ESSAYS ON THE EFFECTS OF OIL PRICE SHOCKS ON EXCHANGE RATES AND THE ECONOMY OF SAUDI ARABIA

by

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B.S., King Saud University, Riyadh, Saudi Arabia, 2005
M.A., The University of Kansas, Lawrence, USA, 2009

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Economics
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Abstract

This dissertation consists of three essays examining the consequences of oil price shocks on exchange rates and the economy of Saudi Arabia.

In the first essay, we examine the impact of oil prices on the US dollar (USD) exchange rate in the flexible monetary model framework. We find evidence, based on the impulse response function analysis from the VEC model, suggesting the negative association between oil prices and the USD against 12 currencies. Furthermore, the results from out-of-sample forecasts indicate that oil prices play an essential role in improving the forecasting power of the monetary model of exchange rate determination.

In the second essay, we analyze how G7 real exchange rates and monetary policy respond to oil supply, aggregate demand, and oil-specific demand shocks initiated by Killian (2009). Our evidence confirms that aggregate demand and oil specific demand shocks are associated with the depreciation of the real exchange rate for five countries whereas oil supply shocks lead to the depreciation of real exchange rate in four countries. Likewise, we find the monetary policy responds significantly only to aggregate demand and oil specific demand shocks in three countries while the monetary policy responds to real exchange rate shocks in four countries.

In the third essay, we investigate the differential effects of oil shocks, developed by Killian (2009), on industrial production, inflation, and the nominal exchange rate of Saudi Arabia. The reported evidence shows that industrial production responds positively only to oil supply shocks. Likewise, we find evidence indicating that there is a positive impact of aggregate demand shocks on inflation. On the other hand, we find evidence suggesting that oil supply and demand shocks are associated with the nominal exchange rate depreciation.

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Dedication

Dedicated to my parents for their unconditional love, support, and encouragement.

Chapter 1 - Oil Prices and the US Dollar Exchange Rate: Evidence from the Monetary Model

1.1 Introduction

Even though the monetary models of exchange rates became the standard instrument of analysis in international finance after the collapse of the Bretton Woods system in 1973, the performance of monetary models in explaining the behavior of nominal exchange rate is still unsatisfactory. Extensive surveys of traditional exchange rate models (Meese, 1990; Meese and Rose, 1991; MacDonald and Taylor, 1992; Frankel and Rose, 1995; Neely and Sarno, 2002; Chueng, et al., 2005) not only summarize the difficulties of these models, but the surveys also tend to agree that these traditional models of exchange rate are inadequate, since they fail to explain exchange rate fluctuations.

As a result, some economists, such as, Groen (2000), Cheung et al. (2005), and Chinn and Moore (2011), advocate that the flexibility of any model of exchange rate determination is necessary to incorporate other non-monetary determinants that might explain the movement of exchange rates into the monetary models of exchange rates. For instance, Cheung et al. (2005) embed other non-monetary determinants such as government debt, terms of trade and net foreign assets into monetary models of exchange rates to examine whether these non-monetary variables capture the movements of exchange rates or not. Likewise, Chinn and Moore (2011) augmented monetary model of exchange rates with order flow variables to predict exchange rates. Hunter and Ali (2014) estimated the augmented monetary model of exchange rates with the real stock price, the government consumption as a percentage of GDP, and the productivity in the traded sector to investigate exchange rate persistence.

On the other hand, several studies (Amano and Norden 1998, Chen and Rogoff 2003, Chen and Chen 2007, Narayan et al. 2008, and Uddin et al. 2014) document the influential role of energy and commodity prices on the movements of exchange rates based on atheoretical models. Hence, this motivates us to rely on some theoretical models of exchange rate determination, such as monetary models, instead of atheoretical models on which existing literature relies (see Mark 2001 for further discussion).

Because the USD is the main settlement currency in international crude oil markets, oil prices impact the USD through the US money demand function directly. Since oil-importing countries need to buy USD to purchase crude oil, their purchases increase the demand for the USD in international currency markets. Therefore, we derive an augmented flexible monetary model of exchange rates to investigate the consequences of oil prices on the movements of the USD exchange rate against 13 currencies, using quarterly data from 1986:Q1 to 2014:Q3.

In doing so, we contribute to the literature in two ways. First, examining the relationship between oil prices and the USD exchange rate in a monetary model framework is unique. Examining whether oil prices enhance the predictability of the monetary model using out-of-sample forecasts is the other contribution.

A quick preview of the results indicates a negative relationship between oil prices and the USD exchange rate against 12 currencies. Specifically, the analysis of the impulse response function shows that the depreciation rate of the USD exchange rate ranges between 0.002 and 0.018 percentage points as a result of a one-standard deviation positive shock to the real price of crude oil. Additionally, the forecast error variance decomposition analysis indicates that variation in the USD exchange rate is largely attributable to changes in the price of oil rather than monetary fundamentals.

We also compare the forecasting power of the basic model of exchange rate to the model augmented with oil prices through one-step-ahead out-of-sample forecasts evaluated by three forecasting accuracy measures. The results of the out-of-sample forecast comparisons indicate that oil prices improve the forecasting power of the monetary model of exchange rate.

This essay is organized in the following order. The next section introduces the flexible price monetary model of exchange rate, augmented with the oil price effect. Section 1.3 reviews existing literature, and section 1.4 describes the data set. Section 1.5 includes a description of the empirical methodology along with a discussion of results. Section 1.6 summarizes the results and conclusions.

1.2 The Monetary Model of Exchange Rates

The monetary model of exchange rate determination posits the link between the nominal exchange rate and a simple set of monetary fundamentals that include output, money supply, and interest rate. The basic intuition of the monetary model of exchange rates is that a country's price level is determined by its demand and supply for money and that the price level in foreign countries should be the same when it is expressed in the same currency. This makes the monetary model an attractive theoretical tool in understanding exchange rate fluctuations over time.

The monetary model of exchange rate under flexible prices consists of money market equilibrium, purchasing power parity (PPP), and uncovered interest parity (UIP). In the money market, the money demand function usually depends on the price level, p, real income, y, and the level of the interest rate, i. However, some studies augment the money demand function with other determinants, such as real effective exchange rates and the inflation rate (Bahmani-

Oskooee and Malixi, 1991), the interest rate spread (Valadkhani, 2008), opportunity cost of holding money, the real value of wealth, and investor confidence (Hall et al., 2012).

Since the US dollar is the primary invoicing currency in international crude oil markets, this in turn suggests that changes in oil prices impact the US money demand function directly. Therefore, we incorporate the real oil price (O_t) into the US money demand function, so the augmented money demand function of the US is given as follows:

$$\frac{m_t}{p_t} = L(y_t, i_t, O_t), \qquad (1.1)$$

where $\frac{m_t}{p_t}$ denotes the real money demand. On the other hand, we assume that the money demand function of the foreign country depends only on the price level, p, real income, y, and the level of the interest rate, i, and is given as follows:

$$\frac{m_t^*}{p_t^*} = L(y_t^*, i_t^*). \qquad (1.2)$$

In money market equilibrium, money demand must equal money supply. Hence, the money demand functions given by equations (1.1) and (1.2) for both domestic and foreign countries, where asterisks denote the foreign country's variables, can be written:

$$m_t - p_t = \phi y_t - \lambda i_t + \delta O_t \qquad (1.3)$$

$$m_t^* - p_t^* = \phi y_t^* - \lambda i_t^*, \qquad (1.4)$$

where $0<\phi<1$ is the income elasticity of money demand; $\lambda>0$ is the interest rate semi-elasticity of money demand; and $\delta > 0$ is the oil price elasticity. This relationship is true because crude oil is priced in US dollars and higher oil prices increase demand for the US dollar, resulting in an appreciation of the US dollar. All variables, with the exception of interest rates, are expressed in logarithm form. Under the flexible price monetary model, the standard PPP relationship is assumed to hold continuously:

$$e_t = p_t - p_t^*, \qquad (1.5)$$

where e_t represents the nominal exchange rate measured in foreign currency to domestic currency. Since the price levels determine the domestic and foreign money supplies, as in equation (1.5), the price level functions can be presented as follows:

$$p_t = m_t - \phi y_t + \lambda i_t - \delta O_t \qquad (1.6)$$

$$p_t^* = m_t^* - \phi y_t^* + \lambda i_t^*. \qquad (1.7)$$

Therefore, we substitute equations (1.6) and (1.7) into equation (1.5) to obtain the exchange rate, e_t, as follows:

$$e_t = (m_t - \phi y_t + \lambda i_t - \delta O_t) - (m_t^* - \phi y_t^* - \lambda i_t^*) . \qquad (1.8)$$

This can be simplified to:

$$e_t = (m_t - m_t^*) - \phi(y_t - y_t^*) - \delta O_t + \lambda(i_t - i_t^*). \qquad (1.9)$$

Note that the monetary model of the exchange rate under flexible prices assumes that UIP, which equates the interest rate differential between two countries to the future change in exchange rate, holds. The UIP condition is given by the following equation:

$$i_t - i_t^* = E(\Delta e_{t+1} | \Omega_t), \qquad (1.10)$$

where $E(.|\Omega_t)$ represents the expectation of future change in nominal exchange rate based on the information set Ω at the current time period. Then, equation (1.9) becomes

$$e_t = (m_t - m_t^*) - \phi(y_t - y_t^*) - \delta O_t + E(\Delta e_{t+1} | \Omega_t) . \qquad (1.11)$$

If e_t is I (0) or I (1), then Δe_{t+1} will equal to zero in the steady state, as in Rapach and Wohar (2002). Thus, equation (1.11) will become:

$$e_t = (m_t - m_t^*) - \phi(y_t - y_t^*) - \delta O_t . \qquad (1.12)$$

Based on equation (1.12), we can infer that a rise in the domestic money supply relative to the foreign money supply, ceteris paribus, leads to the appreciation of the nominal exchange rate (e_t). On the other hand, a rise in domestic output relative to foreign output, ceteris paribus, causes the depreciation of the nominal exchange rate (e_t). Regarding the impact of oil price increases, a rise in oil prices leads to the depreciation of the nominal exchange rate (e_t).

1.3 Literature Review

In the seminal work of Meese and Rogoff (1983), they document the failure of various monetary models and time series models of exchange rate determinations in predicting the movements of exchange rates. Since then, there has been extensive research attempting to explain the movements of exchange rates. This, in turn, encourages researchers to look for other factors that might be able to explain and to predict exchange rate movements. Lastrapes (1992) identifies three real shocks, productivity growth, government budget deficit, and real oil prices, to explore their effects on real exchange rates. He documents evidence showing that these shocks explain more than 80% of exchange rate variations in the long run.

Clarida and Gali (1994) employ the Blanchard-Quah identification scheme to explore the consequences of real shocks, including demand, supply, and money, on the bilateral real exchange rate of the US dollar against the currencies of Canada, Germany, Japan, and the UK. They conclude that real shocks contribute to the variation in real exchange rate by more than 50% of the variance of the real exchange rate variability. Other authors (Throop, 1993; Evans and Lothian, 1993; and Zhou, 1995) confirm that non-monetary shocks play an influential and significant role in explaining the variations of exchange rates.

Moreover, other studies, based on atheoretical models, document the explanatory power of oil prices in capturing the movements of exchange rates. Amano and Norden (1998) examine the essential role of oil prices on real exchange rates of three major currencies with monthly data over the period 1973:01 to 1993:06. They find evidence supporting the existence of a stable long run relationship between oil prices and real exchange rates. Their analysis indicates that higher oil prices lead to the appreciation of the US dollar and the depreciation of the German Mark and the Japanese Yen.

Chaudhuri and Daniel (1998) use the data of 16 OECD countries to examine the effects of oil prices on the US real exchange rate. They report that oil prices can explain the fluctuations of US real exchange rate, since both oil prices and real exchange rates have the same nonstationary behavior. They also find evidence supporting the idea that higher oil prices lead to the appreciation of the US dollar against all countries. Sadorsky (2000) uses various energy prices, including crude oil prices, to examine their impacts on the trade-weighted US exchange rate. He reports evidence supporting the existence of a long run relationship between energy prices and the US dollar exchange rate. Sadorsky also documents the negative relationship between energy prices and the USD exchange rate.

Akram (2004) studies the possibility of a non-linear cointegration relationship between oil prices and the Norwegian exchange rate. He finds evidence supporting the notion of a negative relationship between oil prices and exchange rate; he also points out that this relationship varies with the level and with the trend in oil prices. Chen and Chen (2007) use panel cointegration techniques to investigate the relationship between real oil prices and the US dollar exchange rates against G7 countries. Their evidence indicates not only the presence of a cointegration relationship between oil prices and exchange rates, but also confirms that oil prices are able to predict the movements of exchange rates.

Narayan, et al. (2008) employ both the GARCH and exponential GARCH models to investigate the impact of oil prices on the nominal exchange rate of the Fiji Islands. They find evidence confirming the negative relationship between oil prices and the US dollar relative to the

Fiji exchange rate. Jahan-Parvar and Mohammadi (2008) examine the relationship between oil prices and the real exchange rate for 14 oil-producing countries based on an autoregressive distributed lag model. Their evidence indicates the existence of a stable long run relationship between oil prices and exchange rate, confirming the validity of the Dutch disease hypothesis. In an alternative paper, Mohammadi and Jahan-Parvar (2012) employ threshold and momentum-threshold models to explore the validity of the Dutch disease hypothesis for 13 oil-exporting countries. They find evidence supporting the validity of the Dutch disease only for three countries; in other words, the US dollar tends to depreciate relative to the Bolivian boliviano, Mexican peso, and Norwegian krone. Other studies (Huang and Guo, 2007; Thalassinos and Politis, 2012; and Uddin et al., 2014) also document the essential role of oil prices in explaining the behavior of exchange rates.

1.4 Data

We use quarterly data over the period 1986:Q1 to 2014:Q3 for the nominal exchange rate of the US dollar, West Texas intermediate crude oil prices, GDP, and money supply for the following 14 countries: Australia, Canada, Chile, Denmark, Japan, Mexico, New Zealand, Norway, South Africa, South Korea, Sweden, Switzerland, the United Kingdom (U.K.), and the United States of America (US). The composition of the sample is determined by data availability. In addition, these countries are major trade partners of the US, and the currencies of these countries are actively traded in the international currency market.

The data for GDP and oil prices are obtained from the International Financial Statistics (IFS) database of the International Monetary Fund (IMF) and Federal Reserve Bank of St. Louis, respectively. The nominal exchange rate is measured as US Dollar per one unit of foreign currency; thus, an increase in the nominal exchange rate means a depreciation of the USD.

Money supply is measured by the broad money supply, M3. The nominal exchange rate and money supply data are obtained from the Organization for Economic Co-operation and Development (OECD) database. It is also essential to emphasize that all the data are expressed in logarithm form.

1.5 Empirical Methodology and Results

1.5.1 Preliminary Investigation

The first step of the analysis is to ascertain the order of integration of the economic variables. To do so, we rely on some standard unit root tests, the Augmented Dickey–Fuller "ADF" (1979), the Phillips Perron "PP" (1988), and the Kwiatkowski, Phillips, Schmidt and Shin "KPSS" (1992) tests, to ensure the stationarity of the economic variables[1]. The results of these tests, as presented in Tables 1.1 – 1.6, confirm the nonstationarity of all variables in their levels and the stationarity of the variables in their first difference.

Since our economic variables are integrated of order one, or I (1), then some of these variables may be cointegrated. To check this, we apply the popular cointegration tests developed by Johansen and Juselius (1990). These tests also enable us to gauge the adequacy of modeling the US nominal exchange rate as a function of oil prices and monetary fundamentals. Table 1.7 presents the results of the Johansen and Juselius (1990) cointegration tests[2], which consist of the Trace and the Maximum Eigenvalue tests. Both the Trace and the Maximum Eigenvalue tests confirm the existence of at least one cointegration relationship among our economic variables.

Before proceeding in our analysis, we also assess the stability of the existing cointegration relationship between the USD exchange rate, oil prices, and monetary

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[1] The unit root tests were done in R (version 3.1.2) using functions ur.df, ur.pp, and ur.kpss from package urca (version 1.2-8).

[2] The cointegration tests were done in R (version 3.1.2) using function ca.jo from package urca (version 1.2-8).

fundamentals. To do so, we employ the Quandt–Andrews unknown breakpoint tests developed by Andrews (1993) and Andrews and Ploberger (1994). The essential idea behind the Quandt–Andrews unknown breakpoint does not assign any information regarding the breakpoints prior to the estimation and identifies the breakpoints by comparing the residuals before and after the presumed point of break for every time period. The test statistics are summarized as Sup F, Ave F, and Exp F that all share the same null hypothesis of no structural change. To obtain these test statistics[3], we estimate the following vector error correction model via OLS.

$$e_{j,t} = \alpha + \sum_{i=1}^{k} \beta_i \, e_{j,t} + \gamma(m_t - m_t^*) + \delta(y_t - y_t^*) + \sum_{i=1}^{k} \theta_i \Delta Oil_{t-i} + \phi ECT_{t-1} + \varepsilon_t \,, \qquad (1.13)$$

where $e_{j,t}$ is the USD exchange rate against the foreign country j at time t; $(m_t - m_t^*)$ denotes the US money supply relative to foreign money supply; $(y_t - y_t^*)$ denotes the US output relative to the foreign output; ΔOil_t is the percentage change of oil price at time t. ECT_{t-1} is the error correction term at time period $t-1$, the lag length k is chosen based on the Akaike information criteria "AIC", and ε_t is the error term. Note that the error correction term is given as follows:

$$ECT_t = e_{j,t} - \alpha_0 - \alpha_1(m_t - m_t^*) - \alpha_2(y_t - y_t^*) - \alpha_3 Oil_t. \qquad (1.14)$$

In Table 1.8, we present the estimated break date and the corresponding structural break tests with asymptotic p-values computed by Hansen's (1997) approximation. We fail to reject the null hypothesis of no structural break, confirming the stability of the parameter estimates of the exchange rate's vector error correction equation at 1%, 5%, or 10% significance levels.

[3] The structural break tests were done in R (version 3.1.2) using function sctest from package strucchange (version 1.5-0).

Table 1.1 Augmented Dickey Fuller (1979) Unit Root Test.

	Level Data			First Difference Data		
	None	Trend	Drift	None	Trend	Drift
Oil	0.8698	-3.012	-1.1935	-9.078	-9.1979	-9.2325
Gross Domestic Product:						
Australia	6.5419	-2.3031	-0.5065	-3.5225	-6.4543	-6.4688
Canada	4.0823	-2.4174	-0.7211	-4.1401	-6.1275	-6.1246
Chile	4.6102	-2.4168	-1.942	-8.4519	-11.108	-10.8579
Denmark	2.3055	-1.1268	-1.3505	-8.7677	-9.1232	-9.1092
Japan	3.7074	-1.7792	-4.0849	-5.5998	-7.5056	-6.5805
Mexico	4.2012	-2.6929	-0.5433	-6.8654	-7.9851	-7.9972
New Zealand	4.3364	-2.7699	-0.6646	-10.1054	-13.214	-13.1972
Norway	2.3035	-2.9596	-1.1966	-14.5024	-15.8873	-15.8152
South Africa	3.5054	-1.7922	0.8408	-4.1502	-5.4712	-5.2679
South Korea	4.1979	-1.8482	-2.1259	-10.0935	-12.3452	-12.0334
Sweden	1.6451	-3.5466	-2.1684	-7.0928	-7.3317	-7.3007
Switzerland	3.934	-2.8098	-0.0588	-4.4029	-5.7762	-5.7868
U.K.	3.0812	-1.812	-1.3912	-2.7071	-3.8572	-3.7585
US	5.5083	-1.0612	-1.8954	-3.4698	-6.0906	-5.8485

Note: The 5% critical values for ADF test are: None=-1.95, Trend= -3.43, and Drift=-2.88.

Table 1.2 Augmented Dickey Fuller (1979) Unit Root Test.

