EFFECTS OF OIL AND FOOD PRICE SHOCKS ON THE MACROECONOMIC VARIABLES IN NET OIL IMPORTER COUNTRIES

By

Diana Teloian

Submitted to

Central European University

Department of Economics

In partial fulfillment of the requirements for the degree of Master of Arts in Economics

Supervisor: Gábor Kőrösi

Budapest, Hungary

2017

Abstract

This study examines the effect of food and oil price shocks on the macroeconomic variables of net oil importers: Japan and the USA. I employ two SVAR models with linear and net oil price specifications and by including dummies I control for major events that affected two economies: Asian Financial Crisis and 2011 earthquake for Japan and Global Financial Crisis for both countries. The findings of this study show that US macro-variables are responsive to the external commodity shocks and, except for real output, behave according to economic theory. Results for Japan are statistically insignificant, but mainly consistent with expected outcomes, except for the positive response of Japanese output to oil price increase. However, this could be explained by oil efficiency of Japanese cars which induces the shift of world demand towards Japanese automotive products and raises GDP of Japan. The commodity shocks account for significant variation in inflation and real effective exchange rate of the both countries. Food price shocks mainly transmit through short-term interest rates and real effective exchange rates. Impulse Response Functions show that money supply decreases and interest rates go up following the shock of food and oil prices in both countries. This implies that monetary authorities conduct tight monetary policy to combat increasing inflation.

Table of Contents

1 Introduction 1
2 Literature Review 3
2.1 Oil prices and economic activity 3
2.2 Food prices and macroeconomy 5
3 Country Profiles in Terms of Oil Imports 9
3.1 USA 9
3.2 Japan 10
4 Transmission Mechanism of Oil and Food Price Shocks 12
5 Data and Methodology 14
5.1 Data 14
5.2 Oil Price Specification: Linear and Net 15
5.3 Unit Root Test 15
5.4 SVAR Model 16
5.5 Residual Diagnostics 18
6 Empirical Results 19
6.1 Impulse Response Functions 19
6.1.1 USA 19
6.1.2 Japan 20
6.2 Forecast Error Variance Decomposition 21
6.2.1 USA 21
6.2.2 Japan 22
6.3 Model Checking 23
6.3.1 USA 23
6.3.2 Japan 24
7 Conclusion 25
References 27
Appendix I: Country Profiles 30
Appendix II: Data Description 33
Apendix III: ADF and PP Tests 34

Appendix IV: Break Point Unit Root Test 35
Appendix V: Lag Order Selection Criteria 36
Appendix VI: Lag Exclusion Wald Test 37
Appendix VII: Impulse Response Functions 38
Appendix VIII: Forecast Error Variance Decomposition 46
Appendix IX: Residual Diagnostics 50

List of Tables and Figures

Table 1 Data Description 33
Table 2 ADF and PP Unit Root Tests 34
Table 3 Break Point Unit Root Test 35
Table 4 Lag Length Criteria for USA Models 36
Table 5 Lag Length Criteria for Japanese Models 36
Table 6 Lag Exclusion Test. Model 1. USA 37
Table 7 Lag Exclusion Wald Test. Model 2. USA 37
Table 8 Lag Exclusion Wald Test. Model 1. Japan 37
Table 9 Lag Exclusion Wald Test. Model 2. Japan 37
Table 10 FEVD. Model 1.USA 46
Table 11 FEVD. Model 2. USA 47
Table 12 FEVD. Model 1. Japan 48
Table 13 FEVD. Model 2. Japan 49
Table 14 Tests for Residual Serial Correlation and Heteroskedasticity. USA 50
Table 15 Tests for Residual Serial Correlation and Heteroskedasticity. Japan 50
Table 16 Jarque-Bera Test for Normality of Residuals. USA 51
Table 17 Jarque-Bera Test for Normality of Residuals. Japan 51
Figure 1 Primary energy net import 8
Figure 2 Japan's petroleum and other liquids production and consumption 9
Figure 3 Transmission Channels 12
Figure A.1 Food Price Index 30
Figure A.2 USA primary energy imports and exports (Quadrillion Btu) 30
Figure A.3 Electricity net generation (Billion Kilowatthours) 31
Figure A.4 Petroleum consumption by sector 31
Figure A.5 Japan’s total energy consumption, 2015 31
Figure A.6 Japan's crude oil imports by source,2015 31
Figure A.7 Japan's net electricity generation by fuel, 2000-2015 31
Figure A.8 Impulse Response Functions. Model 1. USA 37
Figure A.9 Impulse Response Functions. Model 2. USA 39
Figure A.10 Impulse Response Functions. Model 1. Japan 41
Figure A.11 Impulse Response Functions. Model 2. Japan 43

1 Introduction

Oil and food are two commodities which are necessities. Crude oil is an important input in production and increase in its price negatively affects oil-importers' economic activity. Food is a major part of consumption basket. In addition, according to World Energy Council report of 2016, in the past decades many countries try to transfer to renewable and low carbon energy sources including biofuels, which are produced from food. Increasing production of biofuels can raise food prices, which may in turn increase cost of food import for food-importers, decrease demand for the food export for food-exporters and, thus, affect economic growth of both trade parties.

Impact of oil price shocks on the economies have been debated since 1973 oil crisis. Studies have shown that oil price hikes preceded all but one US recessions since World War II (Hamilton 1983). Over the past two decades, the world has experienced continuous climb in oil prices in 2001-2008 and 2009-2011. There were sharp declines in oil prices in 2008-09 and 2014-present From Figure A.1. we can see that Food Price Index has followed the similar pattern as oil prices since 2008, which further strengthens interest in the effect of these two commodity prices on economic activity.

While oil price-macroeconomy relationship has gotten much attention from researchers since 1970s, there is very limited number of papers that study relationship between food price shocks and macroeconomic variables. Moreover, based on my research there are only two papers, Alom (2011) and Khan and Ahmed (2011), that study oil and food price shocks' effect on economic activity together in a (Structural) VAR framework for Asia and Pacific countries and Pakistan respectively.

In this study, I estimate 7-variable Structural VAR to study the effect of oil and food prices on macroeconomic variables of the USA and Japan. There are many papers that study effect of oil price shocks on economic activity of these countries, but none that focus on oil and food prices jointly. Hence, this study will fill this gap. By including money supply in the model, I will be able to see how monetary authority reacts to the commodity price shocks. In addition, I consider major events that affected both economies and control them with corresponding dummy variables.

The rest of this study is structured as follows. First, I present available literature on the macroeconomic effects of oil and food price movements. Section three discusses country profiles in terms of oil imports and consumption. Next, I organize oil and food price shocks transmission mechanism to economic activity based on theory. Then I present data and methodology used in the study. Section six contains empirical results, its analysis and residual diagnostics. The last part of the study draws conclusions.

2 Literature Review

2.1 Oil prices and economic activity

The relationship between oil price shocks and macroeconomic variables was analyzed by many researchers after Hamilton pioneered by publishing his influential paper in 1983. He studied quarterly data over the period 1949 to 1980 and showed that out of eight post-World War II US recessions all except the one of 1972 were preceded by significant oil price increase. This does not necessarily mean that sharp jump in crude petroleum price leads to economic downturn, but significant correlation implies that it is one of the factors contributing to the decline in real income.

Mork (1989) has put forward the study of Hamilton (1983) and noted that the work of Hamilton was conducted for the period of only upward movements of oil prices. By extending the data used by Hamilton to include oil price collapse of 1986, Mork (1989) found that no economic boom followed the decline in crude oil prices of 1986. He concluded that the impact of oil prices and macroeconomic activity is different from the one reported by Hamilton (1983). Therefore, Mork decided that relationship can be non-linear and investigated asymmetric oil price-economic activity relationship. He estimated real GNP equation in VAR model with real oil price increases and decreases as separate variables, i.e. employed asymmetric specification of oil price shocks. He found asymmetry in responses to oil price movements: there is negative correlation between oil price increase and economic growth, but the coefficient on real oil price decline is small, positive, and statistically insignificant.

Lee et al. (1995) argued that effect of oil price increase on real GNP growth is greater when long horizon of stable rather than volatile oil price movements precedes the increase. Authors included a variable which reflects the difference of oil price movement from previous pattern in a VAR model, i.e. they employed so called scaled specification of oil price shock. The variable appeared to be statistically significant, confirming that it matters whether real oil price change is unanticipated or it is just an adjustment to a change in previous period. They found that there was an asymmetric response of real GNP to positive and negative normalized oil price shocks, which is consistent with Mork (1989).

Looking at oil price movements Hamilton (1996) noticed that since 1986 most of price increases were corrections to previous price declines. He proposed measuring oil price shock as net oil price increase. If the price of oil at time *t* is greater than a maximum value of previous year, then oil price increase is defined as percentage change from previous year's maximum, otherwise the value of oil price change is set to be zero; such a definition is called the net specification. Figure 2 from Hamilton (1996) shows that the highest change compared to maximum value of previous year's price was in 1990 when Iraq attacked Kuwait. This oil price shock, indeed, preceded recession.

A set of papers showed that the relationship between oil price shock and aggregate economy is asymmetric, non-linear. Employing multivariate VAR model Jiménez-Rodríguez and Sánchez (2005) examined effect of oil price shock on macroeconomic variables in six industrialized OECD countries, including net importers and net exporters of oil. Using asymmetric and net specifications discussed above, authors found negative correlation between oil price increase and GDP growth among oil-importers except Japan. Oil price and monetary policy shocks explained most of the variation in real gross domestic product almost for all countries in the study. Similarly, Cuñado and de Gracia (2003) found asymmetric, but only short run negative oil price effect on Industrial Production Indexes (IPI) for many European countries.

Some studies argue that the relationship between oil prices and macroeconomy is weakening. Bernarke et al. (1997) argued that major part of response of economy to oil price shocks was attributed to tight monetary policy. In similar line, Bohi (1991) claimed that contractionary monetary policy followed both energy price shocks of 1970s in Germany, UK and US. In Japan, monetary policy was expansionary during the second oil price shock and therefore it "escaped" recession in that period. In addition, Bohi noted that oil price shocks of 1970s happened to occur in already declining economic activity in most of these countries, so deflationary policies were already fighting against increasing inflation and energy price shocks could only intensify actions of monetary authorities and retard economy through such way.

Some studies investigate effect of oil prices on exchange rates. Amano and van Norden (1998) documented that real oil price shock determines long run real exchange rate for Germany, Japan and the United States. First, they found evidence of significant cointegration between real domestic oil price and real effective exchange rate for all three currencies. Hence, real oil prices can approximate exogenous terms-of-trade shocks in these countries. Next, they showed empirically that real exchange rates do not Granger-cause oil price. Other papers also present similar result to Amano and van Norden (1998) (Chen and Chen (2007), Lizardo and Mollick (2010), Akram (2004), Chaudhuri and Daniel (1998)). Contrary, some studies show that there exists another direction of causality, i.e. exchange rates influences crude oil prices. For example, Fratzscher et al. (2014) found causal negative relationship between two variables in both directions. The authors reported that a 10% rise in oil prices causes depreciation of US dollar by 0.28 percent, and weakening of USD by 10% leads to increase in oil prices by 7.3%. Zhang et al. (2008) also demonstrated the contribution of USD depreciation on international crude oil prices.

2.2 Food prices and macroeconomy

Availability of literature on food price-economic activity relationship is quite limited, interest in this area has risen after 2008. Abbott et al. (2009) provided analysis of factors that determine food prices. First driver of food prices is that growing demand for food consumption in developing countries exceeds production. Another major cause of food price climb is increase in biofuel production subsidized by the US and EU. This process requires large amount of corn and vegetable oil, thereby increasing the demand and prices for them.

In the past decades, the world tries to promote usage of renewable energy sources such as solar, wind power, hydro and others to combat climate change. According to World Energy Council report of 2016 biofuels can replace oil in the transportation industry and its production has been increasing in the past decade.

United States Department of Agriculture (USDA) reported that in 2012 about 7.1% of fuel used in transportation sector was coming from biofuels. In the same year ethanol, made from corn scratch, was the most important biofuel and represented 94% of bioenergy production. The next by significance was biodiesel which is produced from soybeans, oil crops and animals' fat.

Applying Global VAR for 33 countries spanning 1999-2007 Galesi and Lombardi (2009) found that increasing food prices affected inflation of mostly emerging rather than developed regions. The reason for that can be higher weight of food in consumption basket of former. Statistically significant estimates were found only for Baltic countries, where food price shock increased inflation by 0.5% contemporaneously and the effect was persistent even after two years. The authors reported non-significant effect of food price shock on Industrial Production Indices across countries. The reason they did not find decline in output is that generally food is not an input in production.

Inoue (2017) put forward work of Galesi and Lombardi (2009) and investigated effect of oil and food price shocks on Producer Price Index (PPI), Consumer Price Index (CPI) and

Industrial Production (IP) using global VAR methodology for 22 countries including the US, Asian, European, and Latin American regions. Differently from Galesi and Lombardi (2009) their work covers post-Global Financial Crisis data and includes PPI variable. Their finding implies that CPI response for all economies to price shocks of both commodities is similar in magnitude and direction except for Japan and Korea. The response is insignificant for Japan and CPI of Korea is twice more sensitive to food price shock compared to oil price one. The authors found positive relationship between food price hike and PPI for all the countries both in pre-financial crisis and post-financial crisis periods. Surprisingly, authors claimed that the effect of commodity price shocks on Industrial Production has reversed after global financial crisis (GFC). They found that after GFC for many oil-importing countries the relationship with oil price hike is not negative as the past evidence predicts, but positive and even statistically significant for some countries in short run.

Jongwanich and Park (2011) examined pass-through of food (wheat, rice, palm-oil) prices on domestic inflation in nine developing Asian countries for the period 2007-2008. They found higher pass-through to producer prices in food-exporting rather than food-importing countries. Pass-through to consumer prices is lower, which as they explained is due to government food subsidies in that period.

Khan and Ahmed (2011) applied SVAR framework to study effect of oil and food price shocks on economy of Pakistan and found that the later has more persistent positive relationship with CPI. Consistent with the theory, output decreases in the response of crude oil, but already after second month starts increasing. Whereas, response of output to food price shock is positive for consequent three months following the shock. The authors found that the most responsive variable to the two commodity shocks is exchange rate.

Alom (2011) examined the impact of oil and food prices in Asia and Pacific countries using Structural VAR methodology. Countries that author investigated are Australia, New Zealand, Hong Kong, South Korea, Singapore, India, Taiwan, and Thailand. The author found that in the oil poor countries, New Zealand and Australia, variables, except for exchange rate, are irresponsive to oil price shocks. The reason can be that these two countries are rich in other minerals. Oil importing manufacturing countries like Taiwan and South Korea are highly affected by oil price increases and the effects are consistent with economic theory. Interestingly, the author reported that oil price shocks do not affect oil poor country India. He explained it by India specializing in international financial services. The major effect of food price shock that the study found in all the countries is depreciation of REER.

3 Country Profiles in Terms of Oil Imports

3.1 USA

According to the US Energy Information Administration, in 2016 the USA was the second country that imported largest amount of crude oil after China. Among other energy sources, crude oil has largest net imports (Figure 1). According to EIA report in 2015 the US crude oil imports increased by less than 1 percent, while production rose by 7 percent (Figure A.2).

