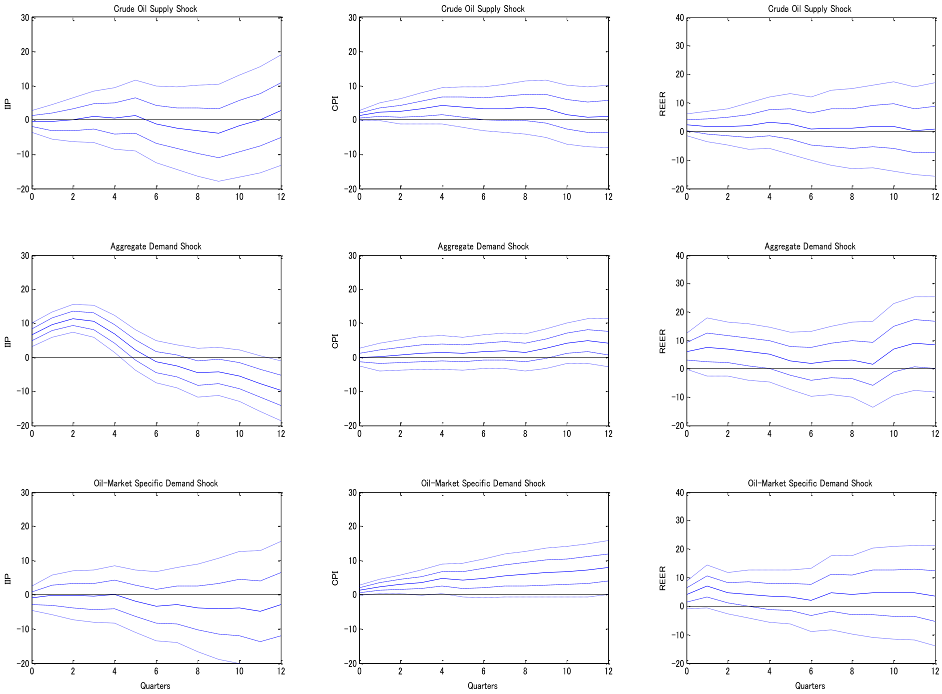
Figures 2.1: Cumulative responses of IIP, CPI and REER to each structural shock, the United States

Notes: Estimation based on model (2.2) - (2.4). One and two-standard error bands are shown by dashed line and dotted line respectively.



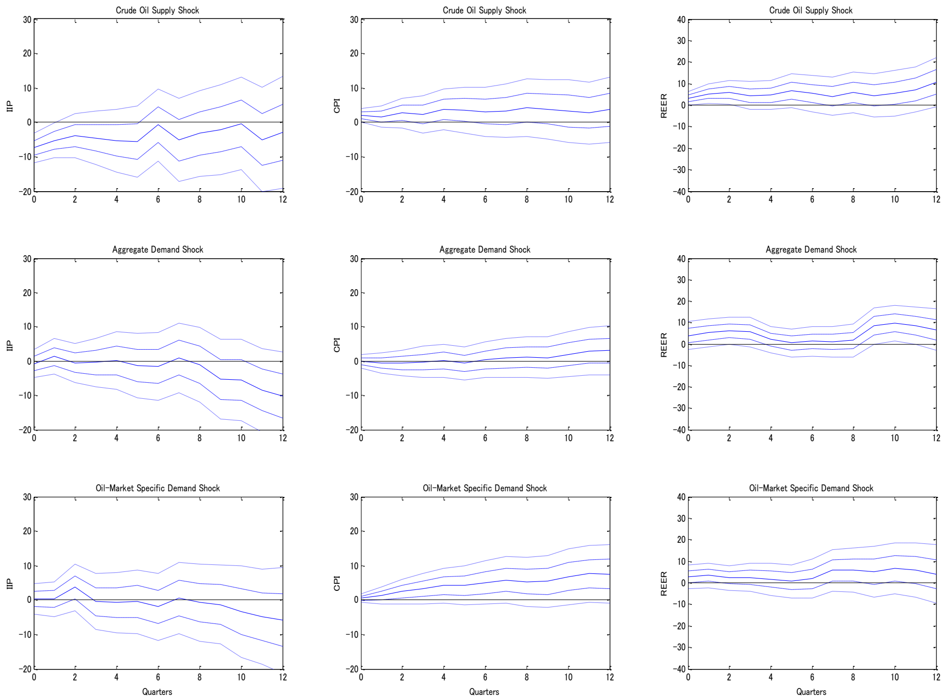
Figures 2.2: Cumulative responses of IIP, CPI and REER to each structural shock, the United Kingdom

Notes: Estimation based on model (2.2) - (2.4). One and two-standard error bands are shown by dashed line and dotted line respectively.



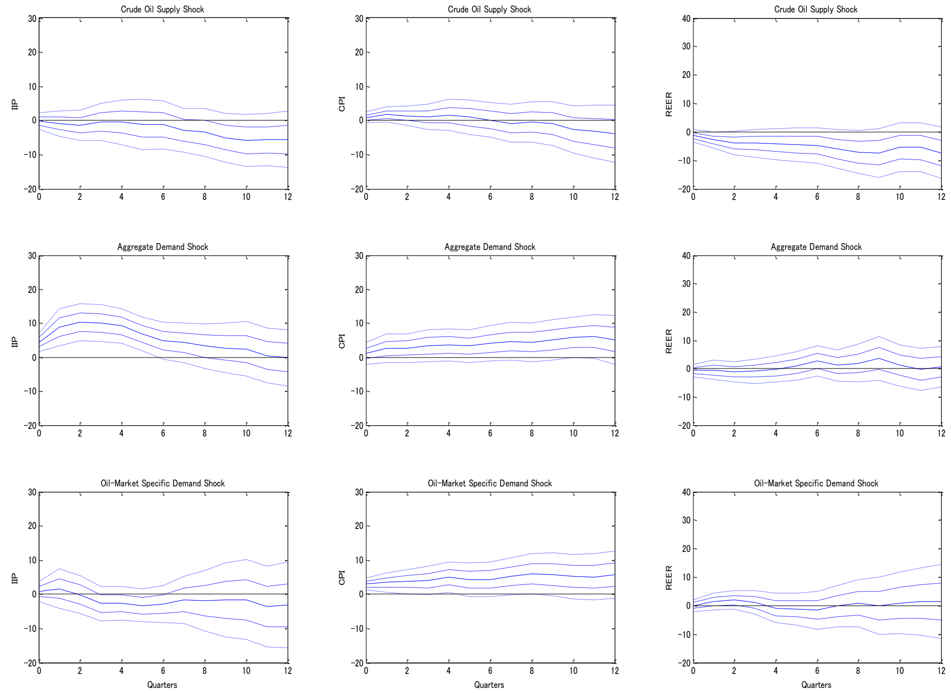
Figures 2.3: Cumulative responses of IIP, CPI and REER to each structural shock, Canada

Notes: Estimation based on model (2.2) - (2.4). One and two-standard error bands are shown by dashed line and dotted line respectively.



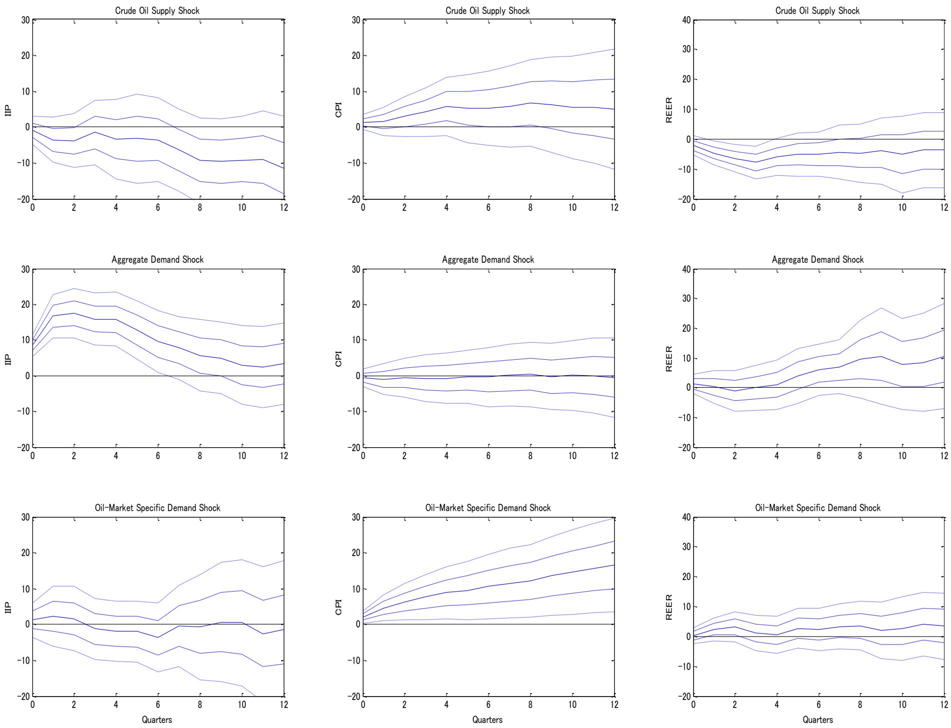
Figures 2.4: Cumulative responses of IIP, CPI and REER to each structural shock, Norway

Notes: Estimation based on model (2.2) - (2.4). One and two-standard error bands are shown by dashed line and dotted line respectively.



