Impact of Exchange Rate Shocks on Japanese Exports: Quantitative assessment using a structural VAR model

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Abstract

In the policy debate over the Japanese macroeconomic performance, the impact of exchange rate fluctuations on Japan's exports has received considerable attention. However, if we take the period from the end of 2008 following the collapse of Lehman Brothers as an example, the "price shock" of the yen's rapid appreciation and the "quantity shock" because of the rapid decline in global aggregate demand were equally responsible for the significant reduction in exports. We analyze this problem using a structural vector autoregression (VAR) model, assuming that there are two exogenous shocks, namely, a foreign demand shock and an exchange rate-specific shock. We evaluate the relative importance of each shock to Japanese aggregate exports. We further expand our VAR system to incorporate and analyze the impact of fluctuations in oil prices as additional exogenous shocks. In the second half of the paper, the relative importance of foreign demand shocks and exchange rate shocks during historic episodes of large exchange rate fluctuations are compared, including the mid-1980s with the high-yen recession after the Plaza Accord, the sharp yen appreciation in the mid-1990s, and the period of the "trade collapse" after the Lehman Brothers bankruptcy in the late 2000s.

Keywords: Japanese economy, Exchange rate, Exports, Structural VAR
JEL classification: F31, F41, Q43

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1 Introduction

Historically, the most important macroeconomic policy objective for policy makers in the United States has been unemployment, whereas it has been budget deficits in continental Europe. Similarly, exchange rates have always received attention in macroeconomic policy debates in Japan. The fear of appreciation of the yen against other currencies started in 1971 with the Smithsonian Agreement. Since then, policy makers have tried to avoid a strong yen to aid Japanese exporters. In particular, the rapid appreciation of the yen after the Plaza Accord in 1985 and the subsequent "strong yen recession" was a traumatic experience for Japanese policy makers and business leaders. Because of this, monetary expansion that leads to a depreciation of yen to increase exports has been considered as a panacea for Japan's macroeconomic weakness until recently. In fact, in the early stages of Abenomics, the announcement of the new Prime Minister's commitment to fight deflation and his intention to appoint a much more dovish central bank governor after the incumbent's term expired in March 2013 prompted a 20end of 2012 to the first half of 2013. A weaker yen resulted in a substantial improvement in Japan's domestic business conditions and macroeconomic performance in 2013 and the first half of 2014.

Despite such conventional wisdom in Japan, a strong yen is not the root of all economic evils and a weak yen is not a magic stick for economic recovery. The slowdown in Japanese exports could have occurred because of reasons other than the strong yen. To see this, in Figure 1, Japan's real effective exchange rate (panel A) is shown along with the movements of nominal and real exports before and after two major appreciations of the yen, namely the Plaza Accord of September 1985 and the US financial crisis triggered by the collapse of Lehman Brothers in September 2008 (panel B). From the graph of the real exchange rate, we see that the appreciation of the yen after the Plaza Accord was only slightly larger than the appreciation after the collapse of Lehman Brothers. To the contrary, from the graph of exports, we observe that real export had not declined as much as nominal exports when the yen appreciated in the mid-1980s. On the other hand, nominal and real exports moved in tandem during the global recession subsequent to the Lehman shock in September 2008. Such a difference in export responses in the mid-1980s and toward the end of the 2000s suggests that the "quantity shock" associated with the rapid decline in global aggregate demand was as equally responsible as the "price shock" of the yen's rapid appreciation, for the significant slowdown in exports during the global re-

2

cession in late 2008 and 2009. In other words, the appreciation of the yen during the global recession after the collapse of Lehman Brothers was partly the result of the severe recession overseas and the decline in foreign demand for Japan's exports.

[Figure 1 here]

Apparently, we were not the first to point out that an appreciation and a depreciation of the yen of the same magnitude can have significantly different impacts on Japan's exports and GDP. One of main purposes of this paper is to provide quantitative evaluation of the effect of purely exogenous exchange rate movements on Japanese exports using a simple empirical framework. Our second purpose is to assess how much of the export decline during historical yen appreciations can be explained by the part of the appreciation not related to fundamentals.

In regard to the first point, we find that the quantitative impact of real effective exchange rate movements on aggregate Japanese exports is similar whether modelled using the exchange rate alone or with the other variables considered in this paper such as a global aggregate demand shock and oil prices. For our second purpose, we selected three historical episodes of yen appreciation, namely, before/after the Plaza Accord in the mid-1980s, the rapid appreciation in 1994–1995, and the global recession in 2008–2009. Among these three events, the relative importance of pure exchange rate shocks compared with other exogenous shocks is largest for the yen appreciation in the mid-1990s. In the period subsequent to the Lehman shock, a negative global aggregate demand shock is the dominant force, while the impact of the exchange rate is much smaller.

The remainder of the paper is organized as follows. In Section 2, we introduce a simple structural VAR as the framework for empirical analysis. We also discuss the measure of global real economic activity proposed by Lutz Kilian and his treatment of oil price shocks. Section 3 describes the data. The next two sections present the empirical results of the structural VAR. Section 4 presents the impulse response functions and Section 5 presents the results of variance decompositions for the growth rate of Japan's exports. In Section 6, we compare the three periods of yen appreciation and assess the role of pure exchange rate shocks on Japan's exports using historical

3

decompositions based on our structural VAR system. Section 7 concludes and discusses our future research agenda.

2   Framework of Empirical Analyses

The main goal of this paper is to provide a quantitative evaluation of the effect of exogenous exchange rate fluctuations on Japanese exports using a simple empirical framework. For this purpose, we use a structural VAR model and estimate it under three different specifications, starting from a two-variable system, and then adding other economic variables.

We start our analysis with a bivariate VAR system as a benchmark, consisting of the real effective exchange rate and export growth rate. Although the influence of the exchange rate is significant, as we will see immediately below, a major part of the variation in export growth cannot be explained by exchange rate movements alone. In our second VAR system, we add a proxy for global real economic activity, which was first introduced in a series of studies by Lutz Kilian (2009). Kilian calculates an index using data of ocean freight transport fares and uses it as a variable representing aggregate demand shocks for crude oil. Here, we use it as a proxy for global aggregate demand shocks which will increase the demand for Japanese exports. It is assumed that foreign demand shocks for Japanese exports will affect the exchange rate, but the exchange rate will not affect foreign demand within the same one-month period. While we believe this is a sensible assumption, impulse response functions and the results of variance decompositions were not significantly affected even if the ordering of variables is reversed.

