The Effects of Oil Price Changes on the Industry-Level Production and Prices in the U.S. and Japan*

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Abstract

In this paper, we decompose the oil price changes into three components as in Kilian (2009) and estimate the dynamic effects of each component on industry-level production and prices in the U.S. and Japan using identified VAR models. The way oil price changes affect each industry depends on what kind of the underlying shock drives the oil price changes as well as the industry's characteristics. Among the three structural shocks that all tend to raise the oil price, an oil supply shock acts mainly as a negative supply shock for oil-intensive industries and acts mainly as a negative demand shock for other industries. A global demand shock acts mainly as a positive demand shock and an oil-specific demand shock acts mainly as a negative supply shock for most industries in the U.S. Meanwhile, an oil-specific demand shock acts mainly as a positive demand shock for many industries in Japan.

Keywords: Oil price; Identified VAR; Industry-level data; Japan
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1 Introduction

There is a large body of empirical studies on the effects of oil price changes on the U.S. economy: their magnitudes, transmission mechanisms, and historical changes have been investigated. Meanwhile, the underlying causes of oil price changes have not been seriously considered until recently. The way oil price changes affect the economy may be very different depending on where the changes fundamentally come from. In particular, global factors such as rapid growth in emerging economies and integration of global supply chains seem to have become increasingly important for oil price changes in themselves and their transmission mechanisms.

Moreover, much has remained unknown about the effects of oil price changes in other countries than the U.S. Some recent empirical studies making international comparison show that the magnitudes of the effects of oil price changes considerably differ even among oil-importing countries. In particular, Japan is shown to be very different in the sense that oil price increases have little or even positive effects on the real economic activity.[1]

In this paper, we investigate the underlying causes of oil price changes and their transmission mechanisms in the U.S. and Japan's economy. We decompose the oil price changes and estimate the dynamic effects of each decomposed component on industry-level production and prices in both countries since the Oil Crisis in the 1970s using identified VAR models. Our models make two major extensions from the standard models used in the previous studies. First, we identify the underlying demand and supply shocks to the global oil market instead of treating oil price changes as exogenous shocks. Second, we use industry-level data as well as aggregate data to investigate the transmission mechanisms of oil price changes in more detail. Our models have three-block structures that consist of the global oil market block, the domestic macroeconomy block, and the domestic industry block. To our knowledge, this is the first attempt to investigate the effects of structural

[1] Among recent studies, for instance, Blanchard and Galí (2007) and Jiménez-Rodríguez and Sánchez (2004) show that the effects of oil price changes in Japan are exceptionally different from other oil-importing countries.

shocks to the global oil market on industry-level production and prices[2].

In identifying structural shocks to the global oil market, we follow Kilian (2009) who recently proposes a structural decomposition of the real price of oil into three components: oil supply shocks, shocks to the global demand for all industrial commodities, and demand shocks that are specific to the global oil market. Those three structural shocks that all tend to raise the oil price have very different effects on the domestic economic activity. While an unexpected disruption of oil supply (the first component above) and an unexpected increase in oil-specific demand (the third component) tend to reduce the domestic industrial production, an unexpected increase in the global demand (the second component) raises the production. One of the main reasons why the recent surge in the oil price after 2002 seemed to have smaller effects on the real economic activity than in the 1970s is that the oil price surge and the economic expansion were both driven by the global demand shocks at the same time.[3]

By examining industry-level effects of oil price changes, we can understand their transmission mechanisms in more detail. Lee and Ni (2002) estimate the effects of exogenous oil price shocks using the U.S. industry-level data and find that the oil price shocks act mainly as supply shocks for oil-intensive industries such as petroleum refinery and act mainly as demand shocks for many other industries.[4] They distinguish between demand and supply shocks depending on whether production and prices move in the same or opposite directions in response to the shocks. Our estimation results of the domestic industry block reveal that whether the oil price changes act

[2]Kilian and Park (2009) briefly analyze the effects of structural shocks to the global oil market on industry-level stock returns using a two-block VAR model.

[3]Blanchard and Galí (2007) list other reasons for the smaller effects: smaller share of oil in production, more flexible labor market, and improvements in monetary policy. Hirakata and Sudo (2009) point out that the declines in oil supply variation and its correlation with total factor productivity could be more important than changes in economic structures.

[4]Lee and Ni (2002) use Hamilton's (1996) "net oil price increase" as an oil price variable. Hooker (1996) casts doubt on the theoretical and empirical grounds of this variable for representing oil price shocks to the macroeconomy and argues that the use of cross-sectional data on industries, regions, or countries are required for a better understanding of the effects of oil price changes, in his reply to Hamilton (1996).

as supply shocks or demand shocks for each industry depends on what kind of the underlying shock drives the oil price changes as well as the industry's characteristics such as oil intensity. For most industries in the U.S., the global demand shocks act mainly as positive demand shocks and the oil-specific demand shocks act mainly as negative supply shocks. Meanwhile, the oil supply shocks act mainly as negative supply shocks for oil-intensive industries and act mainly as negative demand shocks for less oil-intensive industries, as the exogenous oil price shocks studied by Lee and Ni (2002).

Comparison between the U.S. and Japan also helps our understanding of the transmission mechanisms of oil price changes. Compared with the U.S., the oil supply shock has weaker negative or statistically insignificant effects, the global demand shock has stronger positive effects, and most importantly, the oil-specific demand shock has positive rather than negative effects on the production of many industries in Japan. All these can be the background of the results of the above mentioned recent studies that the effects of oil price increases on Japan's economy are small or even positive and very different from other oil-importing countries. The positive response of production to the oil-specific demand shock is possibly caused by global demand shifts, especially in automobiles, towards more oil-efficient products made in Japan. In this sense, unlike the U.S., the oil-specific demand shocks act mainly as demand shocks rather than supply shocks for many industries in Japan.

The remainder of the paper is organized as follows. Section 2 describes our empirical framework and the identified structural shocks to the global oil market. In Section 3, we briefly discuss the estimation results of the domestic macroeconomy block for the U.S. and Japan. Section 4 shows the estimation results of the domestic industry block for each industry in the two countries. In Section 5, we briefly survey the transmission mechanisms of oil price changes and interpret our estimation results in more detail. We also consider the background of the differences between the U.S. and Japan. Section 6 concludes.

2 Empirical Framework

2.1 The Structural VAR Model

Our VAR models consist of the global oil market block, the domestic macroeconomy block, and the domestic industry block. Following Lee and Ni (2002), we impose the block-recursive restrictions such that identified shocks to the global oil market are the same for each country and identified macroeconomic shocks are the same for each industry. In other words, domestic variables have no effects on global oil market variables, and industry-level variables have no effects on aggregate variables. An identified VAR model has the following form:

$$A_0 \, X_t = A_0 \, c + A_0 \, B(L) \, X_t + u_t$$

or

$$A_0 \begin{pmatrix} X_{1t} \\ X_{2t} \\ X_{3t} \end{pmatrix} = A_0 \begin{pmatrix} c_1 \\ c_2 \\ c_3 \end{pmatrix} + A_0 \begin{pmatrix} B_{11}(L) & 0 & 0 \\ B_{21}(L) & B_{22}(L) & 0 \\ B_{31}(L) & B_{32}(L) & B_{33}(L) \end{pmatrix} \begin{pmatrix} X_{1t} \\ X_{2t} \\ X_{3t} \end{pmatrix} + \begin{pmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \end{pmatrix}.$$

X_{1t} is an N_1 dimensional column vector of the global oil market variables, X_{2t} is an N_2 dimensional column vector of the domestic aggregate variables, and X_{3t} is an N_3 dimensional column vector of the domestic industry-level variables. c_1, c_2, and c_3 are vectors of constants. $B(L)$ is a block recursive matrix of polynomials of the lag operator L. Moreover, we assume that A_0 is a lower triangular matrix such that the reduced-form residuals can be decomposed into the structural shocks, u_t. The covariance matrix of the structural shocks, $E(u_t \, u_t')$, is given by an identity matrix of dimension $N(= N_1 + N_2 + N_3)$.

We use monthly data from 1973:1 to 2008:12. The lag length of the VAR is 12. Following Kilian (2009), we consider oil supply shocks, shocks to the global demand for all industrial commodities (global demand shocks[5]), and demand shocks that are specific to the global oil market (oil-specific demand

[5]Kilian (2009) refers to this structural shock as "aggregate demand shock," but this term can be confused with domestic aggregate disturbances in our model.

shocks) as structural shocks to the global oil market. Correspondingly, we use the world crude oil production, the industrial production of OECD plus major six non-member economies (hereafter, the world industrial production),[6] and the West Texas Intermediate spot crude oil price,[7] in the global oil market block ($N_1 = 3$). The latter two data are different from those used in Kilian (2009).[8] We use the nominal price of oil rather than the real price because the deflator is in any way endogenous with respect to the domestic macroeconomy so that our assumption of the block recursive structure would be violated.[9] For the domestic macroeconomy block, we only use the aggregate industrial production ($N_2 = 1$). For the domestic industry block, we use industrial production and producer prices ($N_3 = 2$).[10] We take log-differences of all the above variables. The industrial production in each block and producer prices are seasonally adjusted. The ordering of the variables in the VAR is as mentioned above.[11] The reduced form VAR is estimated consistently by the method of ordinary least squares.

2.2 Structural Shocks to the Global Oil Market

We follow Kilian (2009) to identify the structural shocks to the global oil market. The oil supply shocks are innovations to the global oil production that is assumed not to respond to innovations to the demand for oil within

[6]This index can be downloaded from OECD websites. The major six non-member economies include Brazil, China, India, Indonesia, Russian Federation and South Africa. Fueki and Kawamoto (2009) use this index to decompose oil price changes.

[7]The data prior to 1982 are the posted prices.

[8]Kilian (2009) uses his original measure of global real economic activity based on dry cargo freight rates and the U.S. refiner acquisition cost of imported crude oil deflated by the U.S. CPI. Both variables are the log levels. The world crude oil production he uses is the same as that we use.

[9]Hamilton (2008) and Rotemberg and Woodford (1996) point out this problem. We do not use the refiner acquisition cost of imported crude oil for the same reason.

[10]We use Indices of Industrial Production released by Federal Reserve Board and those released by Japanese Ministry of Economy, Trade, and Industry. For prices data, we use Producer Price Index released by the U.S. Bureau of Labor Statistics and Corporate Goods Price Index released by Bank of Japan.

[11]We tried an alternative ordering in the domestic industry block (prices first) and confirmed that the estimation results are qualitatively little changed.

the same month. The global demand shocks are innovations to the world industrial production that cannot be explained by the oil supply shocks. The oil-specific demand shocks are innovations to the oil price that cannot be explained by either the oil supply shocks or the global demand shocks. The latter structural shock is supposed to reflect changes in precautionary demand arising from uncertainty about the availability of future oil supply, and possibly also reflect changes in speculative demand, etc. Although we use slightly different data from Kilian (2009), the estimation results for the global oil market block in our model are basically similar to his results. Figure 1 plots the historical evolution (annual averages) of the structural shocks implied by our model. As shown in Kilian (2009), there was no unanticipated disruption of oil supply in 1978 or 1979 but there were in 1980 and 1981 associated with the outbreak of Iran-Iraq War. Positive shocks to the global demand have been repeated since 2003 and a large negative shock occurred in 2008. The oil-specific demand shocks have constantly occurred throughout the sample period.

The cumulative responses of the three variables in the global oil market block to one-standard deviation of the identified structural shocks are shown in Figure 2. The oil supply shock has been normalized to represent a negative shock to the oil production, while the other shocks have been normalized to represent positive shocks such that all shocks will tend to raise the oil price. One standard error bands computed through a bootstrap method are indicated by dashed lines. Among the three shocks, the oil-specific demand shock has the largest and most persistent effect on the oil price. It raises the oil price sharply on impact, the level of which remains high for a long time. The global demand shock also has large and persistent effect, which causes a gradual increase of the oil price lasting for about a year (12 months). The oil supply shock has only small and transitory effect, which causes a gradual increase of the oil price lasting for about 4 months. While an unexpected global demand increase is associated with increases in the oil production and the world industrial production, an unexpected oil-specific demand increase is associated with decreases, though delayed for about 10 months after the shocks, in the oil production and the world industrial production. An unexpected disruption of oil supply is also associated with decreases in the oil production and its effect on the world industrial production is statistically insignificant. These results imply that the three shocks have different effect in magnitude and persistence on the oil price and that the effects of oil price changes on the oil production and the world industrial production are very different depending on what kind of the underlying shock drives the oil price changes.

Figure 3 plots a historical decomposition of the oil price into the contribution of the structural shocks. The annual rate of change (log-difference) in the oil price is indicated by dashed line in each panel. The oil supply shocks have made small contribution to the nominal oil price, as to the real price of oil shown in Kilian (2009). Most changes in the nominal oil price before 2000 have been driven by the oil-specific demand shocks. Rapid temporary changes such as the sharp fall following the collapse of the OPEC cartel in late 1985 and the spike after the Iraqi invasion of Kuwait in 1990, which are not vividly shown in the annual figures, were also attributed mainly to the oil-specific demand shocks. Meanwhile, the long-lasting surge in the oil price after 2002 and its sharp fall in 2008 have been driven by the global demand shocks as well as the oil-specific demand shocks.

3 Macroeconomic Effects of Oil Price Changes

In this section, we briefly discuss the estimation results of the domestic macroeconomy block in our models for the U.S. and Japan and make a comparison between them. The domestic macroeconomic block includes only one variable, the aggregate industrial production. The shock to this block captures all domestic aggregate disturbances not driven by the structural shocks identified in the global oil market block. Since our main concerns in this paper are the industry-level effects of oil price changes and a flat comparison between those in the U.S. and Japan, we keep the domestic macroeconomic block as simple as possible.

3.1 Effects on Aggregate Production in U.S.

Figure 4 shows the cumulative responses of the aggregate industrial production in the U.S. to one-standard deviation of the structural shocks identified in the global oil market block and the domestic aggregate shock. The three structural shocks that all tend to raise the oil price have very different effects on the domestic macroeconomic activity. While the oil supply shock and the oil-specific demand shock reduce the industrial production, the global demand shock raises the production for about 10 months. Whereas the decrease in the production caused by the oil supply shock lasts for about 10 months, the decrease caused by the oil-specific demand shock accelerates around 10 months after the shock. Meanwhile, the domestic aggregate shock raises the production gradually and persistently.

Figure 5 plots a historical decomposition of the U.S. aggregate industrial production into the contribution of the three global shocks and the domestic aggregate shock. The annual rate of change in the U.S. industrial production is indicated by dashed line in each panel. Changes in the U.S. industrial production have been driven mainly by the global demand shocks and the domestic aggregate shocks. Since the U.S. production takes a large part of the world production, it seems natural that the global demand shocks have contributed much to the U.S. production. Nonetheless, it should be noted that movements of the U.S. production in the 2000s have been driven mainly by the global demand shocks despite the fact that the U.S. share in the world production have been decreasing in the same period. By contrast, the contribution of the domestic aggregate shocks, which contributed much to the expansion in the 1990s, has decreased in the 2000s. Since the oil price and the industrial production move in the same direction in response to the global demand shocks, the relationship between them seems to have changed in the 2000s when movements in the two variables have been driven by the global demand shocks.

3.2 Effects on Aggregate Production in Japan

The cumulative responses of the aggregate industrial production in Japan are shown in Figure 6. They are considerably different from those in the U.S. The effect of the oil supply shock on Japan's industrial production is statistically insignificant. The positive effect of the global demand shock is larger and more persistent than in the U.S. Most importantly, the oil-specific demand shock has positive rather than negative effect on Japan's production, at least in the short run. The production starts decreasing around a half year after a positive oil-specific demand shock. All these imply that the effects of oil price increases on Japan's economy are small or even positive, which are different from other oil-importing countries including the U.S. Meanwhile, the effect of the domestic aggregate shock is larger than in the U.S.