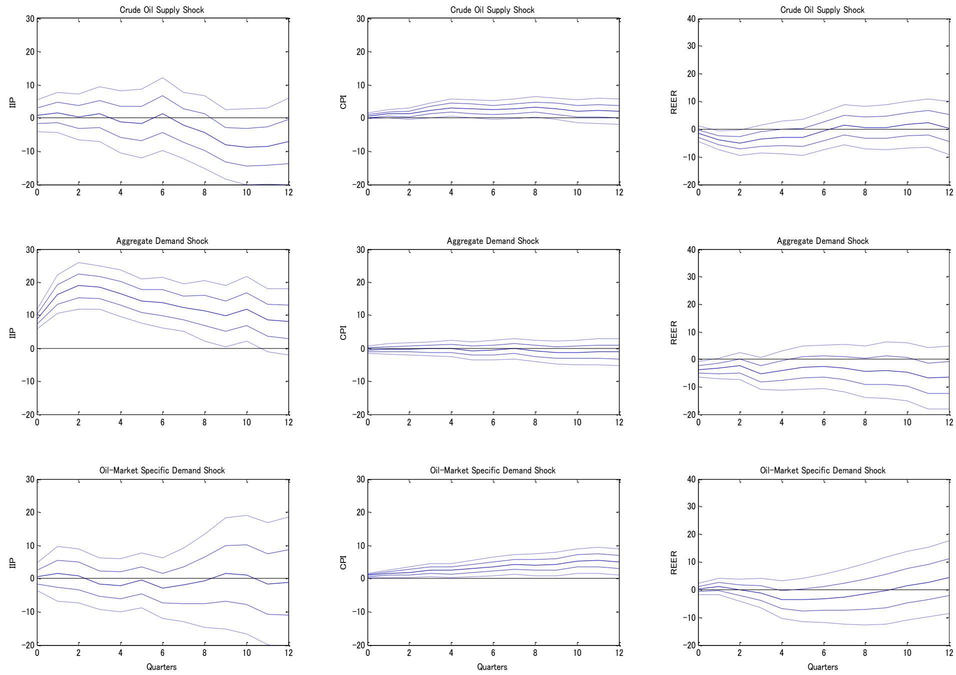
Figures 2.5: Cumulative responses of IIP, CPI and REER to each structural shock, France

Notes: Estimation based on model (2.2) - (2.4). One and two-standard error bands are shown by dashed line and dotted line respectively.



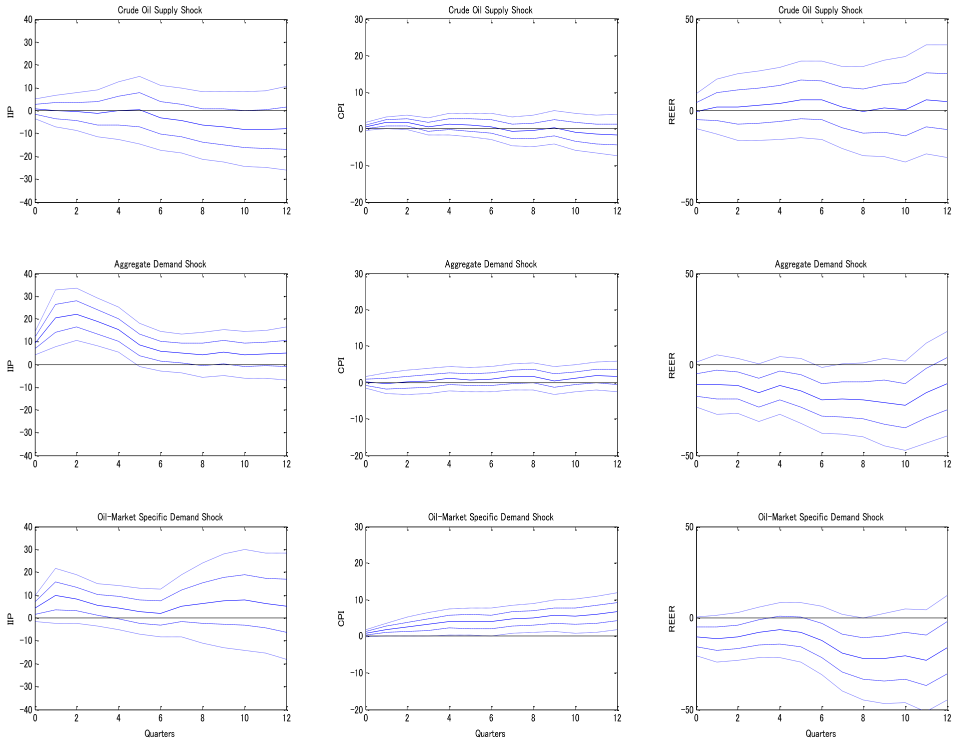
Figures 2.6: Cumulative responses of IIP, CPI and REER to each structural shock, Italy

Notes: Estimation based on model (2.2) - (2.4). One and two-standard error bands are shown by dashed line and dotted line respectively.



Figures 2.7: Cumulative responses of IIP, CPI and REER to each structural shock, Germany

Notes: Estimation based on model (2.2) - (2.4). One and two-standard error bands are shown by dashed line and dotted line respectively.



Figures 2.8: Cumulative responses of IIP, CPI and REER to each structural shock, Japan

Notes: Estimation based on model (2.2) - (2.4). One and two-standard error bands are shown by dashed line and dotted line respectively.

Chapter 3
The Effects of Oil Price Shocks on Expenditure Category CPI

3.1. Introduction

There is a large body of literature that reports on the effects of oil price shocks on aggregate price. However, prices of a detailed category of goods and services have often been ignored in discussions of the effects of an increase in oil price. In this study, we empirically analyze the impact of higher oil price on detailed expenditure categories as well as aggregate price. Based on a two-block structural vector autoregressive (VAR) model proposed by Kilian and Park (2009), we investigate the dynamic effects of oil price shocks on the expenditure category consumer price index (CPI) for the United States and Japan.

Investigating the role of changes in oil price in the economy has been a significant issue for economists as oil price has a direct effect on the price of gasoline or gas, which further has an impact on almost every aspect of the economy. With respect to the interplay between oil price shock and macro economic activity, many early works reported that recessions in the US economy were related to exogenous political events in Organization of the Petroleum Exporting Countries (OPEC) and subsequent rises in the price of oil. For example, Hamilton (1983, 1996) and Hooker (1996) conclude that most of the US recessions were preceded by increases in oil price. Some researchers (Bernanke *et al.*, 1997; Blanchard and Galí, 2007) studied the effects of changes in oil price on price development and industry output. Bernanke *et al.* (1997) studied oil price shocks in terms of inflation, output, and monetary policy. Blanchard and Galí (2007) examined the reason for the reduction in the impacts of oil price shocks on inflation as compared to that in the 1970s. However, these studies focus on aggregate price; the effects of changes in oil price on the prices of detailed category of goods and services remains largely unknown.

Further, Kilian (2009) indicated two more limitations found in most existing literature on the effects of changes in oil price on the global economy and prices. First, early studies (Hamilton, 1983, 1996; Hooker, 1996, 1999) on the relationship between oil price shocks and inflation assumed that oil price shocks were exogenous. In other words, these studies did not consider the possibility of reverse causality from the global economy through oil demand fluctuations. For example, Hooker (1999) analyzes the relationship between oil price and the inflation in the United States by using a Phillips curve framework with a structural break. He concludes that after 1980, changes in oil price do not appear to have a strong impact on core inflation. The second limitation, addressed in Killian (2009), is that previous analyses fail to distinguish the mechanisms underlying structural oil innovations. Killian states that it is impossible to accurately investigate the effects of higher oil prices on the economy without distinguishing what kind of structural shocks cause an increase in oil price in the first place.