Money Supply (M3)						
	Level Data			First Difference Data		
	None	Trend	Drift	None	Trend	Drift
Australia	3.6408	-2.0918	-0.3351	-1.8229	-4.4249	-4.435
Canada	4.718	-1.6765	-0.2038	-1.7757	-4.9107	-4.9332
Chile	1.2241	-3.6582	-4.5176	-1.5039	-3.7176	-2.4373
Denmark	2.3347	-3.113	-0.1339	-6.028	-6.8047	-6.8172
Japan	1.306	-4.3613	-2.9862	-2.0737	-2.6478	-2.494
Mexico	0.4106	-6.1197	-3.2997	-2.5028	-3.1465	-2.9138
New Zealand	5.7351	-1.7899	-1.4793	-2.8367	-5.3779	-5.2829
Norway	4.47	-2.5301	-0.8581	-2.6573	-5.6567	-5.6297
South Africa	3.328	-1.0243	-2.1015	-1.9549	-4.8938	-4.5382
South Korea	1.5133	-4.0562	-6.7109	-1.7086	-4.1111	-2.2977
Sweden	4.614	-2.077	-0.5132	-4.0539	-6.0018	-6.0342
Switzerland	3.9112	-2.0066	-0.1965	-2.7967	-4.4453	-4.4526
U.K.	4.1134	-0.6535	-1.9547	-2.8572	-4.6978	-4.3702
US	5.3074	-1.11	1.7401	-2.3288	-5.8045	-5.2695

Note: The 5% critical values for ADF test are: None=-1.95, Trend= -3.43, and Drift=-2.88.

Table 1.3 Augmented Dickey Fuller (1979) Unit Root Test.

	Nominal Exchange Rate					
	Level Data			First Difference Data		
	None	Trend	Drift	None	Trend	Drift
Australia	-1.2583	-2.2589	-1.8821	-7.6756	-7.6364	-7.687
Canada	-1.2398	-1.7261	-1.4553	-7.1251	-7.1048	-7.1366
Chile	1.6357	-2.144	-2.6737	-7.0038	-7.6849	-7.3618
Denmark	-0.7906	-2.816	-2.6585	-7.3969	-7.3768	-7.3972
Japan	-0.8481	-2.7983	-2.5265	-8.7141	-8.797	-8.7462
Mexico	0.7803	-3.8813	-4.2748	-5.2182	-6.1635	-5.6317
New Zealand	-1.0837	-2.4475	-1.8431	-6.6408	-6.6353	-6.6788
Norway	-0.4238	-2.6093	-2.4949	-7.8643	-7.8018	-7.8378
South Africa	1.4554	-2.0092	-0.9556	-6.8934	-7.1724	-7.2092
South Korea	0.1244	-2.6026	-1.9109	-7.4904	-7.4288	-7.4622
Sweden	-0.1824	-2.5621	-2.5363	-7.5338	-7.4661	-7.4972
Switzerland	-1.8783	-2.4719	-1.6087	-7.7944	-7.855	-7.889
U.K.	-0.5444	-3.3902	-3.4068	-8.0782	-8.0039	-8.0409

Note: The 5% critical values for ADF test are: None=-1.95, Trend= -3.43, and Drift=-2.88.

Table 1.4 Phillips and Perron (1981) and Kwiatkowski et al (1992) Unit Root Test.

	Phillip and Perron (1981) Test				Kwiatkowski-Phillips-Schmidt-Shin (1992) Test			
	Level		First Difference		Level		First Difference	
	Constant	Trend	Constant	Trend	Constant	Trend	Constant	Trend
Oil	-0.698	-2.737	-8.887	-8.833	2.082	2.082	0.073	0.038
Gross Domestic Product:								
Australia	-0.388	-2.289	-9.162	-9.137	2.882	0.182	0.075	0.069
Canada	-0.548	-1.936	-6.465	-6.457	2.860	0.193	0.078	0.065
Chile	-1.870	-2.727	-19.466	-20.795	2.315	0.492	0.276	0.030
Denmark	-1.533	-4.755	-34.783	-35.685	2.270	2.270	0.119	0.041
Japan	-3.930	-1.473	-9.827	-10.729	2.461	0.641	1.007	0.077
Mexico	-0.774	-6.522	-23.841	-23.768	2.361	2.361	0.032	0.021
New Zealand	-1.157	-3.269	-14.988	-14.954	2.698	0.207	0.108	0.049
Norway	-1.006	-3.849	-22.158	-22.499	2.838	0.461	0.123	0.067
South Africa	0.947	-1.299	-6.333	-6.456	2.735	0.643	0.307	0.083
South Korea	-2.512	-3.113	-30.438	-34.651	2.794	0.689	0.445	0.017
Sweden	-2.956	-9.393	-41.330	-43.970	1.625	0.306	0.312	0.146
Switzerland	0.031	-2.442	-7.147	-7.129	2.816	0.174	0.054	0.042
U.K.	-1.806	-1.470	-5.033	-5.170	2.376	2.37	0.281	0.082
US	-1.267	-0.818	-8.501	-8.678	2.847	0.491	0.255	0.096

Note: The 5% critical values for PP test: Constant=-2.882684, and Trend= -3.443263; for KPSS test: Constant=0.463, and Trend= 0.146.

Table 1.5 Phillips and Perron (1981) and Kwiatkowski et al (1992) Unit Root Test.

	Phillip and Perron (1981) Test				Kwiatkowski-Phillips-Schmidt-Shin (1992) Test			
	Level		First Difference		Level		First Difference	
	Constant	Trend	Constant	Trend	Constant	Trend	Constant	Trend
Money Supply (M3):								
Australia	-0.462	-1.672	-4.736	-4.716	2.373	2.373	0.109	0.116
Canada	-0.236	-1.460	-5.628	-5.603	2.369	2.369	0.192	0.195
Chile	-8.180	-3.904	-2.753	-4.569	2.216	2.216	1.606	0.380
Denmark	-0.064	-2.345	-6.590	-6.575	2.339	2.339	0.103	0.078
Japan	-6.239	-4.952	-2.193	-2.515	2.116	2.116	1.075	0.286
Mexico	-7.962	-8.152	-2.331	-2.994	2.269	2.269	1.296	0.283
New Zealand	-1.844	-2.381	-8.651	-8.787	2.403	2.403	0.261	0.059
Norway	-0.704	-1.961	-5.875	-5.883	2.392	2.392	0.085	0.076
South Africa	-1.709	-0.788	-6.247	-6.599	2.392	2.392	0.301	0.114
South Korea	-14.220	-4.495	-2.835	-6.528	2.274	2.274	2.032	0.391
Sweden	-0.628	-2.028	-7.639	-7.612	2.350	2.350	0.077	0.077
Switzerland	0.077	-1.356	-5.334	-5.303	2.326	2.326	0.220	0.209
U.K.	-2.759	-1.830	-7.164	-7.533	2.304	2.304	0.512	0.143
US	1.798	-0.699	-5.748	-6.047	2.382	2.382	0.479	0.112

Note: The 5% critical values for PP test: Constant=-2.882684, and Trend= -3.443263; for KPSS test: Constant=0.463, and Trend= 0.146.

Table 1.6 Phillips and Perron (1981) and Kwiatkowski et al (1992) Unit Root Test.

	Phillip and Perron (1981) Test				Kwiatkowski-Phillips-Schmidt-Shin (1992) Test			
	Level		First Difference		Level		First Difference	
	Constant	Trend	Constant	Trend	Constant	Trend	Constant	Trend
Nominal Exchange Rate:								
Australia	-1.543	-1.906	-7.861	-7.838	0.737	0.737	0.087	0.055
Canada	-1.271	-1.494	-7.531	-7.495	0.896	0.896	0.114	0.108
Chile	-2.970	-2.035	-7.901	-8.093	1.647	1.647	0.492	0.080
Denmark	-2.624	-2.697	-8.268	-8.252	0.829	0.829	0.090	0.072
Japan	-2.953	-3.117	-9.025	-9.058	1.394	1.394	0.163	0.067
Mexico	-5.154	-4.224	-6.999	-7.697	2.035	2.035	0.747	0.117
New Zealand	-1.565	-2.053	-7.247	-7.235	0.862	0.862	0.072	0.050
Norway	-2.116	-2.240	-8.428	-8.384	0.600	0.600	0.056	0.058
South Africa	-1.010	-1.939	-8.561	-8.523	2.108	2.108	0.075	0.059
South Korea	-1.665	-2.239	-7.680	-7.643	1.370	1.370	0.074	0.071
Sweden	-2.150	-2.181	-7.598	-7.559	0.455	0.455	0.061	0.060
Switzerland	-1.714	-2.472	-8.772	-8.730	1.546	1.546	0.071	0.075
U.K.	-2.972	-2.963	-8.239	-8.190	0.132	0.132	0.042	0.041

Note: The 5% critical values for PP test: Constant=-2.882684, and Trend= -3.443263; for KPSS test: Constant=0.463, and Trend= 0.146.

Table 1.7 Johansen and Juselius (1990) Cointegration Test.

	Trace Test				Eigenvalue Max Test			
	$r \leq 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r \leq 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$
Australia	49.70***	27.16	15.22	4.53	25.59***	11.94	10.70	4.53
Canada	51.19***	25.43	12.20	0.90	25.76***	13.23	11.30	0.90
Chile	85.98**	43.28**	7.12	3.32	42.70**	36.16**	3.80	3.32
Denmark	49.36**	28.49	13.75	6.37	20.87	14.74	7.37	6.37
Japan	87.58**	33.75***	15.78	4.95	53.83**	17.97	10.83	4.95
Mexico	62.81**	30.89	13.20	4.89	31.92**	17.69	8.30	4.89
New Zealand	78.74**	31.46	15.67	4.93	47.28**	15.79	10.73	4.93
Norway	61.35**	24.22	14.42	5.75	37.12**	9.80	8.67	5.75
South Africa	87.34**	36.61**	10.83	2.77	50.74**	25.77**	8.06	2.77
South Korea	106.21**	46.99**	17.02	3.84	59.21**	29.97**	13.18	3.84
Sweden	61.61**	21.09	8.65	2.01	40.52**	12.44	6.64	2.01
Switzerland	90.97**	41.97**	21.47**	7.36	49.00**	20.49***	14.11***	7.36
U.K.	57.49**	24.85	9.76	2.63	32.64**	15.09	7.12	2.63

* (**) (***) Indicate the rejection of the null at 1%, 5%, and 10% level of significance respectively.

Table 1.8 Structural Break Tests.

	Break Date	Ave F	Sup F	Exp F
Australia	2008:Q4	5.14 (0.59)	14.3 (0.29)	3.68 (0.47)
Canada	2007:Q2	6.51 (0.35)	10.56 (0.65)	3.66 (0.48)
Chile	2002:Q4	8.29 (0.15)	21.12 (0.03)	7.17 (0.04)
Denmark	1990:Q1	5.98 (043)	11.92 (0.49)	3.59 (0.50)
Japan	1994:Q3	3.48 (0.90)	14.12 (0.30)	3.19 (0.61)
Mexico	1993:Q2	3.92 (0.83)	14.09 (0.30)	3.74 (0.46)
New Zealand	2007:Q2	12.31 (0.03)	18.59 (0.08)	7.29 (0.04)
Norway	1991:Q3	7.28 (0.24)	14.88 (0.24)	5.16 (0.19)
South Africa	2001:Q2	4.84 (0.65)	13.82 (0.32)	3.49 (0.65)
South Korea	1996:Q3	2.72 (0.98)	20.09 (0.06)	5.72 (0.13)
Sweden	2007:Q4	9.39 (0.08)	17.45 (0.12)	5.80 (0.12)
Switzerland	1993:Q4	6.24 (0.38)	14.51 (0.27)	5.05 (0.20)
U.K.	2008:Q4	9.42 (0.08)	14.96 (0.34)	5.53 (0.14)

Numbers in parenthesis are p-values.

1.5.2 The Vector Error Correction Model

It is common in the literature to rely on Vector Autoregressive (VAR) models as empirical tools to investigate the effects of oil price shocks on various macroeconomic and financial variables. However, the standard VAR model is a reduced form model. Interpreting the results obtained from the reduced form is often impossible, unless the reduced form VAR is linked to an economic model. In other words, when economic theory provides an explanation linking forecast errors and fundamental shocks, then we call the resulting model a Structural Vector Autoregressive (SVAR) model. In case there exists a cointegration relationship among the economic variables, then it is possible to apply the SVAR technique to vector error correction models (VECM) with cointegrated variables.

The analysis of a structural vector error correction (SVEC) model starts from the reduced form standard $VAR\ (p)$ model:

$$X_t = A_1X_{t-1} + A_2X_{t-2} + \cdots + A_pX_{t-p} + u_t\ , \qquad (1.15)$$

where $X_t = (O_t, Y_t, e_t, M_t)'$ is a $k \times 1$ vector of observable variables consisting of real oil price, domestic output relative foreign output, nominal exchange rate of the USD, and domestic money supply relative foreign money supply. $A_i's$ are $(k \times k)$ coefficient matrices, and u_t is a $(k \times 1)$ vector of unobservable error terms with $u_t \sim (0, \sum_u)$. The lag order, p, is determined based on the Akaike Information Criterion (AIC).

By assuming that the variables are at most difference stationary, then the reduced form VAR model can be written as a VECM of the form:

$$B_0\Delta X_t = \ \Pi^*X_{t-1} + \ \Gamma_1^*\Delta X_{t-1} + \cdots + \ \Gamma_{p-1}^*\Delta X_{t-p+1} + \varepsilon_t, \qquad (1.16)$$

where Δ denotes the first difference of X_{t-k}, $\Gamma^{*\prime}s$ are $(k \times k)$ matrices of short run coefficients. Π^* is the structural matrix, and ε_t is $(k \times 1)$ structural form error with zero mean and covariance matrix I_K. B_0 is a $(k \times k)$ matrix of contemporaneous relations among the variables in X_t. If we assume that the B_0 matrix is invertible, then we can rewrite equation (1.16) as follows:

$$\Delta X_t = \ \Pi X_{t-1} + \ \Gamma_1\Delta X_{t-1} + \cdots + \Gamma_{p-1}\Delta X_{t-p+1} + u_t, \qquad (1.17)$$

where $\Pi_t = B_0^{-1}\Pi^*$ and $\Gamma_j = B_0^{-1}\Gamma_j^*$ for $j = 1, \dots, p-1$. The $u_t = B_0^{-1}\varepsilon_t$ relates the reduced form disturbance, u_t', to the underlying structural errors ε_t. When Π has a reduced rank of $r \leq k-1$, then $\Pi = \alpha\beta'$ where α and β are $(k \times r)$ matrices consisting of the long run relationship and the speed of adjustment coefficients, respectively. The vector, u_t, is a $(k \times 1)$ white noise error with zero mean and covariance matrix Σ_u. When we substitute Π into equation (1.17), we obtain the model in error correction form as follows:

$$\Delta X_t = \alpha\beta' X_{t-1} + \Gamma_1 \Delta X_{t-1} + \cdots + \Gamma_{p-1} \Delta X_{t-p+1} + u_t. \qquad (1.18)$$

Because the reduced form residuals, $u_t's$, are strongly correlated, it is difficult to eliminate the effects of a single shock on the whole system unless some restrictions are imposed on the system. To do so, we multiply both sides by B_0 in order to obtain,

$$B_0 u_t = \varepsilon_t \qquad (1.19)$$

$$\Sigma = B_0^{-1} \Sigma_\varepsilon (B_0)', \qquad (1.20)$$

where Σ, B_0, and Σ_ε are all $(k \times k)$ matrices. Since the literature has proposed a number of different exact identification schemes, we rely on the most popular Cholesky[4] identification scheme to obtain an exact identification of Σ_ε requiring the imposition of $k \times (k-1)/2$ additional restrictions on B_0^{-1}. Under the Cholesky scheme, the ordering of the variables is crucial for the structural economic interpretation of the VECM. Therefore, we order the variables as follows: real oil price, relative output, nominal exchange rate of the USD, and relative money supply; $X_t = (O_t, Y_t, e_t, M_t)'$.

The economic justification of this recursive ordering is based on four reasons. Since the US is a price taker in the oil market, and the price of crude oil is determined by global demand and supply conditions, then the relative output, exchange rate, and relative money supply will have negligible effects on it. Hence, the price of crude oil is assumed to be exogenous. However, the price of oil can have a contemporaneous effect on the other variables. In other words, a rise

[4] Sims (1980) introduced Cholesky decomposition. It is a recursive identification scheme assuming that the covariance matrix is diagonal, and B_0 matrix is a lower triangular matrix by imposing $k \times (k-1)/2$ extra restrictions to ensure the identification of the structural model.

(decline) of oil price would increase (decrease) the cost of production, since crude oil is used as an input in the production process and the distribution process of goods and services.

Second, relative output is assumed to not respond contemporaneously to any changes in relative money supply and exchange rate. Kim and Ying (2007) documents that the information about money supply and exchange rate is only available with a lag, since they are not observable within a month. Third, we impose that nominal exchange rates do not respond to changes in relative money supply. Fourth, since the relative money supply is a policy variable and controlled by monetary authorities, we allow the relative money supply to respond to changes in the other variables.

Once we estimate the VECM[5], we compute impulse response functions[6] to examine the effects of each structural shock on the other variables. Therefore, to examine the dynamic effects of each structural shock on the movements of the USD nominal exchange rates, we compute the impulse responses with a one standard deviation band.

The analysis of impulse responses is essentially used to trace out the dynamic responses of the equations in the VECM to a set of identified structural shocks. In essence, impulse response analysis enables us to trace out the dynamic impact of changes in each of the variables in the VECM over time. In addition, the identification assumptions impose that the shock is a one-standard deviation movement of one of the shocks.

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[5] The estimates of VECM were done in R (version 3.1.2) using function VECM from package vars (version 1.5-2); the parameter estimates of VECM are attached in the appendix.

[6] The estimated impulse responses were done in R (version 3.1.2) using function irf from package vars (version 1.5-2).

1.5.3 Impulse Response Function Results

Figures 1.1 – 1.4 display the response of the USD exchange rate to the identified structural shocks with a one standard deviation band.

The derived monetary model of exchange rates suggests a negative link between oil prices and the USD exchange rates. Figure 1.1 illustrates the response of the USD exchange rate to real oil price shock and indicates that higher oil prices are associated with the depreciation of the USD exchange rate against all currencies, except the Australian currency. In other words, the plotted impulses indicate that a one-standard deviation shock to the real price of oil is followed by a depreciation of the USD exchange rate against twelve currencies, and the depreciation rate ranges between 0.002 and 0.018 percent points. On the other hand, the USD against the Australian dollar experiences an appreciation rate of 0.016 percent point as a result of a one-standard deviation shock to the real price of oil.

It is also worthy to note that the results indicating the negative relationship between oil prices and the USD exchange rates are consistent with the findings of previous studies, such as Chaudhuri and Daniel (1998), Sadorsky (2000), Chen and Chen (2007), and Uddin et al. (2014).

The monetary model of exchange rates indicates a negative relationship between the nominal exchange rate and relative output. The plotted impulses with a one-standard deviation band, as shown in Figure 1.2, illustrate the response of the USD exchange rate to real output shocks. In particular, a positive shock to relative output causes the USD exchange rate to increase (depreciate) immediately against four currencies whereas it declines (appreciates) immediately against nine currencies. For example, we find the immediate response of a one-standard deviation shock to relative output causes the nominal exchange rate to appreciate by 0.002 and 0.008 percent points for Chile and Sweden respectively.

Likewise, the derived monetary model of exchange rates suggests a positive relationship between relative money supply and nominal exchange rates. Figure 1.3 illustrates the responses of the USD exchange rate to a positive shock to the relative money supply. We find the responses of the USD to a positive shock to the nominal money supply indicate the appreciation of the USD against ten currencies whereas the USD depreciates against four currencies. For instance, we find that the immediate response of a one-standard deviation shock to the relative money supply leads to the depreciation of the USD against the Mexican peso by 0.016 percent points.