A historical decomposition of Japan's aggregate industrial production is shown in Figure 7. The annual rate of change in Japan's industrial production is indicated by dashed line in each panel. As in the U.S., changes in Japan's industrial production have been driven mainly by the global demand shocks and the domestic aggregate shocks. While the contraction in the 1990s were driven mainly by the domestic aggregate shocks, the expansion in the 2000s were driven mainly by the global demand shocks. Compared with the U.S., the overall contributions of domestic aggregate shocks have been larger to Japan's industrial production.

4 Industry-Level Effects of Oil Price Changes

In this section, we show the estimation results of the domestic industry block. As mentioned in the introduction, our motivation for using industry-level data is to investigate the transmission mechanisms of oil price changes in the U.S. and Japan's economy. In particular, an important question is whether the oil price changes act as supply shocks or demand shocks for each industry. Before showing the estimation results, we briefly summarize the basic statistics of the industrial structures in the U.S. and Japan, which may characterize the supply and demand sides of the transmission mechanisms. We will discuss the detailed implications of the estimation results in Section 5.

4.1 Basic Statistics of Industrial Structures

Table 1 shows the value-added share of the 12 industries in the U.S. and Japan selected for the present study in the aggregate industrial production in each country. Although the total share of our selected industries in the U.S. is only around 40 percent, we select key industries for the transmission mechanisms of oil price changes, as discussed in Section 5, including petroleum refineries, automotive products, etc. Since we have to match industry-level production and prices data, we cannot select some broad (three-digit NAICS) industries. Meanwhile, the total share of our selected industries in Japan is around 80 percent, where broad industries data are available for both production and prices but long time-series data for detailed industries are not available. For instance, petroleum refineries are included in "petroleum and coal products" and automotive products are included in "transportation equipment." From Table 1, we can also see that some industries' shares have considerably changed during our sample period. For instance, in the U.S., chemical materials and petroleum refineries increased their shares while fabricated metal product and machinery decreased their shares from 1973 to 2006. In Japan, electric machinery and transportation equipment increased their shares while ceramic, stone, and clay products decreased their share from 1975 to 2005.

We consider two industry characteristics: oil intensity and export dependence. The former means the cost share of oil and a key characteristic for the supply channel of transmission of oil price changes, as discussed in Section 5. The latter means the export share of shipments and a key characteristic for the effects of the global demand shocks. We calculate these characteristics for both countries based on the 2000 Japan-U.S. input-output table released by Japanese Ministry of Economy, Trade, and Industry.

Table 2 shows the cost share of oil in each industry in both countries.[12] The oil intensity of petroleum and coal products which includes petroleum refineries is prominently high in both countries. Those of ceramic, stone, and clay products, chemical products, steel and steel products, and non-steel metals and products are also relatively high. We call the above "oil-intensive industries" and the others "less oil-intensive industries." In the 12-industry average, Japan is less oil-intensive than the U.S.

Table 3 shows the export share of shipments in each industry in both countries. The export dependences of precision instrument, electric machinery, general machinery, and transportation equipment which includes automotive products are prominently high in both countries. We call the above "export-dependent industries." In the 12-industry average, Japan is more export-dependent than the U.S.

4.2 Effects on Industry-Level Production and Prices in U.S.

The estimated cumulative responses of production and prices of the 12 selected industries in the U.S. to one-standard deviation of the three structural shocks identified in the global oil market block are shown in Figure 8 through 13. Each response is accompanied by one standard error bands computed through a bootstrap method. Those charts for the selected industries are shown in the order of the oil intensity. Note that the scales of the responses are different for different industries. For cross-industry comparison, we show the magnitudes of the 12-month cumulative responses for all the 12 industries in Figure 14. Moreover, we summarize the signs of the peak responses within 20 months after each shock in Table 4, following Lee and Ni (2002).[13] Based on this table, we can identify the main effects of each structural shock for

[12] The figures show the input cost shares of "mining" and "petroleum and coal products."

[13] Lee and Ni (2002) plot the responses of level series to a *temporary* level shock rather than the cumulative responses of first-difference series to a *permanent* level shock as ours. Therefore, implications of the responses, especially in the long run, are different between theirs and ours.

each industry. If production and price move in the same (opposite) direction after a shock, the dominant effect of that shock is on the demand (supply) side.

First we look at the responses of production and prices to the oil supply shock shown in Figure 8 and 9. In most industries, an unexpected disruption of oil supply causes a gradual decline in the production lasting for about a year. The production of petroleum refineries declines upon impact and then continue to decline gradually and persistently. Meanwhile, the responses of the prices vary across industries. An unexpected oil supply disruption significantly raises the price of petroleum refineries and reduces the prices of wood product and electrical equipment. It tend to raise the prices of oil-intensive industries and tend to reduce the prices of less oil-intensive industries, though these directions for many industries are only partially statistically significant. This implies that the oil supply shocks act mainly as supply shocks for oil-intensive industries and act mainly as demand shocks for less oil-intensive industries, which is the same as exogenous oil price shocks studied by Lee and Ni (2002).

Figure 10 and 11 show the responses to the global demand shock. An unexpected expansion in the global demand for all industrial commodities causes gradual increases in the production of most industries. While the increases in the production of some export-dependent industries such as machinery and electrical equipment last for about a year, the increases in many industries last for only a few months or half a year. In particular, automotive products, furniture and related product, wood product, and some oil-intensive industries including petroleum refineries have only short-lived increases in the production. At the same time, the positive global demand shock causes gradual and persistent increases in the prices of most industries. The increase in the prices of petroleum refineries is the largest among the industries. The prices of many less oil-intensive industries also increase, though the magnitudes of their increases are smaller than those of oil-intensive industries. These results imply that the global demand shocks act mainly as demand shocks, at least in the short run, for most industries. Note that these global demand shocks act as positive demand shocks for many industries, which differ from the oil supply shocks that act as negative demand shocks for less oil-intensive industries.

The responses to the oil-specific demand shock are shown in Figure 12 and 13. An unexpected increase in demand that is specific to the global oil market causes gradual and persistent decreases, after about half-year lags, in the production of most industries. The decrease in automotive production is the largest and those in the production of oil-intensive industries are relatively smaller in magnitude. At the same time, the positive oil-specific demand shock causes persistent increases in the prices of most industries. The prices of petroleum refineries increase upon impact and then continue to rise until around a year after the shock, and the magnitude of its increase is the largest among the industries. The prices of many less oil-intensive industries including automotive products also increase, though the magnitudes of their increases are smaller than those of oil-intensive industries. These results imply that the oil-specific demand shocks act mainly as supply shocks, more or less, for most industries.

4.3 Effects on Industry-Level Production and Prices in Japan

Next we examine the estimated cumulative responses of production and prices of the 12 selected industries in Japan to the same structural shocks, which are shown in Figure 15 through 20. The magnitudes of the 12-month cumulative responses for all the 12 industries are shown in Figure 21. The signs of the peak responses are summarized in Table 5.

Figure 15 and 16 show the responses to the oil supply shock. An unexpected disruption of oil supply causes a gradual decline in the production of petroleum refineries lasting for about a year. The production of many other industries also decline, though the directions are only partially statistically significant. At the same time, the oil supply disruption causes a gradual increase in the price of petroleum refineries also lasting for about a year.

The prices of some other oil-intensive industries such as ceramic, stone, and clay products and iron and steel products decrease, though the directions are again only partially statistically significant. The effects on the prices of less oil-intensive industries are almost statistically insignificant. Overall, the oil supply shocks act mainly as supply shocks for petroleum refineries but have insignificant effects on many other industries in Japan.

The responses to the global demand shock are shown in Figure 17 and 18. As in the U.S., an unexpected expansion in the global demand for all industrial commodities causes gradual increases in the production of most industries in Japan. While the increases in the production of some oil-intensive industries such as petroleum and coal products last for only about half a year, the increases in the production of many less oil-intensive and export-dependent industries last for about a year and are larger than those of oil-intensive industries in magnitude. Compared with the U.S., the global demand shocks have persistent effects on the production of a wider range of industries including, for instance, transportation equipment. At the same time, a positive global demand shock causes gradual and persistent increases in the prices of many industries, especially oil-intensive industries. Meanwhile, the prices of some less oil-intensive industries such as precision instruments and transportation equipment decrease rather than increase, at least in the short run. As in the U.S., the global demand shocks act mainly as demand shocks for most industries in Japan, but the magnitude and persistence of the effects in some industries are considerably different from those in the U.S.

Lastly the responses to the oil-specific demand shock are shown in Figure 19 and 20. Among the three structural shocks, the responses to this shock are the most different between the U.S. and Japan. In contrast to the U.S., an unexpected increase in demand that is specific to the global oil market causes increases rather than decreases, at least in the short run, in the production of most industries in Japan. While the increases in the production of oil-intensive industries are small and transitory, the increases in the production of some less oil-intensive and export-dependent industries such as general machinery, precision instruments, and transportation equipment last for about a year. Therefore, the oil-specific demand shocks have similar effects on the production to the global demand shocks, though the magnitudes of the former effects are much smaller than the latter. At the same time, the positive oil-specific demand shock causes gradual and persistent increases in the prices of most industries. Unlike in the U.S., the oil-specific demand shocks act mainly as demand shocks rather than supply shocks for many industries in Japan.

From the overall comparison between the U.S. and Japan, the oil supply shock has weaker negative or statistically insignificant effects, the global demand shock has stronger positive effects, and the oil-specific demand shock has positive rather than negative effects on the production of many industries in Japan than in the U.S. Meanwhile, the effects of the three structural shocks that all tend to raise the oil price on the industry-level prices in Japan are weaker than in the U.S. We will discuss the background of these differences in the next section.

5 Discussion

The estimation results for the domestic industry block in Section 4 reveal that whether the oil price changes act as supply shocks or demand shocks for each industry depends on what kind of the underlying shock drives the oil price changes. It also depends on each industry's characteristics: oil price changes tend to act more as supply shocks for oil-intensive industries and tend to act more as demand shocks for less oil-intensive industries, as shown in Lee and Ni (2002). However, our results imply that the global demand shocks act mainly as demand shocks and the oil-specific demand shocks act mainly as supply shocks in the U.S., more or less for most industries. This is a key finding in the present study. With this finding in mind, we briefly survey the transmission mechanisms of oil price changes and interpret our estimation results in more detail. The three structural shocks to the global oil market identified in our model are transmitted to each industry through various channels, some of which are familiar and others are less familiar in the literature.[14]

Another key finding is that the transmission mechanisms are considerably different between the U.S. and Japan. In particular, the oil-specific demand shocks act mainly as demand shocks rather than supply shocks for many industries in Japan. After the discussion on the transmission mechanisms, we consider the background of the differences between the U.S. and Japan.

5.1 Transmission Mechanisms of Oil Price Changes

Oil price changes have been viewed traditionally as cost shocks or productivity shocks to oil-importing countries and many studies have been focused on the supply side of their transmission mechanisms. When an oil price hike pushes up production costs, producers reduce the usage of oil, which could lower the productivity of capital and labor. This cost channel or supply channel of transmission operates mainly in oil-intensive industries. In our estimation results, the magnitudes of the price responses to any kind of the structural shocks to the global oil market are relatively large in oil-intensive industries, especially petroleum refineries. However, the responses of the production of oil-intensive industries are not necessarily large. The effect of an oil-specific demand shock on their production in the U.S. is smaller than that of less oil-intensive industries such as automotive products. A positive global demand shock causes increases rather than decreases in the production of oil-intensive industries, which moves in the same direction as prices. Since the economy-wide cost share of oil is very small, it seems natural to consider that the direct effect of the cost channel by itself cannot explain the whole impact of oil price changes on the economic activity.[15]

Another important channel of the transmission is on the demand side of

[14] The survey below is limited to those related to our estimation results. Since our models do not explicitly consider either monetary policy shocks or endogenous responses of monetary policy to oil price changes, we do not mention the relationship between oil prices and monetary policy.

[15] Hamilton (2008) discusses the empirical relevance of the cost channel in his survey on the transmission mechanisms of oil price changes to the macroeconomy.

the economy. Kilian (2008) categorizes the effects of oil price changes on consumption expenditure into a discretionary income effect, a precautionary savings effect, an uncertainty effect, and an operating cost effect.[16] While the former two effects that operate through consumers' present and expected future income cover a wide range of goods and services, the latter two effects are limited to consumer durables. The uncertainty effect of oil price changes causes consumers to postpone irreversible purchases of consumer durables, and the operating cost effect causes consumers to refrain from purchasing oil-using durables, especially automobiles. In our estimation results, the magnitude of the decrease in the U.S. automotive production caused by a positive oil-specific demand shock is the largest among the U.S. industries. This implies that the oil-specific demand shocks act as demand shocks as well as supply shocks for the U.S. automotive industry, though the negative effect on prices through the demand channel are weaker than the positive effect on prices through the supply channel. Note that the above effects of oil price increases all reduce consumption expenditure, that is, the oil price increases act as negative demand shocks. By contrast, the global demand shocks identified in our model act mainly as positive demand shocks. This is because those shocks by construction contain positive shocks to the income of the U.S. or other countries' residents who purchase the U.S. products. More precisely, however, the global demand shocks act as both positive and negative demand shocks: the positive effects through the positive income shocks and the negative effects through the oil price increases caused by the same shocks are offsetting each other. In our estimation results, the increase in the U.S. automotive production caused by a positive global demand shock is very small and transitory compared with other less oil-intensive industries such as machinery and electrical equipment. This is because the negative effect through the oil price increase in the automotive industry is stronger than in other less oil-intensive industries.

If oil price changes intensively affect a certain sector of the economy,

[16] There are also the effects of oil price changes on firms' investment expenditures, which are presumably small according to Kilian (2008).

whether through the supply or demand channel, sectoral shifts of resources between the affected sector and less affected sectors are likely to occur. In the process of those sectoral shifts, some resources might be unemployed by any sectors due to frictions in capital and labor markets, which could further depress the aggregate economy and amplify the negative effects of oil price changes. This reallocation effect has been pointed out by many researchers including Hamilton (1988) and Davis and Haltiwanger (2001). From our estimation results, we cannot find clear evidences of a sizable amount of resource reallocation across industries both in the U.S. and Japan. Although the magnitudes of the responses of production to each kind of shocks differ considerably across industries, the directions are the same for most industries.

Meanwhile, some of our results imply the existence of demand shifts across countries. The increases in the production of export-dependent industries such as machinery and electric equipment caused by a positive global demand shock tend to be large and more persistent than those of less export-dependent industries both in the U.S. and Japan. This is because, as mentioned above, the global demand shocks partly reflect changes in the income of foreign residents who purchase domestic products. Moreover, one important factor that makes a big difference in the effects of the oil-specific demand shocks between the U.S. and Japan may be a demand shift between the two countries, as discussed below. These global transmission channels of oil price changes are relatively less considered in the literature.[17]

5.2 Differences between U.S. and Japan

Based on the above discussions, we consider the background of the differences between the U.S. and Japan in our estimation results. Compared with the U.S., the oil supply shock has weaker or statistically insignificant effects and the global demand shock has stronger effects on the production of many industries in Japan. These differences are explained by the facts that Japan

[17]For instance, Abeysinghe (2001) estimates an "indirect effect" of oil prices changes on GDP growth of 12 economies, mainly Asian emerging economies, which is transmitted through a trade matrix.

is overall less oil-intensive and more export-dependent economy than the U.S., as shown in Section 4.1.

