OIL PRICE SHOCKS
AND
STOCK MARKET BEHAVIOR

EMPIRICAL EVIDENCE FOR THE U.S. AND EUROPEAN COUNTRIES

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A Dissertation

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EMPIRICAL EVIDENCE FOR THE US AND EUROPEAN COUNTRIES

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I dedicate this dissertation to God and everyone I know.

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OIL PRICE SHOCKS AND STOCK MARKET BEHAVIOR :

EMPIRICAL EVIDENCE FOR THE US AND EUROPEAN COUNTRIES

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ABSTRACT

This dissertation analyze the relationship between oil price shocks and stock market for the US and 13 European countries with monthly data from 1986.1 – 2005.12. Three countries (Denmark, Norway and the UK) among 13 European countries are oil exporting countries. Unrestricted multivariate Vector Autoregression (VAR) with 4 variables (interest rates, real oil price changes, industrial production and real stock returns) is estimated as well as impulse response function and variance decomposition. With regard to impact of oil price shocks on the stock market, in most oil importing countries oil price shocks have significantly negative effect on the stock market in the same month or in one month, while among oil exporting countries only Norway shows a significantly positive response of real stock returns to oil price shocks. Comparing the impacts of oil price shocks and interest rate (monetary) shocks on the stock market, in most oil importing countries oil price shocks have a greater impact than interest rate shocks, except for a few countries where monetary policy responds systemically to oil price shocks by raising interest rates, which leads to a decline in real stock returns. Therefore, taking into account the response of monetary policy to oil price shocks, oil

prices play a crucial role in the stock market of oil importing countries. On the contrary, in oil exporting countries oil price shocks have a smaller impact on the stock market than interest rate shocks, and monetary policy does not respond to the oil price shocks. According to the literature, oil price shocks have an asymmetric effect on economic activity and the stock market in that oil price increases have a greater impact than oil price decreases. However, in this dissertation, the asymmetric pattern is a little different. In the sub-sample period (1996.5-2005.12) when oil price increases more frequently than oil price decreases and the average magnitude of oil price increases is smaller than that of oil price decreases, stock markets in most countries are more influenced by oil price decreases than oil price increases in the variance decomposition analysis. In particular, statistically significant evidence at the 5% level is found that oil price decreases have a greater impact on real stock returns than oil price increases after the mid 1990's in the US.

CHAPTER I

INTRODUCTION

It is not easy to find a factor which had a greater impact on an economy than oil prices since 1970. After the oil price increase caused by the oil embargo of OPEC in 1974 most economies experienced an economic recession, and similar situations continue to occur. Therefore, the relationship between oil prices and the economy has been and continues to be a keen interest to lay people as well as economists.

Over the past 25 years, market capitalizations, expressed as a percentage of GDP, have doubled or tripled in many industrial countries. The increasing role of the stock market in the economy has stimulated research on the relationship between the stock market and the economy. However, in spite of the fact that the stock market plays a significant role in the economy, there are limited number of studies on the relationship between oil prices and the stock market. The US has been examined by Kling (1985), Jones and Kaul (1996), Sadorsky (1999) and for Norway by Gjerde and Saettem (1999), for Greece by Papapetrou (2001) and for developing economies by Maghyereh (2004).

Therefore, I want to analyze the relationship between oil prices and the stock market for European countries as well as the US with the recent data. In particular, I am interested in the asymmetric effect of oil price changes on the stock market because the pattern of oil price fluctuations has changed since the mid 1990's and oil price increases occur more frequently than oil price decreases, while the average magnitude of increases is smaller for decreases. (Table 1.1)

This paper analyzes various aspects of the relationship between oil prices and the

stock market with a Vector Autoregression (VAR) for the US and 13 European countries[1] : Austria, Belgium, Denmark, Finland, France, Germany, Greece, Netherlands, Norway, Italy, Spain, Sweden, and the UK. Among these countries, Denmark (as of 1997), Norway, and the UK are net oil exporting countries. The basic model is a VAR with 4 variables : interest rates, real oil price changes, industrial production, and real stock returns. Monthly data from 1986.1-2005.12 is used. I use the world oil price (UK Brent) and the national oil price with 3 specifications for oil price changes : percentage changes (linear), *SOP* (scaled oil price by Lee et al., 1995) and *NOPI* (net oil price increase by Hamilton, 1996).

By extending the work of Sadorsky (1999), I examine the followings :

First, I look at how the stock market responds to oil price shocks with the impulse response function and accumulated response of real stock returns. I check robustness with a VAR of 4 variables of different ordering : real oil price changes, interest rates, industrial production, and real stock returns and a VAR of 5 variables : interest rates, real oil price changes, industrial production, inflation, and real stock returns.

Second, I compare the impacts of oil price shocks and interest rate (monetary) shocks on the stock market using variance decomposition and impulse response function.

Third, I analyze whether the asymmetric pattern of the stock market in response to oil price shocks is changing recently with variance decomposition and coefficient tests.

The main results of this paper are summarized as follows.

In all countries except Finland and the UK real stock returns respond significantly to oil price shocks immediately or in a month. For most oil importing countries, oil price

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[1] Countries are chosen based on the availability of data such as stock price index, short term interest rates, etc.

shocks have a significantly negative impact on the stock market in a month. On the contrary, among oil exporting countries only Norway shows a significantly positive response of real stock returns to oil price shocks, while it is insignificant in the UK and it is significantly negative in Denmark.

Comparing impacts of oil price shocks and interest rate shocks on stock market, oil price shocks have a greater influence than interest rate shocks in all oil importing countries except Italy, Spain and Sweden, where monetary policy responds systemically to oil price shocks by raising interest rates, leading to a decline in real stock returns. In oil exporting countries, oil price shocks have a smaller impact than interest rate shocks, and monetary policy (interest rates) does not respond systematically to oil price shocks.

According to the literature, oil price changes have the asymmetric effect on the stock market such that an oil price increase has a greater impact on the stock market than an oil price decrease. However, in my analysis the asymmetric response pattern is a little different. In the sub-sample period of 1996.5-2005, when oil price increases occur more frequently and the average magnitude of oil price increases is smaller than that of oil price decreases, stock markets in most countries are more influenced by an oil price decrease than an oil price increase in variance decomposition analysis. I find strong evidence that the asymmetric effect of oil price shocks on the stock market has changed in the US. Because I find a significant asymmetric effect at the 5% level in variance decomposition analysis and coefficient test of a *SOP* specification model that oil price decreases have a greater impact on real stock returns than oil price increases after the mid 1990's.

Through these analyses this paper contributes to the literature of oil prices and the

stock market in the following ways. First, I analyze the influence of oil price shocks on the stock market for European countries for the first time and for the US with recent data. Second, I investigate the contribution of oil price shocks and interest rate (monetary) shocks to stock market movement in those countries. Third, I address the change of asymmetric response patterns for the stock market to oil price shocks with recent data (1996-2005). Fourth, I also compare the responses of the stock market to oil price shocks in oil importing countries with exporting countries (Denmark, Norway, the UK).

The remainder of this paper is organized as follows. In Chapter 2, I review the literature which is related to oil prices and the stock market. Chapter 3 provides the theoretical framework of the paper. In Chapter 4, I describe the data and framework used in the analysis. Chapter 5 presents the empirical results of relationship between oil prices and the stock market and I conclude in Chapter 6.

Figure 1.1 World real oil price
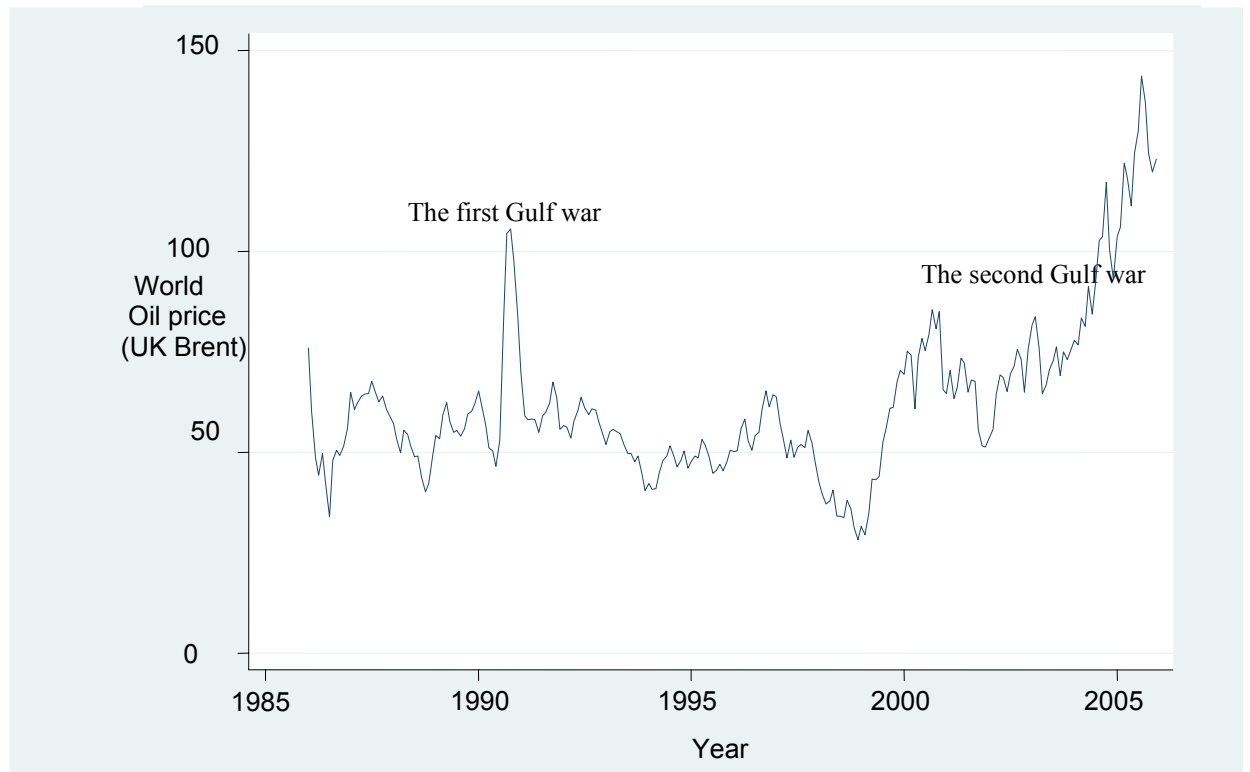
< Date of substantial spot oil price change > [2]

1986. 2 May – closure of some Soviet nuclear reactors in wake of Chernobyl disaster

　　30 October – Yamani ousted as Saudi Oil Minister.

1988. 18 July – Iran accepts UN calls for cease fire.

1989. 12 December – Frigid temperatures in the US.

　　20 December – US invasion of Panama.

1990. 2 August – Iraq invasion of Kuwait ; US led oil boycott.

　　September to December – Middle East tensions.

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[2] "Measuring oil-price shocks using market-based information" by Michele Cavallo and Tao Wu (2006)

1991. January – First Gulf war.

19 August – Soviet coup.

1996. 13 February – Freezing temperatures in the US northeast and in northern Europe.

23 February – Iraq accepted UN resolution 986 : exchange of oil for food.

17 June – UN-Iraq weapons inspection standoff ; Many believe that the oil-sale

deal may be in jeopardy.

3 September – US bombing on southern Iraq.

16 December – Frigid weather across the US.

1998. 26 January – US comments that patience with Iraq is running out.

3 September – Disruption to Russian and Nigerian crude oil supplies ; US-Iraq

tension on weapon inspection.

16 December – UN weapons inspections withdraw from Iraq, a military strike in

Iraq may be possible ; however, despite the air strike, Iraqi oil

continues to flow.

2002. 2 January – Cold weather in the US.

16 December – Strikes in Venezuela continue.

23 December – Ongoing general strike in Venezuela ; Potential war against Iraq

2003. March – Second Gulf war ; US invades Iraq ; Traders expected a relatively short

war in Iraq with minimal damage to oil installations, but the war

looks tougher ; British and US military officials say that it will take

months before oil from Iraq's southern fields is again ready to be

exported ; ongoing civil unrest in Nigeria, where approximately

800,000 barrels per day of oil is shut.

2003. 22 July – Saddam's two sons die at the hands of US troops.

1 August – Pipeline fire in Iraq, suspected to be caused by sabotage ; Heightened concerns about the situation in Iraq.

23-24 August – Concerns over Tropical Storm Jose and another suspension of Basrah oil loadings in Iraq supported oil prices ; New forecasts for a storm (Katrina) hitting the US Gulf Coast and another hefty withdrawal in gasoline stocks pushed crude futures on the New York Mecantile Exchange (Nymex) to a new record.

Table 1.1   Pattern of world oil price fluctuations

World oil price (UK Brent)

Year		70-85	86-96	97-99	00-05
Frequency	**Increase**	68	66	17	40
	Decrease	114	66	19	32
Average Growth rate (%)	**Increase**	0.05849	0.06313	0.0842	0.072
	Decrease	-0.02227	-0.06837	-0.07059	-0.07258

World oil price (3 spot price index)

Year		70-85	86-96	97-99	00-05
Frequency	**Increase**	56	64	18	44
	Decrease	136	68	28	28
Average Growth rate (%)	**Increase**	0.0728	0.0624	0.0704	0.0603
	Decrease	-0.0179	-0.0661	-0.0703	-0.0713

CHAPTER II

LITERATURE REVIEW

Since oil price changes are one of the most significant supply shocks which hit the world economy after World War II, a special consideration has been given to oil prices in the literature. There have been numerous studies related to the interaction among oil prices, the stock market and the overall economy. In this chapter, I review previous papers dividing it into two parts : The first part analyzes theoretical studies on the impact of oil prices. The second part reviews the empirical studies on (1) oil prices and economic activity, (2) the stock market and economic activity, and (3) oil prices and the stock market.

1. Theoretical studies on the impact of oil prices

According to economic theory, oil price changes influence economic activity through both supply and demand channels. Supply side effects could be explained based on the fact that oil is an important input in production. Therefore, oil price increases reduce the demand for oil, decreasing productivity of other input factors which induce firms to lower output. Furthermore, oil price changes have demand side effects through consumption and investment. Consumption is affected indirectly by its positive relation with disposal income. When the oil price increases, an income transfer occurs from oil importing countries to oil exporting countries. Therefore, consumption in oil importing countries decrease and the magnitude of this effect is greater the more the shocks are

perceived to be long-lasting. Oil price increases also have an adverse effect on investment by increasing firm's cost. In addition to these supply and demand effects oil price changes could influence the economy through foreign exchange markets and inflation.

Hamilton (1988) investigates a general equilibrium model of unemployment and business cycle model where it is costly to shift labor and capital inputs between sectors. In such a model he shows that energy price shocks can reduce aggregate employment by inducing workers in adversely affected sectors to remain unemployed while they wait for labor conditions to improve in their sector, rather than move to a sector not adversely affected.

Rotemberg and Woodford (1996) study the impact of oil price shocks on output and real wages with a simple aggregative model by assuming imperfect competition in the product market. Allowing for a modest degree of imperfect competition (such as an implicit collusion between oligopolists) can account for declines in output and real wages after oil price shocks. According to them, an imperfect competition model can explain the effects of oil price shocks on the US economy greater extent than a stochastic growth model (which assumes a perfectly competitive product market).

Finn (2000) shows that perfectly competitive model can also explain the effect of oil price shocks. He uses the concept of utilization rates for productive capital. The main idea of his model comes from the relationship between energy usage and capital services. Specifically, energy is essential to obtain the service flow from capital. Capital utilization rates are determined by energy use. Due to the oil price shocks, the decline of energy use reduces output and labor's marginal product, leading to a decline in wages and labor supplied. According to him, an oil price shock is like an adverse technology shock in

inducing a contraction in economic activity.

Miguel, Manzano and Martin-Moreno (2003) investigate the macroeconomic impact of oil price shocks with a dynamic general equilibrium model of a small open economy for Spain. In their model, oil is included as an imported productive input and oil prices as well as interest rates are assumed to be set by the international market. With respect to the exogenous oil price shocks, their model reproduces Spanish GDP closely from 1970 to the mid 1980's, while it replicates less for the period 1985 - 1998. In addition, they show that oil price increases have a negative and significant effect on welfare.

2. Empirical studies on the impact of oil prices

2.1 Oil prices and economic activity

2.1.1 US and big economies

Hamilton (1983) studies the impact of oil price shocks on the US economy by using a seven-variable VAR system.[3] He finds that all but one economic recession are preceded by dramatic oil price increases after World War II. This does not mean that an oil price increas causes recessions, but there exists a statistically significant correlation between oil price shocks and economic recessions.

Burbidge and Harrison (1984) also run a seven-variable VAR with the monthly data of May 1962 - June 1982 for the US, Japan, Germany, Canada and the UK. According to the impulse response analysis, the impact of oil price shocks on industrial

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[3]Two output variables (real GDP, unemployment), three price variables (implicit price deflator for nonfarm business income, hourly compensation per worker, import price), M1 and oil price

production in the US and UK is sizable while in Japan, Germany and Canada it is relatively small. Price level impacts on the US and Canadian economies are substantial, while they are smaller but still significant in Japan, Germany and the UK.

Gisser and Goodwin (1986) study the impact of oil price shocks on the US economy with data from 1961Q1 - 1982Q4 by testing for a regime shift in 1973. They find that the overall relationship between crude oil price and the US macroeconomy has been stable over the sample period. Furthermore, they find that oil price shocks shift aggregate supply curve causing large real effects but weak direct price effects, while monetary policy primarily shifts the aggregate demand curve causing strong price effects but long-run neutrality with respect to real GDP.

Hooker (1996) finds somewhat different results that in data up to 1973, Granger causality from oil price shocks to US macroeconomic variable exists, but if the data is extended to the mid 1990's the relationship is not robust. He investigates a few potential explanations about this phenomenon such as sample period issues, misspecification of linear VAR equations for the oil price and macroeconomic variables, but none are supported by the data. His analysis concludes that the oil price-macroeconomy relationship has changed in a way which can't be well represented by simple oil price increases and decreases.

Keane and Prasad (1996) use micro panel data to examine the effect of oil price changes on employment and real wages at the aggregate and industry levels. The data set is from the National Longitudinal Survey of Young Men (NLS). It consists of a nationally representative sample of 5,225 males between 14 and 24 years of age in 1996 and interviewed in 12 times during 16 years from 1966 to 1981. The data contains

employment status, wage rates and sociodemographic characteristics. Workers are classified into 11 broadly defined industries on the basis of the 3-digit census industrial classification (CIC) codes. They differentiate skilled and unskilled workers and analyze how various human capital variables interact with real shocks to affect wages and employment variability. Oil price increases cause real wages to decline at the aggregate level and all sectors as well as all skilled workers. But, the relative wage of skilled workers increases. This is the difference between panel data econometric techniques, which control for unobserved heterogeneity, and OLS estimation methods. In the case of employment, oil price increase do not reduce aggregate employment in the long run since oil and labor are net substitutes instead of gross substitutes in production. When the oil price increases, labor supply can increase due to the income effect. Employment probabilities for skilled labor rise even more strongly following an oil price increase because skilled labor may be a good substitute for energy in the production function for most industries.

Lee et al. (1995) and Hamilton (1996) propose non-linear transformations of oil prices to reestablish the negative relationship between increases in oil prices and economic downturns. The transformations are scaled specification (Lee et al., 1995) and net specification (Hamilton, 1996). The objective of scaled specification (*SOP*) is to account for volatility of oil prices by using GARCH, while the objective of net specification (*NOPI*) comes from consumption decisions. Specifically, it is more responsible to measure an oil price increase by comparing the current price of oil with where it has been over previous periods rather than compare the oil price to a previous period alone. So oil price increase is recognized only when current oil price is greater

than its maximum value over the previous periods. According to Lee et al.(1995), oil price changes are likely to have a greater impact on GDP in an environment where the oil price has been stable than where the oil price changes frequently. Hamilton (1996, 2003) finds that by using the net oil price increase (*NOPI*), the historical correlation between oil prices and GDP still exist in early 1990's and a nonlinear function of oil price changes is better to forecast GDP.

2.1.2 Other countries

Recently, these studies are extended to other countries. Cunado and Gracia (2003, 2005) analyze the relationship between oil prices and macroeconomic variables such as inflation and economic activity for many European countries[4] as well as some Asian countries.[5] They mainly use the Granger causality test to check whether oil price changes affect macroeconomic variables. The world oil price is calculated as the ratio between the producer price index for crude oil divided by the producer price index for all commodities, while the national oil prices are measured using the exchange rate of each of the countries. Inflation rates are calculated from the CPI, and economic activity is estimated with industrial production data. All data are quarterly from 1960 to 1999 for European countries, and from 1975Q1 to 2002Q2 for Asian countries. For oil price changes, three specifications are used : real oil price changes[6], net oil price increases (*NOPI*), and scaled oil prices increases (*SOPI*). Before testing Granger causality, they

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[4] Germany, Belgium, Austria, Spain, Finland, France, Ireland, Italy, Luxembourg, UK, Netherlands, Denmark, Greece, Sweden
[5] Japan, Singapore, South Korea, Malaysia, Thailand and Philippines
[6] From now on oil price changes as a specification means percentage changes of oil price

conduct a unit root test and cointegration test. According to the tests, all variables contain a unit root (integrated of order one, $I(1)$), so they take the first difference of them. In the cointegration test, result indicates no cointegration between two variables or among three variables.[7] This means that in general, no long-run relationship between the oil price and economic variables exists.

Cunado and Gracia carry out Granger causality test. For European countries, when the world oil price is used oil price changes cause the industrial production growth for 7 out of 14 countries. However, if the national oil price changes or positive oil price changes in the world oil price or *NOPI* in the world oil price is used it causes industrial production growth in more countries. In the case of *SOPI* calculated by the world oil price, its impact is lower than that of world oil price changes. This means that they do not find evidence that the impact of oil price shocks on macroeconomic variables depends on the volatility of oil market. With the analysis of the trivariate relationship among inflation, industrial production growth rates and oil prices, they find that oil price Granger causes economic activity not only through an inflation channel but also another mechanism. With regard to the asymmetric effect of oil price changes on the economy, oil price increases have a negative and significant effect on industrial production in 8 or 9 out of 14 countries, while oil price decreases have an insignificant effect. For Asian countries they use a similar approach. When they test the Granger causality from oil price to economic growth rates, only Japan with *NOPI* specification and Korea with *SOPI* specification show significance at the 10% level in the world oil price model, while a few more countries show significance when the national oil price is used. With regard to

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[7] Only for UK and Ireland cointegration relationship between inflation and the other variables is found when national oil price is used.

inflation, oil price changes have a greater impact than industrial production. In general, the national oil price has a bigger influence on economic activity than the world oil price. Regarding the asymmetric effects, only South Korea has significance for industrial production when the national oil price is used. For the inflation, asymmetric effects are significant in 2 or 3 out of 6 countries

Jimenez and Sanchez (2005) asses empirically the effect of oil price shocks on real economic activity for some OECD countries.[8] They carry out an unrestricted multivariate VAR with real GDP, real effective exchange rate, real oil price, real wage, inflation, short term interest rates and long term interest rates. Data is quarterly from 1972Q3 to 2001Q4. For the world oil price they use the price of UK Brent crude oil in US dollars, and real world oil price is obtained by dividing it by the US Producer Price Index. They use three non-linear specifications for oil price changes : (1) asymmetric specification such as positive and negative of oil price changes ; (2) scaled specification, increase of SOP ($SOPI$) and decrease of SOP ($SOPD$), which are calculated following AR(4)-GARCH(1,1) ; (3) net specification, $NOPI$ which is measured by max { 0, $\ln p_t - \max\{\ln p_{t-1}, \ln p_{t-2}, \ln p_{t-3}, \ln p_{t-4}\}$ } in addition to oil price changes. Before running a VAR they conduct a unit root test of all variables with DFGLS and P_T , tests of Elliott, $DFGLS_U$ and Q_T tests of Elliott as well as the Augmented Dickey-Fuller (ADF) test. All variables are stationary using the first difference, thus they run a VAR using the first difference.

Granger causality is investigated from oil price shocks to economic variables. With the null hypothesis that all of the oil price coefficients in the equation of GDP are

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[8] US, Euro area, Japan, Canada, France, Italy, Germany, UK and Norway

jointly zero, coefficients of all oil prices are not significant at the 5% level in most countries. But, with the null hypothesis that all of the oil price coefficients are jointly zero in all equations of the system except its own equation, coefficients of all oil prices are significant at the 5% level in all countries except for the US. Finally, they perform a block exogeneity test to see whether oil price changes Granger-cause the other variables and oil price changes are Granger-caused by the remaining variables. In most cases, the null hypothesis that the oil price variable is Granger-caused by the other variables of the system is rejected, while the null hypothesis that the oil price variable Granger-causes the remaining variables of the system is generally not rejected at the 5% significance level. They conclude that oil price change does not affect GDP directly but indirectly through the other economic variables in all countries, while oil price is not caused by the economic variables in most countries.

Next they analyze impulse response of real GDP to oil price shocks. Four different specifications are used and in most countries a non-linear specification model yields a more accurate representation except the UK, in which a linear specification model is more effective. They also compare net oil importing countries with net oil exporting countries such as the UK and Norway. An oil price hike has a significantly negative impact on GDP in all net oil importing countries except Japan. In particular, the magnitude of negative impact in the US and Germany was greater than the other countries. One of the reasons for this result is that they are the only oil importing country for which the real exchange rate appreciates after the oil price increases. For Japan, GDP respond positively to oil price shocks, which could be explained by the fact that Japanese economy is quite resilient to the oil shocks of the 1970's and early 1980's despite its large

dependence on oil. But, this result is not robust because it shows a negative response in different ordering and lags of VAR. For net oil exporting countries such as the UK and Norway, they show similar response patterns, positive response within two quarters followed by a negative response. But, the cumulative effect in the UK is negative while that in Norway is positive. It could be explained by the fact that real exchange rate appreciation in UK is larger than in Norway. In variance decomposition, analysis oil price shocks and short term interest rate shocks are found to be the main contribution to the unexpected changes of GDP in most countries.

Cologni and Manera (2007) investigate the relationship among oil price, inflation and interest rates with a somewhat different approach. They conduct a structural cointegrated VAR model for G-7 countries.[9] The variables used in their model are short term interest rates, monetary aggregate, consumer price index, real GDP, the world oil price[10] and the exchange rate expressed as the ratio of the SDR rate to the US SDR rate for each country except the US. For the US, the ratio of the US SDR rate to the average of the other six countries' SDR rates is used for the exchange rate. Based on the estimated coefficients of the structural VECM, structural oil price shocks affect output significantly only in the UK and Canada.[11] In the impulse response analysis, no significant response of output to oil price shocks at the level of 5% significance is found in all countries, whereas oil price shocks have significant impacts on inflation and exchange rate. In the simulation exercises for estimating the total effect of the oil price shocks in 1990, a significant impact in the US is attributed to monetary policy reaction while for Canada, France and Italy, the total impact is offset partly by easing monetary policy.

[9] Canada, France, Germany, Italy, Japan, UK and U.S.
[10] UK Brent
[11] Negative coefficient for the UK and positive coefficient for Canada

2.1.3 Monetary policy and oil prices

There is also a discussion on the role of monetary policy and oil prices in economic activity.

Romer and Romer (1989) test whether monetary policy plays a role in economic recessions by isolating six exogenous monetary policy shocks after examining the record of policy actions of the Board of Governors and the FOMC (Federal Open Market Committee). These monetary policy shocks are called "Romer dates", which are attempted to create recession to reduce inflation. They run a VAR model to investigate the effect of monetary policy shocks over the period of 1948-1987 and conclude that six out of the eight postwar recessions are caused by the tightening monetary policy shocks. They also check the role of monetary policy shocks by excluding two monetary shocks which are associated with oil price increases, but the results are not different.

Dotsey and Reid (1992) reexamine the effects of oil price shocks and monetary policy shocks on the economy by using VARs. They run a regression to sort out the impacts of oil price shocks and Romer's contractionary monetary policies and find that positive oil price shocks are associated with a decrease in industrial production, while monetary policy (M1) shocks are insignificant. They also use federal funds rates instead of M1 as a monetary policy indicator and show that positive oil price shocks as well as interest rate shocks have a significant role in explaining GNP changes based on impulse response and variance decomposition analysis. They conclude that both tight monetary policy and oil price increases are statistically associated with economic recession.

Bernanke, Gertler and Watson (1997) analyze how much of an economic

recession is attributed to oil price increases and contractionary monetary policy by considering the argument that economic declines are caused by oil price shocks and monetary policy shocks. They use 4 different measures of oil price shocks : the log of the nominal producer price index for crude oil and products, Hoover & Perez's oil dates, the log-difference of the relative price of oil when that change is positive and otherwise is zero, and Hamilton's "net oil price increase." They find that Hamilton's net oil price increase is the most appropriate indicator for the investigation of the macroeconomic effect of oil prices, in that oil price shocks are followed by an output decline and price increase. They also check how systematic monetary policy changes affect the economy and then determine what portion of the last five US recessions are attributed to oil price shocks and the Fed's monetary policy shocks. They find that the majority of the impact of an oil price shock on the economy is explained by contractionary monetary policy in response to inflationary pressures caused by oil price shocks.

Barsky and Kilian (2001) provide evidence that stagflation in the 1970's is not caused by oil price shocks but mainly by monetary expansion and contraction. They show that in the early 1970's dramatic and across-the-board increases in the price of industrial commodities occur, which is an economic boom caused by expansionary monetary policy, not by a specific supply shock. Furthermore, oil price increases in the 1970's is not exogenous as is commonly thought. According to them, even if the political factor in the middle East influences the oil price movement in that period, the two major oil price increases could not happen without a macroeconomic condition that creates excess demand in the oil market. They show that stagflation happens as monetary policy is changed from expansionary to contractionary. Only in the 1970's do high oil price and

stagflation occur simultaneously, and in the subsequent period such a relationship is not found. So they argue that monetary policy can explain the evolution of stagflation as well as that of the oil price in the 1970's.

2.1.4 Asymmetric effect of oil price changes

Mork (1989) investigates whether a strong relationship between oil price changes and the GNP growth rate in the US found by Hamilton continues to hold when the sample period is extended to the oil price collapse in 1986 and the oil price is corrected for the effect of oil price control. He finds that the negative correlation between oil price increases and the GDP growth rate still exists. But the real effects of oil price decreases are different from those of oil price increases, with oil price decreases not having a statistically significant impact on the US economy. An asymmetric effect is apparent.

Pindyck (1991) explains asymmetric effects with irreversible investment under uncertainty. A firm may be faced with the choice of adding energy-efficient capital or energy-inefficient capital. Increased energy price uncertainty due to a higher volatility in energy prices raises the option value associated with waiting to invest. Decreases in energy prices can also be offset by increases in uncertainty.

David and Haltiwanger (2001) use VAR to examines the response of job creation and destruction to separately defined, positive and negative oil price shocks with plant-level census data from 1972Q2 to 1988Q4 on employment, capital per employee, energy use, age and size of plant, and product durability, at the four-digit SIC level. Examining the job creation and destruction between aggregate and allocative transmission

mechanisms, they find that aggregate channels would increase job destruction and reduce job creation in response to an oil price increase, while an oil price decrease reduces job destruction and increases job creation symmetrically. However, allocative channels would increase both job creation and destruction asymmetrically in response to both price increases and decreases.

Ferderer (1996), Hooker (1996,1999), Balke, Brown and Yucel (2002) study the asymmetric effects of oil price shocks on GNP by analyzing the response of interest rates to oil price shocks. They believe monetary policy responds to the oil price increases, while not to oil price decreases. In the impulse response function analysis, response of short term interest rates to the oil price increases and decreases is asymmetric, which means that oil price shocks influence the GDP through interest rates asymmetrically.

2.2 Stock market and economic activity

Over the past twenty five years, market capitalizations, expressed as a percentage of GDP, have doubled or tripled in many industrial countries. The increasing role of the stock market in the economy has stimulated research on the relationship between the stock market and economic activity.

Otoo (1999) examines the impact of changes in equity prices on consumer confidence with the Michigan Survey Research Center (SRC), the Conference Board (CB) measures of consumer sentiment and the Wilshire 5000 stock price index. He believes there are two ways in which movements in the stock market could affect consumer sentiment : (1) an increase in the stock market might reflect higher-than-

expected current wealth, boosting consumer sentiment directly ; (2) rising stock market boosts consumer spending by acting as a leading indicator of higher expected labor income. Under this "leading indicator" hypothesis, a rising stock market boosts sentiment because it signals good economic times ahead. He finds using individual observations that : 1) the sentimental levels of households that owned stock and those that did not respond similarly to a changes in overall equity price and 2) the component of the consumer sentiment index that is most affected by changes in share prices is the index of expected business conditions over the next 12 months instead of views of current or expected personal finances. Using aggregate data he also finds that an increase in equity values boosts consumer sentiment. But consumer sentiment does not affect the stock market. In conclusion, even if the findings do not exclude the traditional wealth effect, movement in the stock market has an impact on consumption.

Poterba (2000) examines wealth creation during the 1990's in the US economy and finds that more than 60 % of wealth creation is due to the rising value of household stock holdings. He also studies a stock market wealth effect on consumption and finds that even without holding equities individuals gained confidence in the economy from the rising stock market and it in return boosts consumer spending.

Mauro (2000) analyzes the relationship between stock returns and output growth for emerging and advanced economies.[12] He uses data on real stock returns obtained as the difference between nominal stock returns and consumer price inflation from MSCI (Morgan Stanley Capital International) and IFC (International Finance Corporation) as well as data on real GDP, industrial production, consumer prices, narrow money, broad

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[12] Annual frequency for a period of at least 22 years for 8 emerging countries and 17 advanced countries, at a quarterly frequency for at least ten years for 6 emerging countries and 18 advanced countries.

money and private credit from the IMF's International Financial Statistics and OECD Analytical Database. Data is yearly or quarterly from the 1970s' to the late 1990's. He tests whether the correlation between stock returns and output growth in advanced countries such as the US is applicable to emerging economies and what type of countries tend to display a stronger association between output growth and lagged stock returns. He carries out an empirical study based on five theories. First, the "passive informant" hypothesis. In this theory it is assumed that stock prices reflect the present discounted value of all future dividends and dividend growth is related to GDP growth. Second, the "accurate active informant' hypothesis. Under this hypothesis, stock price changes provide managers with information about the market's expectations of future economic developments. Managers base their investment decisions upon that information, thereby justifying the market's expectations. Third, the "faulty active informant" hypothesis. Under this hypothesis, managers' decisions about investment are influenced by stock price movements, but managers cannot distinguish between movements reflecting fundamentals and those reflecting market "sentiment." Stock market movements that are not motivated by fundamentals can therefore mislead managers into overinvesting or underinvesting compared with what later turns out to be warranted by fundamentals. Fourth, the "financing" hypothesis based upon Tobin's q theory. Under this hypothesis, when stock prices are high compared to the replacement cost of capital, entrepreneurs are more likely to expand their activities by investing in new physical capital (possibly financed by issuing new shares of their company) rather than by purchasing existing firms. Therefore, high stock returns will tend to be followed by high investment and economic growth. Fifth, the "stock market pressure on managers" hypothesis, which

suggests that stock price changes can affect investment even if they neither convey information nor change financing costs. If investors hold negative views on a firm's prospects and drive down its stock price, managers may have to cut their investment projects to protect themselves from the possibility of being fired or taken over. Conversely, if investors are very optimistic about a firm's prospects and lead its stock price to soar, managers may decide to adopt an aggressive investment strategy to avoid appearing too cautious. He finds a positive and significant correlation between output growth and lagged stock returns in several advanced and developing countries. These relationships are quite robust, so he concludes that the development of stock prices should be taken into account in forecasting output in both advanced and emerging countries.

Jansen (2003) investigates the relationship between stock market and consumer confidence for 11 European countries.[13] He focuses on an indirect causal link which is recently proposed, not traditional channels which are the conventional wealth effects, Tobin's Q theory, and balance sheet channels. Specifically, he argues that higher stock prices may boost consumption via the confidence channel. He thinks that this channel is more important to European countries because in Europe fewer households invest in stocks and the traditional wealth effect is less important than in the US. So, if there is a confidence channel, regardless whether they have a direct stake in the stock market or not, stock returns may influence the behavior of all consumers.

Jensen uses a stock price index and the consumer confidence indicator which is published based on monthly surveys by the European Commission for all EU countries

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[13] Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain, UK

except Luxembourg from January 1986 to August 2001.[14] After examining the time series on stationary he tests whether there exists cointegration between stock prices and consumer confidence. But no cointegration is found, which means that there is no long-run relationship between stock prices and consumer sentiment.

Regarding the short-run relationship between stock prices and the consumer confidence indicator, he investigates contemporaneous correlation and Granger causality. In 9 out of 11 countries,[15] the null hypothesis that contemporaneous correlation between two variables is zero is rejected at the 5% level of significance. Furthermore in the Granger causality test, 7 out of 11 countries show that stock price increases affect consumer confidence with a lag of two weeks at the 5% significance level. However, with a lag of one month Granger causalities from stock price to consumer confidence are detected only in 3 countries[16] at the 5% significance level. On the contrary, there is no Granger causality from consumer confidence to stock prices. Moreover, he finds that stock market confidence is driven by expectations about economy-wide conditions rather than personal finances. This means that the confidence channel is not adjunct to the conventional wealth effect, but rather a genuine independent transmission channel between stock returns and the real economy.

2.3 Oil prices and stock market

2.3.1 US and Big economies

Kling (1985) investigates the relationship between crude oil price changes and

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[14] Except for Greece(1988:10-2001:12), Portugal (1988:1-2001:12) and Spain(1986:7-2001:12)
[15] Except for Germany and Greece
[16] Denmak, Italy, Netherlands

stock market activity for the period of 1973-1982 in the US and finds that crude oil price changes affect the future stock prices in the industries which use oil as input factors.

Jones and Kaul (1996) test on the rationality of stock prices as to whether they reflect the impact of news on current and future real cash flows, thereby finding that oil price increases in the post war period have a significant detrimental effect for the US, Canadian, Japanese and UK stock market.

Sadorsky (1999) investigates the dynamic interaction between oil price and other economic variables including stock returns using an unrestricted VAR with US data. He presents variance decompositions and impulse response functions to analyze the dynamic effect of oil price shocks. Variables include industrial production, interest rate of a 3-month T-bill, oil price (measured using the producer price index for fuels), real stock returns (calculated using the difference between the continuously compounded returns on the S&P 500, and the inflation measured using the consumer price index). Data are monthly from 1947.1 to 1996.4. After unit root and cointegration tests, he runs an unrestricted VAR with ordering of interest rates, real oil price, industrial production and real stock returns. For oil price changes he uses the growth rate of real oil price and oil price volatility (*SOP*) which is calculated by a GARCH(1 1). He finds that oil price changes and oil price volatility have a significantly negative impact on real stock returns. He also finds that industrial production and interest rates responded positively to real stock returns shocks. In particular, he split the full sample period into two sub-periods, pre-1986 and post-1986, because in 1986 the oil price declined significantly and the oil price has been more volatile since 1986. In post-1986 period oil price changes and oil price volatility have a larger impact on the economy than in the pre-1986 period.

According to him, the response of the stock market to oil price shocks is asymmetric. When he uses asymmetric oil price shocks (positive oil price changes and negative oil price changes), positive shocks explain more forecast error of variance in real stock returns, industrial production and interest rates than negative shocks during the full sample period. For the post-1986 period, positive and negative oil price shocks explain almost the same fraction of forecast error variance of real stock returns, while in the pre-1986 period positive oil price shocks contribute more to the forecast error variance in real stock returns than negative oil price shocks. In the case of oil price volatility over the full period and two sub-periods, positive oil price volatility shocks (*SOPI*) had a greater influence on stock returns and industrial production than negative oil price volatility shocks (*SOPD*). In the post-1986 period, oil price movements explain more forecast error variance in stock returns than interest rates.

2.3.2 Other countries

Gjerde and Saettem (1999) investigate the relationship between stock returns and macroeconomic factors by using a multivariate vector autoregression (VAR) in Norway. They use 8 variables : stock returns, interest rates, inflation, industrial production, consumption, the OECD industrial production index, foreign exchange rate and oil price. After unit root tests using Augmented Dickey-Fuller and Phillips-Perron, they run a VAR model. Their findings are as follows. Oil price shocks have a positive impact on the stock market while interest rates changes affect the stock market negatively. Surprisingly, the relationship between stock returns and domestic activity is different from those of big

economies such as the US and Japan, where stock markets rationally signal changes in real activity. However, in Norway changes in real stock returns do not have a significant influence on domestic economic activity, while industrial production significantly affects real stock returns. This means that Norwegian stock market respond inaccurately to economic news from the real sector. According to them, one of the reasons could be from the difference between the companies listed in the stock market and companies in the domestic industry. If most companies listed on the stock exchange are large exporting companies while the industrial production index contains a substantial portion of small companies, then stock market could not lead industrial production. In the forecast error variance decomposition analysis, industrial production explains 8% of the variance of real stock returns 24 months after industrial production shock occurs while innovations in real stock returns contribute only 1% to the variance of changes in industrial production. This shows that the Norwegian stock market yields a delayed response to changes in real activity, instead of signaling such changes. In conclusion, except for the response of economic activity to real stock returns shocks, most result from major economies are valid in a small, open economy like Norway.

Papapetrou (2001) studies the dynamic relationship among the oil price, real stock prices, interest rates, real economic activity and employment with data from Greece. His empirical analysis has been conducted with monthly data from 1989.1 through 1999.6. The output variable is industrial production, 12-month interest rates, real oil price given by the consumer price index for fuels deflated by the consumer price index, an employment variable given by industrial employment, real stock price which is given by the difference between the continuously compounded return on the general stock market

index and the inflation rates, which is calculated using the consumer price index. He also uses an unrestricted VAR approach but chooses a generalized impulse response function and generalized variance decomposition analysis to look at the interrelationship among variables instead of the traditional orthogonalized impulse response function and variance decomposition. This method has an advantage over the traditional orthogonalized impulse response function and variance decomposition in that its outcome is indifferent to the ordering of the variables.. He runs two VARs : industrial production specification (real oil price, real stock returns, interest rates, industrial production), and employment specification (real oil price, real stock returns, interest rates, employment). He finds that an oil price shock has an immediate negative impact on the stock market as well as industrial production and employment. So, a positive oil price shock depresses real stock returns. According to the forecast error variance decomposition analysis, volatility in real stock returns variability is attributed to oil price shocks more than interest rates shocks. However, stock returns do not rationally signal (or lead) changes in real activity and employment in his analysis since growth in industrial production and employment respond negatively to real stock returns. This is a different result from other literature.

Maghyereh (2004) studies the dynamic relationship between oil price shocks and stock market returns for 22 emerging economies.[17] He uses the generalized approach to forecast error variance decomposition and impulse response analysis with data from 1998.1 to 2004.4. Daily closing prices of Brent crude oil are used as primary proxy for the world oil price. After unit root tests of ADF, PP and KPSS, he carries out the VAR analysis. Results from the variance decomposition analysis show very weak evidence that

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[17] Argentina, Brazil, Chile, China, Czech Republic, Egypt, Greece, India, Indonesia, Jordan, Korea, Malaysia, Mexico, Morocco, Hungary, Pakistan, Philippines, Poland, South Africa, Taiwan, Thailand, and Turkey

oil price shocks affect stock market returns in emerging economies. Among 22 countries only in four countries (Turkey, Malaysia, South Africa and Korea) do oil price shocks explain more than 2% of the forecast errors variance while in 15 countries oil price shocks explain less than 1% after 15 days. Countries which show a high response have higher energy intensity consumption than other countries. He concludes that, inconsistent with previous empirical studies in developed economies, stock markets in the emerging economies are inefficient in the transmission of new information of the oil market, and stock market returns in those countries do not rationally signal changes in crude oil price.

2.3.3 Asymmetric effect of oil price changes

Like the relationship between oil price shocks and the economic activity, the impact of oil price changes on stock market is asymmetric such that an oil price increase has a greater influence than an oil price decrease according to Sadorsky (1999).

CHAPTER III

THEORETICAL FRAMEWORK

1. Vector Autoregression (VAR)[18]

1.1 Characteristics of VAR

VAR is introduced by Sims (1980) and based on the idea that many macroeconomic variables and their movements are interrelated. The main advantage of VAR is that it does not use any preconceived economic theory on which the model is built and its practical ability to capture the dynamic relationships among the economic variables of interests.

A VAR model consists of a system of equations that expresses each variable in the system as a linear combination of its own lagged value and lagged values of all the other variables in the system and regresses each variable on all other lagged variables.

For example, a VAR of order p, where the order p represents the number of lags, that includes k variables, can be expressed as:

$$y_t = A_O + \sum_{i=1}^{p} A_i y_{t-i} + u_i$$

Where $y_t = [y_{1t} \ldots y_{kt}]'$ is a column vector of observation on the current values of all variables in the model, A_i is $k \times k$ matrix of unknown coefficients, A_o is a column vector of deterministic constant terms, u_t is a column vector of errors with the properties of $E(u_t) = 0$ for all t, $E(u_s u_t') = \Omega$ if s = t

$$0 \quad \text{if } s \neq t$$

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[18] See Johnston and Dinardo (1997) pp. 287-301 for details.

where Ω is the variance-covariance matrix. u_t's are not serially correlated but may be contemporaneously correlated. Thus, Ω is assumed to have non-zero off-diagonal elements.

1.2 Impulse response function

Examining the estimated coefficients on successive lags in a VAR system is not meaningful enough to give an understanding of the dynamic relationships among the variables in the system. Rather, it is useful to trace out the system's response to typical random shocks that represent positive residuals of one standard deviation unit in each equation in the system. Therefore, Sims (1980) suggests the use of impulse response and variance decomposition to help achieve this analytical interpretation of the VAR system. Suppose that a 2-variables VAR (1) is specified as

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

A perturbation in ε_{it} has an immediate and one-for one effect on y_{1t}. In period t+1, that perturbation in y_{1t} affects y_{1t+1} through the first equation and also affects y_{2t+1} through the second equation. These effects work through to period t+2, and so on. Thus, a random shock in one innovation in the VAR sets up a chain reaction over time in all variables in the VAR. Impulse response functions calculate these chain reactions.

One weakness of the analysis from impulse response functions is that a perturbation in one innovation is not contemporaneously independent of the other innovations in the system, although it eventually leads to a chain reaction over time in all

variables in the system. It is implausible from the above bivariate model to postulate that one innovation receives a perturbation while the other does not. A widely used solution to this problem is to transform the innovations to produce a new set of orthogonal innovations. These innovations are pairwise uncorrelated and have unit variance. The orthogonal innovations, denoted by u_t, can be obtained by triangularizing the system. The transformation may be summarized as

$u_t = p\varepsilon_t$ such that $p\Omega p' = I$, where p is any lower triangular matrix, I is an identity matrix, and Ω is the covariance matrix of the residual ε_t. Therefore, the new innovations $u_t = p\varepsilon_t$ satisfies $E(u_t u_t') = I$

These orthogonalized innovations are developed in such a way that they are uncorrelated across both time and equations. However, one problem of the transformation is that the order in which the residual variables are orthogonalized can have dramatic effects on the numerical results[19].

1.3 Variance decomposition

One of the characteristics of a VAR system is its ability to conditionally forecast, especially short-term forecasts, future movement of the variables in the system by capturing the individual patterns of movement in the system. In the process, the multi-period forecast error variance decompositions show that how much a random shock to one innovation is responsible for predicting subsequent fluctuation of the other innovation that is not already accounted for by its own prior fluctuation. We can calculate

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[19] See Johnston and Dinardo (1997) pp 300

the variance decomposition as follows:

Suppose a VAR(1) model with a coefficient matrix A.

$$y_t = Ay_{t-1} + \varepsilon_t$$

where Ω is a variance-covariance matrix. A and Ω are assumed to be known.