In order to provide further insight into the relationship between oil price and the economy, Kilian (2009) established a structural decomposition of the price of oil into the following three components: (1) oil supply shocks, or shocks to the physical ability to produce oil; (2) aggregate demand shocks, or shocks to the global demand for all industrial commodities; and (3) oil-specific demand shocks, or shocks that are specific to the global oil market. The latter structural shocks may reflect precautionary demand, which is caused by, for example, an uncertainty regarding possible future shortfalls of oil. Applying this identification of structural shocks to a structural VAR model of the global oil market, Kilian (2009) concludes that an unanticipated increase in oil price may have very different effects on the Gross Domestic Product (GDP) and CPI in the United States, depending on the underlying cause of the higher oil price. Specifically, his findings can be summarized as follows: Firstly, oil supply shocks decrease GDP and have little impacts on the price. Secondly, unanticipated demand expansion causes a temporary increase on GDP and shifts price level upward. Lastly, positive oil-specific shocks decrease GDP and increase CPI.

Following this contribution, the structural VAR model of the global oil market proposed by Kilian (2009) has been widely applied to many other oil-related topics. For example, Kilian *et al*. (2009) studied the impact of structural oil shocks on the balance of payments. Alquist and Kilian (2010) focused on the effect of demand and supply shocks in the global crude oil market on the oil futures markets. Kilian and Park (2009) constructed a two-block structural VAR model that included the global oil market block and the US stock market block in order to explore the differences in the responses of industry-level stock returns to changes in oil price.

As stated above, most previous literature sheds light on the response of aggregate price to higher oil price. However, the effects of changes in oil price on the prices of the detailed category of goods and services are largely unknown. Therefore, in this study, our objective is to examine the impact of higher oil price on detailed expenditure category prices as well as aggregate price in terms of their magnitudes, transmission mechanisms, and historical changes. More specifically, we are interested in determining whether changes in oil price function as positive or negative shocks on the individual expenditure category prices and which expenditure category index plays an important role in the response of the aggregate index to changes in oil price. In addition, we compare the United States and Japan to enhance our understanding of the transmission mechanisms of changes in oil price. For this purpose, we apply a two-block structural VAR approach proposed by Kilian and Park (2009).

We extend the existing studies by using detailed expenditure category prices as well as the aggregate price in order to conduct a detailed investigation of the transmission mechanisms of changes in oil price. To the best of our knowledge, this study is the first attempt to investigate the effects of structural shocks to the global oil market on detailed expenditure category prices. Moreover, unlike most previous studies, which focus on the US economy, we compare the effects of oil price shocks in the United States and Japan.

The remainder of the paper is organized in the following manner. In Section 3.2, we provide a detailed description of the data for the global oil market and the CPI. In Section 3.3, we describe our empirical framework. In Section 3.4, we summarize our empirical results, and in Section 3.5 we conclude the study.

3.2. Data Description

The global oil market

Table 3.1 presents an overview of the data set used in this study and its sources. In order to represent the global oil market block, we use world crude oil production, world industrial production, and West Texas Intermediate (WTI) spot crude oil prices to identify structural shocks. The last two variables are different from those used in Kilian (2009). For determining real global economic activity, Kilian (2009) constructs his original series based on dry cargo freight rates. However, we use the index of world industrial production, the weighted sum of the industrial production of all OECD countries as well as six non-member economies—Brazil, China, India, Indonesia, Russia, and South Africa—because dry cargo freight rates may include some irrelevant information on real economic activity that is specific to the ship-freight market, such as weather conditions and demurrage. For the oil price, Kilian (2009) uses the refiner acquisition cost of imported crude oil in the United States. Instead, we use the WTI as it is one of the most popular international oil price indices. The sample period is from December 1974 to December 2010.

Consumer Price Index

The US CPI data used in this study is available on the Web site of the Federal Reserve Economic Data (FRED)[17] or The Bureau of Labor Statistics (BLS)[18]. The CPI data for Japan can be downloaded from the Web site of the Ministry of Internal Affairs and Communications[19].

In order to analyze the effects of changes in oil price on detailed expenditure category prices, we used category-level data as well as the aggregate price index. However, rather than reviewing all individual price indexes, we focus on nine major groups in the expenditure category. In particular, for the United States, we use food and beverages, housing, apparel, transportation, medical care, recreation, education and communications, and other goods and services. As the corresponding expenditure category for Japan, we use food, housing, clothes and footwear, medical care, transportation and communication, culture and recreation, education, and miscellaneous.

In addition, to obtain a better understanding of the price developments of food and beverages, housing, transportation, and medical care, we analyze their lower-level indexes as well. The issue is that the definitions for some sub-categories differ slightly between Japan and the United States. Specifically, there are some lower-level indexes that are published only in the United States. In this case, we calculated these undisclosed indexes for Japan from other indexes and the expenditure weights that are available. For example, the food at home index is undisclosed in Japan whereas the food at home index and food away home index are available. With the respective expenditure weights for each index, we obtained Japan's food at home index by subtracting the food away home and alcoholic beverages indexes from the upper-level food index. Table 3.2 presents the list of price indexes used in this study.

3.3. Methodology

Following Kilian and Park (2009), we estimate a structural VAR model for the United States or Japan's CPI to measure demand and supply shocks in the global oil market. To this end, our model has two-block structures: the global oil market block and the United States or Japan's CPI block.

Description of the structural VAR model

17 http://research.stlouisfed.org/fred2/
18 http://www.bls.gov/cpi/
19 http://www.stat.go.jp/english/data/cpi/index.htm

We consider a restricted VAR model with 24 lags based on monthly data, as described in section 2. The restricted VAR is represented as

$$X_t = \alpha + \sum_{i=1}^{24} \beta_i X_{t-i} + e_t \tag{3.1}$$

where X_t includes the percentage change in global oil production, a detrended series of world industrial production, WTI oil price in dollars, and the consumer price index for the United States or Japan. Further, e_t denotes the reduced-form VAR innovations. The VAR model has a two-year lag because of the possibility that some shocks may be delayed by over a year.

Then, the structural representation of this VAR model is given by

$$A_0 X_t = A_0 \alpha + \sum_{i=1}^{24} A_i \beta_i X_{t-i} + u_t \tag{3.2}$$

where u_t is the vector of structural innovations. In order to identify the structural shocks u_t, it is assumed that A_0^{-1} takes a specific form so that the reduced form errors e_t and the structural errors u_t have a specific relationship, as described below.

$$e_t = \begin{pmatrix} e_{1t}^{\Delta oil\ production} \\ e_{2t}^{world\ IIP} \\ e_{3t}^{WTI\ oil\ price} \\ e_{4t}^{Domestic\ CPI} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{pmatrix} u_{1t}^{oil\ supply\ shock} \\ u_{2t}^{aggregate\ demand\ shock} \\ u_{3t}^{oil-specific\ demand\ shock} \\ u_{4t}^{other\ shocks\ to\ CPI} \end{pmatrix} = A_0^{-1} u_t \tag{3.3}$$

The motivation of the identifying assumptions on A_0^{-1} will be discussed later.

The global oil market block

The global oil market block comprises three equations—global oil production, global industrial production, and oil price. The following are the assumptions related to the global oil market block: First, oil supply shocks are innovations to world oil production that are treated as predetermined with respect to shocks to oil demand. More precisely, the model assumes a vertical short-run supply curve of oil. Next, aggregate demand shocks are innovations to world industrial production that cannot be accounted for by oil supply shocks. Further, aggregate demand shocks also indicate that an increase in the price of oil stemming from oil-specific demand shocks will not cause a decrease in the level of global industrial production within a given month, but may only cause a supply delay of at least a month. Lastly, oil-specific demand shocks are innovations to the price of oil that can be explained neither by demand nor by supply shocks. In other words, oil-specific demand shocks are assumed to reflect changes caused by speculative demand for oil or changes in precautionary demand, which, for example, are caused by uncertainty regarding future oil supply shortage.

The consumer price index block

The CPI block comprises only one equation, the consumer price index for the United States and Japan. The restriction of the last column of A_0^{-1} implies that CPI is not supposed to react to shocks to the global oil production, global industrial production, and oil price within the same month. In other words, while CPI is assumed to respond to all three structural oil shocks, ε_{4t} does not affect the global oil market with a delay of at least one month.

3.4. Empirical Results

In this section, we report the estimation results for the CPI block. First, we investigate aggregate price developments for the United States and Japan. Then, we focus on detailed expenditure category prices and the nature of the transmission of oil price shocks to the CPI. The results below are based on running VAR model (3.2) on indexes for expenditure category prices for each country.