In the third VAR system, we add the price of crude oil and oil production to the second system. In our companion paper (Iwaisako and Nakata 2014), we used a four-variable system that excludes the export growth rate from our five variable system to calculate a series of structural shocks. Then, industry sales data are regressed on the structural shocks to estimate the responses of Japanese industries' output to global demand shocks, oil supply shocks, temporary oil price shocks, and temporary exchange rate shocks. In this paper, we are interested in the response of Japan's aggregate exports to the structural shocks, so that we simply include the export growth rate in the VAR system.

4

For the identification of structural shocks in our five-variable system, we place the following restrictions on the innovations and structural shocks:

$$
u_t = \begin{bmatrix} u_t^{\text{prod}} \\ u_t^{\text{real}} \\ u_t^{\text{poil}} \\ u_t^{\text{fx}} \\ u_t^{\text{exp}} \end{bmatrix} = A_0 \epsilon_t = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} \epsilon_t^{SY} \\ \epsilon_t^{DE} \\ \epsilon_t^{OIL} \\ \epsilon_t^{FEX} \\ \epsilon_t^{TRADE} \end{bmatrix}. \quad (1)
$$

Variables:

- prod_t : growth rate of world crude oil production

- real_t : proxy for global real economic activity (Kilian)

- poil_t : crude oil price

- fx_t : real effective exchange rate

- exp_t : growth rate of Japanese real exports

Structural shocks;

- ϵ_t^{SY} : oil supply shock

- ϵ_t^{DE} : global demand shock

- ϵ_t^{OIL} : temporary oil price shock

- ϵ_t^{FEX} : temporary exchange rate shock

- ϵ_t^{TRADE} : fluctuations in exports that cannot be explained by the four structural shocks above

For a more detailed discussion, let us focus on the exogenous temporary exchange rate shock ϵ_t^{FEX}. The VAR system described above extracts the series ϵ_t^{FEX} as the variation in the real exchange rate that is not associated with either (i) oil supply shocks ϵ_t^{SY}, (ii) global demand shocks ϵ_t^{DE}, or (iii) temporary oil price shocks ϵ_t^{OIL}. Admittedly, it is not obvious

whether temporary exchange rate shocks ϵ_t^{FEX} or temporary oil price shocks ϵ_t^{OIL} are more exogenous. However, changing the variable order in Cholesky factorization does not change the shape of the impulse response functions drastically. Hence, we present empirical results based on the above restriction between innovations in variables and structural shocks in the following empirical analyses.

Our two-variable system and three-variable system can be interpreted as special cases of a five-variable system, on which we put the following restrictions.

$$u_t = \begin{bmatrix} u_t^{\text{fx}} \\ u_t^{\text{exp}} \end{bmatrix} = A_0 \epsilon_t = \begin{bmatrix} a_{44} & 0 \\ a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} \epsilon_t^{FEX} \\ \epsilon_t^{TRADE} \end{bmatrix} \qquad (2)$$

$$u_t = \begin{bmatrix} u_t^{\text{real}} \\ u_t^{\text{fx}} \\ u_t^{\text{exp}} \end{bmatrix} = A_0 \epsilon_t = \begin{bmatrix} a_{22} & 0 & 0 \\ a_{42} & a_{44} & 0 \\ a_{52} & a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} \epsilon_t^{DE} \\ \epsilon_t^{FEX} \\ \epsilon_t^{TRADE} \end{bmatrix} \qquad (3)$$

3   Data

In the empirical analyses below, we use monthly data from 1977 to 2011 for the following variables. As a proxy for global real economic activity, hence exogenous demand shocks to Japanese exports, we use the same variable used in Kilian (2009) and Kilian and Park (2009). Data were downloaded from Lutz Kilian's Web site. Crude oil price data are US crude oil imported acquisition costs by refiners (dollars per barrel) taken from the US Department of Commerce's Web site. For the sample period considered in this paper, the correlation between the US Department of Commerce's data and the IMF's oil price data in their Primary Commodity Prices dataset is more than 95%.[1] US data, therefore, are nearly identical to the average of the

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[1] IMF's oil price data are the average of Brent Crude, Dubai Fateh, and WTI.

international crude oil price. The lag in the VAR estimation is set to 12 months unless otherwise stated.

Japan's real effective exchange rate and monthly real export data are obtained from Bank of Japan's Web site. For real export data, we use both the seasonally adjusted monthly growth rate and the growth rate from the same month in the previous year. As the empirical results are qualitatively very similar, in the following discussions, we report the empirical results using the growth rate from the same month in the previous year.

4   Impulse Response Functions

In Figure 2, the impulse responses of the two-, three-, and five-variable VAR systems are plotted. Rows in the tables represent the variable responding to shocks and columns represent the shock variable.

[Figure 2 here]

Let us start with a discussion of the two-variable system. First, both the real effective exchange rate and exports are positively affected by their own past shocks. Second, while an increase in the real exchange rate, i.e., appreciation of the yen, today reduces exports tomorrow (second row, first column), an autonomous increase in exports does not result in a significant impact on future exchange rates (first row, second column).

Next, in the three-variable system, the global aggregate demand shock, a proxy for global real economic activity, is added to the two-variable system and it is influenced only by its own lagged variables (first row, first column). The global aggregate demand shock leads a significant positive response of export growth (third row, first column). Although not statistically significant, the aggregate demand shock also seems to induce a depreciation of the yen's value against other currencies (second row, first column). On the other hand, the relationship between the variables in the two-variable system, export growth and real exchange rate, does not appear to be significantly affected by the introduction of the aggregate demand shock to the system. Still, in explaining the variation in export growth, the relative

7

importance of the exchange rate shock can vary over time substantially depending on the relative sizes of contemporaneous exogenous exchange rate shocks and aggregate demand shocks.

Our five-variable system also includes the oil price and oil production. Oil production does not appear to have a strong influence on the other four variables. However, because our sample starts from the late 1970s, it does not include the early 1970s when the world economy experienced a large exogenous shock to oil production. Hence, it is not obvious whether the empirical results here can be generalized beyond the sample period considered in this paper. Fluctuations in oil production are affected by own lagged values and nothing else. Even though aggregate demand shocks seem to have a positive impact (first row, second column), this effect is not statistically significant. On the other hand, temporary oil price fluctuations are explained by past aggregate demand shocks (third row, the second column) as well as its own lagged values (third row, third column). Export shocks also seem to have a positive impact on the oil price, but the effect is not statistically significant (third row, fifth column).