Then, $y_{t+1} = Ay_t + \varepsilon_{t+1}$

The optimal forecast of y_{t+1} is the conditional expectation of y_{t+1}, formed at time t.

That is, $\hat{y}_{t+1} = E(y_{t+1} \mid y_t, \ldots, y_1) = Ay_t$

where $\hat{y}_{t+1}$ denotes a forecast vector.

In general, $y_{t+s} = A^s y_t + A^{s-1}\varepsilon_{t+1} + A^{s-2}\varepsilon_{t+2} + \ldots\ldots\ldots + A\varepsilon_{t+s-1} + \varepsilon_{t+s}$

So, the best forecast y_{t+s} becomes

$$\hat{y}_{t+s} = E(y_{t+s} \mid y_t, \ldots, y_1) = A^s y_t$$

Thus, the vector of forecast errors in the forecast for s periods ahead is

$$e_s = y_{t+s} - \hat{y}_{t+s} = \varepsilon_{t+s} + A\varepsilon_{t+s-1} + \ldots\ldots\ldots + A^{s-1}\varepsilon_{t+1}$$

Therefore, the variance-covariance matrix for the forecast errors, s periods ahead, is

$$Var(e_s) = \sum(s) = \Omega + A\Omega A' + A^2\Omega(A')^2 + \ldots\ldots\ldots + A^{s-1}\Omega(A')^{s-1}$$

Suppose there are only two variables, y_{1t} and y_{2t} in the system. Then, the forecast error variance matrix Ω can be rewritten in terms of the variances of the orthogonal innovations as follows,

$$\Omega = p^{-1} var(u)(p^{-1})' = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} \rho_1 & 0 \\ 0 & \rho_2 \end{bmatrix} \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \quad \ldots\ldots\ldots\ldots \quad (3.1)$$

where the c's denote elements of p^{-1} and $\rho_i = var(u_i)$ for $i = 1,2$.

Since each u has a unit variance, ρ_1 and ρ_2 equal 1.

Multiplying out *Eq.*(3.1) yields

$$\text{Var}(\hat{y}_{11}) = c_{11}^2 + c_{12}^2 \quad \text{and Var}(\hat{y}_{21}) = c_{21}^2 + c_{22}^2$$

where the second subscript 1 of $\hat{y}$'s denotes the one period ahead forecast. Since p^{-1} is a lower triangular matrix by construction, and so is p^{-1}, which implies $c_{12} = 0$. Therefore, all the variance of $\hat{y}_{11}$ is attributed to the first orthogonal innovation and is equal to c_{11}^2. The variance of $\hat{y}_{21}$ is decomposed into two parts. A portion, $c_{21}^2/(c_{21}^2 + c_{22}^2)$ is attributed to the first orthogonal innovation and the second orthogonal innovation contributes to the remaining proportion, $c_{22}^2/(c_{21}^2 + c_{22}^2)$ and this result is the decomposition of the forecast error variance. In general, the *s*-period ahead forecast error variance decomposition can be calculated using the variance-covariance matrix for the forecast errors, s periods ahead, and can be expressed in terms of the orthogonal innovation as

$$\sum(s) = \Omega + A\Omega A' + \ldots\ldots\ldots + A^{s-1}\Omega(A')^{s-1} \quad \text{where } \Omega = p^{-1}(p^{-1})'$$

2. Stationarity (vs. Unit root)[20]

The foundation of time series analysis is stationarity. A time series $\{r_t\}$ is said to be strictly stationary if the joint distribution of ($r_{t_1}, \ldots\ldots, r_{t_k}$) is identical to that of ($r_{t_{1+t}}, \ldots\ldots, r_{t_{k+t}}$) for all t, where k is an arbitrary positive integer and ($t_1, \ldots\ldots, t_k$) is a

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[20] See Ruey S. Tsay (2005) pp. 24-71 for details

collection of *k* positive integers. In other words, strict stationarity requires that the joint distribution of ($r_{t_1}, ...r_{t_k}$) is invariant under time shifts. This is a very strong condition that is hard to verify empirically. A weaker version of stationarity is often assumed. A time series $\{r_t\}$ is weakly stationary if both the mean of r_t and the covariance between r_t and $r_{t-\ell}$ are time-invariant, where ℓ is an arbitrary integer. More specifically, $\{r_t\}$ is weakly stationary if (a) $E(r_t) = \mu$, which is a constant and (b) Cov(r_t, $r_{t-\ell}$) = γ_ℓ, which only depends on ℓ. In practice, suppose that we have observed T data points $\{r_t \mid t = 1......T\}$. Weak stationarity implies that the time plot of the data would show that the T values fluctuate with constant variation around a fixed level. In application, weak stationarity enables one to make inferences concerning future observations.

Implicitly, in the condition of weak stationarity, we assume that the first two moments of r_t are finite. From the definitions, if r_t is strictly stationary and its first two moments are finite, then r_t is also weakly stationary. The converse is not true in general. However, if the time series r_t is normally distributed, then weak stationarity is equivalent to strict stationarity.

However, in some studies interest rates, foreign exchange rate or the price series of an asset are of interest. These series tend to be nonstationary. In the time series literature, such a nonstationary series is called *unit-root nonstationary* time series. Consider an ARMA model. If one extends the model by allowing the AR polynomial to have 1 as a characteristic root, then the model becomes the well-known autoregressive intergrated moving-average (ARIMA) model. An ARIMA model is said to be unit-root nonstationary because its AR polynomial has a unit root. Like a random-walk model, an

ARIMA model has strong memory because the coefficients in its MA representation do not decay over time to zero, implying that the past shock of the model has a permanent effect on the series. A conventional approach for handling unit-root nonstationary is to use *differencing*.

CHAPTER IV

DATA DESCRIPTION AND MODEL

1. Data description

I study the impact of oil price shocks on the stock market based on Sadorsky (1999). Previous studies analyze the US and Greece with monthly data before 2000 and emerging economies with daily data from 1998-2004. I extend my research to the US and 13 European countries with monthly data from 1986.1~2005.12.

The data series and notation used in my study are as follows. Nominal oil price is the price index in US dollars of UK Brent crude oil from IMF. World real oil price is calculated as the ratio between nominal oil price divided by the US Producer Price Index for all commodities. National real oil prices are obtained using the exchange rate of each of the countries and deflated using the CPI of each of the countries. For oil price shocks, different kinds of oil price specifications have been used, such as the log-difference of nominal oil price (Hamilton, 1983), oil price increase distinguished from oil price decrease (Mork, 1989), oil price volatilities (Lee, Ni, and Ratti, 1995), the relative magnitudes of increase (Hamilton, 1996), and the log ratio of the current real oil price to a weighted average of real prices in the prior 20 quarters (Davis and Haltiwanger, 2001). Among these I use three specifications as follows :

(1) $dlroil_t$: Monthly changes of real oil prices, the conventional first log difference

transformation of real oil price variables (linear specification)

$$dlroil_t = \ln roil_t - \ln roil_{t-1} = lroil_t - lroil_{t-1}$$

$roil_t$: real oil price in period t in \$US or in local currency

$dlroilp_t$: real oil price increase, max $(0,\ dlroil_t)$

$dlroiln_t$: real oil price decrease, min $(0,\ dlroil_t)$

(2) SOP_t: Scaled oil price by Lee et al (1995). Oil price volatilities. This argues that
oil price shocks are more likely to have a significant impact in an
environment where oil prices have been stable than in an environment
where oil price movements have been frequent and erratic because price
changes in a volatile environment are likely to be soon reversed.

For this specification, a GARCH(1,1) model is estimated

$$dlroil_t = \alpha + \sum_{i=0}^{p} \alpha_i dlroil_{t-i} + \sum_{i=0}^{q} \beta_i z_{t-i} + \varepsilon_t, \quad \varepsilon_t \mid I_{t-1} \sim N(0, h_t)$$

$$h_t = \gamma_0 + \gamma_2 \varepsilon_{t-1}^2 + \gamma_2 h_{t-1}$$

$$SOP_t \quad : \quad \frac{\hat{\varepsilon}_t}{\sqrt{\hat{h}_t}}$$

$SOPI_t$: scaled oil price increase, max $(0,\ SOP_t)$

$SOPD_t$: scaled oil price decrease, min $(0,\ SOP_t)$

$\{z_{t-i} : i \geq 1\}$ denotes an appropriately chosen vector contained in
information set I_{t-1}

(3) $NOPI_t$: Net oil price increases by Hamilton (1996). This specification argues
that if one wants a measure of how unsettling an increase in the price of
oil is likely to be for the spending decisions of consumers and firms, it
seems more appropriate to compare the current price of oil with where it
has been over the previous years rather than during the previous quarter

alone. If oil prices are lower than they have been at some point during the most recent years, no positive oil shocks are said to have occurred.

$$NOPI_t = \max (0,\ lroil_t - \max (lroil_{t-1} \ldots\ldots\ldots lroil_{t-p}))$$

I use industrial production as a measure of economic activity. Industrial production data are from the OECD for European countries, and from FRED for the US. I use short term interest rates from IMF data of IFS for Belgium, Denmark, Finland, Spain, Germany, Greece, Italy, Norway, Sweden, and the UK. For the short term interest rate of Austria I use OECD data from Main Economic Indicators. For the Netherlands, the call money rate is used from Bank of Netherlands and for France, the money market rate is used from INSEE (National Institute for Statistics and Economic Studies). For the US I use the three month treasury bill rate from FRED. I use real stock returns which are the difference between the continuously compounded return on stock price index and the inflation rate (which is calculated using the consumer price index). Stock price indexes for all European countries except Finland are from the OECD and for the stock price index of Finland I use IMF data. For the US I use the S&P 500 index for stock prices.

r : short term interest rates

lr : natural log of short term interest rates

dlr : first log difference of short term interest rates

ip : industrial production

lip : natural log of industrial production

$dlip$: first log difference of industrial production

rsr : real stock returns

Figure 4.1 World real oil price in US dollars and national oil price in local currency
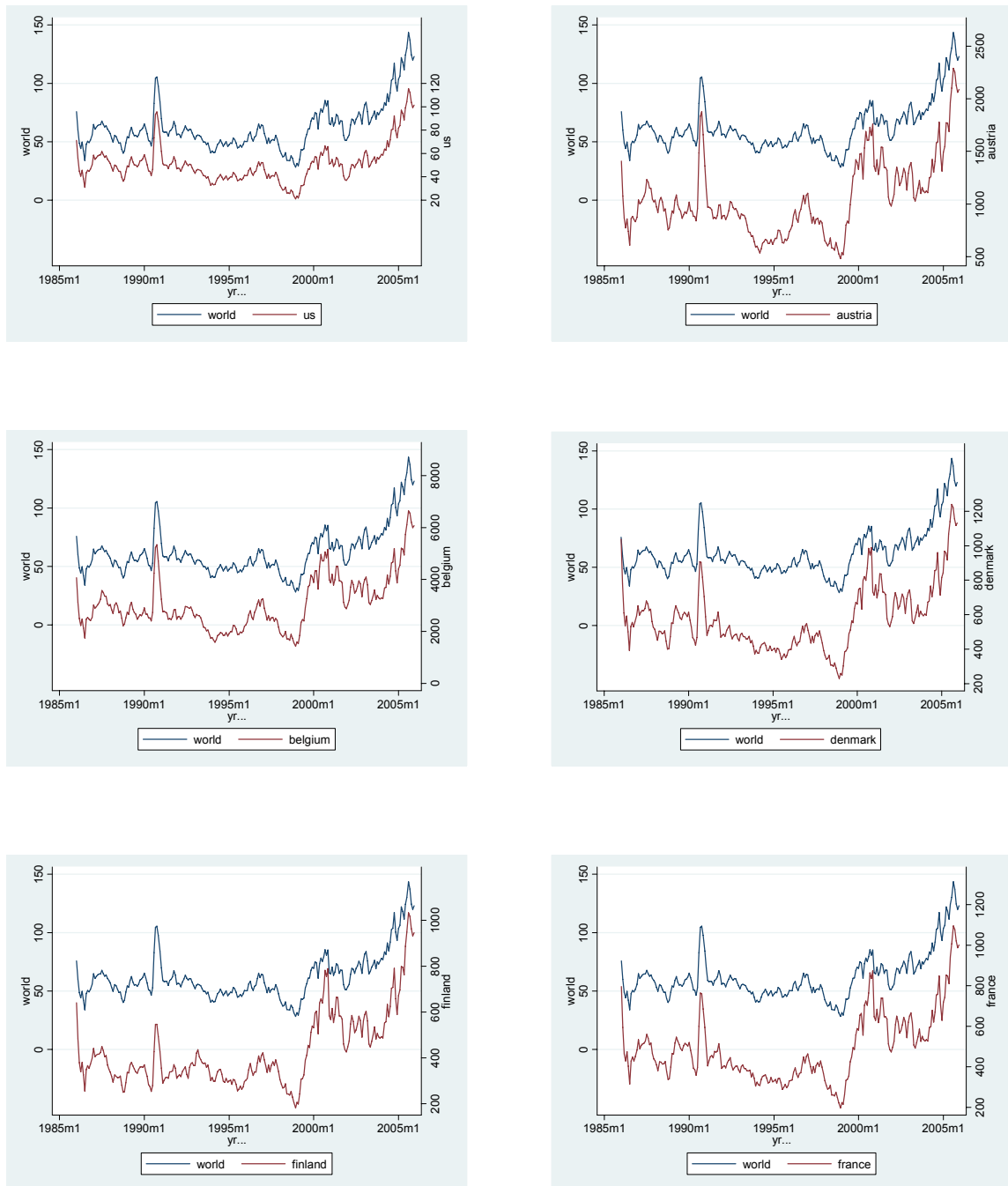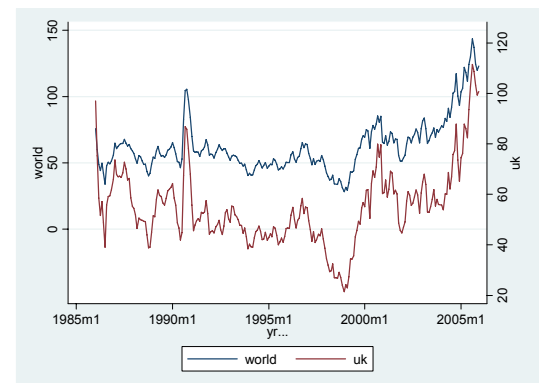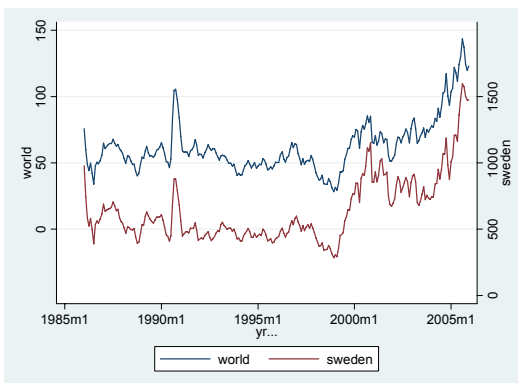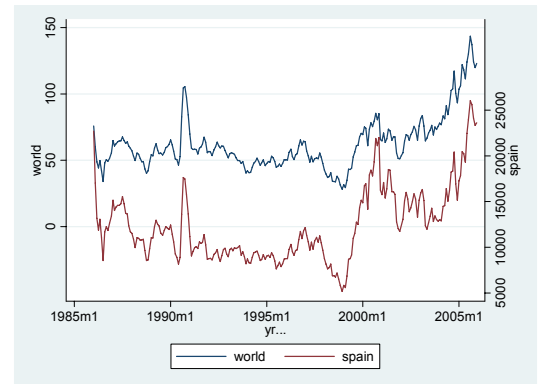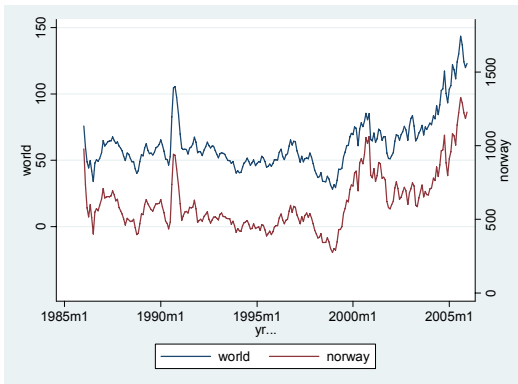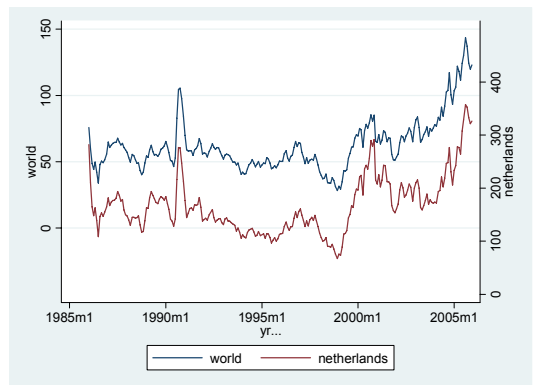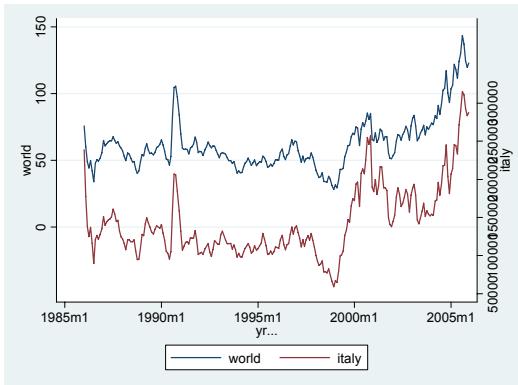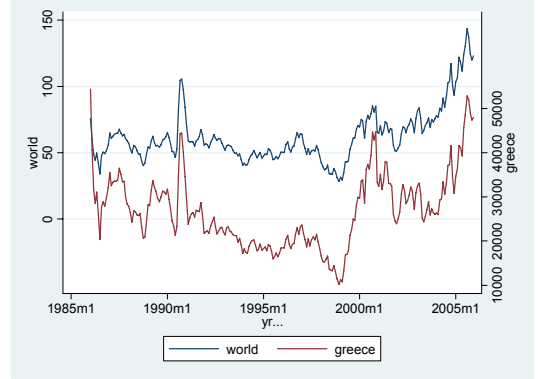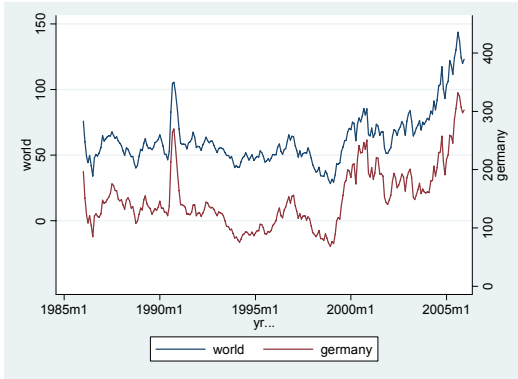
Figure 4.2 World oil price change and real stock returns change
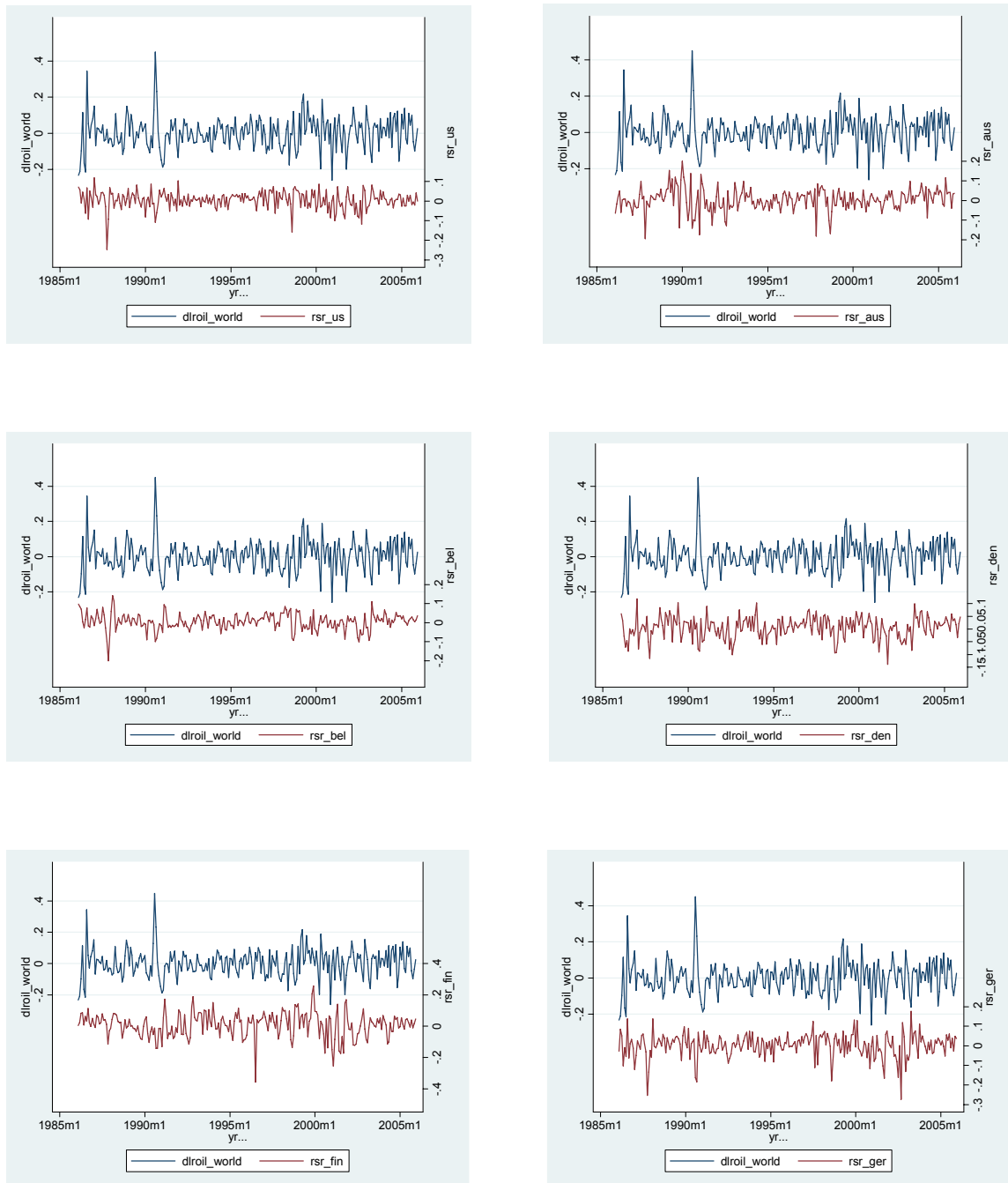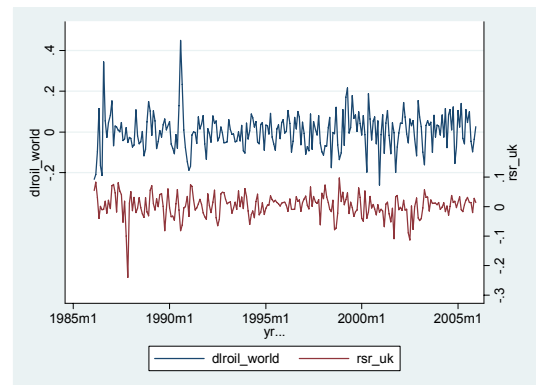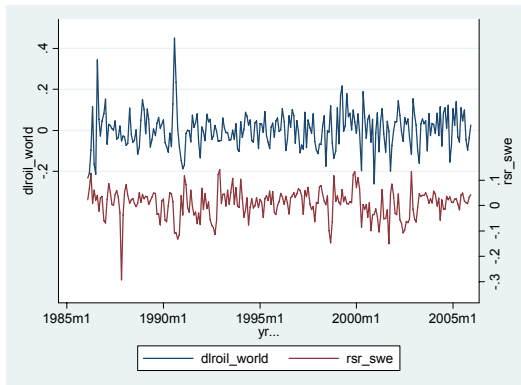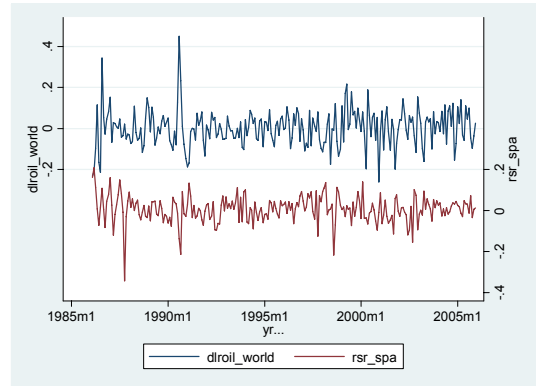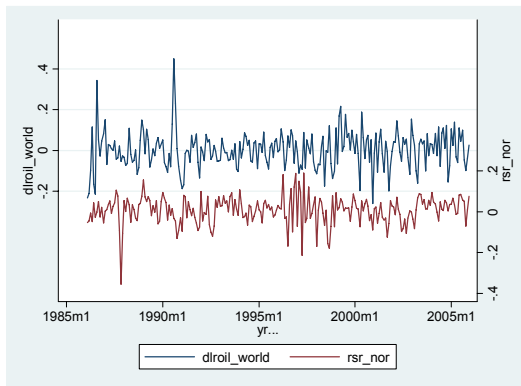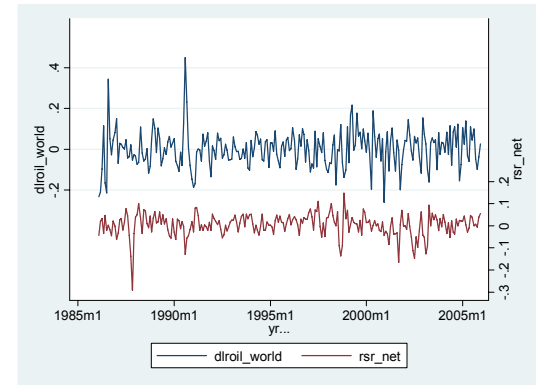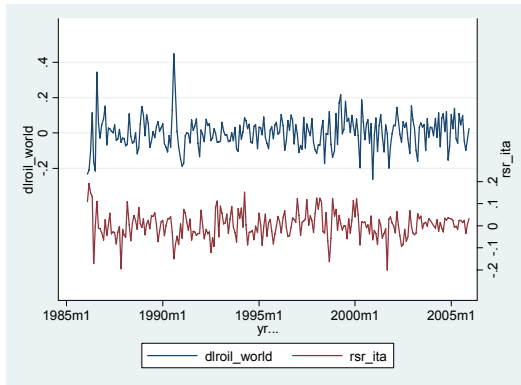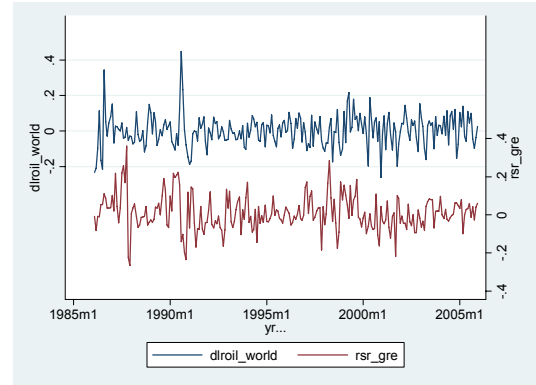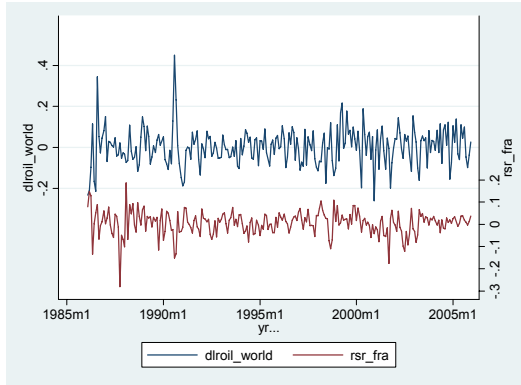
2. Model

I estimate an unrestricted VAR with four variables (interest rates, real oil price change, industrial production, real stock returns). I follow Sadorsky (1999) in the ordering of variables. So, I also assume interest rate (monetary) shocks are independent of contemporaneous disturbances to the other variables but interest rate shocks influence oil prices. I use 6 for the order, p.[21]

$$y_t = A_O + \sum_{i=1}^{p} A_i y_{t-i} + u_i$$

y_t = [interest rate, real oil price changes, industrial production, real stock returns]'

A_i is 4×4 matrix of unknown coefficients, A_o is a column vector of deterministic constant terms, u_t is a column vector of errors with the properties of

$E(u_t) = 0$ for all t, $E(u_t u_t') = \Omega$ if s = t, $E(u_s u_t') = 0$ if s ≠ t

where Ω is the variance-covariance matrix. u_t's are not serially correlated but may be contemporaneously correlated. Thus, Ω is assumed to have non-zero off-diagonal elements.

For the oil price specification of *SOP,* I follow a GARCH(1,1) model with the appropriate ARMA model which have statistically significant parameter estimators.

For the oil price specification of *NOPI*

$$NOPI_t = \max (0, \, lroil_t - \max (lroil_{t-1} \ldots\ldots lroil_{t-6}))$$

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[21] I check optimal lags based on LR, AIC, BSIC, but they are not consistent.

Figure 4.3 Alternative measures of world oil price shocks
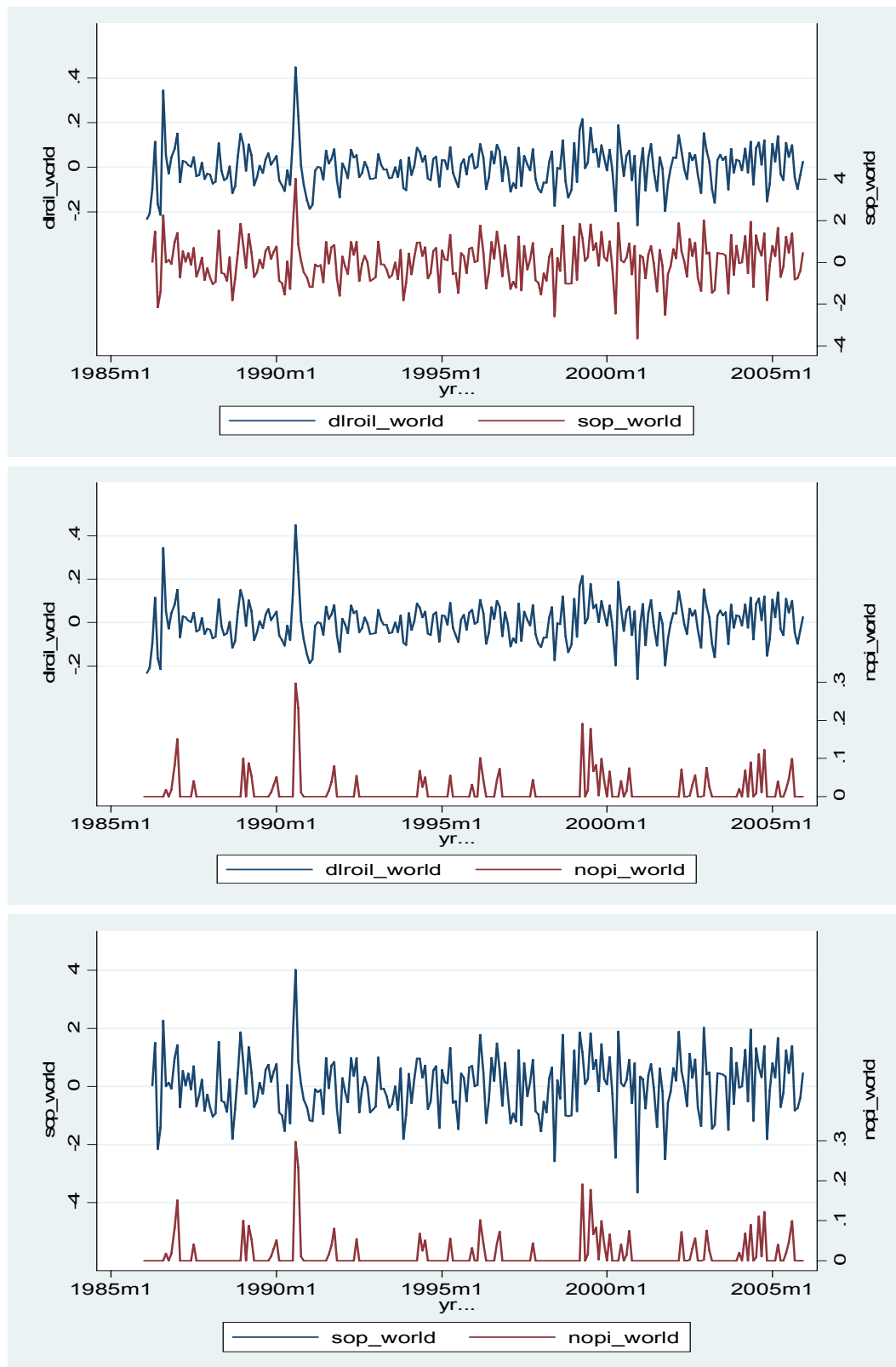
CHAPTER V

RELATIONSHIP BETWEEN OIL PRICES AND STOCK MARKET

Now I analyze the empirical results with various oil price specifications (linear, *SOP, NOPI*) models described in the previous section. Most of countries in my sample are net oil importing countries, but the UK and Norway are net oil exporting countries, while Denmark switched from a position of net oil importing country to oil exporting country in 1997.

1. Unit root tests

Before I run a VAR, I conduct unit root tests of four variables with PP (Phillips Perron) and KPSS. Outcomes of those tests are presented in Table 5.1-5.2. According to the PP test,[22] all variables in log level except real stock returns, *SOP and NOPI* cannot reject at the 5% level the null hypothesis that each variable contains a unit root with a constant as well as a constant and a trend. However, the first log difference rejects the null hypothesis at the 5% level. Only real stock returns, *SOP* and *NOPI* in level reject the null hypothesis. In the KPSS test with lag-truncation parameters of one and four[23], all variables except real stock returns, *SOP* and *NOPI* reject at the 5% level the null hypothesis that they are level and trend stationary, while the first log difference cannot reject the null. In the cases of real stock returns, *SOP* and *NOPI* they cannot reject the null hypothesis of level and trend stationary. In conclusion, there is evidence that all variables except the real stock returns, *SOP* and *NOPI* appear to be *I*(1) processes.

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[22] Data-driven lag selection procedures are used.
[23] I follow Papapetrou (2001)'s lag selection in his paper.

Table 5.1   Results of Unit root tests (PP)

< Real oil price >

| | in log level | | in first log difference | |
	Constant	Constant &Trend	Constant	Constant &Trend
World	-2.186	-2.995	-13.152 ***	-13.155 ***
US	-2.392	-2.711	-12.998 ***	-13.012 ***
Austria	-2.183	-2.938	-12.921 ***	-12.926 ***
Belgium	-2.189	-3.003	-13.102 ***	-13.139 ***
Denmark	-2.646 *	-3.25 *	-13.062 ***	-13.092 ***
Finland	-2.03	-3.528 **	-13.202 ***	-13.23 ***
France	-2.303	-3.078	-12.92 ***	-12.927 ***
Germany	-2.093	-2.848	-12.92 ***	-12.927 ***
Greece	-2.867 **	-3.011	-13.013 ***	-13.051 ***
Italy	-2.559	-3.625 **	-12.992 ***	-13.017 ***
Netherland	-2.56	-3.145 *	-13.057 ***	-13.083 ***
Norway	-2.422	-3.311 *	-13.347 ***	-13.376 ***
Spain	-2.723 *	-3.507 **	-13.049 ***	-13.084 ***
Sweden	-1.885	-3.194 *	-12.979 ***	-13.02 ***
UK	-2.974 **	-3.171 *	-13.421 ***	-13.453 ***

*** , ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

< Interest rates >

| | in log level | | in first log difference | |
	Constant	Constant &Trend	Constant	Constant &Trend
US	-1.394	-1.273	-8.982 ***	-9 ***
Austria	-0.279	-1.582	-11.073 ***	-11.137 ***
Belgium	-0.879	-1.924	-11.135 ***	-11.111 ***
Denmark	-0.73	-2.525	-12.483 ***	-12.419 ***
Finland	-0.787	2.04	-10.372 ***	-10.348 ***
France	-0.672	-2.087	-13.099 ***	-13.074 ***
Germany	-0.92	-1.765	-14.078 ***	-14.077 ***
Greece	0.536	-1.957	-11.629 ***	-11.716 ***
Italy	-0.597	-2.06	-11.125 ***	-11.097 ***
Netherland	-0.679	-1.791	-16.98 ***	-16.97 ***
Norway	-1.326	-2.69	-16.528 ***	-16.496 ***
Spain	-0.519	-2.527	-12.979 ***	-12.986 ***
Sweden	-0.076	-2.026	-12.453 ***	-12.467 ***
UK	-1.369	-1.968	-9.188 ***	-9.181 ***

*** , ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

<Industrial Production>

	in log level				in first log difference			
	Constant		Constant &Trend		Constant		Constant &Trend	
US	-0.439		-1.17		-14.286	***	-14.26	***
Austria	-0.204		-2.893		-27.118	***	-27.218	***
Belgium	-0.963		-4.755	***	-29.321	***	-29.253	***
Denmark	-1.149		-6.383	***	-19.804	***	-19.76	***
Finland	-0.093		-2.141		-23.928	***	-23.894	***
France	-0.837		-2.086		-23.965	***	-23.936	***
Germany	-0.634		-2.06		-22.957	***	-22.919	***
Greece	-1.406		-3.959	**	-30.979	***	-30.956	***
Italy	-2.206		-2.245		-18.951	***	-19.095	***
Netherland	-1.631		-9.042	***	-35.235	***	-35.144	***
Norway	-1.929		-3.643	**	-31.645	***	-32.232	***
Spain	-0.865		-2.522		-28.484	***	-28.427	***
Sweden	-0.423		-2.311		-18.812	***	-18.769	***
UK	-2.885	**	-1.735		-22.986	***	-23.852	***

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

<Real stock returns in level>

	Constant		Constant &Trend	
US	-15.427	***	-15.421	***
Austria	-13.645	***	-13.674	***
Belgium	-9.872	***	-9.84	***
Denmark	-12.58	***	-12.605	***
Finland	-10.631	***	-10.616	***
France	-12.801	***	-12.775	***
Germany	-14.537	***	-14.51	***
Greece	-1.892	***	-10.906	***
Italy	-12.118	***	-12.095	***
Netherlands	-10.445	***	-10.423	***
Norway	-13.038	***	-13.044	***
Spain	-12.882	***	-12.849	***
Sweden	-10.404	***	-1.383	***
UK	-12.151	***	-12.137	***

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

< SOP in level >

	Constant		Constant &Trend	
World	-15.705	***	-15.726	***
US	-15.728	***	-15.762	***
Austria	-15.894	***	-15.885	***
Belgium	-15.819	***	-15.807	***
Denmark	-15.418	***	-15.52	***
Finland	-15.379	***	-15.428	***
France	-15.416	***	-15.48	***
Germany	-15.761	***	-15.756	***
Greece	-15.659	***	-15.704	***
Italy	-15.41	***	-15.454	***
Netherland	-15.449	***	-15.498	***
Norway	-15.413	***	-15.472	***
Spain	-15.29	***	-15.365	***
Sweden	-13.077	***	-13.171	***
UK	-15.546	***	-15.599	***

*** , ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

< NOPI in level >

	Constant		Constant &Trend	
World	-12.013	***	-11.996	***
US	-12.009	***	-12.004	***
Austria	-11.752	***	-11.733	***
Belgium	-11.747	***	-11.728	***
Denmark	-12.329	***	-12.376	***
Finland	-12.237	***	-12.285	***
France	-12.294	***	-12.337	***
Germany	-11.738	***	-11.72	***
Greece	-12.551	***	-12.603	***
Italy	-12.426	***	-12.454	***
Netherland	-12.354	***	-12.386	***
Norway	-12.08	***	-12.1	***
Spain	-12.444	***	-12.497	***
Sweden	-12.553	***	-12.608	***
UK	-12.751	***	-12.782	***

*** , ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

Table 5.2   Results of Unit root tests (KPSS)

\<Real oil price in log level\>

	lag = 1				lag =4			
	Level stationarity		Trend stationarity		Level stationarity		Trend stationarity	
World	3.16	***	1.39	***	1.37	***	0.613	***
US	1.77	***	1.45	***	0.771	***	0.632	***
Austria	3.18	***	1.39	***	1.37	***	0.605	***
Belgium	3.36	***	1.36	***	1.44	***	0.591	***
Denmark	2.54	***	1.56	***	1.11	***	0.683	***
Finland	4.95	***	1.33	***	2.13	***	0.591	***
France	3.11	***	1.61	***	1.34	***	0.702	***
Germany	3.23	***	1.44	***	1.39	***	0.623	***
Greece	1.84	***	1.74	***	0.797	***	0.756	***
Italy	3.64	***	1.34	***	1.59	***	0.597	***
Netherlands	2.5	***	1.5	***	1.02	***	0.658	***
Norway	3.22	***	1.44	***	1.4	***	0.636	***
Spain	3.1	***	1.56	***	1.35	***	0.689	***
Sweden	4.67	***	1.68	***	2	***	0.739	***
UK	1.54	***	1.39	***	0.681	**	0.615	***

***, **, * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

\<Real oil price in first log difference\>

	lag = 1		lag =4	
	Level stationarity	Trend stationarity	Level stationarity	Trend stationarity
World	0.132	0.0213	0.135	0.022
US	0.162	0.0242	0.162	0.0245
Austria	0.154	0.0249	0.151	0.0247
Belgium	0.151	0.0247	0.147	0.0244
Denmark	0.22	0.0271	0.217	0.0273
Finland	0.201	0.0269	0.202	0.0274
France	0.205	0.0256	0.205	0.0261
Germany	0.156	0.0252	0.153	0.0248
Greece	0.229	0.026	0.23	0.0267
Italy	0.196	0.0269	0.197	0.0275
Netherlands	0.199	0.0268	0.197	0.0269
Norway	0.194	0.0245	0.203	0.0261
Spain	0.216	0.0266	0.217	0.0271
Sweden	0.226	0.0238	0.228	0.0244
UK	0.188	0.0234	0.193	0.0244

***, **, * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

<Interest rates in log level>

	lag = 1				lag =4			
	Level stationarity		Trend stationarity		Level stationarity		Trend stationarity	
US	5.99	***	0.766	***	2.42	***	0.314	***
Austria	6.98	***	1.18	***	2.83	***	0.483	***
Belgium	9.89	***	0.8	***	4.02	***	0.33	***
Denmark	10	***	0.732	***	4.09	***	0.31	***
Finland	10.4	***	0.741	***	4.23	***	0.308	***
France	10	***	0.853	***	4.06	***	0.354	***
Germany	6.27	***	1.36	***	2.54	***	0.556	***
Greece	10.5	***	2.68	***	4.26	***	1.09	***
Italy	10.8	***	1.56	***	4.37	***	0.645	***
Netherlands	7.85	***	0.895	***	3.19	***	0.366	***
Norway	7.9	***	0.644	***	3.23	***	0.269	***
Spain	10.5	***	1.34	***	4.26	***	0.559	***
Sweden	10.5	***	1.06	***	4.27	***	0.443	***
UK	9.02	***	0.485	***	3.67	***	0.201	**

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

<Interest rates in first log difference>

	lag = 1				lag =4			
	Level stationarity		Trend stationarity		Level stationarity		Trend stationarity	
US	0.27		0.247	***	0.158		0.145	*
Austria	0.36	*	0.14	*	0.259		0.102	
Belgium	0.0878		0.0866		0.0707		0.0697	
Denmark	0.0832		0.0596		0.0796		0.0572	
Finland	0.0968		0.0959		0.0813		0.0806	
France	0.0922		0.075		0.0847		0.069	
Germany	0.198		0.118		0.167		0.101	
Greece	0.603		0.193	**	0.0449		0.148	**
Italy	0.101		0.0842		0.0749		0.0627	
Netherlands	0.168		0.119	*	0.139		0.0985	
Norway	0.0559		0.0559		0.0483		0.0483	
Spain	0.186		0.113		0.135		0.0828	
Sweden	0.135		0.0495		0.12		0.0448	
UK	0.106		0.0904		0.0741		0.0634	

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

<Industrial production in log level>

	lag = 1		lag =4	
	Level stationarity	Trend stationarity	Level stationarity	Trend stationarity
US	11.9 ***	1.21 ***	4.81 ***	0.491 ***
Austria	11.7 ***	1.55 ***	4.74 ***	0.652 ***
Belgium	10.8 ***	1.04 ***	4.42 ***	0.459 ***
Denmark	11.5 ***	0.644 ***	4.75 ***	0.357 ***
Finland	11.6 ***	1.65 ***	4.69 ***	0.684 ***
France	10.9 ***	0.933 ***	4.42 ***	0.385 ***
Germany	9.45 ***	0.78 ***	3.87 ***	0.323 ***
Greece	9.56 ***	1.84 ***	3.93 ***	0.795 ***
Italy	10.1 ***	0.999 ***	4.11 ***	0.42 ***
Netherlands	11.6 ***	0.799 ***	4.75 ***	0.405 ***
Norway	10.6 ***	2.49 ***	4.35 ***	1.09 ***
Spain	11 ***	1.05 ***	4.46 ***	0.436 ***
Sweden	11.9 ***	0.98 ***	4.81 ***	0.412 ***
UK	10 ***	1.33 ***	4.09 ***	0.557 ***

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

<Industrial production in first log difference>

	lag = 1		lag =4	
	Level stationarity	Trend stationarity	Level stationarity	Trend stationarity
US	0.29	0.284 ***	0.19	0.186 **
Austria	0.0508	0.025	0.0994	0.0493
Belgium	0.0219	0.0191	0.0392	0.0341
Denmark	0.0133	0.00957	0.0261	0.0187
Finland	0.0872	0.0651	0.137	0.102
France	0.064	0.0639	0.0801	0.0796
Germany	0.00698	0.0698	0.0881	0.0825
Greece	0.026	0.0193	0.0579	0.0431
Italy	0.204	0.046	0.221	0.0512
Netherlands	0.0179	0.00721	0.0387	0.0157
Norway	0.0618	0.00756	0.165	0.0208
Spain	0.0492	0.0498	0.0726	0.0735
Sweden	0.0607	0.0608	0.0816	0.0818
UK	0.389 *	0.0595	0.566 **	0.0943

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

<Real stock returns in level>

	lag = 1		lag =4	
	Level stationarity	Trend stationarity	Level stationarity	Trend stationarity
US	0.143 0	0.0807	0.16	0.0913
Austria	0.225	0.125 *	0.187	0.105
Belgium	0.0982	0.0912	0.0917	0.0851
Denmark	0.128	0.0707	0.103	0.0577
Finland	0.112	0.0986	0.0984	0.087
France	0.0817	0.0678	0.0708	0.0588
Germany	0.0779	0.075	0.0721	0.0694
Greece	0.199	0.0931	0.166	0.0788
Italy	0.0958	0.0816	0.0809	0.0707
Netherlands	0.164	0.156 **	0.141	0.134 *
Norway	0.109	0.0584	0.0967	0.0521
Spain	0.0984	0.0899	0.106	0.097
Sweden	0.0908	0.0862	0.0749	0.071
UK	0.127	0.0651	0.122	0.063

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

< SOP in level >

	lag = 1		lag =4	
	Level stationarity	Trend stationarity	Level stationarity	Trend stationarity
World	0.113	0.0385	0.121	0.0419
US	0.135	0.0451	0.145	0.049
Austria	0.083	0.0586	0.0803	0.0589
Belgium	0.0756	0.0571	0.0755	0.0571
Denmark	0.161	0.0282	0.165	0.0296
Finland	0.148	0.0303	0.152	0.0316
France	0.158	0.029	0.163	0.0304
Germany	0.0793	0.0364	0.0833	0.0385
Greece	0.151	0.0539	0.151	0.0546
Italy	0.137	0.0306	0.143	0.0324
Netherlands	0.144	0.0313	0.148	0.0327
Norway	0.161	0.0297	0.164	0.0308
Spain	0.165	0.0221	0.171	0.0233
Sweden	0.241	0.0616	0.198	0.0516
UK	0.146	0.031	0.151	0.0327

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

< NOPI in level >

	lag = 1		lag =4	
	Level stationarity	Trend stationarity	Level stationarity	Trend stationarity
World	0.0774	0.0559	0.0646	0.0468
US	0.111	0.0629	0.0917	0.0522
Austria	0.0626	0.0483	0.0507	0.0392
Belgium	0.0629	0.0476	0.0509	0.0386
Denmark	0.252	0.0766	0.187	0.0575
Finland	0.235	0.062	0.176	0.0472
France	0.248	0.0793	0.183	0.0592
Germany	0.0654	0.0486	0.0528	0.0394
Greece	0.28	0.0892	0.202	0.0653
Italy	0.189	0.0628	0.146	0.049
Netherlands	0.216	0.0745	0.161	0.0564
Norway	0.18	0.07	0.136	0.0533
Spain	0.263	0.0708	0.198	0.0541
Sweden	0.249	0.0609	0.192	0.0477
UK	0.192	0.0578	0.151	0.0458

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

2. Cointegration tests

Since the interest rates, oil price and industrial production contain a unit root, I conduct a cointegration[24] test suggested by Johansen to see whether these variables have a common stochastic trend. The results of cointegration tests (Table 5.3) show that in most cases no cointegration is found among the interest rates, oil price and industrial production. Only in the UK is the null hypothesis of no cointegration rejected at the 5% level of significance with world oil price and at the 1% level of significance with national oil price. For Italy, the null hypothesis of no cointegration is rejected with world oil price while for Finland the null hypothesis is rejected with national oil price at the 5% level of significance.