The effect of oil price shocks on aggregate price

Figures 3.1 illustrate each country's aggregate price responses to each of the three structural shocks.

The pattern of responses to unanticipated oil supply disruptions appears similar between two countries. We find some evidence that oil supply shocks cause a slight temporary increase in the level of aggregate price. In fact, the price level declines in the long run, which supports Kilian (2009)'s findings. In both countries, the peak response occurs in the first year, followed by a gradual decline below the initial level. Most responses are statistically insignificant.

Aggregate demand shocks lead to a significant increase in the aggregate price index for both countries, but the amount of increase is relatively larger in the United States. Moreover, in the United States, the shocks cause a sustained level of shifts in aggregate price, which is statistically significant in all horizons; in Japan, the lower one-standard error band implies statistical significance for the first three years only.

Unanticipated oil-specific demand shocks lead to a temporary rise in aggregate price in the first two and a half years, followed by a decline below the starting point. Unlike the United States, the corresponding effects on Japan's aggregate price index are a significant increase for the first three and a half years. Moreover, the amount of increase is relatively larger than in the United States. This difference may reflect the fact that the oil-specific demand shock leads a global demand shift towards Japan's oil efficient products, especially in automobiles. And the price level in Japan increases under the good economic performance.

Oil price shocks on expenditure category prices

Figures 3.2–3.9 illustrate the estimated cumulative responses of expenditure category prices of the 16 selected categories in the United States and Japan to the 3 structural shocks identified in the global oil market block.

As in the response pattern of the aggregate price index, the pattern of responses to oil supply disruptions appears similar in many categories in the United States and Japan. For example, in both the United States and Japan, oil supply innovations cause a sustained and highly statistically significant decrease in the level of food at home, alcoholic beverages, and household furnishings and operations indexes. However, the magnitude and persistence of the effects in some categories differ greatly among two countries.

For example, oil supply disruptions significantly lower the level of shelter index in the United States. This may be reasoned by that oil supply shock can be considered as negative to economic activity according to the findings of Kilian (2009), thus it is natural to think that shelter index decrease in recession period. On the other hand, they have no significant effect on the level of shelter index in Japan. This difference may reflect the fact shelter index in the United States, by its calculation method, is more sensitive to exogenous shocks than that of Japan. In the formula used in Japan, when households move out and the houses become vacant, it is assumed that the rent stayed at the same price for a period until the next tenant. On the other hand, in the United States, in the case of moving-out, the index is to be estimated from other samples. Another difference is that unanticipated oil supply shocks cause a significant increase in the public transportation index in Japan, while the corresponding response in the US public transportation index is largely flat and statistically insignificant in all horizons.

The response patterns of the food at home and fuels and utilities indexes to aggregate demand shocks appear rather similar between the United States and Japan. The shocks cause large sustained increases from initial levels and the responses are mostly statistically significant. The major difference is that in the United States, unanticipated aggregate demand expansion causes a significant increase in the shelter, housing furnishings and operations, and public transportation indexes. On the other hand, in Japan, the responses of these indexes are not positive in almost all horizons. This difference may explain the result that the aggregate demand shocks shift the aggregate price index significantly upward in both countries, although the statistical significance reduces gradually in Japan.

The similarity in the impulse response pattern to oil-specific demand shocks is evident in the fuels and utilities and private transportation indexes. Unanticipated oil-specific demand expansion results in a persistent and significant increase in the fuels and utilities index in both the United States and Japan. The shock also causes an upward shift in the private transportation index from initial levels. The response of the US private transportation index is positive in all horizons, while in Japan, the response is insignificant between the 15th and 23rd months and the 43rd month onwards.

The following are the major differences in the responses of expenditure category prices between the United States and Japan, which may affect the development of the aggregate price index: In the United States, unanticipated oil-specific demand shocks bring a persistent decrease in the food at home, alcoholic beverages, food away from home, housing furnishings and operations, and other goods and services indexes. The response of the housing furnishings and operations index is statistically significant for all horizons. The responses of other indexes show statistical significance only after several months of the initial shocks. Interestingly, unlike in the United States, these price indexes do not go below the initial level in Japan. Unanticipated oil-specific demand expansion results in a sustained increase in the food at home and alcoholic beverages indexes. Although the stimulus effect reduces gradually, the indexes do not reduce below the initial level. Contrary to the United States, an increase in the oil-specific demand leads to a temporary rise in the food away from home, housing furnishings and operations, and other goods and services indexes, which reach the maximum level almost one year later, followed by a decline to the starting point.

3.5. Conclusion

Based on a two-block structural VAR model proposed by Kilian and Park (2009), we investigated the dynamic effects of changes in oil price on expenditure category CPI for the United States and Japan. To the best of our knowledge, ours is the first study to shed light on the transmission effects of oil price shocks on detailed CPI.

The main findings of our study can be summarized in the following manner: First, we revealed that each expenditure category price index responded very differently to the same structural shock. Second, we found that whether changes in oil price function as a positive stimulus or negative shock on the individual expenditure category prices also depends on what kind of underlying shock drives changes in oil price. Finally, we also revealed that the transmission mechanisms of higher oil price differ considerably between the United States and Japan. In other words, the manner in which changes in oil price affect each expenditure category price differ between the United States and Japan, and these differences may lead to differences in the response of aggregate prices in both countries to changes in oil price.

The results of our study imply that the policymaker, specifically the central bank, needs to understand the origins of a given oil price increase as each shock may require different policy adjustments. For example, given an increase in oil price, the central bank would merely increase the interest rates if the oil price surge stems from a demand shock. However, in the case of an exogenous oil supply shock or oil-specific demand shock, the central bank must initially consider whether it should suppress inflation by increasing interest rate and accepting output loss or just ignore the ongoing inflation. If it chooses to suppress inflation, then it might consider how much it must increase the interest rates in order to prevent changes in oil price from passing directly into core inflation. Although, understanding the origins of a higher oil price is important in the central bank's decision-making process, identifying the origin of shock is not easy. However, based on the fact that each expenditure category price responded very differently to the structural shocks and how the shocks affect each index also depends on the origins of the shocks, a category-level analysis may help policymakers to identify the source of the shocks.

Although our two-block structural VAR model enabled us to conduct a detailed investigation of the transmission mechanisms of changes in oil price, it abstracts from possible time-variation in parameters in the model. Considering the length of our sample period (from December 1974 to December 2010), there is a possibility that structural breaks occurred in the global oil market or domestic economy. To cope with this problem, time-varying VAR models that take into consideration possible structural breaks are promising way to facilitate our understanding of the transmission mechanisms of oil price shocks. In addition, further research is necessary to make a monetary policy explanation fully convincing. Assessing the effects of oil price shocks on expenditure category prices in other countries is a topic worth investigating in a future research study.

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Table 3.1: Data sources

Variable	Data source
World Production of Oil	Oil and Gas Journal
World Industrial Production	Organization for Economic Co-operation and Development(OECD)
WTI crude oil price	Federal Reserve Bank
Consumer Price Index (CPI) for the United States	Federal Reserve Economic Data
Consumer Price Index (CPI) for Japan	Ministry of Internal Affairs and Communications

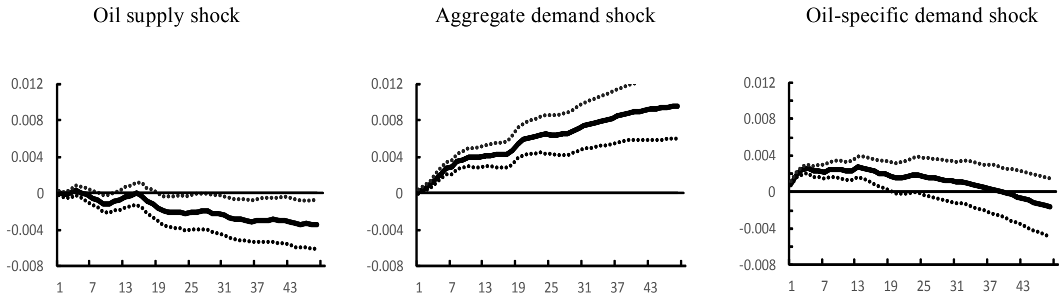
Source: Oil and Gas Journal, Organization for Economic Co-operation and Development(OECD), Federal Reserve Bank, Federal Reserve Economic Data, Ministry of Internal Affairs and Communications.