In addition, the temporary rise in the crude oil price has a small positive impact on the world economy (second row, third column) and clear positive impact on Japanese exports (fifth row, third column). The latter result is puzzling, but is consistent with the finding by Fukunaga, Hirakata, and Sudo (2011) about the oil price's effect on output. Fukunaga et al. argue that Japanese companies' comparative advantage in energy-saving technology stimulates Japan's exports when the oil price increases. However, whether such an explanation is persuasive enough requires more detailed microeconomic evidence, which is an issue for future research.

5   Variance Decomposition

In Table 1, the results of variance decompositions performed with three different VAR systems are shown. In addition to the full sample results, variance decompositions are calculated for the previous and subsequent 2000 subsamples. As a robustness check, we report the results of variance decompositions using seasonally adjusted month-to-month growth rates as an export variable, in addition to the 12-month growth rate.

[Table 1 here]

First, in the variance decompositions for the two-variable VAR system, the fraction of exports variation explained by exchange rate shocks is 15% when the seasonally adjusted growth rate is used as an export variable and is 22% when the growth rate from the same month in the previous year is used. While the exchange rate has slightly higher explanatory power in the latter, both results suggest about 80% of the variation in export growth can be explained by factors other than exogenous exchange rate shocks.

Turning to the results of the three-variable system, 11% of seasonally adjusted monthly growth and 33% of the 12-month growth of exports are explained by global aggregate demand shocks. The share of lagged export values drops by about 10 percentage points in the three-variable system, from 85% to 75%, compared with the two-variable system, when monthly growth is used as an export variable. If the 12-month growth rate is used, the share of lagged values drops by about 30 percentage points, from 78% to 47%. Therefore, foreign demand shocks are more important in explaining export variation at longer horizons. On the other hand, the share of exchange rate shocks accounts for 14% of the variation in seasonally adjusted export growth and about 20% of the variation in 12-month growth. So in either case, the share of exchange rate shocks remains almost the same in the three-variable system as in the two-variable system. Finally, in a comparison of earlier and latter subsamples, the share of global aggregate demand shocks is higher in the subsample after 2000. This result is consistent with the informal discussion in Section 1 about the behaviors of nominal and real exports in the mid-1980s and in the late 2000s.

Finally, in the five-variable VAR decompositions, the importance of global demand is also higher in the second half of the subsample. Thus, the share of export shocks is lower and this is consistent with the results for the three-variable system. The influence of oil supply shocks is extremely limited. In contrast, temporary fluctuations in the crude oil price in the latter subsample is extremely significant. While it has very limited impact on Japanese exports in earlier subsamples, it explains as much as 22% of monthly Japanese export growth and 47% of the 12-month growth rate in the subsample after year 2000. Hence, temporary movements of the crude oil price have a considerable impact on export fluctuations in Japan in recent years. However, its share of the 12-month export growth rate is unrealistically high, which will require a more careful analysis in future research.

9

6 Comparison of Historical Episodes

In this section, we select three historical episodes of yen appreciation and provide a quantitative evaluation of the relative importance of exogenous exchange rate shocks in explaining export variation in these episodes. For this purpose, we perform historical decompositions of the 12-month real export growth rate using the full sample. Figures 3 and 4 show the result for three particular periods, namely the mid-1980s (around the Plaza Accord in September 1985), mid-1990s (around 1995/96 when the yen recorded its historical high against the US dollar), and late 2000s (around the collapse of Lehman Brothers and the subsequent global economic downturn).

Figure 3 shows the results of the historical decomposition for the three-variable system. The graph in panel C suggests that the decline in exports immediately after the onset of the global recession in late 2008 and 2009 and the subsequent sharp recovery in 2010 are both explained by shocks to exports. Compared with the episode in the late 2000s, the real exchange rate and aggregate demand played much more important roles in the 1980s and 1990s. The relative importance of the autonomous decline and recovery of Japanese exports might be explained by excessive inventory adjustment by Japanese firms as suggested by Shioji and Uchino (2011). On the other hand, in the comparison of the relative importance of exchange rate shocks and aggregate demand shocks, the latter is more important in explaining the fluctuations in Japanese exports in the late 2000s, while the former is more important in the episodes in the 1980s and 1990s. These results are consistent with the variance decomposition discussion in the previous section and Table 1.

[Figure 3 here]

In Figure 4, the historical decompositions of the five-variable VAR are shown. First, we confirm that oil supply shocks do not have a significant impact on export variation in either the impulse response or variance decomposition results. Furthermore, the absolute magnitude of the impacts of exchange rate shocks and global demand shocks on Japanese exports in the five-variable system are not significantly different from those in the three-variable system. On the other hand, fluctuations in the oil price are independent of oil supply and had limited importance in 1980s data. It is far more important in the 1990s and 2000s data, especially the latter. In

Panel B, for the periods from mid- 1992 to the first half of 1993 and from mid-1996 to early1997, oil price shocks stimulate exports. In the data for the 2000s shown in panel C, oil shock prices contributed positively to exports in the period from the second half of 2007 to the summer of 2008. After the collapse of Lehman Brothers in the fall of 2008, the oil price first has a large negative impact on Japanese exports, and then from mid-2010 has a large positive impact. As mentioned in the discussion on the variance decomposition results, the explanatory power of oil price shocks for Japanese exports during this period seems to be too large and requires further studies in future.

[Figure 4 here]

7   Conclusions

In this paper, using a simple structural VAR in which foreign demand shocks and temporary exchange rate shocks coexist, we provided a quantitative evaluation of their relative importance in explaining variation in Japanese exports. We also expanded our VAR system to consider the impact of oil price fluctuations and found that temporary oil price fluctuations seem to play an important role in explaining Japanese exports in the sample after 2000. In the second half of the paper, we compared the roles of exchange rate shocks and global demand shocks in three historical episodes of yen appreciation. We found that the relative importance of exchange rate shocks in explaining export fluctuations was most pronounced in the fluctuations of the yen in the mid-1990s. While they were less pronounced than in the 1990s, exchange rate shocks were also important in the yen appreciation after the Plaza Accord in the mid-1980s. Conversely, in the "trade collapse" period during the global recession in the late 2000s, subsequent to the collapse of Lehman Brothers in 2008, global aggregate demand shocks were much more important than exchange rate movements in explaining the sharp decline and recovery of Japanese exports. However, it should be noted that the absolute size of exchange rate shocks are virtually the same in all three historical episodes. Instead, the magnitude of other factors, especially the size of foreign demand shocks, differ significantly in the different time periods.