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[24] If two or more series are themselves non-stationary, but a linear combination of them is stationary, then the series are said to be cointegrated.

Table 5.3   Results of Cointegration tests

WP	Hypothesis	r=0		r =< 1	r=<2		Hypothesis	r=0		r =< 1	r=<2
US	Trace test	14.6186		6.8585	1.104	Gre	Trace test	28.2728		6.0317	0.025
	λ max test	7.7601		5.7544	1.104		λ max test	22.2411	**	6.0068	0.025
Aus	Trace test	27.783		5.5569	0.243	Ita	Trace test	30.9023	**	7.5007	1.663
	λ max test	20.2261		5.3136	0.243		λ max test	23.4015	**	5.8381	1.663
Bel	Trace test	24.6726		6.2248	0.243	Net	Trace test	17.1285		7.8138	2.186
	λ max test	18.4479		5.9821	0.243		λ max test	9.3147		5.6276	2.186
Den	Trace test	16.3618		5.0542	0.04	Nor	Trace test	26.3527		7.5274	1.683
	λ max test	11.3076		5.0542	0.04		λ max test	18.8253		5.8446	1.683
Fin	Trace test	27.6013		8.6818	0.404	Spa	Trace test	24.0637		6.7303	0.806
	λ max test	18.9195		8.2777	0.404		λ max test	17.3333		5.9239	0.806
Fra	Trace test	27.9216		5.9296	0.246	Swe	Trace test	15.3785		4.0269	0.0004
	λ max test	21.9921	**	5.6836	0.246		λ max test	11.3517		4.0204	0.0004
Ger	Trace test	16.4766		6.85	0	UK	Trace test	41.9359	**	4.3297	1.891
	λ max test	9.6265		6.85	3.76		λ max test	37.6062	**	2.4383	1.891

NP	Hypothesis	r=0		r =< 1	r=<2		Hypothesis	r=0		r =< 1	r=<2
US	Trace test	14.4687		7.0696	1.2009	Gre	Trace test	27.7087		5.2147	0.051
	λ max test	7.3992		5.8687	1.2009		λ max test	20.494		5.1642	0.051
Aus	Trace test	25.783		5.5569	0.243	Ita	Trace test	27.4037		8.7937	1.155
	λ max test	20.2261		5.3136	0.243		λ max test	18.61		7.6385	1.155
Bel	Trace test	28.6091		9.6704	0.467	Net	Trace test	18.3884		9.7142	3.355
	λ max test	18.9327		9.2007	0.476		λ max test	8.6742		6.3591	3.355
Den	Trace test	17.747		5.5031	0.1	Nor	Trace test	24.5197		8.5173	2.152
	λ max test	12.2438		5.403	0.1		λ max test	16.0024		6.3651	2.152
Fin	Trace test	29.8192	**	6.9853	0.172	Spa	Trace test	23.6541		7.8478	0.316
	λ max test	22.839	**	6.8132	0.172		λ max test	15.8063		7.5317	0.316
Fra	Trace test	28.7144		7.984	0.486	Swe	Trace test	16.0278		5.4576	0.139
	λ max test	20.716		7.5123	0.486		λ max test	10.5702		5.3191	0.139
Ger	Trace test	17.8612		7.3563	0.0001	UK	Trace test	38.3215	***	5.7777	2.189
	λ max test	10.5049		7.3562	0.0001		λ max test	32.5438	***	3.5891	2.189

***, ** denotes rejection of the null hypothesis at the 1 and 5% level of significance

3. Impact of oil price shocks on stock market

In this section I assess the impact of oil price shocks on real stock returns. According to Sims, most estimated coefficients from a VAR model are not statistically significant. I therefore look at impulse response functions and variance decompositions. Impulse response functions are dynamic simulations showing the response of an endogenous variable over time to a given shock, while variance decompositions show us the contributions of each source of shocks to the variance of the future forecast error for each endogenous variable.[25]

3.1 Impulse response functions and accumulated responses

I now test the effect of oil price shocks on real stock returns by using orthogonalized impulse response functions and accumulated impulse response with linear and non-linear (*SOP & NOPI*) oil price specifications in a basic VAR model. Table 5.4 and Figures 5.1-5.6 show the impulse response of real stock returns from a one standard deviation shock of oil price. 95% confidence bounds are also provided to assess the statistical significance of the impulse response functions. These figures show that in most countries an oil price shock has a negative and statistically significant impact on real stock returns at the 5% level instantaneously or in one month. Outcomes are a little

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[25] Even if some evidence is found that there is a cointegration in few countries I run unrestricted VAR due to the facts i) unrestricted VAR is superior in terms of forecast variance to a restricted VECM at short horizons when the restriction is true (Engle and Yoo (1987), Clements and Hendry(1995), Hoffmand and Rasche(1996) ii) performance of unrestricted VARs and VECMs for impulse response analysis over short-run is nearly identical (Nafa and Tufte, 1997)

different depending on which oil price (World oil price or national oil price), or what kinds of oil price specification (linear, *SOP, NOPI*) is used. But, when I use the world oil price, the response of real stock returns is somewhat more significant compared to the national oil price, and models with linear and *SOP* oil price specification have more significant results than that of *NOPI* oil price specification. In the case of linear and *SOP* specification models with world oil price, only responses in Finland and the UK are not significant among 14 countries. When I use national oil price, the responses of real stock returns in Denmark, Finland[26], Netherlands and Spain becomes less significant. In the model of *NOPI* specification only 4 countries (Belgium, Germany, Greece, Italy in world oil price model and the US, Germany, Greece, Sweden in national oil price model) have significant responses.

According to the literature which analyzes the impact of oil price shocks on industrial production or GDP, oil price shocks negatively affect them. This implies that oil price shocks affect the earnings of companies which use oil in production and it there causes their production to decline. If the stock market is efficient, those negative impacts of oil price shocks will be reflected in the stock price and the real stock returns will decrease. These impulse response analysis outcomes could be interpreted to be consistent with the literature in that sense. In most countries, real stock returns respond to oil price shocks in a month while in the US and Germany, real stock returns react immediately to the oil price shocks in all cases. Therefore, we can think that stock markets in the US and Germany are more efficient than those in other countries.

The accumulated effects of oil price shocks on the real stock returns after 1, 3, 6, 9, 12 months are presented in Table 5.7. A 100% increase of oil price yields the highest

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[26] Response of real stock return to oil price shock is significant at 5% level in linear specification model.

accumulated effects on real stock returns one or three month later. Its effects then decrease until 12 months later and beyond stay the same in general. The highest accumulated effect is 4.2 % after 3 months in Greece and is greater than 1% in most countries, while the accumulated effect is less than 1% in oil exporting countries such as Denmark, Norway and the UK. Only Norway has positive accumulated effects.

Table 5.4 Orthogonalized impulse response function of stock returns to oil price shocks (r, oil, ip, rsr)

		US	AUS	BEL	DEN	FIN	FRA	GER	GRE	ITA	NET	NOR	SPA	SWE	UK
WP	Linear	n	n	n	n	x	n	n	n	n	n	p	n	n	x
	SOP	n	n	n	n	x	n	n	n	n	n	p	n	n	x
	NOPI	x	x	n	x	x	x	n	n	n	x	x	x	x	x
NP	Linear	n	n	n	x	n	n	n	n	n	x	p	x	n	x
	SOP	n	n	n	x	x	n	n	n	n	x	p	x	n	x
	NOPI	n	x	x	x	x	x	n	n	x	x	x	x	n	x

n : negatively significant at 5% level,   p : positively significant at 5% level,   x : insignificant at 5% level

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Table 5.5 Orthogonalized impulse response function of stock returns to oil price shocks (oil, r, ip, rsr)

		US	AUS	BEL	DEN	FIN	FRA	GER	GRE	ITA	NET	NOR	SPA	SWE	UK
WP	Linear	n	n	n	n	x	n	n	n	n	n	p	n	n	x
	SOP	n	n	n	n	x	n	n	n	n	n	p	n	n	x
	NOPI	x	x	x	x	x	x	n	n	x	x	x	x	n	x

n : negatively significant at 5% level, p : positively significant at 5% level, x : insignificant at 5% level

Table 5. 6 Orthogonalized impulse response function of stock returns to oil price shocks (r, oil, ip, inf, rsr)

		US	AUS	BEL	DEN	FIN	FRA	GER	GRE	ITA	NET	NOR	SPA	SWE	UK
	Linear	n	n	n	x	x	n	n	n	n	n	p	n	n	x
WP	SOP	n	n	n	n	n	n	n	n	n	n	p	n	n	x
	NOPI	n	n	n	x	x	x	n	n	n	n	x	x	n	x

n : negatively significant at 5% level, p : positively significant at 5% level, x : insignificant at 5% level

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Figure 5.1 Orthogonalized impulse response function of stock returns to oil price shocks (World oil price : linear specification - r, oil, ip, rsr)

Graphs by irfname, impulse variable, and response variable
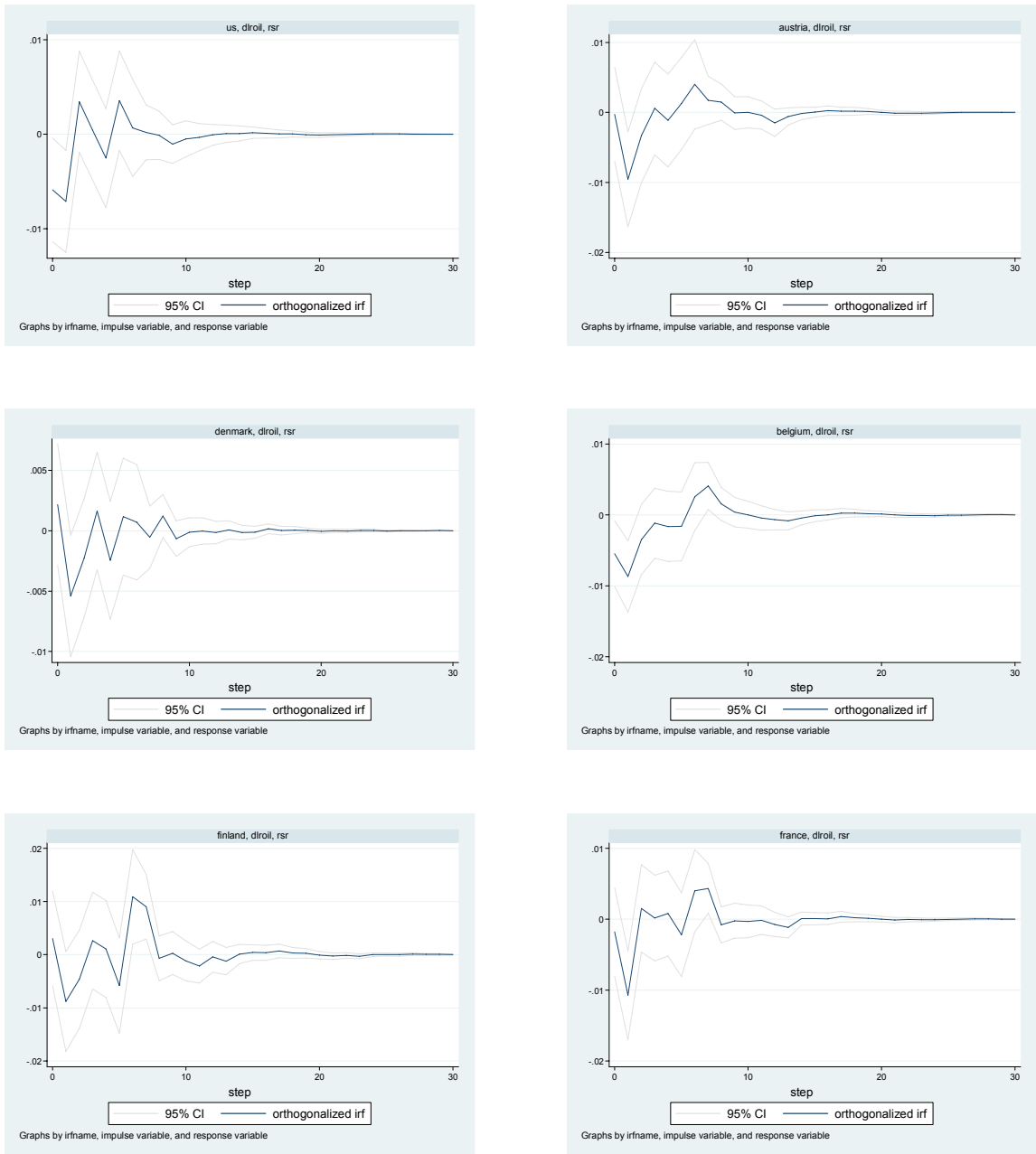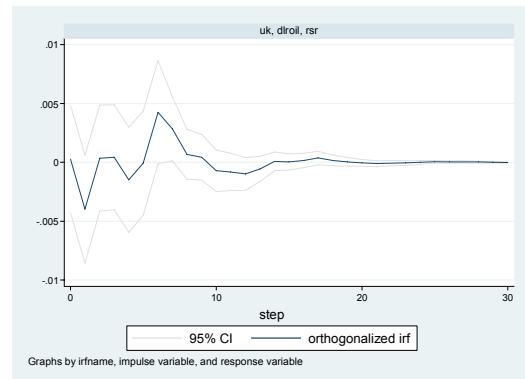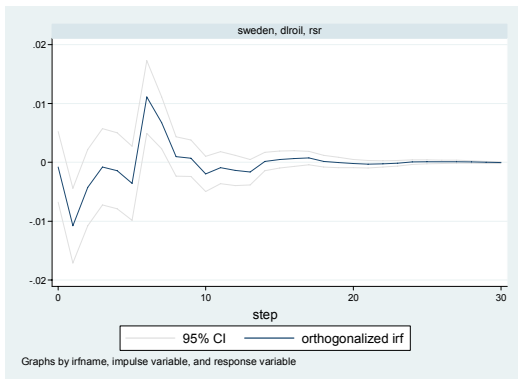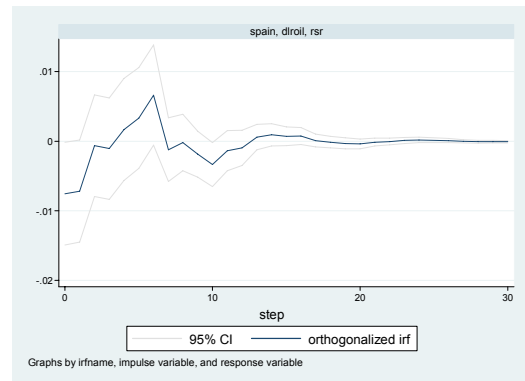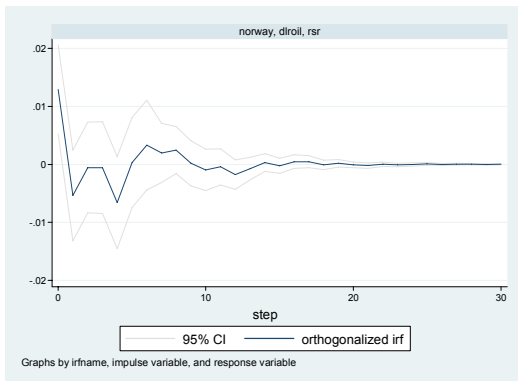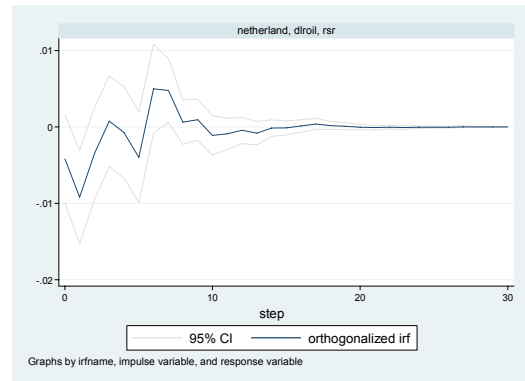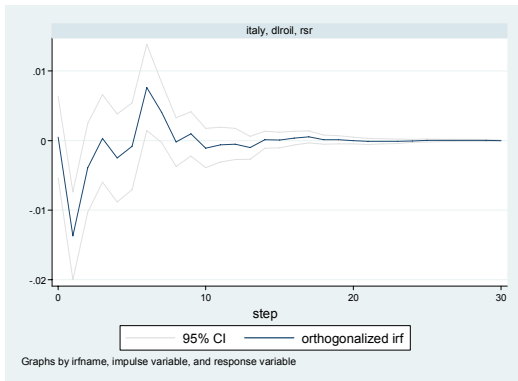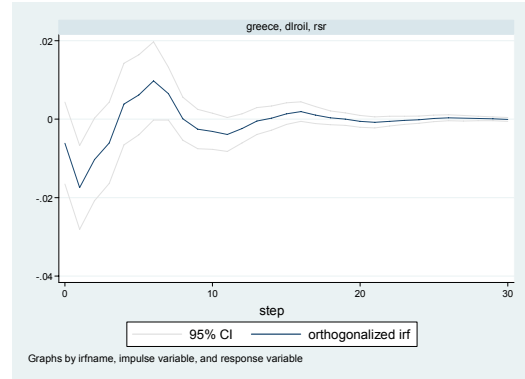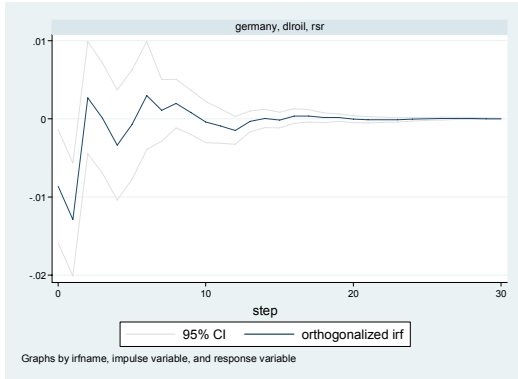
Figure 5.2 Orthogonalized impulse response function of stock returns to oil price shocks (World oil price : SOP - r, oil, ip, rsr)

Graphs by irfname, impulse variable, and response variable
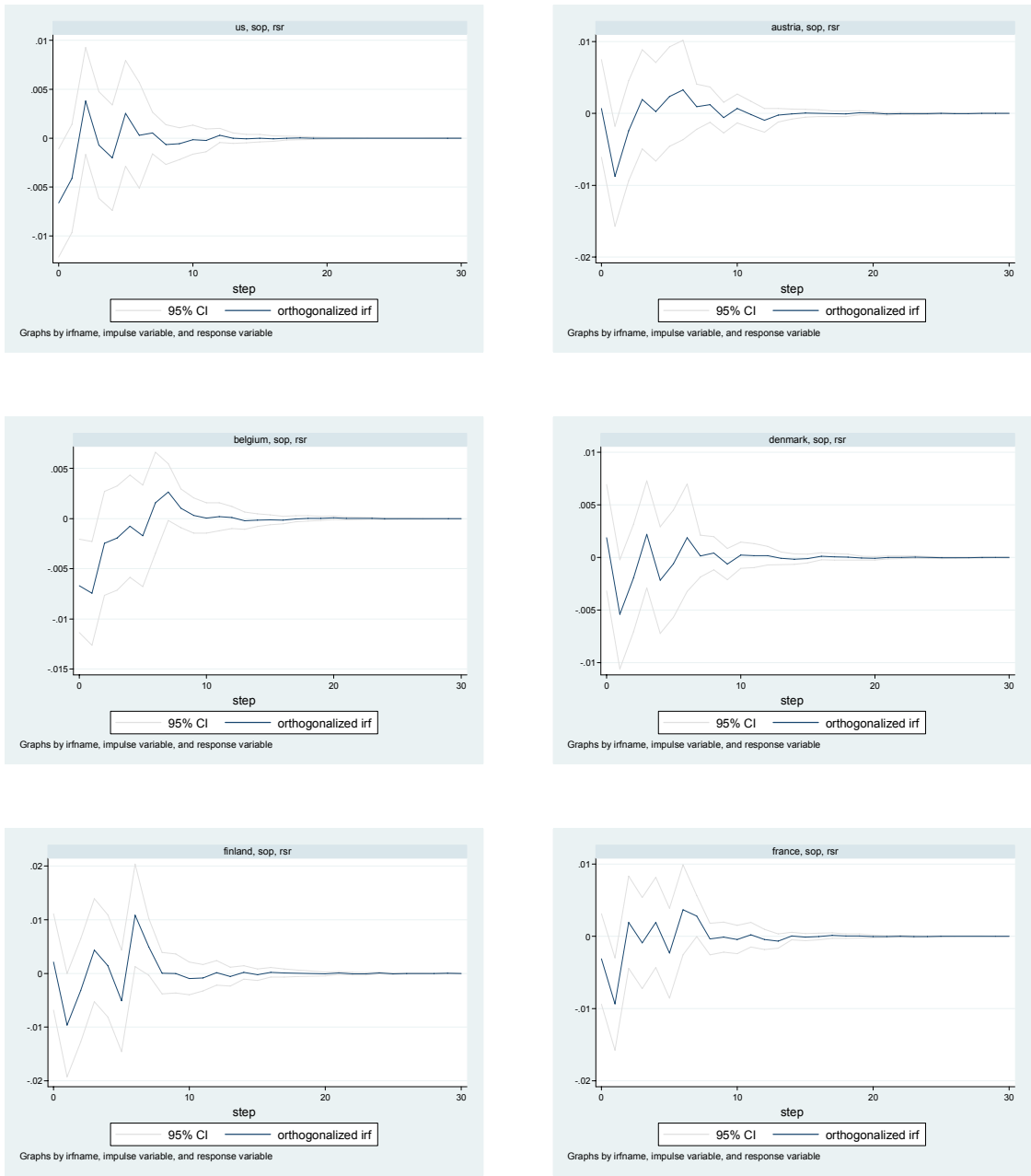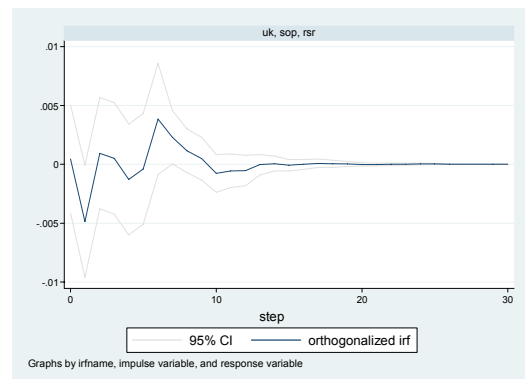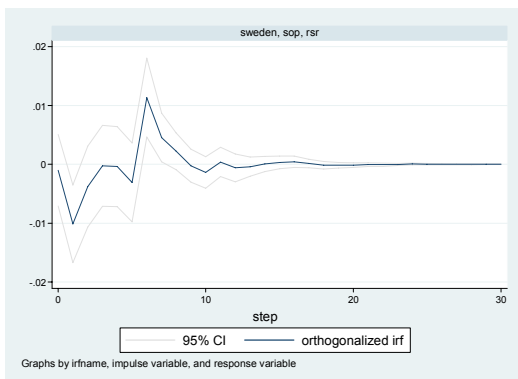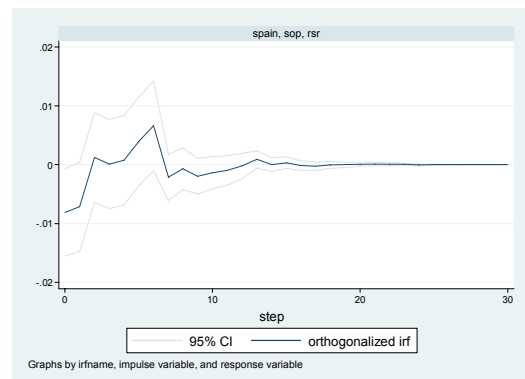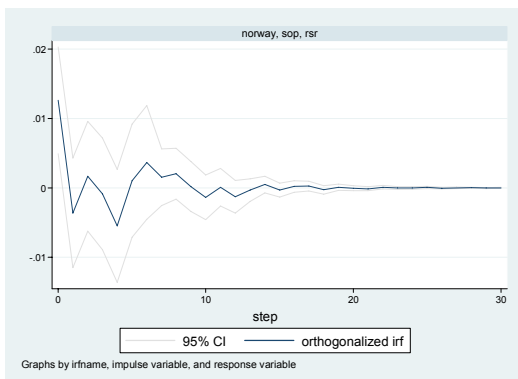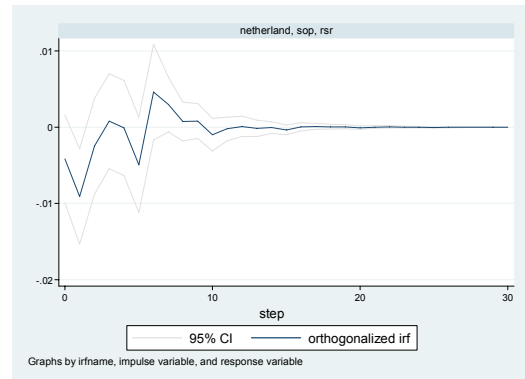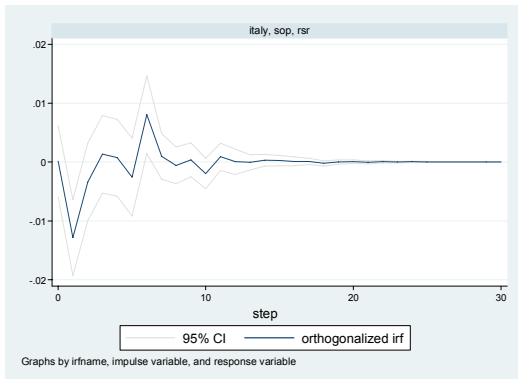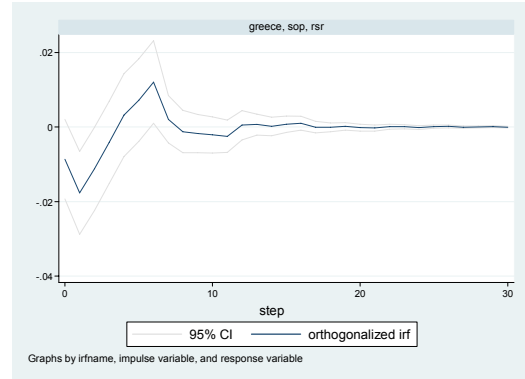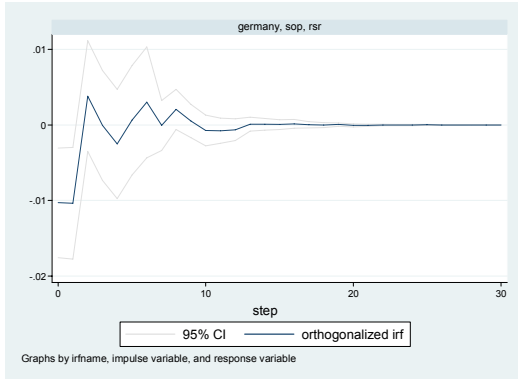
Figure 5.3 Orthogonalized impulse response function of stock returns to oil price shocks (World oil price : NOPI - r, oil, ip, rsr)

Graphs by irfname, impulse variable, and response variable
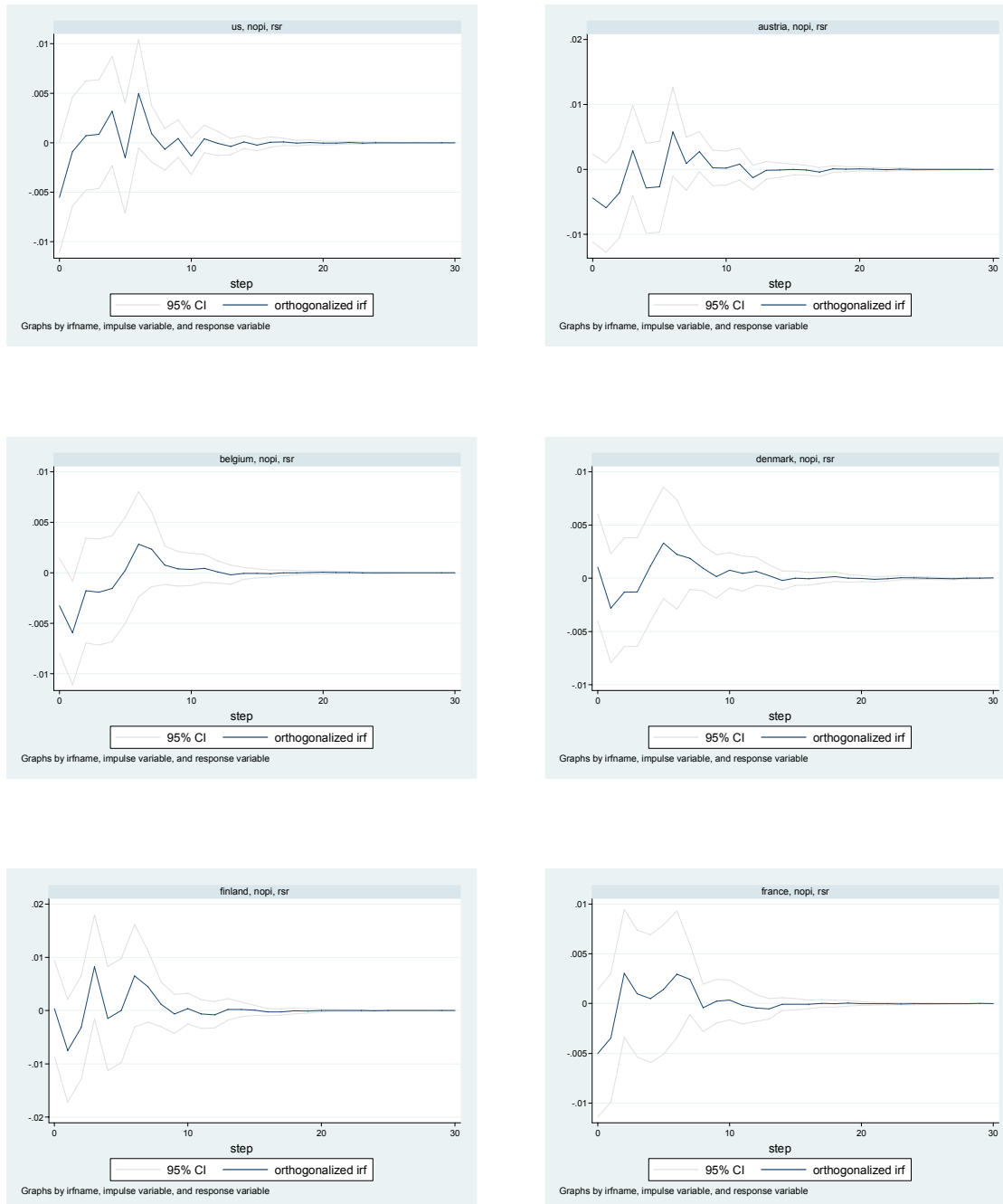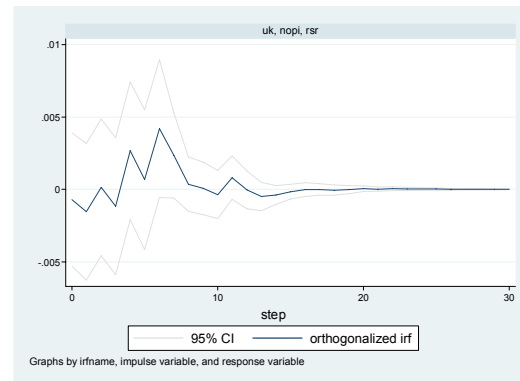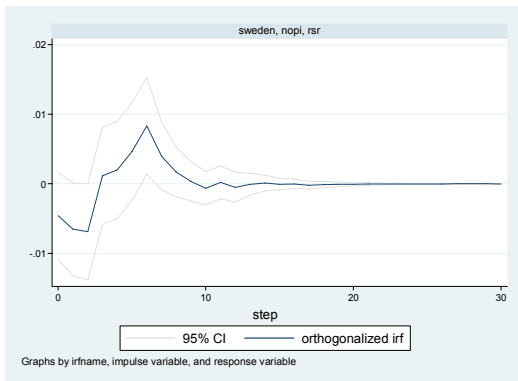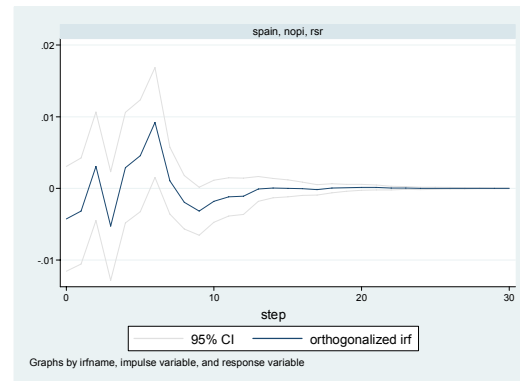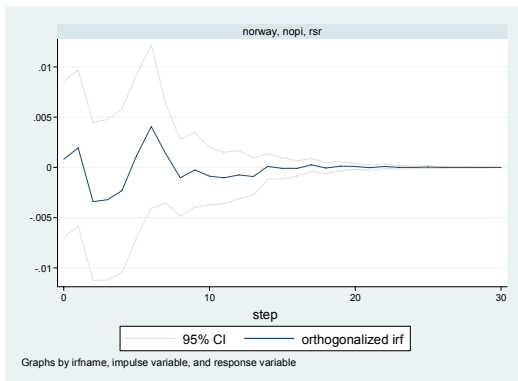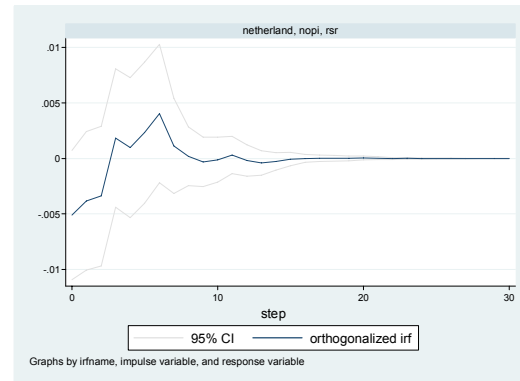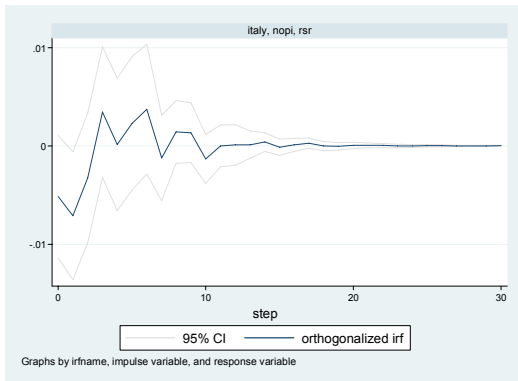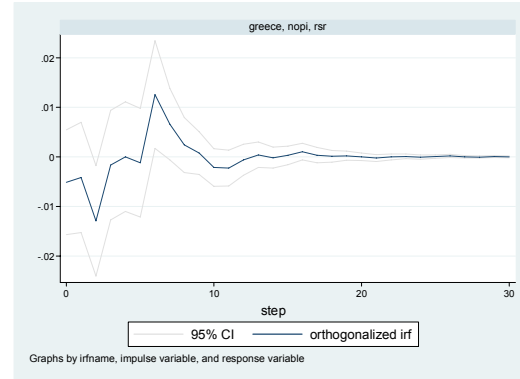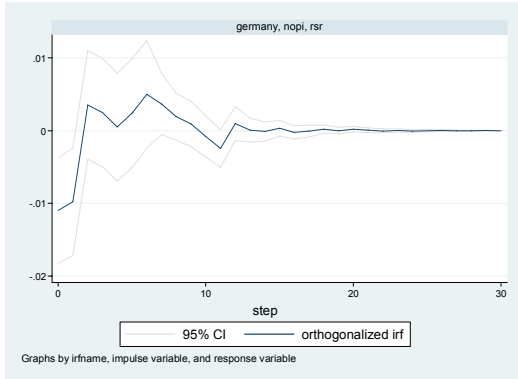
Figure 5.4 Orthogonalized impulse response function of stock returns to oil price shocks (National oil price : linear specification - r, oil, ip, rsr)

Graphs by irfname, impulse variable, and response variable
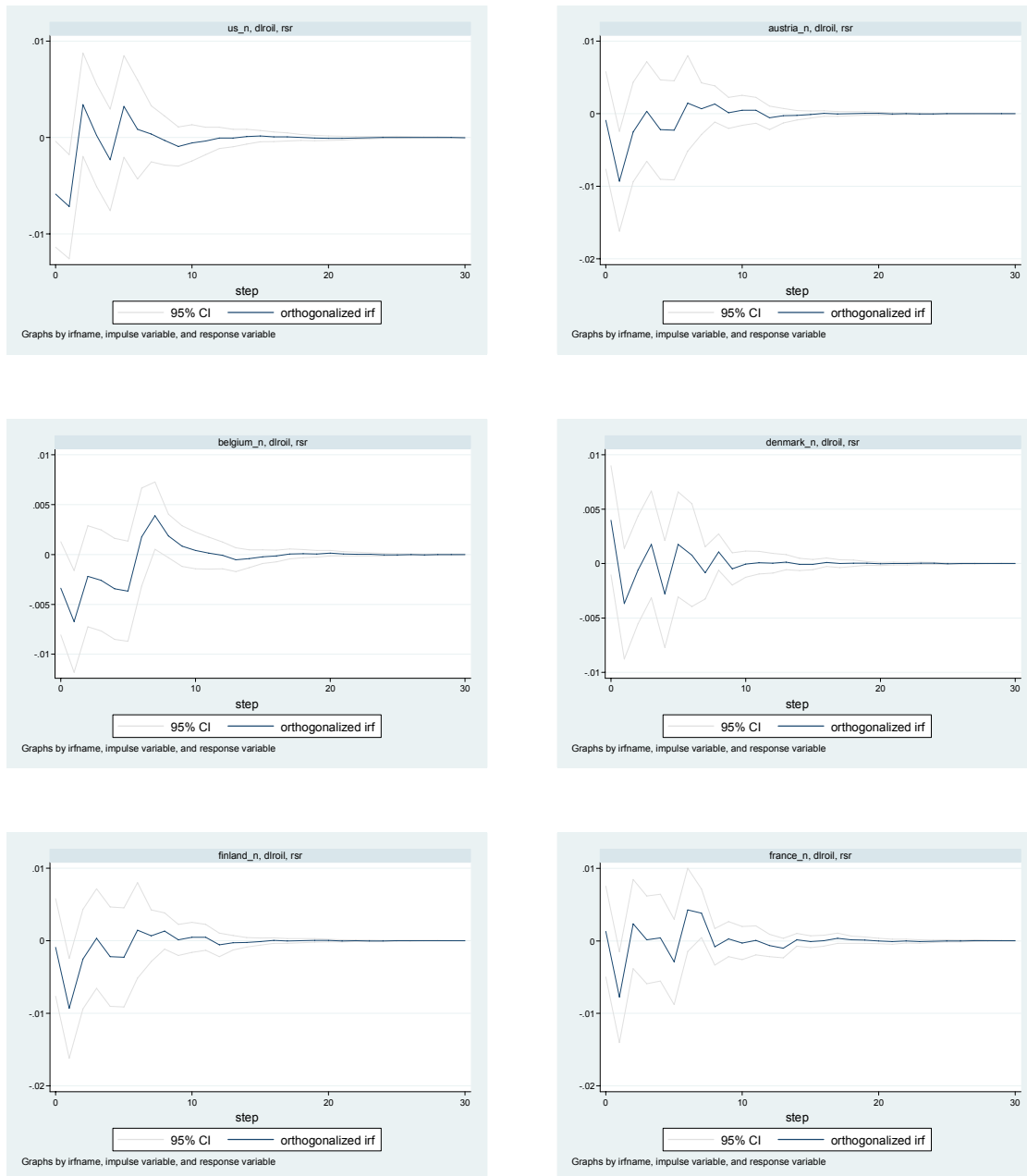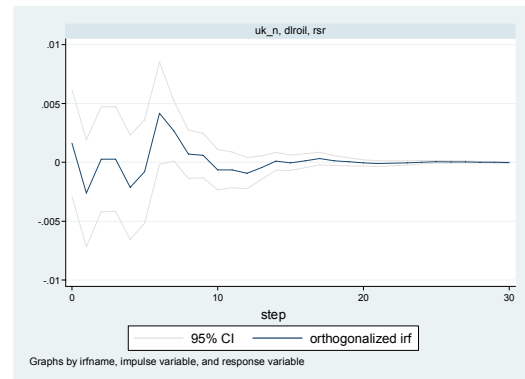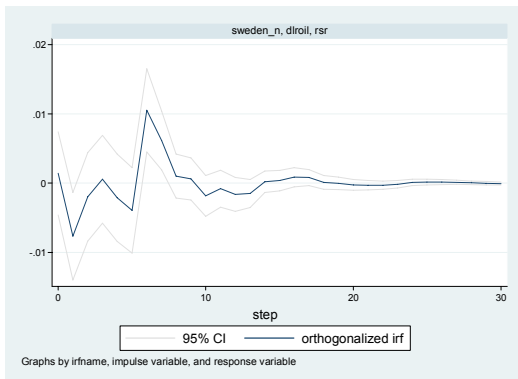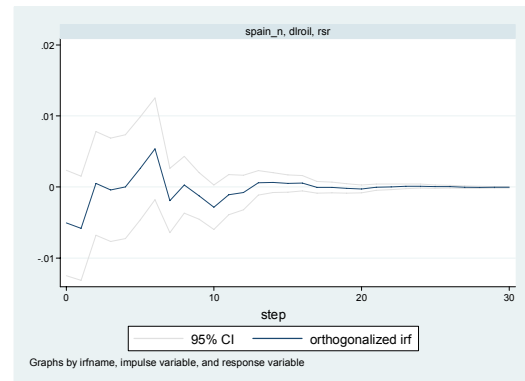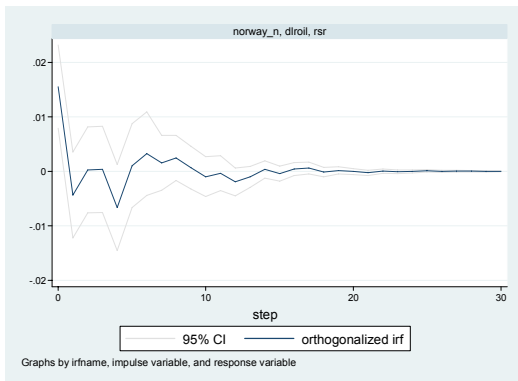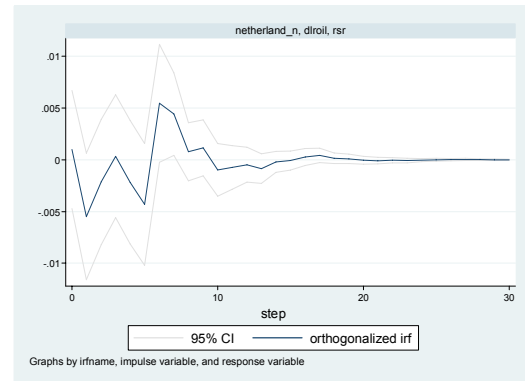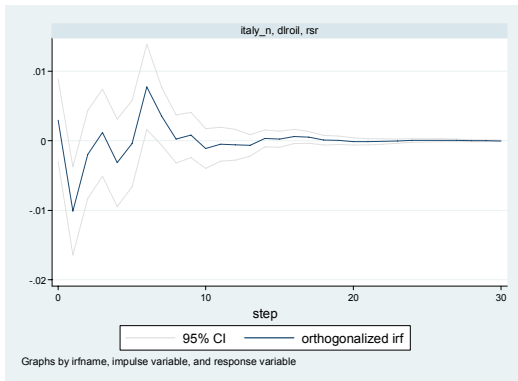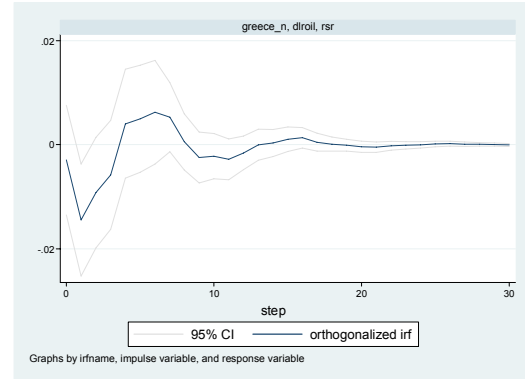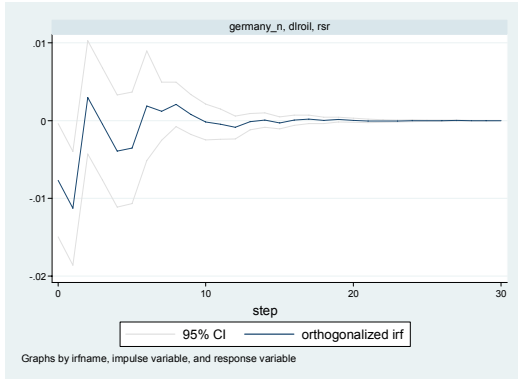
Figure 5.5 Orthogonalized impulse response function of stock returns to oil price shocks (National oil price : SOP - r, oil, ip, rsr)