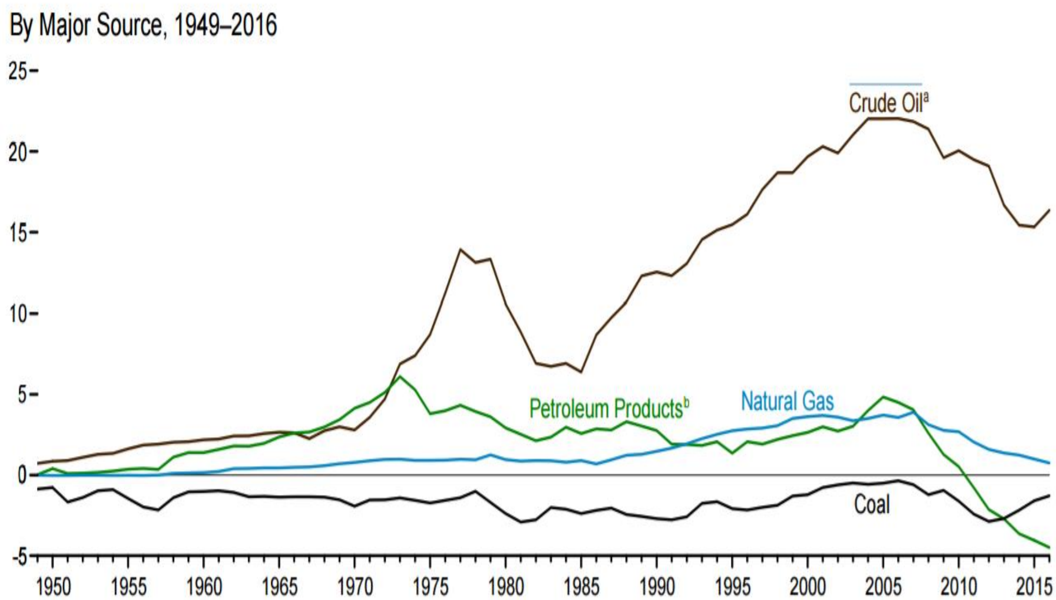


Figure 1 Primary energy net import. Source: EIA, May 2017 Monthly Energy Review

Despite oil production of the US increasing since 2005, it remains the top world net crude oil importer. Major oil exporter to the US from non-OPEC countries are Canada, Mexico, Columbia and from OPEC countries Saudi-Arabia, Venezuela, and Iraq. Petroleum is not a vital in electricity generation, where coal is a dominant source (Figure A.3). Most of the oil in the US is used in transportation and industrial sectors (Figure A.4).

3.2 Japan

Before 2011, Japan was the third largest nuclear power consumer after the US and France; 27% of power generation in the country was coming from nuclear reactors (EIA 2017). In March 2011, there was a 9.0 magnitude earthquake followed by tsunami, which caused a serious damage to Fukushima-Daiichi nuclear power plants. Since then Japan shut down all nuclear reactors and substituted it mainly with petroleum and other liquids, natural gas, and coal. Such substitution of nuclear power with more expensive fossil fuels, in addition to currency depreciation and rising oil prices in 2014 led to the first in past 30 years trade deficit of Japan. The country had third largest net oil imports (consumption minus production) after USA and People's Republic of China in 2016 and consumed about 4000 thousand barrels of oil per day in 2016 (Figure 2).

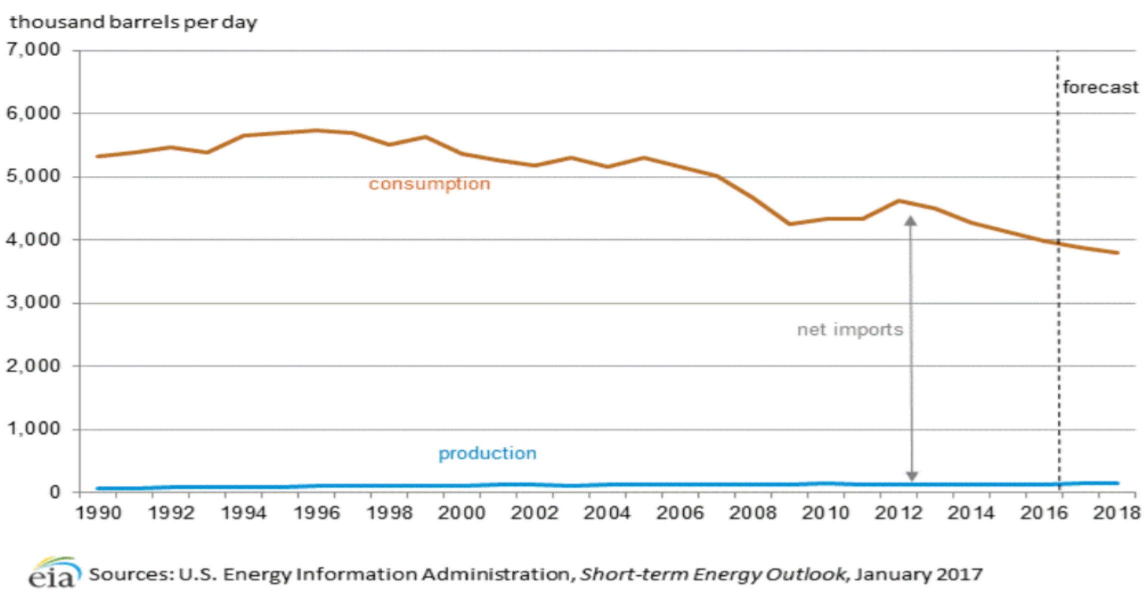


Figure 2 Japan's petroleum and other liquids production and consumption, 2000-2018

Based on the 2013 statistics most of the petroleum products was consumed in transportation (43%) and industry (30%) sectors. Oil accounts for major share in energy consumption (42%), followed by coal (27%) and natural gas (23%) (Figure A.5). Japan imports oil mainly from Middle East; in 2015, the largest source of crude oil imports was Saudi Arabia (34%) and United Arab

Emirates (25%) (Figure A.6). According to 2015 statistics, petroleum has marginal share in net electricity generation (Figure A.7).

Although oil remains major source of energy in the country, its consumption has declined since 2012 because of aging population, efficiency of energy, and expected return to nuclear power generation. Japan's oil demand depends almost entirely on imports rather than production. Therefore, the country holds 412 thousand barrels of oil stocks as of 2016 (74 percent of government-owned and 26 percent of commercial-controlled) as a buffer for a sudden supply interruptions. Moreover, Japan has established agreements with UAE and Saudi Arabia to have a priority in crude oil purchase in case of supply shortage in exchange for lending petroleum storage space to them.

4 Transmission Mechanism of Oil and Food Price Shocks

Many studies confirmed asymmetric response of aggregate economic activity to oil price shocks and some try to explain where this asymmetry generates and what the transmission mechanism is. Following transmission channels are discussed in the literature:

- *Supply-side shock effect.* Oil price increase reduces output growth as oil is one of the major inputs used in the production. Further, real wage growth decreases in a result of declining productivity. Hence, due to supply-side oil price shock unemployment raises, capital utilization drops and output declines (Chuku et al. 2010).
- *Income transfer and aggregate demand effect.* Oil price increase positively affects purchasing power of an oil-exporting country relative to an oil-importing one; this works as wealth transfer process. Demand for goods and services in oil-producing countries increases in a result of improved revenue and balance of payments, the opposite happens in oil-importing states, where aggregate demand declines by more than it increases in oil-exporter countries (Brown and Yucel 2002).
- *Inflation effect.* Oil price increase puts upward pressure on prices. Inflation and reduced GDP are considered as most likely consequences of oil price shock (Chuku et al. 2010).
- *The real balance effects.* In a result of oil price jump money demand increases in oil-importing countries. If monetary authority does not increase money supply to meet increased demand, then short run interest rates increase, which can lead to exchange rate depreciation (Brown and Yucel 2002).
- *Possible monetary policy effect.* Some studies claim that monetary policy can transmit oil price shock, while others argue that it cannot affect real consequences of oil price increase. Figure

3 depicts how monetary authority responds to oil price shock with tight monetary policy to reduce inflation, which in turn can lead to worse economic activity.

- *Sector adjustment effect.* Asymmetry effect of oil price shock is also explained by incorporating adjustment costs that accompany commodity price changes within industries of economy. Raising oil prices directly retard economic activity on the top of adjustment costs. Falling oil prices boost economy, but there are also adjustment costs which offsets positive impact of declining commodity price.
- *Psychological effect.* Uncertainty about duration of oil price shocks can decrease demand for consumption and induce firms from investments (Khan and Ahmed 2011).

Increase in food prices causes decline in demand for food export. Furthermore, employees require better wages, which reduces labor demand and deteriorates production (Alom 2011). In addition, money demand and interest rates increase in a result of food price shock and this depreciates exchange rate (Khan and Ahmed 2011).

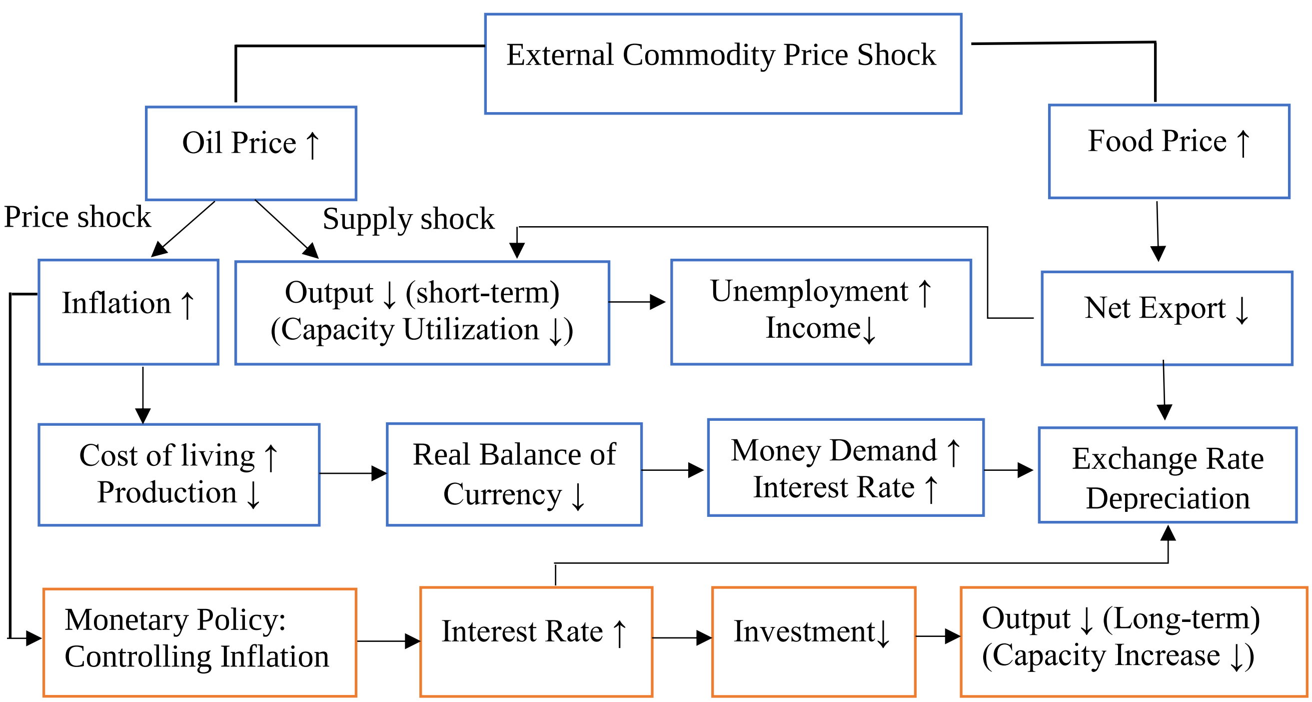


Figure 3 Transmission Channels. Author's compilation based on Tang et al. (2010) and Alom (2011)

5 Data and Methodology

5.1 Data

In this study, in addition to real oil prices in domestic currency and Food Price Index (*FPI*) I employ five macroeconomic variables: real Gross Domestic Product (*GDP*), Consumer Price Index (*CPI*), real money supply measured by *M2* which is deflated by CPI of corresponding country, short-term interest rates represented by money market rates (*R*) and Real Effective Exchange Rate (*REER*). Main source of these series is International Financial Statistics (IFS). The detailed description of the variables and sources is presented in Table 1.

All variables except interest rates are in natural logarithm terms. The variables are seasonally adjusted in EViews using X-12 Census, method X-11with multiplicative term, except interest rate and consumer price index that are seasonally adjusted with an additive term.

Data for the USA covers 1990Q1-2016Q4, for Japan the time span is 1994Q1-2016Q4. For the USA, I use Brent Crude Oil price in US dollars and for Japan - Dubai oil price in Japanese Yen. The reason for the choice of these benchmark oil prices is their relevance for the corresponding regions. Country CPI-s divided nominal prices to convert them to real terms.

Since data studied includes 2008 financial crisis, I include a dummy for it. The dummy for 2007Q3-2009Q1 did not remove an outlier in residuals. Therefore, following Dimitriou et al. (2013) I incorporated three dummies for the phases of global financial crisis (GFC). GFC_1 takes value 1 for the period of “initial financial turmoil” – 2007Q3-Q32008- and zero for the rest of the time; GFC_2 is a dummy for “sharp financial market deterioration” – 2008Q4; GFC_3 takes value 1 for “macroeconomic deterioration” in 2009Q1. For the Japanese data, besides global financial crisis, I control for Asian Financial crisis and 2011 earthquake that destroyed Fukushima-Daiichi nuclear power plants by including dummies for periods 1997Q2-1999Q2 and 2011Q1 respectively.

5.2 Oil Price Specification: Linear and Net

I employ two classic asymmetric oil shock specifications widely used in literature: linear and net. Natural logarithm of real oil price measures linear oil price shock (*OIL*). Real oil price is measured in domestic currency and is computed as follows:

$$ROP_{JPN} = OP_{USD} \frac{YEN/USD}{CPI_{JPN}}$$

$$ROP_{USA} = \frac{OP_{USD}}{CPI_{USA}}$$

In 1996 Hamilton introduced the net specification. The rationale behind such definition was discussed in section two. He transformed explanatory variable to net oil price increase, *NOPI*, which stands for the difference between logarithm of real oil price in quarter (year/month) *t* (OIL_t) and maximum value of OIL over the previous four quarters (previous year/twelve months).

Hence, for our quarterly data, $NOPI_t$ is defined as follows:

$$NOPI_t = \max\{0, OIL_t - \max\{OIL_{t-1}, OIL_{t-2}, OIL_{t-3}, OIL_{t-4}\}\}$$

5.3 Unit Root Test

I employ unit root tests to check stationarity of time series. First, I conduct standard Augmented Dickey Fuller (ADF) and Philips Peron (PP) tests with null hypothesis of non-stationarity. Results are presented in Table 2.

However, Perron (1989) showed that standard unit root tests fail to reject the null hypothesis of unit root when the series is trend stationary with one-time structural break. His point has triggered development of unit root tests which are unbiased towards structural breaks, such as Zivot and Adrews (1992) and Perron and Vogelsang (1992) with a single structural break and Clemente-Montanes-Reyes (1998) and Minimum Lagrange Multiplier (Lee and Strazicich 2003) unit root tests with two structural breaks.