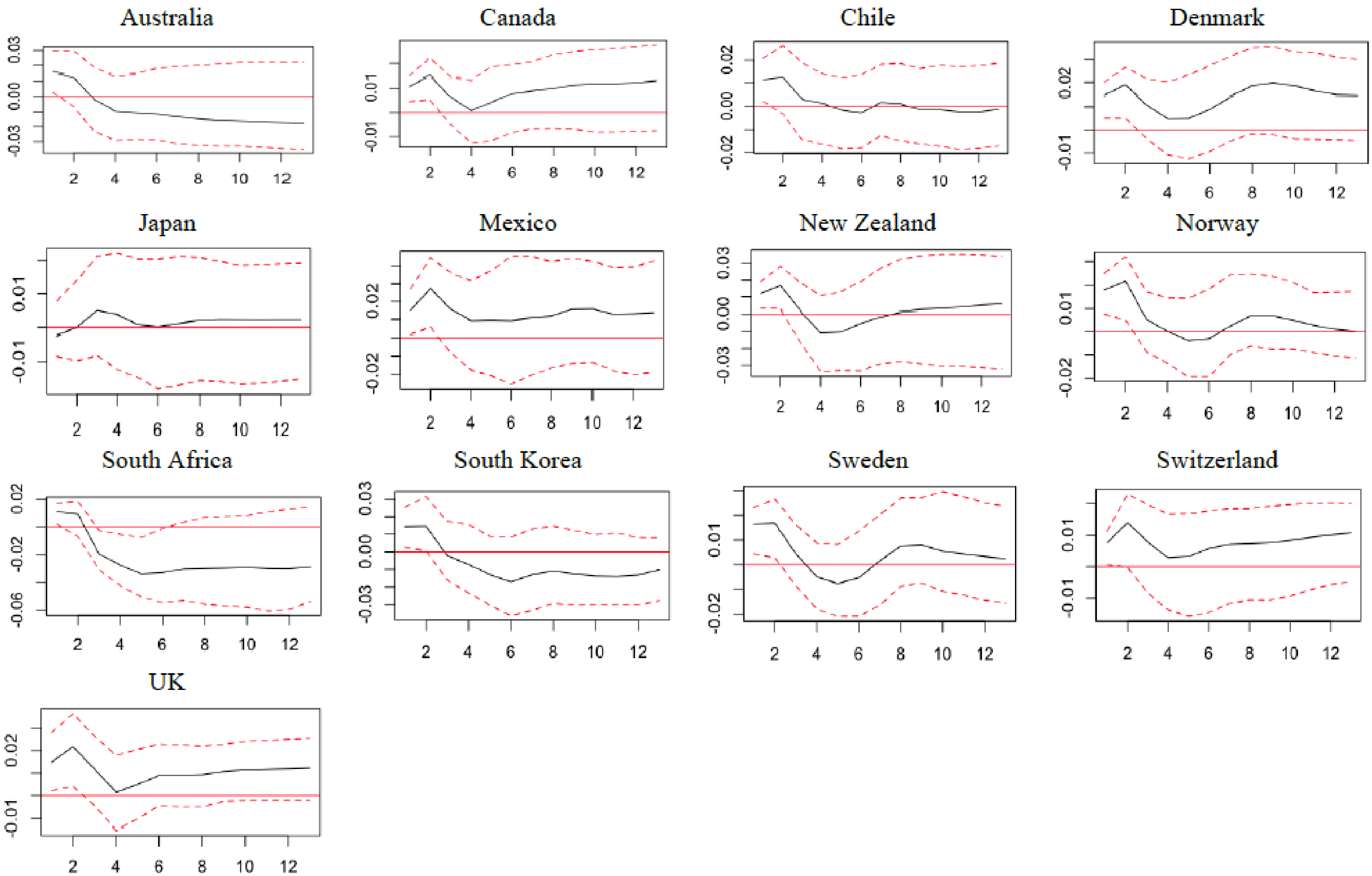
It is worthy to document that the reported findings regarding the impacts of monetary fundamentals on the movements of the USD exchange rate are consistent with the findings of Rapach and Wohar (2004) for Australia, Canada, Denmark, and Sweden, Lizardo and Mollick (2010) for Mexico and the UK, Hunter and Ali (2015) for Japan, and Bruyn et al. (2013) for south Africa.

Lastly, the impact of a positive shock to the exchange rate to itself is shown in Figures 1.4 The plotted impulses with a one-standard deviation bands show that the USD rises (depreciates) during the first two quarters then starts declining (appreciating) in the remaining time period against most currencies. The plotted impulses indicate that the USD increases (depreciates) against the currencies of Canada, Mexico, Norway, and South Africa until the fourth or fifth quarter, and then it starts to decrease (appreciate) or stabilize until the end of the time period. We find the response of the USD against the New Zealand currency to be positive (depreciating) until the fifth quarter, and then it stabilizes over the remaining period. To summarize, we find that a one-standard deviation shock to the USD exchange rate leads to the depreciation of the USD exchange rate within a range of 0.020 and 0.041 percent points.

These results have implications for policy makers, economic researchers, and traders. The USD depreciation, as suggested by economic analysis, has positive and negative effects on the US economy. First, the depreciation of the USD helps in reducing the US trade deficit, since the fall of the USD increases the price competitiveness of US exports in foreign markets and decreases the price competitiveness of foreign goods in the US market. This, in turn, will increase employment since there will be less demand subtracted from the economy. In other words, higher US exports will improve domestic economic activity and improve employment, while lower imports of foreign goods means less domestic spending on foreign goods resulting in a boost to the domestic economy and employment.

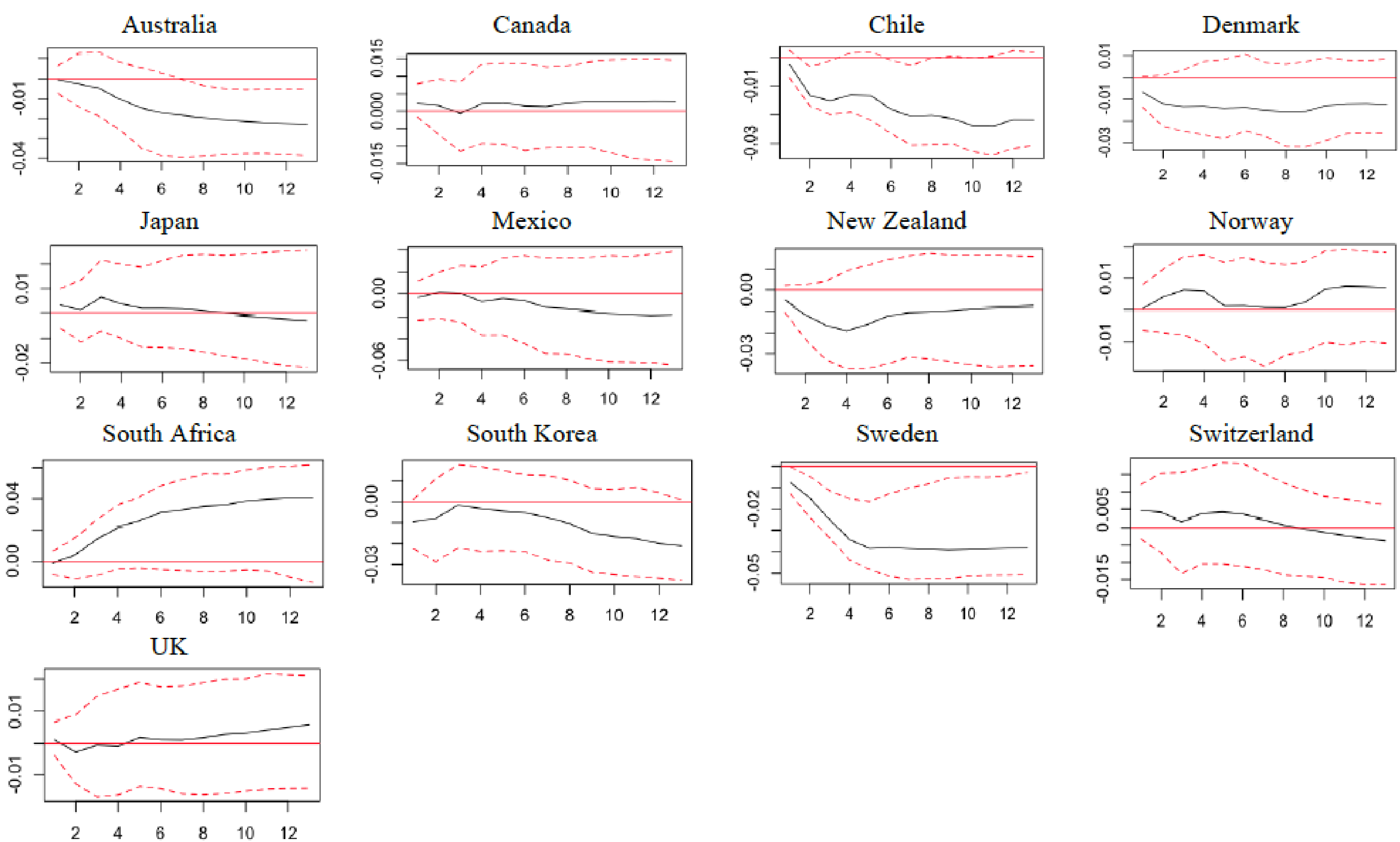
Second, world commodity prices tend to increase as a result of the depreciation of the US dollar. For instance, when the USD experienced a sharp depreciation between 2002 and 2007, there was a sharp surge in gold prices from $300 per ounce to more than $600 per ounce, and crude oil price increased from $20 per barrel to approximately $140 per barrel. The index of non-fuel commodity prices also experienced an increase by 85%. Third, the depreciation of the USD discourages foreign investors to hold dollar assets due to its low expected return. Finally, the depreciation of the USD reduces the US net foreign debt. This is possible because US foreign assets and US foreign liabilities are denominated in foreign currencies and USD, respectively. So, a real depreciation of the USD tends to raise the value of US external assets, while the value of US external liabilities does not rise. Consequently, this reduces the US external debt.

Figure 1.1 The Response of the USD Exchange Rate to Oil Price Shocks



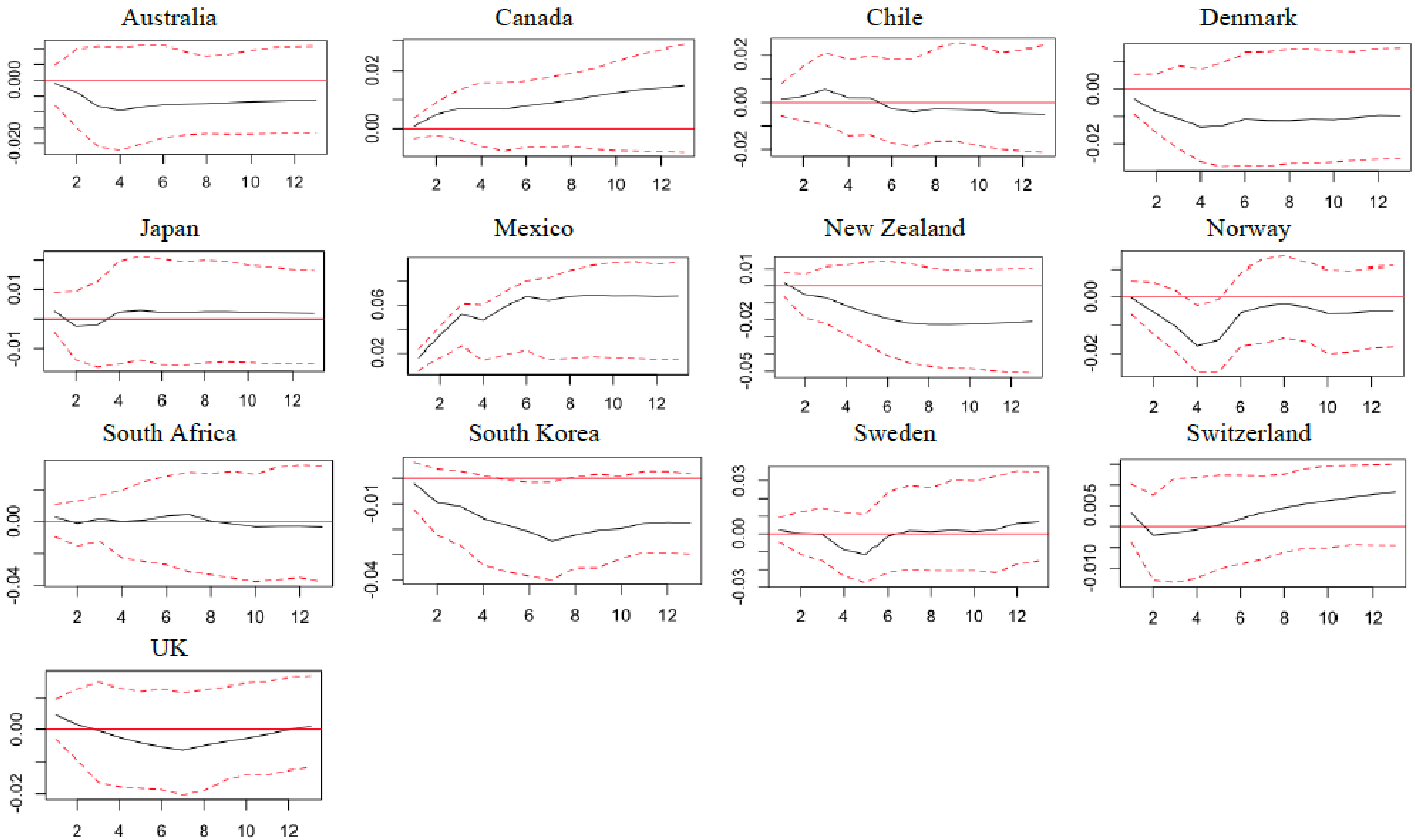
Note: The vertical axis represents the USD exchange rate whereas the horzintal axis represents time horizon "Quarters."

Figure 1.2 The Response of the USD Exchange Rate to Relative Output Shocks



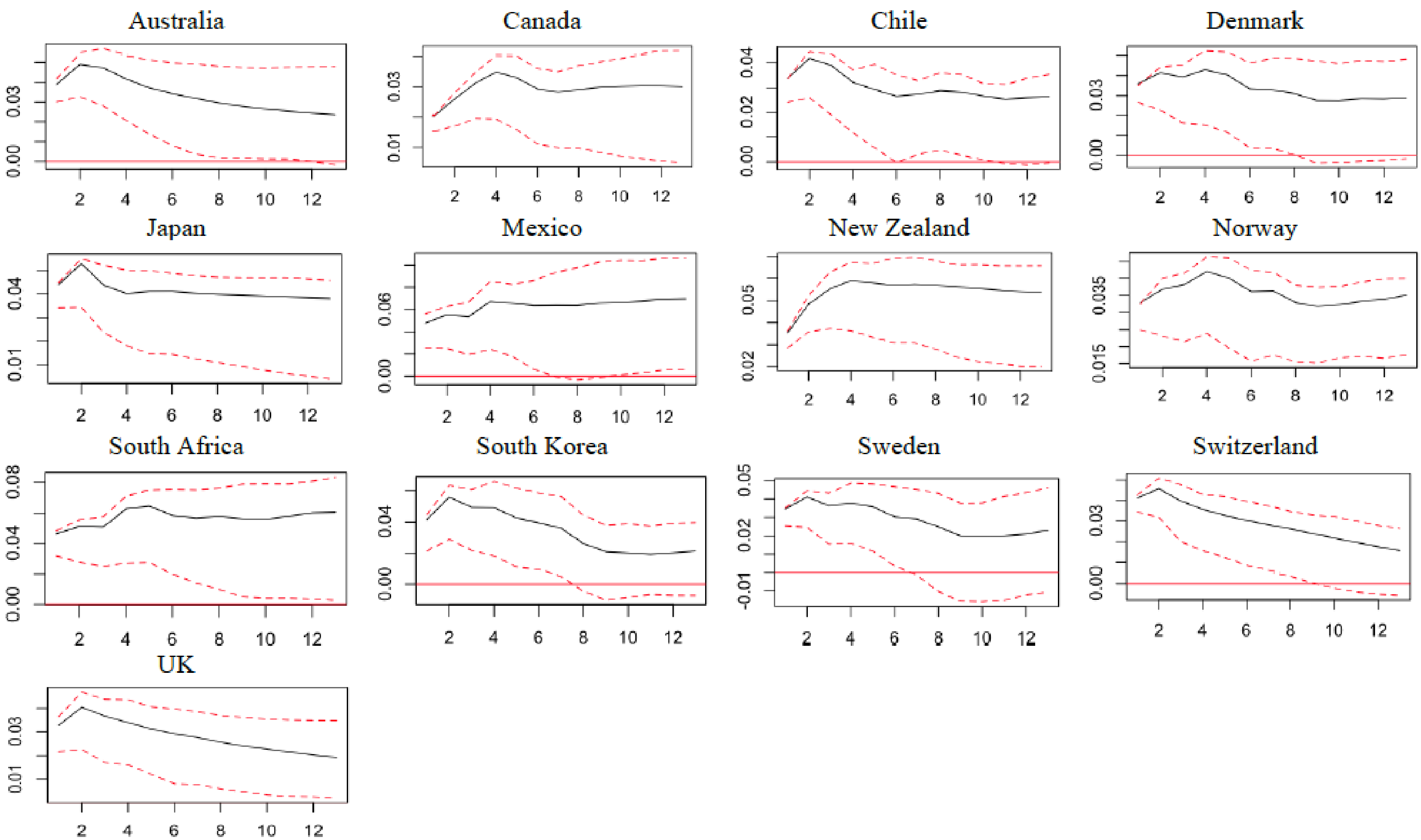
Note: The vertical axis represents the USD exchange rate whereas the horzintal axis represents time horizon "Quarters."

Figure 1.3 The Response of the USD Exchange Rate to Relative Money Supply Shocks



Note: The vertical axis represents the USD exchange rate whereas the horzintal axis represents time horizon "Quarters."

Figure 1.4 The Response of the USD Exchange Rate to Exchange Rate Shocks



Note: The vertical axis represents the USD exchange rate whereas the horzintal axis represents time horizon "Quarters."

1.5.4 Forecast Error Variance Decomposition Analysis

While the impulse response function illustrates the qualitative response of the USD exchange rate to shocks in the price of oil and other structural shocks, the forecast error variance decomposition[7] (FEVD) illustrates the relative importance of the structural shocks in explaining the variations of the USD exchange rate and the variations of other variables.

Table 1.9 presents the contribution of all structural shocks on the USD exchange rate based on the forecast error variance decomposition. Because the price of oil is ordered first in the VEC model, this decomposition assumes that the initial period has all variance in the forecasts attributed to the price of oil and none to the other variables. Therefore, we find that as the forecast horizon increases, there is more variation attributed to the other changes based on the correlation of the changes and the dynamics of the system.

The forecast variation helps us to understand the important role of oil price shocks and other structural shocks in determining the movements of the USD exchange rate. It is evident from the results shown in Table 1.9 that the variation of the USD exchange rate is attributed largely to its own shocks, and as the forecast horizon increases, the contribution of the exchange rate shock on the movements of the USD declines.

Among the other structural shocks, we find the variation in the USD exchange rate is driven to some extent by oil price changes. In particular, we find that between 0.27% and 22.91% is attributed to the change in oil price during the first quarter. After eight quarters, or two years, the results indicate that the variation in the USD exchange rate attributed to the change in oil prices lies within a range of 0.34% and 15.02%. This indicates a decline of the contribution of oil prices in explaining the movements of the USD exchange rates. However, we find that, as the

[7] The estimates of FEVD were done in R (version 3.1.2) using function fevd from package vars (version 1.5-2).

forecast horizon increases, changes in oil prices yield more variation in the value of the USD against seven currencies. The USD variation lies approximately within a range of 6.01% and 15.12%.

Furthermore, the FEVD results indicate that the impact of monetary fundamentals on the USD variation tends to increase as the forecast horizon increases for most countries. However, the change attributable to monetary fundamentals is relatively small compared to the change attributable to the movement in oil prices. For example, the pattern of the forecast variation indicates that shocks to relative output (money supply) explain the USD fluctuations after twelve quarters or three years, within the range of 0.39% and 53.61% (0.24% and 16.79%).

In the case of the USD against the Japanese yen, changes in relative output play a larger role than changes in the relative money supply and oil prices. Strictly speaking, we find that changes in the value of the USD against the Japanese yen are attributed to changes in the relative output by approximately 0.78%. However, about 0.54% of the USD variation is attributable to shocks to the price of oil after one year. As the forecast horizon increases, the contribution of the oil price and relative output shocks decreases; in other words, we find that oil and relative output shocks contribute to explaining roughly 0.34% and 0.39%, respectively, of the movements of the USD exchange rate.

Table 1.9 Forecast Error Variance Decomposition.