The biggest difference is in the effects of the oil-specific demand shocks. The production, as well as the prices, of many industries in Japan increases rather than decreases in response to a positive oil-specific demand shock. Therefore, the oil-specific demand shocks act mainly as positive demand shocks, similarly to the global demand shocks. This implies the existence of some oil-specific factors of global demand shifts towards Japanese products that cannot be explained by the global demand shocks. We consider the oil-efficiency of Japanese products as one of such factors. In particular, Japanese automotive manufacturers have produced smaller and more oil-efficient cars than the U.S. manufacturers since before 1970s. The Oil Crisis in the 1970s caused a massive demand shift towards small cars and severe damages to the U.S. carmakers who produced only large cars, as documented by Bresnahan and Ramey (1993) among others. At the same time, Japanese carmakers sharply raised their shares in the U.S. market.[18] In 2004-06, Japanese cars are still more fuel-efficient than the U.S. cars, as shown in Figure 22, and the market share of Japanese cars in the U.S. has been still increasing. These demand shifts may be an important factor of the stark difference between the U.S. and Japan in the response of automotive production to the oil-specific demand shocks, which is the biggest difference among our selected industries. Moreover, the demand for automotive products induces the production of many other industries such as steel, precision instruments, etc. Although the value-added share of passenger cars (excluding buses and trucks) in Japanese industrial production is only about 8.5 percent, the economy-wide impacts of the demand shifts towards Japanese cars may be not so small.

[18] There is a large body of empirical studies on the U.S. automobile market. For instance, Goldberg (1998) examines the effects of the Corporate Average Fuel Economy Standards enacted in 1975 on automobile sales, prices, and fuel consumption, considering demand shifts towards more fuel-efficient vehicles.

6 Concluding Remarks

In this paper, we decompose the oil price changes into three components as in Kilian (2009) and estimate the dynamic effects of each component on industry-level production and prices in the U.S. and Japan using identified VAR models. Our results reveal that the way oil price changes affect each industry depends on what kind of the underlying shock drives the oil price changes as well as the industry's characteristics. We also find that the transmission mechanisms are considerably different between the U.S. and Japan.

Our results imply that global demand shifts across countries are important factors for oil price changes in themselves and their transmission mechanisms. We have considered the global demand shocks as an underlying causes of oil price changes and discussed global demand shifts towards more oil-efficient products. It would be fruitful to investigate the differences in the effects of oil price changes among various countries other than the U.S. and Japan for our better understanding of their transmission mechanisms. Moreover, developing open-economy dynamic stochastic general equilibrium models that incorporate the global oil market is also a promising way for deepening our understanding and for interpreting various empirical results on the effects of oil price changes.

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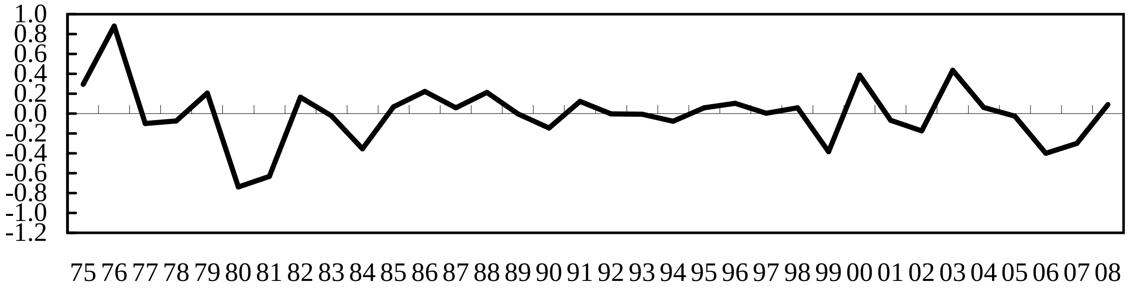
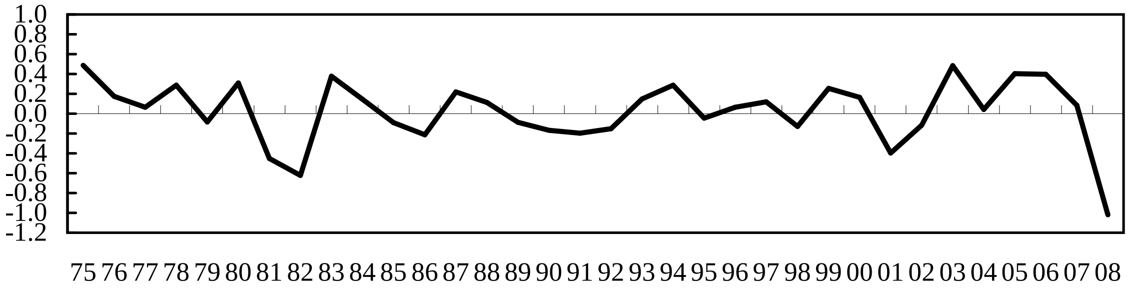
Figure 1: Historical evolution of the structural shocks

Oil Supply Shocks



Global Demand Shocks



Oil-Specific Demand Shocks

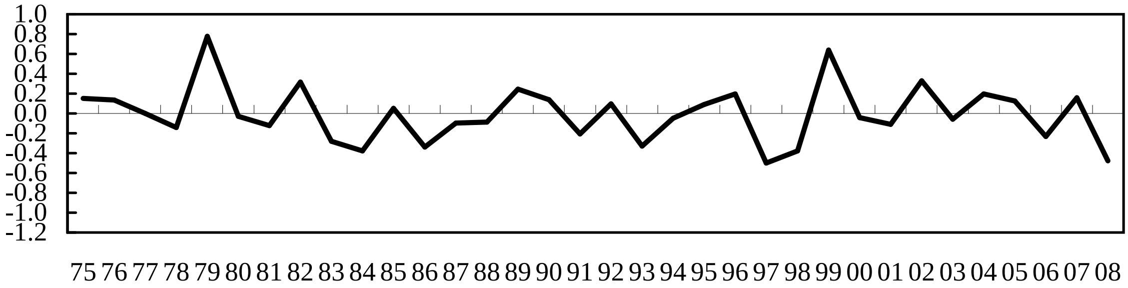


Figure 2: Cumulative responses in the global oil market block

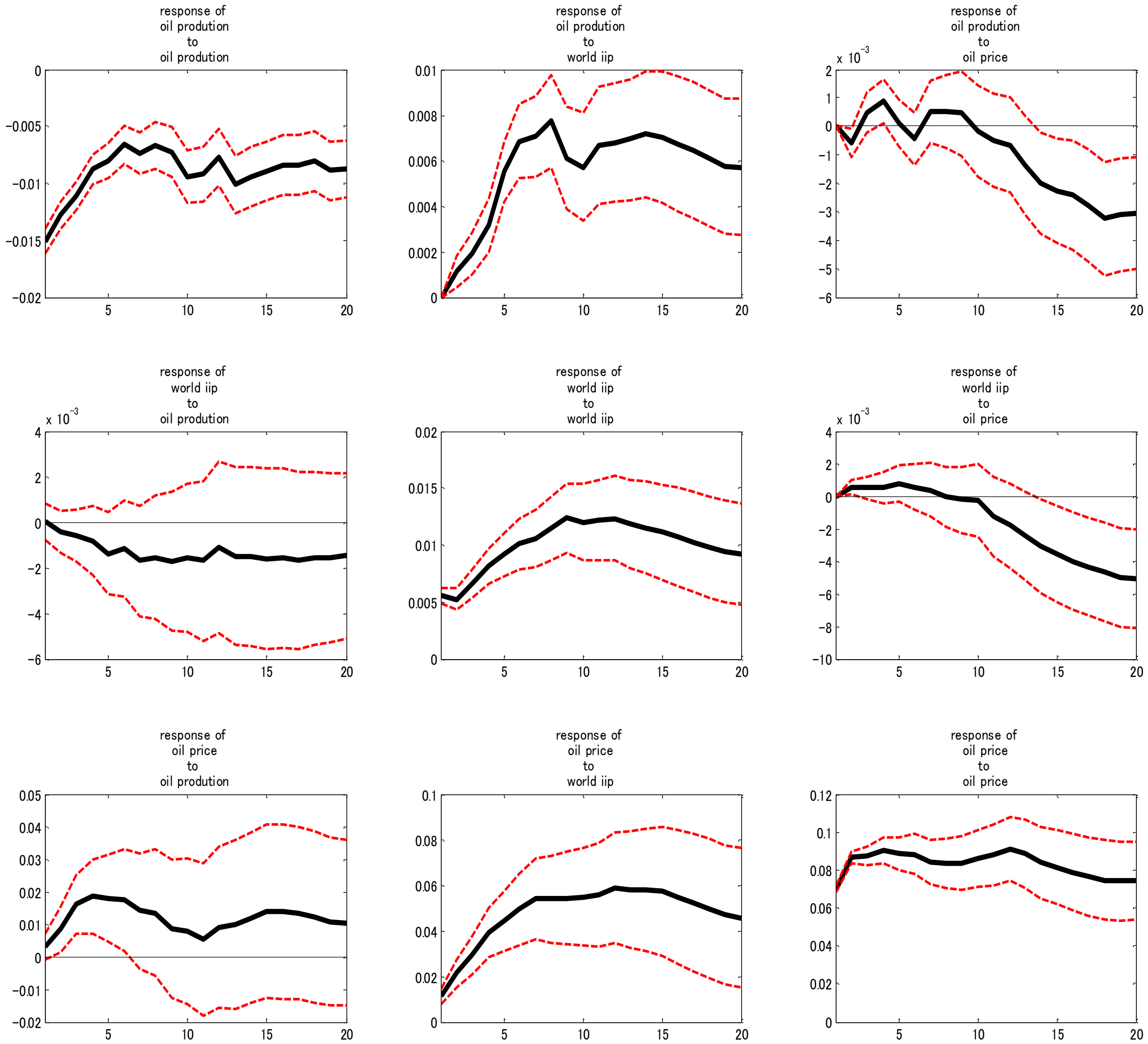
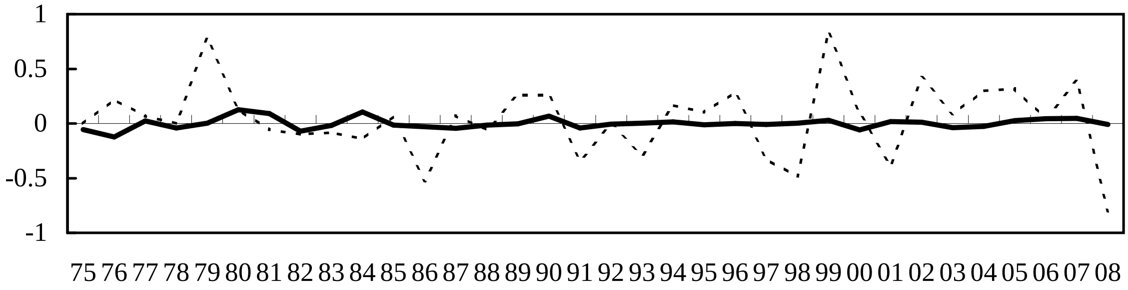
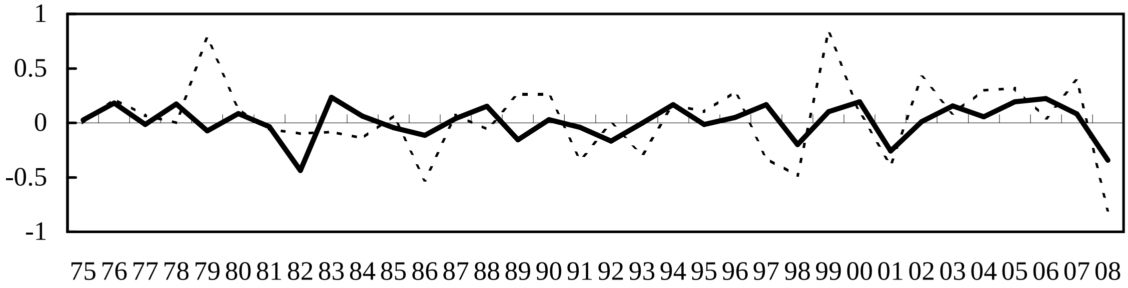


Figure 3: Historical decomposition of nominal oil price

Oil Supply Shocks



Global Demand Shocks



Oil-Specific Demand Shocks

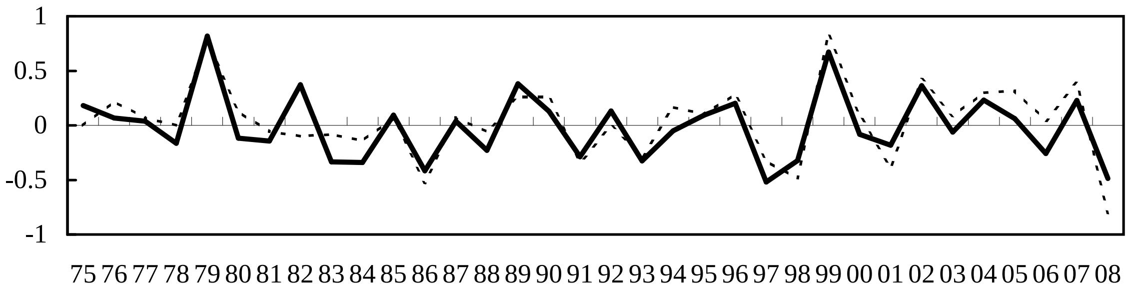


Figure 4: Cumulative responses of aggregate production (U.S.)