In this study, I conduct Break Point Unit Test of innovation outlier type with one structural break in EViews; break date selection method is based on minimization of Dickey-Fuller t-statistics. The results reported in Table 3 show that the first differences of the series are stationary.

5.4 SVAR Model

To analyze effect of oil and food price shocks I use Structural Vector Auto-Regressive (SVAR) model. In contrast to Vector Auto-Regressive (VAR) framework, SVAR allows to identify structural shocks based on economic theory (Breitung et al. 2004).

$$AY_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots \cdots + A_p Y_{t-p} + B\varepsilon_t$$

$$Au_t = B\varepsilon_t$$

$\varepsilon_t \sim N(0, I_n)$ is a structural shock

u_t are reduced form disturbances with the following variance-covariance matrix of $n\ (n+1)/2$ non-redundant elements:

$$\sum\nolimits_u = A^{-1}BB^T A^{-1^T}$$

Y_t is $n \times 1$ vector of variables ((Y_t = $(OIL_t/NOPI_t, FPI_t, GDP_t, CPI_t, M2_t, R_t, REER_t)$), A and B are $n \times n$ structural matrices, A is a fixed coefficient $n \times n$ non-singular matrix of contemporaneous relations. p represents number of lags, i.e. order of SVAR model. The total number of elements in A and B are $2n^2$. To identify the model, in general, the following number of restrictions are required:

$$2n^2 - \frac{n(n+1)}{2} = n^2 + \frac{n(n-1)}{2}$$

As we set B matrix to identity, there are $\frac{n(n-1)}{2}$ restrictions left to be identified, which in our studies is 21 (7(7-1)/2).

I run two SVAR models for each country. In Model 1 *OIL* is defined as logarithm of real oil prices (*ROP*) and in Model 2 the first equation is of net oil price increase (*NOPI*). I impose the following contemporaneous restrictions for $Au_t = B\varepsilon_t$:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \begin{bmatrix} u_{OIL} \\ u_{FPI} \\ u_{GDP} \\ u_{CPI} \\ u_{M2} \\ u_{R} \\ u_{REXR} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} \end{bmatrix} \begin{bmatrix} \varepsilon_{OIL} \\ \varepsilon_{FPI} \\ \varepsilon_{GDP} \\ \varepsilon_{CPI} \\ \varepsilon_{M2} \\ \varepsilon_{R} \\ \varepsilon_{REXR} \end{bmatrix}$$

Identification restrictions on matrix A, which I treat like useful hypothesis, are set based on Kim and Roubini (2000), Lee and Ni (2002), Alom (2011) and Sek (2009). First equation implies that oil price is exogenous. Second equation assumes that food price responds to oil prices only. Third row stands for real GDP which contemporaneously responds to CPI, oil and food prices. Fourth row is of Consumer Price Index equation that depends on the commodity prices and output. Equation five represents monetary policy feedback rule and implies that money supply responds contemporaneously to oil and food prices, output, and inflation. It is assumed that interest rates respond contemporaneously to all the variables except real effective exchange rate. The last equation is of real effective exchange rate, which reacts contemporaneously to all the variables in the system.

5.5 Residual Diagnostics

After estimating SVAR models I conduct residual diagnostics. First, I check for autocorrelation in errors using Lagrange Multiplier (LM) test with a null hypothesis of no serial correlation up to some fixed lag order *h.* In the presence of autocorrelation in residuals estimates are still not biased if regressors are exogenous. However, serial correlation in errors diminishes validity of test statistics and standard errors and, hence, of hypothesis results. Since I have lagged dependent variables in the VAR model, seral correlation in residuals can not only affect efficiency, but also consistency of the coefficients (Wooldridge 2015).

Next, I examine heteroskedasticity in error terms using White test with no cross terms under the null hypothesis of homoscedasticity. In case of heteroskedastic residuals standard errors are not valid. Hence, the OLS coefficients are no longer efficient and best linear unbiased estimators (BLUE), but are still unbiased and consistent.

Finally, I check normality of error terms by running Jarque-Bera test which has null hypothesis of normally distributed residuals. The test statistic follows Chi-squared distribution with degrees of freedom (df) equal to two. Non-normality of errors is less dangerous than serial correlation and heteroskedasticity because it does not violate efficiency or consistency of estimates, but it does affect p-values. It is an issue with a very small sample, but with a large one the distribution is approximately normal based on Central Limit Theorem (Statistics Solutions 2013).

6 Empirical Results

First, I choose optimal number of lags for each model based on Akaike Information Criterion (AIC) and LR (Table 4 and 5). I choose two lags for each model. Then I estimate Structural VAR described in the previous section with the first differences of all the variables except NOPI. Next, I run Lag Exclusion Wald Tests with Chi-squared test statistic for the joint significance of all endogenous variables at each lag for all equations jointly. Results are reported in Tables 6 through 9.

6.1 Impulse Response Functions

6.1.1 USA

Figures A.8 and A.9 show impulse responses of the US macroeconomic variables to one standard deviation innovations of linear and net oil price increase respectively with +/- 2 standard error bands (95% CI). I will comment impulse response functions from Model 1. Except for the GDP, responses are consistent with economic theory. Consumer Price Index increases in response to the rise in oil prices and the response is statistically significant. After 4 quarters inflation returns to pre-shock equilibrium. As can be viewed, money supply decreases while interest rate responds positively to oil price shock. These imply that central bank conducts tight monetary actions in response to oil price shock to decrease growing inflation. Following the oil price increase, real effective exchange rate depreciates. The only puzzle that I get is a first period positive relationship between real output and oil price shock, which is small and insignificant. However, after first period GDP declines as predicted by economic theory. Responses of the US macroeconomic variables to net oil price specification shock (Figure A.9) are same in direction, though smaller in magnitude.

In response to food price shock, inflation starts gradually increasing and reaches to peak at third period and by the 5th quarter the effect dies out. Money supply does not react to food price shock instantly, declines between quarter 1 and 3, then moves towards the pre-shock mean value. I observe different behavior of interest rate in case of food price shock compared to oil price increase. Following one standard deviation innovation in food prices, interest rate drops and then immediately moves towards the initial equilibrium. Due to food price shock real effective exchange rate depreciates with almost same magnitude as in the case of oil price shock. Persistency and magnitude of responses of the variables to FPI shock from Model 2 are like the ones from Model 1.

6.1.2 Japan

Figure A.10 illustrates impulse responses of Japanese macroeconomic variables to one standard deviation innovations in linear oil and food prices. Responses resulted from Hamiltonian (net) specification are displayed in Figure A.11. Except for the depreciation of real effective exchange rate in case of linear model, all the IRFs are statistically insignificant. The Figure A.10 reveals that linear oil price shock positively affects GDP. Inflation does not react to oil price raise immediately, it is increasing between first and second quarter and by 4th period the response dies out. Due to oil price shock money supply decreases up until quarter 3 and then approaches zero line by quarter four. I observe increase of money market rates of Japan following oil price hike.

The dynamics of responses in a model with NOPI specification of oil shock (Figure A.12) show statistically significant increase in real output in the first quarter. The rest of the variables have insignificant impulse responses. Inflation decreases initially and then starts rising immediately until quarter 3. Money supply does not respond instantly, but decreases between 1.5th and 3rd quarters and by 7th period reaches pre-shock equilibrium level. Response of interest rates to NOPI shock is similar, yet more persistent, to the one from Model 1.

Reponses of economy to FPI shock is similar in both models, but statistically insignificant. All the variables are irresponsive initially and react with 1 quarter delay. Contrary to its response to oil price shocks, real output decreases between quarter one and two in response to food price increase. In terms of sign, after 1st quarter the rest of the macroeconomic variables respond to food price shock similarly as to the oil price increase.

6.2 Forecast Error Variance Decomposition

Forecast error variance decomposition (FEVD) of linear and non-linear models for USA and Japan for the 1,3,6,9 and 12 quarters are displayed in Table 10 through 13. Variance decomposition shows how much of the forecast error of a variable can be explained by its own shock as well as by other variables' shocks. Generally, the highest share of variation of each variable comes from its own shock.

6.2.1 USA

Table 10 shows that oil explains 2.91% of output variation, it is the largest source of GDP fluctuation other than its own shock (94.20%). Contribution of OIL price shock to the variation of inflation is substantial (36.70%). Notably, in the first quarter contribution of FPI to CPI variation is negligible, less than 1%. However, after 2nd quarter its predictive power increases and becomes third largest after CPI's own shock and oil price shocks. FPI explains 8.11% of CPI variation by the 9th and 12th period.

The impact of oil price shock to money supply is 18.77% at quarter 1 and 16.28% by the end of 12th quarter. Besides the shock of M2, OIL is the largest contributor to the variation of money supply followed by CPI (12.54%).

In the first quarter, the largest source of fluctuation in interest rates besides its own shock is FPI (9.18%), further its portion is preceded by GDP, which explains about 25% of forecast error variance in R after 3 years.

Oil and food price shocks are substantial and almost equal contributors to the real effective exchange rate variation, by the 9th period they explain 15.59 and 12.72 percent of REER fluctuation each.

Overall, OIL explains the highest share of variation in all the macroeconomic variables, except for interest rates' fluctuation which is mainly explained by FPI (around 9%).

The major difference between Model 1 and the model with the net oil price specification (Table 11) is that portion of variation in M2 attributed to oil shock (NOPI) is not large as it was in Model 1. Other than that, Table 11 shows that the share of food and oil price shocks to the variation of macroeconomic variables is proportional, but smaller in magnitude, to the model with linear oil price specification.

6.2.2 Japan

Table 12 and 13 display forecast error variance decomposition of macroeconomic variables of Japan from Model 1 and Model 2 respectively. In the model with linear oil price specification only OIL and FPI explain fluctuation in GDP in quarter 1. As can be seen, in subsequent quarters money supply explains larger variation in real output (around 6.5%) after GDP's own shock, followed by almost equal contribution of commodity shocks, around 3-4% each.

In quarter 1 the variation of inflation is contributable mostly to GDP (3.76%) besides its own shock. From quarter 3 OIL, FPI, GDP and REER almost equally contribute to the variation in inflation (about 3.35-4.86% each).

Interestingly, fluctuation in money supply is attributed to inflation (about 60%) more than to its own shock (about 24%). From quarter 3 the next largest contributor to the variation of M2 is OIL (about 7%).

In the first quarter, GDP and oil price shock explain 3.33 and 3.32 forecast error variance of interest rates respectively and are main sources of variation other than interest rates' own shock. Subsequently, real output explains around 5% and food and oil price shocks each around 4% of variation in R.

The share of interest rates in variation of REER is highest (around 12%) after its own shock, followed my contribution of oil price shock (around 8%).

Most noticeable difference in FEVDs of Models 1 and 2 is that in the last NOPI's contribution to the variation in REER is marginal, around 1%, while FPI explains about 3% of variation in real effective exchange rate. In addition, the variation in CPI is not explained equally by FPI and oil shock NOPI as it was the case in Model 1 (Table 12).

6.3 Model Checking

6.3.1 USA

Results of Residual Diagnostics for USA Model 1 and 2 are displayed in Table 14 and Table 16. LM test for serial correlation shows that there is no serial correlation among residuals up to 3rd lag in both models. Based on ARCH-LM test I fail to reject the null hypothesis of no autoregressive conditional heteroskedasticity in the residuals up to 16 lags. Jarque-Bera test for normality of residuals show that four out of seven variables are normally distributed, while those three that are not, have skewness and kurtosis around one and five respectively.

6.3.2 Japan

Results of Residual Diagnostics for USA Model 1 and 2 are displayed in Table 15 and Table 17. In case of Japan, I detect no serial correlation in errors up to lag 10. In addition, I fail to reject null hypothesis of no heteroscedasticity. These two results indicate that conventional standard errors are correct and estimates are efficient. Residuals of three out of seven variables do not follow normal distribution.

7 Conclusion

In this study, I used linear and net oil price specifications and analyzed the effect of oil and food price fluctuations on the economic activity in the USA and Japan by employing SVAR model. Impulse responses of the US macroeconomic variables, except for GDP, are statistically significant and consistent with expected results, while in case of Japan most of the impacts are milder and statistically insignificant. Food price shocks transmit through short-term interest rates and real effective exchange rates. Central banks respond to the innovation in oil prices.

One "puzzle" that emerges is that in both oil importer countries real output increases following the oil price shocks. However, in case of US real GDP increases only marginally in the first period and then drops below the pre-shock equilibrium consistently with expected results. On the other hand, increase in real output of Japan in response to oil price shock is greater in both models and even statistically significant in the second one. The possible explanation for the difference in output responses between the USA and Japan is that Japanese products, particularly cars, are oil efficient (Fukunaga et al. 2010). Oil price jump shifts world demand towards Japanese cars, and even market share of Japanese carmakers in the USA increases; this has positive effect on the real output of Japan. Moreover, increased demand for Japanese cars may stimulate production of precision instruments and steel in the country.

According to Forecast Error Variance Decomposition both oil and food prices explain significant variation in the US inflation, where oil has much more predictive power than FPI. In addition, they account for a major portion of fluctuation in the US real effective exchange rates. Compared to other variables, oil is the major contributor to forecast error variance of GDP after output's own shock. Impulse Responses of variables to the external commodity shocks reveal that monetary authority conducts tight policy to decrease rising inflation that results from increased oil and food prices, but money supply decrease is lower in case of FPI shock.

Most of the macroeconomic variables of Japan respond to the innovation in the two commodity prices with a quarter delay. One possible explanation can be that government of Japan holds large amount of crude oil stocks and has agreements with oil exporters UAE and Saudi Arabia. Positive impact of oil price shock on Japanese real output can be explained by potential of substitution of oil with natural gas and nuclear power, better energy efficiency and declining population in Japan (Yoshino and Taghizadeh-Hesary (2014)).

In the future, the model can be examined by replacing real output with Industrial Production (IP). As mentioned earlier transportation and industries are the major consumers of petroleum in the USA, hence, increase in oil prices can adversely affect IP. In addition, it is worth solving the "puzzle" of positive response real GDP to commodity shocks the way Chen et al. (2014) did. The authors compared price level response to positive oil price shocks of China's trading partners and found that in response of oil price shock their inflation increases more than price level of China, which stimulates export of China and increases its output. Similar study might show whether this happens in case of Japan and the USA, i.e. whether behavior of price level of trading partners explains positive relationship between oil price raise and output growth in these two countries.

References

Abbott, P. C., Hurt, C., & Tyner, W. E. (2009). *What's driving food prices? March 2009 Update* (No. 48495). Farm Foundation.

Akram, Q. F. (2004). Oil prices and exchange rates: Norwegian evidence. *the econometrics Journal*, *7*(2), 476-504.

Alom, F. (2011, August). Economic effects of oil and food price shocks in Asia and Pacific countries: an application of SVAR model. In *New Zealand Agricultural and Resource Economics Society Conference* (pp. 25-26).

Amano, R. A., & Van Norden, S. (1998). Exchange rates and oil prices. *Review of International Economics*, *6*(4), 683-694.

Bernanke, B. S., Gertler, M., Watson, M., Sims, C. A., & Friedman, B. M. (1997). Systematic monetary policy and the effects of oil price shocks. *Brookings papers on economic activity*, *1997*(1), 91-157.

Bohi, D. R. (1991). On the macroeconomic effects of energy price shocks. *Resources and Energy*, *13*(2), 145-162.