Table 3.2: Expenditure category CPI of the United States and Japan

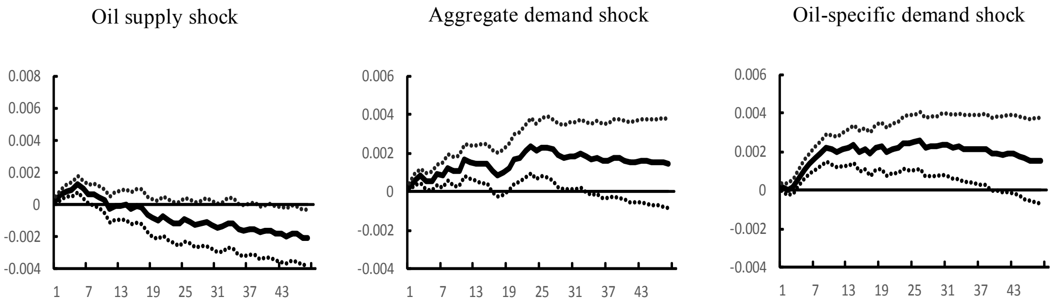
The U.S.		Japan	
Food and beverages		Based on similarity in definition, food index is used as a substitute	
	Food at home		Obtained by excluding alcoholic beverages and eals outside the home from food index
	Alcoholic beverages		Alcoholic beverages
	Food away from home		Based on similarity in definition, meals outside index is used as a substitute
Housing		Housing	
	Shelter		Based on similarity in definition, rent index is used as a substitute
	Fuels and utilities		Based on similarity in definition, fuel, light & water charges index is used as a substitute
	Household furnishings and operations		Obtained by summing repairs & maintenance index and furniture & household utensils index
Apparel		Clothes & footwear	
Medical care		Medical care	
	Medical care commodities		Obtained by medicines & health fortification and medical supplies & appliances
	Medical care services		Medical services
Transportation		Transportation	
	Public transportation		Public transportation
	Private transportation		Private transportation
Communication		Communication	
Education		Education	
Recreation		Based on similarity in definition, culture & recreation index is used as a substitute	
Other goods and services		Based on similarity in definition, miscellaneous index is used as a substitute	

Source: Federal Reserve Economic Data, Ministry of Internal Affairs and Communications

The United States



Japan



Figures 3.1: Cumulative responses of aggregate level CPI for the United States and Japan

Notes: Estimation is based on models (3.1)–(3.3). The dotted lines represent two-standard error bands.

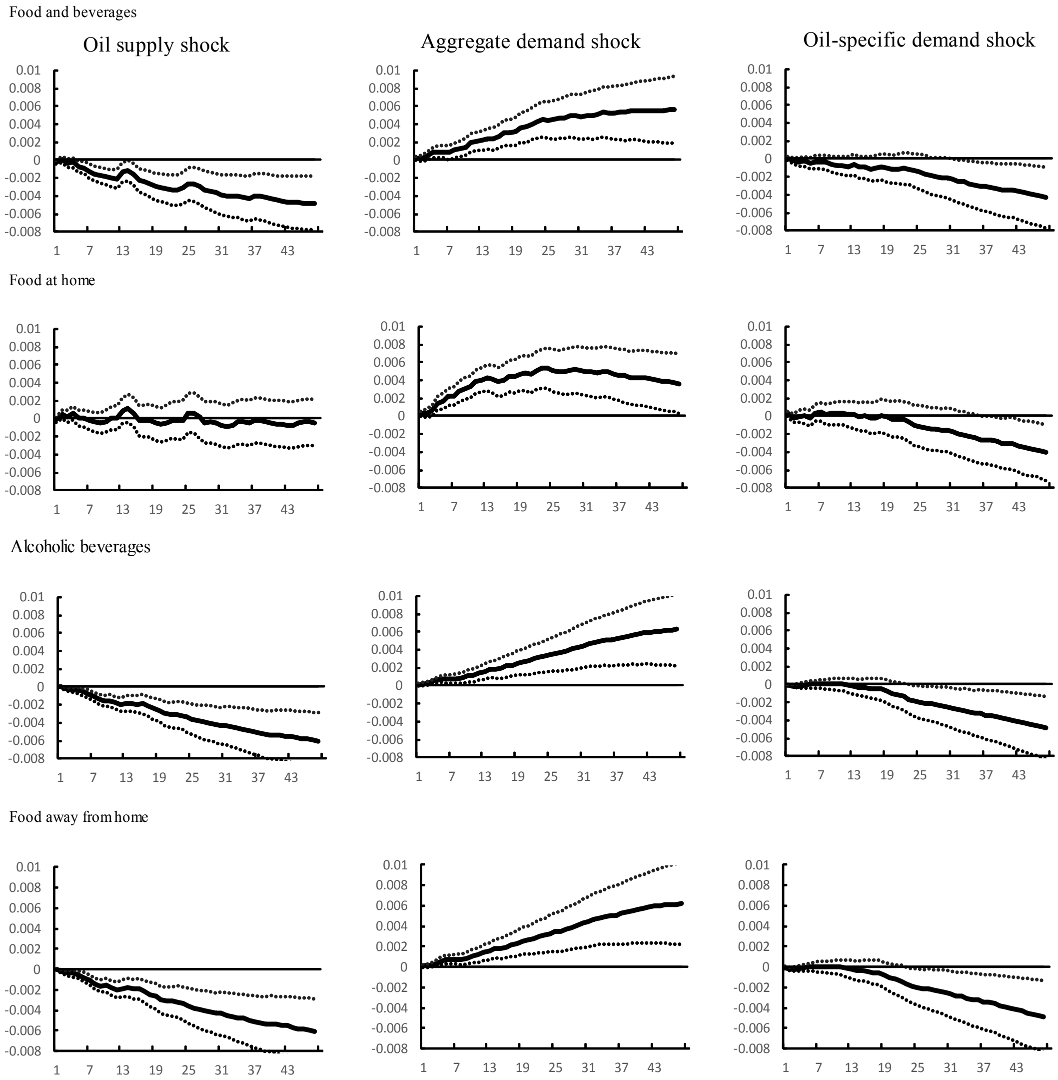


Figure 3.2: Cumulative responses of the food and beverages, food at home, alcoholic beverages, and food away from home indexes in the United States

Notes: Estimation is based on models (3.1)–(3.3). The dotted lines represent two-standard error bands.