Historically, Japanese policy makers have tried to lower the yen's value to stimulate the economy by stimulating exports. The empirical results

11

of this paper suggest that the importance of the exchange rate has been exaggerated in policy debate. Other economic factors such as the level of global economic activity and the oil price have also had large impacts on Japanese export fluctuations. Therefore, it is dangerous to generalize the conventional wisdom about the yen impact on Japanese exports and the economy. In particular, the effect of expansionary monetary policy in trying to depreciate the yen could be muted when aggregate global demand is extremely weak.

The analysis in this paper has left some important issues for future research and they should be studied carefully to draw concrete policy implications. First, the analysis with the five-variable VAR found that temporary oil price increases had positive effects on Japan's exports and that this effect was particularly large in the 2000s. This is consistent with what Fukunaga et al. (2011) found about the effect of oil price increases on Japan's output. However, looking at the results of the historical decomposition for the 2000s in Figure 4, the impact of temporary oil price shocks was far more important than exchange rate shocks and global demand shocks. Perhaps it is too large to be taken seriously. It also should be noted that, even though this paper has argued that the effect of the exchange rate on exports has been exaggerated, the exchange rate can also affect corporate profit levels without having a large impact on exports. Therefore, the impact of the exchange rate on the corporate profits of Japanese companies should be examined separately from the impact on exports.

Finally, this paper ignored the possibility of structural change in the relationship between the yen exchange rate and Japanese exports. It is conceivable that the quantitative impact of the exchange rate on exports has weakened as Japanese corporations move their production bases overseas. Although there is substantial empirical evidence of shifts in production facilities overseas at an industrial level (see, for example, the Ministry of Economy, Trade and Industry 2014), their impact at the macroeconomic level requires further investigation in future research.

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Table 1 Variance Decomposition for Export Growth

We estimate two-, three-, and five-variable VARs including Japan's export growth and real effective exchange rate for the period from 1975 to 2011, as well as subsamples divided at the end of 1999. In the tables below, variance decompositions for the variation in export growth are reported. For the definitions of structural shocks, see the explanations of equation (1) in the main text. In panels (1a), (1b), and (1c), the monthly growth rate of seasonally adjusted data are used as the export growth variable. In panels (2a), (2b), and (2c), the 12-month growth rate from the same month in previous year was used.

(1a) Monthly/two-variable

	ϵ_t^{FEX}	ϵ_t^{TRADE}
1975–2011	15.0	85.0
1975–1999	14.9	85.1
2000–2011	31.2	68.8

(1b) Monthly/three-variable

	ϵ_t^{DE}	ϵ_t^{FEX}	ϵ_t^{TRADE}
1975–2011	11.1	14.3	74.6
1975–1999	2.4	15.1	82.5
2000–2011	34.0	17.3	48.7

(1c) Monthly/five-variable

	ϵ_t^{SY}	ϵ_t^{DE}	ϵ_t^{OIL}	ϵ_t^{FEX}	ϵ_t^{TRADE}
1975–2011	2.3	5.9	10.3	12.0	69.6
1975–1999	4.6	1.7	2.9	14.7	76.0
2000–2011	3.6	19.1	22.3	9.6	45.3

(2a) 12 months/two-variable

	ϵ_t^{FEX}	ϵ_t^{TRADE}
1975–2011	21.8	78.2
1975–1999	42.4	57.6
2000–2011	32.8	67.2

(2b) 12 months/three-variable

	ϵ_t^{DE}	ϵ_t^{FEX}	ϵ_t^{TRADE}
1975–2011	33.2	19.9	46.9
1975–1999	15.5	23.3	61.2
2000–2011	69.5	9.4	21.0

(2c) 12 months/five-variable

	ϵ_t^{SY}	ϵ_t^{DE}	ϵ_t^{OIL}	ϵ_t^{FEX}	ϵ_t^{TRADE}
1975–2011	0.3	15.1	39.3	11.0	34.3
1975–1999	4.4	14.9	3.2	18.1	59.4
2000–2011	2.1	29.7	46.8	3.4	18.1

Figure 1
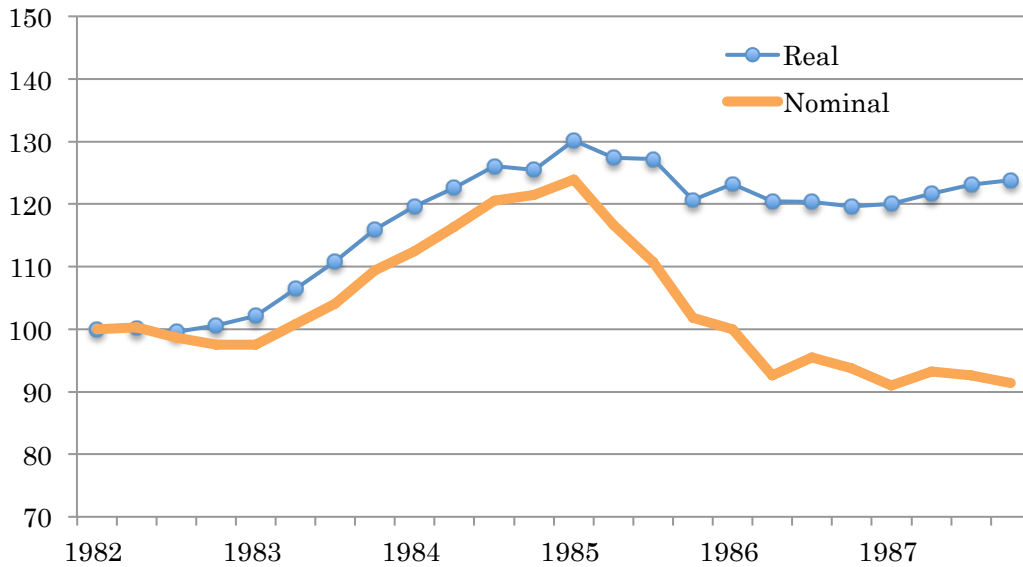## Exchange Rate and Japanese Exports