Breitung J., Brüggemann R., Lütkepohl H. Structural vector autoregressive modeling and impulse responses //Applied time series econometrics. – 2004.

Brown, S. P., & Yücel, M. K. (2002). Energy prices and aggregate economic activity: an interpretative survey. *The Quarterly Review of Economics and Finance*, *42*(2), 193-208.

Chaudhuri, K., & Daniel, B. C. (1998). Long-run equilibrium real exchange rates and oil prices. *Economics letters*, *58*(2), 231-238.

Chen, S. S., & Chen, H. C. (2007). Oil prices and real exchange rates. *Energy Economics*, *29*(3), 390-404.

Chen, S., Chen, D., & Härdle, W. K. (2014). The Influence of Oil Price Shocks on China's Macroeconomy.

Chuku, C., Effiong, E., & Sam, N. (2010). Oil price distortions and their short-and long-run impacts on the Nigerian economy.

Country Analysis Brief: Japan, EIA, 2017. Retrieved from https://www.eia.gov/beta/international/analysis_includes/countries_long/Japan/japan.pdf

Cuñado, J., & de Gracia, F. P. (2003). Do oil price shocks matter? Evidence for some European countries. *Energy Economics*, *25*(2), 137-154.

Dimitriou, D., Kenourgios, D., & Simos, T. (2013). Global financial crisis and emerging stock market contagion: A multivariate FIAPARCH–DCC approach. *International Review of Financial Analysis*, *30*, 46-56.

DOE, EIA-0035(2017/5). Monthly Energy Review. Retrieved from https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

Fratzscher, M., Schneider, D., & Van Robays, I. (2014). Oil prices, exchange rates and asset prices.

Fukunaga, I., Hirakata, N., & Sudo, N. (2010). *The effects of oil price changes on the industry-level production and prices in the US and Japan* (No. w15791). National Bureau of Economic Research.

Galesi, A., & Lombardi, M. J. (2009). External shocks and international inflation linkages: a global VAR analysis.

Hamilton, J. D. (1983). Oil and the macroeconomy since World War II. *Journal of political economy*, *91*(2), 228-248.

Hamilton, J. D. (1996). This is what happened to the oil price-macroeconomy relationship. *Journal of Monetary Economics*, *38*(2), 215-220.

Headey, D., & Fan, S. (2008). Anatomy of a crisis: the causes and consequences of surging food prices. *Agricultural Economics*, *39*(s1), 375-391.

Headey, D., Malaiyandi, S., & Fan, S. (2010). Navigating the perfect storm: reflections on the food, energy, and financial crises. *Agricultural Economics*, *41*(s1), 217-228.

Huang, B. N., Hwang, M. J., & Peng, H. P. (2005). The asymmetry of the impact of oil price shocks on economic activities: an application of the multivariate threshold model. *Energy Economics*, *27*(3), 455-476.

Inoue, T., & Okimoto, T. (2017). *Measuring the Effects of Commodity Price Shocks on Asian Economies*. Research Institute of Economy, Trade and Industry (RIETI).

Jiménez-Rodríguez, R., & Sánchez, M. (2005). Oil price shocks and real GDP growth: empirical evidence for some OECD countries. *Applied economics*, *37*(2), 201-228.

Jongwanich, J., & Park, D. (2011). Inflation in developing Asia: pass-through from global food and oil price shocks. *Asian-Pacific Economic Literature*, *25*(1), 79-92.

Khan, M. A., & Ahmed, A. (2011). Macroeconomic effects of global food and oil price shocks to the Pakistan economy: a Structural Vector Autoregressive (SVAR) analysis. *The Pakistan Development Review*, 491-511.

Kim, S., & Roubini, N. (2000). Exchange rate anomalies in the industrial countries: A solution with a structural VAR approach. *Journal of Monetary Economics*, *45*(3), 561-586.

Korhonen, I., & Ledyaeva, S. (2010). Trade linkages and macroeconomic effects of the price of oil. *Energy Economics*, *32*(4), 848-856.

Lee, J., & Strazicich, M. C. (2003). Minimum Lagrange multiplier unit root test with two structural breaks. *Review of Economics and Statistics*, *85*(4), 1082-1089.

Lee, K., Ni, S., & Ratti, R. A. (1995). Oil shocks and the macroeconomy: the role of price variability. *The Energy Journal*, 39-56.

Lee, K., & Ni, S. (2002). On the dynamic effects of oil price shocks: a study using industry level data. *Journal of Monetary Economics*, *49*(4), 823-852.

Lizardo, R. A., & Mollick, A. V. (2010). Oil price fluctuations and US dollar exchange rates. *Energy Economics*, *32*(2), 399-408.

Mork, K. A. (1989). Oil and the macroeconomy when prices go up and down: an extension of Hamilton's results. *Journal of political Economy*, *97*(3), 740-744.

Perron, P. (1989). The great crash, the oil price shock, and the unit root hypothesis. *Econometrica: Journal of the Econometric Society*, 1361-1401.

Sek, S. K. (2009). Interactions between monetary policy and exchange rate in inflation targeting emerging countries: the case of three East Asian countries. *International Journal of Economics and Finance*, *1*(2), 27.

Statistics Solutions. (2013). Normality [WWW Document]. Retrieved from http://www.statisticssolutions.com/academic-solutions/resources/directory-of-statistical-analyses/normality/

Tang, W., Wu, L., & Zhang, Z. (2010). Oil price shocks and their short-and long-term effects on the Chinese economy. *Energy Economics*, *32*, S3-S14.

Wooldridge, J. M. (2015). Chapter 12. *Introductory econometrics: A modern approach*. Nelson Education.

World Energy Resources 2016. World Energy Council.

https://www.worldenergy.org/wp-content/uploads/2016/10/World-Energy-Resources-Full-report-2016.10.03.pdf
Yoshino, N., & Taghizadeh-Hesary, F. (2014). Economic impacts of oil price fluctuations in developed and emerging economies. *IEEJ Energy Journal*, *9*(3), 58-75.
Zhang, Y. J., Fan, Y., Tsai, H. T., & Wei, Y. M. (2008). Spillover effect of US dollar exchange rate on oil prices. *Journal of Policy Modeling*, *30*(6), 973-991.

Appendix I: Country Profiles

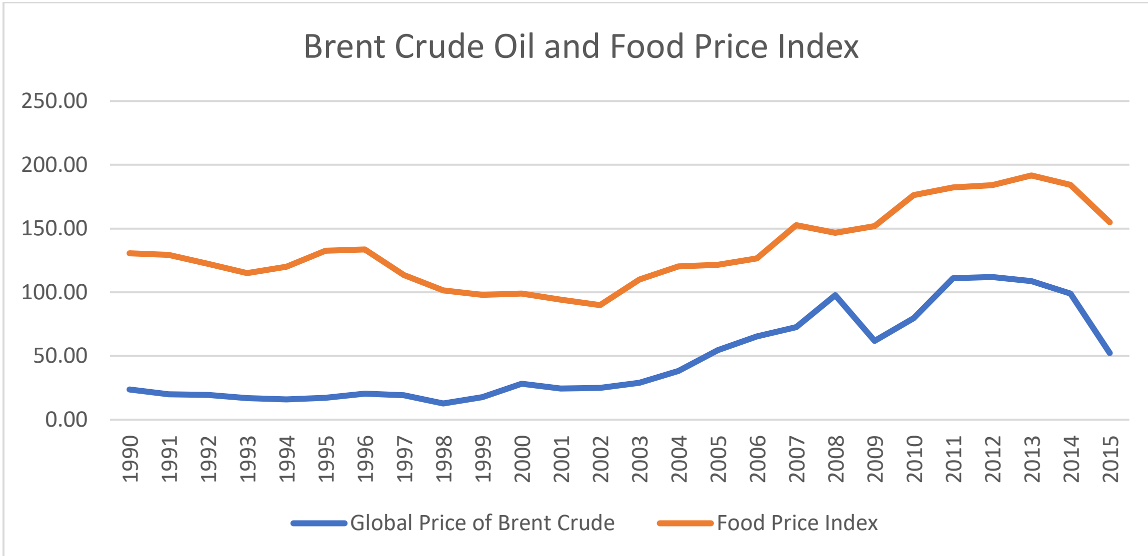


Figure A.1 Food Price Index and Brent Crude Oil. Source of data FAO and FRED

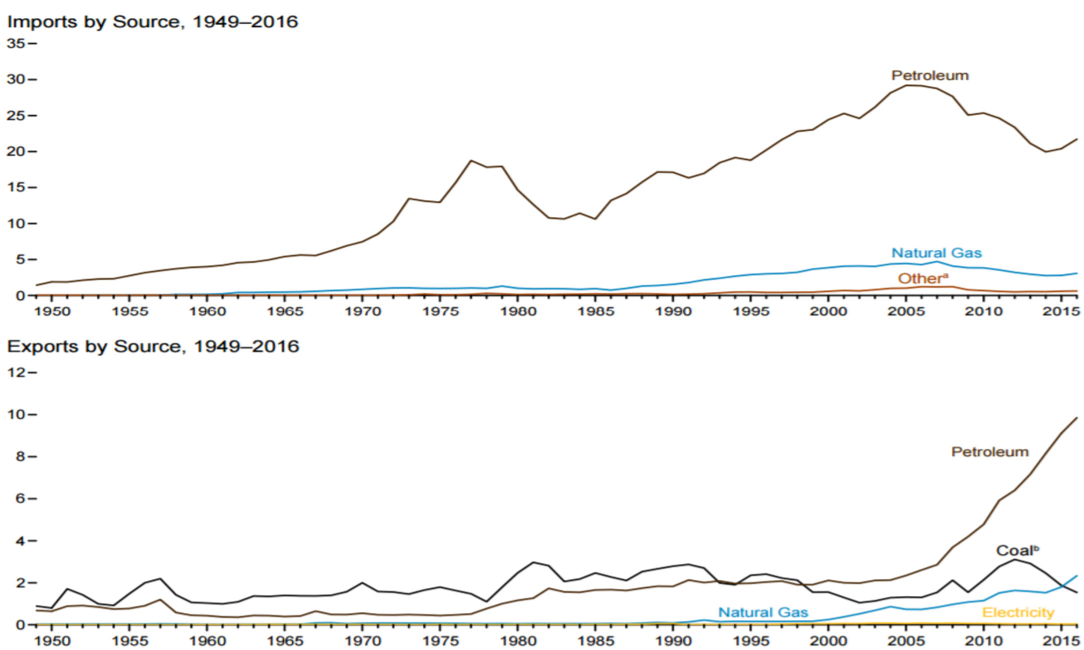


Figure A.2 USA Primary energy imports and exports (Quadrillion Btu).

Source: EIA, May 2017 Monthly Energy Review

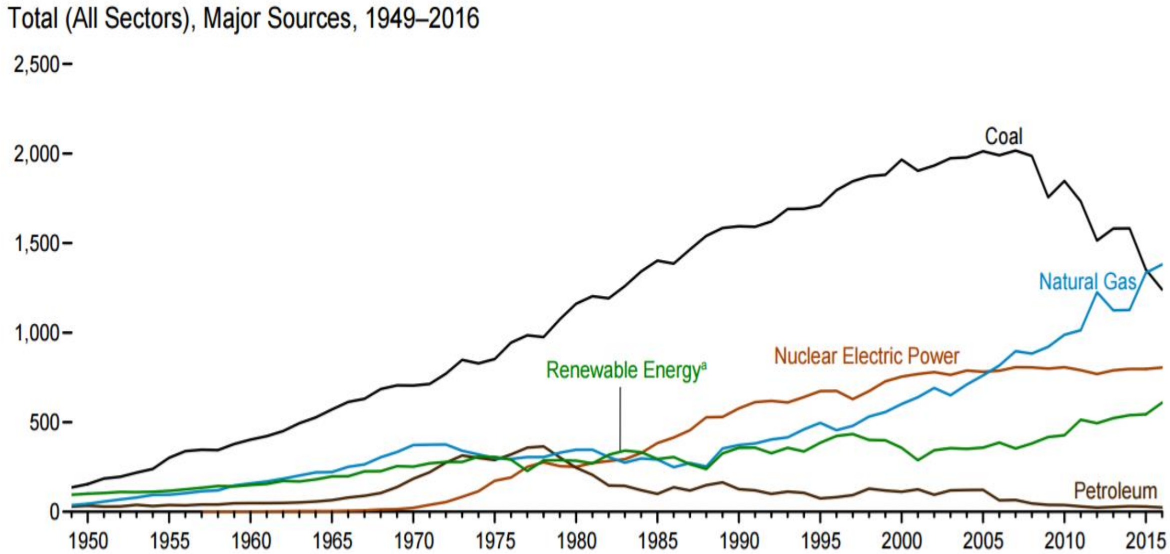


Figure A.3 Electricity net generation (Billion Kilowatthours).

Source: EIA, May 2017 Monthly Energy Review

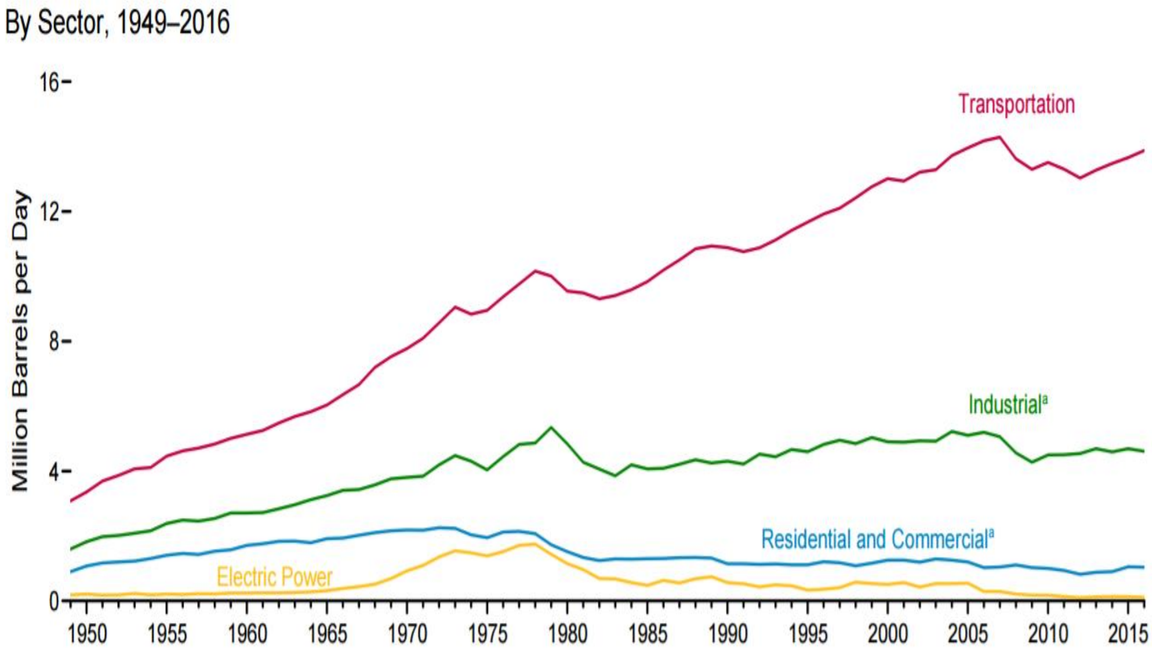
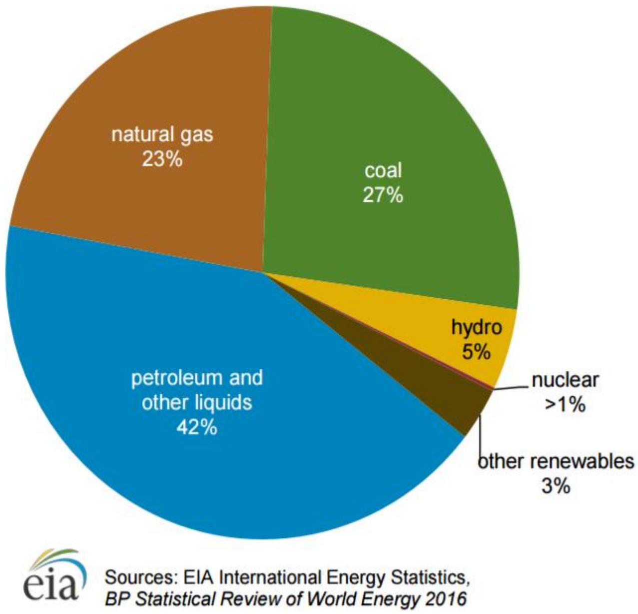


Figure A.4 Petroleum consumption by sector.