Graphs by irfname, impulse variable, and response variable
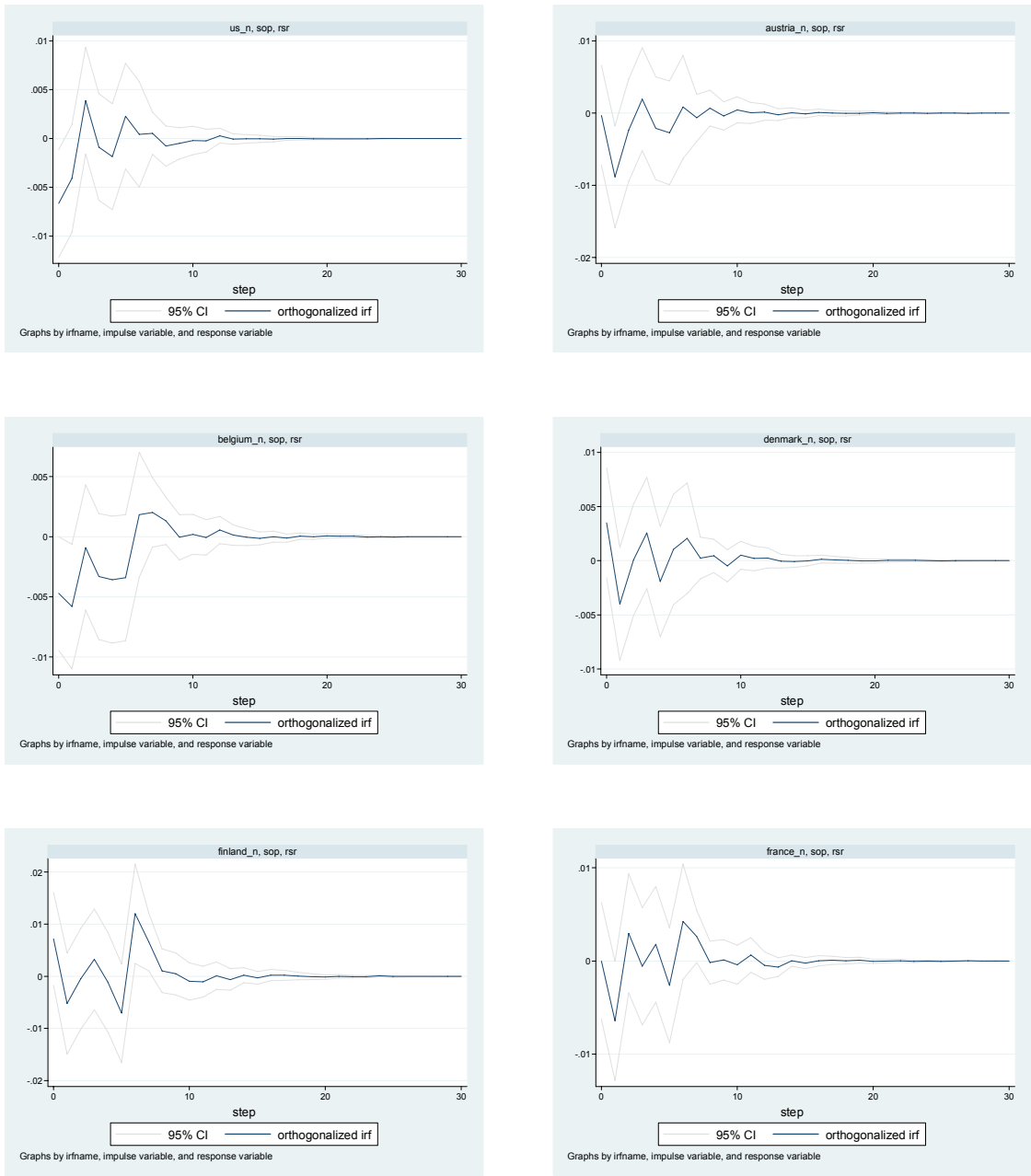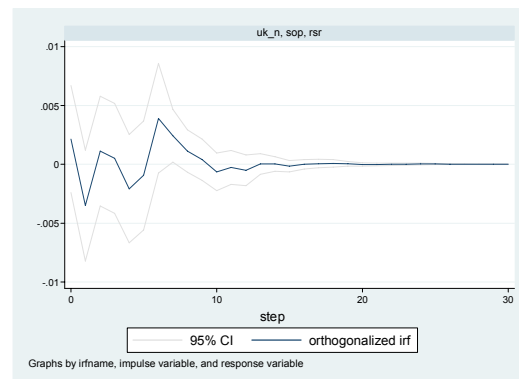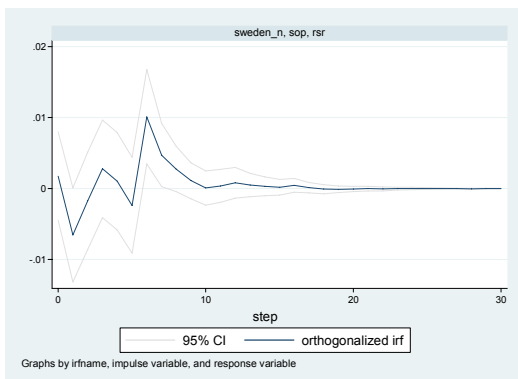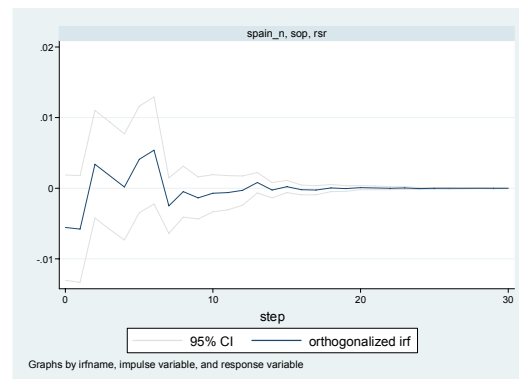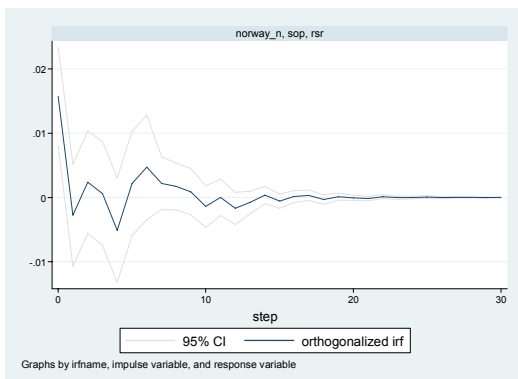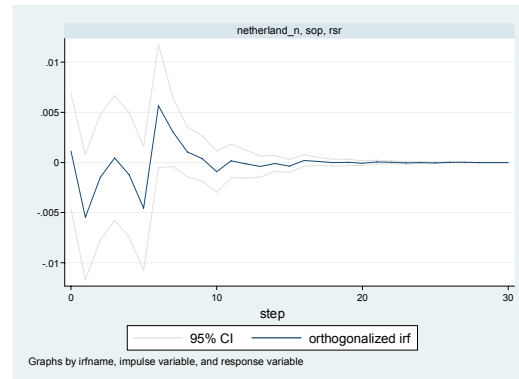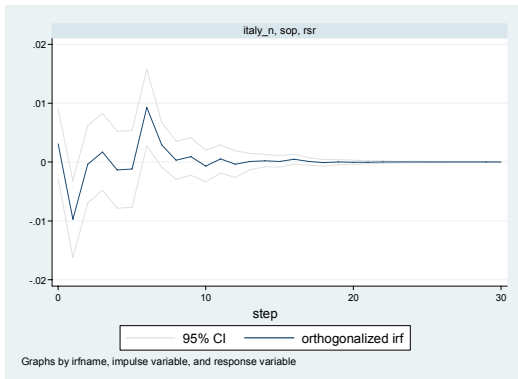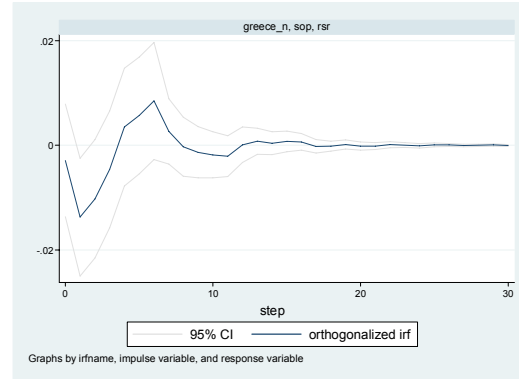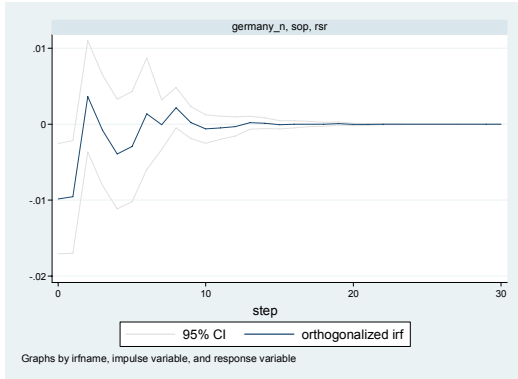
Figure 5.6 Orthogonalized impulse response function of stock returns to oil price shocks (National oil price : NOPI - r, oil, ip, rsr)

Graphs by irfname, impulse variable, and response variable
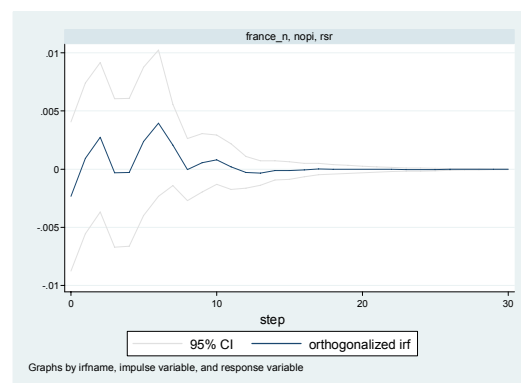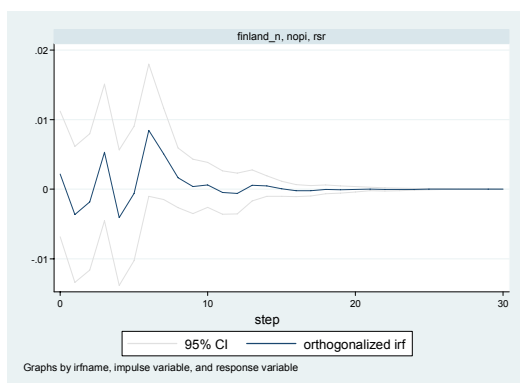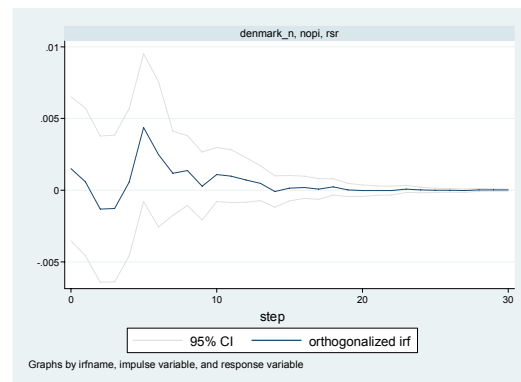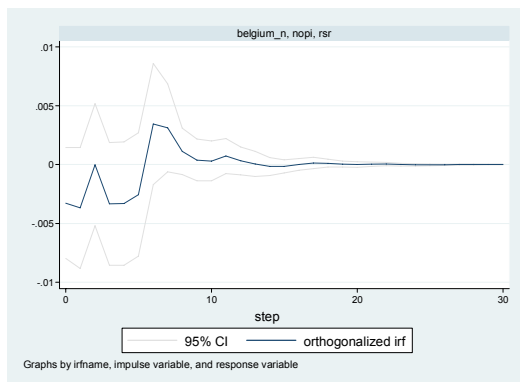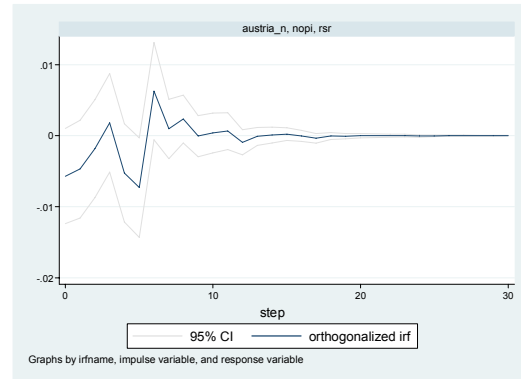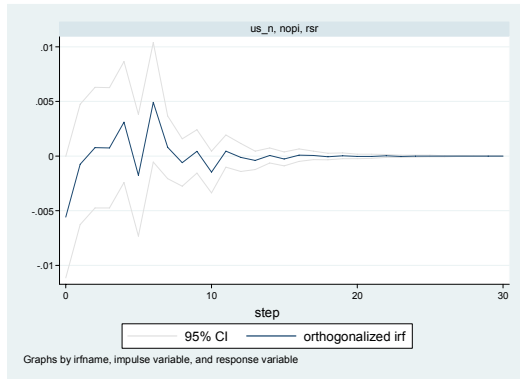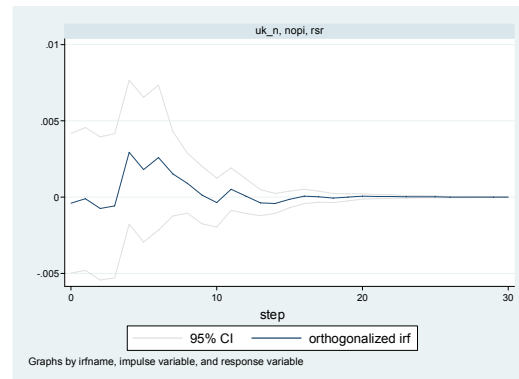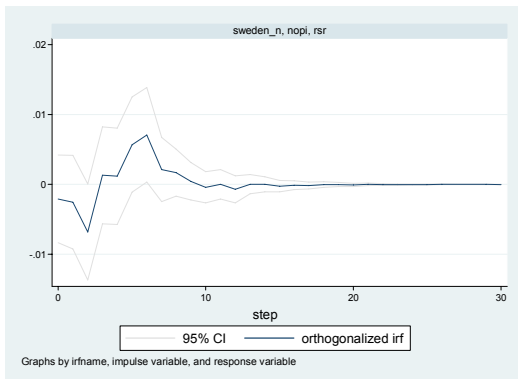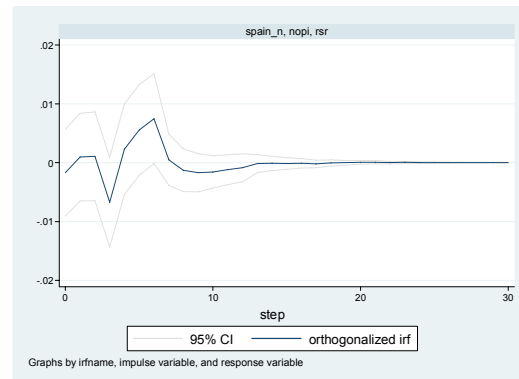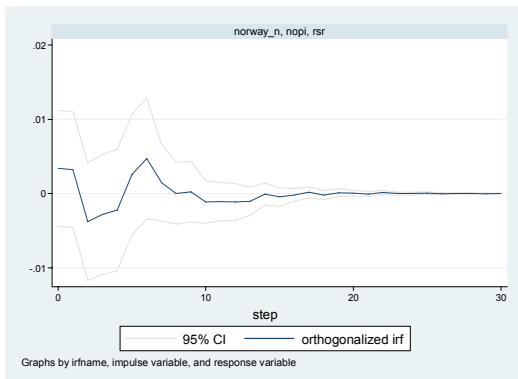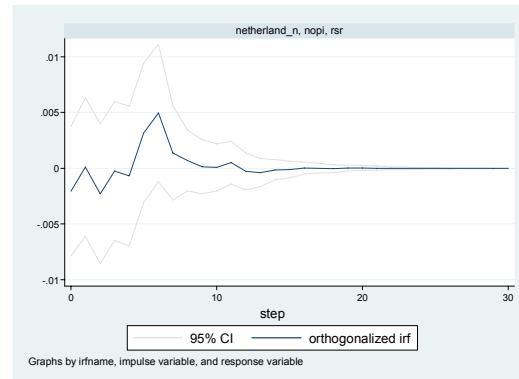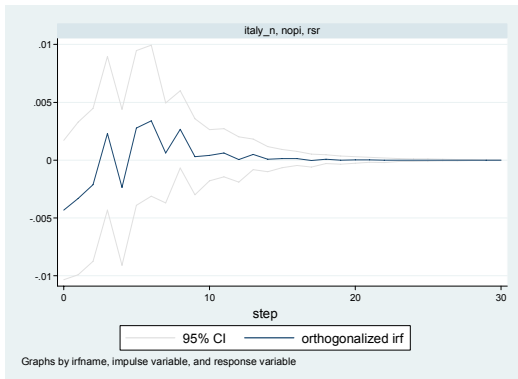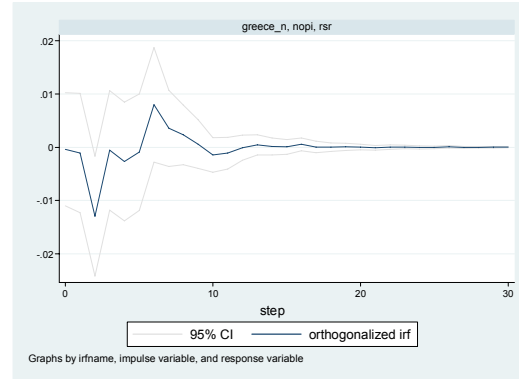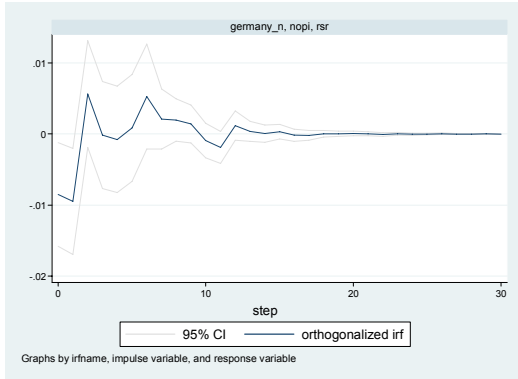
Table 5.7 Accumulated response of stock returns to oil price shocks (World oil price - r, oil, ip, rsr)

linear	US	Aus	Bel	Den	Fin	Fra	Ger	Gre	Ita	Net	Nor	Spa	Swe	UK
1	-0.013	-0.01	-0.014	-0.003	-	-0.012	-0.022	-0.024	-0.013	-0.013	0.013	-0.015	-0.01	-
3	-0.008	-0.013	-0.019	-0.004	-	-0.019	-0.019	-0.04	-0.017	-0.016	0.006	-0.016	-0.016	-
6	-0.009	-0.008	-0.019	-0.004	-	-0.008	-0.02	-0.02	-0.012	-0.015	0.004	-0.01	-0.01	-
9	-0.009	-0.005	-0.013	-0.004	-	-0.005	-0.016	-0.016	-0.007	-0.008	0.009	-0.008	-0.01	-
12	-0.009	-0.007	-0.014	-0.005	-	-0.006	-0.019	-0.025	-0.01	-0.011	0.005	-0.014	-0.005	-

SOP	US	Aus	Bel	Den	Fin	Fra	Ger	Gre	Ita	Net	Nor	Spa	Swe	UK
1	-0.01	-0.008	-0.014	-0.003	-	-0.012	-0.021	-0.026	-0.013	-0.013	0.009	-0.015	-0.01	-
3	-0.007	-0.009	-0.019	-0.004	-	-0.011	-0.017	-0.042	-0.016	-0.015	0.01	-0.014	-0.015	-
6	-0.007	-0.003	-0.019	-0.004	-	-0.008	-0.016	-0.019	-0.01	-0.015	0.009	-0.003	-0.007	-
9	-0.007	-0.001	-0.015	-0.004	-	-0.006	-0.014	-0.02	-0.007	-0.01	0.013	-0.008	0	-
12	-0.007	-0.002	-0.015	-0.004	-	-0.006	-0.016	-0.024	-0.007	-0.011	0.011	-0.01	-0.001	-

NOPI	US	Aus	Bel	Den	Fin	Fra	Ger	Gre	Ita	Net	Nor	Spa	Swe	UK
1	-	-	-0.009	-	-	-	-0.021	-0.009	-0.013	-	-	-	-	-
3	-	-	-0.013	-	-	-	-0.015	-0.024	-0.014	-	-	-	-	-
6	-	-	-0.011	-	-	-	-0.007	-0.012	-0.009	-	-	-	-	-
9	-	-	-0.008	-	-	-	-0.001	-0.003	-0.005	-	-	-	-	-
12	-	-	-0.007	-	-	-	-0.003	-0.008	-0.004	-	-	-	-	-

- : impulse response is insignificant at the 5% level   (%)

3.2 Oil exporting countries

In my sample, there are three countries which are net oil exporters the UK, Norway and Denmark. These countries show a similar response pattern of real stock returns to the oil price shocks. For Norway, a significant positive response of real stock returns follows immediately when an oil price shock occurs.[27] When a 100% shock of the oil price occurs, real stock returns increase almost 1.3% immediately. In the case of the UK and Demark, they show a positive response right after an oil price shock, which is not significant at the 5% level. In the UK, the response of real stock returns is not significant while in Denmark the response is significantly negative. These are different from those of net oil importing countries, which show a negative response in general. Only in Norway are the accumulated effects of real stock returns to an oil price shock positive.

3.3 Oil importing countries

The main difference between oil importing countries and oil exporting countries is the direction in the response of the stock market to oil price shocks. All oil importing countries show negative responses of the stock market to oil price shocks and the responses are all significant except in Finland when I use the world oil price with linear and *SOP* specification. However, when I use the national oil price, the response of the stock market in Finland, Netherlands and Spain is negative but insignificant. When I use the *NOPI* specification, most countries show insignificant responses to oil price shocks : the US, Austria, Finland, France, Netherland, Sweden, Spain in the world oil price model

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[27] Impulse response of GDP to oil price shocks is also significantly positive (Jimenez and Sanchez, 2005)

and Austria, Belgium, Finland, France, Italy, Netherlands, Spain in the national oil price model. Only Germany and Greece respond negatively to the oil price shock at the 5% significance level in all cases.

3.4 Robustness check

For the robustness of these outcomes, I run a VAR of different ordering :[28] real oil price changes, interest rates, industrial production, real stock returns and a VAR of 5 variables : interest rates, real oil price changes, industrial production, inflation, and real stock returns. The results[29] of theses VARs are almost the same as the basic VAR. Only in the VAR of 5 variables is the response of real stock returns to oil price shocks with *NOPI* a little more significant (Tables 5.5-5.6 and Figures in Appendix 2).

4. Comparison of impacts of oil price shocks and interest rate (monetary) shocks on stock market

The interest rates are considered to be one of the most influential factors to explain the movement of the stock market, and the short-term interest rates is an important monetary policy tool. There is an argument that the interest rates are significant channel of oil price shocks to the economy because monetary policy tightens, presumably in response to the inflationary pressures from oil price shocks.[30] Here I want to look at the impacts of oil price shocks and interest rate shocks taking into account those arguments.

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[28] I assume that oil price shocks can affect interest rates contemporaneously (within a month), which is not allowed in the basic VAR model.
[29] The impulse response functions are shown in Annex 2.
[30] It based on the fact that oil and energy costs are too small relative to total production cost to account for the entire decline in output that has followed increases in the price of oil.

4.1 Variance decomposition and impulse response function

Tables 5.8-5.10 presents the forecast cast error variance decomposition of real stock returns, which shows how much of the unanticipated changes of real stock returns are explained by oil price shocks and interest rate shocks. Variance decomposition suggests that oil price shocks are a considerable source of volatility for real stock returns in a basic VAR model. Particularly, the contribution of oil price shocks to the stock market is greater than that of interest rates shocks in most countries.[31] This means that oil price shocks should be the primary factor when stock market movement is taken into account.

The contribution of an oil price shock to the real stock returns ranges from 3% to 10% in the case of world oil price with a linear specification. Also the model with a linear specification shows a bigger contribution of an oil price shock to the stock market than models with *SOP* and *NOPI*. This result is consistent with Sadorsky (1999).

One interesting aspect is the magnitude of contribution of oil price shocks and interest rate shocks to the stock market. In Sadorsky (1999) the contribution of oil price shocks became greater than that of interest rate shocks after 1986 in the US. In my analysis, the contribution of oil price shocks to stocks market in the US is greater than that of interest rate shocks in all models too. Like the US, among oil importing countries Austria, Belgium, Finland, France, Germany, Greece, Netherlands, and Sweden have

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[31] It is different from the case when the impact of oil price shocks on the GDP is analyzed (Jimenez and Sanchez 2005). In that case, interest rates shocks to GDP volatility is greater in most countries in the linear specification model.

greater contribution of oil price shocks to the stock market than that of interest rate shocks while Denmark, Italy, Norway, Spain, and the UK have a smaller contribution of oil price shocks to the stock market than the interest rate shocks in the linear specification model. Denmark, Italy, Norway, Sweden, and the UK in the *SOP* specification model, and Denmark, Italy, Norway, Spain, Sweden, and the UK in the *NOPI* specification model, have a greater influence of interest rate shocks than that of oil price shocks. Since innovations in short term interest rates could represent monetary shocks in my model, it can be interpreted that in the US, Austria, Belgium, Finland, France, Germany, Greece, and Netherlands oil prices play a more significant role in the stock market than monetary policy does. In most cases, the contributions of oil price shocks to the real stock returns are statistically significant.

In addition, I analyze the impulse response of real stock returns to interest rate shocks in order to compare with the impulse response of real stock returns to oil price shocks. The response of real stock returns to interest rate shocks is insignificant in most countries. In impulse response analysis, I also find that oil price shocks have a greater impact on the stock market than interest rate shocks. Interestingly, countries such as Italy, Spain and Sweden where the impact of interest rate shocks is greater than oil price shocks are included in the countries in which real stock returns show a negative response to interest rate shocks at the 5% level of significance. (Table 5.11)

Therefore, taking into account the argument that the interest rates are the critical channel of oil price shocks since monetary policy systematically responds to the oil price increase by raising the interest rates, I look at the impulse response function of real stock returns to interest rate shocks as well as the impulse response function of interest rate to

the oil price shocks together. (Table 5.13 and Figures 5.7-5.9) In Finland, Italy, Spain, and Sweden interest rates increase significantly when oil price shocks occurs and real stock returns drop significantly in response to the increase of the interest rates. This could be evidence that in those countries monetary policy become tighter to prevent inflation when the oil price increases, which causes stock prices to decline. According to the variance decomposition analysis, Italy, Spain, and Sweden have a greater impact of interest rate shocks than that of oil price shocks. Therefore, systematic response of monetary policy to the oil price shocks could explain why the influence of interest rate shocks on the stock market is greater in those countries. Even if the contribution of interest rate shocks to the stock market in Finland is smaller than that of oil price shocks, its contribution is relatively bigger than those of the other oil importing countries.

To analyze the impact of systematic monetary policy more precisely, I use a VAR of a different ordering : real oil price changes, interest rates, industrial production, and real stock returns. According to this ordering, I assume that the oil price shocks can affect interest rates contemporaneously (within a month), which is not allowed in a basic VAR model. However, in both cases the response of interest rates to oil price shocks appears in a few months not within a month, so there is no significant difference in both cases. (Tables 5.8-5.10, 5.14 and Figures in Appendix 2)

One interesting point is that when I use the world oil price, monetary shocks contribute to stock market volatility in a similar percentage in both a linear and *SOP* model, while oil price shocks influence stock market volatility in a linear model more than in a *SOP* model. This is similar to the outcome of Sadorsky (1999) who analyze the US. However, it is the opposite to the case when the impact of oil price shocks on the

GDP is analyzed (Jimenez and Sanchez 2005). In the case of the relationship between oil price shocks and GDP, contribution of oil price shocks to GDP volatility is greater in the *SOP* model than in the linear model.

4.2 Oil exporting countries

In all oil exporting countries the impact of interest rate shocks is greater than that of oil price shocks as we expect. Furthermore, evidence is not found that monetary policy systematically responds to oil price shocks.

4.3 Oil importing countries

In most oil importing countries, (8 out of 11), oil price shocks have a greater influence on the stock market than interest rate shocks do. Only in Italy, Spain or Sweden (depending on the oil price specification) do interest rate shocks have a greater impact on the stock market than oil price shocks do. However, if the impact of oil price shocks on the interest rates is taken into account, the influence of oil price shocks on the stock market in those countries might be bigger. Because in Italy, Spain, and Sweden the interest rates increase when oil price shocks happen, which leads to the decline of real stock returns. Therefore, oil price shocks are a primarily influential factor to the movement of the stock market in oil importing countries.

Table 5.8 Variance decomposition after 24 months of stock returns to oil price shocks and interest rate shocks (World oil price : Linear specification)

VAR (RSR)	shock to	Ordering (r, oil, ip, rsr)		Ordering (oil, r, ip, rsr)	
		R	OIL	OIL	R
US		1.1	5.9 **	6 **	1
Austria		3	4 *	4.1 *	3
Belgium		2.3	8.5 **	8.8 **	2
Denmark		4.2 *	2.9	2.7	4.4 *
Finland		2.9	5.6 **	5.5 **	3
France		1.1	5.9 **	5.9 **	1.1
Germany		3	7.5 **	7.5 **	3
Greece		2.3	8.3 **	8.2 **	2.4
Italy		13.7 ***	9.7 ***	9.8 ***	13.6 ***
Netherlands		1.4	7 **	7.5 **	1.3
Norway		8.9 **	6 **	5.9 **	8.9 **
Spain		4.8 **	4.7 *	4.7 *	4.8 *
Sweden		10 **	10.3 ***	10.3 ***	9.9 **
UK		3.9	3	2.8	4.1

***, **, * denotes significance at the 1%, 5%, 10% level

Table 5.9 Variance decomposition after 24 months of stock returns to oil price shocks and interest rate shocks (World oil price : SOP specification)

VAR (RSR)	shock to	Ordering (r, oil, ip, rsr)		Ordering (oil, r, ip, rsr)	
		R	OIL	OIL	R
US		1.2	4.4 *	4.4 *	1.1
Austria		2.9	3.3	3.3	2.9
Belgium		2.5	7 *	7.3 *	2.2
Denmark		4.3 *	2.8	2.7	4.4 *
Finland		2.7	4.7 **	4.6 *	2.7
France		1.2	4.8 *	4.8 *	1.2
Germany		2.6	6.9 **	6.9 **	2.6
Greece		2.1	8.7 **	8.6 **	2.3
Italy		14.1 ***	9.4 ***	9.6 ***	13.9 ***
Netherlands		1.5	6.6 **	6.8 **	1.3
Norway		9.3 **	5.1 *	5 *	9.3 **
Spain		4.2 *	4.8 *	4.7 *	4.2 *
Sweden		9.6 **	8.8 **	8.8 **	9.6 **
UK		4.4	3	2.8	4.5 *

***, **, * denotes significance at the 1%, 5%, 10% level

Table 5.10 Variance decomposition after 24 months of stock returns to oil price shocks and interest rate shocks
(World oil price : NOPI specification)

VAR (RSR)	shock to	Ordering (r, oil, ip, rsr)		Ordering (oil, r, ip, rsr)	
		R	OIL	OIL	R
US		1.1	3.6	3.6	1.1
Austria		2.6	4.2	4.3	2.5
Belgium		2.3	3.9	3.9	2.2
Denmark		4.8 *	2	2	4.8 *
Finland		3.5	3.1	3.2	3.5
France		1	2.3	2.4	1
Germany		3.3	7.8 **	7.9 **	3.2
Greece		2.7	5	5	2.7
Italy		16.6 ***	3.9	3.2	17.3 ***
Netherlands		2.2	3.1	3.3	2.1
Norway		9.2 **	1.3	1.4	9.1 **
Spain		5.2 **	5.1 *	5.1 *	5.2 **
Sweden		9.8 **	7.1 *	7.3 *	9.7 **
UK		4.2	2.3	2.3	4.1

***, **, * denotes significance at the 1%, 5%, 10% level

Table 5.11 Orthogonalized impulse response function of stock returns to interest rate shocks (r, oil, ip, rsr)

		US	AUS	BEL	DEN	FIN	FRA	GER	GRE	ITA	NET	NOR	SPA	SWE	UK
	Linear	x	x	x	n	n	x	x	x	n	x	p-n	n	n	x
WP	SOP	x	x	x	n	x	x	x	x	n	x	p-n	n	n	x
	NOPI	x	x	x	n	n	x	x	x	n	n	p-n	n	n	x

n : negatively significant at 5% level, p : positively significant at 5% level, x : insignificant at 5% level

Impulse response function of stock returns to oil price shocks - r, oil, ip, rsr

		US	AUS	BEL	DEN	FIN	FRA	GER	GRE	ITA	NET	NOR	SPA	SWE	UK
	Linear	n	n	n	n	x	n	n	n	n	n	p	n	n	x
WP	SOP	n	n	n	n	x	n	n	n	n	n	p	n	n	x
	NOPI	n	x	n	x	x	x	n	n	n	x	x	x	x	x

n : negatively significant at 5% level, p : positively significant at 5% level, x : insignificant at 5% level

Table 5.12 Orthogonalized impulse response function of stock returns to interest rate shocks (oil, r, ip, rsr)

		US	AUS	BEL	DEN	FIN	FRA	GER	GRE	ITA	NET	NOR	SPA	SWE	UK
	Linear	x	x	x	n	n	x	x	x	n	x	p-n	n	n	x
WP	SOP	x	x	x	n	x	x	x	x	n	x	p-n	n	n	p
	NOPI	x	x	n	n	n	x	x	x	n	n	p-n	n	n	x

n : negatively significant at 5% level, p : positively significant at 5% level, x : insignificant at 5% level

Impulse response function of real stock return to oil price shocks - oil, r, ip, rsr

		US	AUS	BEL	DEN	FIN	FRA	GER	GRE	ITA	NET	NOR	SPA	SWE	UK
	Linear	n	n	n	n	x	n	n	n	n	n	p	n	n	x
WP	SOP	n	n	n	n	x	n	n	n	n	n	p	n	n	x
	NOPI	x	x	n	x	x	x	n	n	x	x	x	x	n	x

n : negatively significant at 5% level, p : positively significant at 5% level, x : insignificant at 5% level

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Table 5.13 Orthogonalized impulse response functions of interest rates to oil price shocks and stock returns to interest rate shocks (r, oil, ip, rsr)

	oil price shocks to interest rates			interest rate shocks to real stock returns		
	dlroil	SOP	NOPI	dlroil	SOP	NOPI
US	x	x	x	x	x	x
Austria	x	x	p	x	x	x
Belgium	p	p	p	x	x	x
Denmark	x	n	p	n	n	n
Finland	p	p	p	n	x	n
France	x	x	x	x	x	x
Germany	p	p	p	x	x	x
Greece	x	x	x	x	x	x
Italy	p	p	p	n	n	n
Netherlands	p	p	x	x	x	n
Norway	x	x	x	p-n	p-n	p-n
Spain	p	p	p	n	n	n
Sweden	p	x	p	n	n	n
UK	x	x	x	x	x	x

n : negatively significant at 5% level,   p : positively significant at 5% level,   x : insignificant at 5% level

Table 5.14 Orthogonalized impulse response functions of interest rates to oil price shocks and stock returns to interest rate shocks (oil, r, ip, rsr)

	oil price shocks to interest rates			interest rate shocks to real stock returns		
	dlroil	SOP	NOPI	dlroil	SOP	NOPI
US	x	x	x	x	x	x
Austria	x	x	p	x	x	x
Belgium	p	p	p	x	x	x
Denmark	x	x	x	n	n	n
Finland	**p**	**p**	**p**	**n**	x	**n**
Germany	p	p	p	x	x	x
France	x	x	x	x	x	x
Greece	x	x	x	x	x	x
Italy	**p**	**p**	**p**	n	n	n
Netherlands	p	p	x	x	x	n
Norway	x	x	x	p-n	p-n	p-n
Spain	**p**	**p**	**p**	**n**	**n**	**n**
Sweden	**p**	x	**p**	**n**	**n**	**n**
UK	x	x	x	x	p	x

n : negatively significant at 5% level, p : positively significant at 5% level, x : insignificant at 5% level

Figure 5.7 Orthogonalized impulse response function of interest rates to oil price shocks and stock returns to interest rate shocks (World oil price : linear specification - r, oil, ip, rsr)

Graphs by irfname, impulse variable, and response variable

Graphs by irfname, impulse variable, and response variable

Graphs by irfname, impulse variable, and response variable
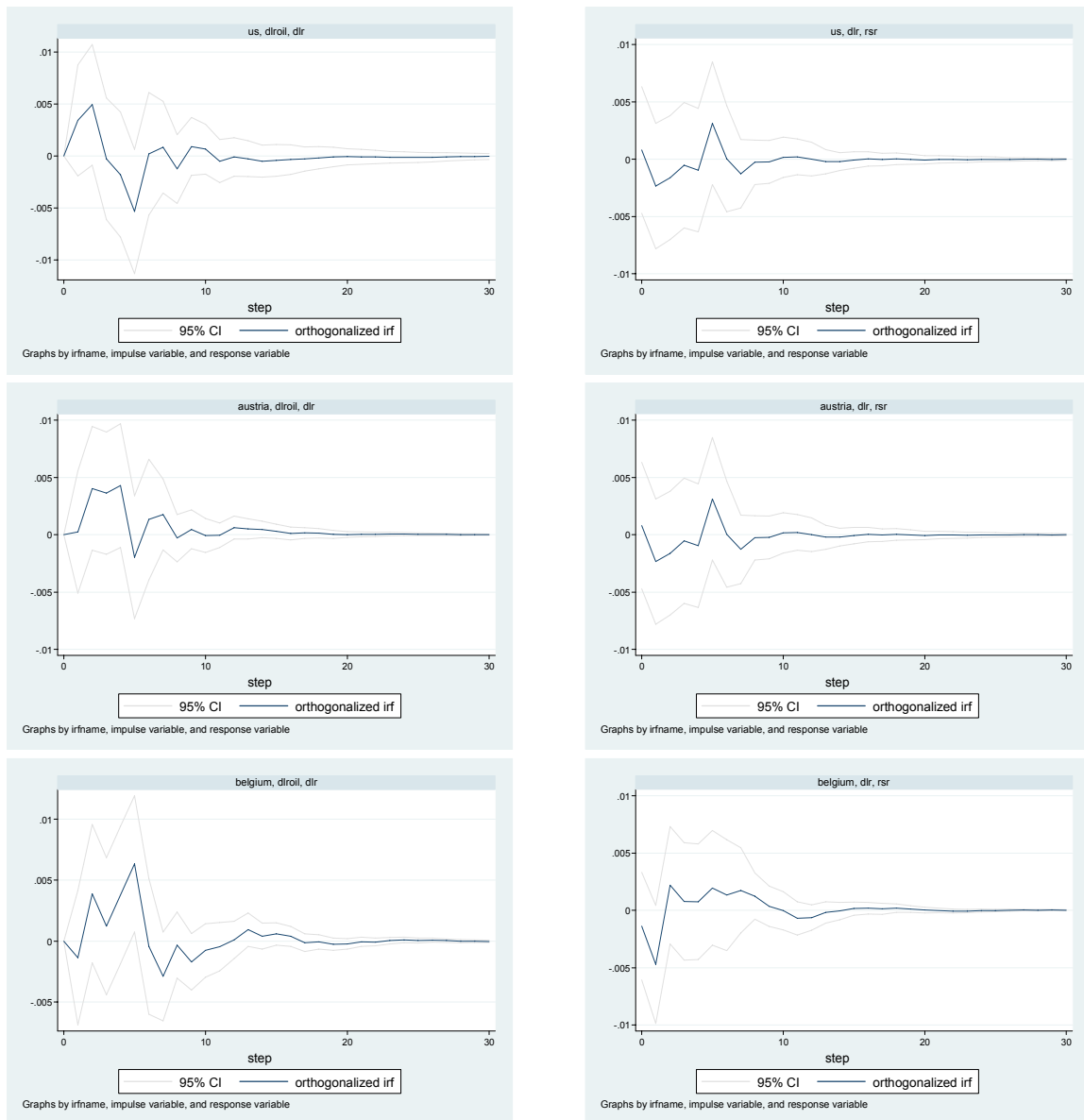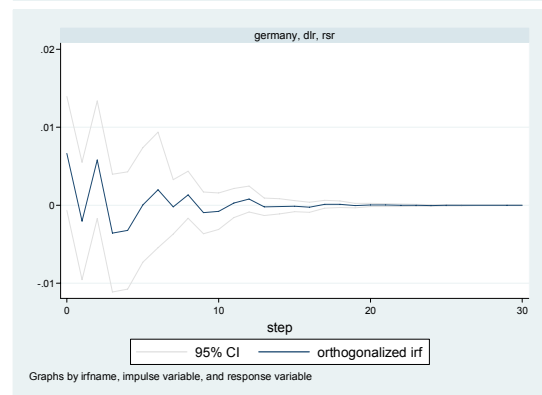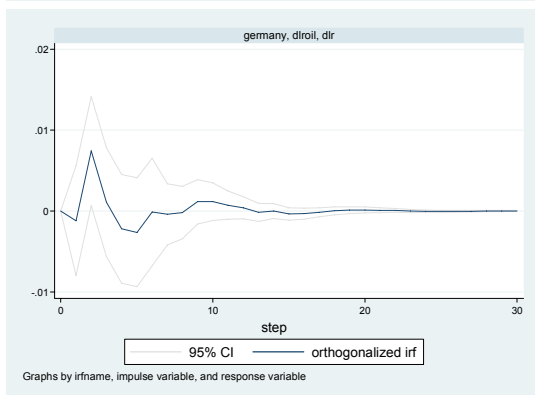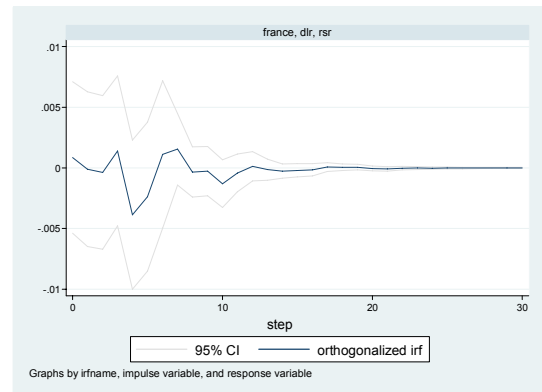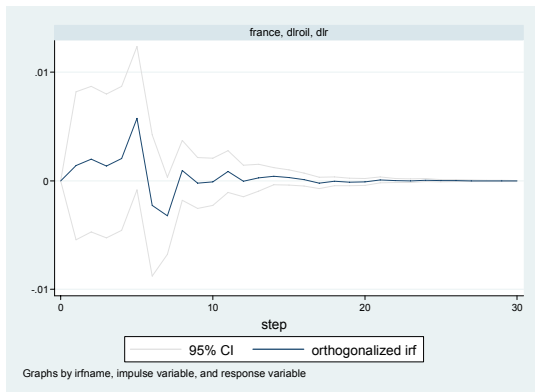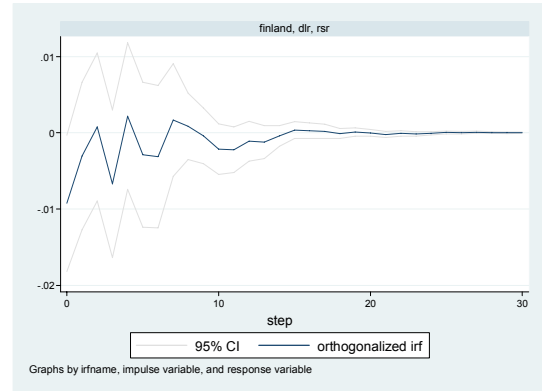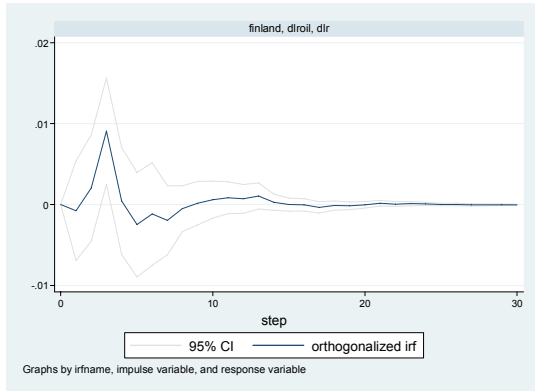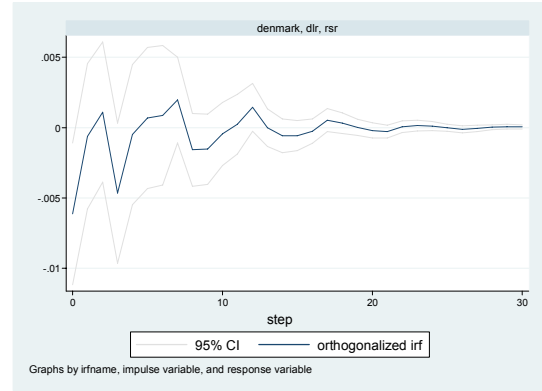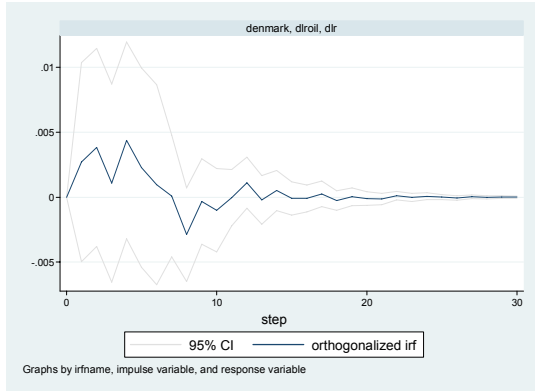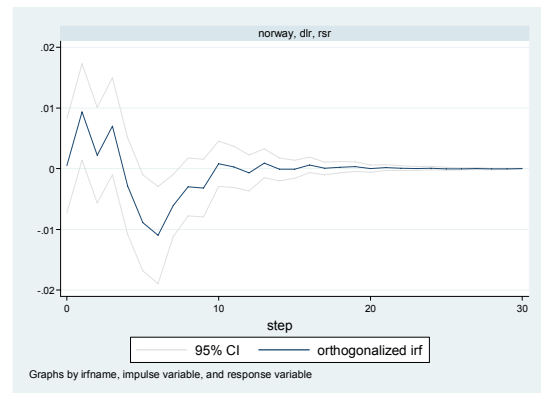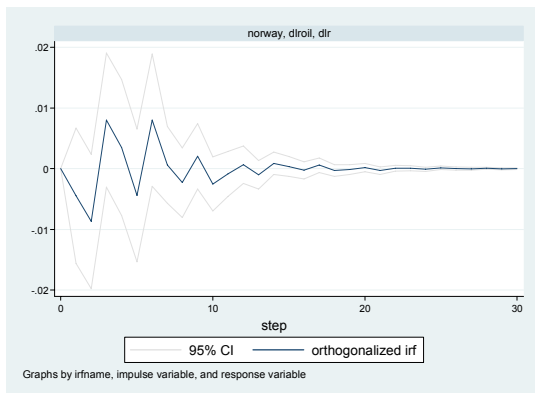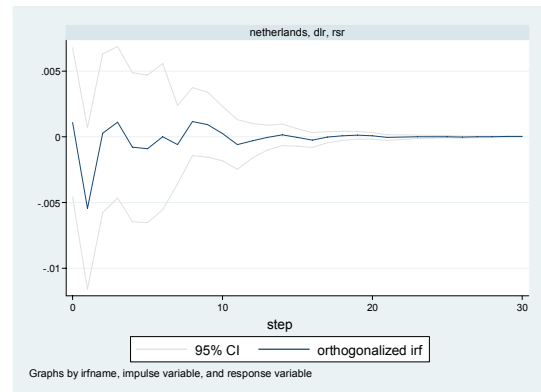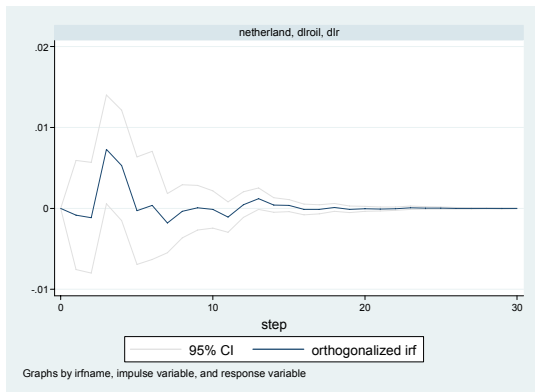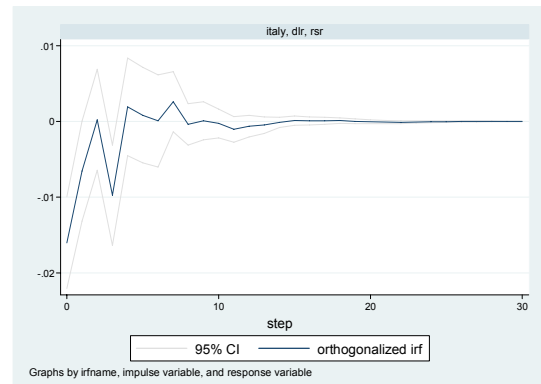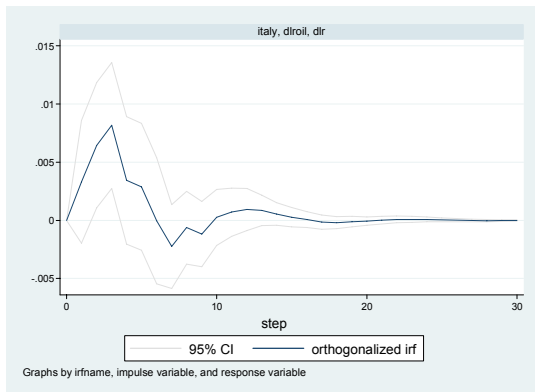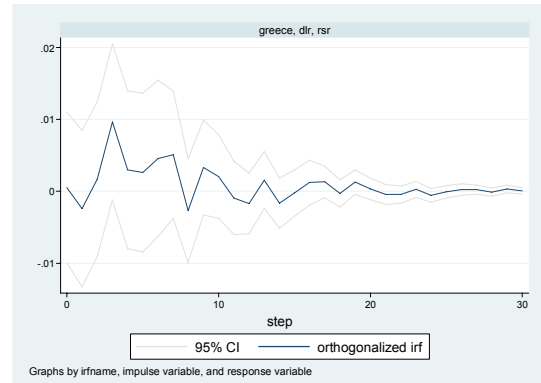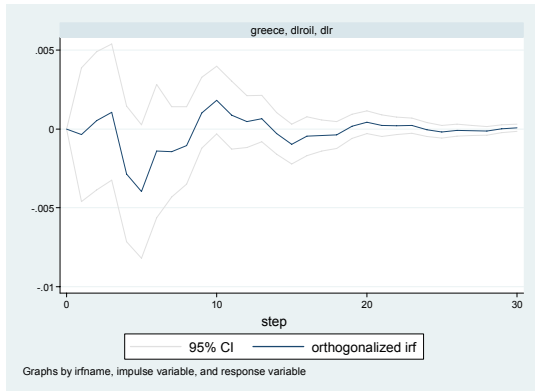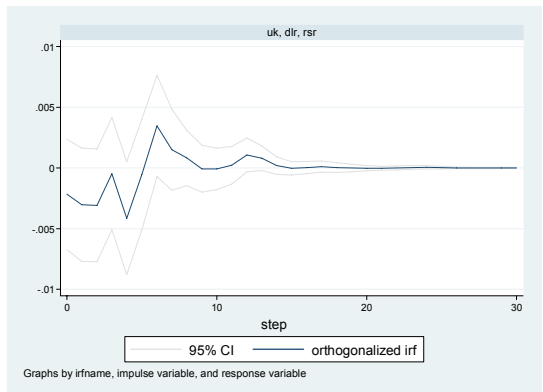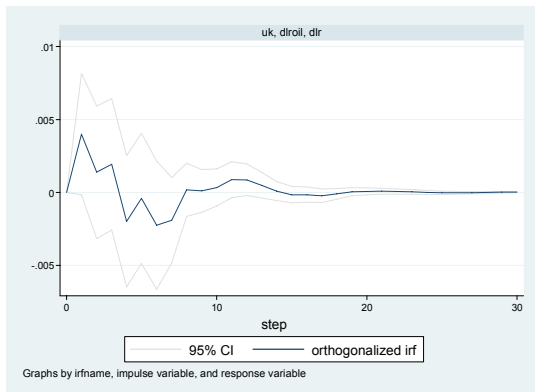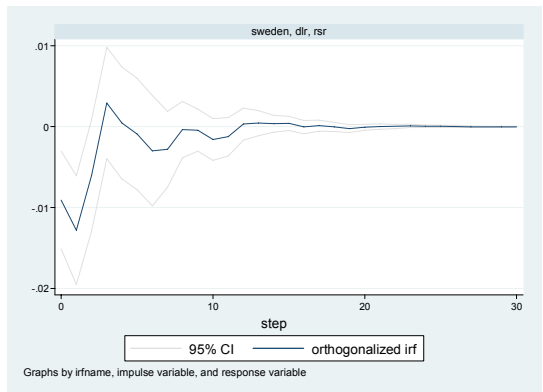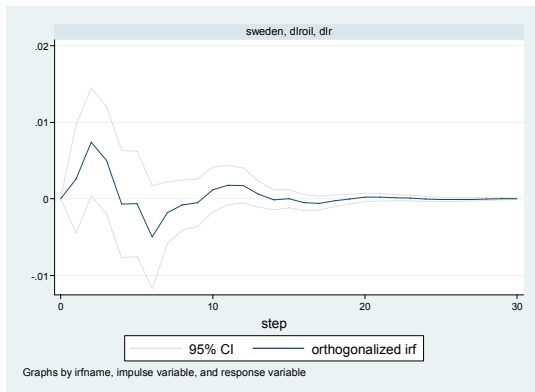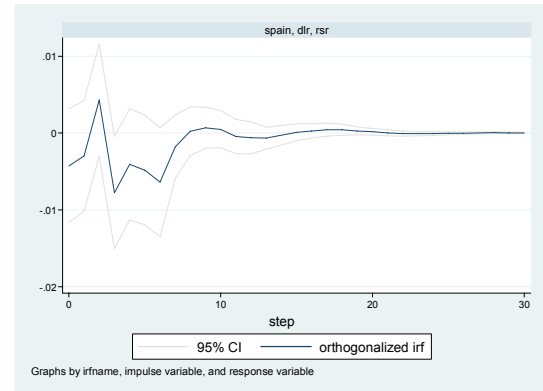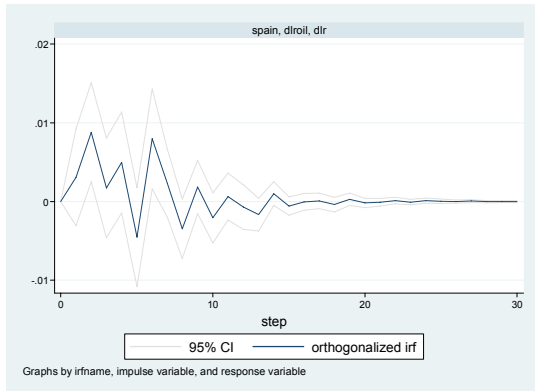
Figure 5.8 Orthogonalized impulse response function of interest rates to oil price shocks and stock returns to interest rate shocks (World oil price : SOP specification - r, oil, ip, rsr)