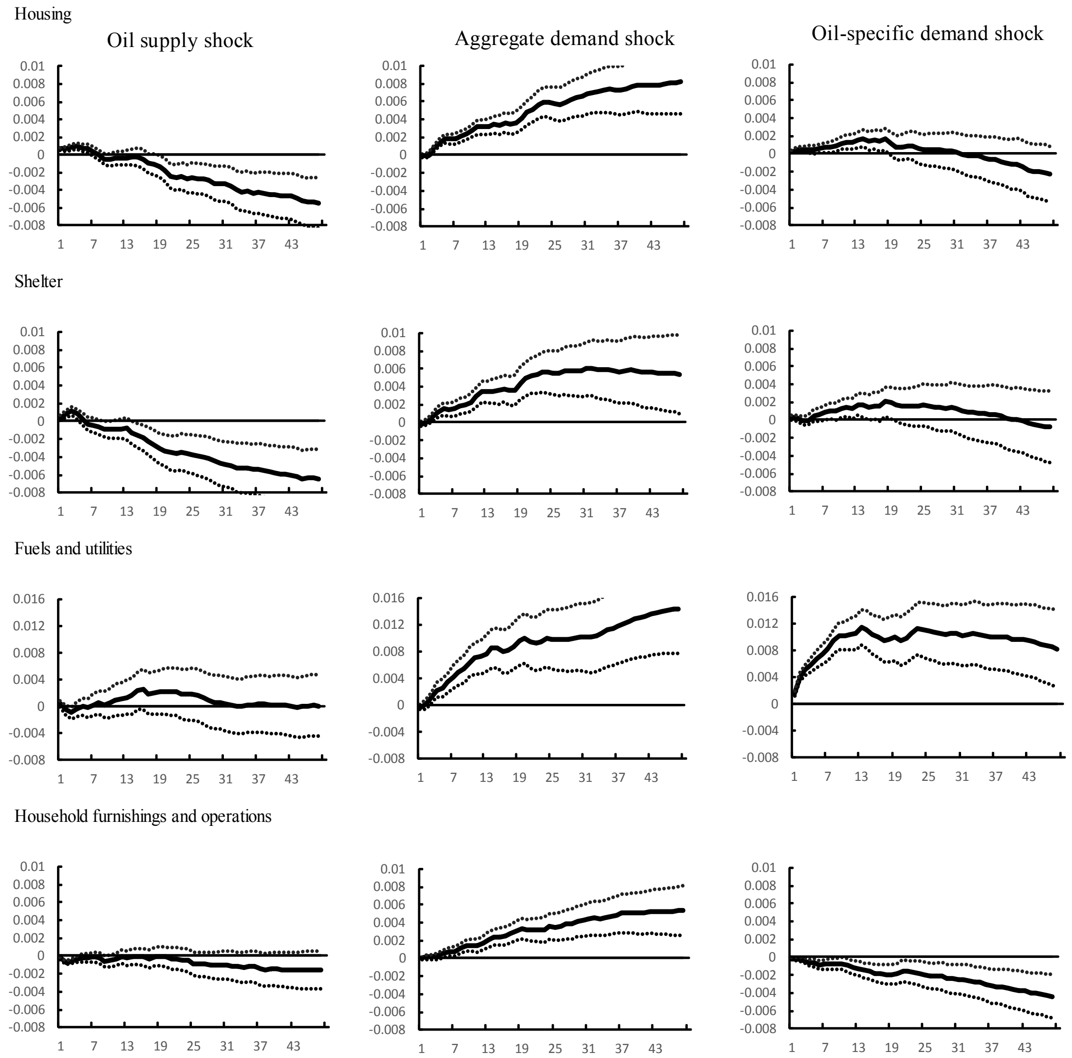


Figure 3.3: Cumulative responses of the housing, shelter, fuels and utilities and household furnishings and operations indexes in the United States

Notes: Estimation is based on models (3.1)–(3.3). The dotted lines represent two-standard error bands.

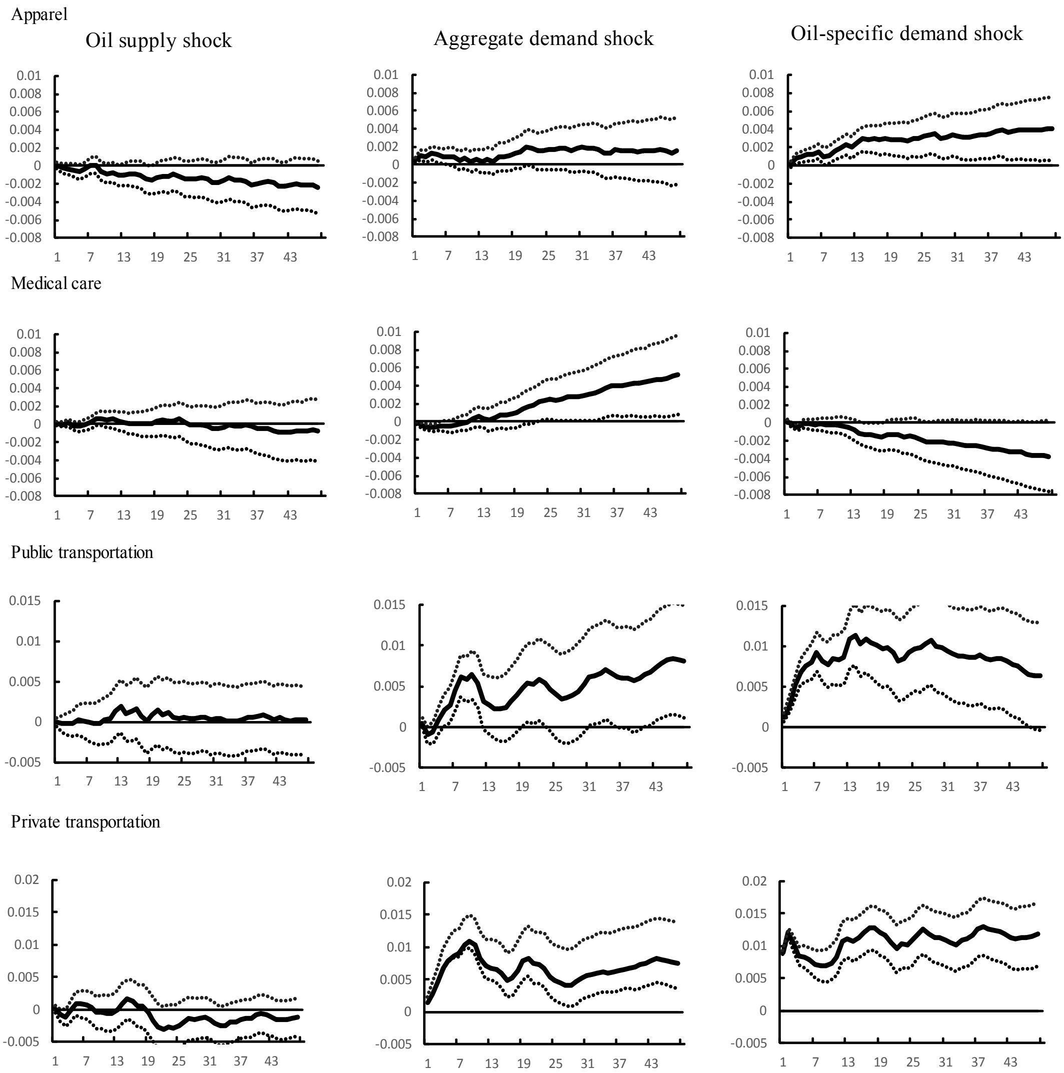


Figure 3.4: Cumulative responses of the apparel, medical care, public transportation, and private transportation indexes in the United States

Notes: Estimation is based on models (3.1)–(3.3). The dotted lines represent two-standard error bands.