Source: EIA, May 2017 Monthly Energy Review



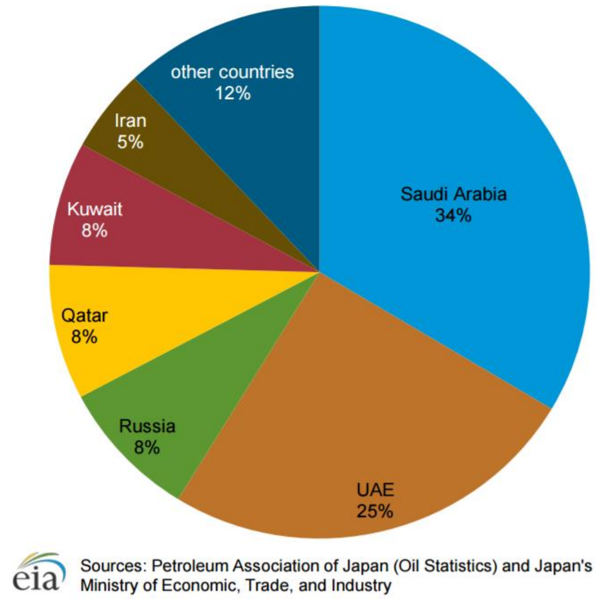


Figure A.5 Japan's total energy consumption, 2015

Figure A.6 Japan's crude oil imports by source,2015

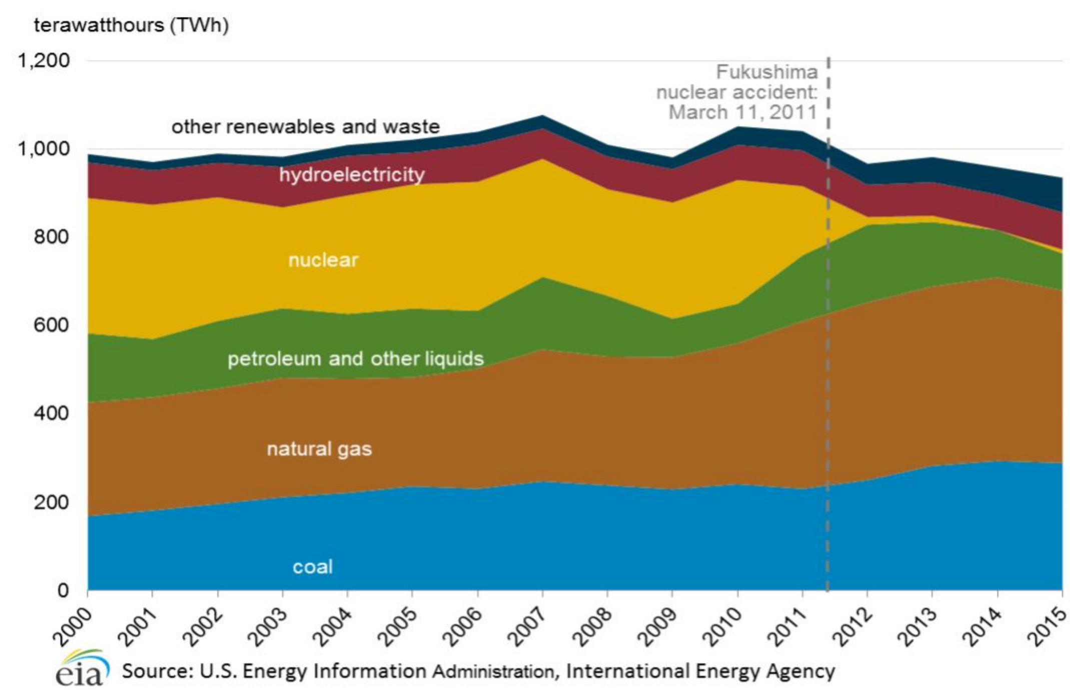


Figure A.7 Japan's net electricity generation by fuel, 2000-2015

Appendix II: Data Description

Table 1 Data Description

Variable Name	Description	Sources
OIL	Logarithm of real price of oil (Brent for USA and Dubai for Japan) denominated in national currency.	FRED https://fred.stlouisfed.org/
FPI	Logarithms of Food Price Index	FAO http://www.fao.org/
GDP	Logarithms of real Gross Domestic Product in national currency	International Financial Statistics (IFS) http://data.imf.org/
CPI	Logarithms of Consumer Price Index	
M2	Logarithm of real Money Supply in national currency	
R	Level of Money Market Rate	
REER	Logarithm of Real Effective Exchange Rate	
GFC_1	Dummy for “initial financial turmoil” – 2007Q3-Q32008	
GFC_2	Dummy for “sharp financial market deterioration” – 2008Q4	
GFC_3	Dummy for “macroeconomic deterioration” - 2009Q1.	
Fukushima	Dummy for earthquake and tsunami in Japan – 2011Q1	
Asian	Dummy for Asian Financial Crisis for the period of 1997Q2-1999Q2	

Apendix III: ADF and PP Tests

Table 2 ADF and PP Unit Root Tests

	Variable	ADF				PP			
		Level		First Difference		Level		First Difference	
		(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
USA	**CPI**	-2.333	-1.769	-7.253***	-7.690***	-3.134**	-1.498	-7.111***	-7.365***
	R	-2.604*	-4.614***	-4.854***	-4.790***	-2.229	-2.861	-4.203***	-4.214***
	GDP	-1.576	-0.913	-4.505***	-6.669***	-1.496	-0.881	-6.682***	-6.782***
	REER	-1.706	-1.654	-7.602***	-7.606***	-1.461	-1.404	-7.452***	-7.424***
	M2	2.284	-2.824	-6.862***	-7.754***	2.862*	-2.818	-6.835***	-7.690***
	OIL	-1.783	-2.219	-8.031***	-8.009***	-1.478	-1.790	-7.893***	-7.867***
	FPI	-1.828	-2.591	-7.350***	-7.314***	-1.596	-2.178	-6.965***	-6.918***
	NOPI	-6.112***	-6.070***	-12.177***	-12.122***	-5.668***	-5.612***	-38.237***	-39.441***
JAPAN	**CPI**	-1.376	-0.836	-7.468***	-7.482***	-1.557	-1.438	-7.613***	-7.617***
	R	-4.198***	-4.097***	-4.781***	-4.929***	-4.253***	-3.656**	-4.235***	-4.270***
	GDP	-1.352	-2.672	-8.679***	-8.668***	-1.352	-2.885	-8.685***	-8.673***
	REER	-1.781	-3.384*	-7.573***	-7.541***	-1.678	-2.603	-7.574***	-7.540***
	M2	-0.857	-1.838	-7.860***	-7.844***	-0.789	-2.054	-7.855***	-7.840***
	OIL	-1.632	-1.390	-7.854***	-7.870***	-1.632	-1.669	-7.869***	-7.828***
	FPI	-1.844	-2.301	-6.635***	-6.604***	-1.577	-1.885	-6.623***	-6.593***
	NOPI	-6.274***	-6.295***	-13.383***	-13.309***	-6.244***	-6.266***	-21.755***	-21.813***

* $p<0.05$ ** $p<0.01$ *** $p<0.001$
(i) – with constant, (ii) – with constant and trend

Appendix IV: Break Point Unit Root Test

Table 3 Break Point Unit Root Test

	variable	Break Point Unit Root Test							
		Level				First Difference			
		Constant		Constant & Trend		Constant		Constant & Trend	
		t-statistic	Break date	t-statistic	Break date	t-statistic	Break date	t-statistic	Break date
USA	**CPI**	-3.863	2003Q4	-3.851	2014Q2	-8.673***	2008Q4	-8.631***	2008Q4
	R	-5.023***	2007Q3	-5.231***	2008Q3	-5.819***	2008Q4	-5.591***	2008Q4
	GDP	-2.508	1996Q1	-3.836	2007Q4	-7.084***	2006Q1	-7.202***	2006Q1
	REER	-2.152	1995Q2	-2.82	2005Q4	-8.487***	2008Q4	-8.428***	2008Q4
	M2	0.083	1997Q4	-3.392	2011Q2	-8.554***	1995Q1	-8.828***	2008Q4
	OIL	-3.535	2003Q3	-3.414	2003Q3	-9.151***	2008Q4	-9.091***	2008Q4
	FPI	-3.912	2006Q3	-3.942	2006Q3	-9.357***	2008Q4	-9.377***	2008Q4
	NOPI	-6.896***	1999Q3	-6.778***	2011Q1	-13.117***	2007Q4	-13.074***	2007Q4
JAPAN	**CPI**	-2.248	2014Q1	-3.469	2014Q1	-8.750***	2014Q2	-8.697***	2014Q2
	R	-4.347*	1998Q3	-4.538	2006Q2	-5.974***	2007Q1	-6.632***	2007Q1
	GDP	-2.651	2009Q2	-5.386***	2008Q3	-11.441***	2009Q1	-11.699***	2009Q1
	REER	-3.131	2004Q1	-4.118	2008Q3	-8.245***	2008Q4	-8.182***	2008Q4
	M2	-3.292	2008Q4	-3.481	2005Q4	-8.762***	2014Q2	-8.820***	2008Q3
	OIL	-3.160	2003Q3	-4.101	2014Q3	-9.628***	2008Q4	-9.574***	2008Q4
	FPI	-3.569	2006Q3	-3.720	2007Q1	-8.641***	2008Q4	-8.545***	2008Q4
	NOPI	-7.169***	2007Q4	-7.139***	2007Q4	-14.329***	2007Q4	-14.250***	2007Q4

* $p<0.05$ ** $p<0.01$ *** $p<0.001$

Appendix V: Lag Order Selection Criteria

Table 4 Lag Length Criteria of the Models for USA

	Lag	LogL	LR	FPE	AIC	SC	HQ
Model 1	0	1733.701	NA	7.04E-24	-33.44511	-32.72453*	-33.15332
	1	1837.611	185.4081	2.41E-24	-34.52178	-32.54018	-33.71936*
	2	1894.663	93.96778	2.10e-24*	-34.67966*	-31.43704	-33.36661
	3	1934.929	60.79482	2.61E-24	-34.50842	-30.00479	-32.68474
	4	1977.887	58.96173	3.19E-24	-34.38994	-28.6253	-32.05564
	5	2032.715	67.72895*	3.25E-24	-34.50422	-27.47856	-31.65929
Model 2	0	1821.733	NA	2.47E-24	-34.49487	-33.78292*	-34.20644
	1	1925.017	184.7185	8.73E-25	-35.53879	-33.58092	-34.74560*
	2	1981.879	94.04151*	7.65e-25*	-35.68998*	-32.4862	-34.39204
	3	2023.59	63.36889	9.18E-25	-35.54981	-31.10012	-33.74711

*indicates lag order selected by the criterion

Table 5 Lag Length Criteria of the Models for Japan

	Lag	LogL	LR	FPE	AIC	SC	HQ
Model 1	0	1532.505	NA	2.09E-24	-34.6629	-33.46426*	-34.1805
	1	1628.407	162.8103	7.11e-25*	-35.75364*	-33.1566	-34.70845*
	2	1671.661	66.38997*	8.50E-25	-35.62001	-31.62456	-34.01203
	3	1718.15	63.78735	9.89E-25	-35.56162	-30.16776	-33.39084
	4	1759.31	49.77503	1.40E-24	-35.3793	-28.58703	-32.64573
	5	1820.32	63.84815	1.39E-24	-35.65861	-27.46794	-32.36224
Model 2	0	1603.270329	NA	6.11e-25*	-35.89127*	-34.70083*	-35.41192*
	1	1652.224745	83.27878	6.20E-25	-35.89022	-33.31094	-34.85163
	2	1696.262321	67.82799*	7.26E-25	-35.77615	-31.80802	-34.1783
	3	1733.764568	51.72724	1.03E-24	-35.51183	-30.15486	-33.35474

*indicates lag order selected by the criterion

Appendix VI: Lag Exclusion Wald Test

Table 6 Lag Exclusion Test. Model 1. USA

	D(OIL,1)	D(FPI,1)	D(GDP,1)	D(CPI,1)	D(M2,1)	D(R,1)	D(REER,1)	Joint
Lag 1	26.28416	15.58832	7.298282	21.42946	19.23192	66.57892	33.22649	188.5977
	[0.000448]	[0.029155]	[0.398497]	[0.003184]	[0.007491]	[7.24e-12]	[2.40e-05]	[0.000000]
Lag 2	13.37018	19.021	9.386366	4.120348	24.92713	5.979835	17.73801	116.8246
	[0.063586]	[0.008122]	[0.226094]	[0.765816]	[0.000782]	[0.542106]	[0.013210]	[1.82e-07]
df	7	7	7	7	7	7	7	49

Table 7 Lag Exclusion Wald Test. Model 2. USA

	NOPI	D(FPI,1)	D(GDP,1)	D(CPI,1)	D(M2,1)	D(R,1)	D(REER,1)	Joint
Lag 1	28.57932	18.15955	7.694359	17.35343	15.02018	66.02615	32.04656	175.6836
	[0.000173]	[0.011271]	[0.360315]	[0.015254]	[0.035742]	[9.35e-12]	[3.98e-05]	[3.33e-16]
Lag 2	6.101851	18.87045	12.53273	4.247826	16.71024	6.342605	24.11674	114.7174
	[0.527908]	[0.008603]	[0.084346]	[0.750831]	[0.019363]	[0.500362]	[0.001087]	[3.44e-07]
df	7	7	7	7	7	7	7	49

Table 8 Lag Exclusion Wald Test. Model 1. Japan

	D(OIL,1)	D(FPI,1)	D(GDP,1)	D(CPI,1)	D(M2,1)	D(R,1)	D(REER,1)	Joint
Lag 1	3.310283	18.68069	10.29378	5.854446	4.923176	57.52198	17.37083	150.7643
	[0.854893]	[0.009249]	[0.172527]	[0.556844]	[0.669338]	[4.71e-10]	[0.015155]	[2.73e-12]
Lag 2	10.53034	9.369512	5.957269	10.35973	11.96761	14.44883	3.454217	74.95234
	[0.160458]	[0.227204]	[0.544748]	[0.169088]	[0.101629]	[0.043751]	[0.840051]	[0.009933]
df	7	7	7	7	7	7	7	49