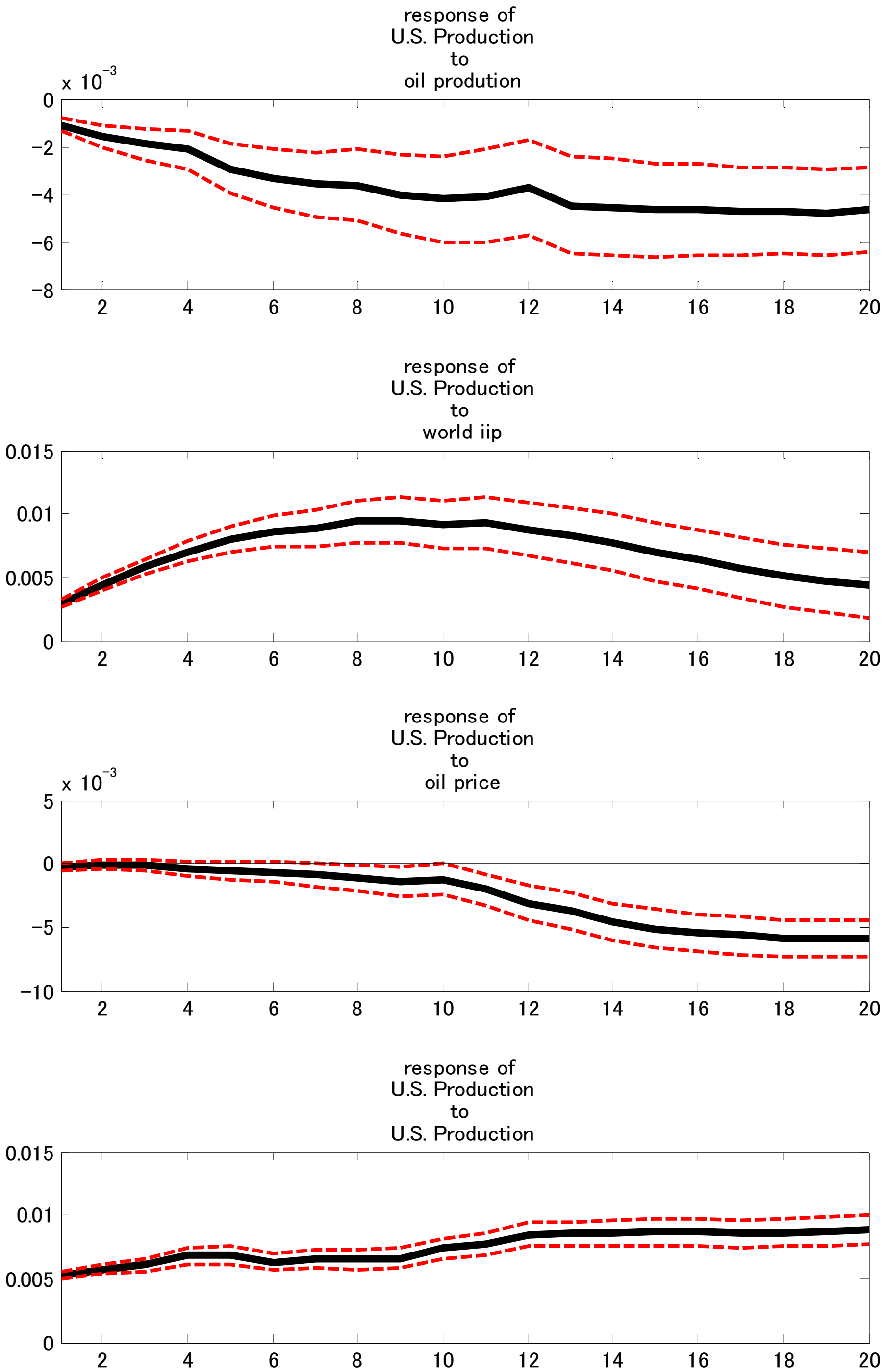
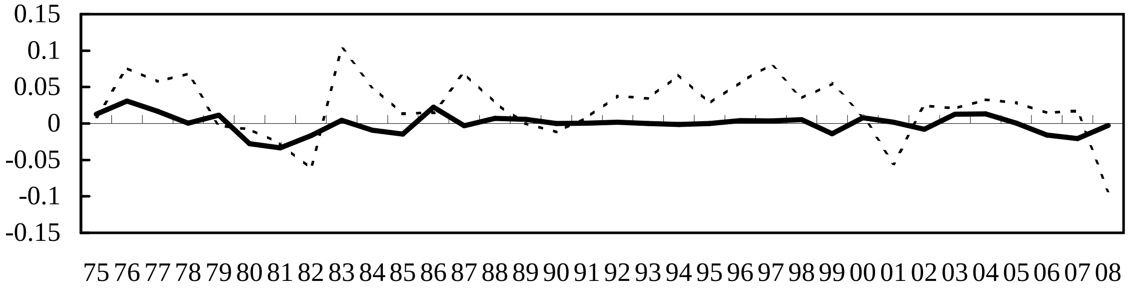
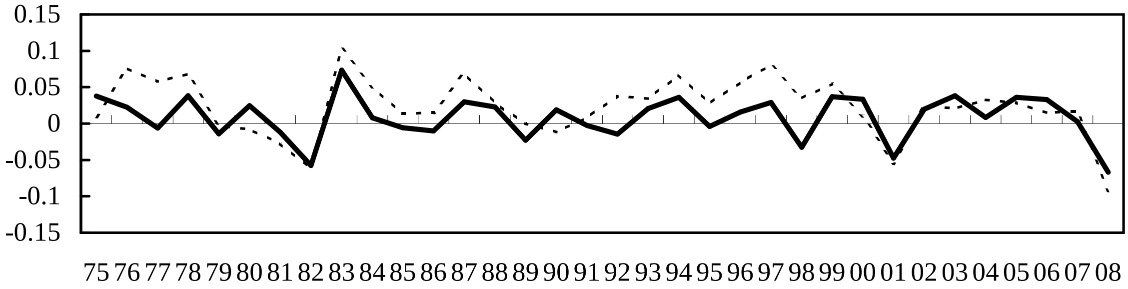


Figure 5: Historical decomposition of aggregate production (U.S.)

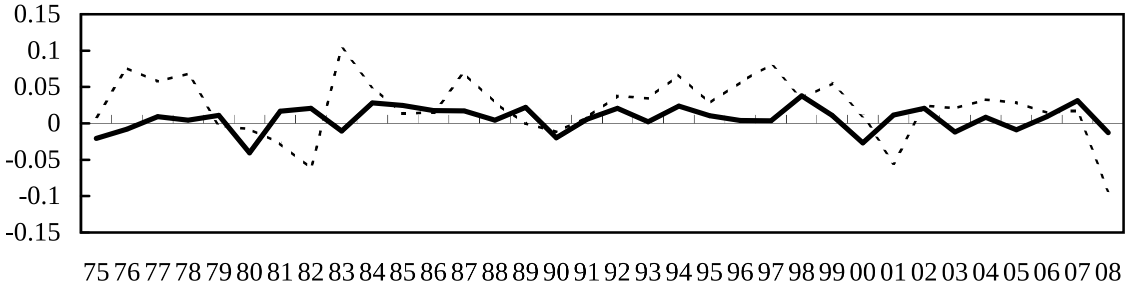
Oil Supply Shocks



Global Demand Shocks



Oil-Specific Demand Shocks



Domestic Aggregate Shocks

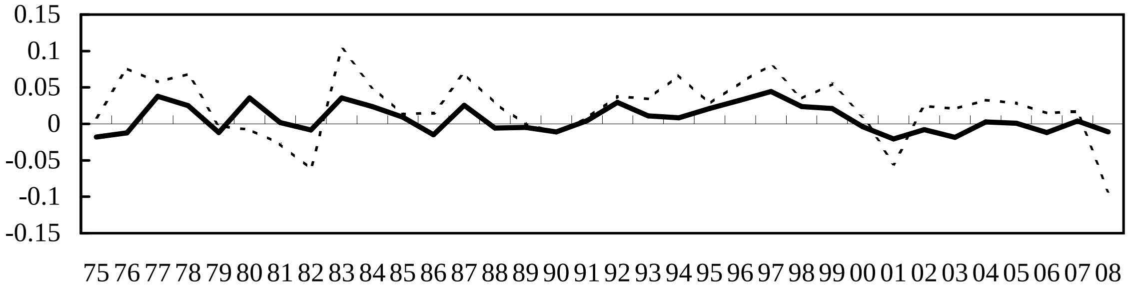


Figure 6: Cumulative responses of aggregate production (Japan)

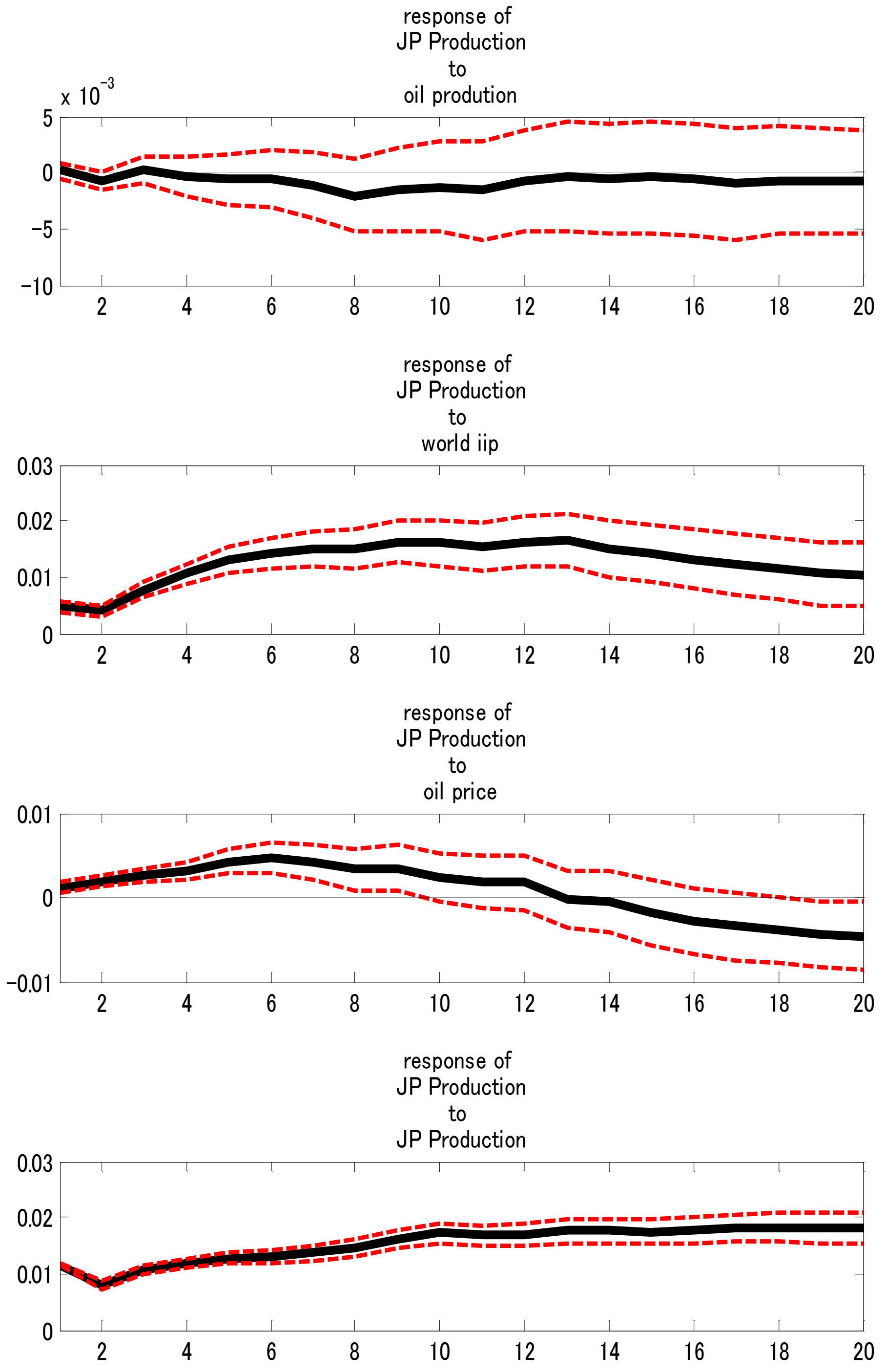
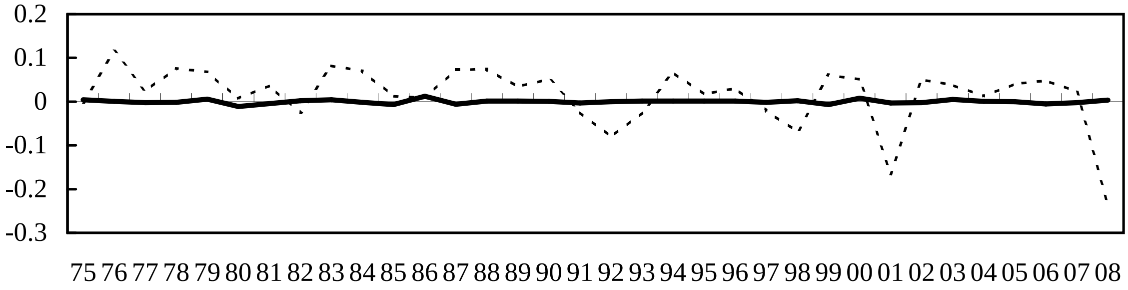
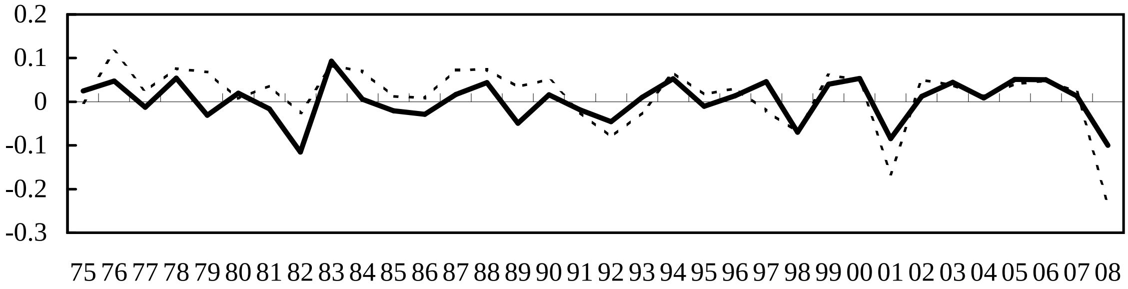


Figure 7: Historical decomposition of aggregate production (Japan)

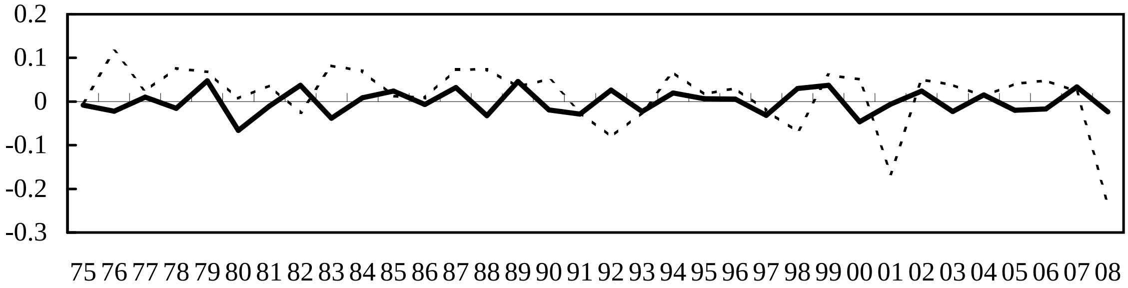
Oil Supply Shocks



Global Demand Shocks



Oil-Specific Demand Shocks



Domestic Aggregate Shocks

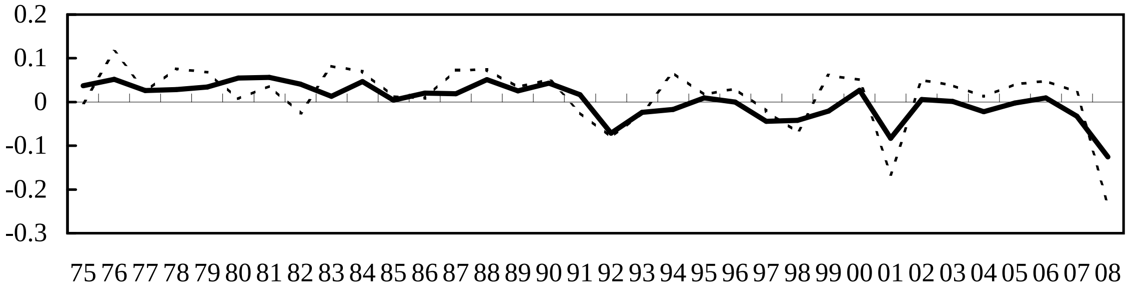


Figure 8: Cumulative responses of production to oil supply shock (U.S.)