Graphs by irfname, impulse variable, and response variable

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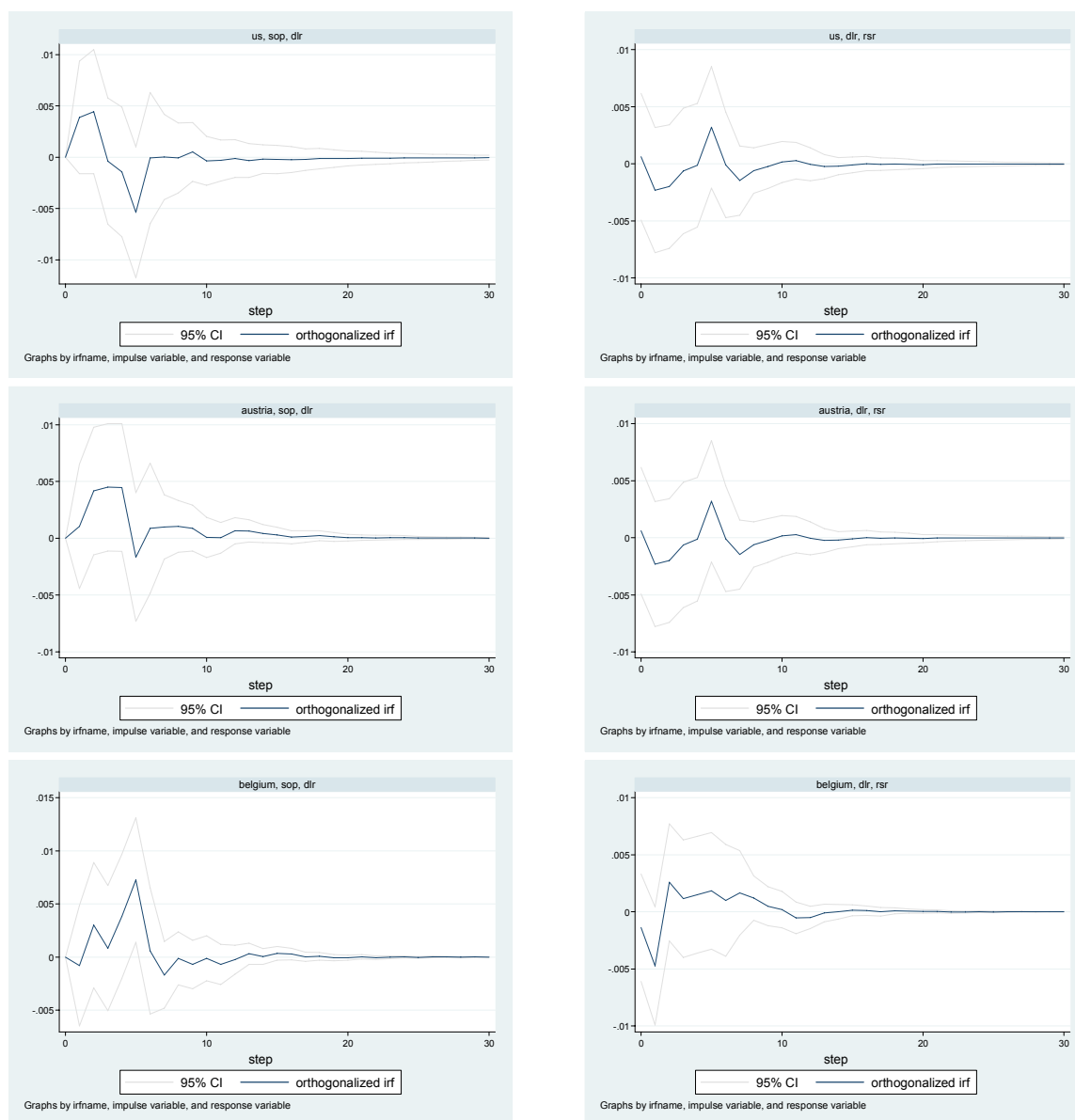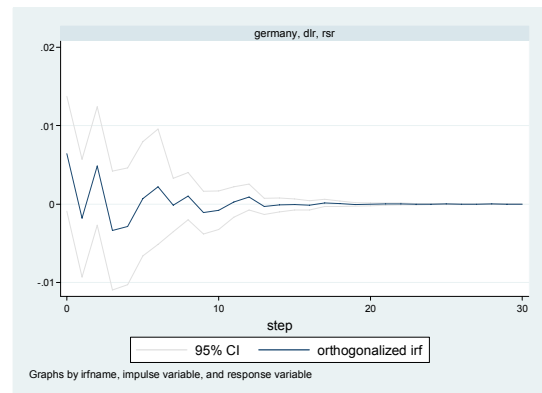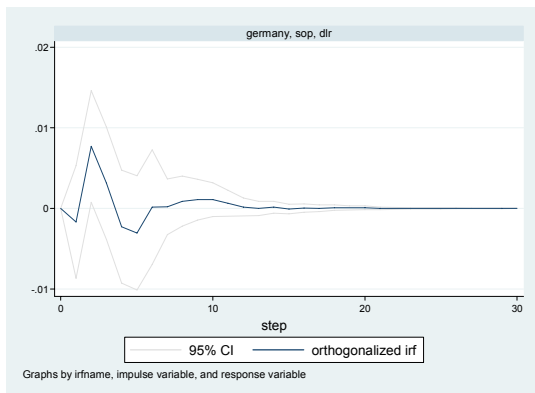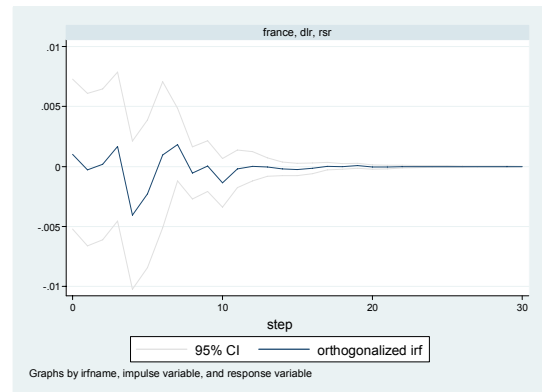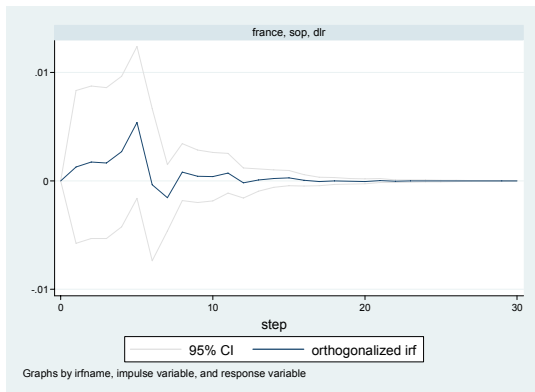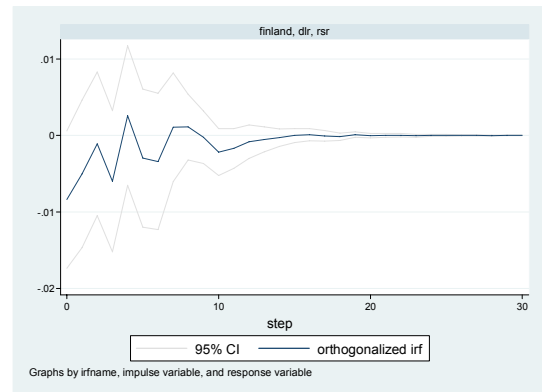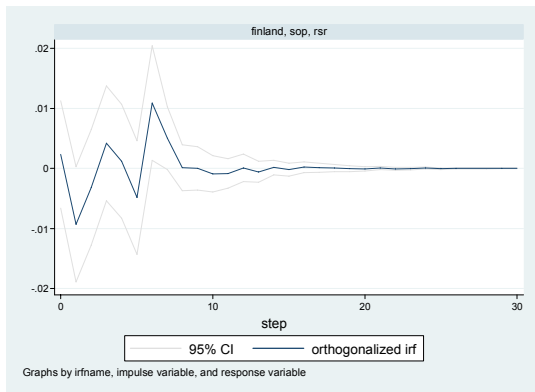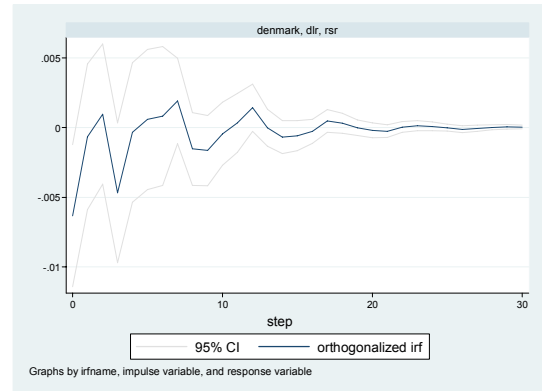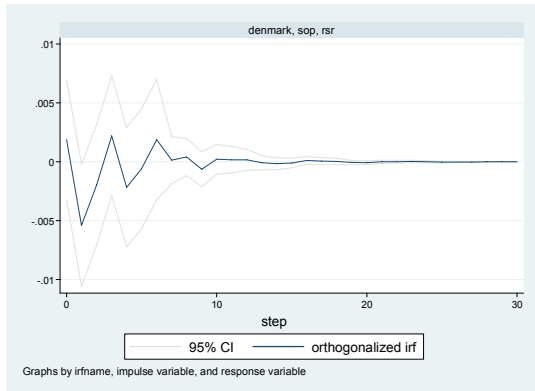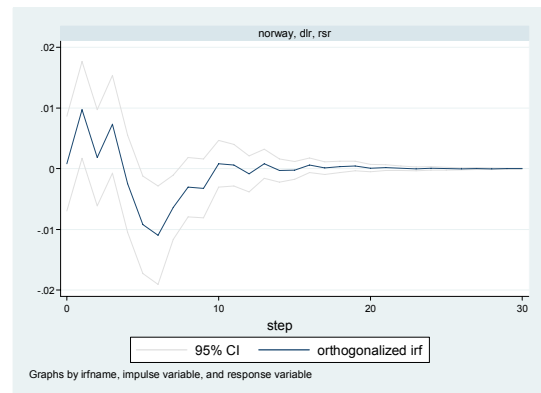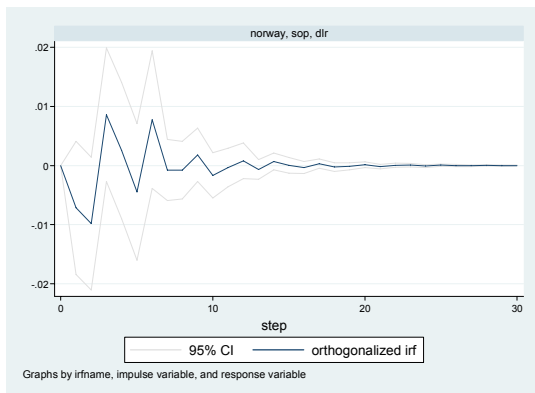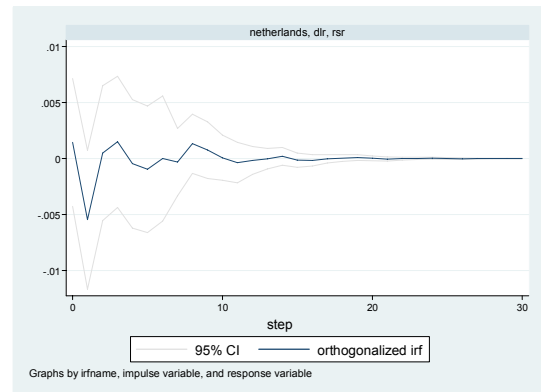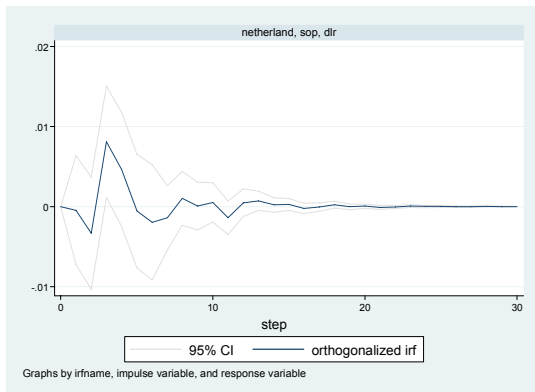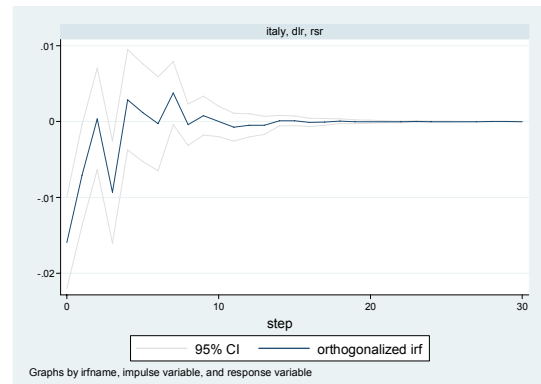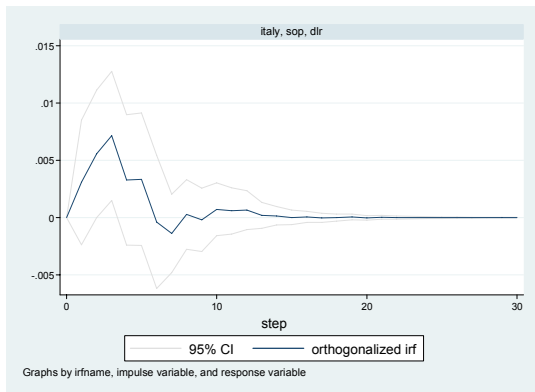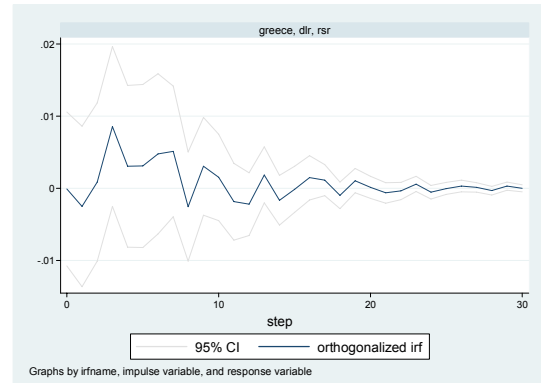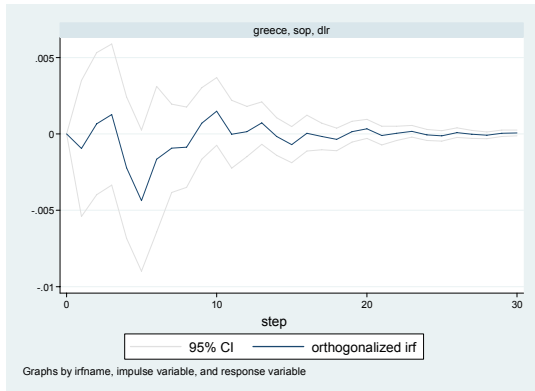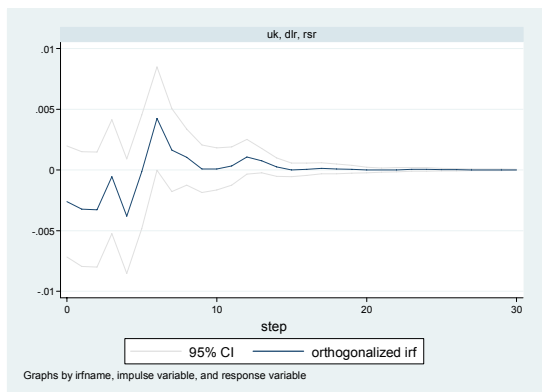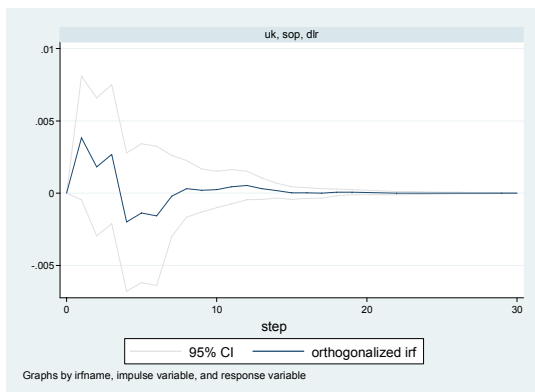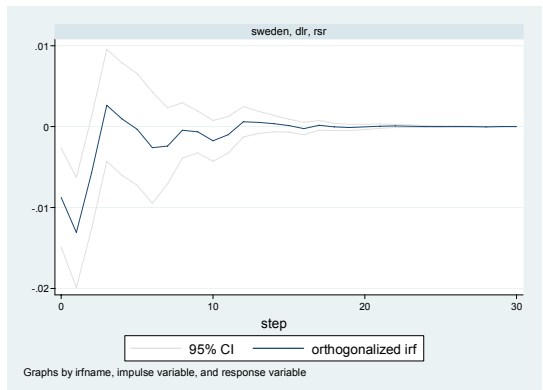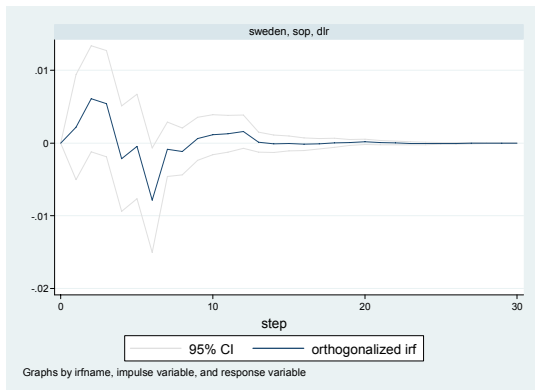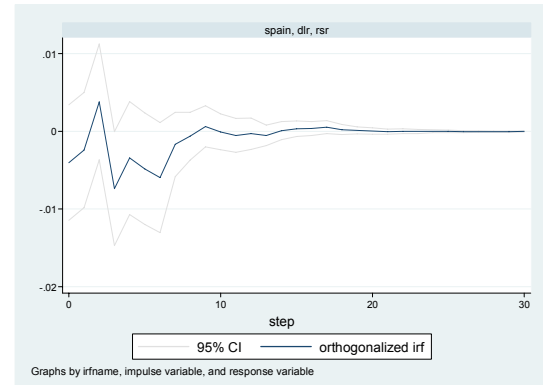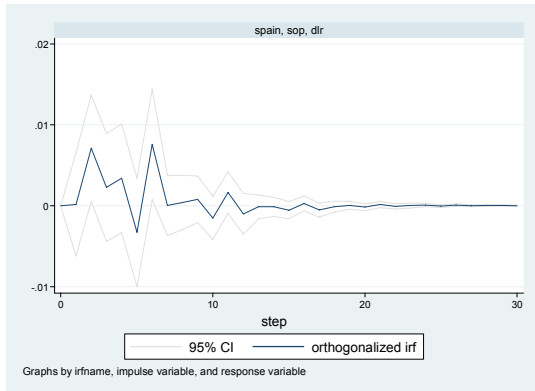
Figure 5.9 Orthogonalized impulse response function of interest rates to oil price shocks and stock returns to interest rate shocks (World oil price : NOPI specification - r, oil, ip, rsr)

Graphs by irfname, impulse variable, and response variable

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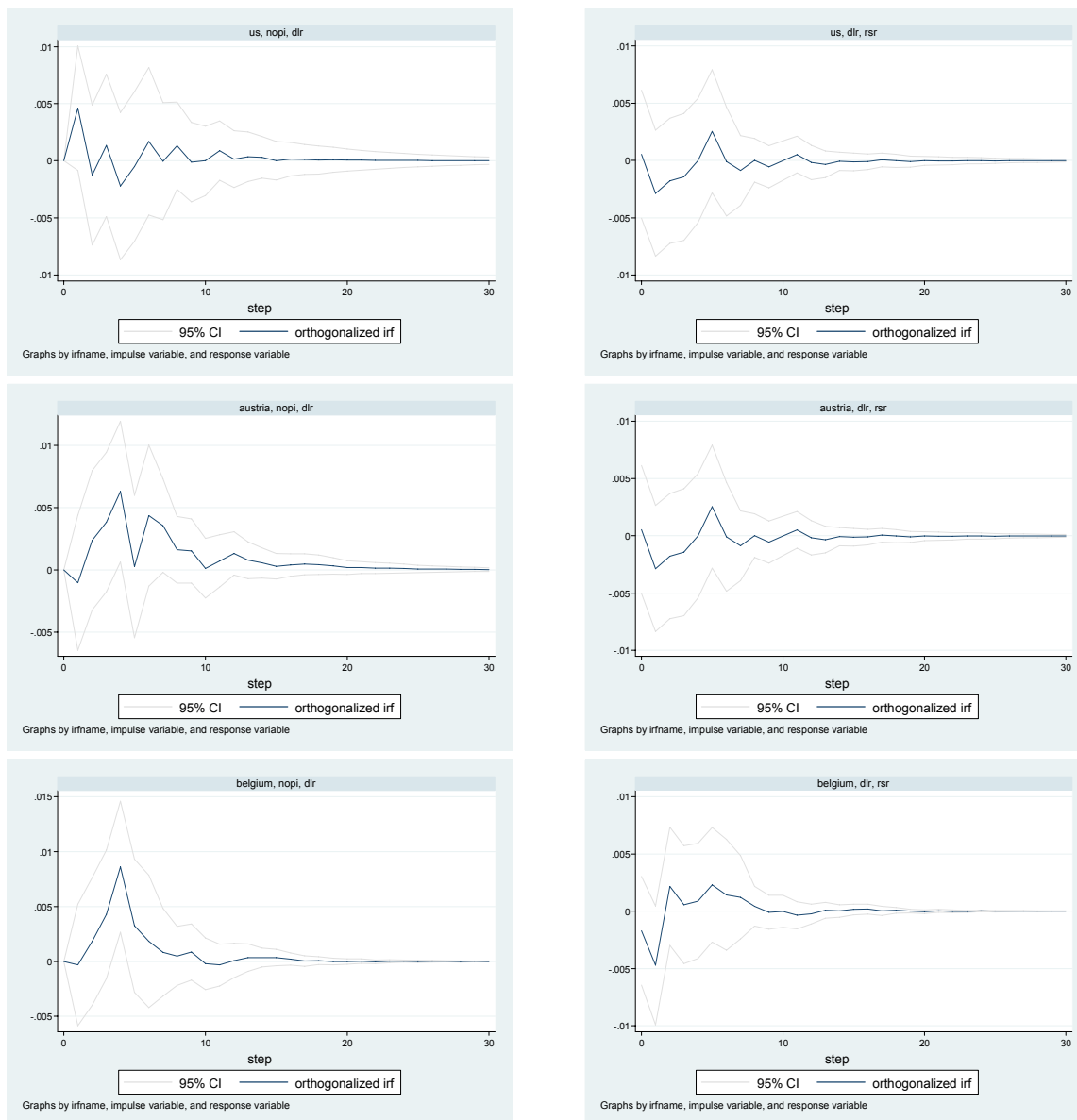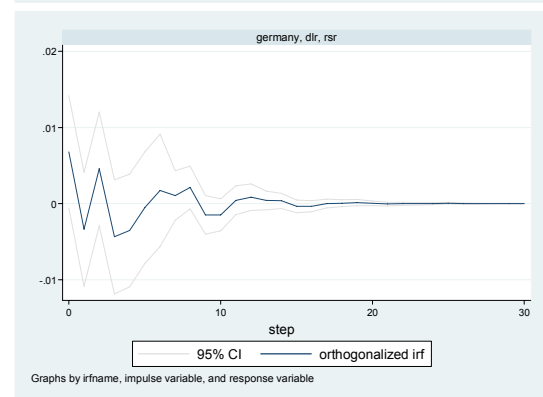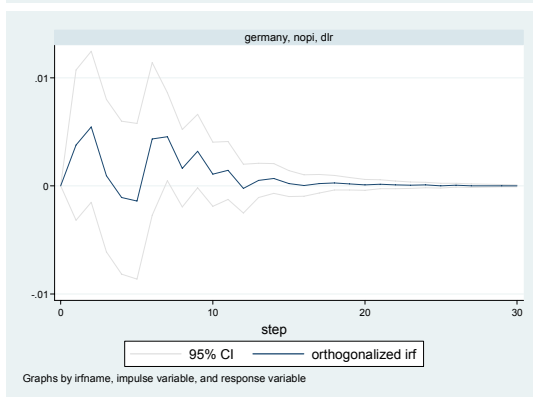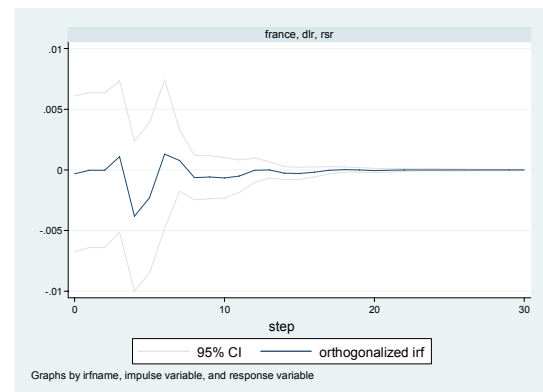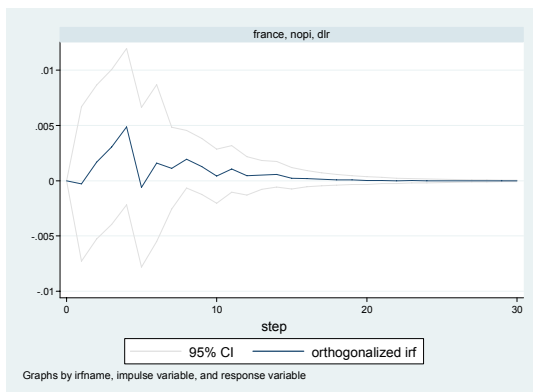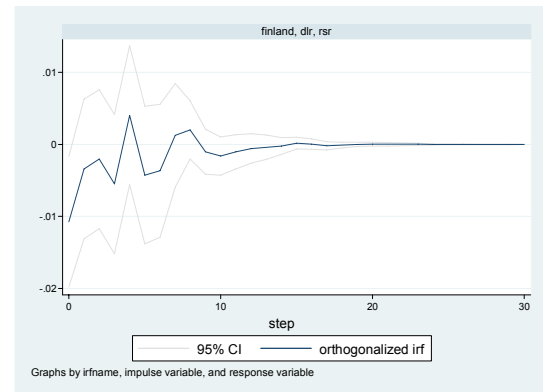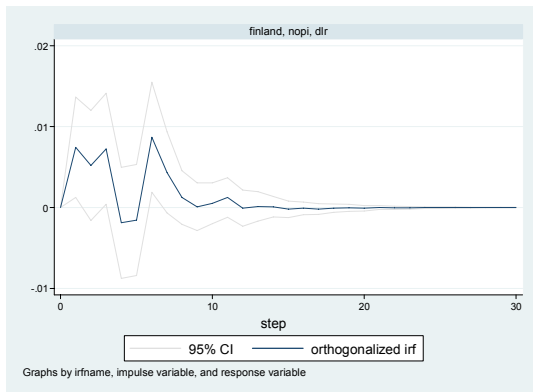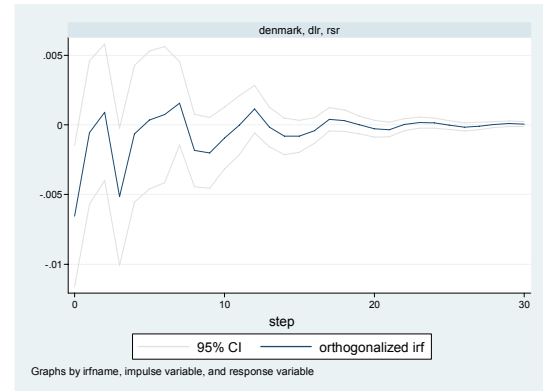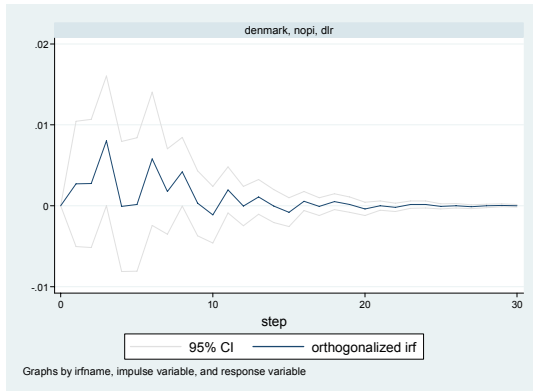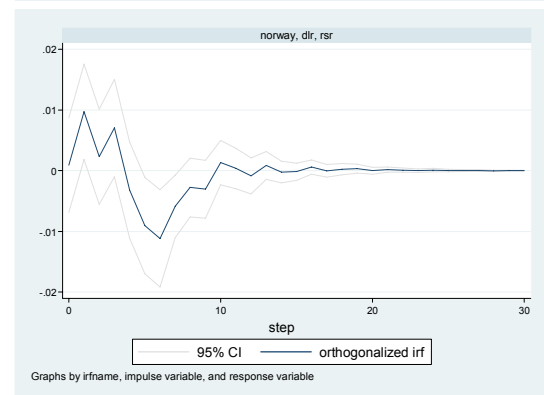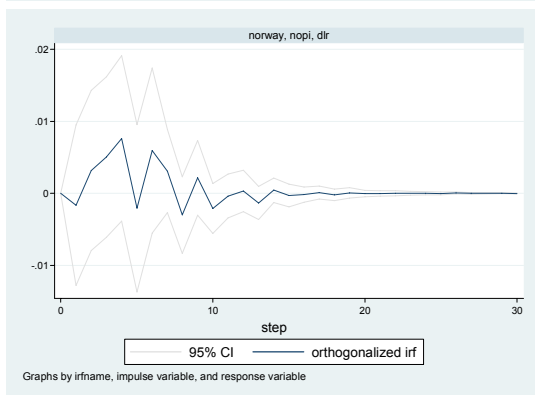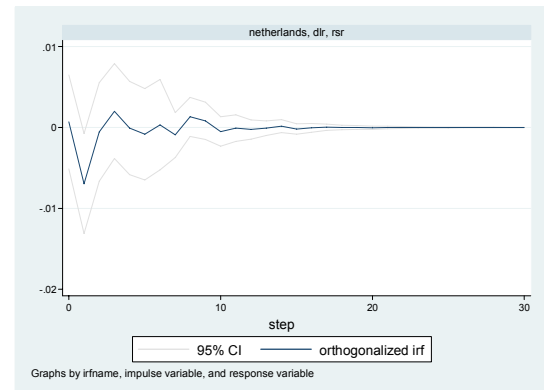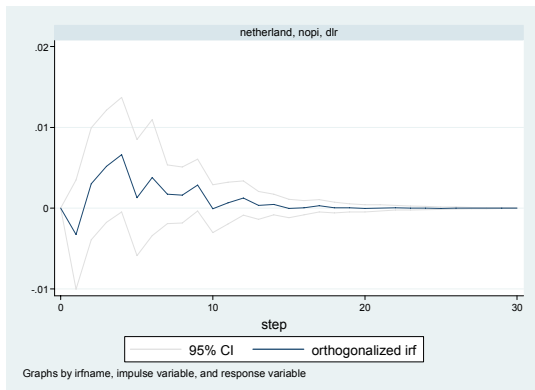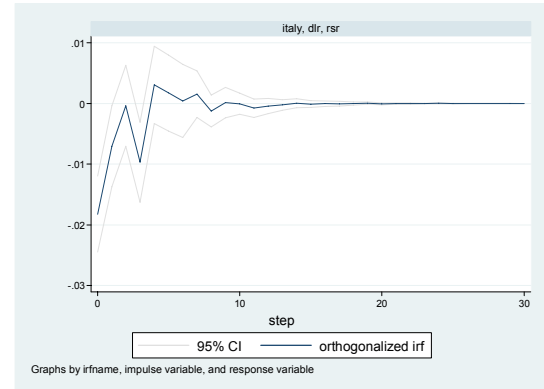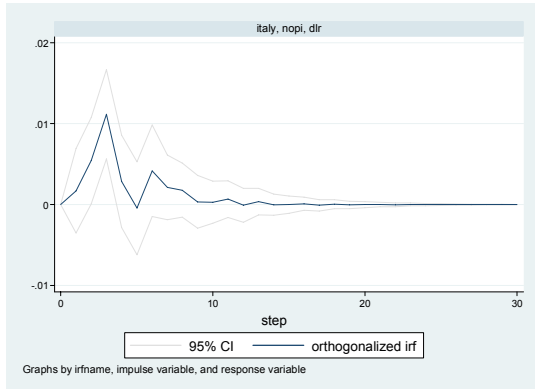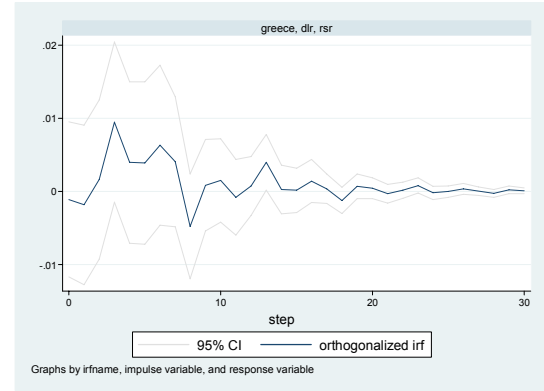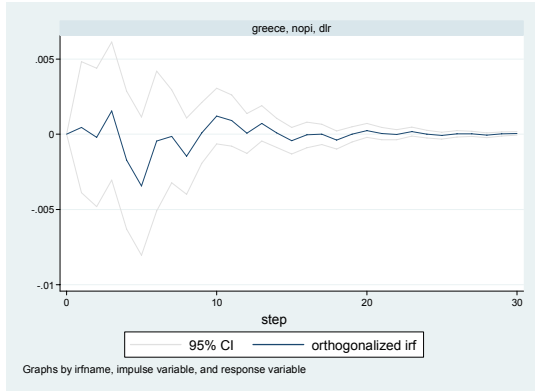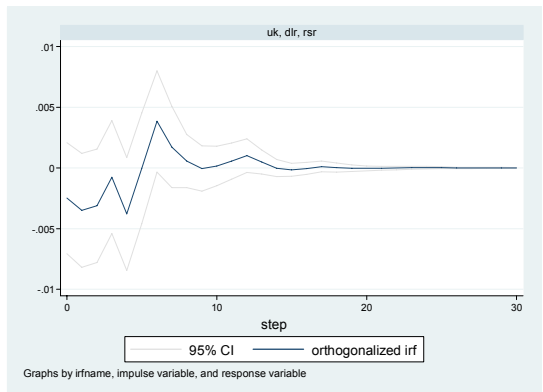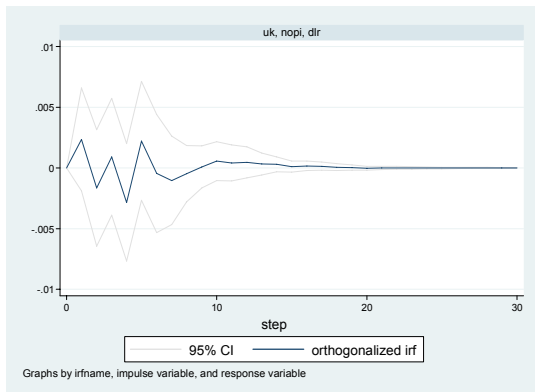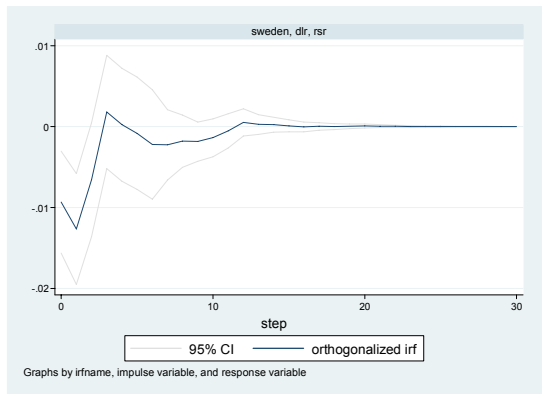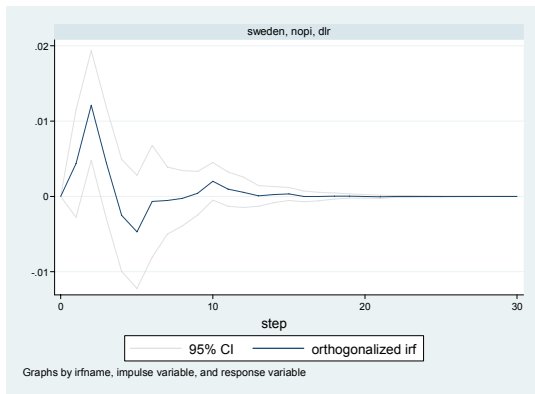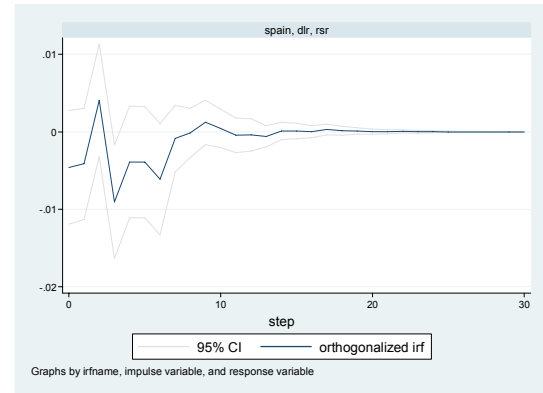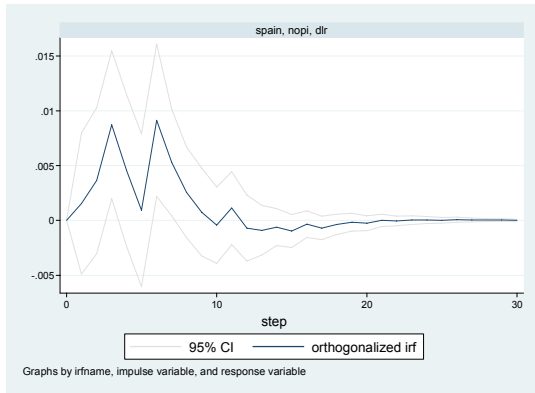
5. Asymmetric effect of oil price shocks

5.1 Variance decomposition and coefficients tests

With regard to oil price shocks, one interesting issues is the asymmetric effect. This means that the impacts of oil price increases and oil price decreases are not the same. According to the literature, oil price increases have a greater (or significant) influence on the economy and the stock market than oil prices decreases do.

I try to check whether there exists an asymmetric effect of oil price shocks on the stock market in European countries like the US. In particular, one issue which draws our attention is that the pattern of oil price fluctuation has changed since the mid 1990's. Before the mid 1990's, most oil price changes are oil price decreases, and the average magnitude of oil price decreases is relatively smaller than oil prices increases. However, after the mid 1990's the oil price increases more frequently than the oil price decreases and the magnitude of oil price increases is smaller than that of oil price decreases. So, I want to look at whether the asymmetric pattern of impact of oil price shocks on stock market is influenced by this different oil price fluctuation pattern.

I run VARs with 5 variables by splitting oil price changes into oil price increases (*dlroilp, SOPI*) and oil price decreases[32] (*dlroiln, SOPD*). I also split sample period into two sub-sample periods : 1986.1-1996.4 and 1996.5-2005.12. The reason to choose 1996.4 as criteria is that Sadorsky uses data only up to 1996.4, and it is quite an appropriate time to reflect the change of oil price fluctuation too. By splitting the sample period, I can compare the asymmetric pattern before and after 1996.4. I run VARs with 5

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[32] Since Stata is programmed to give a positive standard deviation shock, I multiplied all of data by -1 and then analyzed variance decomposition for oil price decreases.

variables for 3 different sample periods : the full sample period (1986.1 -2005.12), the first sub-sample period (1986.1-1996.4) and the second sub-sample period (1996.5-2005.12). For VARs I use 6 lags for the full sample period and 3 lags[33] for sub-sample period by taking into account degrees of freedom.

$$y_t = A_O + \sum_{i=1}^{p} A_i y_{t-i} + u_i$$

y_t = [interest rates, positive real oil price changes, negative real oil price changes, industrial production, real stock returns]'

A_i is 5×5 matrix of unknown coefficients, A_o is a column vector of deterministic constant terms, u_t is a column vector of errors with the properties of

$$E(u_t) = 0 \text{ for all t, } E(u_t u_t^{'}) = \Omega \quad \text{if s = t}, \quad E(u_s u_t^{'}) = 0 \quad \text{if s} \neq \text{t}$$

where Ω is the variance-covariance matrix. u_t's are not serially correlated but may be contemporaneously correlated. Thus, Ω is assumed to have non-zero off-diagonal elements.