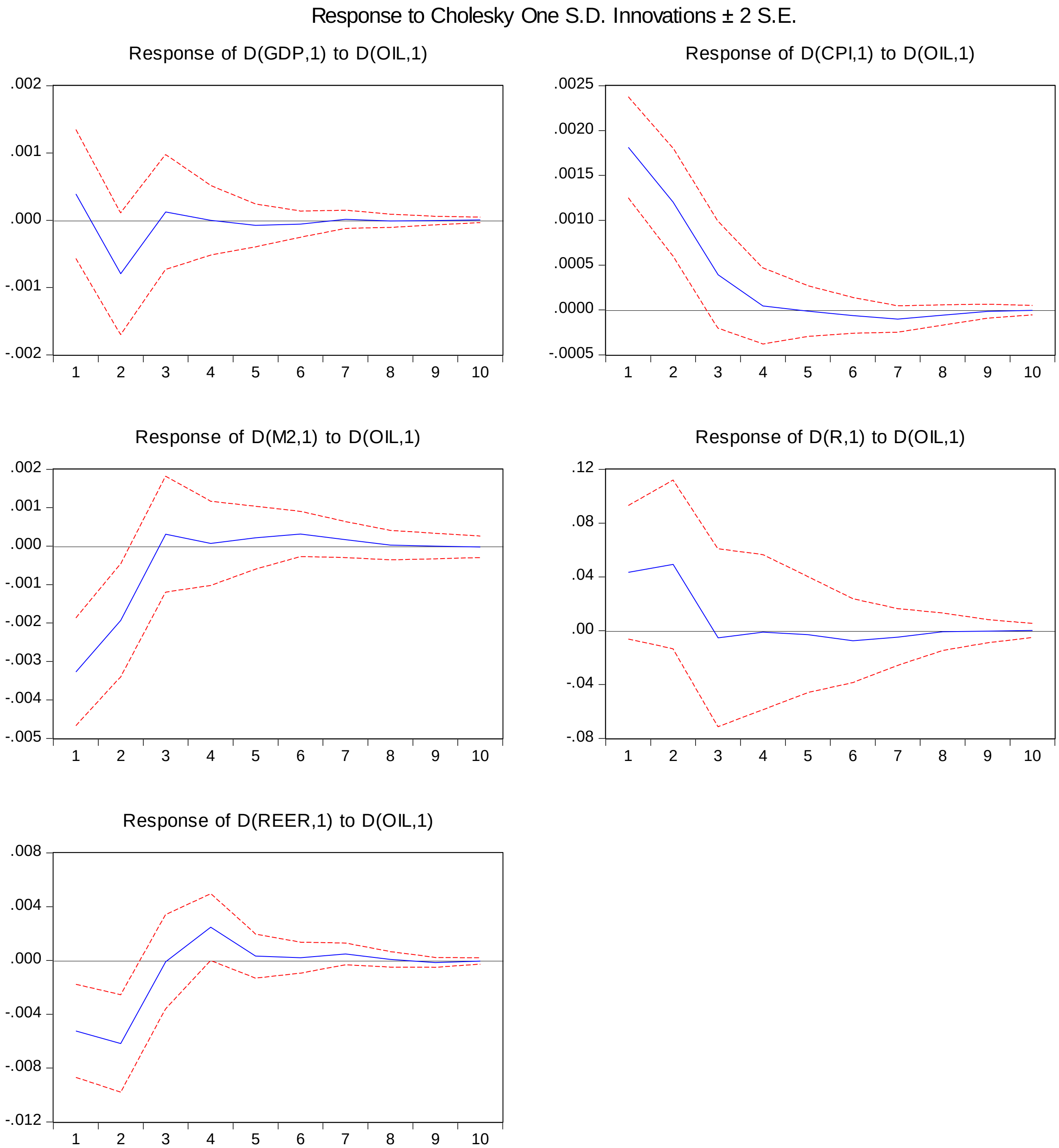
Table 9 Lag Exclusion Wald Test. Model 2. Japan

	NOPI	D(FPI,1)	D(GDP,1)	D(CPI,1)	D(M2,1)	D(R,1)	D(REER,1)	Joint
Lag 1	12.84396	17.0326	9.891788	5.458572	4.32955	57.46309	13.12018	150.3862
	[0.076003]	[0.017187]	[0.194789]	[0.604186]	[0.741133]	[4.84e-10]	[0.069234]	[3.11e-12]
Lag 2	8.614273	9.606509	5.479835	9.833868	12.78603	14.75132	2.359678	68.16993
	[0.281548]	[0.211990]	[0.601617]	[0.198185]	[0.077496]	[0.039323]	[0.937288]	[0.036336]
df	7	7	7	7	7	7	7	49

Numbers in [ ] are p-values

Appendix VII: Impulse Response Functions

Figure A.8 Impulse Response Functions. Model 1. USA



(continued)

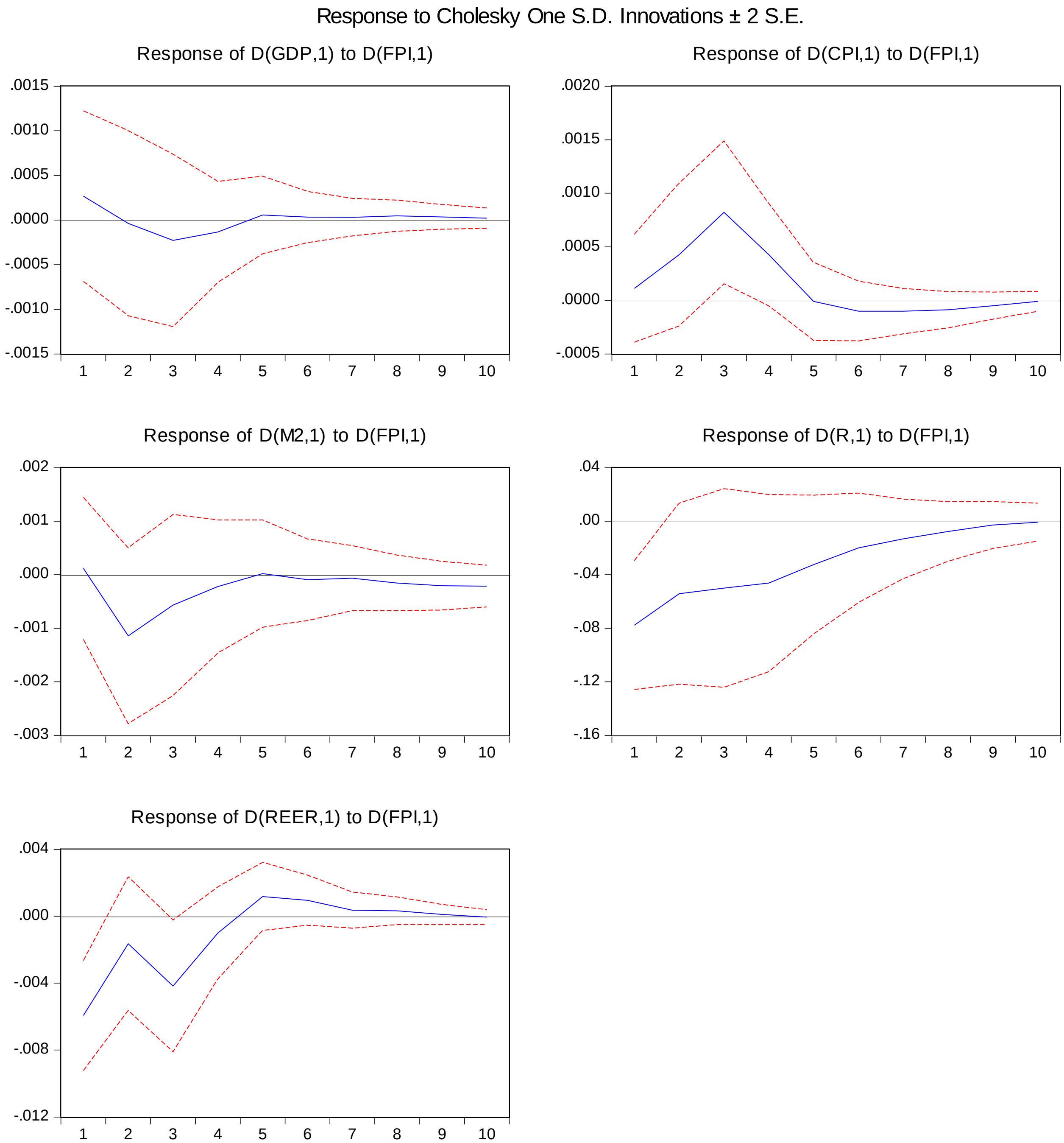
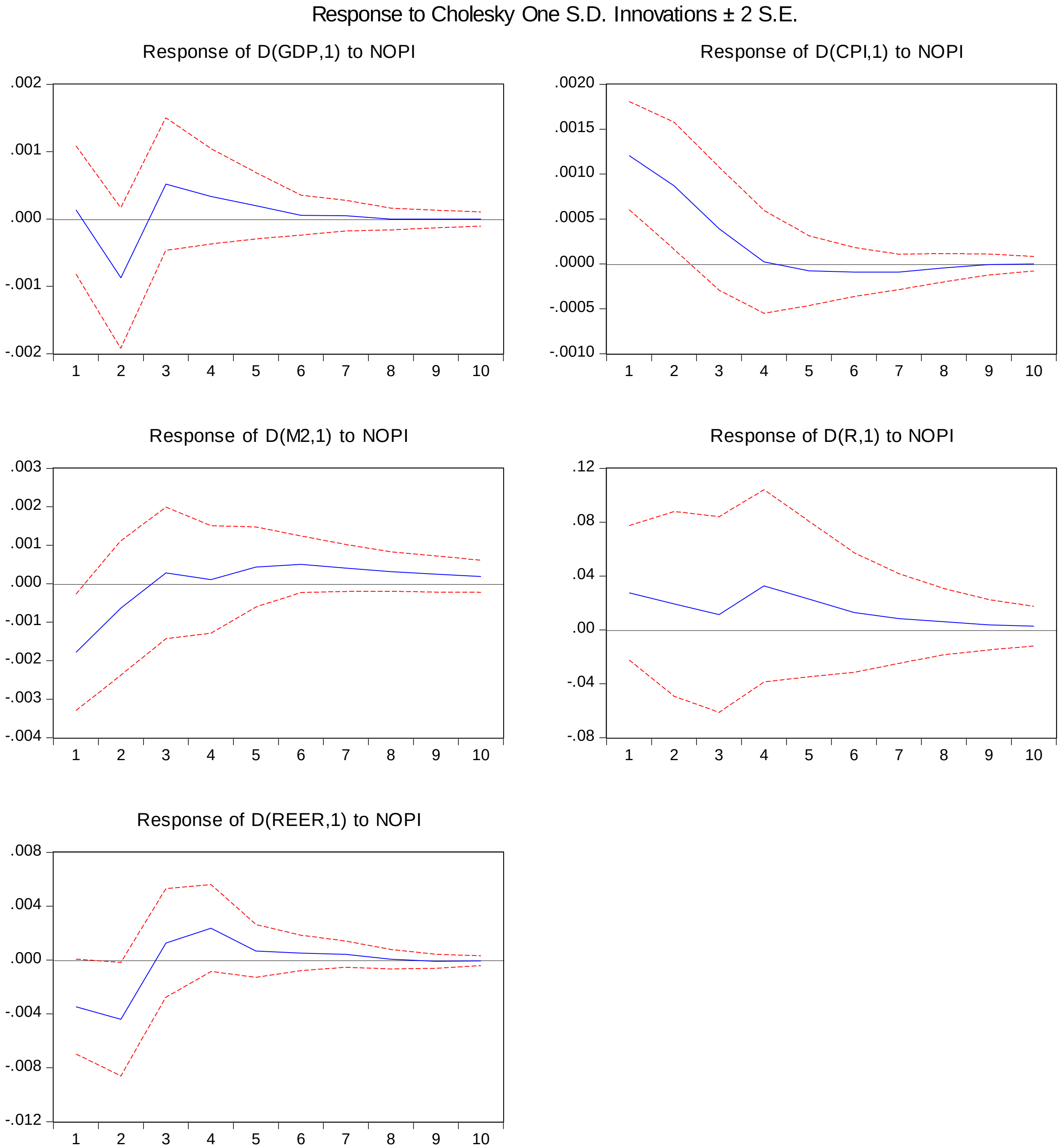

Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of D(GDP,1) to D(FPI,1)
.0015
.0010
.0005
.0000
-.0005
-.0010
-.0015
1 2 3 4 5 6 7 8 9 10
Response of D(CPI,1) to D(FPI,1)
.0020
.0015
.0010
.0005
.0000
-.0005
1 2 3 4 5 6 7 8 9 10
Response of D(M2,1) to D(FPI,1)
.002
.001
.000
-.001
-.002
-.003
1 2 3 4 5 6 7 8 9 10
Response of D(R,1) to D(FPI,1)
.04
.00
-.04
-.08
-.12
-.16
1 2 3 4 5 6 7 8 9 10
Response of D(REER,1) to D(FPI,1)
.004
.000
-.004
-.008
-.012
1 2 3 4 5 6 7 8 9 10

Figure A.9 Impulse Response Functions. Model 2. USA



(continued)