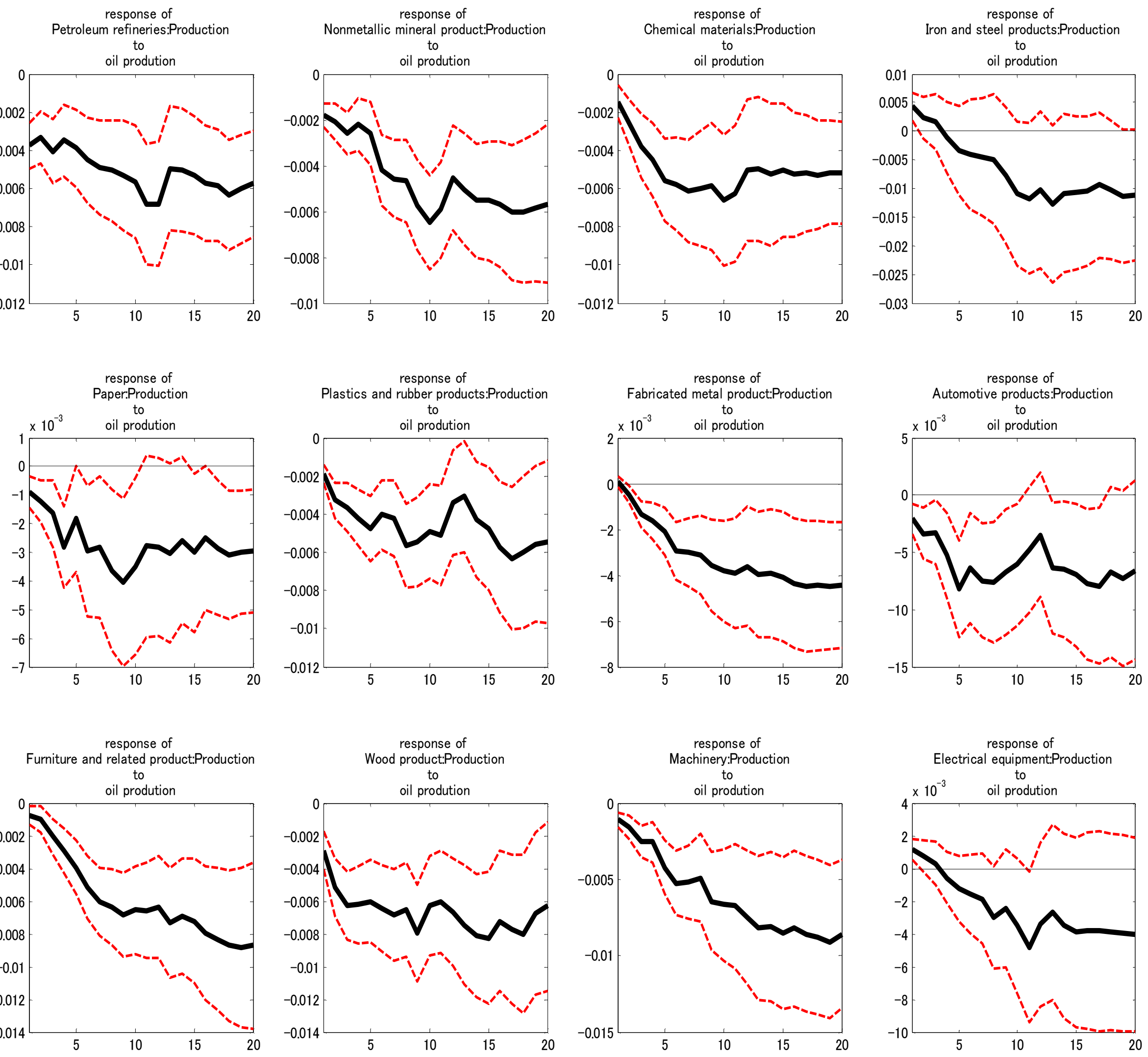


Figure 9: Cumulative responses of prices to oil supply shock (U.S.)

Figure 10: Cumulative responses of production to global demand shock (U.S.)

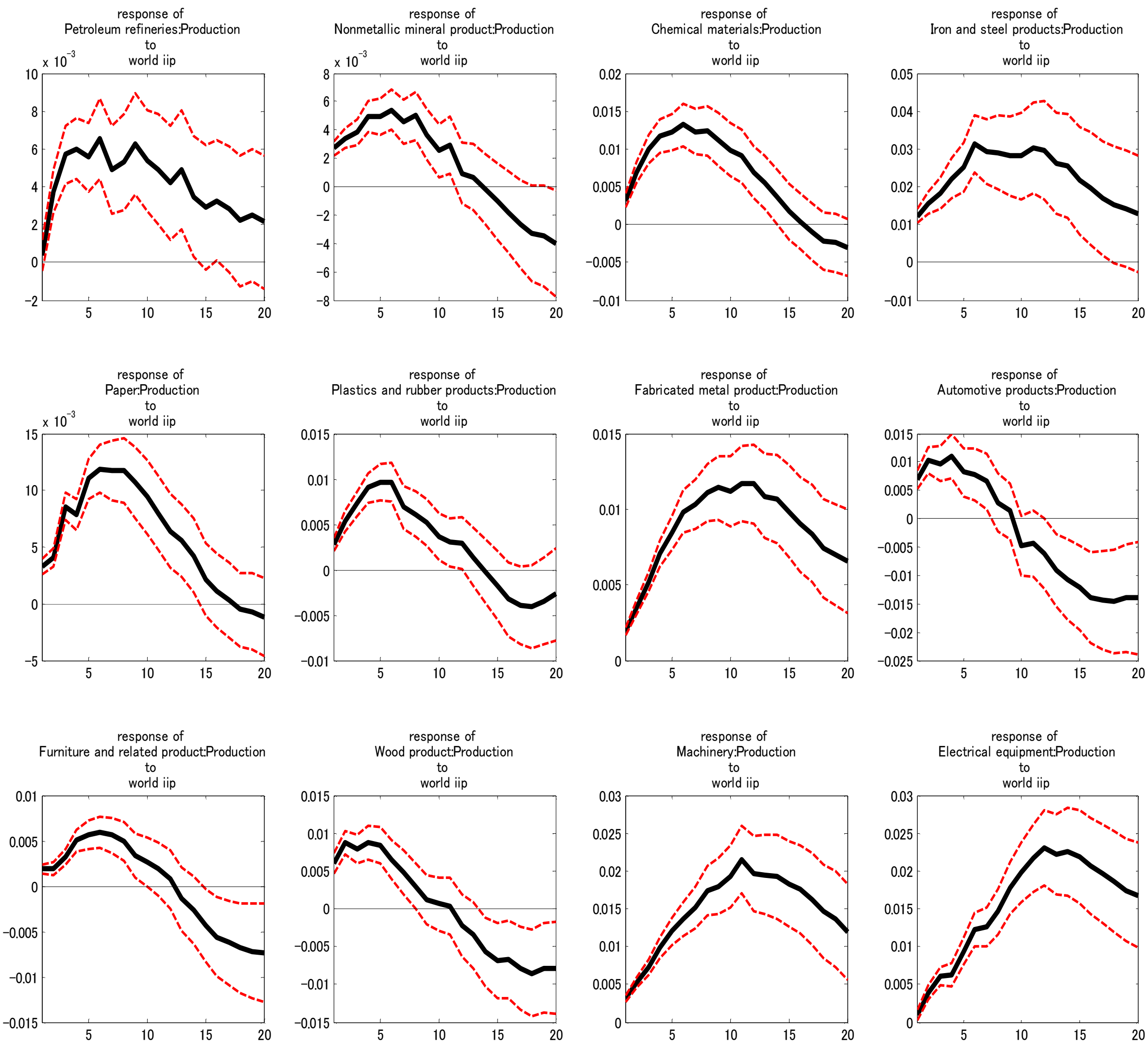


Figure 11: Cumulative responses of prices to global demand shock (U.S.)

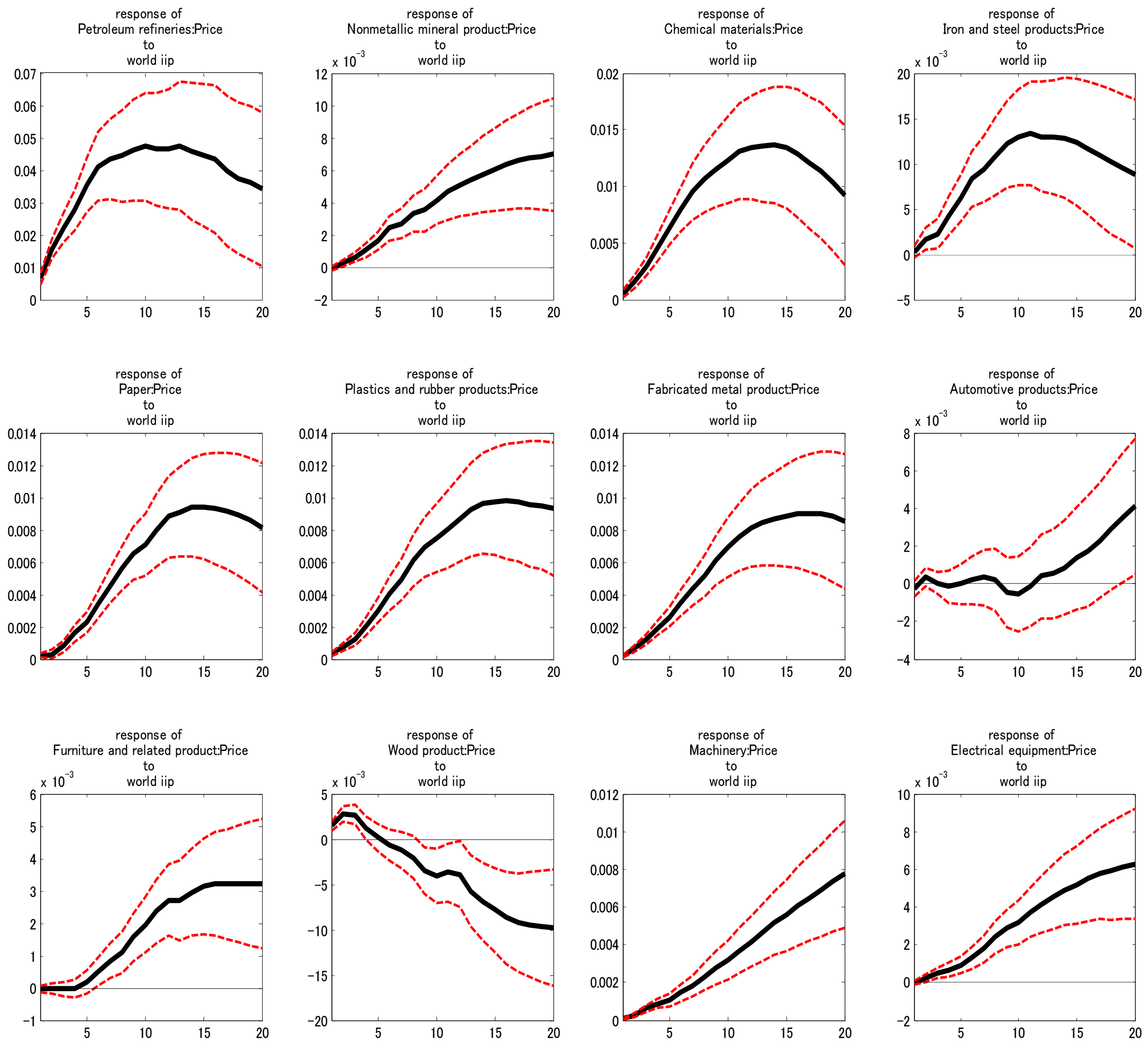


Figure 12: Cumulative responses of production to oil-specific demand shock (U.S.)

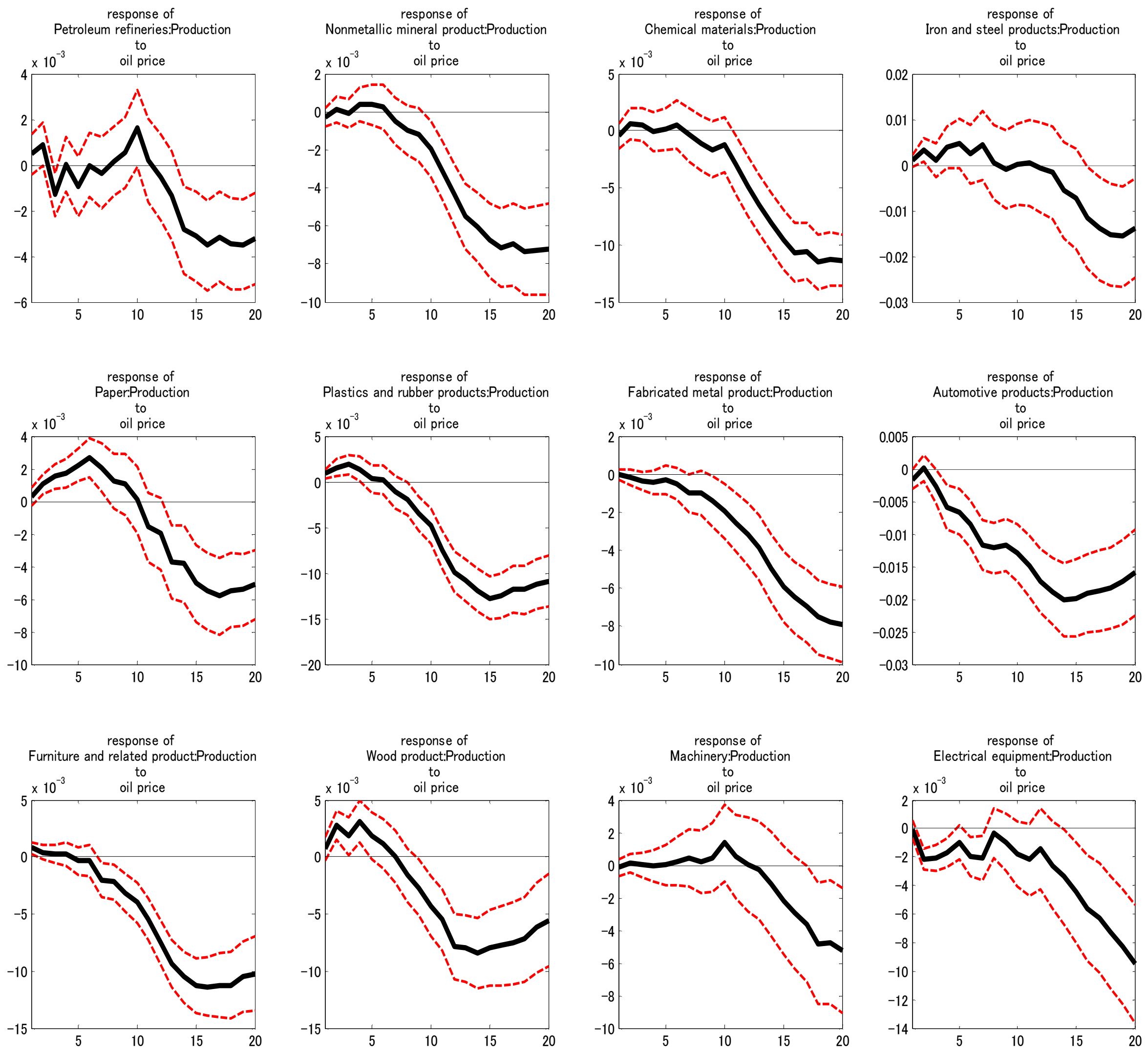


Figure 13: Cumulative responses of prices to oil-specific demand shock (U.S.)