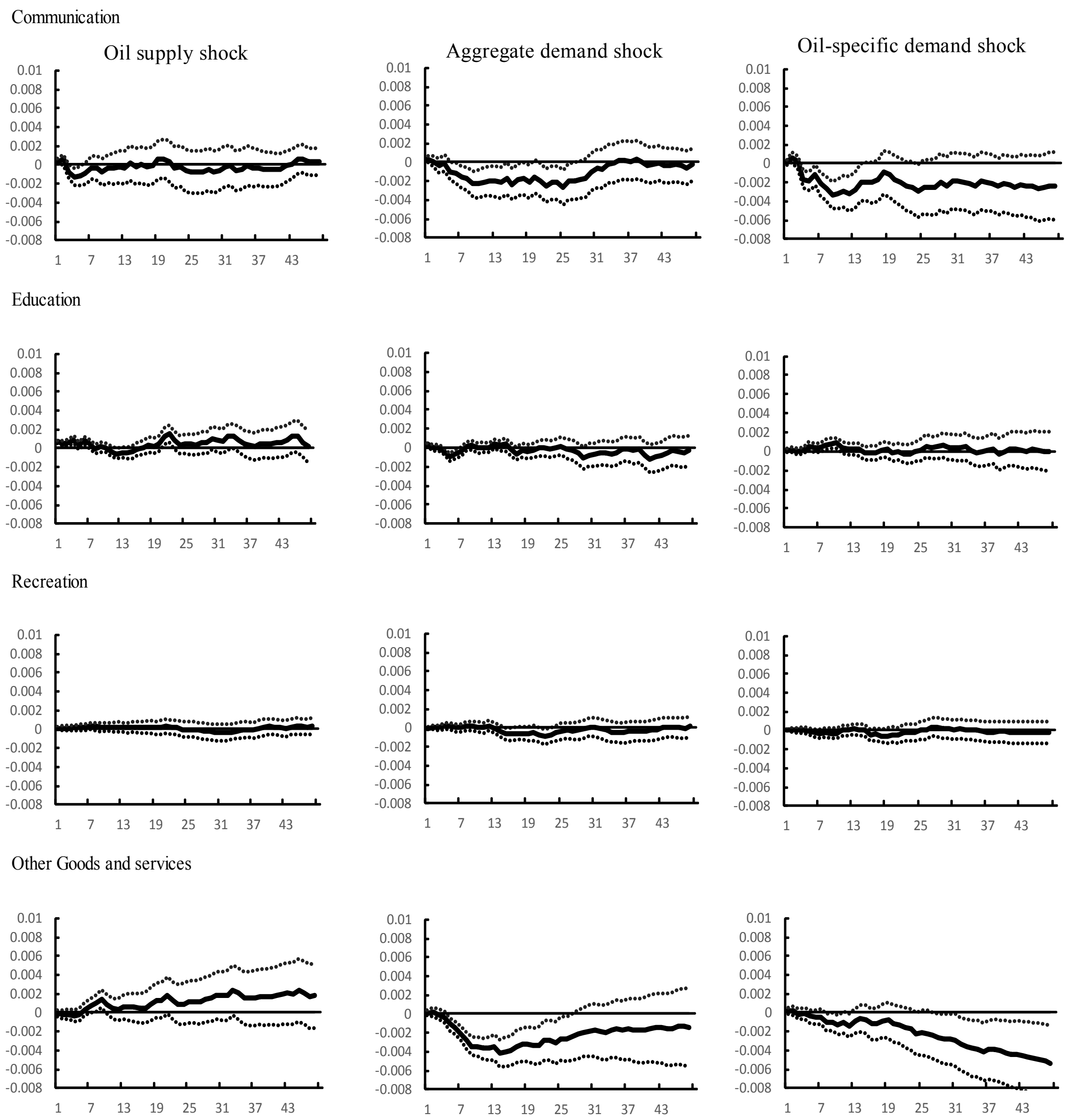
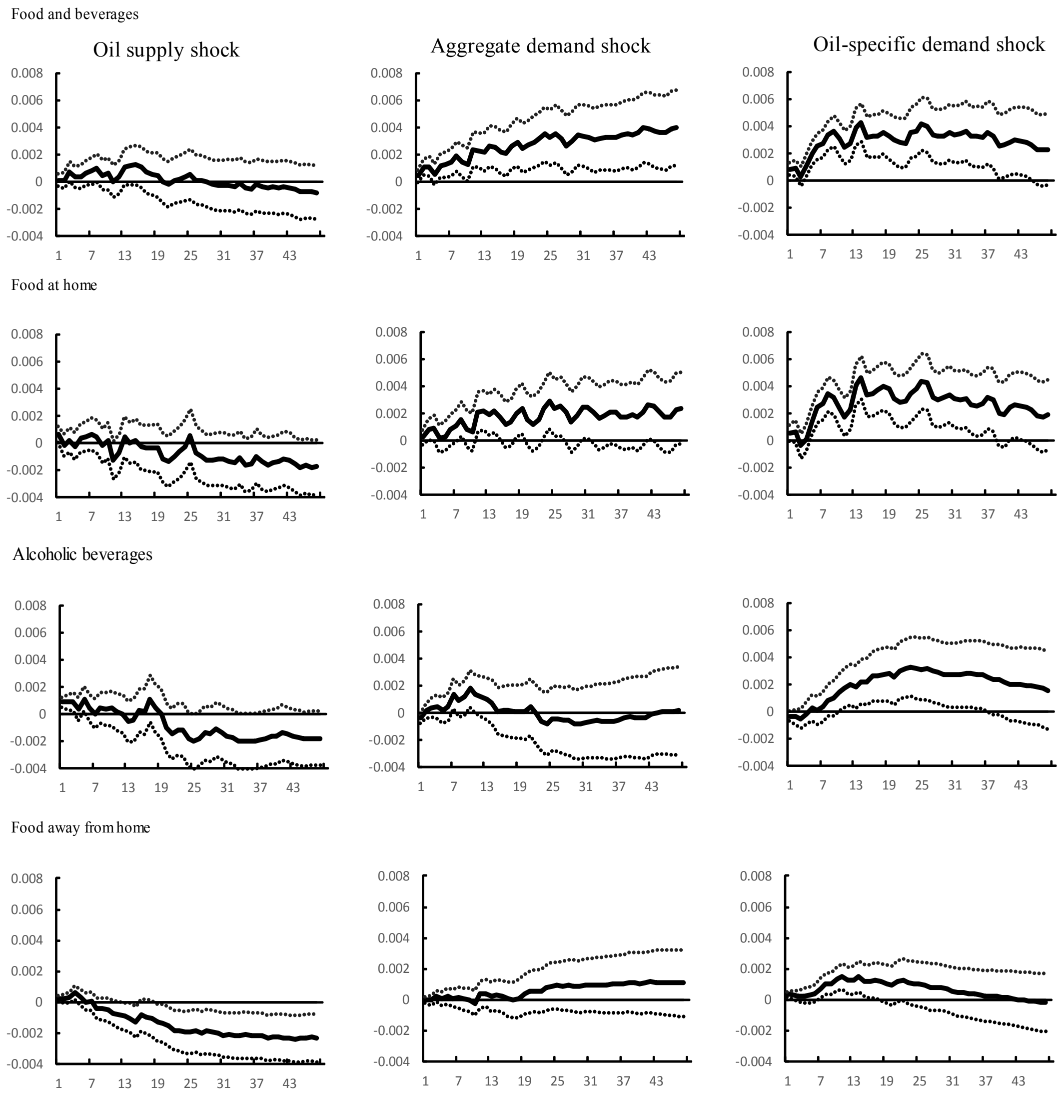


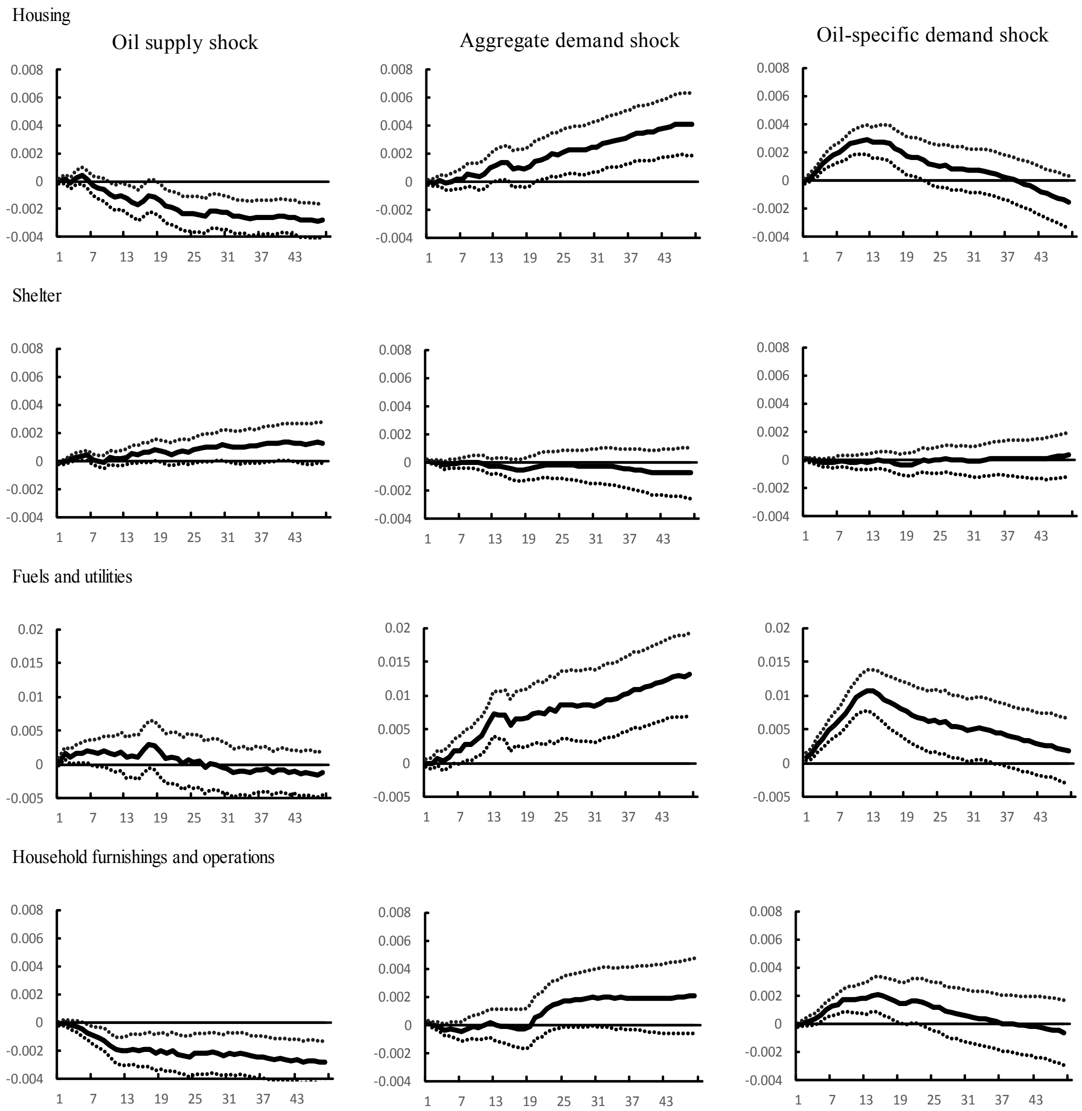
Figure 3.5: Cumulative responses of the communication, education, recreation, and other goods and services indexes in the United States

Notes: Estimation is based on models (3.1)–(3.3). The dotted lines represent two-standard error bands.



Figures 3.6: Cumulative responses of the food and beverages, food at home, alcoholic beverages, and food away from home indexes in Japan

Notes: Estimation is based on models (3.1)–(3.3). The dotted lines represent two-standard error bands.