The outcomes of variance decomposition analysis with significance are shown in Table 5.15. The asymmetric pattern of the impact of oil price shocks on the stock market is different depending on the sample periods. When I use the full sample period and the first sub-sample period, two kinds of asymmetric effects coexist, while the impact of an oil price increase is a little dominant. However, in the second sub-sample period, the oil price decrease has a greater impact on the stock market than the oil price increase in all countries except Norway in linear specification model and 3 countries (Belgium, Denmark, Greece) in *SOP* specification model. I also check the statistical significance of the contribution to the forecast error variance of real stock returns. Most cases in the full

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[33] I check optimal lags based on LR, AIC, BSIC, but they are not consistent.

sample period are significant at the 10% or 5% level, while only a few cases in the sub-sample period are significant at the 10% or 5% level. Particularly, the US shows a significant change of asymmetric pattern before and after 1996.4. Before 1996.4 the oil price increase has a greater impact on the stock market, even if it is not statistically significant, while in full sample period and after 1996.4 the oil price decrease has a bigger influence on the stock market at the 5% level of significance in linear and *SOP* specification models. In Belgium, the impact of an oil price increase is greater in the full sample period, while the impact of an oil price decrease is greater in second sub-sample period in linear specification model. This pattern change is significant at the 10% level. In Germany, the impact of an oil price increase is greater in the full sample period and the first sub-sample period, while the impact of an oil price decrease is greater in the second sup-sample period, which is significant at least 10% level. Based on this finding I can cautiously conclude that the asymmetric pattern of oil price shocks on the stock market is changing due to the change of oil price fluctuation pattern.

To make sure of the asymmetric effect, I also use the traditional method which compares the coefficients of oil price increase and oil price decrease in the following regression models.

For full sample period :

$$rsr_t = \alpha_o + \sum_{i=1}^{6} \alpha_{1i} dlr_{t-i} + \sum_{i=1}^{6} \alpha_{2i} dlroilp_{t-i} + \sum_{i=1}^{6} \alpha_{3i} \, dlroiln_{t-i} + \sum_{i=1}^{6} \alpha_{4i} dlip_{t-i} + \sum_{i=1}^{6} \alpha_{5t} rsr_{t-i}$$

$$rsr_t = \alpha_o + \sum_{i=1}^{6} \alpha_{1i} dlr_{t-i} + \sum_{i=1}^{6} \alpha_{2i} SOPI_{t-i} + \sum_{i=1}^{6} \alpha_{3i} SOPD_{t-i} + \sum_{i=1}^{6} \alpha_{4i} dlip_{t-i} + \sum_{i=1}^{6} \alpha_{5t} rsr_{t-i}$$

For sub-sample period :

$$rsr_t = \alpha_o + \sum_{i=1}^{3} \alpha_{1i} dlr_{t-i} + \sum_{i=1}^{3} \alpha_{2i} dlroilp_{t-i} + \sum_{i=1}^{3} \alpha_{3i} dlroiln_{t-i} + \sum_{i=1}^{3} \alpha_{4i} dlip_{t-i} + \sum_{i=1}^{3} \alpha_{5t} rsr_{t-i}$$

$$rsr_t = \alpha_o + \sum_{i=1}^{3} \alpha_{1i} dlr_{t-i} + \sum_{i=1}^{3} \alpha_{2i} SOPI_{t-i} + \sum_{i=1}^{3} \alpha_{3i} SOPD_{t-i} + \sum_{i=1}^{3} \alpha_{4i} dlip_{t-i} + \sum_{i=1}^{3} \alpha_{5t} rsr_{t-i}$$

After estimating the coefficients of each variable I carry out conventional Chi-square (χ^2) tests of the null hypothesis.

$$H_0 : \alpha_{2i} = \alpha_{3i} \qquad H_1 : \alpha_{2i} \neq \alpha_{3i}$$

The results obtained by carrying out this test of pair-wise equality of the coefficients are presented in Table 5.16. In most cases the null hypothesis cannot be rejected. However, it suggests that there is evidence of an asymmetric effect for Greece, Norway, and Spain in linear specification model and for the US, Germany, Greece, Norway, Spain in *SOP* specification model.

In conclusion, I find strong evidence that the asymmetric effect of oil price shocks on the stock market has changed in the US since in both tests the US has significance at the 5% level for *SOP* specification model. Therefore, we can think that in the US an oil price decrease has a greater impact on the real stock returns than oil price increases after the mid 1990's.

5.2 Oil exporting countries

In general, an oil price decrease has a greater impact on the stock market than that of an oil price increase, regardless of sample period.

5.3 Oil importing countries

In most countries an oil price increase has a greater impact on the stock market than that of an oil price decrease before the mid 1990's, while an oil price decrease has a greater impact on the stock market than that of an oil price increase after the mid 1990's. This means that the asymmetric response pattern of the stock market to the oil price shocks might change due to the change of oil price fluctuation patterns since mid 1990's.

5.4 Robustness check

For the robustness of these outcomes, I use a lag for the sub-sample period. The results are presented in Tables 5.17-5.18. They are very similar to outcomes when I use 3 lags but a little less significant.

Table 5.15 Asymmetric effect of oil price shocks on stock returns
(Variance decomposition, 3 lags for sub-sample period)

linear (WP)

	1986-2005 (Lag 6)		1986-1996.4 (Lag 3)		1996.5-2005 (Lag 3)	
	p	n	p	n	p	n
US	3.9 *	5.8 **	4.58	0.56	2.6	9.1 *
Austria	2.87	2.59	5.8	4.3	2	4.5
Belgium	6.91 *	3.15	6.2	2.4	5.7	10.5 *
Denmark	2.78	3.4	2	3.4	2.6	2.7
Finland	3.15	3.1 *	3.9	8.9 *	1.7	2.5
France	5.22 **	2.67	5.3	1.2	1.2	7.6
Germany	5.62 **	2.47	11.5 **	1.3	1.3	6.7
Greece	7.17 *	3.4	4.8	6.1 *	3.6	5.8
Italy	5.78 *	7.12 **	11.9 **	9.3 **	2.7	4.2
Netherlands	4.2 *	4.66 *	7.1	2.1	1.1	3.2
Norway	3.35	5.83 **	3.2	4.7 *	6.4	5.1
Spain	6.06 **	2.51	4.9	3.2	3.2	6.8
Sweden	6.91 **	5.02 **	9 *	2.5	0.8	3.2
UK	4.02 *	2.82 *	2.6	3.1	0.6	3.5

SOP (WP)

	1986-2005 (Lag 6)		1986-1996.4 (Lag 3)		1996.5-2005 (Lag 3)	
	p	n	p	n	p	n
US	3.1	7.3 **	2.6	1.3	2.9	10.3 **
Austria	2.27	2.02	4.2	2.2	1.6	3
Belgium	6.21 *	2.94	4.9	2.9	9	4.6
Denmark	2.65	3.27	2.5	0.5	1.9	1.6
Finland	2.19	3.71 *	3.8	7.6 *	1.6	3.1
France	4.16 *	1.87	5.1	2.8	1	3.2
Germany	4.51 *	3.53 *	11.4 **	1.1	1.8	7.4 *
Greece	5.17	4.59	4.2	6.7	6.3	1.8
Italy	5.78 **	7.5 **	12.7 **	5.8 *	2	2.6
Netherlands	4.65	5.01 **	4.4	3	2.6	3.9
Norway	2.75	6.91 **	2.6	5.3 **	4.3	6.9
Spain	5.19 *	3.06	5.8	2.8	3.8	7
Sweden	5.96 *	5.59 **	8.5	2.7	0.8	2.6
UK	2.51	4.43 **	2	3.9	0.3	2.8

***, ** , * denotes significance at the 1%, 5%, 10% level

Table 5.16 Asymmetric effect of oil price shocks on stock returns
(Coefficients tests, 3 lags for sub-sample period)

	$H_0 : \alpha_{2i} = \alpha_{3i}$	$H_0 : \alpha_{2i} = \alpha_{3i}$	$H_0 : \alpha_{2i} = \alpha_{3i}$
Linear (WP)			
	1986 - 2005	1986 - 1996.4	1996.5 - 2005
	(Lag 6)	(Lag 3)	(Lag 3)
US	10.2	0.89	5.06
Austria	2.3	0.52	1.33
Belgium	2.88	2.7	3.85
Denmark	8.13	3.07	0.41
Finland	3.42	2.71	2.21
France	4.54	0.52	1.32
Germany	1.4	5.79	3.24
Greece	6.35	6.91 *	1.9
Italy	9.68	3.47	1.8
Netherlands	6.42	3.06	1.78
Norway	8.32	7.99 **	3
Spain	7.07	0.98	7.17 *
Sweden	7.55	1.35	1
UK	7.02	1.2	1

	$H_0 : \alpha_{2i} = \alpha_{3i}$	$H_0 : \alpha_{2i} = \alpha_{3i}$	$H_0 : \alpha_{2i} = \alpha_{3i}$
SOP (WP)			
	1986 - 2005	1986 - 1996.4	1996.5 - 2005
	(Lag 6)	(Lag 3)	(Lag 3)
US	14.36 **	2.39	8.29 **
Austria	0.64	0.6	1.22
Belgium	5.86	1.63	4.39
Denmark	6.94	0.27	0.26
Finland	4.6	2.62	2.64
France	1.72	1.72	1.7
Germany	3.56	4.53	6.54 *
Greece	5.92	7.44 *	1.2
Italy	7.86	1	1.6
Netherlands	10.04	3.46	3.48
Norway	6.93	9.58 **	1.64
Spain	8.09	1.99	8.99 **
Sweden	7.73	0.91	1.54
UK	7.65	1.2	1.9

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

Table 5.17 Asymmetric effect of oil price shocks on stock returns
(Variance decomposition, 1 lag for sub-sample period)

linear (WP)

	1986 - 2005 (Lag 6)				1986 - 1996.4 (Lag 1)				1996.5 - 2005 (Lag 1)		
	p		n		p		n		p	n
US	3.9	*	5.8	**	3.5		0.5		2.5	6.3
Austria	2.87		2.59		4.3		3.2		1.5	3.7
Belgium	6.91	*	3.15		8		5		4	9.3
Denmark	2.78		3.4		1.7		0.7		1.9	2.6
Finland	3.15		3.1	*	2.3		6.7	*	1.1	2.2
France	5.22	**	2.67		5.3		4		1.5	7.1
Germany	5.62	**	2.47		11.2	**	1		1.3	4.4
Greece	7.17	*	3.4		4.4		3.2		1.4	3.2
Italy	5.78	*	7.12	**	9.4	*	14.5	***	2.2	3.7
Netherlands	4.2	*	4.66	*	6		2.7		0.9	8
Norway	3.35		5.83	**	0.1		3.4		4.9	3
Spain	6.06	**	2.51		6		4.9		3.1	5.9
Sweden	6.91	**	5.02	**	10.1	*	4.1		0.6	3.1
UK	4.02	*	2.82	*	4.5		3.5		0.7	4.4

SOP (WP)

	1986 - 2005 (Lag 6)				1986 - 1996.4 (Lag 1)				1996.5 - 2005 (Lag 1)		
	p		n		p		n		p	n
US	3.1		7.3	**	1.5		0.1		2.6	6.6
Austria	2.27		2.02		2.5		1.3		0.5	2.6
Belgium	6.21	*	2.94		6		2.3		5.7	5.3
Denmark	2.65		3.27		1.1		0.8		0.6	1.5
Finland	2.19		3.71	*	1.2		2.9		0.9	1.9
France	4.16	*	1.87		4		0.9		1.0	3.8
Germany	4.51	*	3.53	*	10.8	**	0.2		1.6	4.3
Greece	5.17		4.59		2.3		5		3.2	1.3
Italy	5.78	**	7.5	**	8.8	*	5.6	*	1.4	3.4
Netherlands	4.65		5.01	**	3.8		2.8		1.5	4.8
Norway	2.75		6.91	**	0.9		3.2		2.9	5.1
Spain	5.19	*	3.06		6		0.6		3.1	5.9
Sweden	5.96	*	5.59	**	6.2		1.8		0.4	2.7
UK	2.51		4.43	**	3.8		3.8		0.1	4.3

***, ** , * denotes significance at the 1%, 5%, 10% level

Table 5.18 Asymmetric effect of oil price shocks on stock returns
(Coefficients tests, lag for sub-sample period)

	$H_0 : \alpha_{2i} = \alpha_{3i}$	$H_0 : \alpha_{2i} = \alpha_{3i}$	$H_0 : \alpha_{2i} = \alpha_{3i}$
Linear (WP)			
	1986 - 2005	1986 - 1996.4	1996.5 - 2005
	(Lag 6)	(Lag 1)	(Lag 1)
US	10.2	0.39	4.32
Austria	2.3	0.03	1.14
Belgium	2.88	1.58	0.77
Denmark	8.13	0.06	0.78
Finland	3.42	1.41	0.02
France	4.54	1.37	0.59
Germany	1.4	0.48	1.36
Greece	6.35	0.49	0.49
Italy	9.68	7.02 ***	0.94
Netherlands	6.42	1.14	1.20
Norway	8.32	0.51	1.86
Spain	7.07	1.67	5.08 **
Sweden	7.55	0.79	0.35
UK	7.02	1.89	1.80

	$H_0 : \alpha_{2i} = \alpha_{3i}$	$H_0 : \alpha_{2i} = \alpha_{3i}$	$H_0 : \alpha_{2i} = \alpha_{3i}$
SOP (WP)			
	1986 - 2005	1986 - 1996.4	1996.5 - 2005
	(Lag 6)	(Lag 1)	(Lag 1)
US	14.36 **	0.45	6.11 **
Austria	0.64	0.03	0.43
Belgium	5.86	0.36	1.29
Denmark	6.94	0.02	0.83
Finland	4.6	0.19	0.08
France	1.72	0.02	0.87
Germany	3.56	2.22	3.18 *
Greece	5.92	1.82	0.01
Italy	7.86	0.41	1.25
Netherlands	10.04	1.48	2.20
Norway	6.93	4.05 **	0.40
Spain	8.09	0.26	6.23 **
Sweden	7.73	0.10	0.99
UK	7.65	0.57	2.78 *

***, ** , * denotes rejection of the null hypothesis at the 1%, 5%, 10% level of significance

CHAPTER VI

CONCLUSION

Evidence that oil price shocks have a significant impact on the stock market in the US and European countries is found. However, the impacts of oil price shocks on the stock market are different between oil exporting countries and oil importing countries. I also find evidence for a change in asymmetric effect of oil price shocks on the stock market.

Empirical results from the impact of oil price shocks on real stock returns show that in all countries except Finland and the UK real stock returns respond significantly to oil price shocks immediately or in a month. For most oil importing countries, oil price shocks have a significantly negative impact on the stock market in a month, while in the US and Germany the response of real stock returns are instantaneous to oil price shocks. On the contrary, among oil exporting countries only Norway shows a significantly positive response of the stock market to oil price shocks, while it is insignificant in the UK and significantly negative in Denmark. These results are robust to alternative VARs - a VAR with 4 variables : real oil price changes, interest rates, industrial production, real stock returns (different ordering from the basic VAR) and a VAR with 5 variables : interest rates, real oil price changes, industrial production, inflation, real stock returns.

Comparing the impacts of oil price shocks and interest rate shocks on the stock market, oil price shocks have a greater influence on the stock market than interest rate shocks in most oil importing countries. In variance decomposition analysis, in 3 out of 11 oil importing countries (Italy, Spain, and Sweden) oil price shocks have a smaller impact

on the stock market than interest rate shocks, while in impulse response function analysis, 4 out of 11 oil importing countries (Finland, Italy, Spain, and Sweden) show an significant response of real stock returns to interest rate shocks. Interestingly, 3 oil importing countries (Italy, Spain, and Sweden) are common in both cases. So, I conduct an impulse response function analysis to investigate whether systematic monetary policy (interest rates) to oil price shocks could explain the greater impact of interest rate shocks in certain oil importing countries. The 7 out of 11 oil importing countries (Belgium, Finland, Germany, Italy, Netherlands, Spain and Sweden) show a significantly positive response of interest rates to oil price shocks. Strong evidence is found that in Italy, Spain and Sweden, where the impact of interest rate shocks on the stock market is greater than oil price shocks, monetary policy responds systemically to oil price shocks by raising the interest rates, leading to a decline in real stock returns. Therefore, oil price shocks are primarily influential factor to stock market behavior in oil importing countries. Conversely, in oil exporting countries oil price shocks have a smaller impact than interest rate shocks, and monetary policy (interest rates) does not respond systematically to oil price shocks.

For the analysis of the asymmetric effect of oil price shocks, I split the sample period into two sub-periods : 1986.1-1996.4 and 1996.5-2005.12. According to the literature, oil price changes have the asymmetric effect on the stock market such that oil price increases have a greater impact on the stock market than oil price decreases. However, in my analysis the asymmetric response pattern is a little different. In the full sample period of 1986 - 2005 and sub-sample period of 1896-1996.4 there exist mixed asymmetric response patterns. It means that in some oil importing countries oil price

increases have a greater impact than oil price decreases, while in some oil importing countries oil price decreases have a greater impact than oil price increases. But the impact of an oil price increase is a little dominant. A striking finding is that in the sub-sample period of 1996.5-2005.12, when the oil price increases more frequently and the average magnitude of oil price increases is smaller than that of oil price decreases, the stock market in most countries are more influenced by an oil price decrease than an oil price increase in variance decomposition analysis. In the case of oil exporting countries, an oil price decrease has a greater impact on the stock market than an oil price increase, regardless of sample period in general. Particularly, I find strong evidence that the asymmetric effect of oil price shocks on the stock market has changed in the US. Because it shows a significant asymmetric effect at the 5% level in variance decomposition and coefficient tests of a *SOP* specification model that oil price decreases have a greater impact on real stock returns than oil price increases after the mid 1990's.

In conclusion, oil price shocks have a significant impact on the stock market in most countries, and the impacts in oil importing countries are quite different from those in oil exporting countries. Future work should examine the industrial classification of firms most affected by oil price shocks. Is the impact greater on energy intensive industries? Is the impact greater depending on the products produced by firms? Is the impact greater on firms with market power? Do results by industry differ between oil importing or exporting countries? All these factors may affect how oil prices should affect stock prices. Finally, it should be noted that a weakness of my study is that it does not present an economic model relating oil prices to firm's dividends and performance. These issues remain on the agenda for future work.

REFERENCE

Balke, N.S., S.P.A. Brown, and M.K. Yucel (2002), "Oil price shocks and the U.S. Economy: where does the asymmetry originate ?" Energy journal 23(3):27-52

Barnett, S.A., and P. Sakellaris (1998), Nonlinear response of firm investment to Q : Testing a model of convex and non-convex adjustment costs, Journal of monetary economics, 42, 261-288

Barsky, R.B., and L. Kilian (2002), "Do we really know that oil casued the Great Stagflation? A monetary approach," NBER Macroeconomics Annual, 2001 16/1:137-183

Bernanke, Ben S, and Kenneth N. Kuttner (2005), "What explains the stock market's reaction to federal reserve policy?" Journal of Finance 60(3) 1221-1257

Bernanke, Ben S. Mark Gertler, and Mark Watson (1997), "Systemic monetary policy and the effects of oil price shocks" Brookings papers on economic activity 1:91-157

Burbidge, J., and A. Harrison. (1984), "Testing for the Effects of Oil-Price Rises Using Vector Autoregression," International Economic Review 25: 459-484

Cavallo, Michele, and Tao Wu (2006), "Measuring Oil-price shocks using market-based information" Federal reserve bank of San Francisco working paper series

Cheung, Yin-Wong, Lilian K.Ng (1998), "International evidence on the stock market and aggregate economic activity" Journal of Empirical Finance, 5(3) 281-296

Choe, Kwang yoon (2002), "Differential impacts of oil price shock on small vs. large firms as a source of real effect on the economy" University of Missouri dissertation paper

Clements, M.P., and D.F. Hendry (1995), "Forecasting in Cointegrated System" Journal of Applied Econometrics 10:127-146

Cologni, Alessandro and Matteo Manera (2007), "Oil prices, inflation and interest rates in a structural cointegrated VAR model for the G-7 countries" Energy economics

Cunado, J., and F. Perez de Gracia (2003), "Do oil price shocks matter ? Evidence for some European countries" Energy Economics 25:137-154

Cunado, J., and F. Perez de Gracia (2005), " Oil prices, economic activity and inflation : evidence for some Asian countries" The Quarterly Review of Economics and Finance 45:65-83

Davis, S.J., and J.Haltiwanger (2001), "Sectoral job creation and destruction response to oil price changes" Journal of Monetary Economics 48:465-512

Dotsey, M., and Reid, M. (1992), "Oil shocks, monetary policy, and economic activity," Federal reserve bank of Richmond economic review, July 14-27

Engle, R.F., and B.S. Yoo (1987), "Forecasting and Testing in cointegrated system" Journal of Econometrics 35:143-159

Fama.E.F.,(1981), "Stock returns, real activity, inflation, and money" American Economic Review 71:545-565

Ferderer, J. (1996), "Oil price volatility and the macroeconomy," Journal of Macroeconomics 18: 1-26

Finn, M.G..(2000), " Perfect Competition and the Effects of Energy Price Increase on Economic Activity," Journal of Money, Credit and Banking 32:400-416

Gisser, M., and T.H. Goodwin(1986), "Efficient Pricing During Oil Supply Distribution," Energy Journal7(2):51-68

Gjerde, Oystein and Saettem, Frode (1999), "Causal relations among stock returns and macroeconomic variables in a small, open economy" Journal of International financial market, Institutions and Money 9:61-74

Guo, Hui and Kevin L.Kliesen (2005), "Oil price volatility and U.S. macroeconomic activity" Federal reserve bank of St.Louis review 87(6) : 669-683

Hamilton, J.D.(1983), "Oil and the Macroeconomy since World War II," Journal of Political Economy 91:228-248

Hamilton, J.D. (1988), "A Neoclassical Model of Unemployment and the Business Cycle," Journal of Political Economy 96: 593-617

Hamilton, J.D. (1996), "This is what happened to the Oil price-Macroeconomy Relationship," Journal of Monetary Economics 38: 215-220

Hamilton, James D., and Ana Maria Herrera (2004), "Oil shocks and aggregate macroeconomic behavior : the role of monetary policy" Journal of money, credit, and banking 36(2) : 265-286

Hoffman, D.L., and R.H. Rasche (1996) "Assessing Forecast performance in a Cointegrated system" Journal of Applied Econometrics 11:495-517

Hooker, M.A. (1996), "What happened to the Oil price-Macroeconomy Relationship" Journal of Monetary Economics 38: 195-213

Hooker, M.A. (1999), "Oil and Macroeconomy Revisited." Mimeo, Federal Reserve Board, Washington, D.C., August.

Hooker, M.A (2000), "Are Oil Shocks Inflationary? Asymmetric and Nonlinear Specifications versus Changes in Regime." Mimeo, Federal Reserve Board, Washington, D.C., August

Huang, Bwo-Nung, M.J.Hwang, Hsiao-Ping Peng (2005), " The asymmetry of the impact of oil price shocks on economic activities : An application of the multivariate threshold model" Energy Economics 27:445-476

Jansen, W.Jos (2003), "The stock market and consumer confidence : European evidence" Economics Letters 79(1) 89-98

Jimenez-Rodriguez, Rebeca and Marcelo Sanchez (2005), "Oil price shocks and real GDP growth: empirical evidence for some OECD countries. Applied Economics 37:201-228

Johansen, S., Juselius, K., (1990), "Maximum likelihood estimation and inference on cointegration-with applications to demand for money." Oxf. Bull. Econ. 52, 169-210

Johnston, J., and Dinardo, J (1997), "Econometric methods" Fourth edition

Jones, C.M., and G. Kaul (1996) "Oil and the Stock Market", Journal of Finance 51:463-491

Jones, Donald W., Paul N. Leiby and Inja K. Paik (2004), "Oil price shocks and the macroeconomy : what has been learned since 1996" Energy Journal 25(2)

Rotemberg, Julio J., and Michael Woodford (1996), "Imperfect competition and the effects of energy price increases on economic activity" Journal of Money, credit and banking 28(4) : 549-5

Keane, M. P., and E.S. Prasad (1996), " The employment and wage effects of oil price changes : a sectoral analysis" The Review of Economics and Statistics 78(3) : 389-400

Kilian, Lutz (2006), "Not all oil price shocks are alike : disentangling demand and supply shocks in the crude oil market" University of Michigan and CEPR

Kling, John L (1985), "Oil price shocks and stock market behavior" Journal of Portfolio Management 12(1)

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P., Shin, Y., (1992), "Testing the null hypothesis of stationarity against the alternative of a unit root." Journal of Econometrics 54, 159-178

Lee, B, -S., (1992), "Causal relations among stock returns, interest rates, real activity, and inflation" Journal of Finance 47 : 1591-1603

Lee, Byung Rhae (1998), "Monetary policy and the effects of oil price shocks on the

Japanese economy" University of Missouri dissertation paper

Lee, Chien-Chiang (2005), "Energy consumption and GDP in developing countries : A cointegrated panel analysis" Energy Economics 27:415-427

Lee, Chien-Chiang (2007), "Energy consumption and GDP revisited : A panel analysis of developed and developing countries" Energy Economics
Lee, K.S. Ni, and R.A. Ratti (1995), "Oil shocks and the Macroeconomy: The role of Price Variability," Energy Journal 16(4):39-56

Lee, K.S., and Shawn Ni (2002), "On the dynamic effects of oil price shocks : a study usig industry level data" Journal of Monetary Economics 49 : 823-852

Maghyereh, Aktham (2004), " Oil price shocks and emerging stock markets : a generalized VAR approach" International Journal of Applied Econometrics and Quantitative Studies 1(2) 27- 40

Mauro, Paolo (2000), "Stock retruns and output growth in emerging and advanced economies" IMF working paper WP/00/89

Miguel, C. de, B.Manzano, and J.M. Martin-Moreno (2003), "Oil price shocks and aggregate fluctuations" Energy Journal 24(2): 47-61

Mork, K.A.(1989), "Oil and the Macroeconomy when Prices Go Up and Down: An Extension of Hamilton's Results," Journal of Political Economy 97:740-744

Naka, A. and D. Tufte (1997), "Examining Impluse Response Functions in Cointegrated system" Applied Economics 29:1593-1603

Otoo, M.W. (1999), Consumer sentiment and the stock market, Finance and Economics Discussion Paper 1999-60 (November), Federal Reserve Board

Papapetrou, Evangelia (2001), "Oil price Shocks, Stock Market, Economic Activity and Employment In Greece," Energy Economics 23:511-532

Phillips, P.C.B., Perron, P., (1988), "Testing for a unit root in time series regression." Biometrika 75, 335-346.

Pindyck, R., (1991), "Irreversibility, uncertainty and investment." Journal of Economic Literature. 29(3) : 1110-1148

Poterba, J.M. (2000), Stock market wealth and consumption, Journal of Economic Perspectives, 14, 11-118

Sadorsky, P(1999), "Oil price shocks and stock market activity," Energy Economics 21: 449-469

Stock, J.H. and M.W. Watson (2001), "Forecasting output and inflation : The role of asset prices" NBER working paper 8180, Cambridge, MA.

Tsay, Ruey S (2005), "Analysis of financial time series" Second edition

APPENDIX

1. **Data source - 1986.1 to 2005.12**

   Nominal oil price : IMF data from IFS, UK Brent (11276AADZF)

   Real oil price of world : Nominal oil price deflated by the US PPI

   Real oil price of each country : Nominal oil price * exchange rate and deflated by the CPI of each country

   < US >

   Consumer Price Index : FRED (Federal Reserve Economic Data) from Consumer Price Index for All Urban Consumers: All Items (CPIAUCSL), seasonally adjusted

   Industrial Production : FRED (Federal Reserve Economic Data) from Industrial Production Index (INDPRO, 2002 = 100), seasonally adjusted

   Share Prices : S&P 500 Index From COMPUSTAT NORTH AMERICA (I0002-S&P 500 comp-Ltd)

   Short-term interest rates : FRED (Federal Reserve Economic Data) from 3 month treasury bill (TB3MS)

   Producer Prices Indexes : FRED (Federal Reserve Economic Data) from Producer Price Indexes : All commodities (PPIACO)

   < European countries >

   Exchange Rate : FRED (Federal Reserve Economic Data)

   Consumer Price Index : OECD data from Main Economic Indicators (2000 = 100), seasonally adjusted with X-11 procedure

   Industrial Production : OECD data from Main Economic Indicator (seasonally adjusted)

   Share Prices : OECD data from Main Economic Indicators, except for Finland from IMF (17262...ZF. industrial)

   Short-term interest rates : IMF data from IFS for Germany, Belgium, Spain, Greece, Sweden, UK (Treasury bill rate - line 60c), for Finland, Italy, Denmark, Norway (Money market rate – line 60 b). For Austria from OECD data from Main Economic Indicators. For Netherlands, call money rate from Bank of Netherlands. For France, money market rate from INSEE(National Institute for Statistics and Economic Studies).

2. Orthogonalized impulse response functions of alternative VARs

Figure 1. Orthogonalized impulse response function of stock returns to oil price shocks
(World oil price : linear specification - oil, r, ip, rsr)

Graphs by irfname, impulse variable, and response variable

Figure 2. Orthogonalized impulse response function of stock returns to oil price shocks
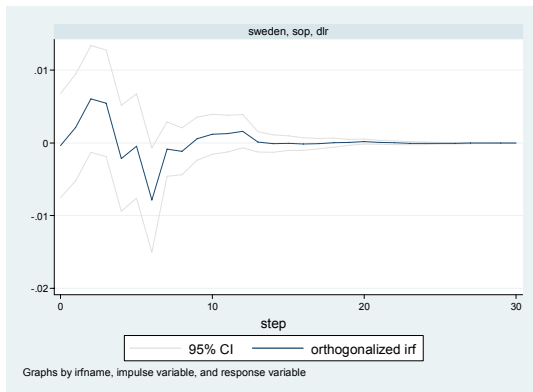(World oil price : *SOP* specification - oil, r, ip, rsr)

Graphs by irfname, impulse variable, and response variable
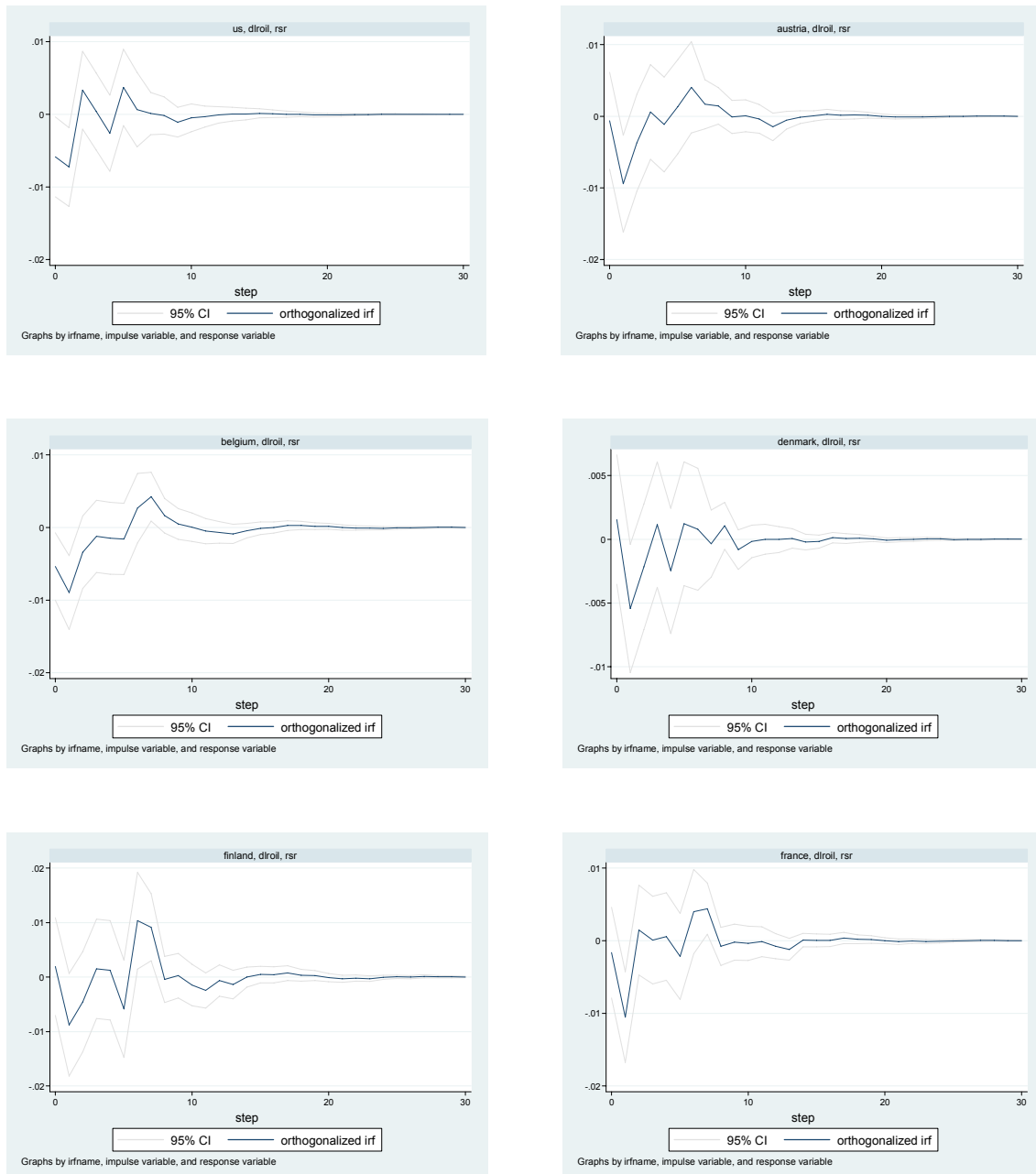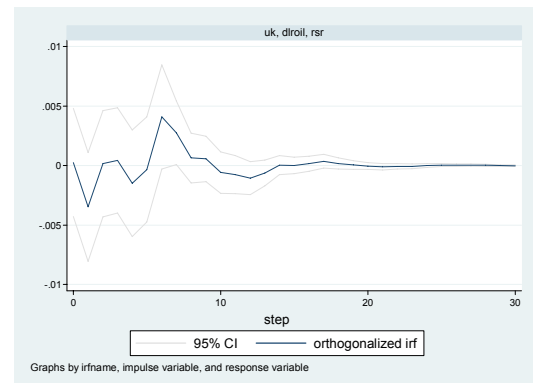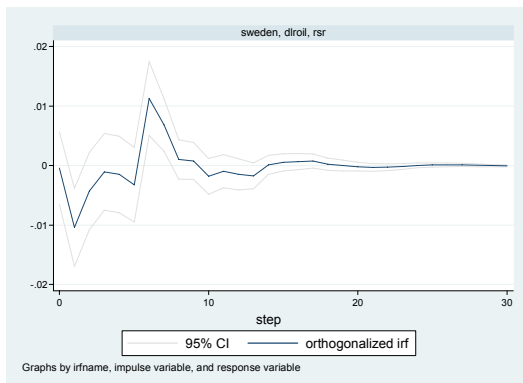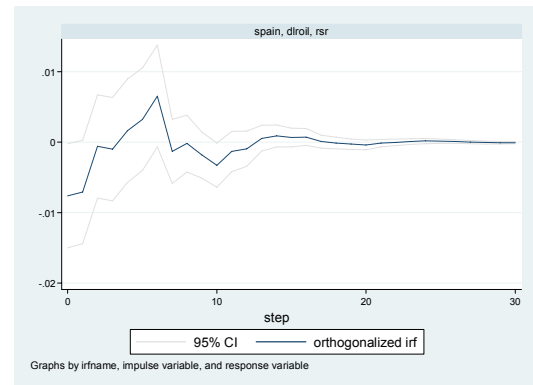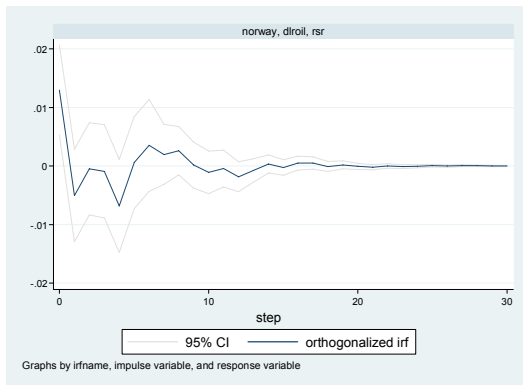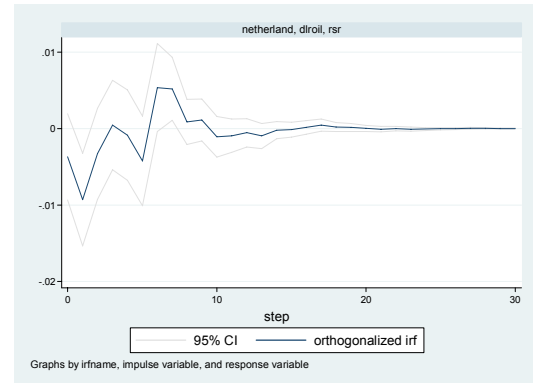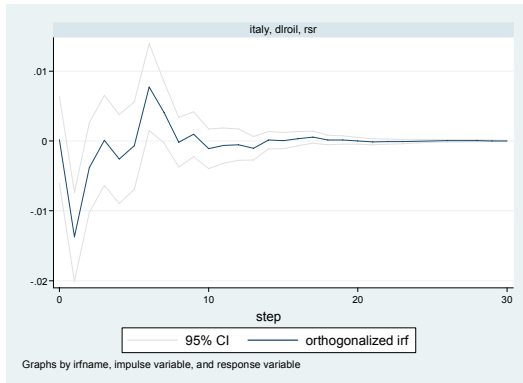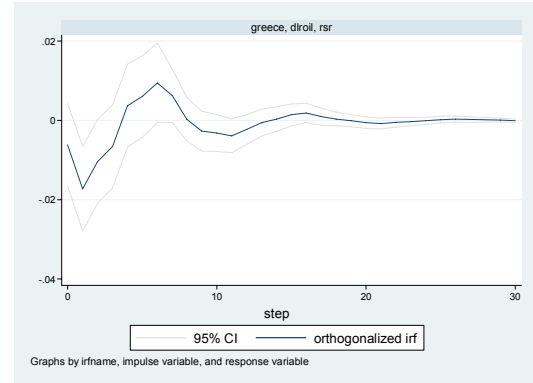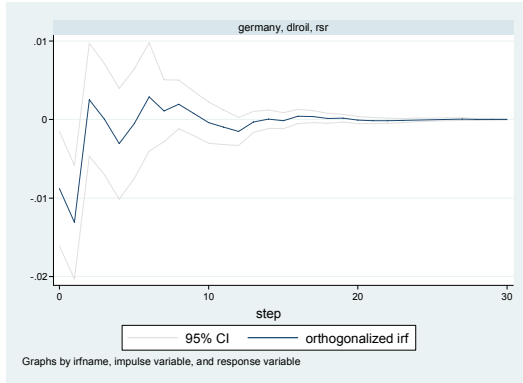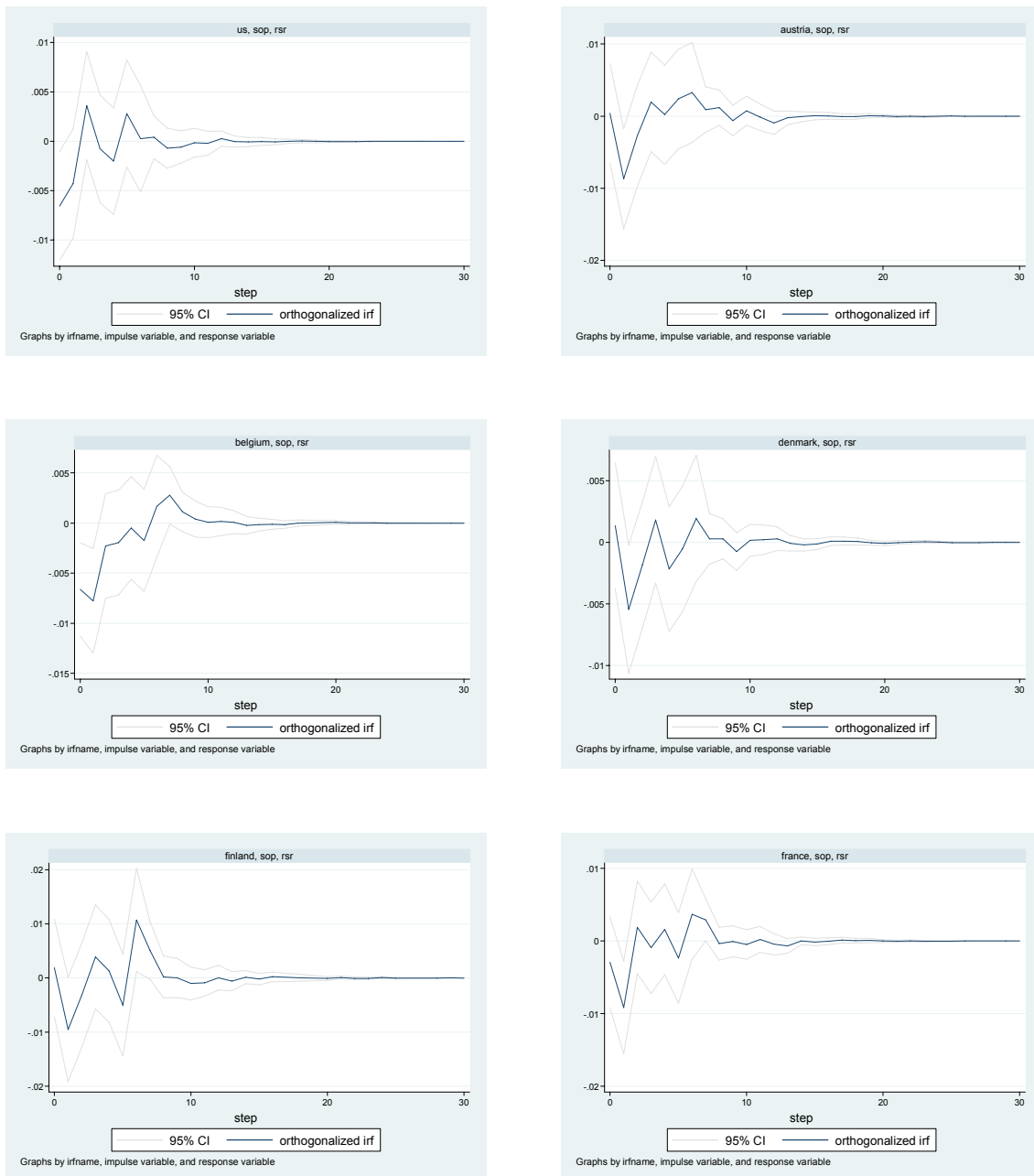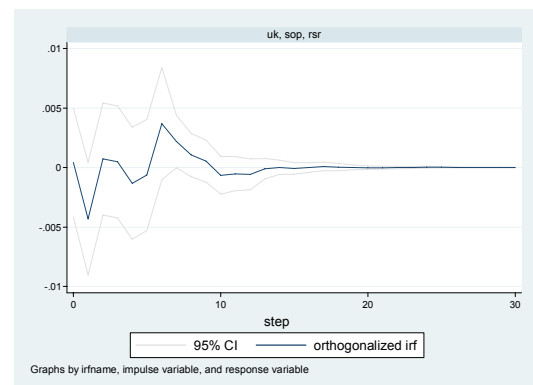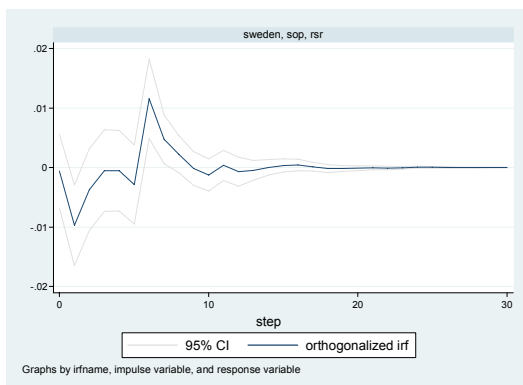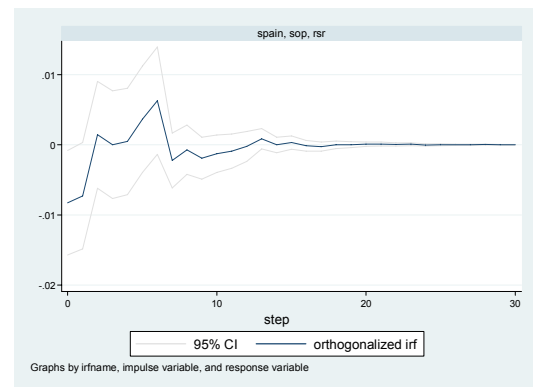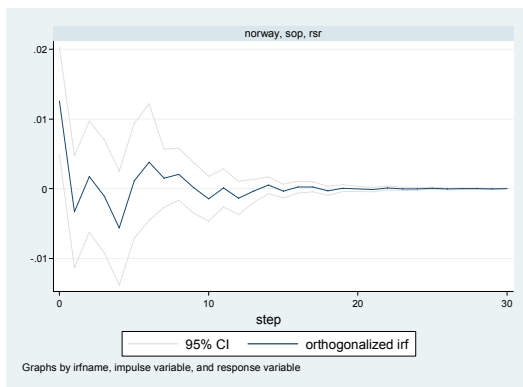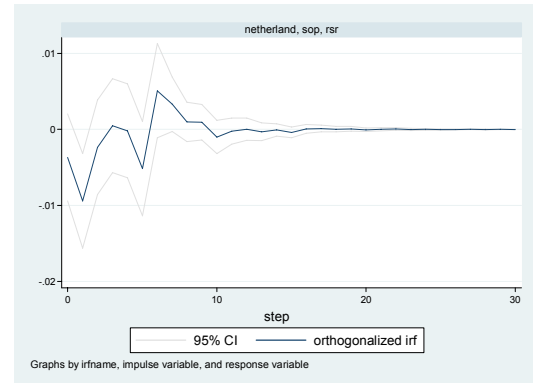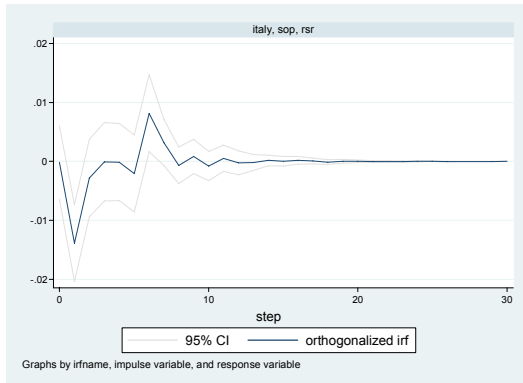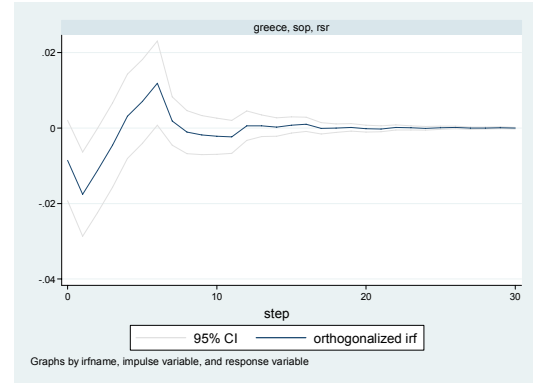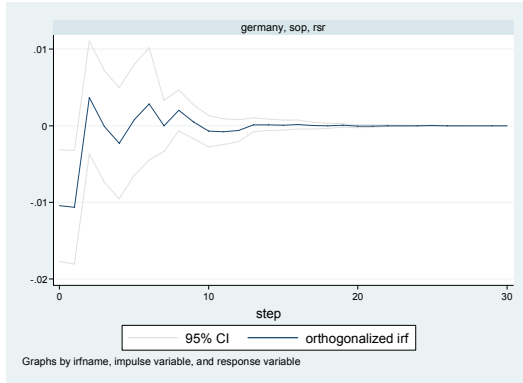
Figure 3. Orthogonalized impulse response function of stock returns to oil price shocks
(World oil price : *NOPI* specification - oil, r, ip, rsr)