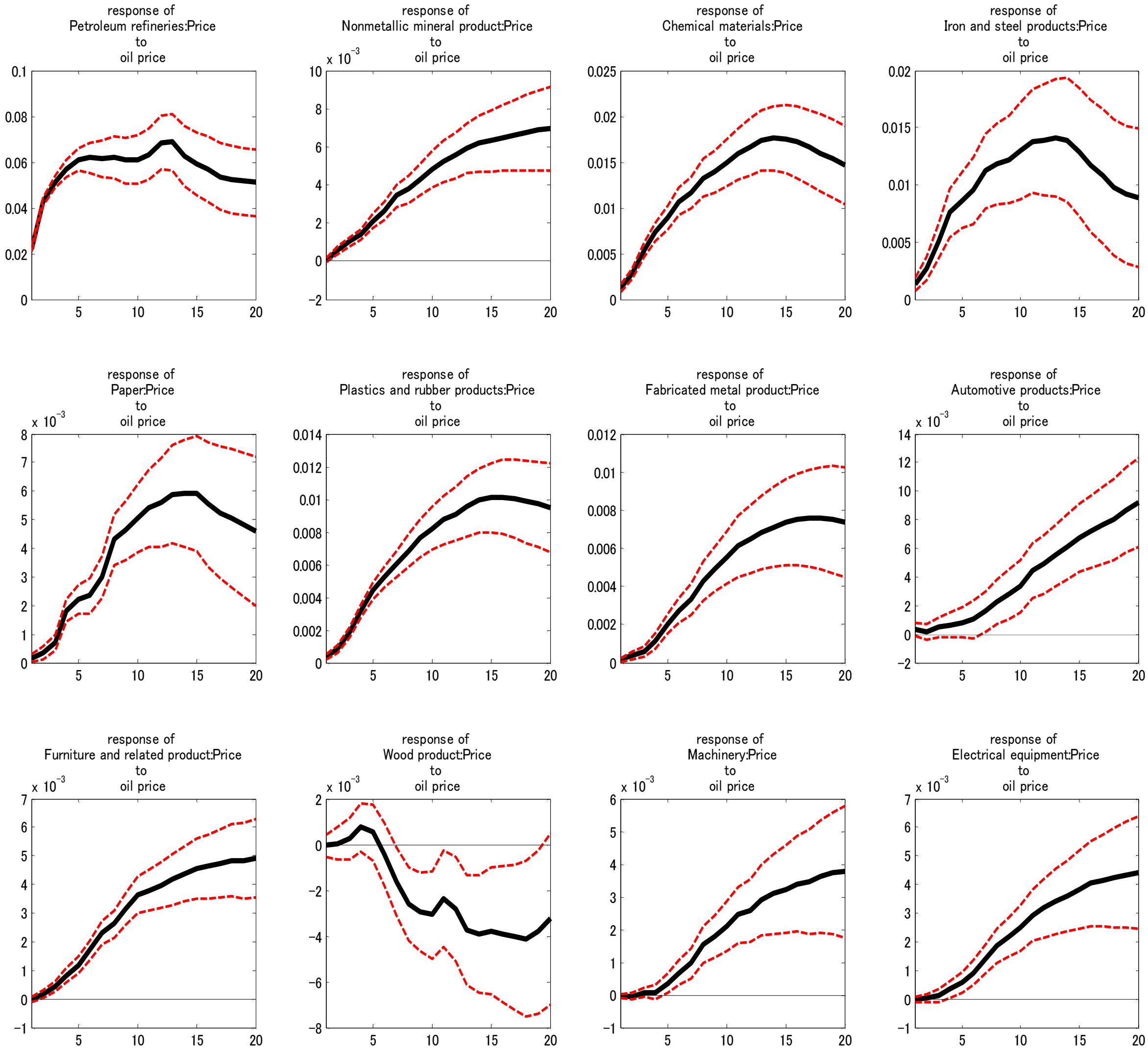


Figure 14: Magnitudes of 12-month cumulative responses (U.S.)

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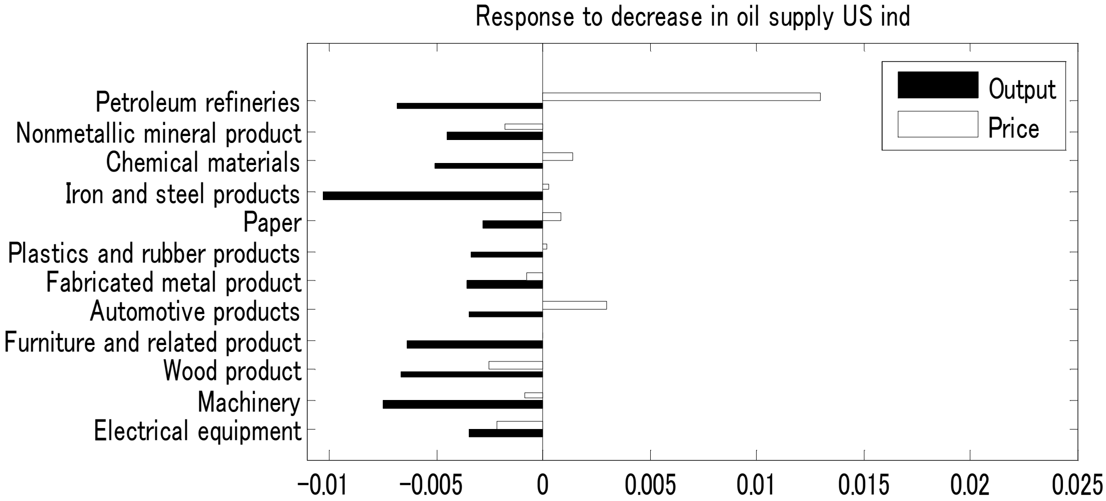

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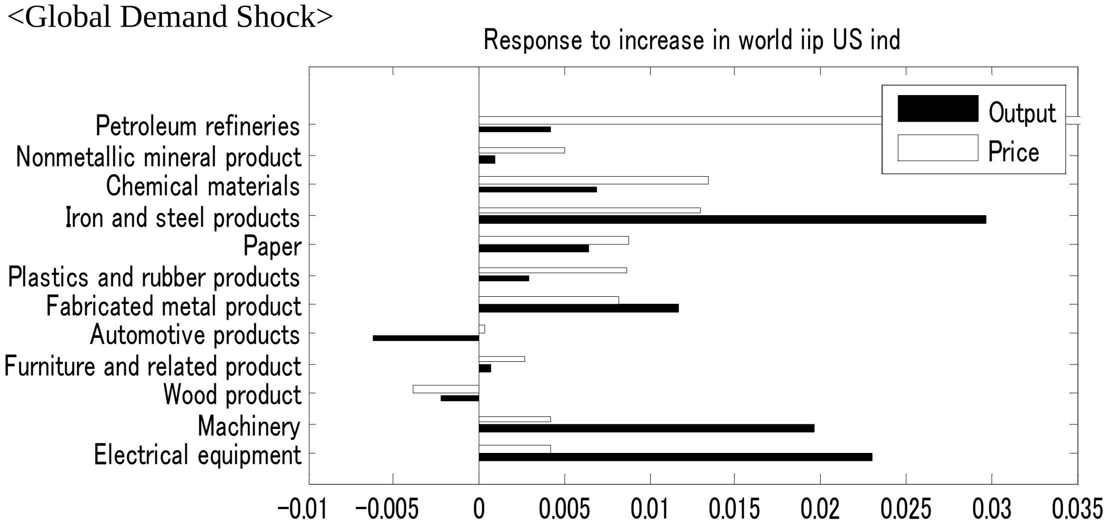

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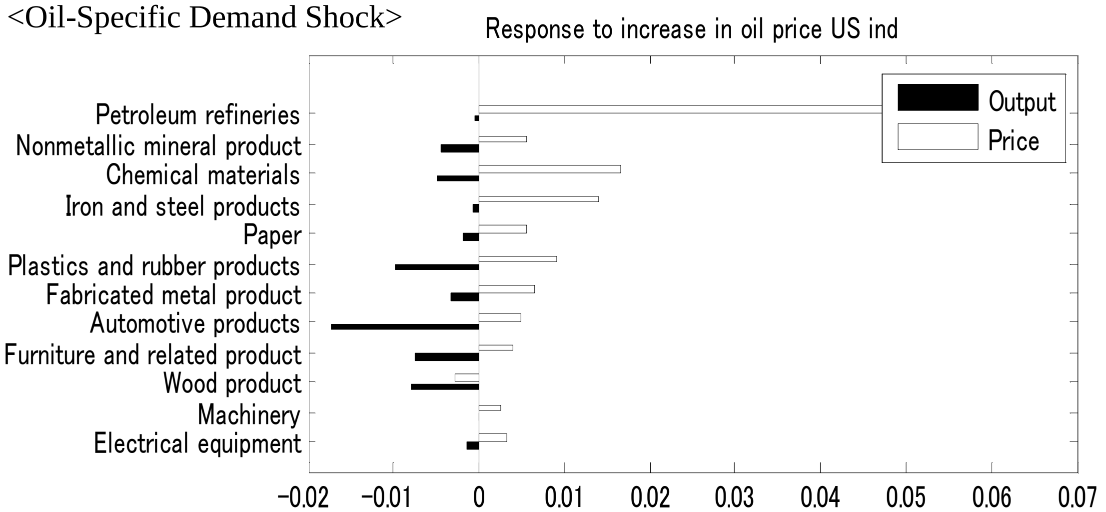


Figure 15: Cumulative responses of production to oil supply shock (Japan)

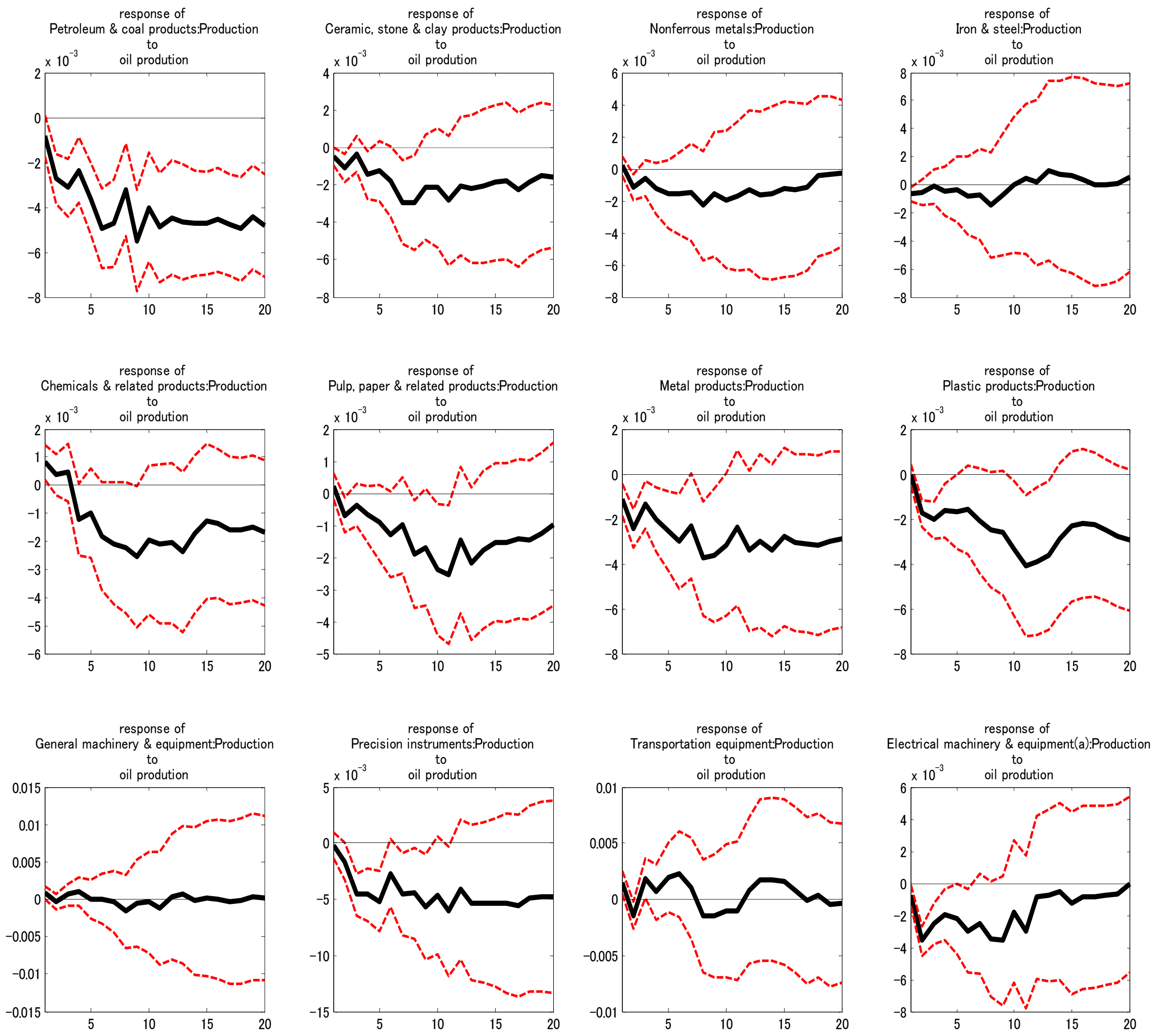


Figure 16: Cumulative responses of prices to oil supply shock (Japan)

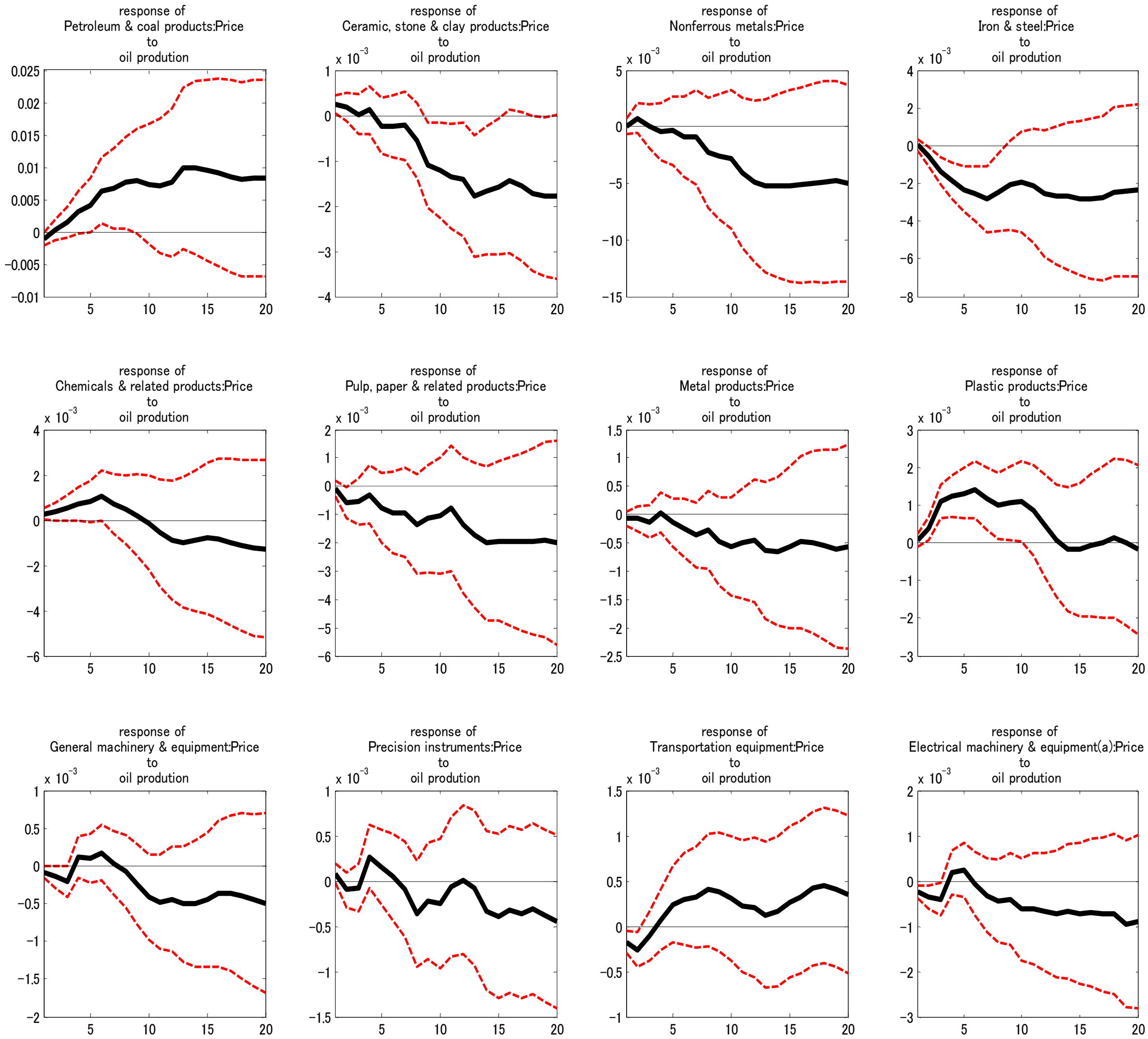


Figure 17: Cumulative responses of production to global demand shock (Japan)