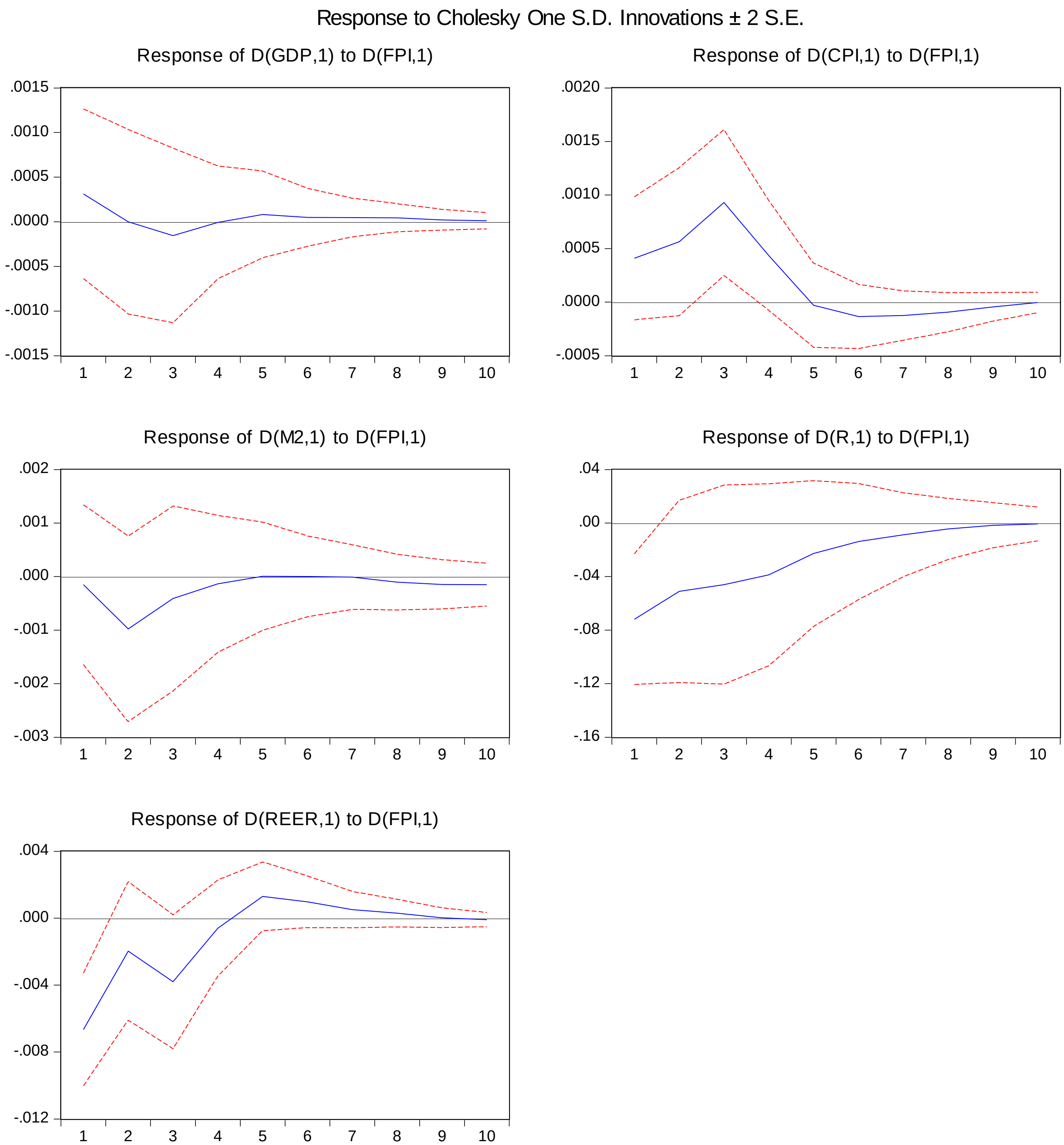
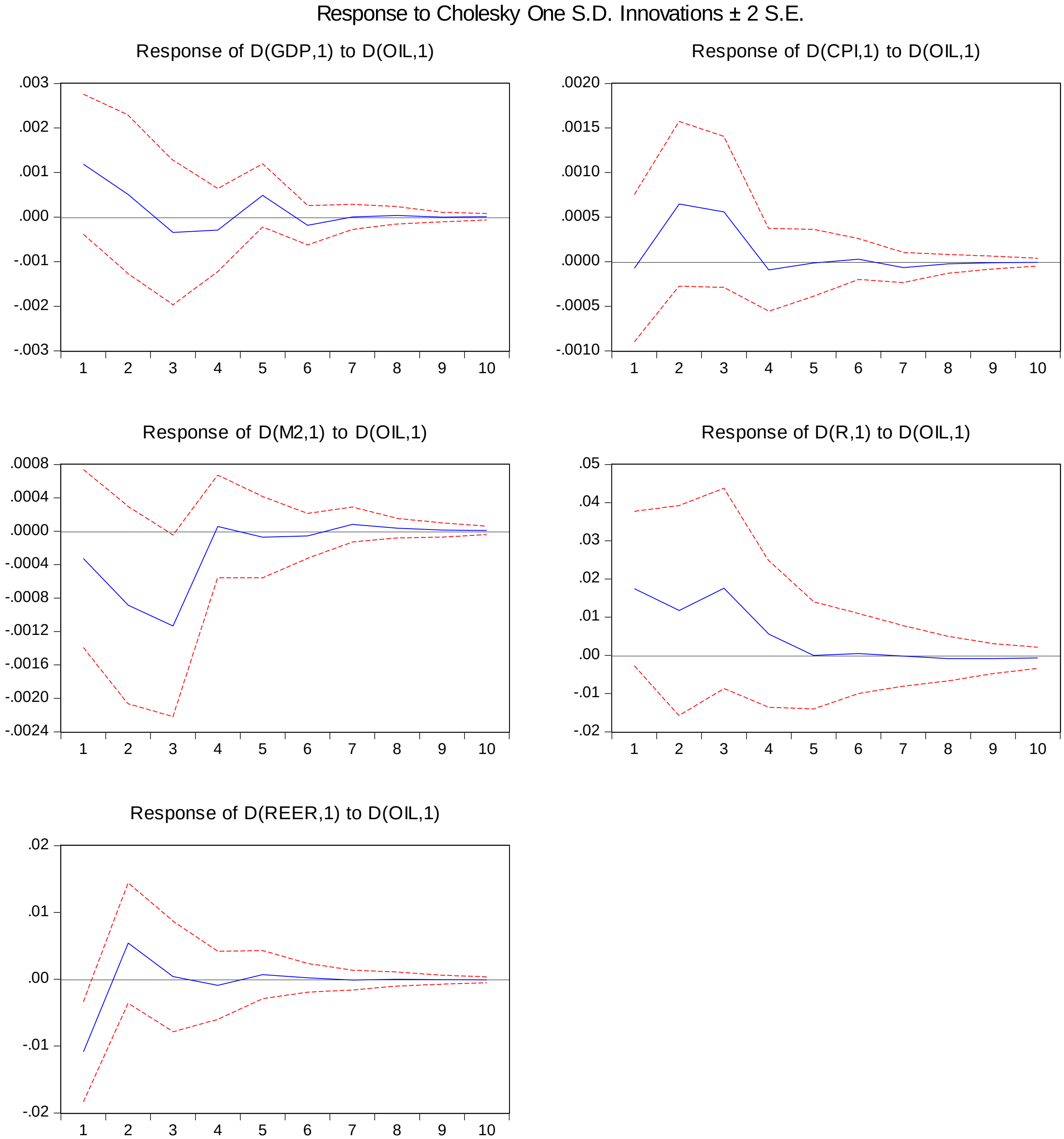

Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of D(GDP,1) to D(FPI,1)
Response of D(CPI,1) to D(FPI,1)
Response of D(M2,1) to D(FPI,1)
Response of D(R,1) to D(FPI,1)
Response of D(REER,1) to D(FPI,1)

Figure A.10 Impulse Response Functions. Model 1. Japan



(continued)

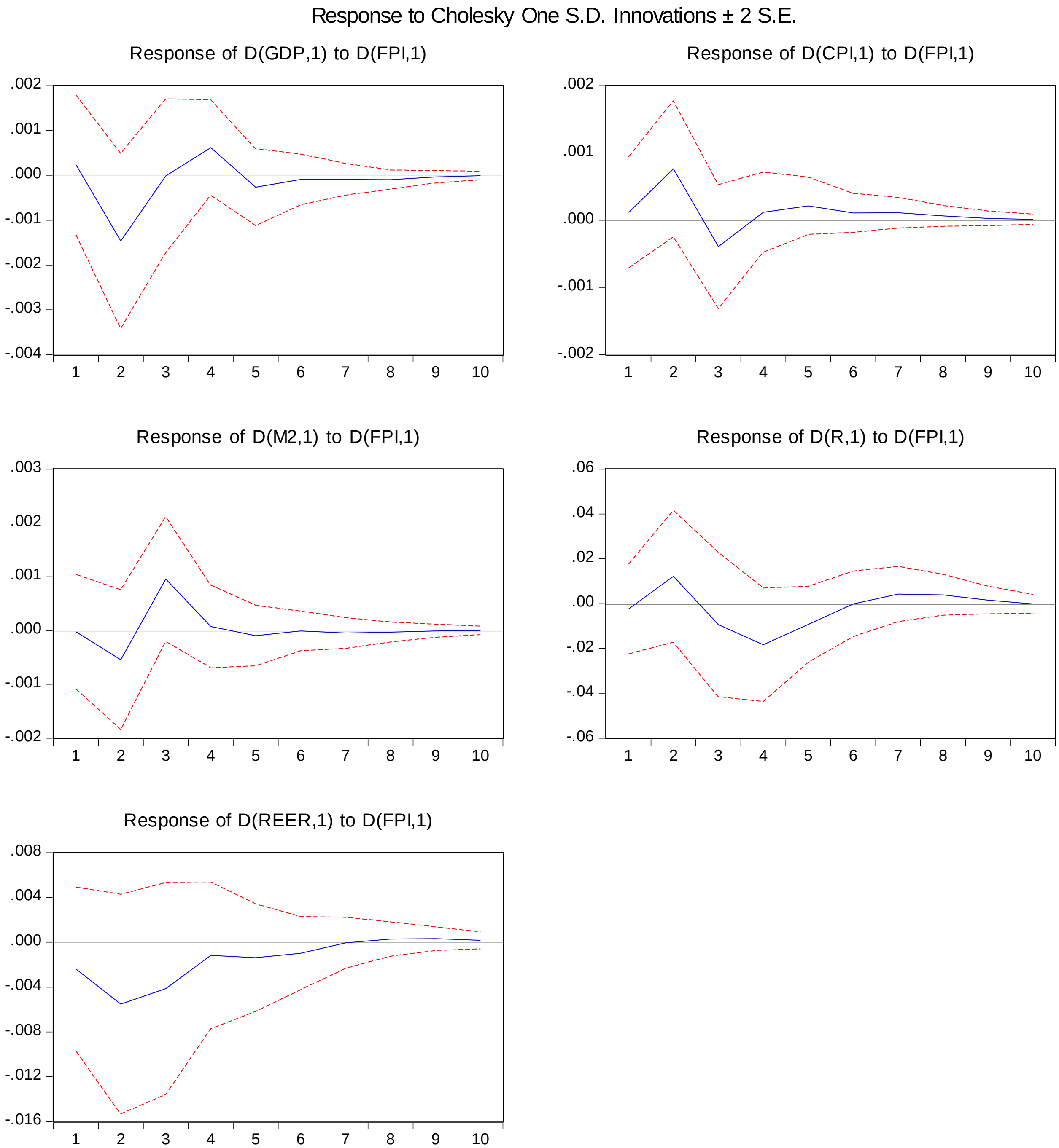
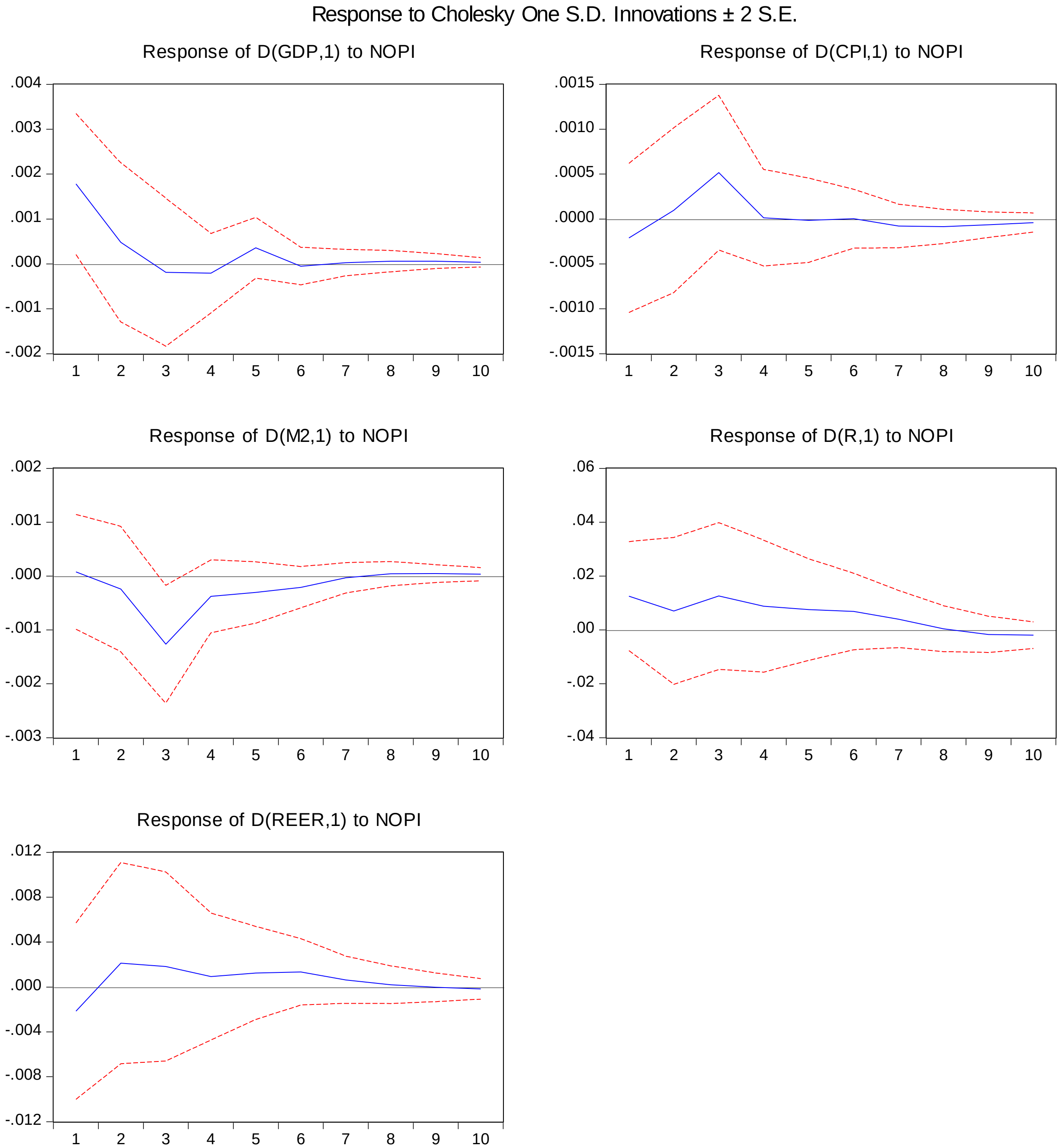
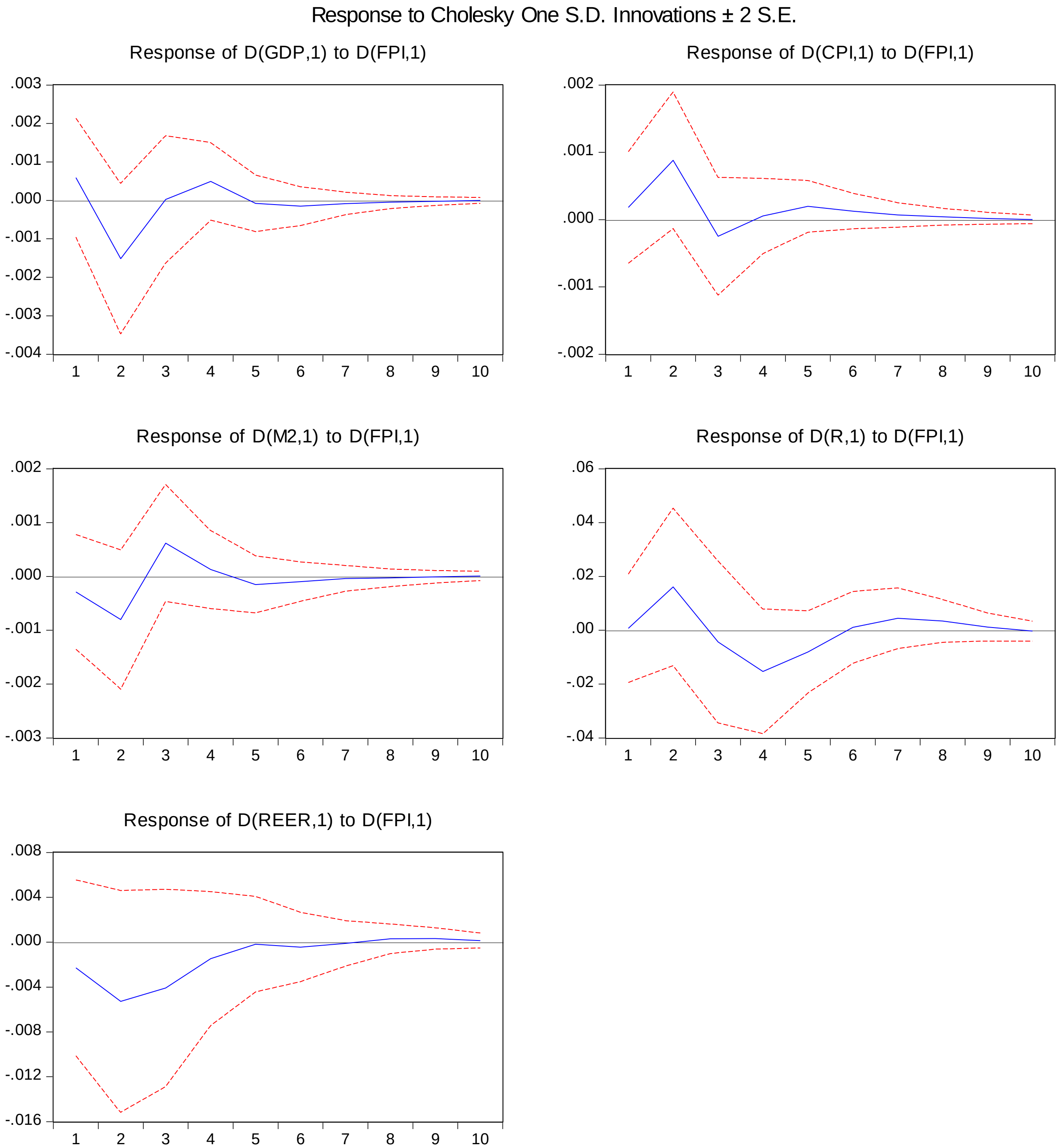

Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of D(GDP,1) to D(FPI,1)
.002
.001
.000
-.001
-.002
-.003
-.004
1 2 3 4 5 6 7 8 9 10
Response of D(CPI,1) to D(FPI,1)
.002
.001
.000
-.001
-.002
1 2 3 4 5 6 7 8 9 10
Response of D(M2,1) to D(FPI,1)
.003
.002
.001
.000
-.001
-.002
1 2 3 4 5 6 7 8 9 10
Response of D(R,1) to D(FPI,1)
.06
.04
.02
.00
-.02
-.04
-.06
1 2 3 4 5 6 7 8 9 10
Response of D(REER,1) to D(FPI,1)
.008
.004
.000
-.004
-.008
-.012
-.016
1 2 3 4 5 6 7 8 9 10

Figure A.11 Impulse Response Functions. Model 2. Japan



(continued)


Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of D(GDP,1) to D(FPI,1)
Response of D(CPI,1) to D(FPI,1)
Response of D(M2,1) to D(FPI,1)
Response of D(R,1) to D(FPI,1)
Response of D(REER,1) to D(FPI,1)

Appendix VIII: Forecast Error Variance Decomposition

Table 10 FEVD. Model 1.USA

Variable	Horizon	OIL	FPI	GDP	CPI	M2	R	REER
GDP	1	0.63	0.30	99.07	0.00	0.00	0.00	0.00
	3	2.92	0.46	94.93	0.29	0.54	0.57	0.29
	6	2.91	0.53	94.34	0.32	0.67	0.89	0.34
	9	2.91	0.55	94.21	0.32	0.69	0.97	0.35
	12	2.91	0.55	94.20	0.32	0.69	0.97	0.36
CPI	1	33.01	0.13	3.09	63.77	0.00	0.00	0.00
	3	38.28	6.82	2.82	50.96	0.52	0.59	0.02
	6	36.79	7.99	2.80	49.60	1.26	0.84	0.72
	9	36.72	8.11	2.80	49.39	1.31	0.87	0.78
	12	36.71	8.11	2.81	49.40	1.32	0.88	0.78
M2	1	18.77	0.03	2.67	16.93	61.61	0.00	0.00
	3	18.40	2.08	5.51	12.84	55.43	2.50	3.25
	6	17.03	1.97	5.26	12.20	55.80	3.15	4.59
	9	16.47	1.98	5.76	12.49	54.64	4.21	4.45
	12	16.28	2.07	6.01	12.54	54.14	4.56	4.40
R	1	2.87	9.18	5.45	0.48	5.95	76.07	0.00
	3	3.14	8.30	21.98	1.38	5.01	58.99	1.20
	6	2.69	9.20	24.87	1.85	4.77	54.01	2.61
	9	2.69	9.28	25.03	1.85	4.74	53.77	2.64
	12	2.69	9.28	25.04	1.85	4.74	53.76	2.64
REER	1	8.34	10.70	0.06	0.40	0.64	4.31	75.56
	3	14.91	12.56	0.41	1.04	5.94	6.51	58.62
	6	15.56	12.69	0.76	1.45	5.87	6.85	56.83
	9	15.59	12.72	0.76	1.47	5.87	6.85	56.74
	12	15.59	12.72	0.76	1.47	5.87	6.85	56.74

Table 11 FEVD. Model 2. USA

Variable	Horizon	NOPI	FPI	GDP	CPI	M2	R	REER
GDP	1	0.08	0.41	99.51	0.00	0.00	0.00	0.00
	3	3.77	0.44	93.33	0.92	0.75	0.58	0.22
	6	4.21	0.46	92.15	1.21	0.82	0.83	0.32
	9	4.22	0.47	92.07	1.22	0.83	0.87	0.32
	12	4.22	0.47	92.06	1.22	0.83	0.87	0.32
CPI	1	14.22	1.64	3.19	80.96	0.00	0.00	0.00
	3	17.92	10.25	2.91	67.17	1.03	0.70	0.03
	6	17.28	11.34	3.04	64.68	1.93	0.99	0.75
	9	17.28	11.48	3.04	64.44	1.97	1.01	0.77
	12	17.27	11.48	3.05	64.42	1.97	1.03	0.77
M2	1	5.16	0.04	2.07	31.09	61.64	0.00	0.00
	3	4.49	1.40	5.00	25.67	58.70	3.03	1.71
	6	4.70	1.33	4.98	24.02	58.13	4.32	2.52
	9	4.90	1.32	5.93	23.44	56.27	5.69	2.45
	12	4.91	1.36	6.43	23.31	55.54	6.01	2.44
R	1	1.15	7.85	4.28	0.17	8.65	77.90	0.00
	3	0.92	7.27	21.74	1.09	8.04	60.40	0.55
	6	1.84	7.39	25.58	2.74	7.52	53.64	1.29
	9	1.89	7.36	25.95	2.99	7.44	53.02	1.35
	12	1.90	7.35	25.96	3.01	7.45	52.98	1.35
REER	1	3.61	13.32	0.12	0.15	0.01	2.40	80.39
	3	7.37	13.99	0.35	2.25	7.44	5.96	62.65
	6	8.42	14.05	0.63	2.67	7.25	6.30	60.68
	9	8.44	14.09	0.67	2.67	7.26	6.29	60.57
	12	8.44	14.09	0.68	2.67	7.26	6.29	60.57

Table 12 FEVD. Model 1. Japan

Variable	Horizon	OIL	FPI	GDP	CPI	M2	R	REER
GDP	1	2.54	0.10	97.36	0.00	0.00	0.00	0.00
	3	2.79	3.43	85.22	1.06	6.56	0.55	0.38
	6	3.21	3.98	81.79	1.50	6.59	0.84	2.10
	9	3.21	4.00	81.70	1.50	6.62	0.84	2.13
	12	3.21	4.00	81.70	1.50	6.62	0.84	2.13
CPI	1	0.04	0.09	3.76	96.12	0.00	0.00	0.00
	3	4.12	4.20	3.35	83.61	0.95	0.28	3.50
	6	4.03	4.44	3.35	81.16	1.53	0.65	4.83
	9	4.05	4.52	3.35	80.93	1.65	0.66	4.85
	12	4.05	4.52	3.35	80.92	1.65	0.66	4.86
M2	1	0.42	0.00	2.68	70.52	26.38	0.00	0.00
	3	7.26	4.04	2.79	60.57	23.65	0.85	0.84
	6	7.21	4.04	3.00	59.95	23.59	1.10	1.11
	9	7.23	4.05	3.00	59.90	23.59	1.11	1.12
	12	7.23	4.05	3.00	59.90	23.59	1.12	1.12
R	1	3.32	0.06	3.33	0.63	0.07	92.59	0.00
	3	4.43	1.43	5.60	0.42	2.12	85.68	0.32
	6	4.29	3.64	5.27	0.52	4.03	81.33	0.92
	9	4.27	3.81	5.27	0.52	4.29	80.89	0.95
	12	4.27	3.81	5.27	0.53	4.30	80.88	0.95
REER	1	9.02	0.44	0.08	0.99	0.88	7.12	81.46
	3	8.70	3.14	1.82	1.53	2.17	11.40	71.23
	6	8.62	3.33	2.09	1.69	2.48	11.80	69.99
	9	8.61	3.34	2.09	1.69	2.50	11.85	69.92
	12	8.61	3.34	2.09	1.69	2.50	11.85	69.91

Table 13 FEVD. Model 2. Japan

Variable	Horizon	NOPI	FPI	GDP	CPI	M2	R	REER
GDP	1	5.62	0.62	93.76	0.00	0.00	0.00	0.00
	3	5.31	4.09	82.35	1.39	6.31	0.35	0.19
	6	5.42	4.38	80.16	1.62	6.39	0.54	1.49
	9	5.43	4.39	80.09	1.63	6.41	0.55	1.51
	12	5.43	4.39	80.09	1.63	6.41	0.55	1.51
CPI	1	0.29	0.21	2.98	96.52	0.00	0.00	0.00
	3	1.79	4.86	2.87	84.25	1.09	0.48	4.66
	6	1.72	4.99	2.88	81.44	1.51	0.72	6.74
	9	1.81	5.01	2.88	81.24	1.58	0.74	6.75
	12	1.82	5.01	2.88	81.22	1.58	0.74	6.76
M2	1	0.02	0.33	1.74	71.60	26.31	0.00	0.00
	3	5.64	3.76	2.18	62.01	23.96	0.99	1.45
	6	6.37	3.80	2.43	60.15	23.89	1.16	2.19
	9	6.38	3.80	2.46	60.07	23.86	1.21	2.21
	12	6.38	3.80	2.46	60.06	23.86	1.22	2.22
R	1	1.70	0.01	3.61	0.65	0.03	94.00	0.00
	3	2.17	1.66	5.55	0.47	2.01	87.53	0.61
	6	3.00	3.19	5.15	0.63	4.04	82.51	1.48
	9	3.08	3.35	5.19	0.65	4.27	81.98	1.49
	12	3.10	3.35	5.18	0.65	4.28	81.92	1.51
REER	1	0.34	0.38	0.06	1.25	1.16	9.90	86.91
	3	0.74	2.96	1.73	1.55	2.42	13.48	77.12
	6	0.97	3.04	2.26	1.57	2.78	13.95	75.44
	9	0.99	3.04	2.27	1.58	2.79	14.02	75.30
	12	1.00	3.04	2.27	1.58	2.80	14.02	75.29

Appendix IX: Residual Diagnostics

Table 14 Tests for Residual Serial Correlation and Heteroskedasticity. USA

Test	Model 1			Model 2		
LM test for serial correlation[1]	**Lags**	**LM-stat**	**Probs**	**Lags**	**LM-stat**	**Probs**
H0: no serial correlation at lag order h	1	65.385	0.059	1	65.098	0.062
	2	58.197	0.173	2	66.105	0.052
	3	44.101	0.672	3	39.420	0.834
VAR Residual Heteroskedasticity	**Chi-sq**	**df**	**Prob.**	**Chi-sq**	**df**	**Prob.**
Tests: No Cross Terms (only levels and squares)	874.004	868	0.437	868.876	868	0.485

[1]Probs from chi-square with 49 degrees of freedom

Table 15 Tests for Residual Serial Correlation and Heteroskedasticity. Japan

Test	Model 1			Model 2		
LM test for serial correlation[2]	**Lags**	**LM-Stat**	**Probs**	**Lags**	**LM-Stat**	**Probs**
H0: no serial correlation at lag order h	1	59.17657	0.1513	1	57.62441	0.1864
	2	40.89042	0.7884	2	58.74276	0.1606
	3	54.13841	0.2847	3	49.74712	0.4434
	4	49.43934	0.4556	4	62.2822	0.0963
	5	59.80261	0.1387	5	53.0012	0.3225
	6	28.67508	0.991	6	41.02134	0.7841
	7	37.49748	0.8847	7	44.70088	0.6479
	8	46.08141	0.5922	8	36.12507	0.9142
	9	34.27554	0.9452	9	33.23421	0.9587
	10	49.78005	0.4421	10	38.13994	0.869
VAR Residual Heteroskedasticity Tests:	**Chi-sq**	**df**	**Prob.**	**Chi-sq**	**df**	**Prob.**
No Cross Terms (only levels and squares)	894.4516	924	0.7515	894.5604	924	0.7507

[2]Probs from chi-square with 49 degrees of freedom

Table 16 Jarque-Bera Test for Normality of Residuals. USA

Null Hypothesis: Residuals are Normally Distributed (skewness and kurtosis are around 0 and 3 respectively)

	Model 1				Model 2			
Variable	**t-stat**	**p-value**	**skewness**	**kurtosis**	**t-stat**	**p-value**	**skewness**	**kurtosis**
u1	3.206	0.201	-0.388	3.360	35.864	0.000	1.155	4.691
u2	3.197	0.202	0.241	3.705	5.570	0.076	0.200	4.009
u3	0.466	0.792	-0.068	2.703	0.212	0.899	-0.079	2.847
u4	29.019	0.000	-0.921	4.800	34.155	0.000	-0.845	5.225
u5	26.653	0.000	0.878	4.734	20.966	0.000	0.667	4.735
u6	21.899	0.000	-0.511	4.990	26.201	0.000	-0.635	5.092
u7	2.059	0.357	-0.002	3.686	1.581	0.454	-0.019	3.600

Table 17 Jarque-Bera Test for Normality of Residuals. Japan

Null Hypothesis: Residuals are Normally Distributed (skewness and kurtosis are around 0 and 3 respectively)

	Model 1				Model 2			
variable	**t-stat**	**p-value**	**skewness**	**kurtosis**	**t-stat**	**p-value**	**skewness**	**kurtosis**
u1	15.952	0.000	-0.859	4.163	13.138	0.001	0.874	3.700
u2	0.399	0.819	0.035	2.680	0.587	0.746	-0.106	3.663
u3	1.900	0.387	-0.345	2.807	1.818	0.403	-0.333	2.787
u4	176.454	0.000	1.654	9.053	169.497	0.000	1.648	8.903
u5	61.879	0.000	-0.848	6.705	50.275	0.000	-0.793	6.323
u6	3183.813	0.000	-4.219	31.060	3306.247	0.000	-4.257	31.620
u7	6.445	0.040	-0.141	4.288	8.527	0.014	-0.157	4.483