Panel A: Real effective exchange rate
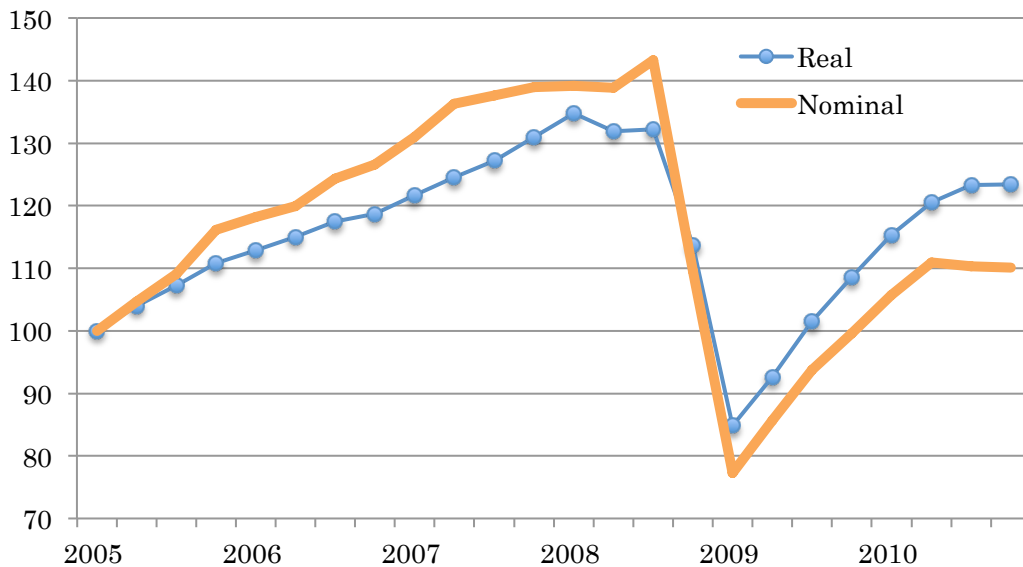(Monthly: January 1975 to December 2013)

Figure1 (continued)

Panel B: Real and nominal export responses to large exchange rate shocks

Before and after Plaza Accord in September 1985 (1982:Q1–1987:Q4)

### Before and after the collapse of Lehman Brothers' in September 2008 (2005:Q1–2010:Q4)

Seasonally adjusted quarterly data from Japan's SNA statistics. Actual data were normalized so that the beginning of each subsample (first quarter of 1982 and 2005) is set to be 100.

Figure 2
Impulse Responses by Two-, Three-, and Five-Variable VAR Systems

Panel A: Cumulative impulse responses by two-variable VAR
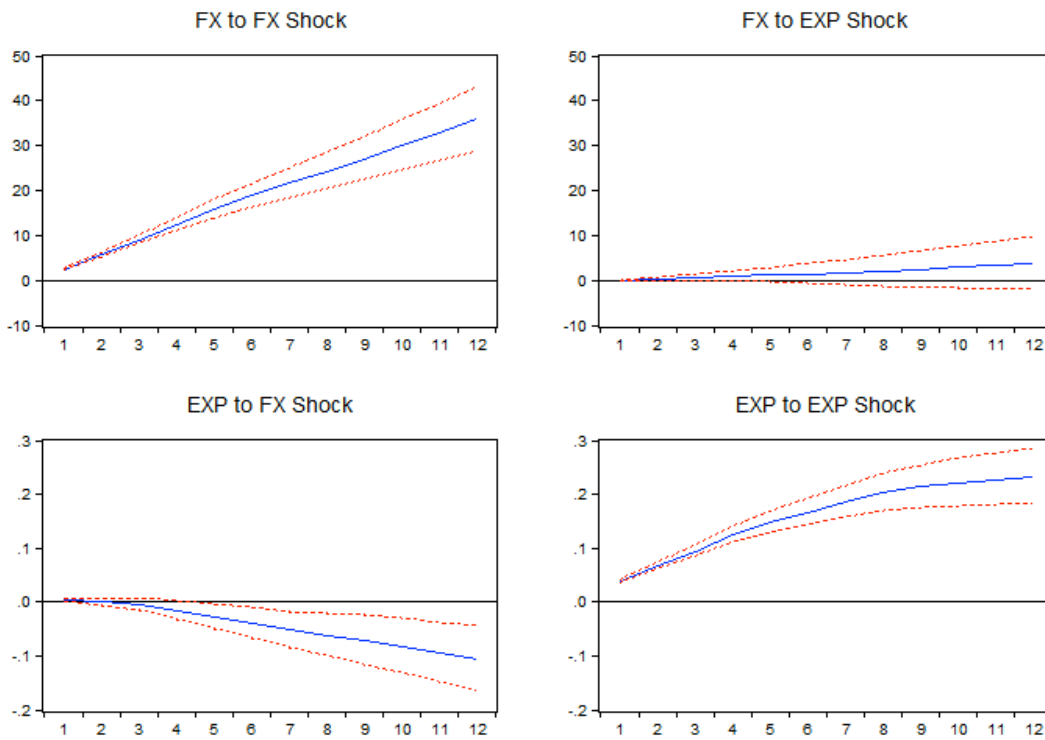
Note: ±2 standard error bounds are shown in dashed-lines above and below impulse responses.

Figure 2 (continued)