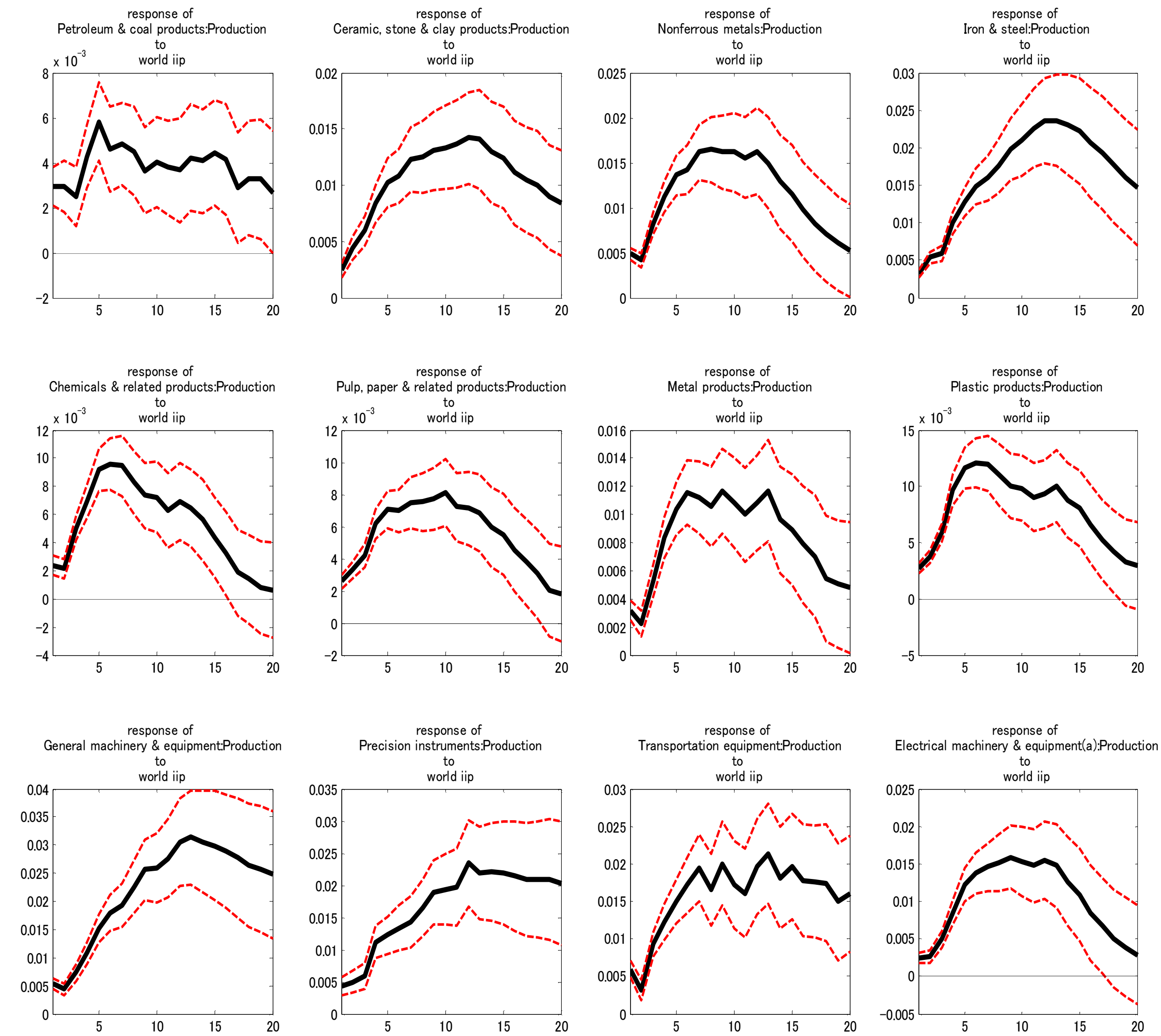


Figure 18: Cumulative responses of prices to global demand shock (Japan)

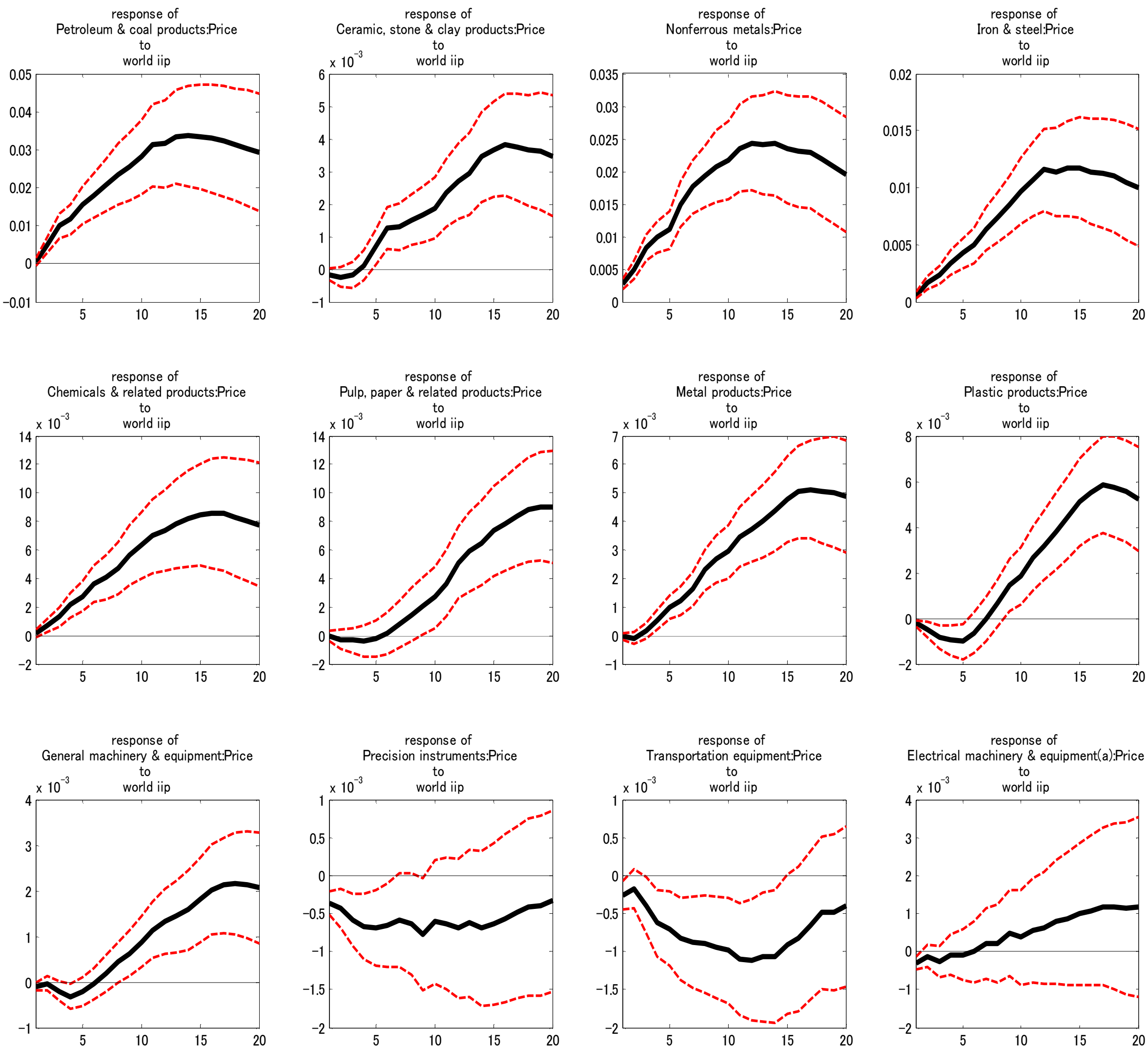


Figure 19: Cumulative responses of production to oil-specific demand shock (Japan)

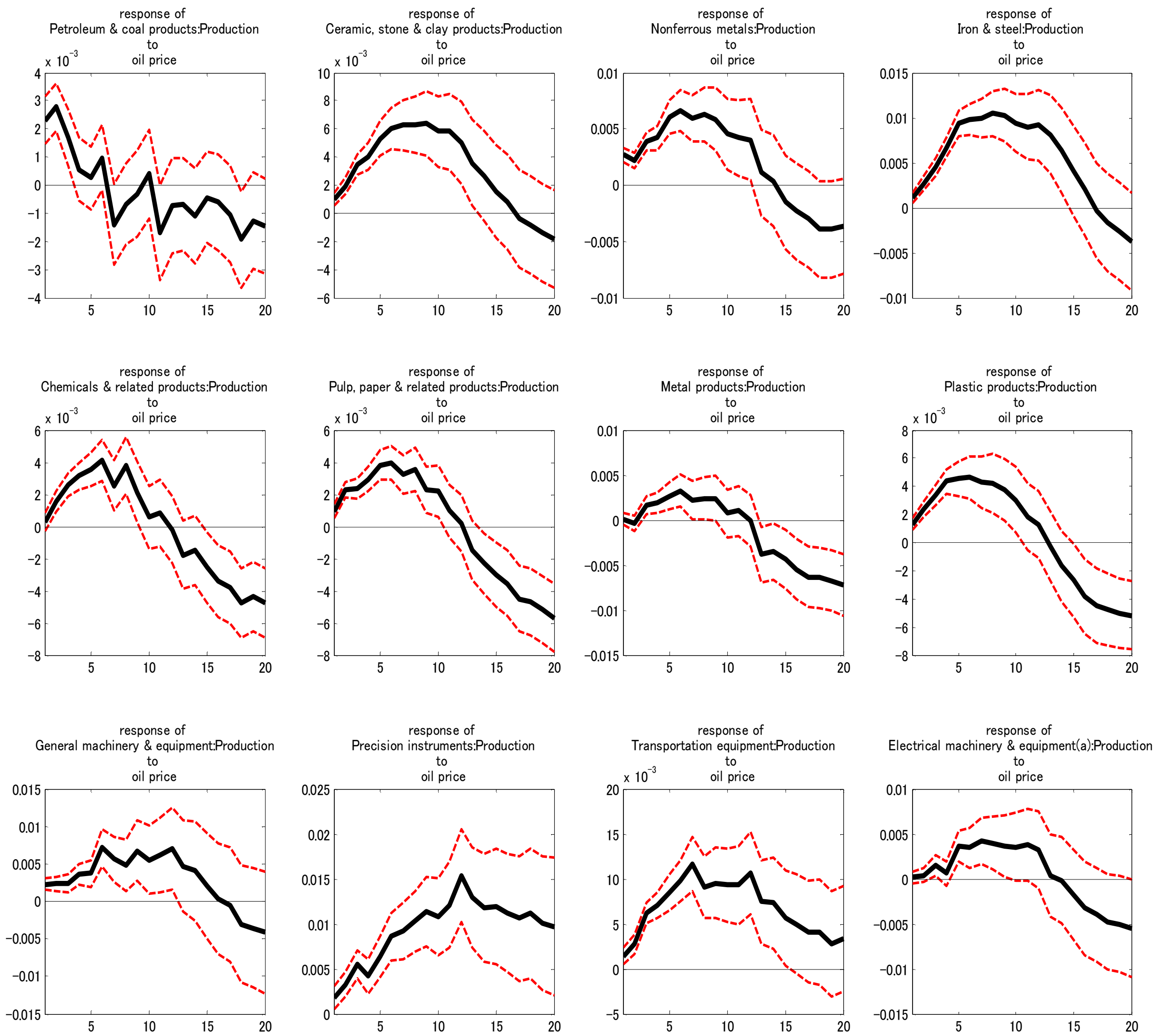


Figure 20: Cumulative responses of prices to oil-specific demand shock (Japan)

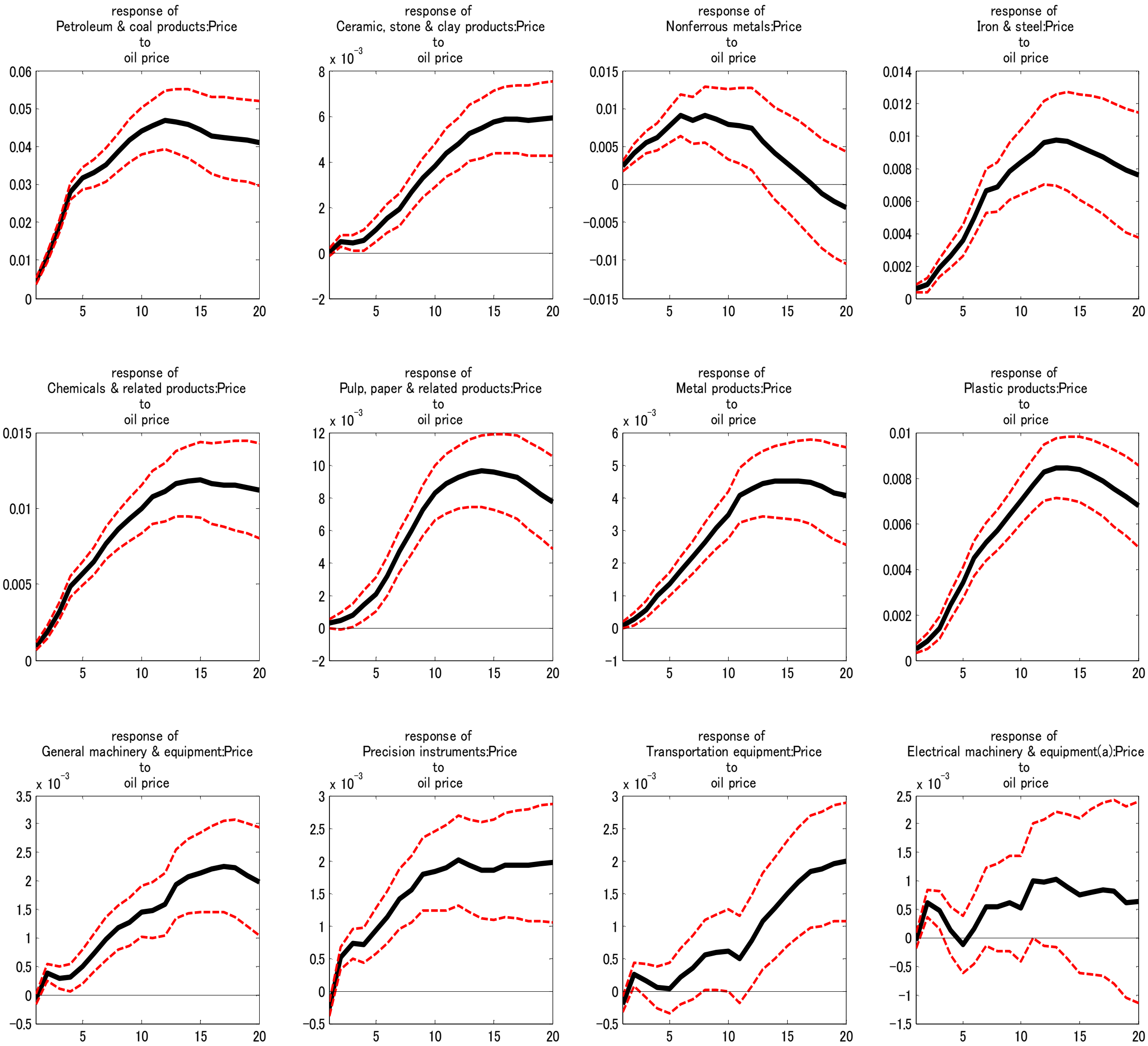
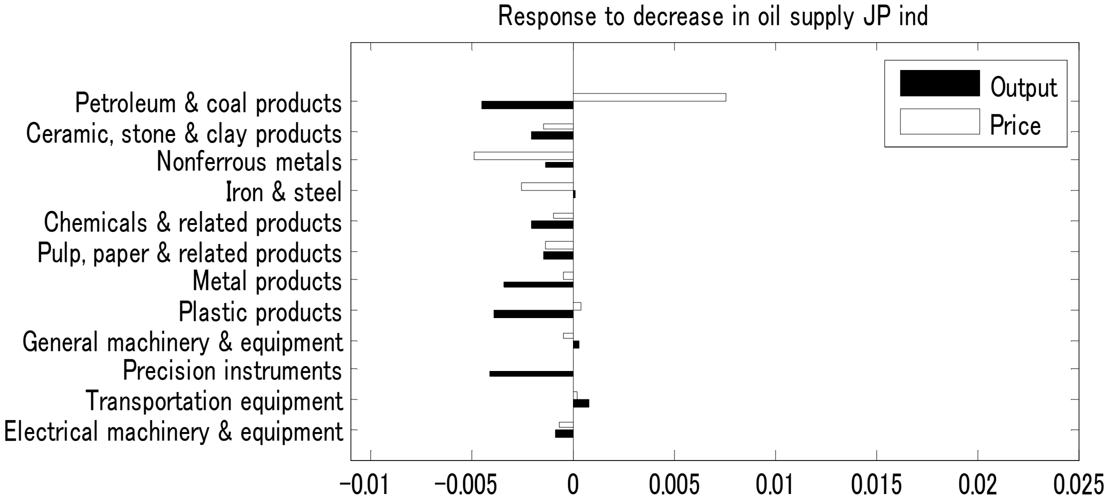
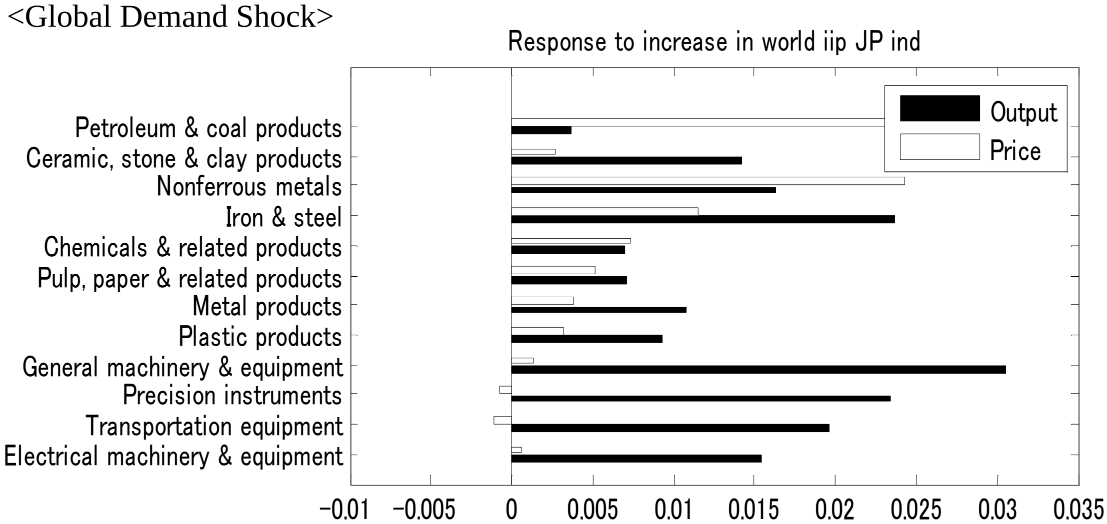