Variable	H	Australia Oil Shock	Y Shock	EX Shock	M Shock	Canada Oil Shock	Y Shock	EX Shock	M Shock	Chile Oil Shock	Y Shock	EX Shock	M Shock
USD	1	14.61	0.02	85.36	0.00	21.39	0.92	77.69	0.00	10.26	0.432	89.30	0.00
	4	5.87	1.62	91.01	1.48	10.03	0.33	87.59	2.04	4.69	9.010	86.00	0.28
	8	7.58	9.04	81.26	2.11	8.04	0.35	88.01	3.60	2.86	17.53	78.91	0.68
	12	10.58	15.46	71.73	2.22	9.29	0.45	83.87	6.39	2.05	25.05	71.78	1.09
		Denmark				**Japan**				**Mexico**			
USD	1	13.74	2.97	83.28	0.00	0.27	0.52	99.20	0.00	8.28	0.34	91.36	0.00
	4	8.93	6.86	82.36	1.85	0.54	0.78	98.05	0.61	6.37	0.30	84.44	8.87
	8	9.23	9.57	78.39	2.81	0.34	0.51	98.79	0.34	3.20	0.81	80.60	15.36
	12	12.78	10.45	73.58	3.19	0.34	0.39	99.01	0.24	2.78	1.76	78.66	16.79
		New Zealand				**Norway**				**South Africa**			
USD	1	10.29	1.67	88.04	0.00	22.91	0.01	77.07	0.00	5.47	0.03	94.48	0.00
	4	4.63	6.74	85.59	3.02	11.70	1.29	81.18	5.82	10.04	5.18	84.51	0.25
	8	2.49	5.14	83.47	8.89	7.08	0.74	86.94	5.22	15.02	12.98	71.83	0.15
	12	1.78	4.05	82.46	11.69	5.64	1.44	88.5	4.34	15.12	18.15	66.34	0.37
		South Korea				**Sweden**				**Switzerland**			
USD	1	10.00	4.68	85.31	0.00	18.09	3.82	78.08	0.00	3.20	1.20	95.58	0.00
	4	4.29	1.58	91.43	2.69	7.23	24.87	66.27	1.61	4.51	0.78	93.75	0.95
	8	6.36	2.03	81.69	9.91	4.13	43.70	50.32	1.83	4.34	0.85	94.06	0.74
	12	8.03	6.67	72.14	13.15	3.39	53.61	41.61	1.37	6.01	0.83	91.75	1.40
		United Kingdom											
USD	1	16.96	0.09	82.93	0.00								
	4	13.83	0.15	84.50	1.49								
	8	11.50	0.19	83.99	4.30								
	12	13.37	0.67	81.66	4.29								

Note: Y shock represent the relative output shock, EX shock represents the exchange rate shock, and M shock represents the relative money supply shock.

1.5.5 Out of Sample Forecasts

An alternative way to gauge whether oil prices enhance the predictability of the monetary model of exchange rate determination is through the evaluation of out-of-sample forecasts. Using one-step-ahead out-of-sample forecasts, we compare the forecasting performance of the composite flexible price monetary model containing oil prices, the composite model, as given by equation (1.12) relative to the benchmark model derived in Rapach and Wohar (2002) as given below by equation (1.21).

$$e_t = (m_t - m_t^*) - \phi(y_t - y_t^*) \qquad (1.21)$$

The one-step-ahead out-of-sample forecasts are obtained from a recursive forecasting scheme, which divides the dataset into two subsamples. The first subsample contains the in-sample observations, R. The first subsample is used to estimate the model coefficients. The second subsample is used to generate the out-of-sample forecasts, P. In this study, we generate the out-of-sample forecasts recursively from 2010:Q1 to 2014:Q3 in order to forecast the USD exchange rate after the recent financial crisis of 2008; this also implies that R=96 and P=19.

To assess the out-of-sample forecast performance, we employ the MSE-T and ENC-T tests of Clark and McCracken (2001) and the mean squared error (MSE) ratio. Clark and McCracken (2001) point out that the Diebold–Mariano (1995) test is not appropriate to compare forecasts of nested models. Hence, they developed tests to assess the forecasting performance of nested models.

Using Clark and McCracken's (2001) method, let $u_{1,t+1}$and $u_{1,t+2}$ denote the one-step-ahead forecast error from the restricted model, the benchmark model, and the one-step-ahead forecast error from the unrestricted model, the composite model, respectively. Define the loss differential function for the MSE-T as follows:

$$d_{n,t+1} = u_{1,t+1}^2 - u_{2,t+1}^2 \qquad (1.22)$$

Building on Diebold and Mariano (1995), Clark and McCracken (2001) develop the MSE-T test of equal forecast accuracy, which is as follows:

$$MSE - T = (P-1)^{\frac{1}{2}} \frac{\overline{d}_n}{\sqrt{S_{dd}}} \qquad (1.23)$$

where $\overline{d}_n$, is the mean of d_n , S_{dd} is the variance of d_n , and P is the number of one-step-ahead forecasts. Here, the null hypothesis is that $d_n = 0$, and the alternative hypothesis is that the composite model has a lower $\mathrm{MSE} - \mathrm{T}$.

In addition, Clark and McCracken (2001) develop the ENC-T encompassing test, which draws upon Harvey et al. (1998). Define the loss differential function for the ENC-T as follows:

$$C_{t+1} = u_{1,t+1}(u_{1,t+1} - u_{2,t+1}) \qquad (1.24)$$

The ENC-T encompassing test of Clark and McCracken (2001) is given as follows:

$$ENC - T = (P-1)^{1/2} \frac{\bar{c}}{\sqrt{S_{cc}}} \qquad (1.25)$$

where $\bar{c}$ is the mean of C_{t+1}, and S_{cc} is the variance of C_{t+1}. Under the null hypothesis, the benchmark model encompasses the composite model, suggesting that the covariance between $u_{1,t+1}$ and $(u_{1,t+1} - u_{2,t+1})$ should be less than or equal to zero. Under the alternative hypothesis, the composite model contains more information suggesting a positive covariance, or the composite model outperforms the benchmark model.

The ENC-T and MSE-T tests are one-sided tests that have been shown to have good size and power properties. The variances of these tests are computed based on the Newey-West HAC consistent covariance estimator.

The last measure is the mean squared error (MSE) ratio to gauge the forecasting performance of the benchmark forecast relative to the composite forecast. Based on the mean squared error (MSE) ratio, we test the null hypothesis of equal mean squared error (MSE) of both models. When the MSE ratio equals one, both models have the same forecasting power. However, when the MSE ratio is greater than one, the composite model outperforms the benchmark model in forecasting and vice versa.

Table 1.10 shows the resulting forecast accuracy measures[8]. Based on the mean square error (MSE) ratio, we find evidence indicating that the composite model outperforms the benchmark model in predicting the movements of the US dollar for eight currencies. In addition, the MSE-T statistics are larger than the critical value in eight cases. Thus, we reject strongly the null of equal mean squared forecast errors indicating that the one-step-ahead forecast errors from the benchmark model are significantly larger than those from the composite model.

Finally, the ENC-T statistics are larger than the critical value in eight cases. This in turn suggests that the composite model contains added information for the US dollar exchange rate for eight currencies. Thus, the composite model encompasses the benchmark model in eight of the cases. Overall, these forecasting accuracy measures indicate that the price of oil enhances the predictability power of the monetary model of exchange rate.

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[8] Forecasting accuracy measures were done using RATS (version 3.1.2) using clarkforetest.src procedure downloaded from www.estima.com.

Table 1.10 Forecasting Accuracy Measures.

Test	$\frac{MSE_{Benchmark}}{MSE_{Comp}}$	$MSE-T$	$ENC-T$
Australia	1.42*	6.90*	6.67*
Canada	0.59	-2.44	-0.29
Chile	1.06*	1.60*	1.75*
Denmark	2.89*	2.53*	3.70*
Japan	1.12*	1.87*	1.97*
Mexico	0.52	-2.17	-0.12
New Zealand	3.99*	6.32*	7.23*
Norway	2.92*	2.58*	7.27*
South Africa	0.77	-2.91	-2.21
South Korea	1.00	0.07	0.22
Sweden	2.99*	4.21*	5.47*
Switzerland	5.45*	10.31*	9.72*
U.K.	0.63	-2.92	-0.39

* Indicates that the composite model is better in forecasting the USD.

1.6 Conclusion

The main objective of this paper is to investigate the impact of higher oil prices on the value of the USD against 13 major currencies, using quarterly data over the period 1986:Q1 through 2014:Q3. To meet this objective, we derived a flexible monetary model of the exchange rate containing the real price of crude oil.

Since our cointegration results indicate the existing of at least one cointegrating relationship between oil prices, monetary fundamentals, and the USD exchange rate, we estimated a vector error correction model and analyzed the effects of oil price movements on the USD exchange rate by computing impulse response functions.

We find evidence of a negative relationship between oil prices and the USD exchange rate. Furthermore, the forecast error variance decomposition analysis suggests that shocks to the real price of oil play a larger role in the movements of the USD exchange rate than do monetary fundamentals. We also find evidence suggesting an essential role of oil price in enhancing the forecasting power of the flexible monetary model of the exchange rate based on three measures of forecasting accuracy.

Chapter 2 - Oil Price Shocks and G7 Real Exchange Rates: The Role of Monetary Policy

2.1 Introduction

In recent years, both oil prices and exchange rates have experienced sharp fluctuations, as shown in Figure 2.1 and 2.2. Swings in oil prices are transmitted to financial markets and various economic activities through exchange rates. For example, changes in the exchange rate impact stock markets (Basher et al., 2012; Bello, 2013), oil and currency portfolios (Beine, 2006), terms of trade (Amano and Norden, 1998; Backus and Crucini, 2000), currency and energy options (Salmon and Schleicher, 2007), the labor market (Burgess and Knetter, 1998), economic growth (Hausmann et al., 2005), investments (Harchaoui et al., 2005), and energy and currency risk management (Marimoutou et al., 2009; Sadegui and Shavvalpour, 2006).

The terms of trade are the main channel in which changes in oil prices are transmitted to exchange rates as economic theory suggests. Cashin et al. (2004) develop a model for two sectors of tradable and non-tradable goods. Based on their model, each sector uses both inputs of tradable (oil) and non-tradable (labor) goods. The tradable sector's output prices are fixed in international markets, and real exchange rates are linked to the non-tradable sector's output prices. When oil prices go up, labor prices fall due to competitiveness of the tradable sector. If the non-tradable sector depends more heavily on imported crude oil than the tradable sector, then the output price of the non-tradable sector increases, and the real exchange rate rises as well. The opposite results are expected when the non-tradable sector is less dependent on imported crude oil than the tradable sector.

Figure 2.1 Oil Prices and G7 Real Exchange Rates Movements (I)

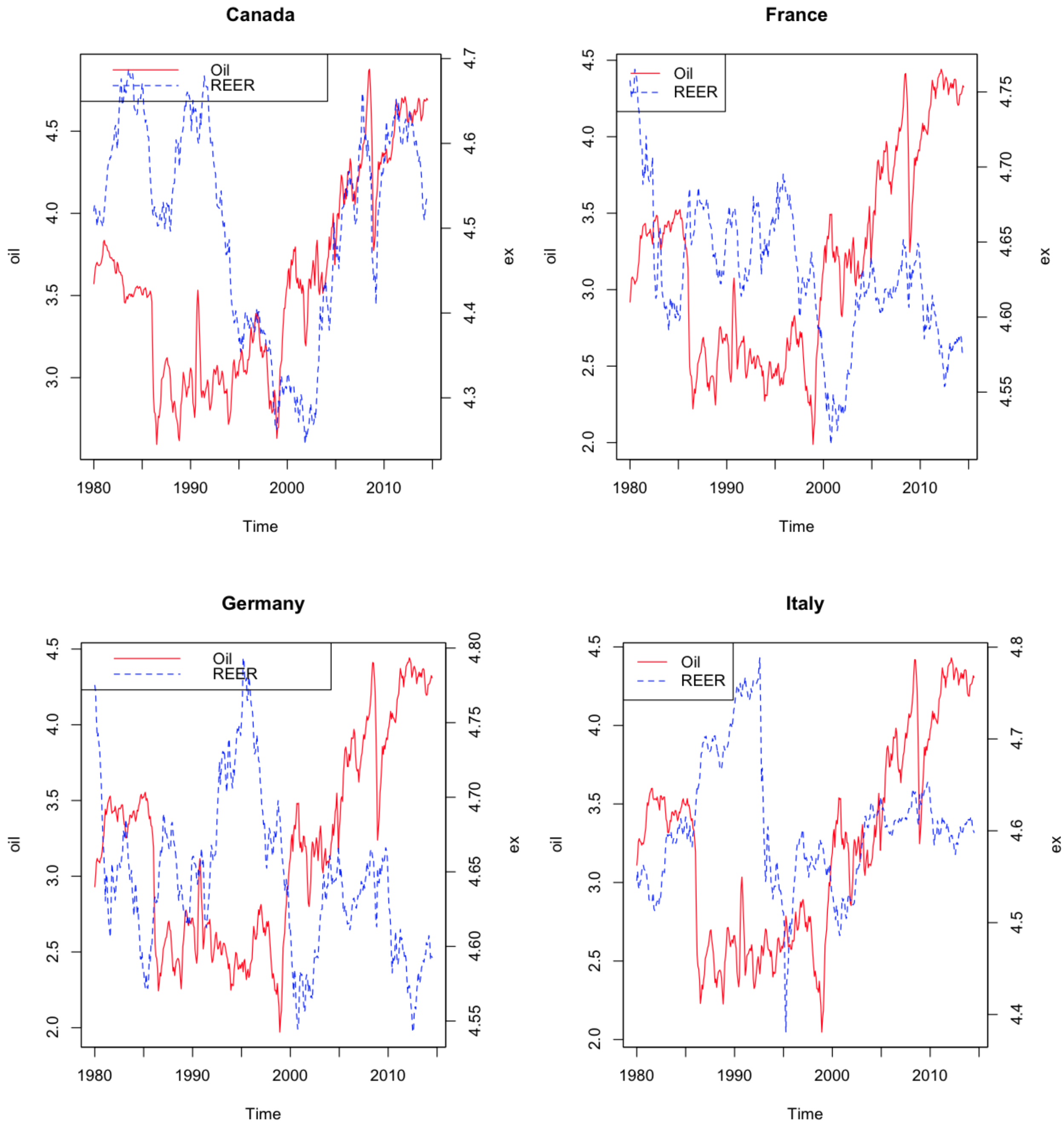
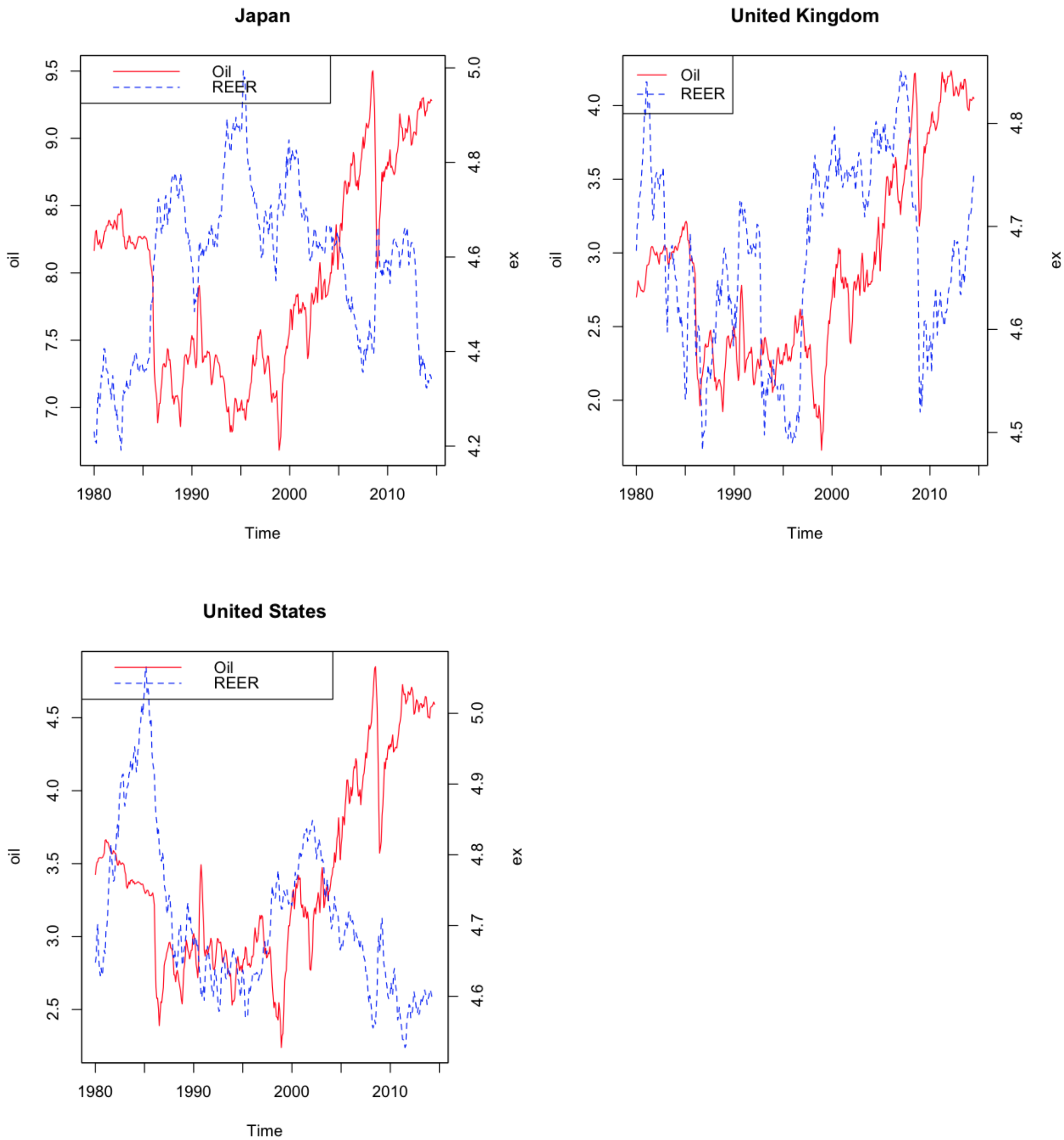


Figure 2.2 Oil Prices and G7 Real Exchange Rates Movements (II)



Several studies (Sadorsky 2000, Akram 2004, Chen and Chen 2007, Narayan et al. 2008, and Uddin et al. 2014) indicate that the price of crude oil plays a crucial role in capturing the exchange rate movements. It is also clear that existing studies tend to interpret changes in oil prices as exogenous supply shocks due to exogenous factors, such as wars or political instability in the Middle East or any other oil producing countries that lead to oil supply disruption.

However, Kilian (2009) argues that the impact of oil shocks varies depending on the underlying source of oil shocks. He states that the common beliefs in the literature before 2009 was that changes in oil prices were mainly driven by oil supply disruptions, and those led to the existence of major recessions in the US. Kilian argues that those beliefs are no longer valid. Therefore, Kilian (2009) distinguishes between oil supply shocks, aggregate demand shocks, and oil-specific demand shocks based on the underlying source causing oil prices to surge. In particular, he points out that aggregate demand shocks are driven by booming world economy, whereas oil-specific demand shocks are driven by precautionary demand for oil in the crude oil market due to concerns about future oil shortfalls. Killian (2009) also indicates that oil supply shocks are result from oil production shortfall from oil producing countries.

Investigating the differential effects of oil price shocks has been applied using various macro and financial activities, such as the crude oil market and US macroeconomic aggregates (Kilian, 2009), external balances (Kilian et al., 2009), US stock market (Kilian and Park, 2009), and US monetary policy (Kilian and Lewis 2011). These studies show that the economic variables respond differently to oil supply and demand shocks.

Since identifying the response of exchange rates to oil supply and demand shocks has not been examined yet, this motivates us to examine the differential effects of oil supply and demand shocks on the real exchange rates of G7 countries. Through this research, this essay contributes to the literature in two ways. First, we investigate how G7 real exchange rates respond to oil supply and demand shocks. Second, we re-assess the role of monetary policy in reacting to real exchange rate shocks and oil shocks as well.

This essay shows that the response of real exchange rates to oil shocks varies depending on the source of the oil shock. In other words, we find that oil supply, aggregate demand, and oil-specific demand shocks are associated with the depreciation of the French, German, Italian, Japanese, and US real exchange rate. We also find that the Canadian and British real exchange rates appreciate with all structural oil shocks. The forecast error variance decomposition analysis indicates that the contribution of oil supply shocks to real exchange rate movements is the lowest compared to demand shocks. Oil-specific demand shocks contribute largely to real exchange rate movements for all countries, except Canada. Only the aggregate demand shocks seem to be the primary contributor to changes in the Canadian real exchange rate.