Panel B: Cumulative impulse responses by three-variable VAR
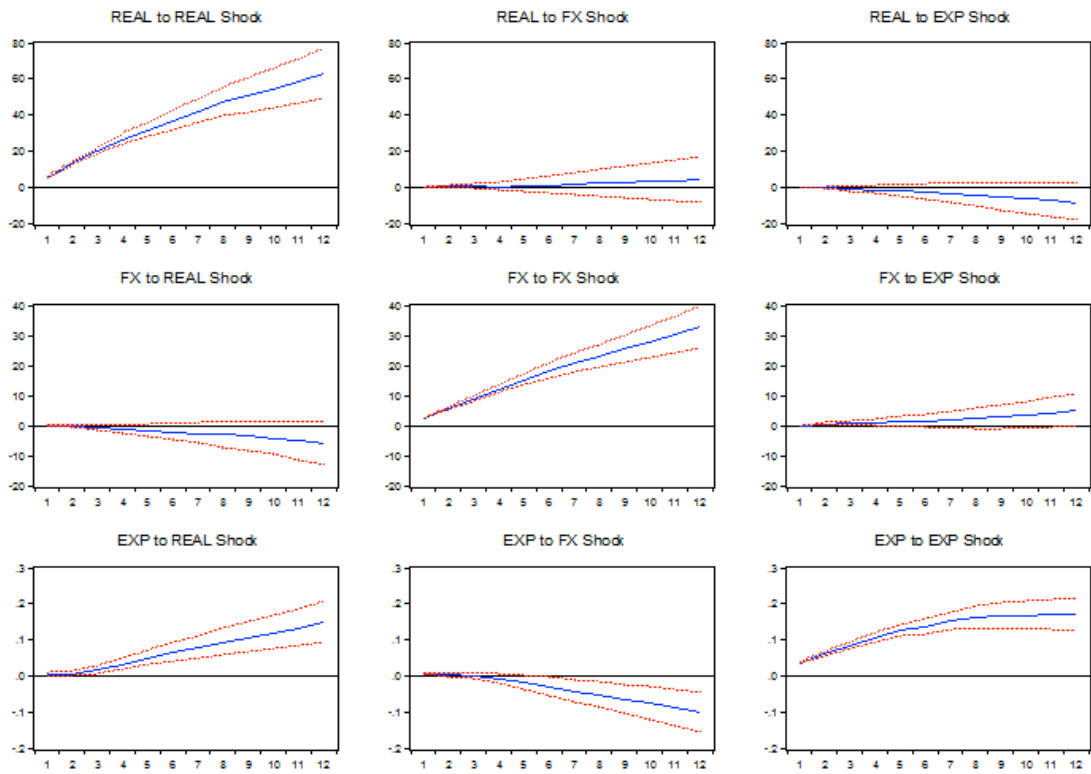
Figure 2 (continued)

Panel C: Cumulative impulse responses by five-variable VAR
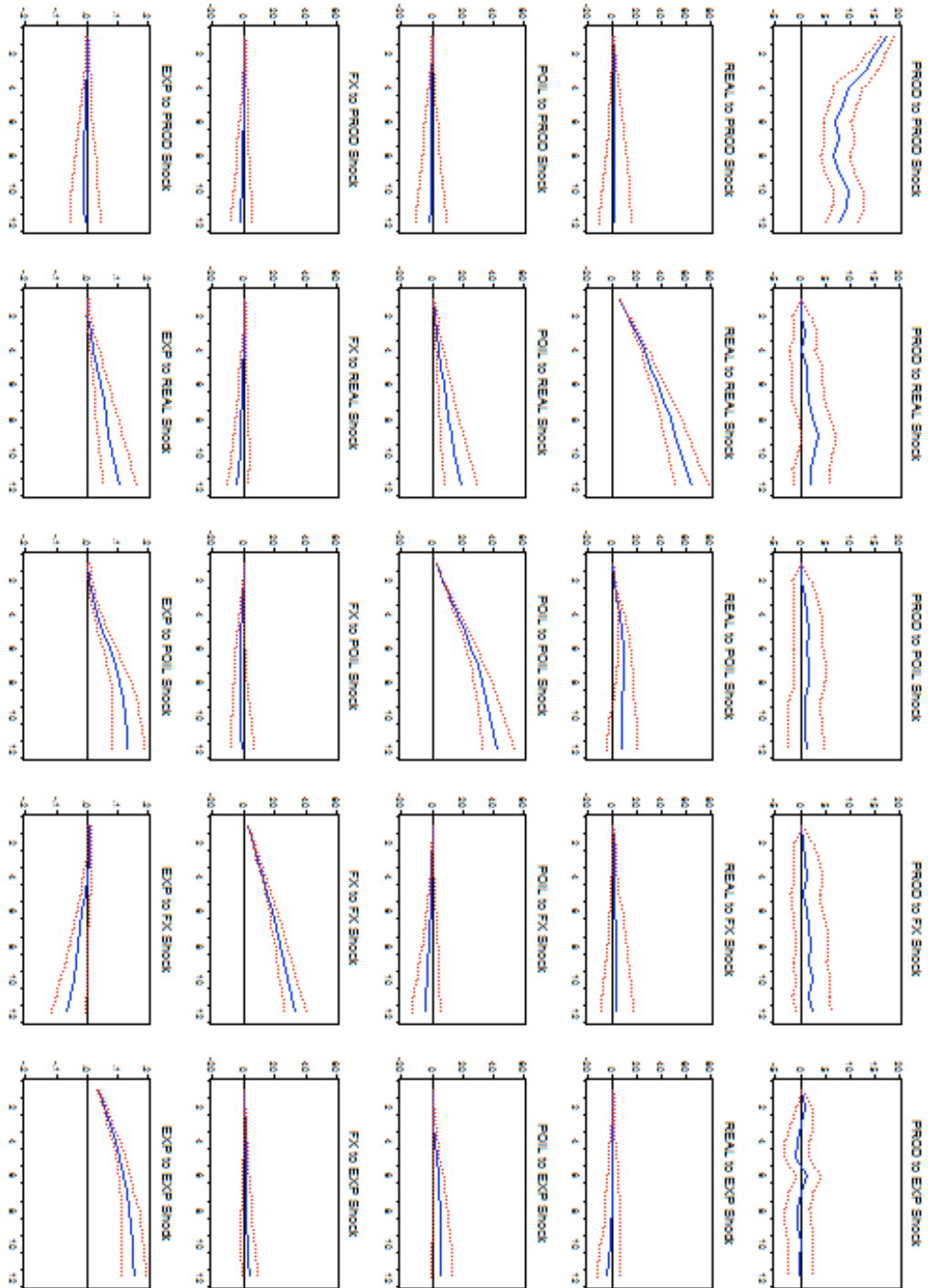
Figure 3

Historical Decomposition by the Three-variable VAR System

tshock (blue solid line): Unexpected change in export growth.

real economic activity (green bar): Contribution of contemporaneous global
aggregate demand shock to **tshock**.