Graphs by irfname, impulse variable, and response variable
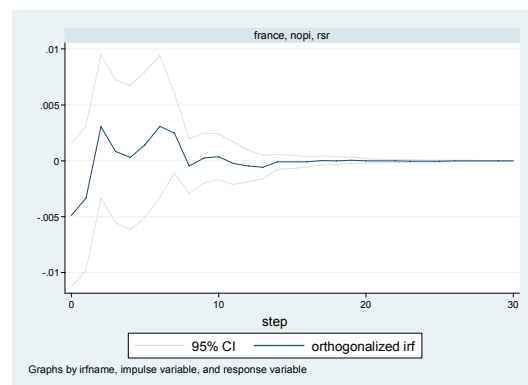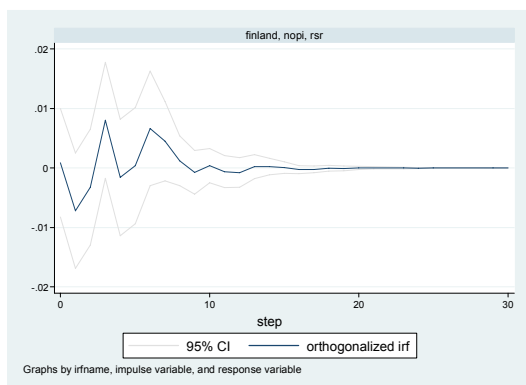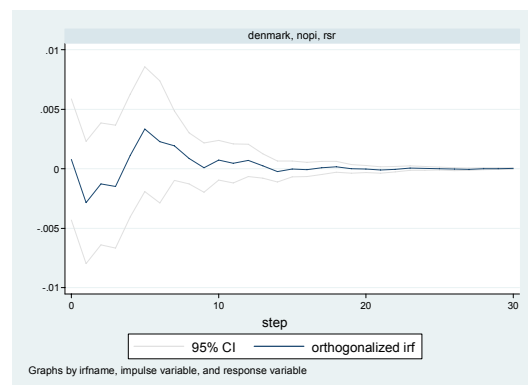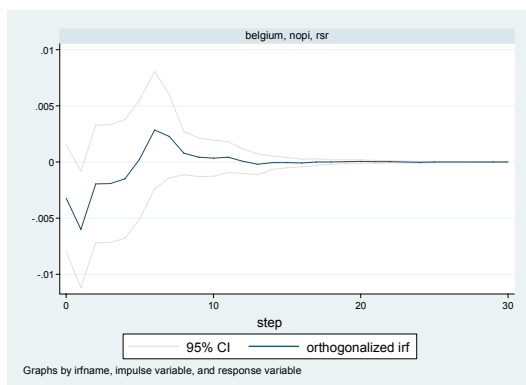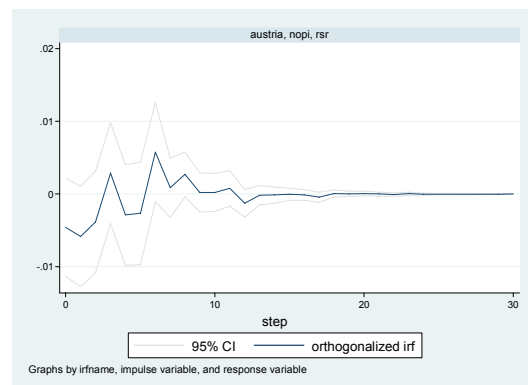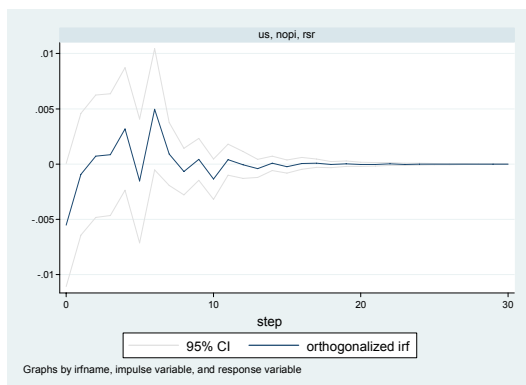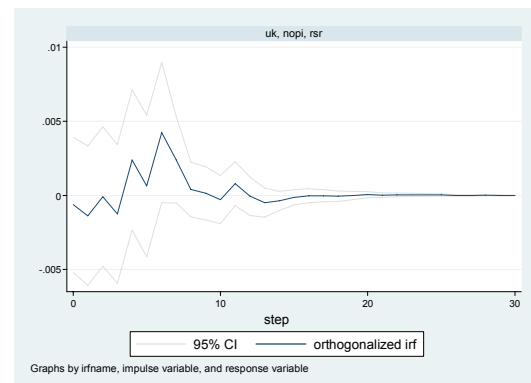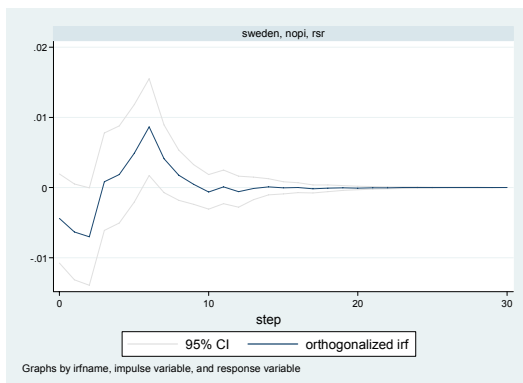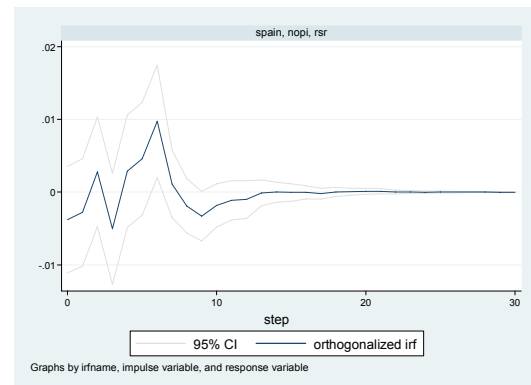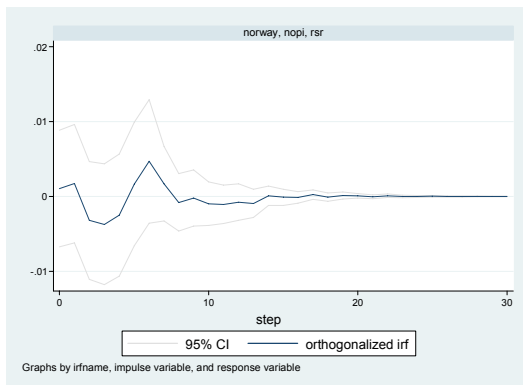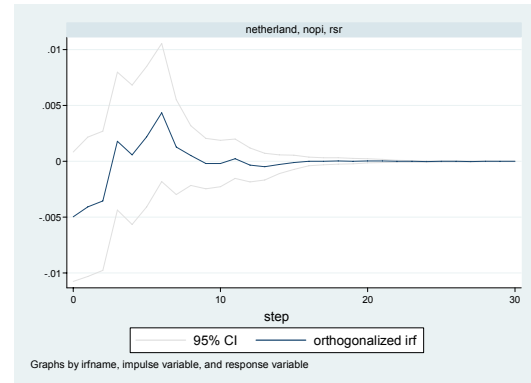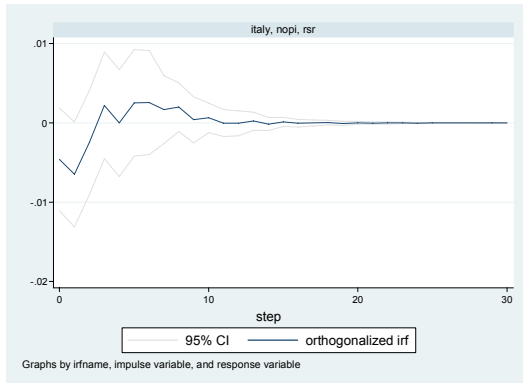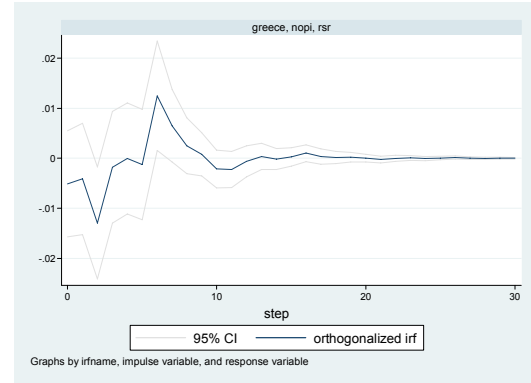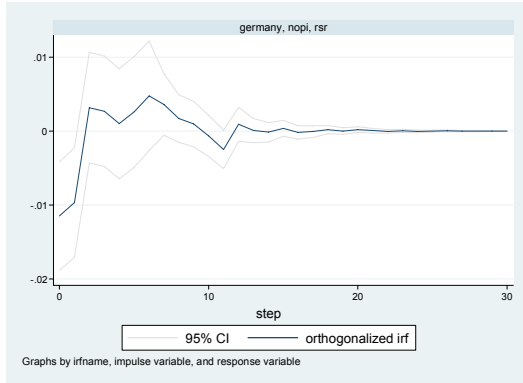
Figure 4. Orthogonalized impulse response function of stock returns to oil price shocks
(World oil price : linear specification - oil, r, ip, inf, rsr)

Graphs by irfname, impulse variable, and response variable
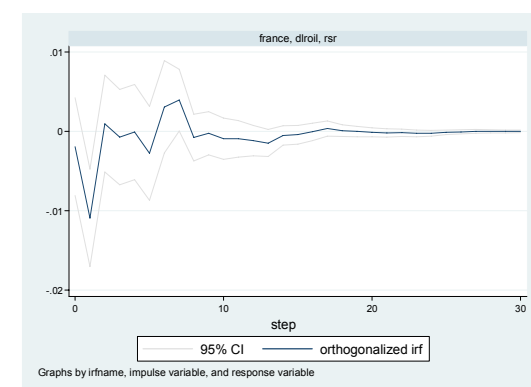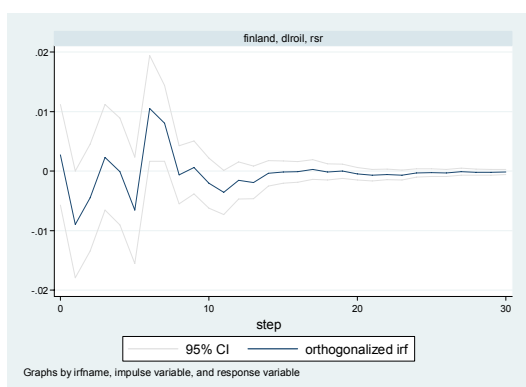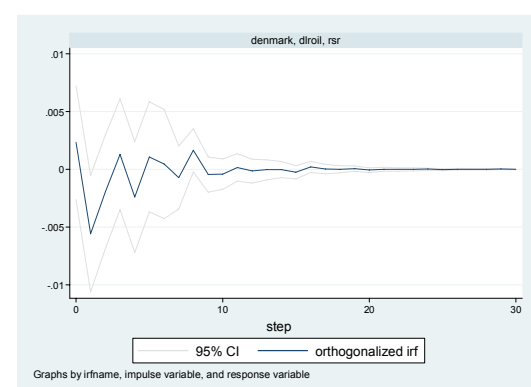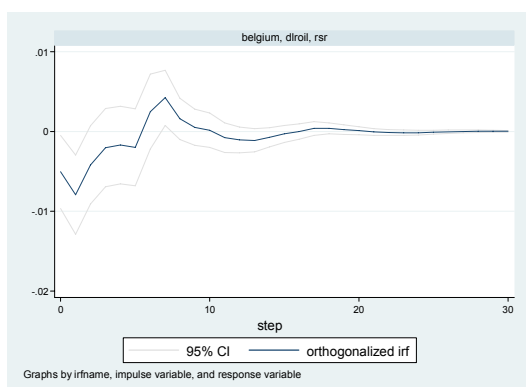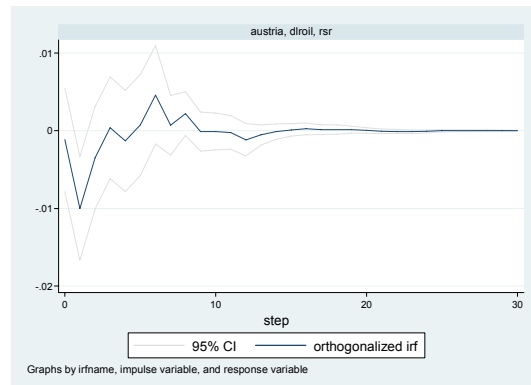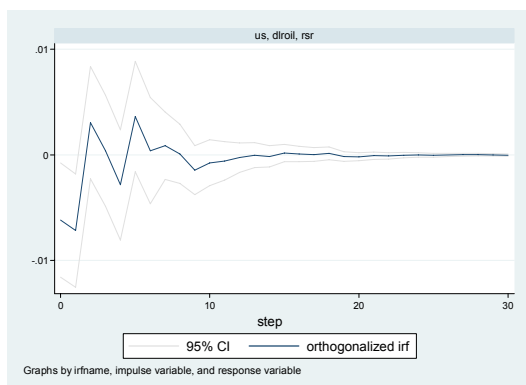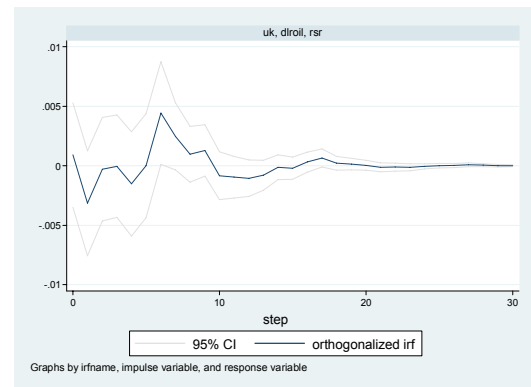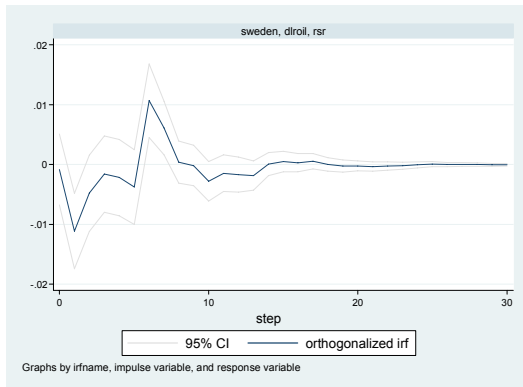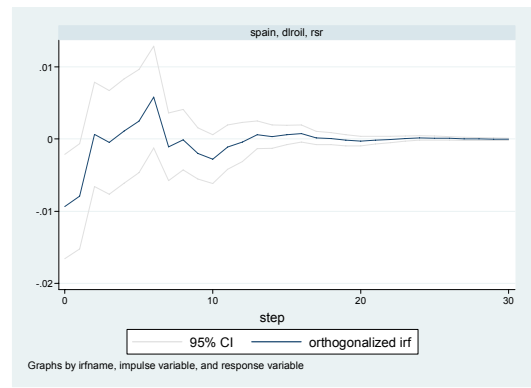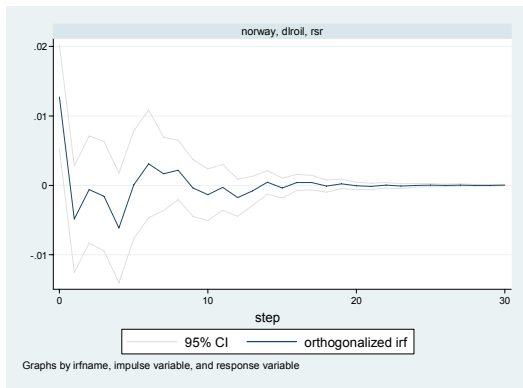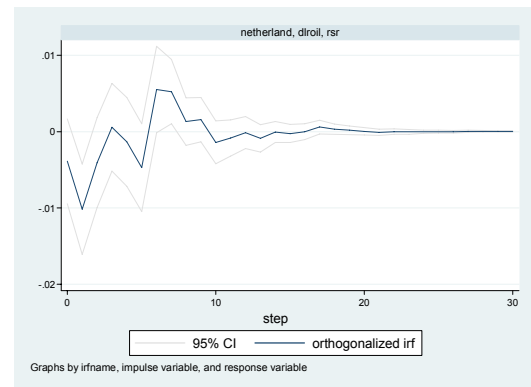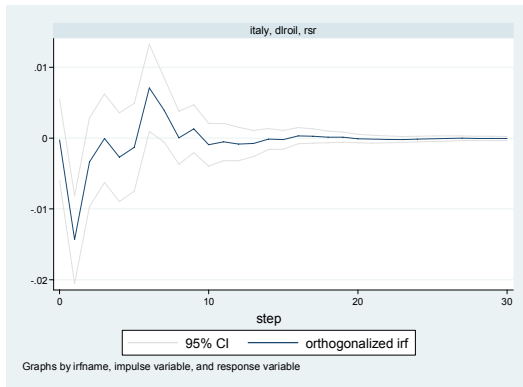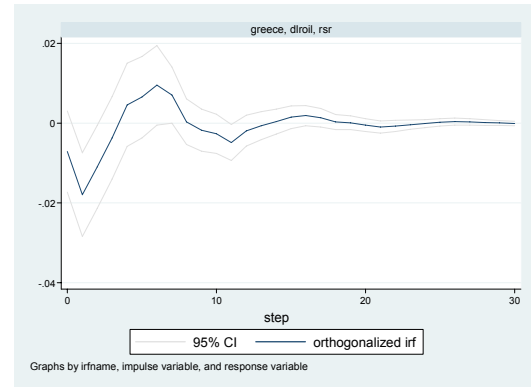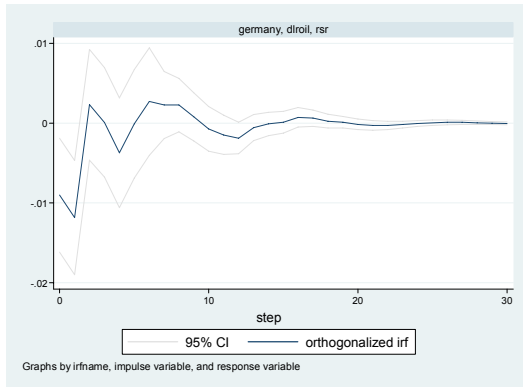
Figure 5. Orthogonalized impulse response function of stock returns to oil price shocks
(World oil price : *SOP* specification - oil, r, ip, inf, rsr)

Graphs by irfname, impulse variable, and response variable
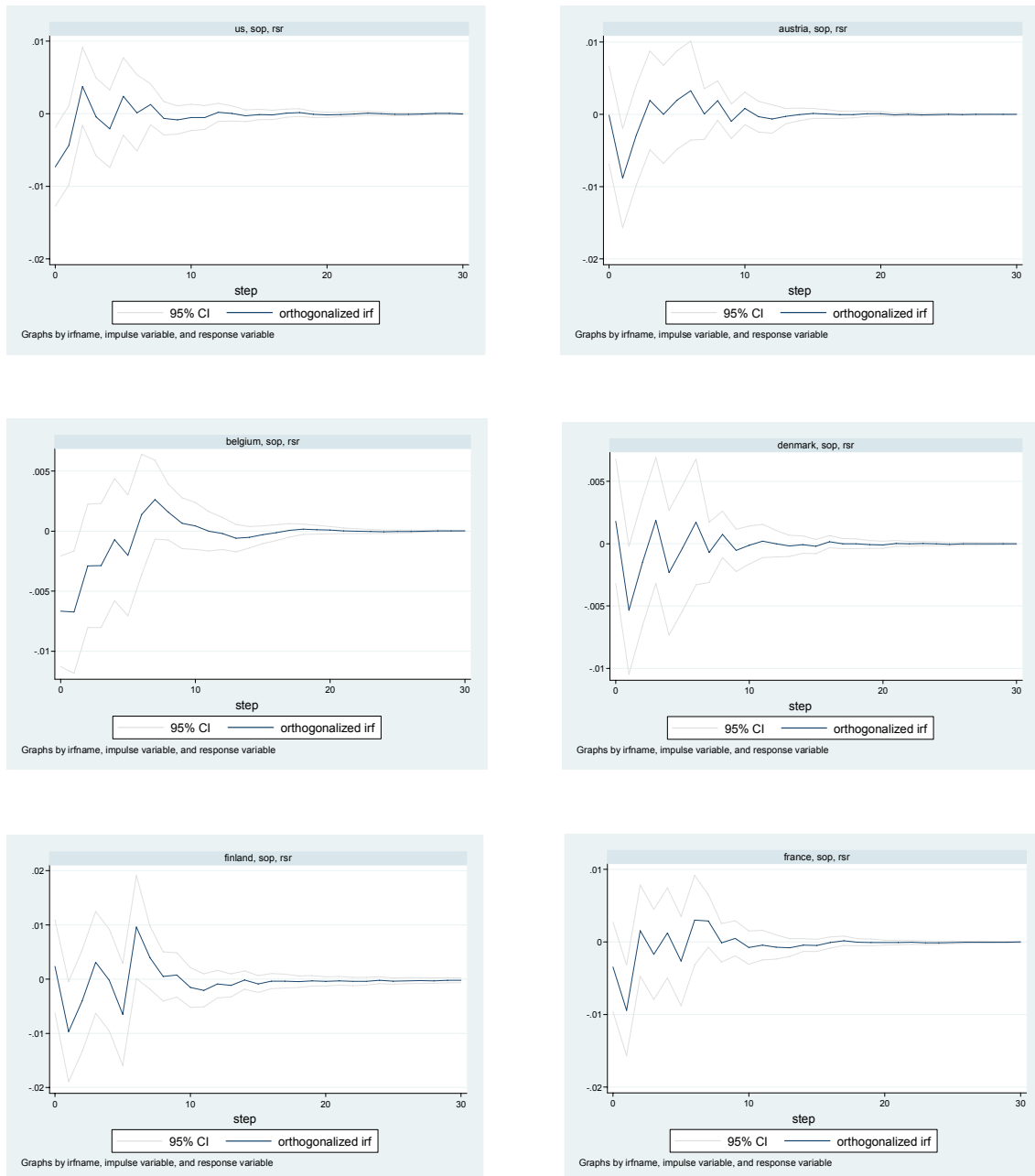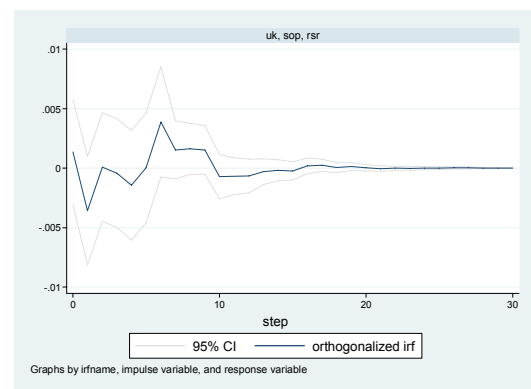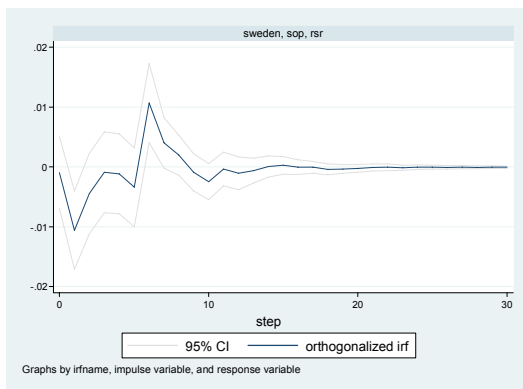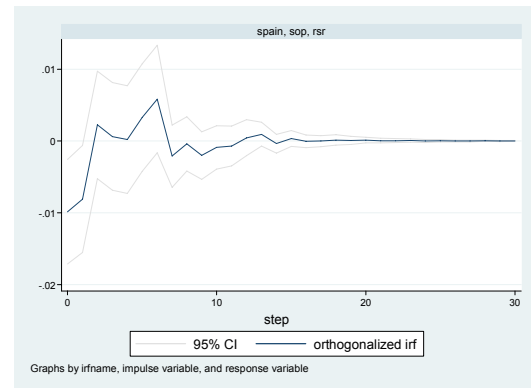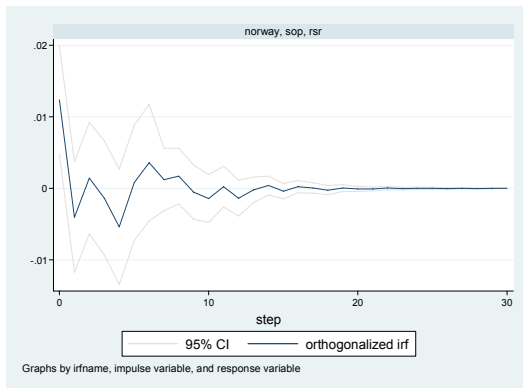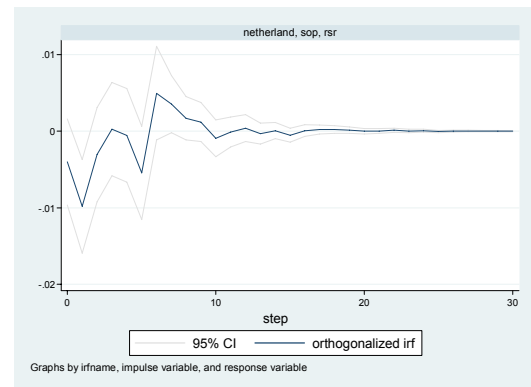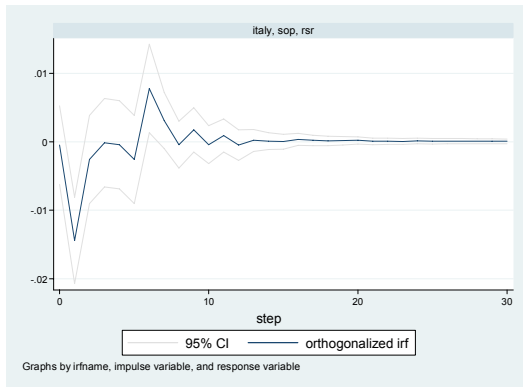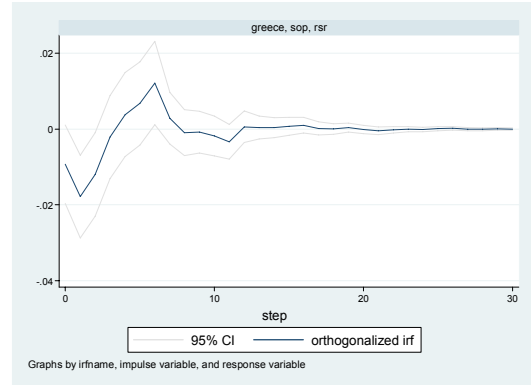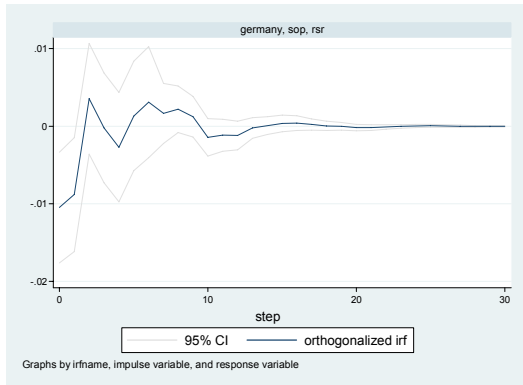
Figure 6. Orthogonalized impulse response function of stock returns to oil price shocks
(World oil price : *NOPI* specification - oil, r, ip, inf, rsr)

Graphs by irfname, impulse variable, and response variable
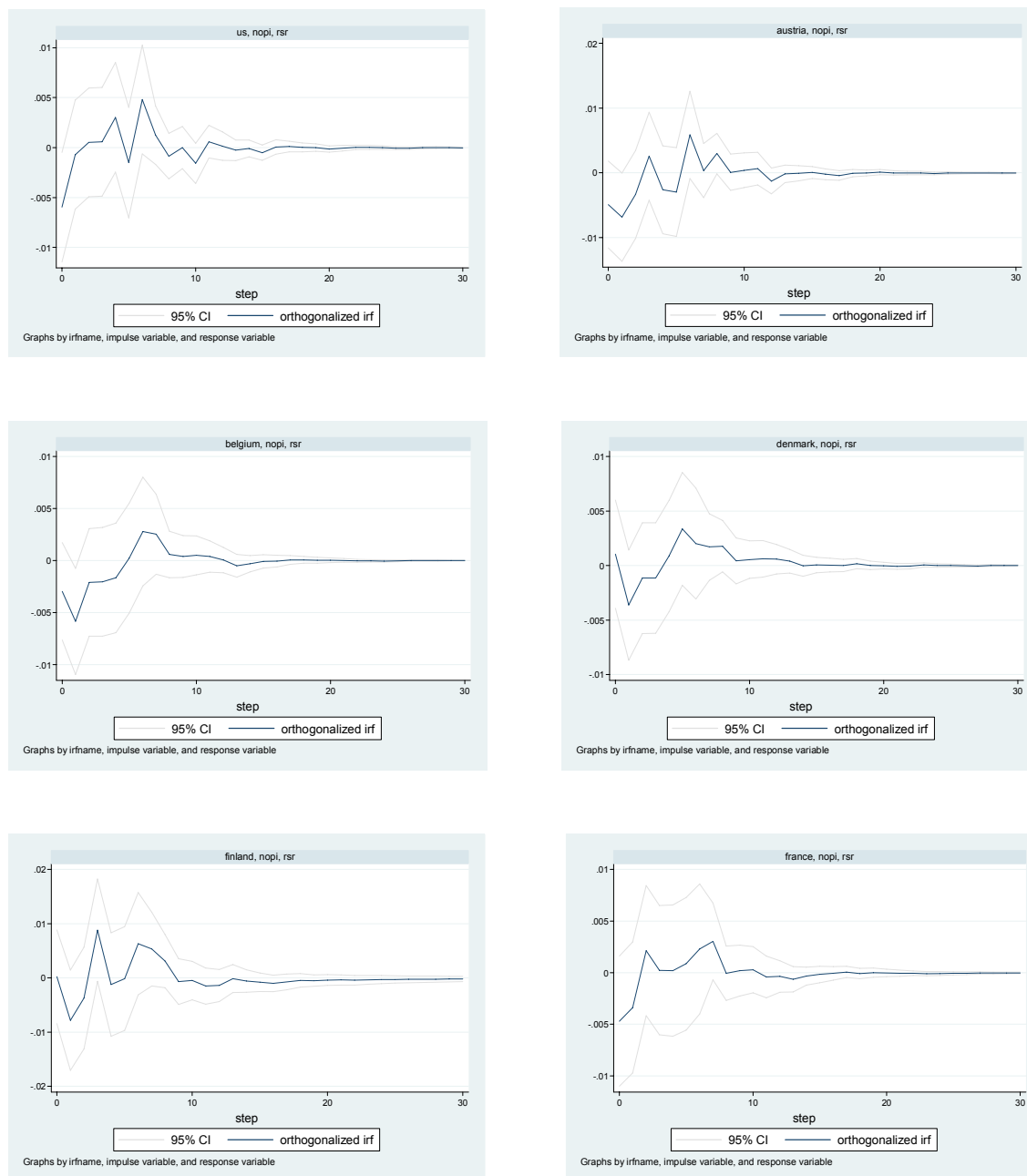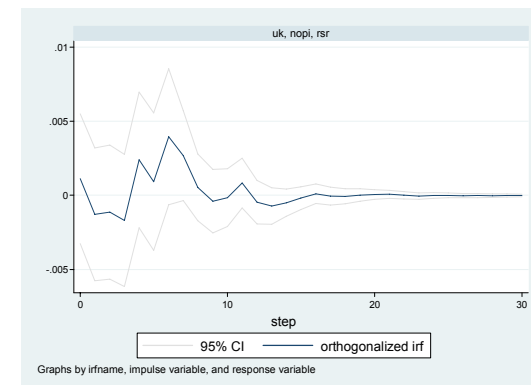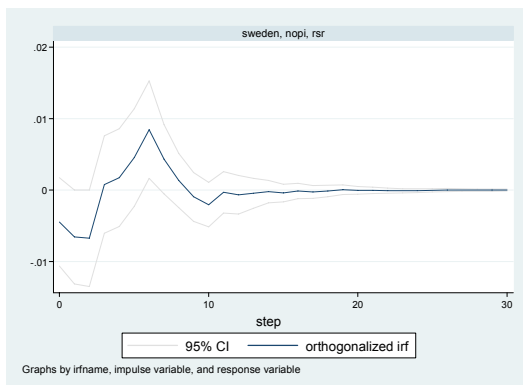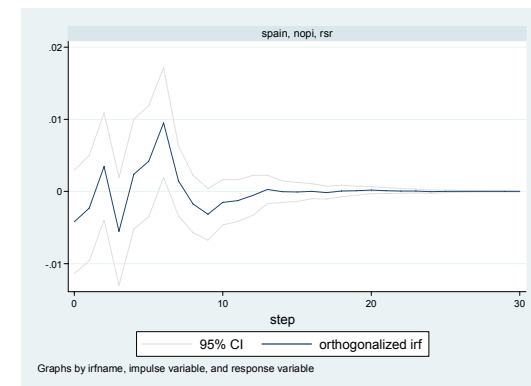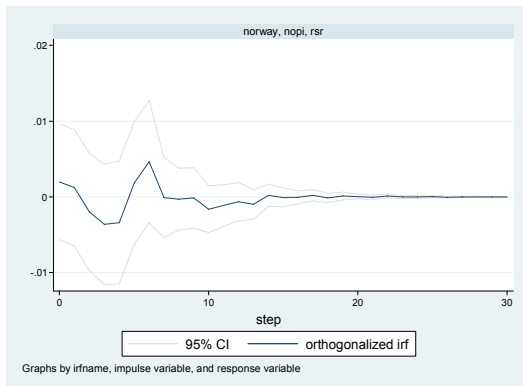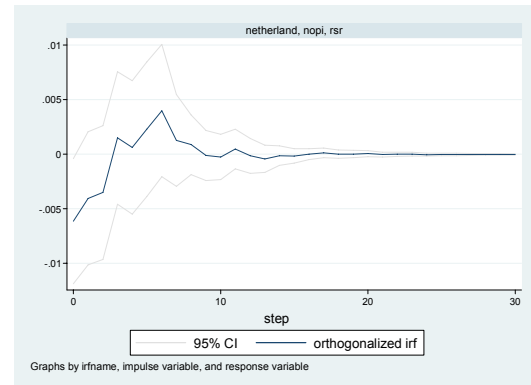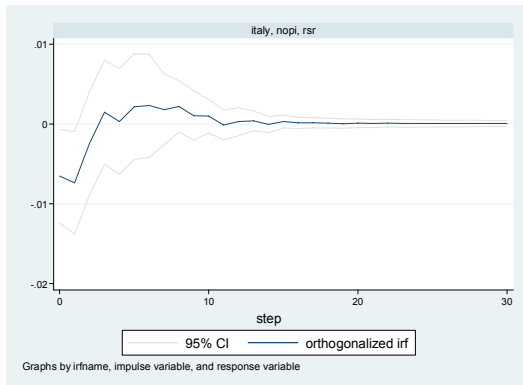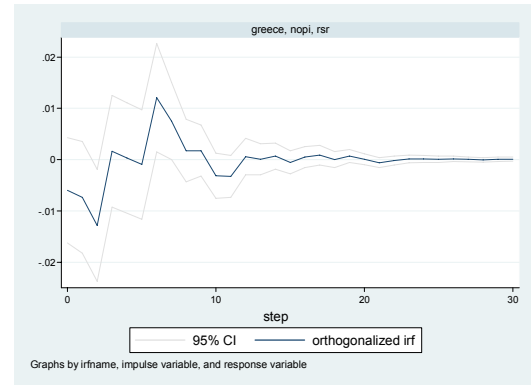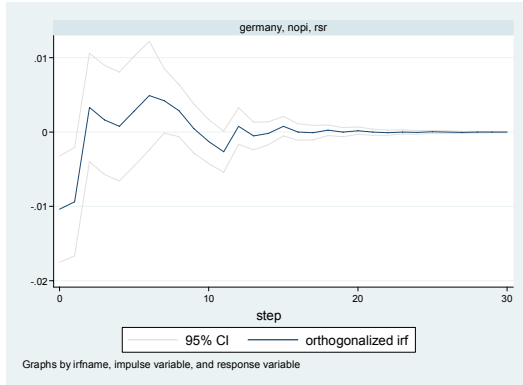
Figure 7. Orthogonalized impulse response functions of interest rates to oil price shocks
and stock returns to interest rates shocks (World oil price : linear specification
- oil, r, ip, rsr)

Graphs by irfname, impulse variable, and response variable

Graphs by irfname, impulse variable, and response variable

Graphs by irfname, impulse variable, and response variable
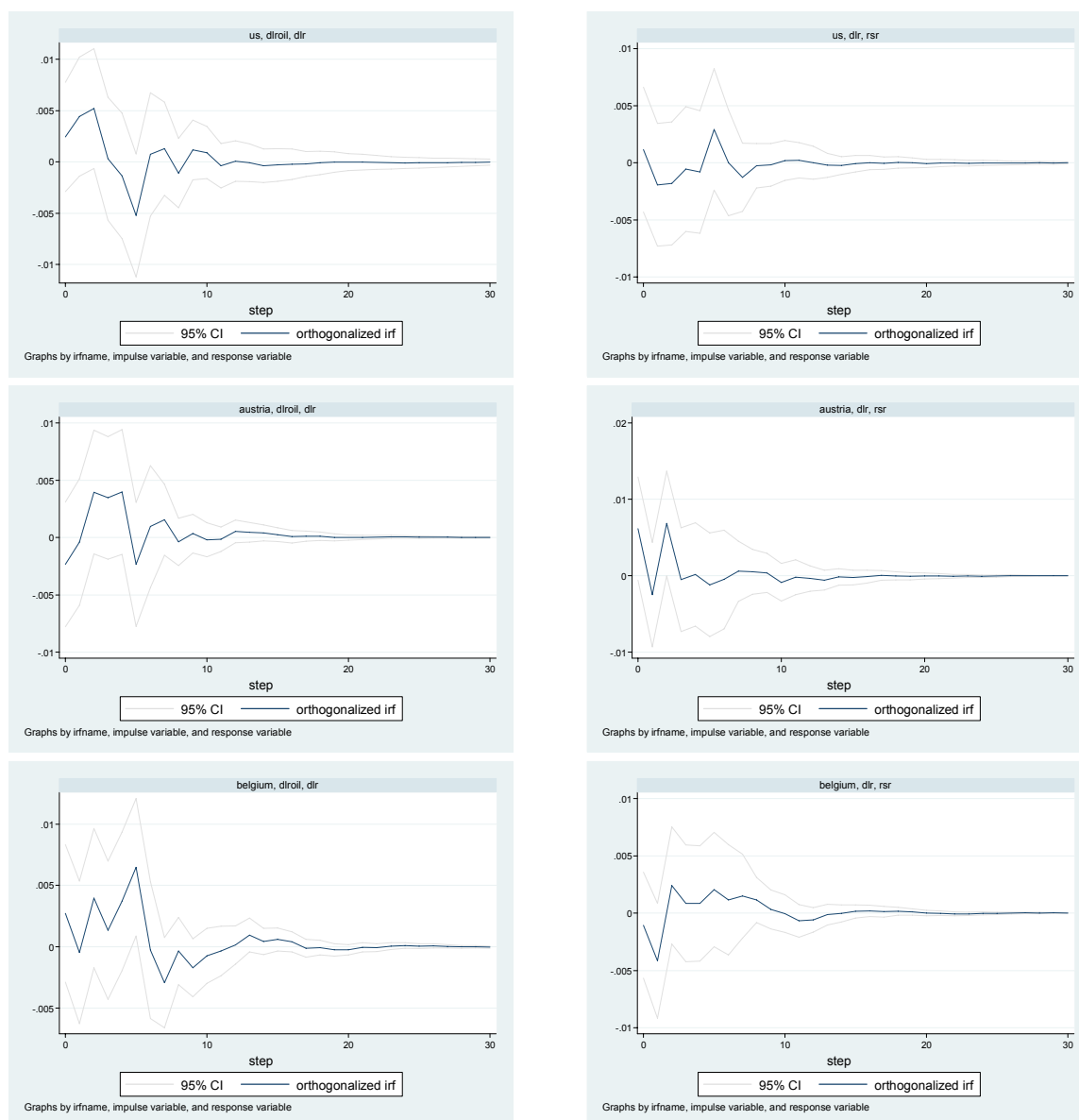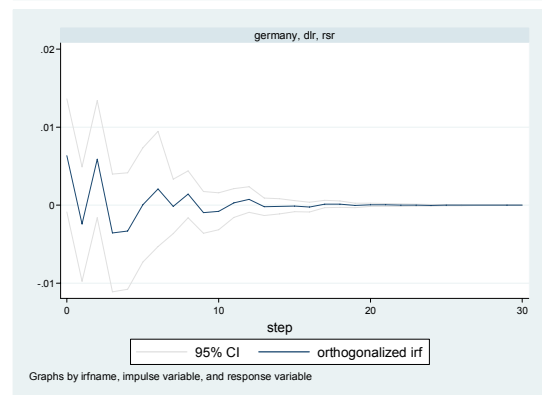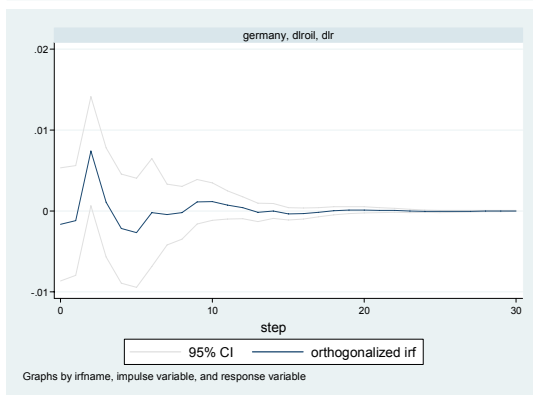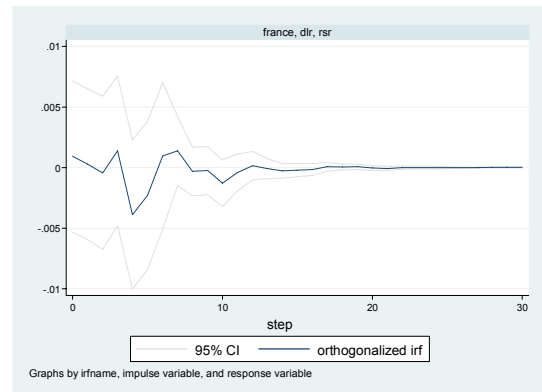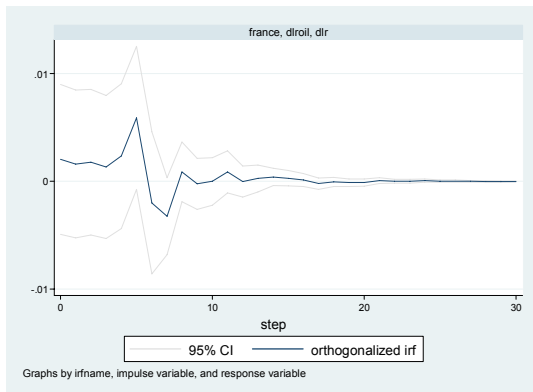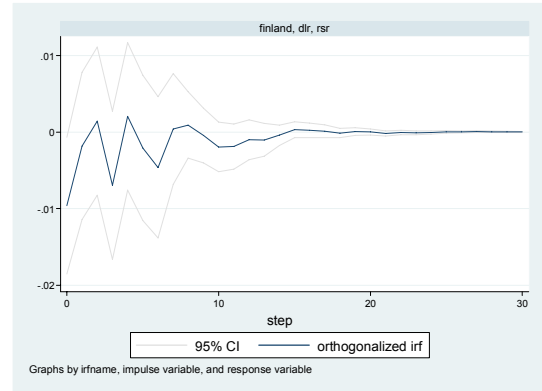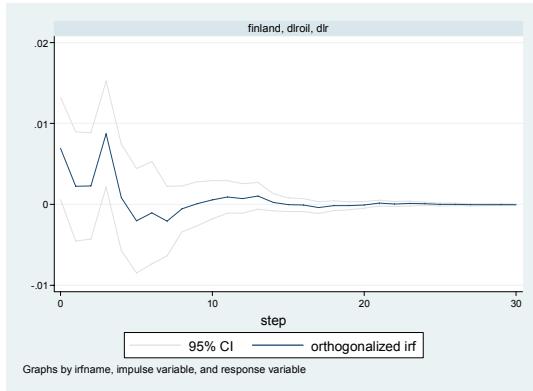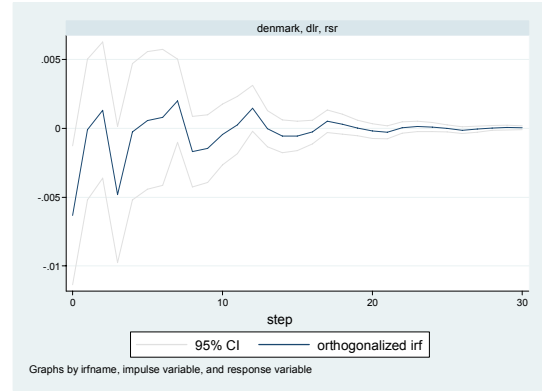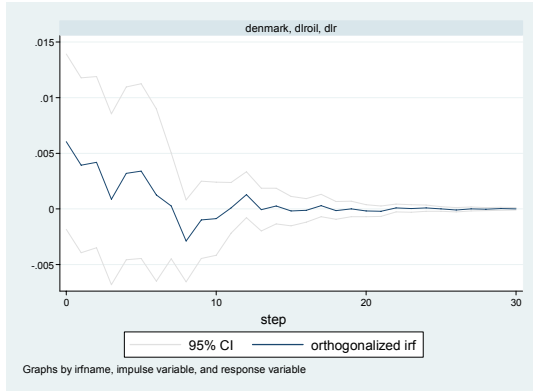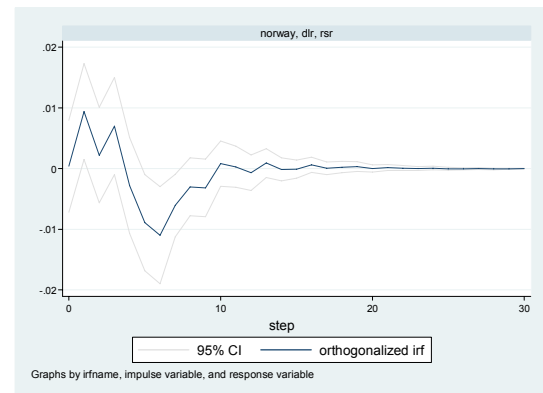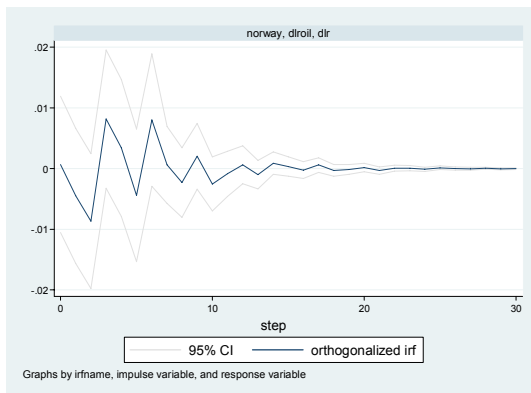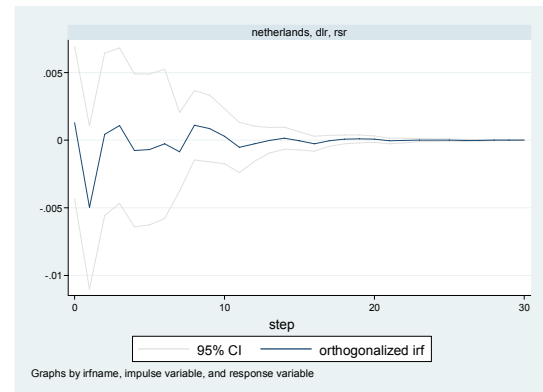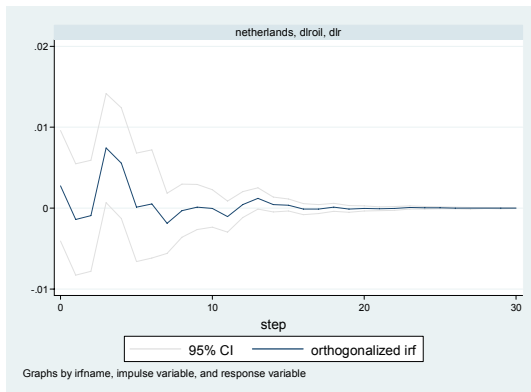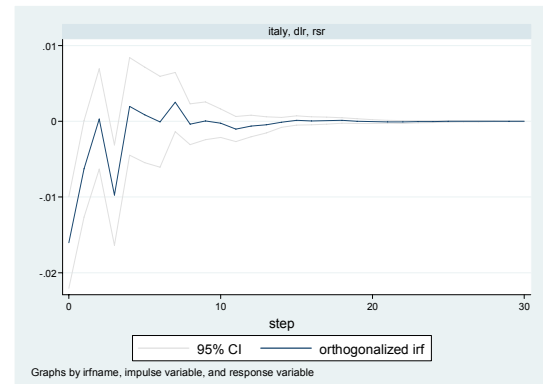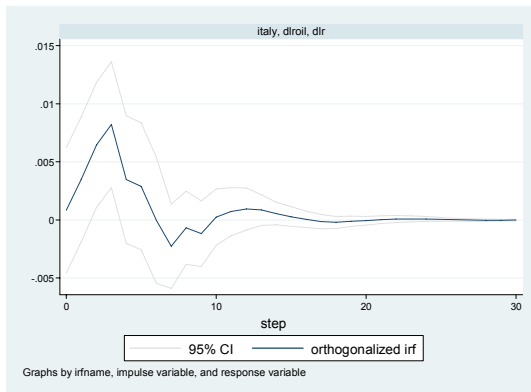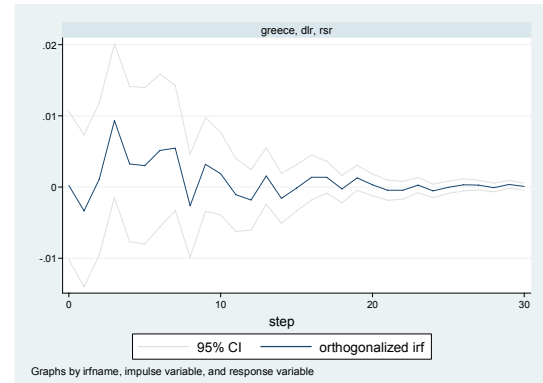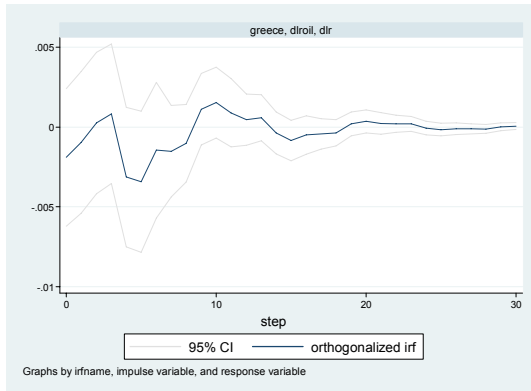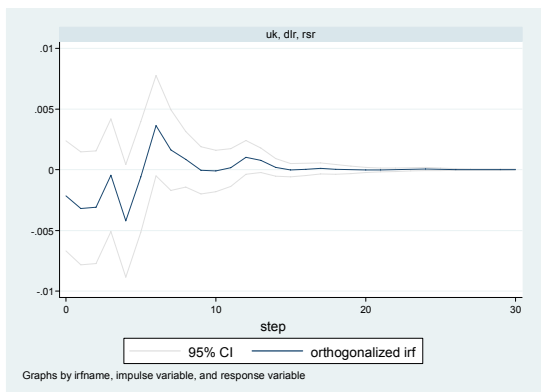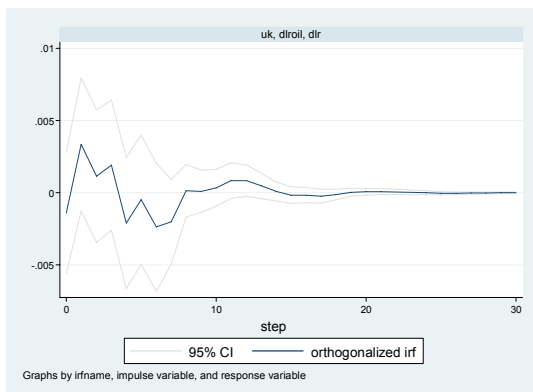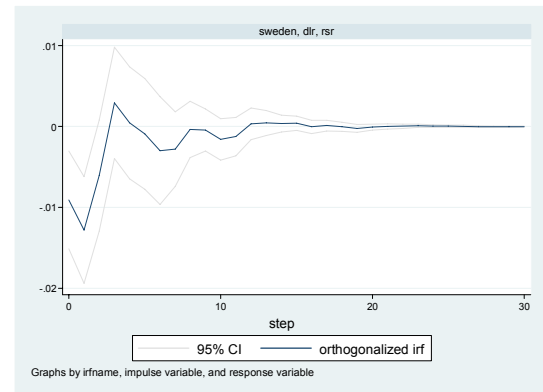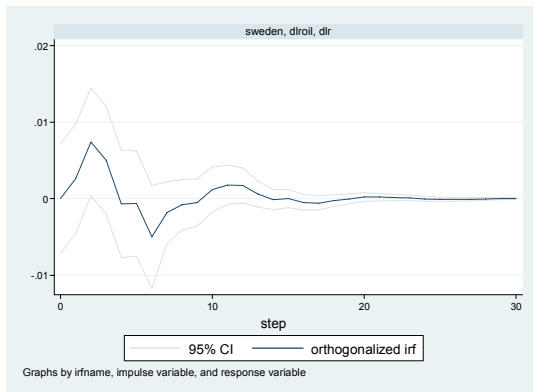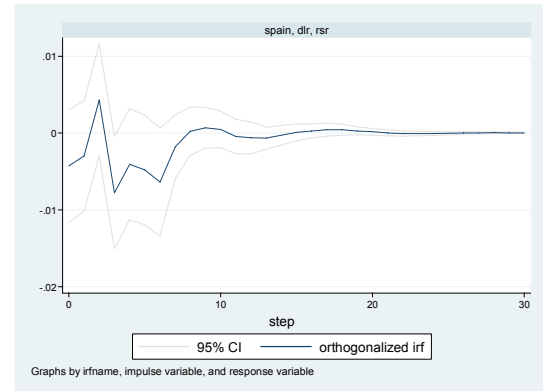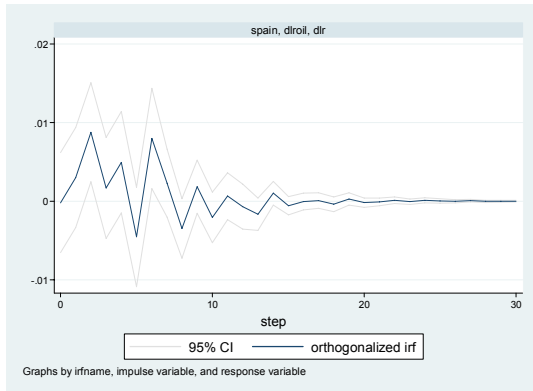
Figure 8. Orthogonalized impulse response functions of interest rates to oil price shocks
and stock returns to interest rates shocks (World oil price : SOP specification
- oil, r, ip, rsr)