Moreover, this essay finds evidence suggesting that monetary policy authorities tend to raise the interest rate in responding to aggregate demand and oil-specific demand shocks for Japan, the UK, and US. However, monetary policy does not seem to be an effective response to oil supply shocks for all countries. This is consistent with some studies, such as Hamilton and Herrera (2004) and Kilian and Lewis (2011). The results indicate that only the central banks of Italy, Japan, the UK, and the US respond to real exchange rate shocks. This is consistent with the findings of Lubik and Schorfheide (2007) for the UK, Clarida et al. (1998) for Japan and European countries, and Glick and Leduc (2013) for the US.

The remainder of the essay is organized as follows. Section 2.2 presents the theoretical model while section 2.3 reviews the literature. Section 2.4 describes the data used and its sources. Section 2.5 outlines the empirical methodology and presents the empirical results. Section 2.6 discusses the role of monetary policy. Section 2.7 discusses the implications of the results, and section 2.8 checks the robustness of the results. Section 2.9 contains our conclusions.

2.2 Theoretical Model

In this section, we present a simple theoretical model based on Evans (2011) showing how changes in oil prices are transmitted to exchange rates through the terms of trade channel. The real exchange rate is defined as the relative price of the basket of all goods consumed by foreign households in terms of the price of the basket of all the goods consumed by domestic households. It can be defined as follows:

$$Q_t = \frac{SP^*}{P} \qquad (2.1)$$

where $Q_t, P, and\ P^*$ are the real exchange rate, the domestic consumer price index, and foreign consumer price index, respectively. The log of the nominal exchange rate, the domestic currency price of foreign exchange, is denoted by S; thus, SP^* is the foreign price index in terms of dollars. Based on this definition, the depreciation (appreciation) in the real value of the domestic currency corresponds to the rise (fall) of $Q_t$indicating an increase (decrease) in the price of foreign goods relative to US goods.

Understanding the behavior of real exchange rates is crucial in macroeconomic models. To do so, macroeconomic models of exchange rates (Evans 2011) determine price indexes relative to a particular form for the consumption basket based on the Constant Elasticity of Substitution (CES), or Cobb Douglas functions, illustrated below. Assuming the CES functional form and that there are only two goods available to domestic consumers, the consumption basket is defined over the consumption of goods a and b as:

$$F = f(a,b) = (\lambda^{\frac{1}{\theta}} a^{\frac{\theta-1}{\theta}} + (1-\lambda)^{\frac{1}{\theta}} b^{\frac{\theta-1}{\theta}})^{\frac{\theta-1}{\theta}} \qquad (2.2)$$

where $\lambda \in (0,1)$ and $\theta > 0$. The index function F is a function aggregating the consumption of both goods into F. The consumption price index is identified as the minimum expenditure that buys one unit of the consumption index F, so that the expenditure is minimized by the consumption price index P, where the expenditure is as follows:

$$Z = aP^a + bP^b \qquad (2.3)$$

such that $f(a,b) = 1$; P^a and P^b are the prices of goods a and b, respectively. To minimize Z such that $f(a,b) = 1$, we set up the Lagrange function as follows:

$$\mathcal{L} = aP^a + bP^b - \varphi[1 - (\lambda^{\frac{1}{\theta}}a^{\frac{\theta-1}{\theta}} + (1-\lambda)^{\frac{1}{\theta}}b^{\frac{\theta-1}{\theta}})^{\frac{\theta-1}{\theta}}] \qquad (2.4)$$

Then, after taking the first order conditions with respect to a and b, in addition to some simplification steps, we reach the following condition:

$$\frac{b}{a} = \frac{1-\lambda}{\lambda}(\frac{P^b}{P^a})^{-\theta} \qquad (2.5)$$

Based on equation (2.5), the relative demand for good b depends on the relative price $\frac{P^b}{P^a}$, and the ratio of shares in the basket $(\frac{1-\lambda}{\lambda})$. The elasticity of substitution between goods a and b is defined by θ.

By substituting equation (2.5) into the definition of total expenditure as given by equation (2.3), we get the demand for each good a and b as follows:

$$\begin{cases} a = \frac{\lambda(P^a)^{-\theta}}{(\lambda(P^a)^{1-\theta}+(1-\lambda)(P^b)^{1-\theta})}Z \\ b = \frac{(1-\lambda)(P^b)^{-\theta}}{(\lambda(P^a)^{1-\theta}+(1-\lambda)(P^b)^{1-\theta})}Z \end{cases} \qquad (2.6)$$

When we substitute the demand for each good a and b into equation (2.2) such that $f(a,b) = 1$, we get:

$$1 = \left(\lambda^{\frac{1}{\theta}}[\frac{\lambda(P^a)^{-\theta}}{(\lambda(P^a)^{1-\theta}+(1-\lambda)(P^b)^{1-\theta})}Z]^{\frac{\theta-1}{\theta}} + (1-\lambda)^{\frac{1}{\theta}}[\frac{(1-\lambda)(P^b)^{-\theta}}{(\lambda(P^a)^{1-\theta}+(1-\lambda)(P^b)^{1-\theta})}Z]^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \qquad (2.7)$$

By simplifying and solving for Z, we get the price index as follows:

$$P = (\lambda(P^a)^{1-\theta} + (1-\lambda)(P^b)^{1-\theta})^{\frac{1}{1-\theta}} \qquad (2.8)$$

By definition, an expenditure of Z buys $\frac{Z}{P}$ units of the consumption index, F. Thus, we can use equation (2.8) to rewrite the demand for goods a and b given by equations (2.6) as follows:

$$\begin{cases} a = \lambda(\frac{P^a}{P})^{-\theta}F \\ b = (1-\lambda)(\frac{P^b}{P})^{-\theta}F \end{cases} \qquad (2.9)$$

To get a better understanding of the real exchange rate behavior, we need to understand that variation in real exchange rates may come from different sources. This is true because national price indices are composed of the prices of many different types of goods.

Thus, goods produced have been separated into two categories: traded and non-traded goods. The traded goods consist of goods that can be consumed in any country regardless of where they are produced. The non-traded goods include any goods produced that can only to be consumed domestically. Under this categorization, real exchange rate fluctuations can be decomposed into variations in the relative price of both traded and non-traded goods across countries.

With the log approximation of the consumption-based price indices, we can decompose real exchange rate fluctuations. To do so, assume that the domestic consumption basket, $F(T, N)$, is defined in terms of traded goods, T, and non-traded goods, N, with price indices P^T and P^N. This in turn enables us to rewrite equation (2.8) representing the domestic price level in period t as follows:

$$P_t = (\lambda({P_t}^T)^{1-\theta} + (1-\lambda)({P_t}^N)^{1-\theta})^{\frac{1}{1-\theta}} \qquad (2.10)$$

Log linearizing this expression around the point where ${P_t}^N \equiv {P_t}^T$ yields:

$$P_t = {P_t}^T + (1-\lambda)({P_t}^N - {P_t}^T) \qquad (2.11)$$

In a similar manner, we approximate the log price level for the foreign country as follows:

$$P_t^* = P_t^{T^*} + (1 - \lambda^*)(P_t^{N^*} - P_t^{T^*}) \qquad (2.12)$$

where $P_t^{T^*}$ and $P_t^{N^*}$denote the logs of foreign currency price indices for traded and non-traded goods respectively, andλ^* is the share parameter for traded goods in the foreign consumption basket. Based on the real exchange rate given by equation (1), the log real exchange rate can be written as follows:

$$q_t = s + p^* - p \qquad (2.13)$$

By combining equation (11) and (12) with the definition of the log real exchange rate, we obtain:

$$q_t = \left(s + P^{T^*} - P^T\right) + \{(1 - \lambda)(P^T - P^N) - (1 - \lambda^*)\left(P^{T^*} - P^N\right)\} \qquad (2.14)$$

where the first term on the right is the log relative price of foreign traded goods in terms of traded goods of the domestic country. The second term is a weighted difference between the relative prices of non-traded to traded goods across countries.

If the home country is more dependent on imported oil, then a positive shock to the price of oil might increase the prices of traded goods in the home country with a proportion greater than the foreign country causing a real depreciation of the home currency. As a result of oil price shocks worsening the terms of trade, the home country may need to increase the nominal exchange rate to enhance competitiveness, which also leads to a further real depreciation.

2.3 Literature Review

Numerous empirical studies not only consider the terms of trade as the essential channel transmitting oil prices into the exchange rate to investigate the effects of oil prices on the exchange rate, but also confirm the influential role of oil price shocks on exchange rates. Amano and Norden (1998) use oil prices as a proxy for the terms of trade to examine the consequences of oil price increases on the movements of the real effective exchange rates of Germany, Japan, and the US. Their results reveal that higher oil prices lead to the depreciation of the German and Japanese real exchange rates, whereas higher oil prices cause the US real exchange rate to appreciate. Sadorsky (2000) examines whether various energy prices impact the trade-weighted US exchange rate and documents evidence indicating the existence of a negative relationship between energy prices and the USD exchange rate.

Likewise, Yousifi and Wirjanto (2004) analyze the impact of oil prices on exchange rates for OPEC countries via the GMM methodology and confirm the negative relationship between oil prices and exchange rates. Using panel cointegration analysis, Chen and Chen (2007) also examine the effects of oil prices on the movements of bilateral real exchange rates of G7 countries, and document that changes in oil prices result in the depreciation of G7 real exchange rates.

Coudert et al. (2007) find empirical evidence supporting the existence of a stable long run relationship between the USD real effective exchange rate and oil prices. They report that higher oil prices lead to the appreciation of the USD real effective exchange rate. Huang and Guo (2007) also show that higher oil prices lead to the appreciation of the Chinese real exchange rate against the US dollar in the long run.

Narayan et al. (2008) also find evidence based on GARCH and E-GARCH models supporting the negative relationship between oil prices and the US dollar exchange rate against the currency of the Fiji Islands. Based on the autoregressive distributed lag (ARDL) model, Jahan-Parvar and Mohammadi (2008) show that oil price increases lead to the depreciation of the US dollar against the currencies of 14 oil-exporting countries. However, in an alternative paper, Mohammadi and Jahan-Parvar (2012) reexamine the validity of the Dutch disease hypothesis using threshold and momentum-threshold models. Their findings show that the Dutch disease hypothesis is valid for only three countries out of 13 oil-exporting countries; in other words, the real exchange rates of the Bolivian boliviano, Mexican peso, and Norwegian krone tend to appreciate against the US dollar.

Thalassinos and Politis (2012) also assess the relationship between the US dollar exchange rate and oil prices and conclude that the USD real exchange rate is negatively correlated with oil prices in the long run. Novorny (2012) also documents the negative relationship between Brent crude oil prices and the US dollar exchange rate. Uddin et al. (2014) look into the relationship between real oil prices and the Japanese real exchange rate, using wavelet analysis; they conclude the influential role of oil prices on real exchange rate.

2.4 Data

We use monthly data spanning from 1980:01 to 2014:07 for G7 countries Canada, France, Germany, Italy, Japan, the UK, and the US. These are the wealthiest countries, and their economies represent more than fifty percent of net global income. The dataset is obtained from various sources and consists of real effective exchange rate, policy interest rate, the US crude oil imported acquisition cost by refiners as a measure of oil prices, global crude oil production, and a global industrial production index.

Real exchange rate and policy interest rate data are obtained from the International Financial Statistics database of the International Monetary Fund (IMF). The global industrial production index is downloaded from the Organization for Economic Co-operation and Development (OECD) database. The global crude oil production data are obtained from the US Energy Information Administration. Three alternative measures of oil prices are used; the US crude oil imported acquisition cost by refiners, the producer price index for petroleum, and the west Texas intermediate oil prices are obtained from the US Energy Information Administration, the US Bureau of Labor Statistics, and the Federal Reserve Bank of St. Louis respectively. It is also important to note that we convert oil prices to domestic prices. Furthermore, it is important to note that we expressed all variables, with the exception of policy interest rate, in logarithm form.

2.5 Empirical Methodology and Results

2.5.1 Unit Root Tests

It is common procedure in empirical analysis to investigate the stochastic properties of the series considered in our models by analyzing their order of integration. To do so, we employ various standard unit root tests. In particular, we apply the Augmented Dickey-Fuller (1979), "ADF" test, the Phillips Perron (1988), "PP" test, and the Kwiatkowski et al. (1992), "KPSS" test. Tables 2.1 and 2.2 summarize the results of these tests. The results confirm the nonstationarity of the data in their levels and the stationarity when the first differences of the data are taken[9].

[9] The unit root tests were done in R (version 3.1.2) using functions ur.df, ur.pp, and ur.kpss from package urca (version 1.2-8).

Table 2.1 Augmented Dickey Fuller (1979) Unit Root Test.

	Level Data			First Difference Data		
	None	Trend	Drift	None	Trend	Drift
Oil	0.13	-2.71	-1.52	-11.64	-11.68	-11.64
Global Industrial Production	3.24	-1.41	-0.87	-7.80	-8.09	-8.10
Global Oil Production	1.59	-2.71	0.76	-14.84	-15.04	-14.93
Real Effective Exchange Rates:						
Canada	-0.04	-1.53	-1.53	-12.49	-12.46	-12.48
France	-0.89	-3.16	-2.88	-13.59	-13.62	-13.62
Germany	-0.72	-2.89	-2.91	-13.19	-13.20	-13.21
Italy	0.07	-2.31	-2.27	-14.09	-14.07	-14.08
Japan	0.11	-2.13	-2.38	-12.51	-12.64	-12.49
U.K.	0.05	-2.65	-2.52	-12.28	-12.26	-12.27
U.S.	-0.18	-2.51	-1.79	-13.25	-13.23	-13.24

Note: The 5% critical values are for None=-1.95, Trend= -3.43, and Drift=-2.88.

Table 2.2 Phillips and Perron (1981) and Kwiatkowski et al. (1992) Unit Root Test.

	Phillip and Perron (1981) Test				Kwiatkowski-Phillips-Schmidt-Shin (1992) Test			
	Level		First Difference		Level		First Difference	
	Constant	Trend	Constant	Trend	Constant	Trend	Constant	Trend
Oil	-1.05	-2.18	-12.02	-12.03	3.87	1.45	0.14	0.02
G Industrial Production	-0.87	-1.67	-13.96	-13.94	6.77	0.92	0.06	0.06
G Oil Production	1.08	-2.68	-20.21	-20.37	6.05	0.43	0.35	0.06
Real Effective Exchange Rates:								
Canada	-1.49	-1.49	-15.83	-15.81	1.46	1.07	0.11	0.10
France	-2.85	-3.06	-16.09	-16.08	2.68	0.22	0.09	0.05
Germany	-2.81	-2.75	-15.21	-15.20	1.33	0.47	0.10	0.05
Italy	-2.13	-2.17	-15.03	-15.02	0.55	0.45	0.07	0.06
Japan	-2.18	-1.89	-15.35	-15.45	1.26	1.14	0.31	0.03
U.K.	-2.37	-2.47	-14.88	-14.87	0.85	0.44	0.04	0.04
U.S.	-1.60	-2.34	-14.17	-14.17	2.04	0.39	0.13	0.09

Note: The 5% critical values for PP test: Constant=-2.882684, and Trend= -3.443263; for KPSS test: Constant=0.463, and Trend= 0.146.

2.5.2 The Vector Autoregressive (VAR) Model

To examine the response of real effective exchange rate to oil supply and demand shocks, we need first to derive these shocks following Killian (2009).

Even though we follow the procedure of Kilian (2009) to derive the oil supply, aggregate demand, and oil-specific demand shocks, we actually differ from Kilian in three points. First, we use the global industrial production index capturing the demand for all industrial commodities, instead of using Kilian's real economic activity index that he developed based on the demand for six industrial commodities. Second, we ensure the stationarity of variables in our model. Lastly, Kilian assigns 24 lags in his SVAR model, whereas we rely on the Akaike information criteria (AIC) to determine the appropriate lag length, which is 3 lags for our VAR model.

The starting point in the analysis is to estimate the following reduced form VAR model[10]:

$Z_t = \alpha + \sum_{i=1}^{k} \mathrm{A}_i \mathrm{Z}_{t-i} + e_t$, (2.15)

where $Z_t = (Prod, GIP, Oil, REER)'$ is a (4×1) vector consisting of the percent change in global crude oil production, "$Prod$", percent change of global industrial production, "GIP", percent change of real oil price, "Oil", and percent change of real effective exchange rate "$REER$"respectively, as given order. The lag length k is chosen based on the AIC criteria, and the vector of reduced form residuals $e_t = (e_{prod}, e_{GIP}, e_{oil}, e_{REER})'$ is uncorrelated with variables in the time period $t-1$ or earlier.

Then, we assume that the reduced form residuals, e_t, are decomposed into crude oil market shocks based on:

$e_t = A_0^{-1}\varepsilon_t$ (2.16)

This enables us to rewrite equation (2.16) in terms of the structural shocks to the crude oil market, if we pre-multiply equation (2.15) by A_0 to obtain the following equation:

$A_0 Z_t = \alpha + \sum_{i=1}^{k} \mathrm{A}_i \mathrm{Z}_{t-i} + \varepsilon_t$ (2.17)

Then we apply a recursive identification scheme, as in Kilian (2009), to identify the structural VAR model as follows:

$$e_t = \begin{bmatrix} e_{Prod_t} \\ e_{GIP_t} \\ e_{Oil_t} \\ e_{REER_t} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{Sup} \\ \varepsilon_t^{AD} \\ \varepsilon_t^{A} \\ \varepsilon_t^{REER} \end{bmatrix} \qquad (2.18)$$

where ε_t^{Sup} is the oil supply shocks, ε_t^{AD} denotes the aggregate demand shocks, ε_t^{D} denotes the oil-specific demand shock, and ε_t^{REER} denotes real exchange rate shocks.

[10] The parameter estimates of the VAR model are attached in the appendix.

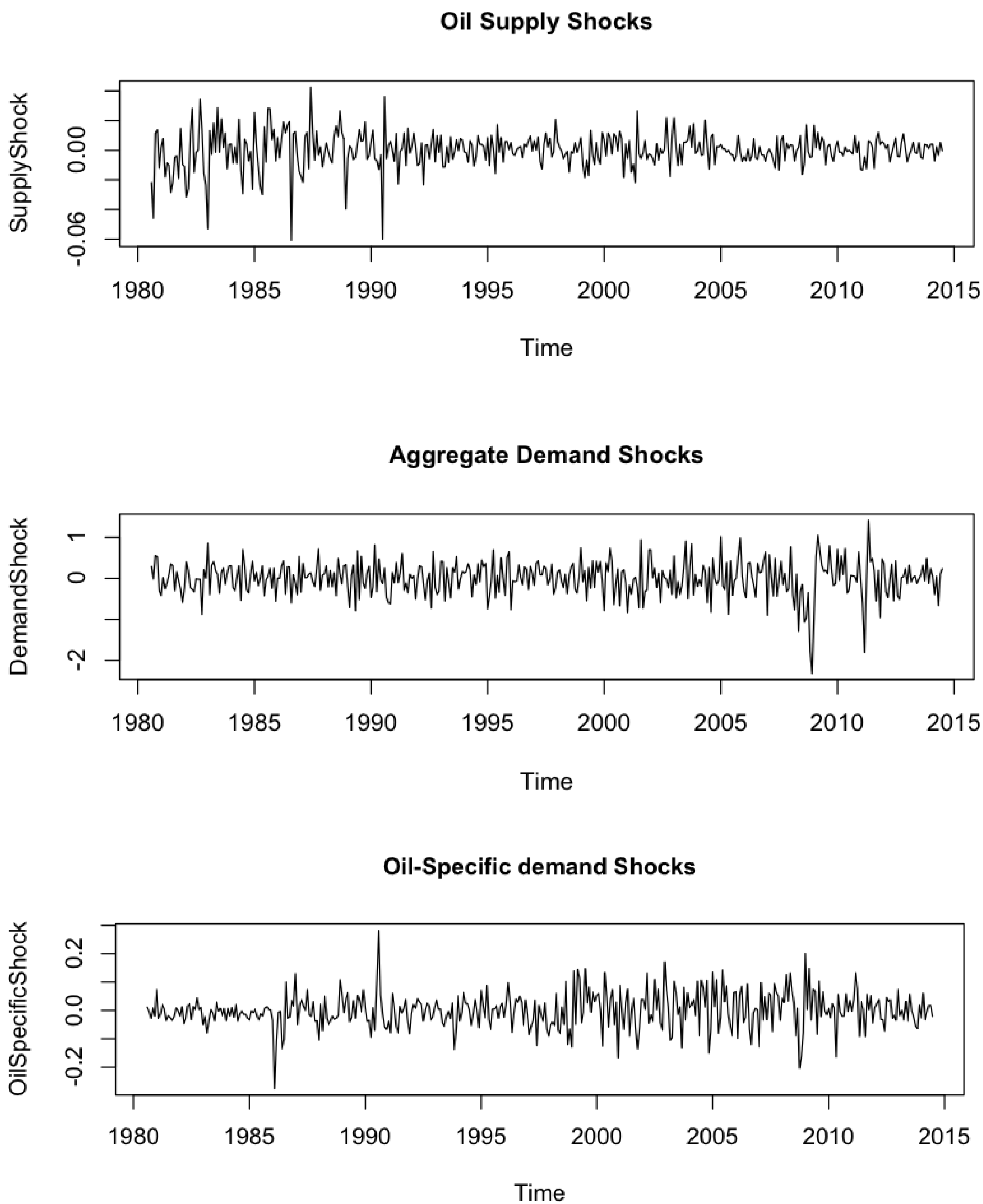
Following Killian (2009), there are four identification assumptions in equation (2.18). First, oil supply does not respond contemporaneously to aggregate demand, oil-specific demand shocks, and real exchange rate shocks within the month due to the uncertainty of the state of the oil market and the high costs associated with oil production. Second, global demand for oil responds contemporaneously to innovations in the oil supply but not to innovations in the price of oil and exchange rate. Third, the price of oil responds to changes in global demand for oil and changes in the oil supply, but not to real exchange rate shocks. These assumptions are in line with the law of demand and supply, illustrating that changes in prices are due to changes in supply and demand for a certain commodity. Lastly, real exchange rate is assumed to respond to all other shocks.