Figures 3.7: Cumulative responses of the housing, shelter, fuels and utilities, and household furnishings and operations indexes in Japan

Notes: Estimation is based on models (3.1)–(3.3). The dotted lines represent two-standard error bands.

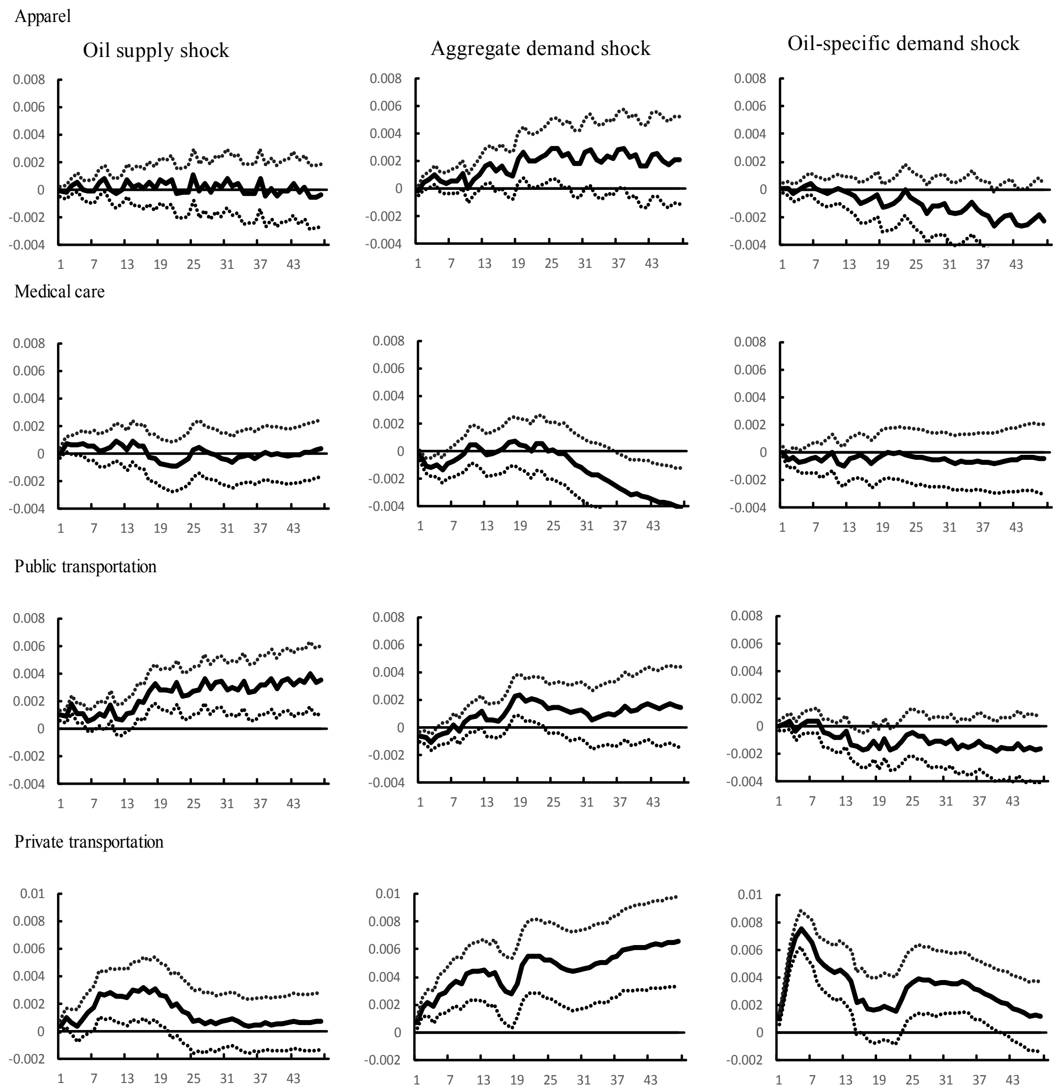
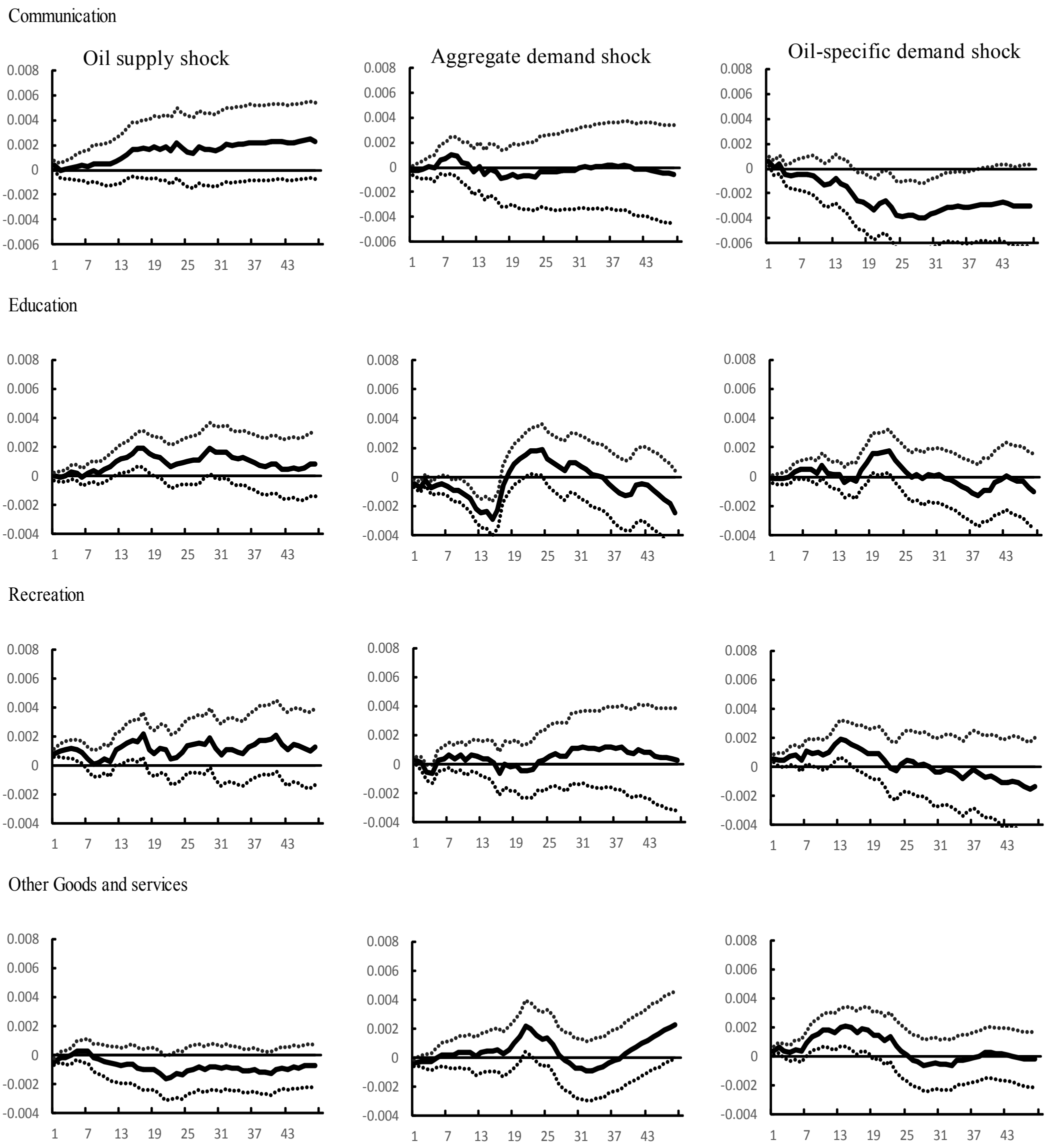


Figure 3.8: Cumulative responses of the apparel, medical care, public transportation, and private transportation indexes in Japan

Notes: Estimation is based on models (3.1)–(3.3). The dotted lines represent two-standard error bands.



Figures 3.9: Cumulative responses of the communication, education, recreation, and other goods and services indexes in Japan

Notes: Estimation is based on models (3.1)–(3.3). The dotted lines represent two-standard error bands.

Publication list

Chapter 1

Investigating effects of oil price changes on the US, the UK and Japan

Yoshizaki, Yasunori.

Economic Bulletin 31, 2641–2652 (2011).

Chapter 2

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

Yoshizaki, Yasunori., Hamori, Shigeyuki.

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Chapter 3

The Effects of Oil Price Shocks on Expenditure Category CPI

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