real effective exchange rate (red bar): Contribution of contemporaneous exchange
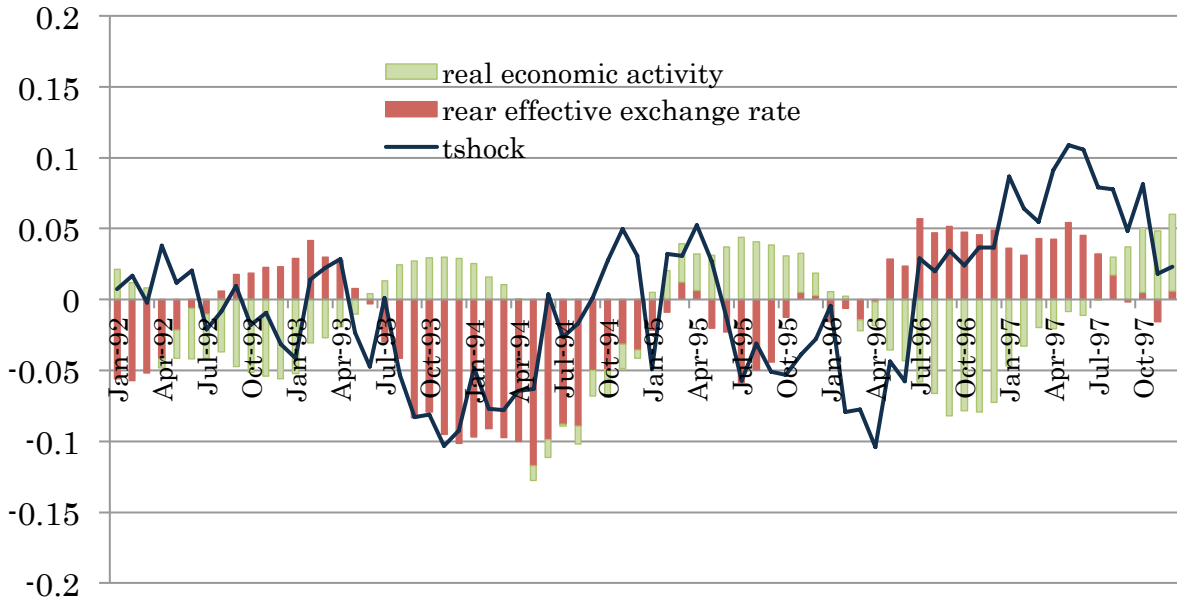rate shock to **tshock**.

Panel A: January 1983 to December 1988
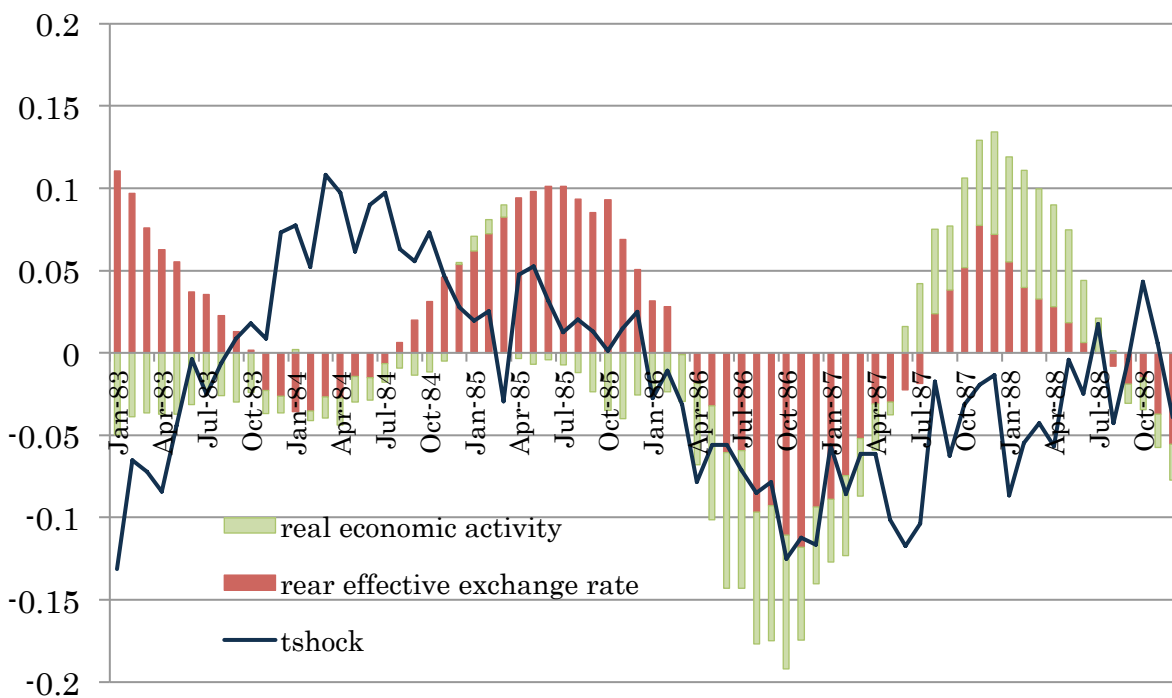
Figure 3 (continued)

Panel B: January 1992 to December 1997

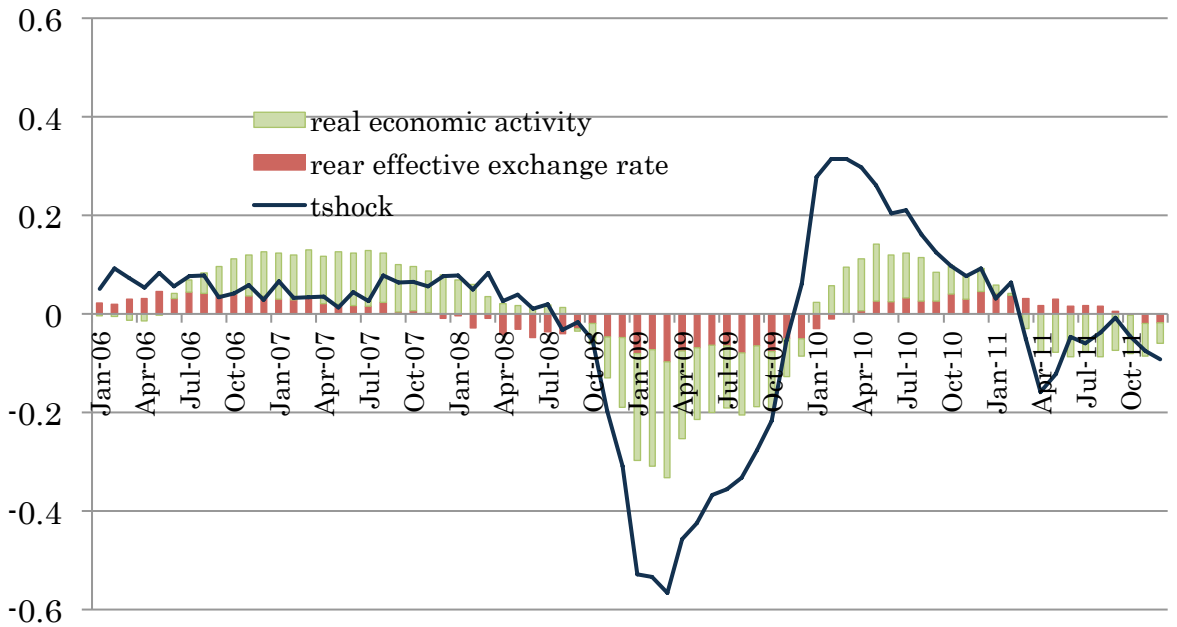## Panel C: January 2006 to December 2011