Figure 2.3 displays the identified oil structural shocks based on equation (2.18). To assess the validity of our identification scheme, we check whether these shocks reflect changes in crude oil markets over time. The plotted structural oil shocks indicate that crude oil price fluctuations are mainly driven by a combination of aggregate demand and oil-specific demand shocks rather than oil supply shocks. In other words, the booming global economy primarily drove oil price increases in 1979. Likewise, the Iranian revolution and the Soviet Invasion of Afghanistan raised concern about the availability of oil, which resulted in surges in oil prices due to the oil-specific (precautionary demand) shocks.

The collapse of the OPEC cartel in 1986 is viewed as a negative oil-specific demand shock leading to oil price declines, whereas the Iraq Invasion of Kuwait in August 1990 is viewed as a positive oil-specific demand shock causing oil prices to rise. Following the global financial crisis in 2008, the fall of oil prices is attributed to the decline of demand for crude oil.

Next, in order to examine the response real exchange rates of G7 countries to structural oil shocks, we compute the cumulative impulse response functions over a 12-month period with a one-standard deviation bands.

Figure 2.3 The Identified Structural Shocks to Crude Oil Market



2.5.3 Impulse Response Function Analysis

Figures 2.4 - 2.7 present the impulse responses with a one-standard deviation bands for all countries. Clearly, the response of real exchange rates to oil price shocks differs based on the underlying source of the oil shock.

In other words, we find that the Canadian real exchange rate appreciates with all structural oil shocks as shown in Figure 2.4. While the Canadian real exchange rate tends to depreciate after the second months and continues depreciating over the 12-month period due to oil supply shocks, it appreciates following an aggregate demand shock until the third month then declines. Likewise, the Canadian real exchange rate appears to respond positively to oil-specific demand shocks and continues to swing during the remaining period.

For France, Germany, and Italy, the plotted impulse responses, as illustrated in Figures 2.4 and 2.5, indicate that the decline of real exchange rates is associated with oil supply shocks. This response occurs immediately for France, Germany, and Italy and continues until the fourth month, when real exchange rates begin to appreciate over the remaining time horizon. Similarly, the plotted impulse responses indicate the depreciation of the French, German, and Italian real exchange rate over the time period due to aggregate demand and oil specific demand shocks.

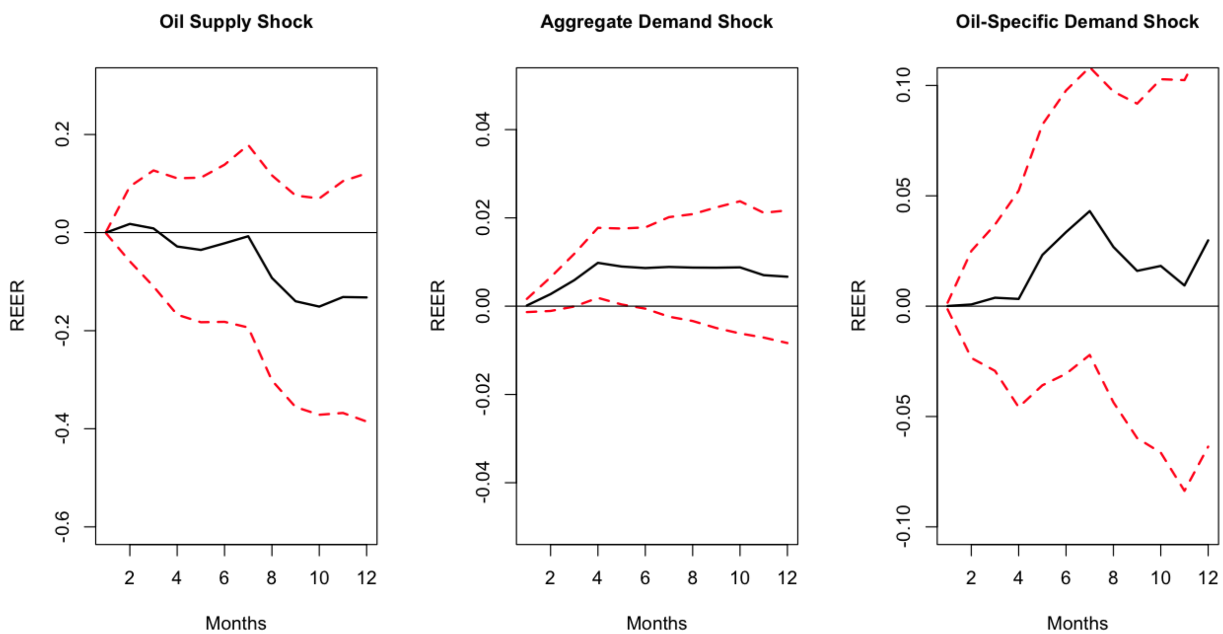
The response of Japanese and British real exchange rate to structural oil shocks illustrated in Figure 2.6. In particular, we find that Japanese real exchange rate responds negatively only to demand shocks and continues depreciating over the time horizon. On the other hand, we find oil supply shocks are associated with the appreciation of Japanese real exchange rate. For the UK, the plotted impulses indicate that oil supply and aggregate demand shocks are associated with the appreciation of the British real exchange rate immediately. Over time horizon, we find the British real exchange rate tend to depreciate as a results of oil supply shocks.

The US dollar real exchange rate seems to responds positively following oil supply and aggregate demand shocks only during the first month, then start depreciating over the remaining period as illustrated in Figure 2.7. However, we find the US real exchange rate responds negatively to oil specific demand shocks until the sixth month, then start appreciating over the remaining period.

In sum, we find that the aggregate demand shocks impact the movements of real exchange rates differently across countries. Likewise, we find that the impact of oil-specific demand shocks leading to the depreciation of the real exchange rates over the 12-month time horizon for Germany, Italy and Japan. The negative response of real exchange rates of countries depending heavily on imported crude oil is rational. However, oil supply shocks seem to not have a large impact on these countries. This is might be due to the minor effects of oil supply shocks, as Killian (2009) argues.

Figure 2.4 The Responses of Canadian and French Real Exchange Rates to Structural Oil Shocks

Canada



France

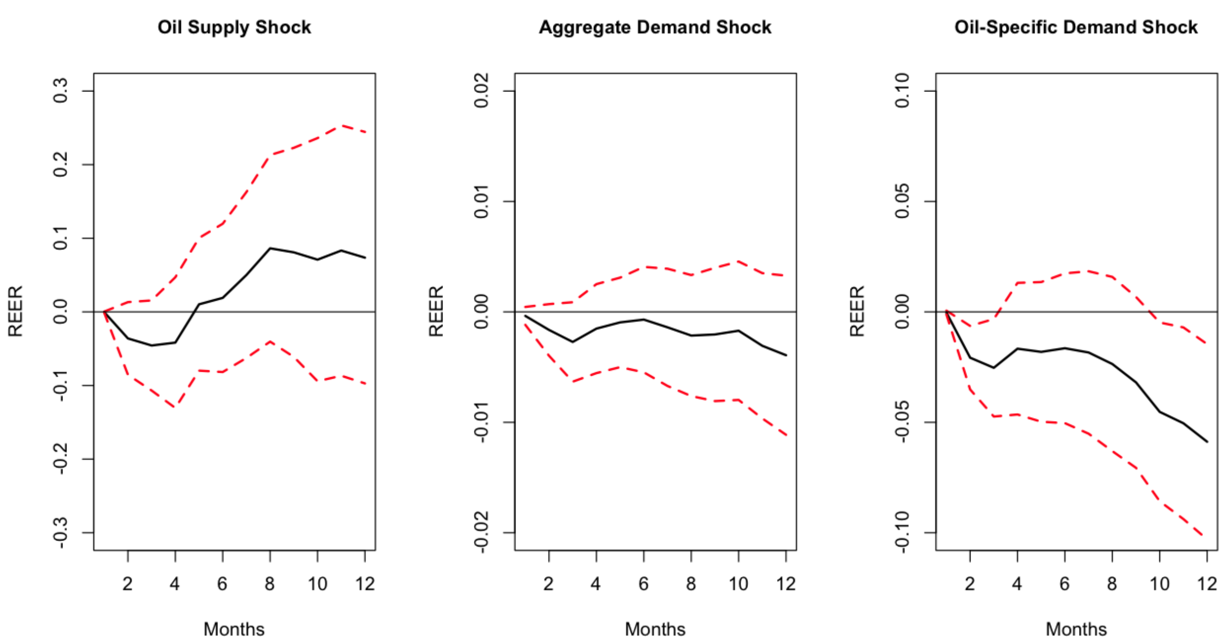
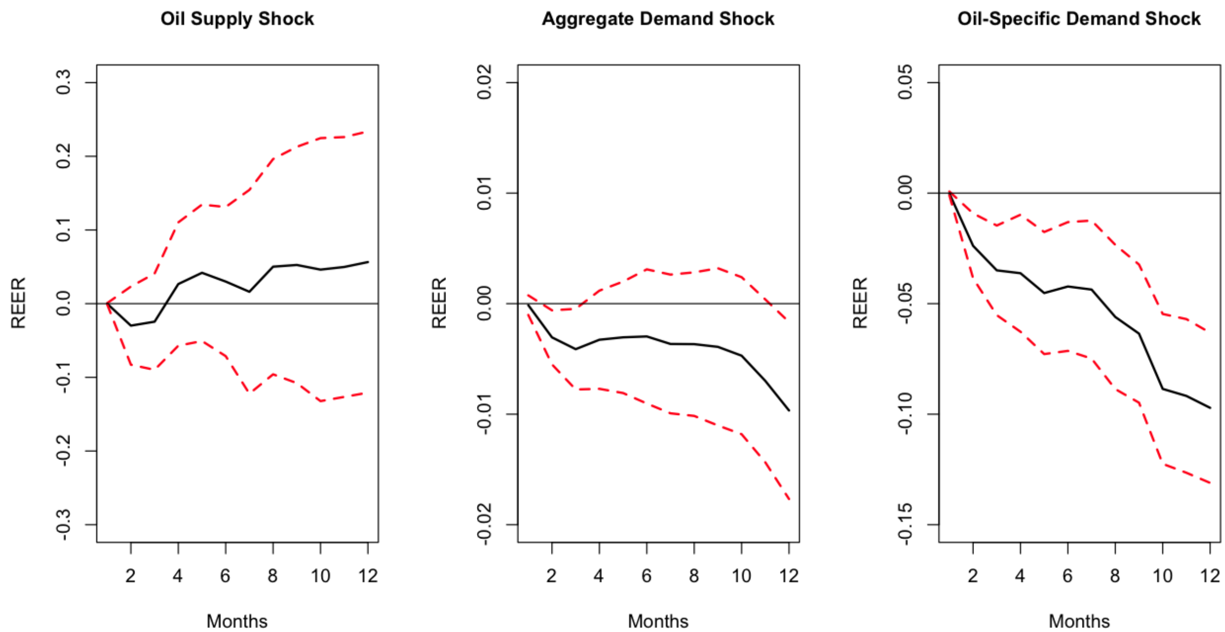


Figure 2.5 The Responses of German and Italian Real Exchange Rates to Structural Oil Shocks

Germany



Italy

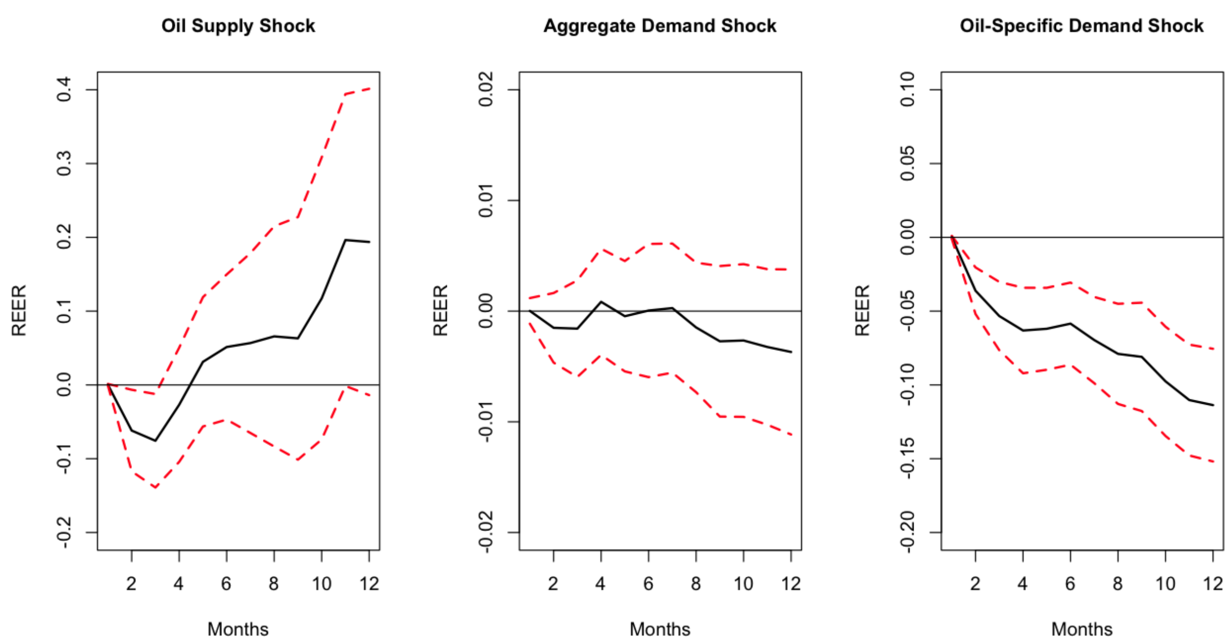
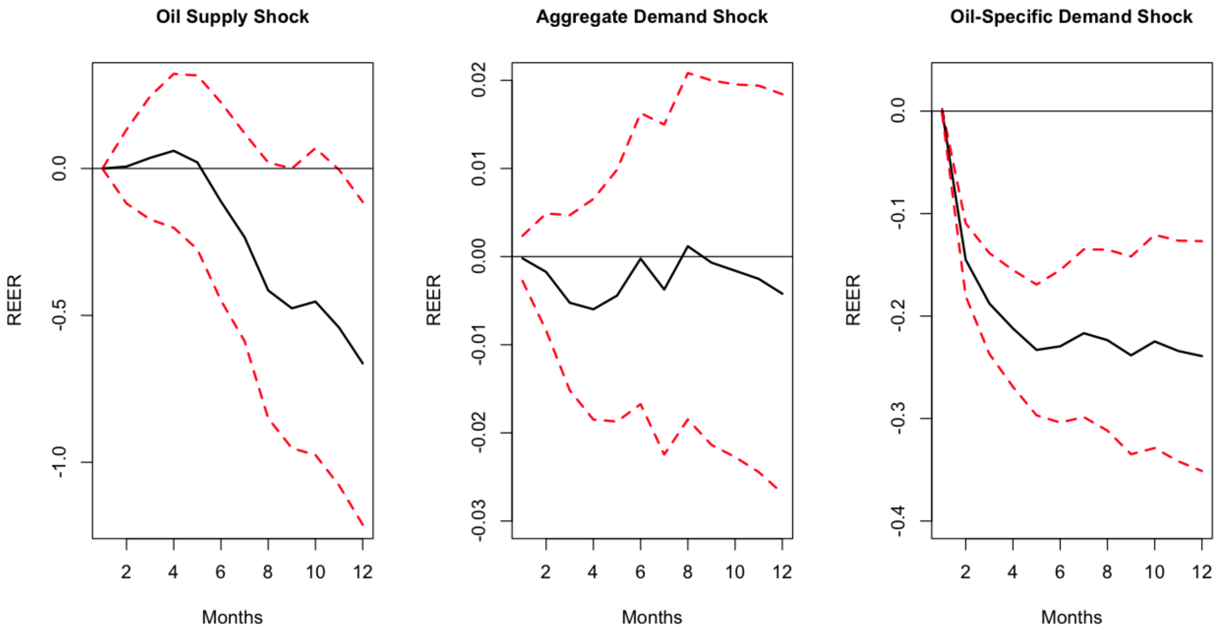


Figure 2.6 The Responses of Japanese and British Real Exchange Rates to Structural Oil Shocks