Figure 21: Magnitudes of 12-month cumulative responses (Japan)

<Oil Supply Shock>



<Global Demand Shock>



<Oil-Specific Demand Shock>

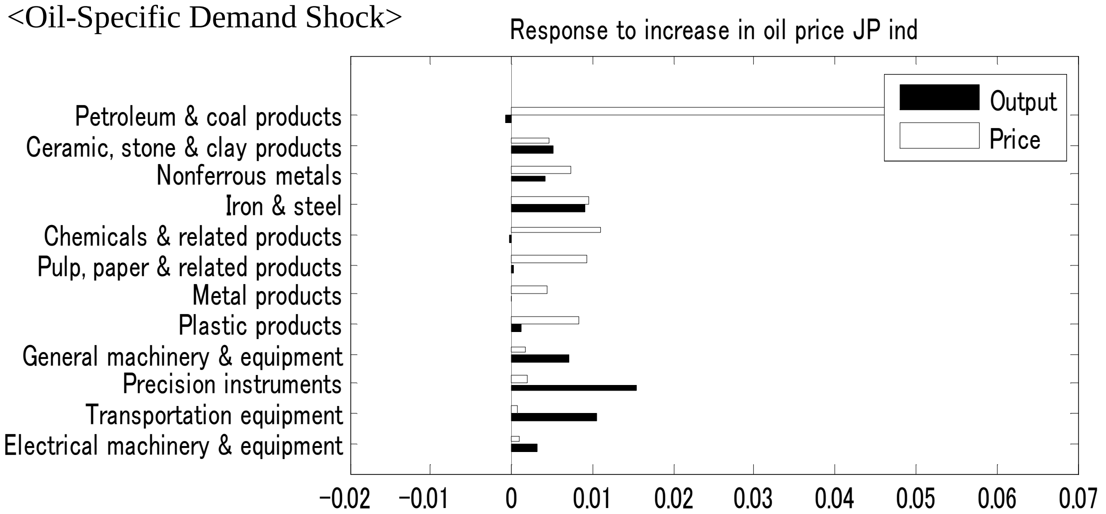
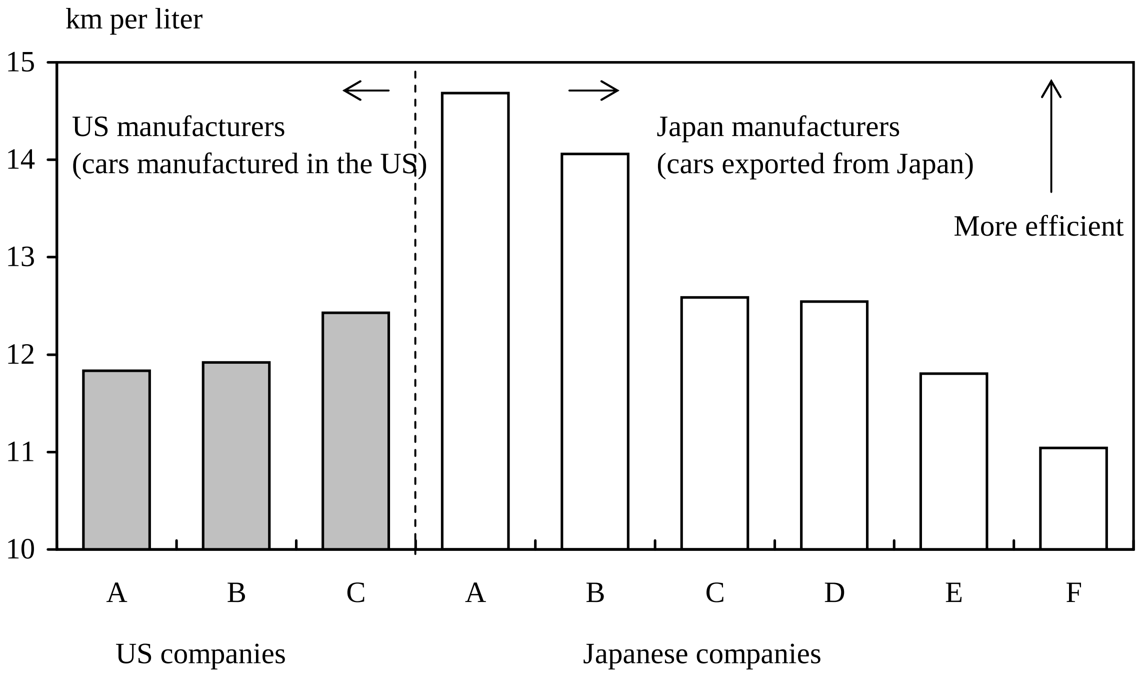


Figure 22: Average fuel consumption of cars sold in U.S.



Note: Fuel consumption is calculated for each company as 2004-2006 averages.
Fuel consumption of different vehicle types are averaged using their sales volume as weights.

Source: Research and Statistics Department, Bank of Japan (2007)

Table 1: Value-added share of production

<U.S.>

Industry	Share in 2006 (%)	Share in 1973 (%)
Fabricated metal product	5.5	6.7
Chemical materials	5.4	4.4
Machinery	5.0	8.6
Petroleum refineries	3.9	1.3
Automotive products	3.3	3.5
Plastics and rubber products	3.2	2.9
Paper	2.6	3.1
Nonmetallic mineral product	2.3	2.7
Furniture and related product	1.5	1.6
Wood product	1.4	2.1
Iron and steel products	1.4	3.1
Electrical equipment	0.6	1.1
12-industry total	36.3	41.3

<Japan>

Industry	Share in 2005 (%)	Share in 1975 (%)
Electric machinery and equipment	18.4	11.0
Transportation equipment	16.9	11.8
General machinery and equipment	13.2	12.8
Chemicals and related products	11.8	9.5
Iron and steel products	6.0	6.6
Metal products	5.7	5.0
Plastic products	3.8	2.8
Ceramic, stone and clay products	2.9	5.7
Pulp, paper and related products	2.4	3.5
Nonferrous metals and products	2.1	1.9
Precision instruments	1.0	1.6
Petroleum and coal products	1.0	2.9
12-industry total	85.2	75.3

Source: Industrial Production, Federal Reserve Board.
Indices of Industrial Production, Japanese Ministry of Economy, Trade, and Industry.

Table 2: Oil intensity (Cost share of mining and petroleum and coal products)

<U.S.>

Industry	Share in 2000 (%)
Petroleum and coal products	68.5
Ceramic, stone and clay products	6.2
Chemical products	6.2
Steel and steel products	5.5
Non-steel metals and products	2.8
Pulp, paper and wooden products	0.7
Plastic, rubber and leather products	0.5
Other metal products	0.3
Transportation equipment	0.3
General machinery	0.2
Electric machinery	0.1
Precision instruments	0.1
12-industry average	6.4

<Japan>

Industry	Share in 2000 (%)
Petroleum and coal products	40.6
Ceramic, stone and clay products	9.7
Non-steel metals and products	7.3
Steel and steel products	6.4
Chemical products	4.8
Pulp, paper and wooden products	1.2
Other metal products	0.5
Plastic, rubber and leather products	0.4
General machinery	0.3
Precision instruments	0.3
Transportation equipment	0.3
Electric machinery	0.2
12-industry average	4.0

Source: The 2000 Japan-U.S. input-output table,
Japanese Ministry of Economy, Trade, and Industry.

Table 3: Export dependence (Export share of shipments)

<U.S.>

Industry	Share in 2000 (%)
Electric machinery	30.2
Precision instruments	29.6
General machinery	26.3
Transportation equipment	20.4
Non-steel metals and products	17.3
Chemical products	17.2
Plastic, rubber and leather products	9.6
Pulp, paper and wooden products	6.6
Steel and steel products	6.4
Ceramic, stone and clay products	6.4
Other metal products	6.3
Petroleum and coal products	5.7
12-industry average	14.9

<Japan>

Industry	Share in 2000 (%)
Precision instruments	33.9
Transportation equipment	33.4
Electric machinery	33.1
General machinery	27.9
Steel and steel products	17.0
Chemical products	15.6
Non-steel metals and products	15.3
Plastic, rubber and leather products	8.6
Ceramic, stone and clay products	6.9
Other metal products	3.8
Pulp, paper and wooden products	2.1
Petroleum and coal products	1.6
12-industry average	17.1

Source: The 2000 Japan-U.S. input-output table,
Japanese Ministry of Economy, Trade, and Industry.

Table 4: Signs of peak responses (U.S.)

<Oil Supply Shock>

Industry	Peak effect on output	Peak effect on prices	Oil supply shock effects
Petroleum refineries	–*	+*	Decrease in supply
Nonmetallic mineral product	–*	–	Decrease in demand
Chemical materials	–*	+*	Decrease in supply
Iron and steel products	–	+*	Decrease in supply
Paper	–*	0	
Plastics and rubber products	–*	0	
Fabricated metal product	–*	0	
Automotive products	–*	+*	Decrease in supply
Furniture and related product	–*	0	
Wood product	–*	–*	Decrease in demand
Machinery	–*	0	
Electrical equipment	–	–*	Decrease in demand

<Global Demand Shock>

Industry	Peak effect on output	Peak effect on prices	Global demand shock effects
Petroleum refineries	+*	+*	Increase in demand
Nonmetallic mineral product	+*	+*	Increase in demand
Chemical materials	+*	+*	Increase in demand
Iron and steel products	+*	+*	Increase in demand
Paper	+*	+*	Increase in demand
Plastics and rubber products	+*	+*	Increase in demand
Fabricated metal product	+*	+*	Increase in demand
Automotive products	Mixed	+*	
Furniture and related product	Mixed	+*	
Wood product	Mixed	–*	
Machinery	+*	+*	Increase in demand
Electrical equipment	+*	+*	Increase in demand

<Oil-Specific Demand Shock>

Industry	Peak effect on output	Peak effect on prices	Oil-Specific demand shock effects
Petroleum refineries	–*	+*	Decrease in supply
Nonmetallic mineral product	–*	+*	Decrease in supply
Chemical materials	–*	+*	Decrease in supply
Iron and steel products	–*	+*	Decrease in supply
Paper	–*	+*	Decrease in supply
Plastics and rubber products	–*	+*	Decrease in supply
Fabricated metal product	–*	+*	Decrease in supply
Automotive products	–*	+*	Decrease in supply
Furniture and related product	–*	+*	Decrease in supply
Wood product	–*	–*	Decrease in demand
Machinery	–*	+*	Decrease in supply
Electrical equipment	–*	+*	Decrease in supply

Note: "+" and "−" represent peak positive and negative responses. "*" means that the peak responses are significant. "0" means the peak responses are negligible. "Mixed" means that the positive and negative responses are of similar magnitudes.

Table 5: Signs of peak responses (Japan)

<Oil Supply Shock>

Industry	Peak effect on output	Peak effect on prices	Oil supply shock effects
Petroleum and coal products	−*	+*	Decrease in supply
Ceramic, stone and clay products	−*	−*	Decrease in demand
Nonferrous metals and products	−	−	Decrease in demand
Iron and steel products	0	−*	
Chemicals and related products	−	0	
Pulp, paper and related products	−*	−	Decrease in demand
Metal products	−*	−	Decrease in demand
Plastic products	−*	+*	Decrease in supply
General machinery and equipment	0	0	
Precision instruments	−*	0	
Transportation equipment	0	0	
Electric machinery and equipment	−*	0	

<Global Demand Shock>

Industry	Peak effect on output	Peak effect on prices	Global demand shock effects
Petroleum and coal products	+*	+*	Increase in demand
Ceramic, stone and clay products	+*	+*	Increase in demand
Nonferrous metals and products	+*	+*	Increase in demand
Iron and steel products	+*	+*	Increase in demand
Chemicals and related products	+*	+*	Increase in demand
Pulp, paper and related products	+*	+*	Increase in demand
Metal products	+*	+*	Increase in demand
Plastic products	+*	+*	Increase in demand
General machinery and equipment	+*	+*	Increase in demand
Precision instruments	+*	−*	Increase in supply
Transportation equipment	+*	−*	Increase in supply
Electric machinery and equipment	+*	+	Increase in demand

<Oil-Specific Demand Shock>

Industry	Peak effect on output	Peak effect on prices	Oil-Specific demand shock effects
Petroleum and coal products	Mixed	+*	
Ceramic, stone and clay products	+*	+*	Increase in demand
Nonferrous metals and products	Mixed	+*	
Iron and steel products	+*	+*	Increase in demand
Chemicals and related products	Mixed	+*	
Pulp, paper and related products	Mixed	+*	
Metal products	Mixed	+*	
Plastic products	Mixed	+*	
General machinery and equipment	+*	+*	Increase in demand
Precision instruments	+*	+*	Increase in demand
Transportation equipment	+*	+*	Increase in demand
Electric machinery and equipment	Mixed	+	

Note: "+" and "−" represent peak positive and negative responses. "*" means that the peak responses are significant. "0" means the peak responses are negligible. "Mixed" means that the positive and negative responses are of similar magnitudes.