Graphs by irfname, impulse variable, and response variable

Graphs by irfname, impulse variable, and response variable

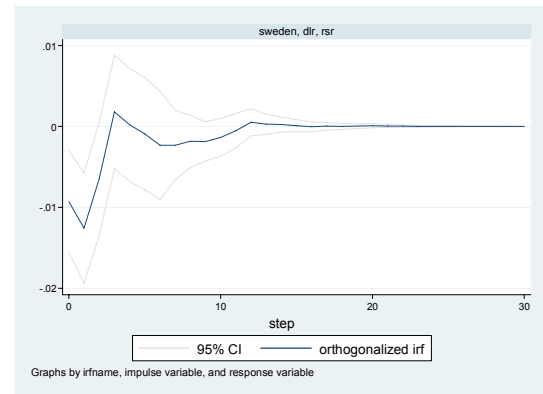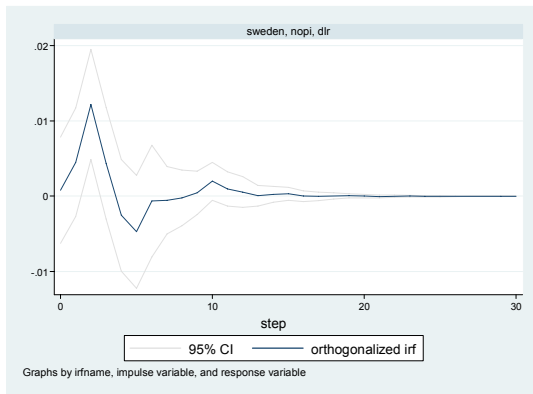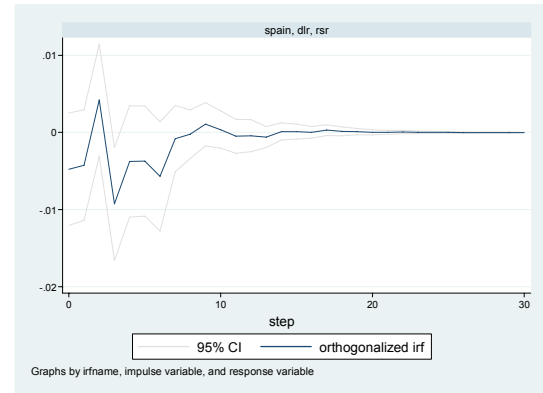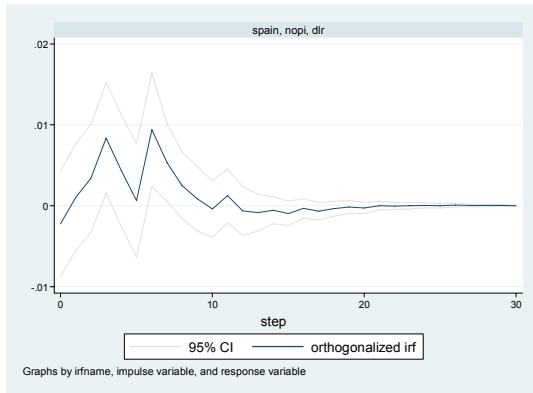Graphs by irfname, impulse variable, and response variable
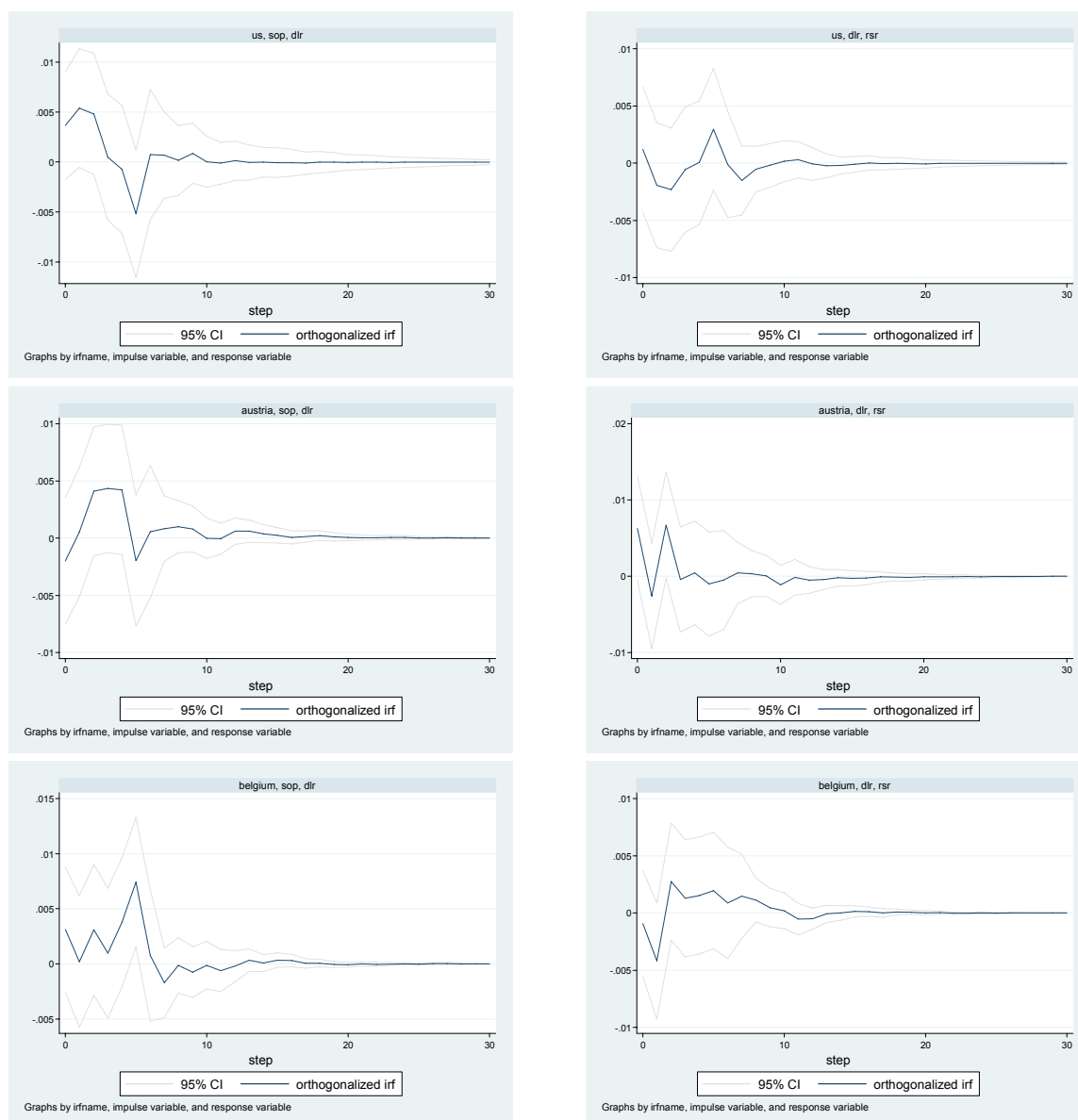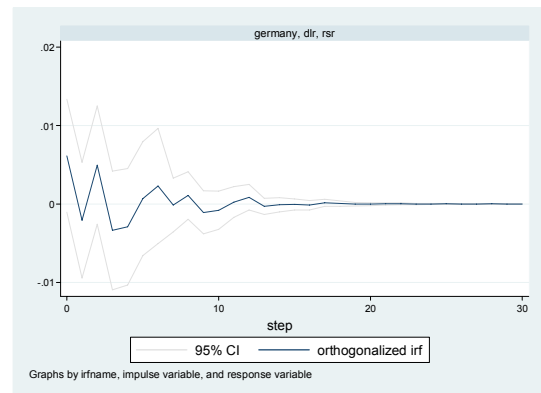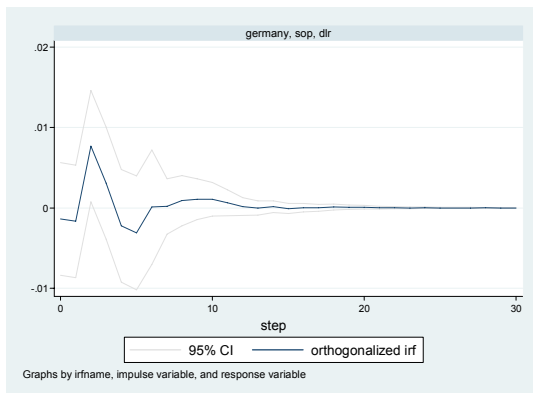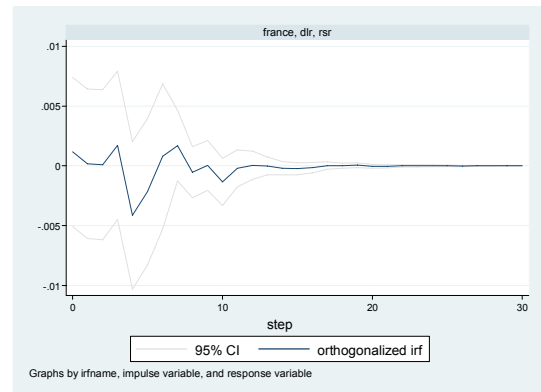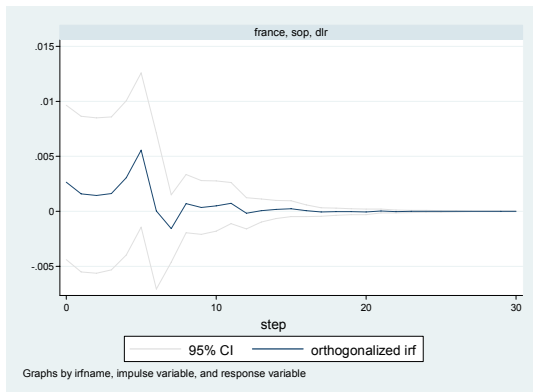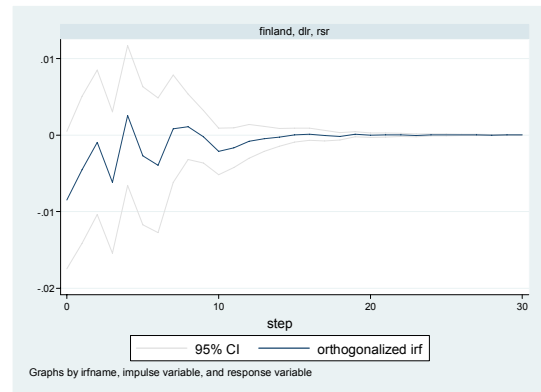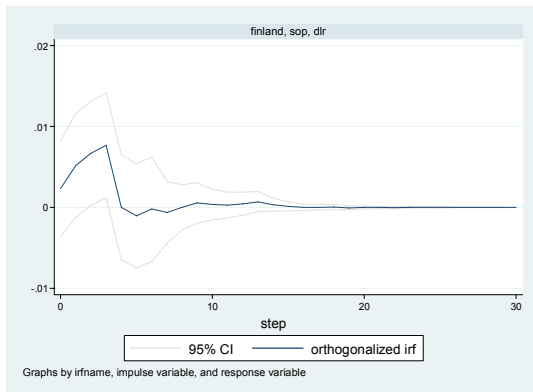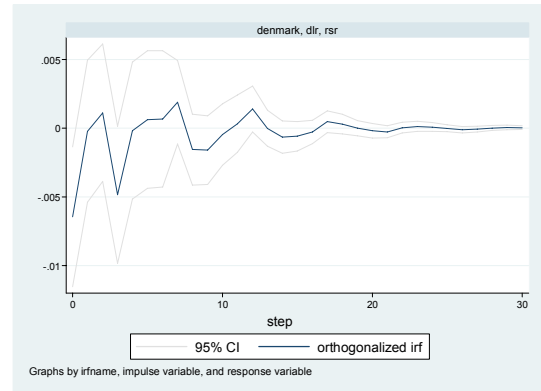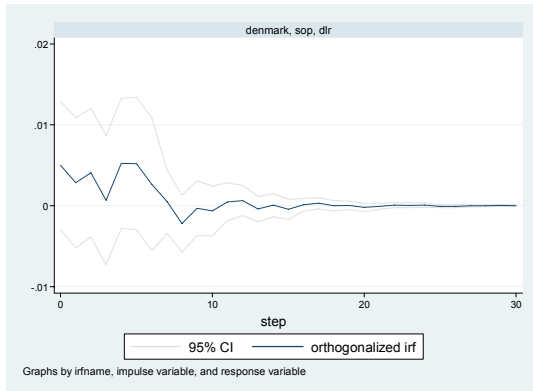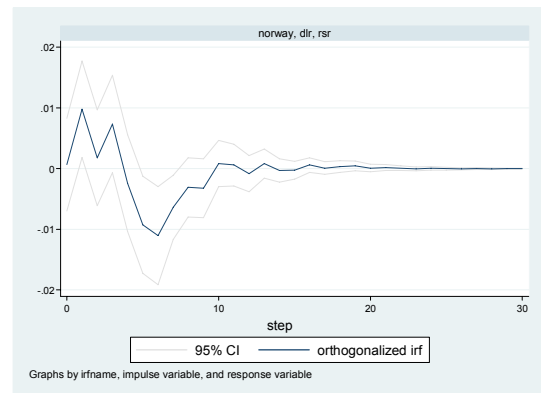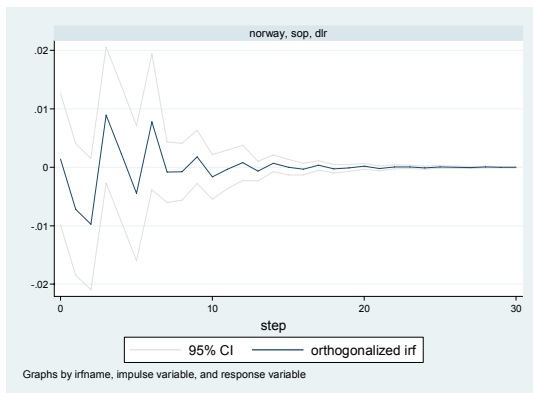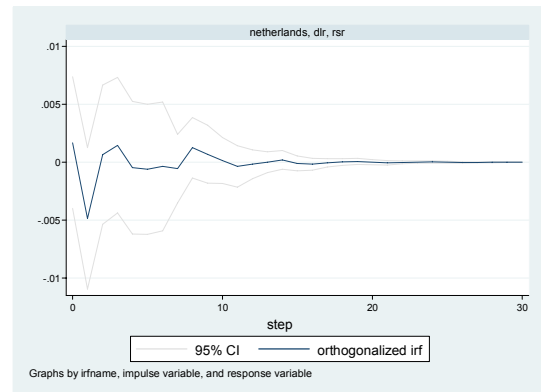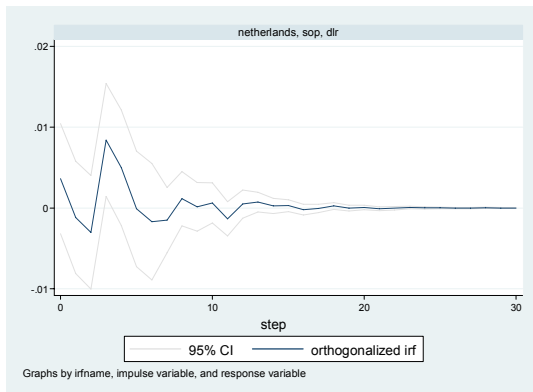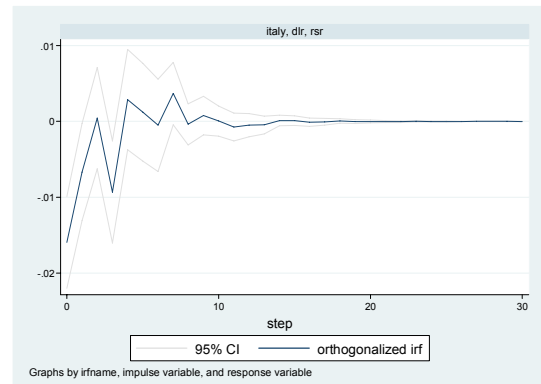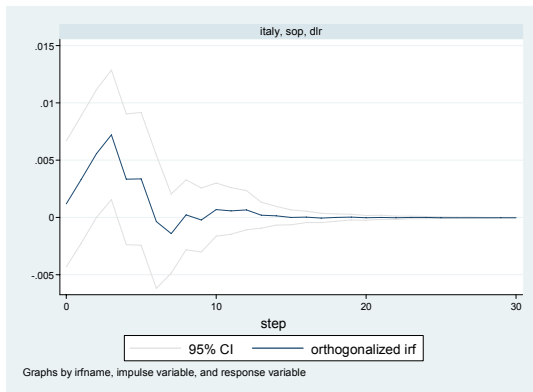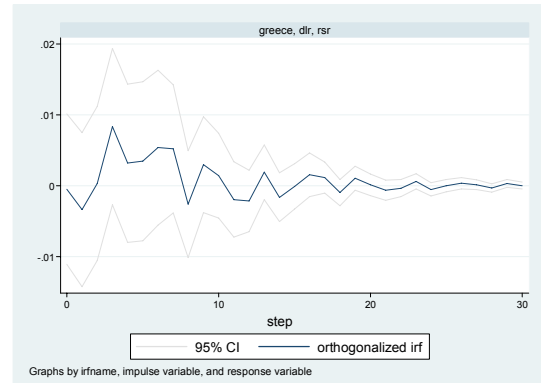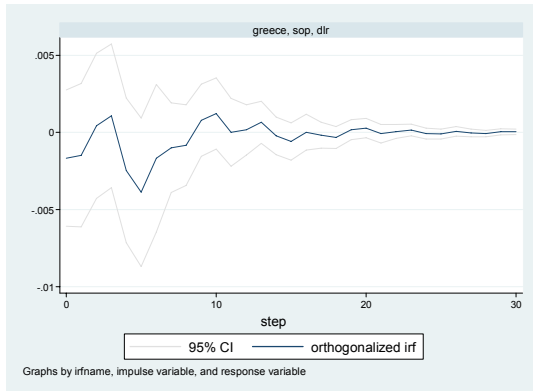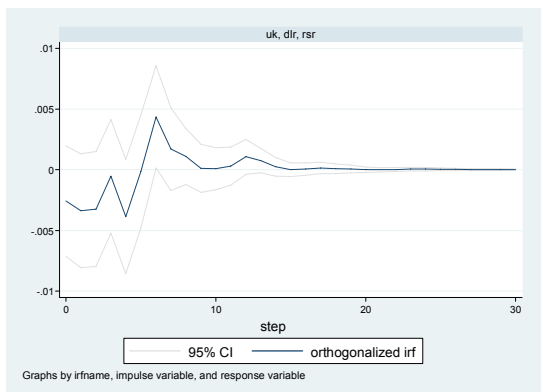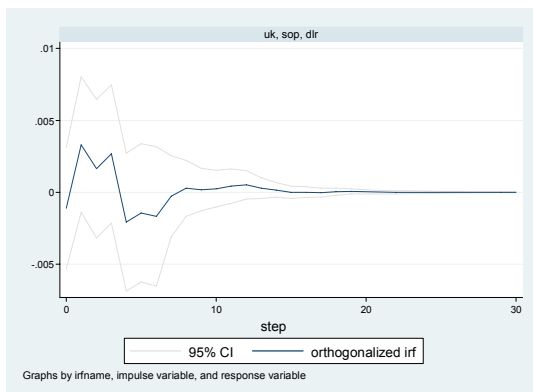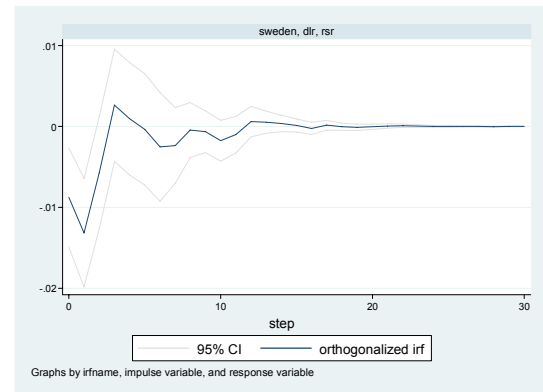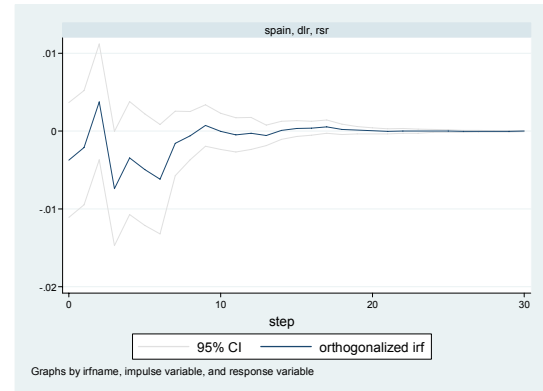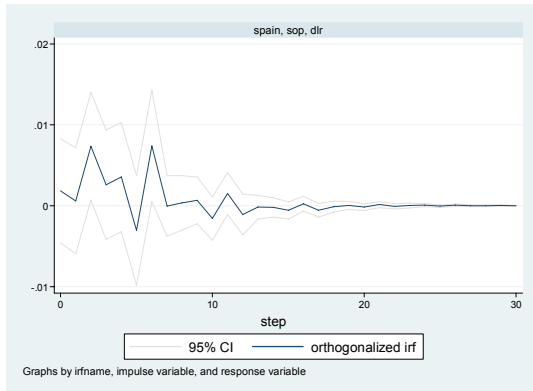
Figure 9. Orthogonalized impulse response functions of interest rates to oil price shocks
and stock returns to interest rates shocks (World oil price : NOPI specification
- oil, r, ip, rsr)

Graphs by irfname, impulse variable, and response variable

Graphs by irfname, impulse variable, and response variable

Graphs by irfname, impulse variable, and response variable
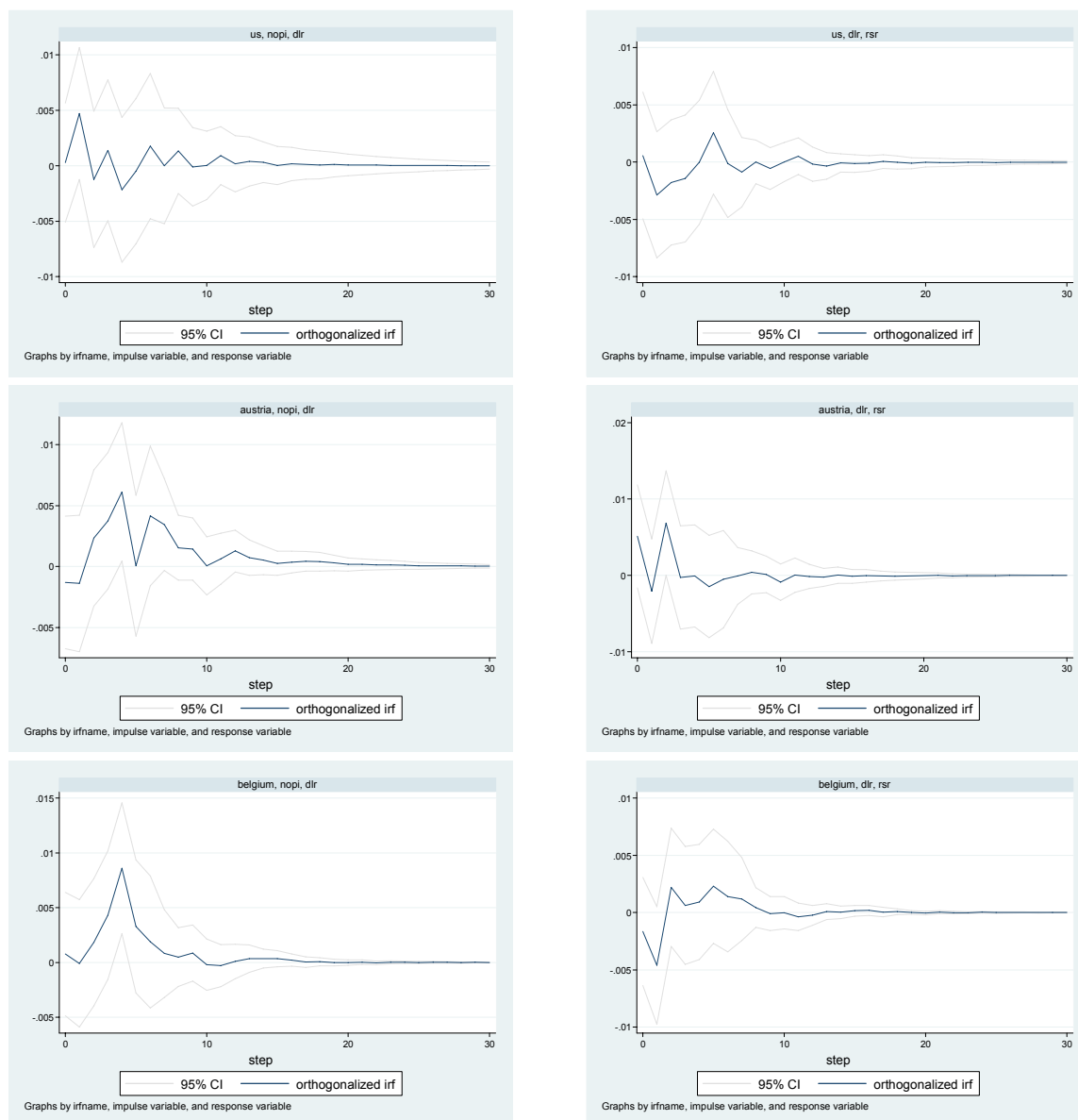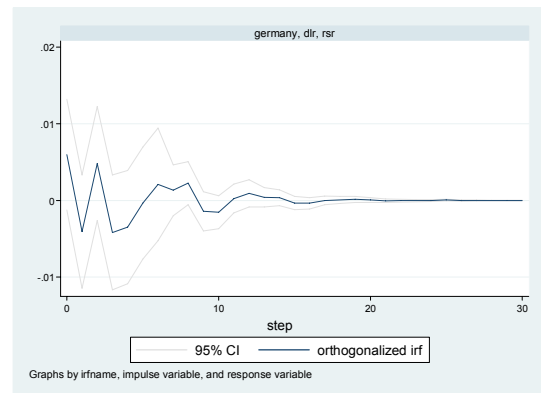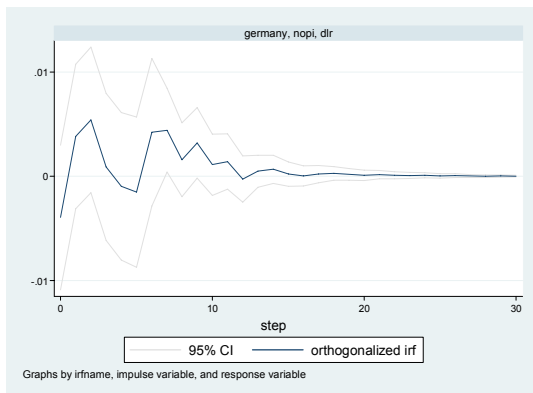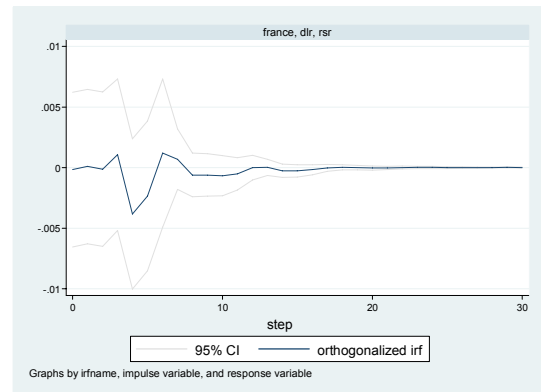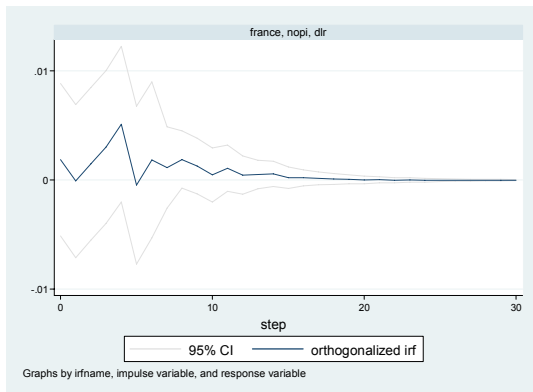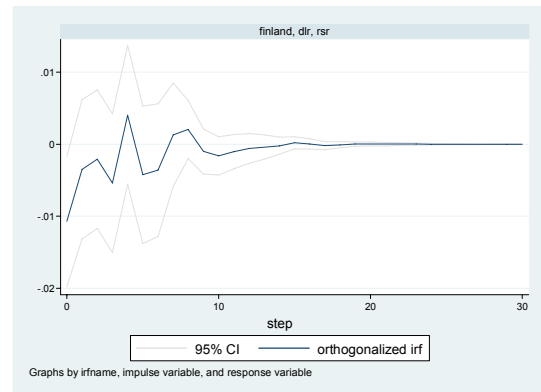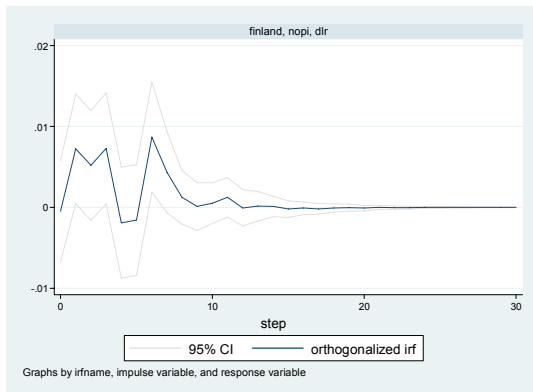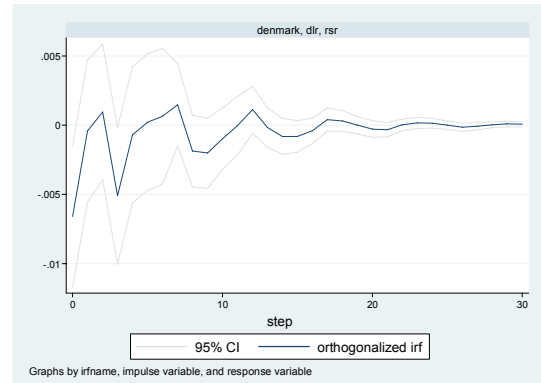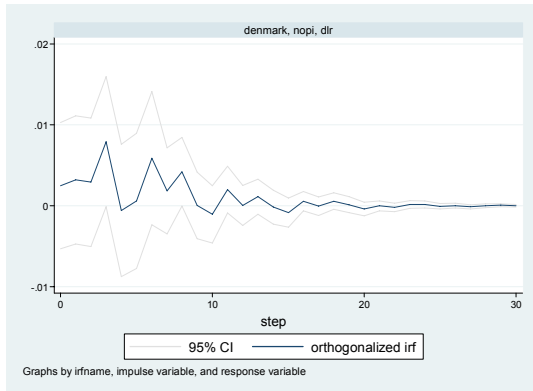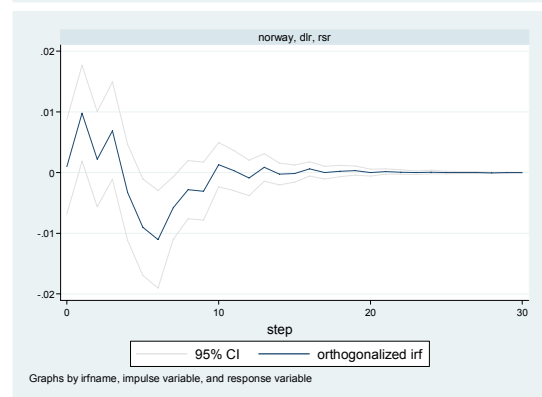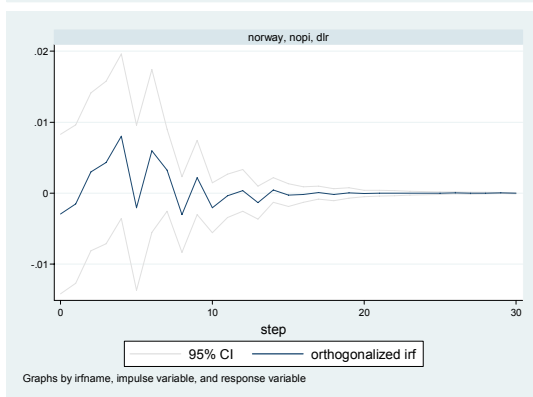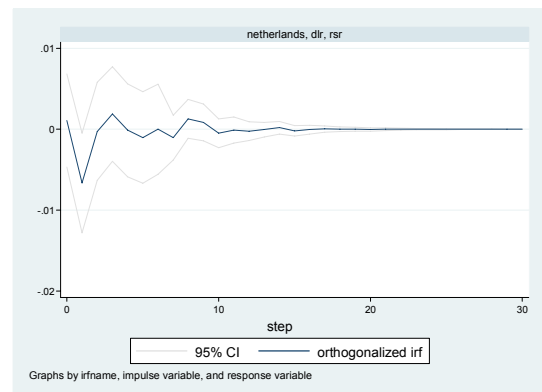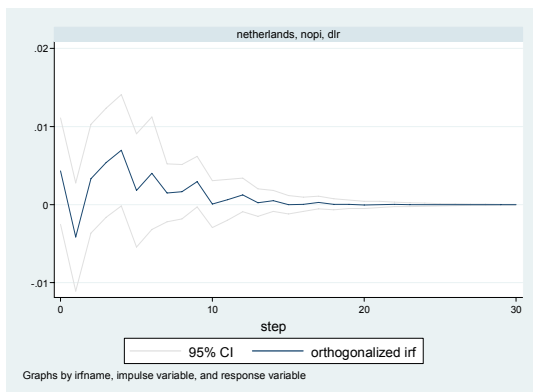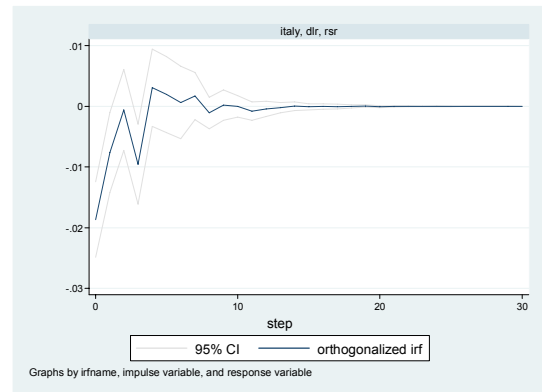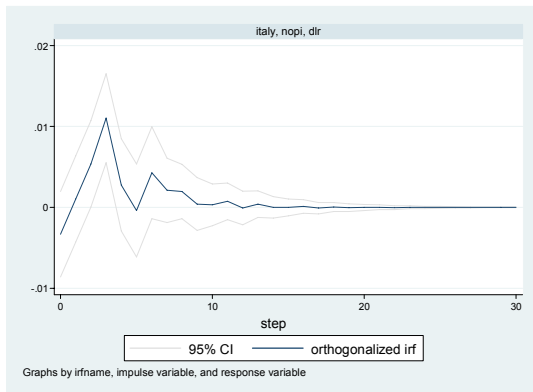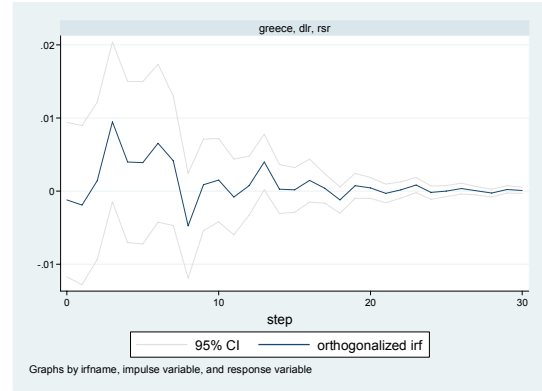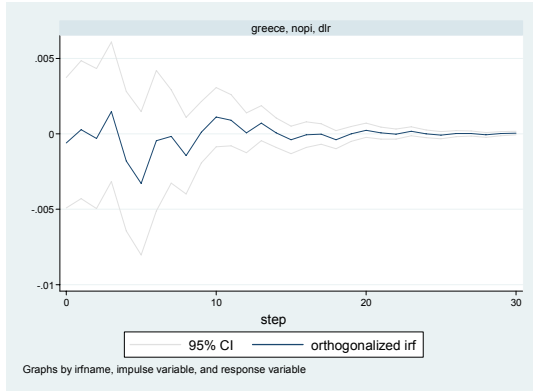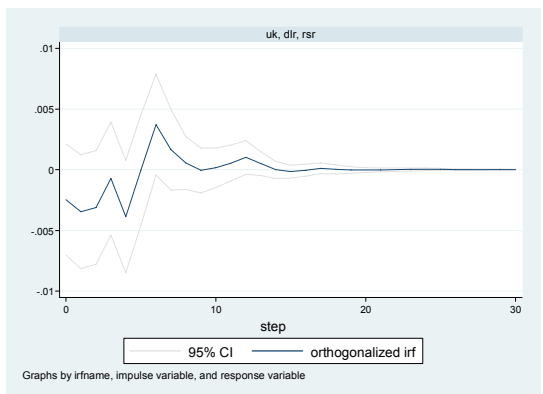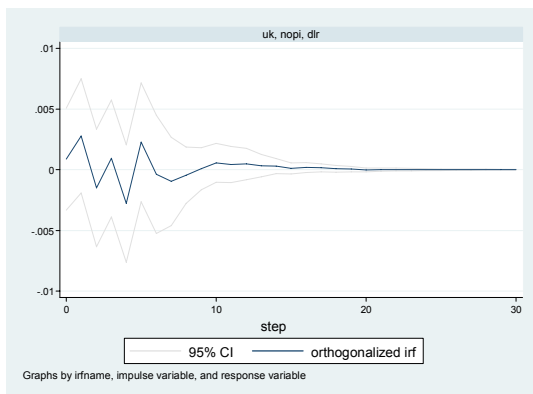
VITA

Jungwook Park was born on Jaunary 23, 1968, in Daegu, Korea. Graduating from Kyung-Sung High School in February 1987 he received bachelor's degree in Economics on February 1992 from Yonsei University and studied Public administration in Graduate school of Seoul National University from February 1992 to May 1995. In 2007 he received Ph.D in Economics from the University of Missouri-Columbia. From August 2005 to May 2007 he taught Money and Banking to undergraduate students at the University of Missouri-Columbia.

He passed the higher examination for senior government officials in 1991 and has worked for the Ministry of Commerce, Industry and Energy since 1992. In that ministry, he worked for the Electronics Industry Policy Division, Asia Division, Automobile and Shipbuilding Industry Division, and Korean Electricity Commission. In addition he worked at the Permanent Representative of Korea in Geneva and the Presidential Commission on Sustainable Development.

He has been married to Sohee Lee since November, 1994, and has one son, Chan.