Japan



UK

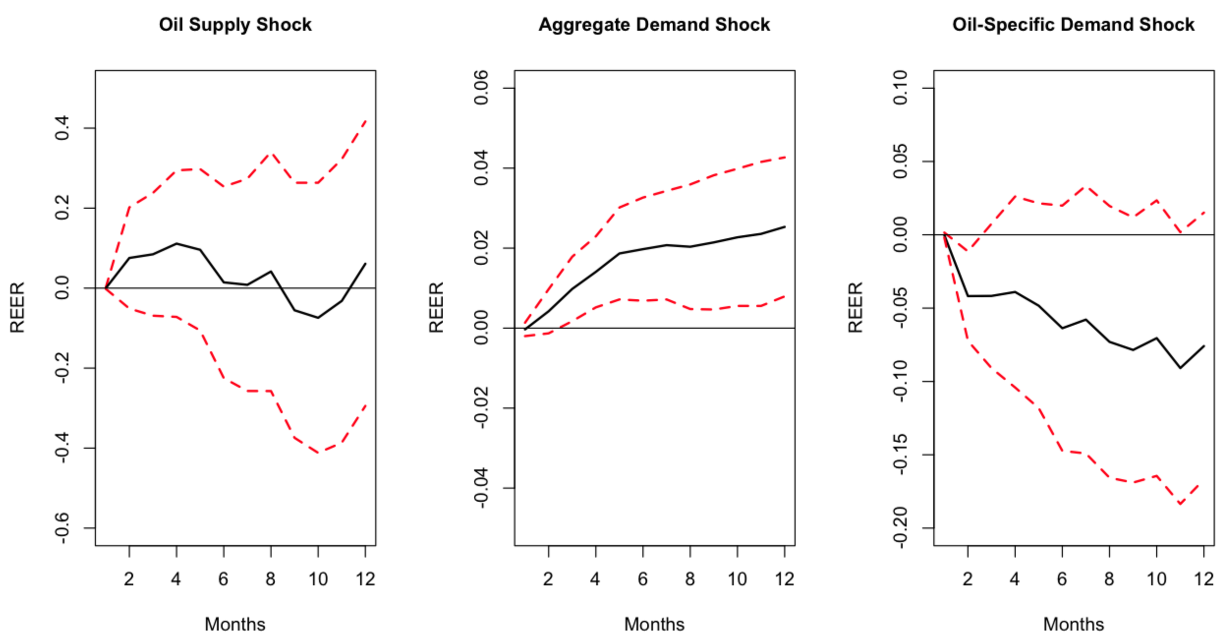


Figure 2.7 The Responses of US Real Exchange Rates to Structural Oil Shocks

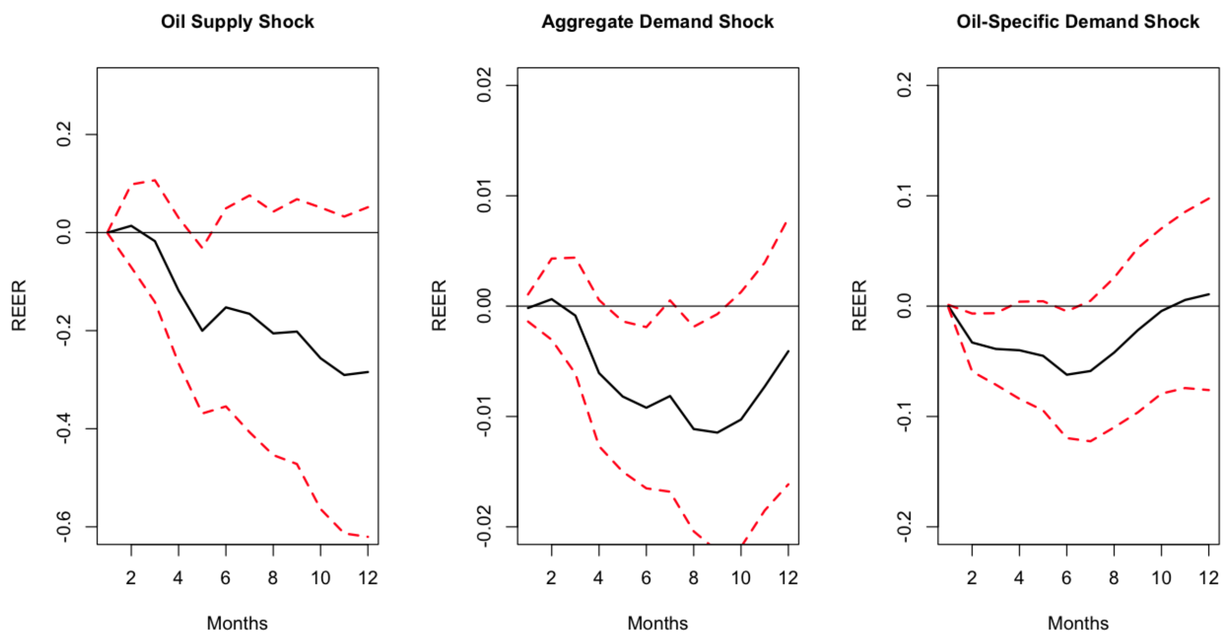


Table 2.3 presents the impacts of a one-standard deviation shock on real exchange rate movements. The Italian real exchange rate depreciates by 0.06, 0.002, and 0.04 percent points as a result of oil supply, aggregate demand, and oil-specific demand shocks, respectively. In the case for Canada, a one-standard deviation shock to oil supply, aggregate demand, and oil-specific demand results in the appreciation of the real exchange rate by 0.0001, 0.00001, and 0.00003 percent points, respectively. This indicates that the impacts of oil price shocks vary based on the underlying sources of the oil shock. Similar analysis applies to other countries.

Table 2.3 T he Effect of one standard deviation Shock.

	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}
Canada	0.00007	0.00001	0.00003
France	-0.00038	-0.00037	-0.00039
Germany	-0.00013	- 0.00004	-0.00014
Italy	-0.05705	- 0.00154	-0.03634
Japan	0.05229	- 0.00005	-0.142083
UK	0.00025	0.00032	-0.00023
US	0.03335	0.00056	-0.00023

2.5.4 Structural Break Tests

Now, since we decompose shocks to crude oil market into oil supply and demand shocks, it is important to check the stability of the relationship between oil shocks and real exchange rates throughout the time period of our analysis. In other words, we have to ensure that there has been no structural change in the relationship between the identified structural oil price shocks and the real exchange rate during the period of our analysis.

To do so, we employ the Quandt–Andrews unknown breakpoint tests developed by Andrews (1993) and Andrews and Ploberger (1994). These tests estimate the potential structural break dates and do not require any prior information regarding the dates of structural breaks. These tests are SupF, Ave F, and Exp F, and they test the null hypothesis of no structural change against the alternative of an existing structural break. To obtain these test statistics[11], we estimate the following model via OLS.

$$REER_{j,t} = \alpha + \sum_{i=1}^{k} \beta_i \, REER_{j,t} + \sum_{i=1}^{k} \theta_i \varepsilon_{t-i}^{Sup} + \sum_{i=1}^{k} \delta_i \varepsilon_{t-i}^{AD} + \sum_{i=1}^{k} \gamma_i \varepsilon_{t-i}^{D} + e_t \qquad (2.20)$$

[11] The structural break tests were done in R (version 3.1.2) using function sctest from package strucchange (version 1.5-0).

where $REER_{j,t}$ denotes the real effective exchange rate for country j at time period t, and ε_{t-i}^{Sup}, ε_{t-i}^{AD}, ε_{t-i}^{D} are the identified oil price shocks as oil supply, aggregate demand, and oil-specific demand shocks, respectively. The error term is e_t, and k is the lag length that is chosen based on the Akaike information criteria "AIC."

Table 2.4 summarizes the results of the structural break tests; in particular, the second column is the estimated break date. The remaining columns are the corresponding Ave F, Sup F, and Exp F statistics and their p values in parenthesis. These results indicate the stability of coefficient estimates for all countries[12], except the UK.

Therefore, we test the stability of each coefficients before and after the identified break date for the case of the UK. The results are presented in table 2.5 and indicate the stability of coefficients. The estimated break date, March of 2008, is associated with the 2007-08 financial crisis as documented by some studies, such as Stavárek (2012).

[12] We also apply Chow (1960) test of structural change to examine whether certain exogenous events impact the relationship between oil price shocks and real exchange rates. For the case of the Euro member countries, we find the introduction of the Euro does not impact the relationship between oil shocks and real exchange rates. Likewise, we find that the development of fracking technology in Canada and the US does not affect the relationship between oil shocks and exchange rates.

Table 2.4 Structural Break Tests.

	Break Date	Ave F	Sup F	Exp F
Canada	August 2007	4.58	13.02	3.10
		(0.50)	(0.25)	(0.45)
France	April 1985	2.16	5.92	1.25
		(0.97)	(0.95)	(0.98)
Germany	July 1988	3.67	6.44	2.04
		(0.70)	(0.91)	(0.78)
Italy	August 1992	3.55	10.47	2.09
		(0.73)	(0.48)	(0.77)
Japan	May 1988	3.46	6.62	1.98
		(0.75)	(0.90)	(0.80)
U.K.	March 2008	11.78**	20.56**	7.61**
		(0.01)	(0.02)	(0.01)
U.S.	April 1985	3.14	13.05	2.97
		(0.82)	(0.25)	(0.49)

** Indicates the rejection of the null hypothesis at 5%.

Table 2.5 Structural Break Tests for the UK.

	Date break	Ave F	P-value	Sup F	P-value	Exp F	P-value
Pre-break date	September 1992	6.70	(0.64)	13.76	(0.60)	4.03	(0.69)
Post-break date	February 2009	8.45	(0.37)	17.97	(0.24)	6.12	(0.25)

Since the structural break tests indicate instability between structural oil shocks and the British real exchange rate, we split the UK sample into pre-break and post-break date. Figure 2.8 illustrates the impulse responses with a one-standard deviation bands for both sub-samples. Panel A of Figure 2.8 shows the plotted impulses during the pre-break date period while panel B of Figure 2.8 illustrates the plotted impulses during the post-break date period.

In the pre-break sample, the plotted impulses indicate the appreciation of the real exchange rate is associated with all structural oil shocks over the time period as shown in panel

A of Figure 2.8. The appreciation following an aggregate demand shock starts from the first month, and fluctuates over the time period. The real exchange rate responds negatively to oil supply shocks during the first month, then start appreciating after the second month till the remaining time period. The impact of oil-specific demand shock on real exchange rate movements appears during the first five months; after that real exchange rate start swinging till the end of the time period.

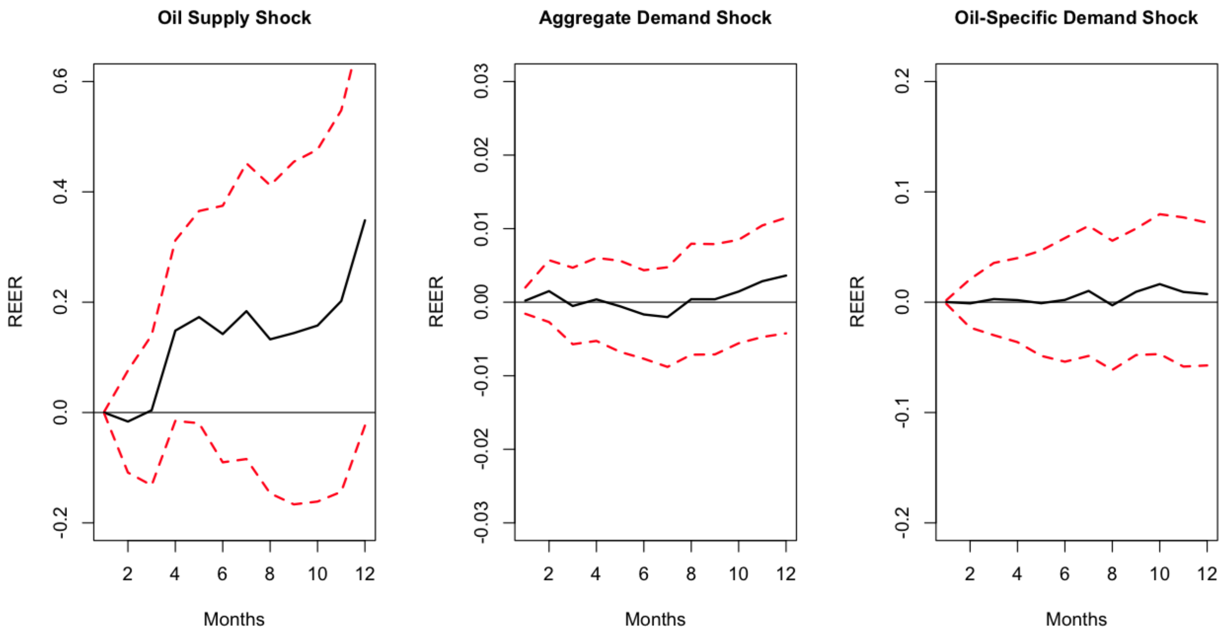
For the post-break sample, the plotted impulse responses, as shown in panel B of Figure 2.8, indicate the significant impact of aggregate demand shocks leading to significant appreciation of the British real exchange rate over the time horizon. However, oil supply (oil-specific demand) shocks have immediate positive (negative) impacts on the real exchange rate. Over time horizon, the real exchange rate tends to swing following oil supply and oil-specific demand shocks experiencing both appreciation and depreciation points.

Even though the UK became a net-oil importer in 2013, we find evidence suggesting the appreciation of the British real exchange rate for both sub-samples. This might be rational for the UK as an oil-exporting country prior to 2013 but not after 2013 as a net importer. A possible explanation for this might be attributed to their high reserve of crude oil in 2014, which is three billion barrels of crude oil (US EIA)[13]. It is worth emphasizing that the UK is a large economy trading with the rest of the world and its currency is one of the most active trading currencies in international currency markets. These factors increase the demand for the UK's currency.

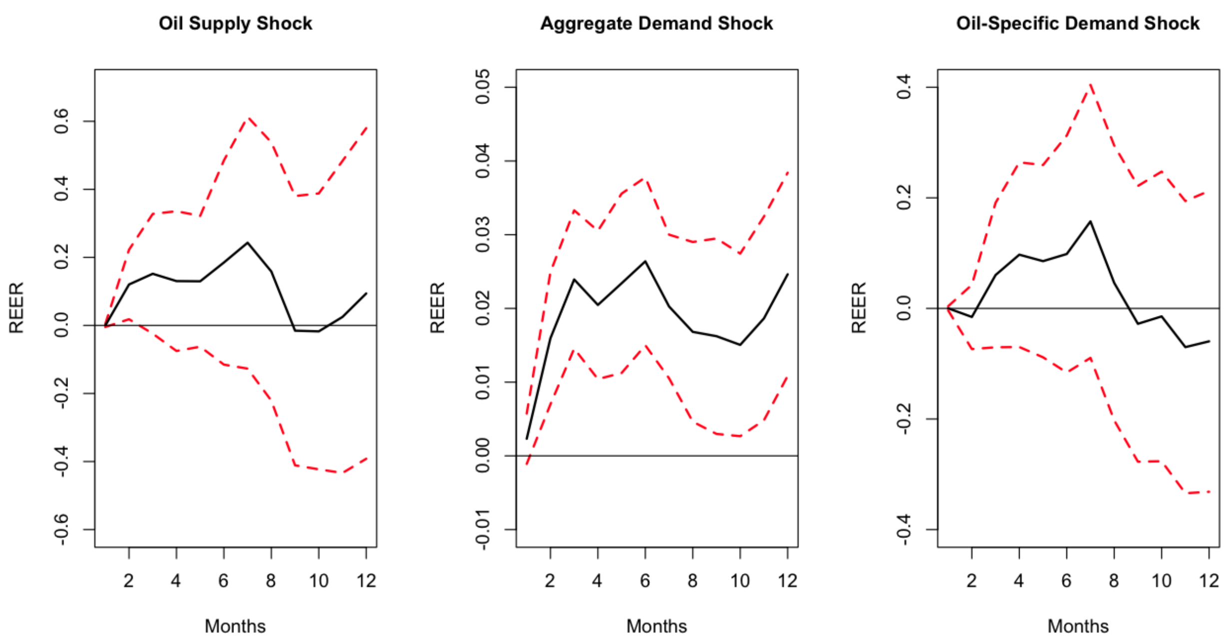
[13] http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=57&aid=6&cid=regions&syid=2010&eyid=2014&unit=BB

Figure 2.8 The Responses of British Real Exchange Rates to Structural Oil Shocks

Panel A



Panel B



The appreciation of the Canadian real exchange rate is expected, since Canada is one of the main oil-exporting countries; this would hold true for the UK prior to 2013. An expectation of appreciation might be also reasonable for the UK after 2013 if we take into account the large oil reserve and the discovery of new oil wells in the North Sea in 2014. Even though the US still depends on imported crude oil, it falls under those same appreciation expectations, since it became the largest oil-producer in the world in 2013. Additionally, the U.S. dollar is the main settlement currency in international crude oil markets. This increases the demand for the US dollar in international currency markets and leads to the appreciation of the US dollar exchange rate.

2.5.5 The Role of Energy Intensity

Energy intensity is defined as the energy use per dollar of Gross Domestic Product (GDP) and is also the amount of energy needed to support economic activity. Energy intensity is important factor explaining oil vulnerability. In other words, lower energy intensity keeps oil vulnerability down whereas higher energy intensity leads to an increase in vulnerability to oil shocks.

Schubert and Turnovsky (2011) review the existing literature on developed oil-importing economies and document that the vulnerability of these economies to oil shocks has declined in recent years. According to them, the existing literature attributes the reduction in vulnerability of developed economies to oil price shocks might be due to the fall in energy intensity to GDP or due to the role of monetary policy.

For the US, energy intensity[14] has declined in recent years as documented by Schubert

[14] Energy Intensity data for the US are obtained from annual energy outlook whereas the data for other countries are not available for public download.

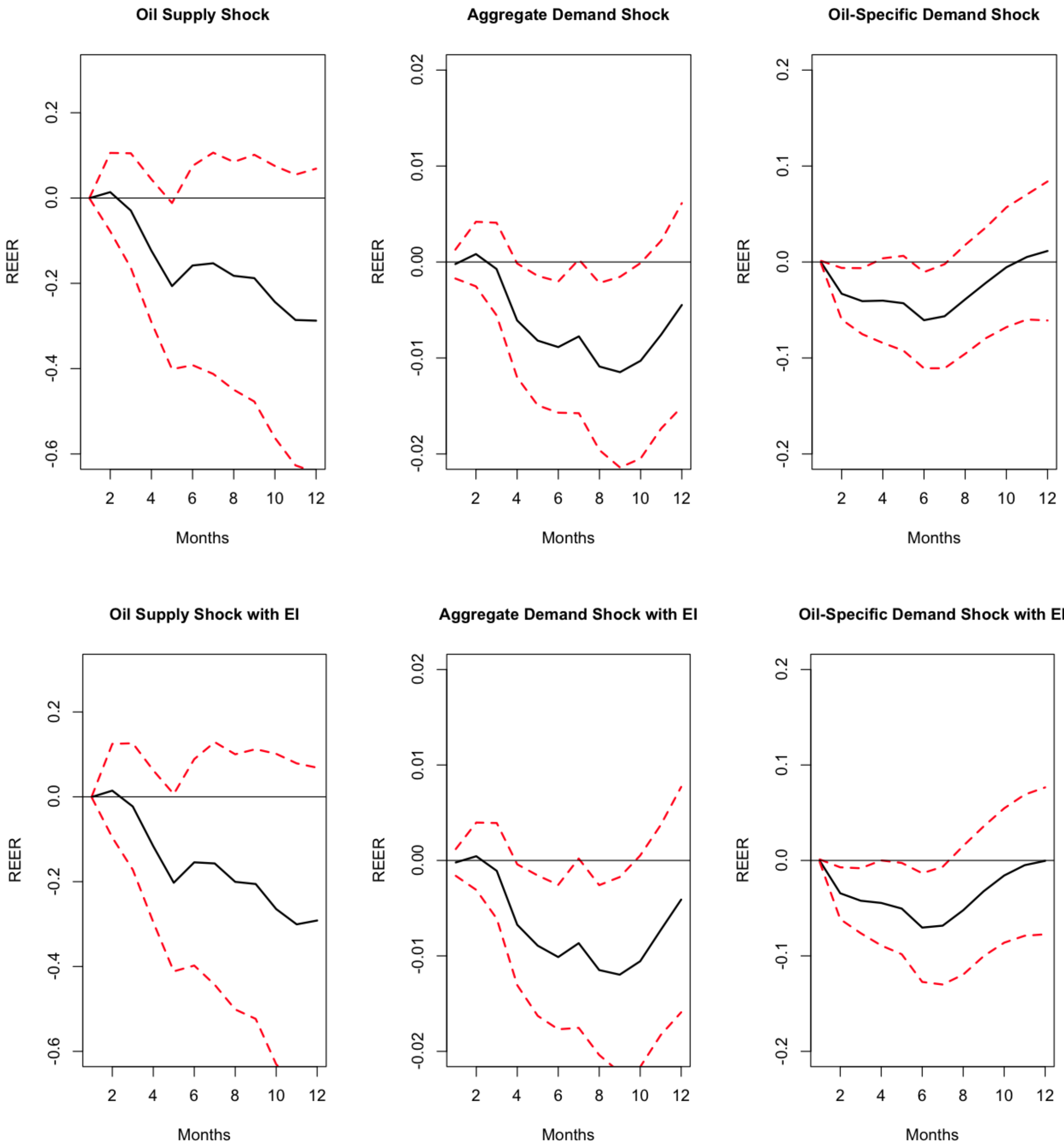
and Turnovsky (2011); this in turn implies that the US economy is less vulnerability to oil shocks. However, in order to examine whether this holds or not for the US real exchange rate. In other words, we investigate whether the US real exchange rate is vulnerable to structural shocks or not. To do so, we estimate the following VAR model:

$$A_0 Z_t = \alpha + \sum_{i=1}^{k} \mathrm{A}_i \mathrm{Z}_{t-i} + \varepsilon_t \qquad (2.21)$$

where $Z_t = (Prod, GIP, Oil, ProdEI, GIPEI, OilEI, REER)'$ is a (7×1) vector consisting of the percent change in global crude oil production, "$Prod$", percent change of global industrial production, "GIP", percent change of real oil price, "Oil", and $ProdEI, GIPEI, Oil$EI are the interaction terms between energy intensity and global oil production, industrial production, and oil prices; $REER$ denotes the percent change of real effective exchange rate. After applying the recursive identification scheme, we would be able to examine the dynamic response of real exchange rates to the structural oil shocks (supply and demand) as well as oil shocks interacted with energy intensity. Note that $\varepsilon_t^{Sup}, \varepsilon_t^{AD}, \varepsilon_t^{D}, \varepsilon_t^{SupEI}, \varepsilon_t^{ADEI}, \varepsilon_t^{DEI}$ are the shocks of oil supply, aggregate demand, oil-specific demand, oil supply interacted with energy intensity, aggregate demand interacted with energy intensity, oil specific demand interacted with energy intensity, respectively.