Figure 4
Historical Decomposition by the Five-Variable VAR System

tshock (blue solid line): Unexpected change in export growth.

oil production (orange bar): Contribution of contemporaneous oil production shock to **tshock**.

oil price (blue bar): Contribution of contemporaneous temporary oil price change to **tshock**.

real economic activity (green bar): Contribution of contemporaneous global aggregate demand shock to **tshock**.

real effective exchange rate (red bar): Contribution of contemporaneous exchange rate shock to **tshock**.
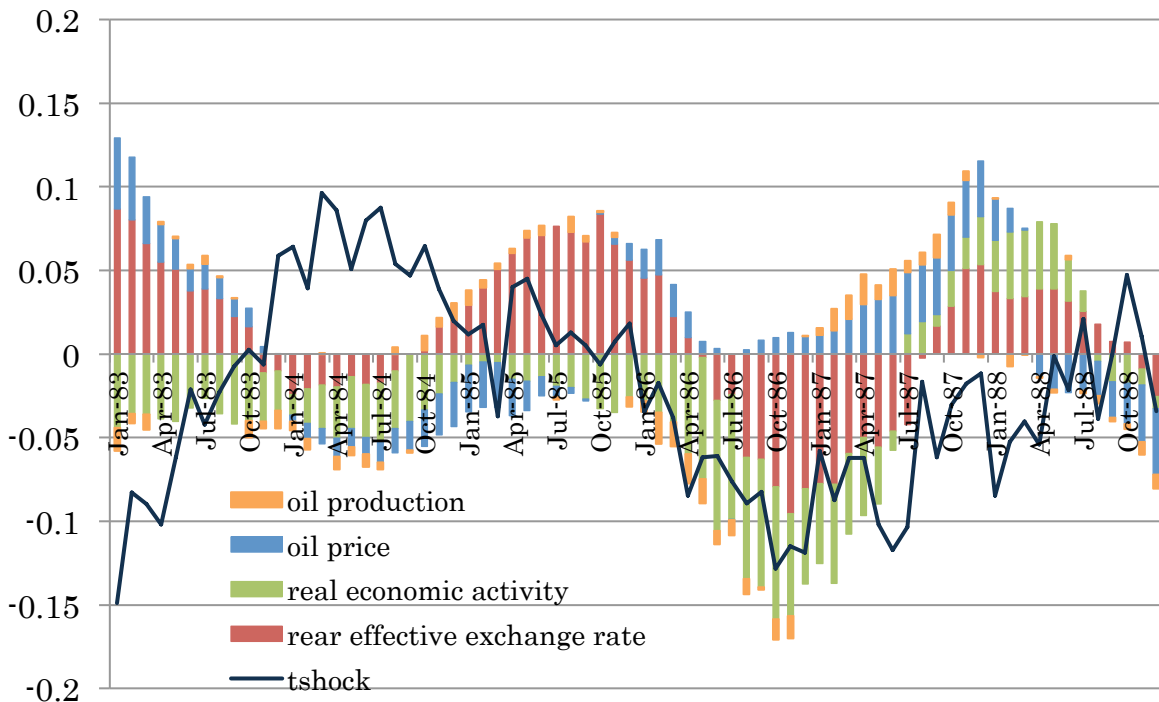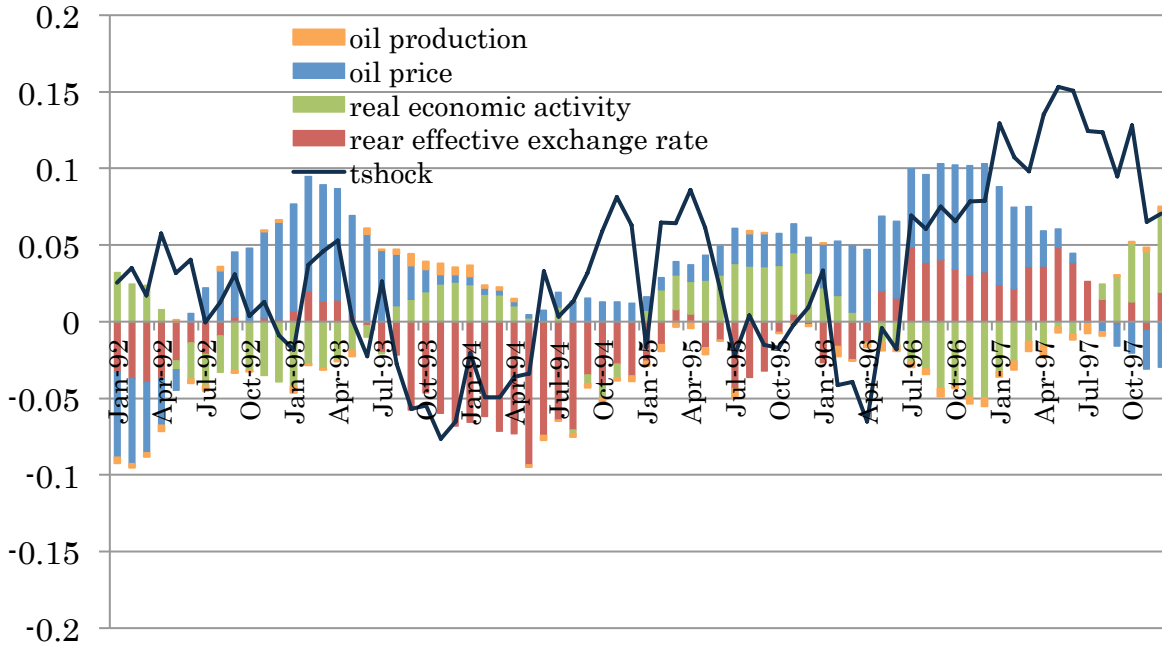
Panel A: January 1983 to December 1988

Figure 4 (continued)

Panel B: January 1992 to December 1997

Panel C: January 2006 to December 2011