Figure 2.9 displays the impulse responses with a one-standard deviation bands based on equation (2.21). The plotted impulses indicate that response of real exchange rates to oil shocks interacted with energy intensity is the same response to sole structural oil shocks. This implies that energy intensity does not make the US real exchange rate less vulnerable to structural oil shocks. This might be rational since the US dollar is the main settlement currency in trading crude oil in international oil markets.

Figure 2.9 The Responses of Real Exchange Rates to Structural Oil Shocks



2.5.6 Forecast Error Variance Decomposition

To understand the relative contribution of each structural shock in explaining the movements of real exchange rates, we use the forecast error variance decomposition (FEVD). FEVD analysis illustrates the relative importance of each structural oil shock and enables us to trace out the effects of a one standard deviation change on real exchange rate movements over time horizons (Tables 2.6 and 2.7). The variance decomposition results[15] suggest that the structural oil price shocks are a considerable source of real exchange rate fluctuations over time. In other words, the total contribution of all three oil price shocks on the movements of G7 real exchange rates varies within a range of 0.304 percent and 17.683 percent during the first month and increases to a range of 1.1 percent and 18.831 after 12 months.

The results indicate that oil-supply shocks are the least important in explaining the movements of real exchange rates for the group of seven countries. In general, the contribution of oil supply shocks in explaining real exchange rate volatility is between 0.004 and 0.28 percent after the first month. As forecasting horizon increases to 12 months, this range only increases to between 0.121 and 1.75 percent.

On the other hand, we find that the aggregate demand and oil-specific demand shocks play important roles in explaining real exchange rate swings over the 12-month time horizon. Aggregate-demand shocks seem to be the second most important shocks in explaining real exchange rate fluctuations for all countries, except Canada. For example, aggregate demand shocks explain about 0.69 percent of real exchange rate fluctuation during the first months; as the forecasting horizon increases to 6 months, we find that aggregate demand shocks explain

[15] The estimates of FEVD were done in R (version 3.1.2) using function fevd from package vars (version 1.5-2).

approximately 1.21 percent of real exchange rate movements. When the forecast horizon moves to 6 months or more, the role of aggregate demand shocks in illustrating real exchange rate movements appears to be about 1.19 percent.

Oil-specific demand shocks are the most important shocks in explaining the movements of real exchange rates as the forecast error variance decomposition results show for all countries, except Canada. The range of the impact of oil-specific demand shocks in explaining the movements of real exchange rates for all countries, except Canada, ranges between 0.22 and 17.67 percent during the first month of the forecasting horizon. As the forecasting horizon increases to 12-months, we find the contribution of oil-specific demand shocks tends be very important, ranging between 1.87 and 18.22 percent.

Oil-specific demand shocks explain about 17.67 percent of the Japanese real exchange rate variations during the first month; as forecast horizon increases to three months, we find that oil-specific demand shocks explain approximately 18.04 percent. Moving into the sixth through twelfth forecasting horizons, oil-specific demand shocks appear to explain about 18.22 percent of the exchange rate variation.

For the Canadian real exchange rate, the results indicate that aggregate demand shocks are more important than oil-specific demand shocks in explaining the movements of the real exchange rate. We find that aggregate demand shocks explain about 0.20 percent of real exchange rate variation in the first month, whereas oil-specific demand shocks illustrate only about 0.01 percent in the same month. After three-months, we find aggregate demand shocks explain about 1.81 percent of real exchange rate swings, while oil-specific demand shocks explain only 0.02 percent of real exchange rate fluctuations. As the forecasting horizon increases, the forecast error variance decomposition results indicate that about 1.91 and 0.98 percent of real exchange rate changes are explained by aggregate demand and oil-specific demand shocks, respectively.

Overall, the conclusion inferred from the forecast error variance decomposition results is confirmed by the dominant view from the impulse response function analysis. In other words, structural oil shocks play an essential role in explaining the variations in real exchange rates.

Table 2.6 Forecast Variance Decomposition.

	Canada				France				Germany			
H	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total
1	0.00004	0.0029	0.0001	0.00304	0.0019	0.0069	0.0454	0.0542	0.0003	0.0313	0.0491	0.0807
3	0.00274	0.0181	0.0002	0.02104	0.0032	0.0121	0.0514	0.0667	0.0065	0.0336	0.0503	0.0904
6	0.00281	0.0191	0.0097	0.03161	0.0174	0.0119	0.0504	0.0797	0.0069	0.0335	0.0531	0.0935
12	0.00281	0.0191	0.0098	0.03171	0.0175	0.0119	0.0504	0.0798	0.0069	0.0335	0.0531	0.0935
	Italy				Japan				US			
H	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total
1	0.0025	0.0056	0.0521	0.0602	0.00003	0.0001	0.1767	0.17683	0.0006	0.0015	0.0177	0.0198
3	0.0038	0.0108	0.0542	0.0688	0.00116	0.0036	0.1804	0.18516	0.0076	0.0264	0.0175	0.0515
6	0.0087	0.0169	0.0531	0.0787	0.00121	0.0049	0.1822	0.18831	0.0157	0.0304	0.0187	0.0648
12	0.0088	0.0171	0.0531	0.079	0.00121	0.0049	0.1822	0.18831	0.0157	0.0305	0.0187	0.0649

Note: the reported numbers are percentage rate.

Table 2.7 Forecast Variance Decomposition for the UK.

	Pre-Break				Post - Break			
H	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total
1	0.0009	0.0016	0.0022	0.0047	0.0028	0.0032	0.0350	0.041
3	0.0028	0.0056	0.0022	0.0106	0.0028	0.0283	0.0319	0.063
6	0.0029	0.0059	0.0022	0.011	0.0046	0.0429	0.0326	0.0801
12	0.0029	0.0059	0.0022	0.011	0.0046	0.0447	0.0326	0.0819

2.6 The Role of Monetary Policy

In this section, we explore the role of monetary policy in G7 countries in response to the identified oil price shocks and real effective exchange rate shocks as plotted in Figures 2.3, 2.10, and 2.11, respectively.

An extensive number of studies discuss the essential role of monetary policy in responding to the consequences of real exchange rate and oil price shocks. Most of the existing literature attempts to answer the following questions. Does monetary policy react to oil price shocks? Does monetary policy react to real exchange rate shocks? Answering these questions is not new in the literature; however, the provided answers regarding these equations vary. Therefore, we attempt to address these questions and see whether our answers agree with the existing studies or not.

Figure 2.10 The Evolution of Real Exchange Rates Shocks

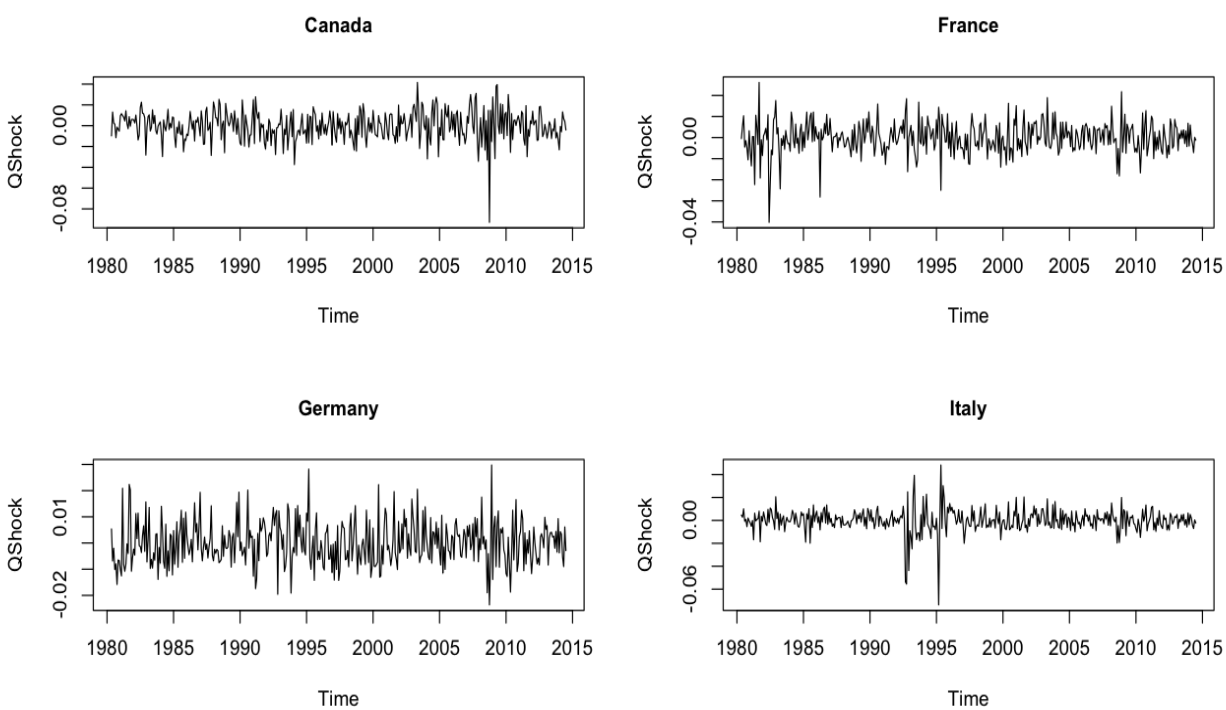
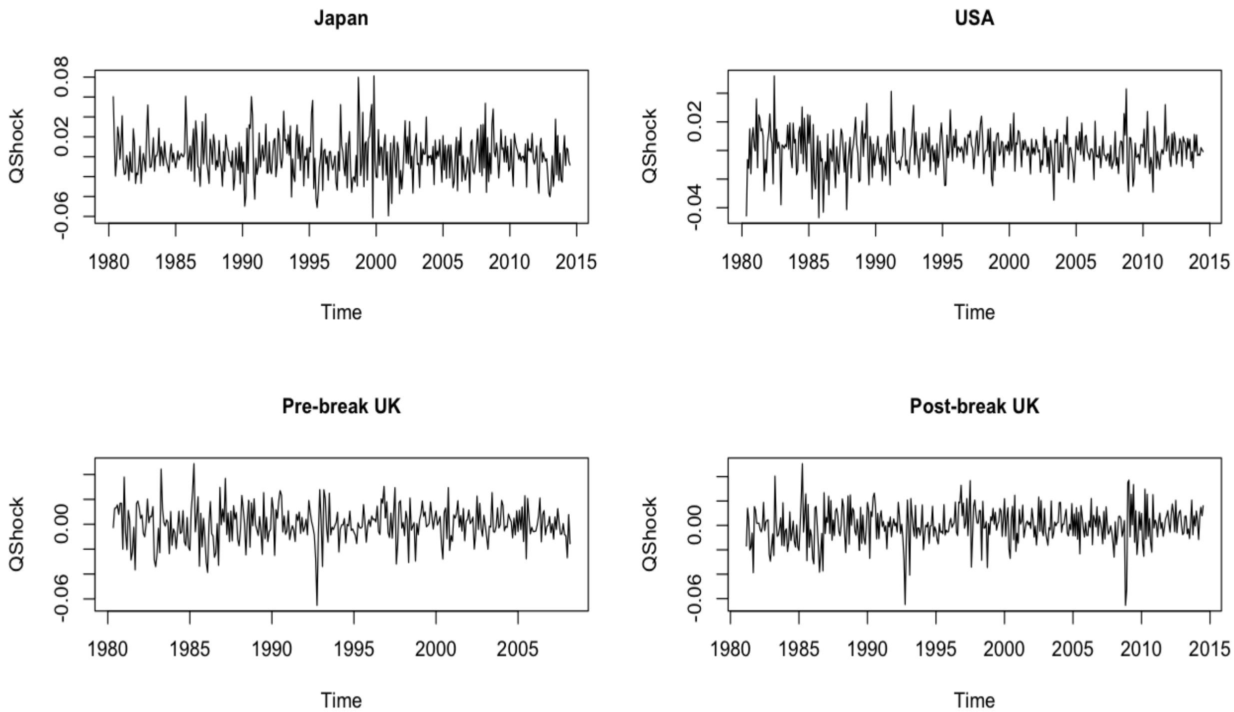


Figure 2.11 The Evolution of Real Exchange Rates Shocks



Regarding the first question, there is an existing debate about the effectiveness of monetary policy in reducing the consequences of oil price shocks. Bernanke et al. (1997) argue that much of the recessionary consequences (i.e. lower output and lower employment rate) are due to the upward movements of the interest rate resulting from the Fed's endogenous response to higher inflation induced by oil shocks. However, Hamilton and Herrera (2004) challenge the conclusion of Bernanke et al. (1997) and alleviate the responsibility of monetary policy in the transmission of oil price shocks to economic activities. In addition, they argue that the model of Bernanke et al. (1997) is misspecified and underestimates the direct consequences of oil price shocks on real output. Hamilton and Herrera also attribute the misleading perception of the monetary policy driven by the Federal Reserve to Bernanke et al. (1997). Bachmeier (2008) also shows that monetary policy does not play a role in the transmission of oil shocks to the economy.

Kilian and Lewis (2011) re-examine the findings of Bernanke et al. (1997) with additional data and econometric techniques and find that a systematic monetary policy does not react to oil shocks after 1987. Kilian and Lewis (2011) also explore the response of monetary policy to differential oil price shocks developed by Kilian (2009) and find that monetary policy tends to respond positively with statistical significance to aggregate demand shocks and oil specific demand shocks by raising the interest rate. They find that monetary policy reacts negatively to oil supply shocks, but it is statistically insignificant.

On the other hand, there are several studies attempting to answer the second question. Because changes in real exchange rates are considered an indicator for monetary policy when there is uncertainty about the exchange rate, many studies explore whether monetary policy responds to real exchange rate variability or not.

Clarida et al. (1998) find evidence showing that in Japan and some European countries, monetary policy reacts to changes in exchange rates. Lubik and Schorfheide (2007) show that the central banks of Canada and the UK respond to exchange rate variations, while the central banks of Australia and New Zealand do not. Similarly, Dong (2008) finds monetary authorities in Australia, Canada, and the UK respond to exchange rate fluctuations, whereas the monetary authority in New Zealand does not.

Alstadheim et al. (2013) show that, in Canada, Sweden, and the UK, the response of monetary policy to exchange rates varies over time. Additionally, Glick and Leduc (2013) document that the US monetary policy reacts to changes in the dollar exchange rate. Børnland and Halvorsen (2014) examine whether monetary policy responds to exchange rate fluctuations and find evidence showing that monetary policy reacts to changes in exchange rates only in Canada, Sweden, Norway, and New Zealand, but not in Australia and the UK[16].

To explore whether the G7 central banks respond to the identified oil price and real exchange rate shocks, we regress the interest rate on oil and exchange rate shocks, as shown in equation (22). Before we go further in our analysis, we check the stationarity of the interest rate data based on the unit root tests described in subsection (2.5.1) and find the data are nonstationary in levels but stationary in the first difference.

In order to explore how monetary authorities in G7 countries react to structural shocks, we estimate the following model via OLS.

$$R_{j,t} = \beta_0 + \beta_1 \varepsilon_t^{Sup} + \beta_2 \varepsilon_t^{AD} + \beta_3 \, \varepsilon_t^{D} + \beta_4 \varepsilon_t^{REER} + e_t \qquad (2.22)$$

where $R_{j,t}$ denotes the change in the interest rate for country j at time t. Also, note that ε_{t-i}^{Sup}, ε_{t-i}^{AD}, ε_{t-i}^{D} denote the identified oil supply shock, aggregate demand shock, and oil-specific demand shock for country j at time t, respectively. The ε_t^{REER} variable denotes the identified real exchange rate shock for country j at time t, and $e_t$is the error term.

Tables 2.8 and 2.9 present the estimated parameters[17] of oil price and real exchange rate shocks as given in equation (2.22). The response of policy interest rate to oil supply shocks seems to be negative in all cases, but it is statistically insignificant. The policy interest rate tends to respond positively and statistically significantly to aggregate demand and oil specific demand shocks for Japan, the UK, and the US. This finding agrees with Kilian and Lewis (2011) who

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[16] For further reading see i.e. Eichenbaum and Evans (1995), Faust and Rogers (2003), Zettelmeyer (2004), and Gali and Monacelli (2005).

[17] The parameter estimates were done in R (version 3.1.2) using function dynlm from package dynlm (version 0.3.3).

illustrate that raising the interest rate in the US in response to a positive aggregate demand shock is consistent with the implemented monetary policy before the oil price shock of 1973. They also argue that the implemented monetary policy leading to cut the interest rate as a result of an oil supply shock is consistent with the Federal Reserve's view that surges in oil prices are adverse aggregate demand shocks.

It is also essential to emphasize that since the formation of the European Union in January 1999, the monetary policy of France, Germany, and Italy is implemented by the European central bank.

Table 2.8 Monetary Policy Responses to Structural Shocks.

	$\widehat{\beta_1}$	$\widehat{\beta_2}$	$\widehat{\beta_3}$	$\widehat{\beta_4}$
Canada	-5.09	0.09	-0.35	-2.99
	(-1.17)	(1.39)	(-0.52)	(-1.23)
France	-1.98	0.06	0.11	2.79
	(-0.66)	(1.05)	(0.48)	(0.64)
Germany	-0.56	0.03	0.13	-0.39
	(-0.58)	(0.67)	(0.84)	(-0.26)
Italy	-1.68	0.06	-0.32	-4.11*
	(-0.74)	(1.34)	(-0.84)	(-1.98)
Japan	-1.87	0.19**	0.61**	-2.17**
	(-1.03)	(3.91)	(3.66)	(-2.06)
U.S.	-2.36	0.16**	0.31***	7.28**
	(-1.21)	(4.16)	(1.61)	(3.33)

Numbers in parenthesis are t-values based on Newey-West (1987) standard errors.
*, **, *** Indicate the significance levels at 1%, 5%, and 10% respectively.

Table 2.9 British Monetary Policy Responses.

	$\widehat{\beta_1}$	$\widehat{\beta_2}$	$\widehat{\beta_3}$	$\widehat{\beta_4}$
Pre-break date	-3.09	0.38**	0.16	2.58
	(-1.54)	(5.58)	(0.67)	(1.58)
Post-break date	0.15	0.09**	0.67**	1.98***
	(0.12)	(3.01)	(3.22)	(1.61)

Numbers in parenthesis are t-values based on Newey-West (1987) standard errors.
*, **, *** Indicate the significance levels at 1%, 5%, and 10% respectively.

The parameter estimates of real exchange rate shocks (β_4) indicate that only the monetary authorities represented by the central banks of Italy, Japan, the UK, and the US respond significantly to real exchange rate fluctuations. This in turn indicates that the monetary policy has been, to some extent, directed towards stabilizing the nominal exchange rates for these countries. We find no evidence of monetary policy in other countries responding to exchange rate fluctuations. This might be due to the absence of policy coordination among G7 countries regarding exchange rate. Fratzscher (2009) documents that G7 countries played essential roles in managing their exchange rates in the early years, since the breakdown of Bretton Woods Fixed Exchange Rate System. However, their role in policy coordination regarding the movements of exchange rates became weaker after 1995.

Another explanation for the weak role of monetary policy in responding to exchange rate movements in these countries is the use of alternative instruments by policy makers. One of the alternative instruments implemented by monetary authorities is the central bank intervention in the currency market for stabilization purposes. For example, the Bank of Japan tends to intervene in the currency market in recent years to stabilize its exchange rate, as stated by Archer (2005). Dupuy (2008) argues that some of the Euro zone major trading partners, such as Japan and the

US, tend to manipulate their currency to low levels to stimulate their exports and sustainable growth.

2.7 Implications For Monetary Policy

Structural oil price shocks play an essential role in capturing the movements of real exchange rates, though the impact may vary depending on the underlying source of these shocks. Thus, our empirical results have several important implications on the economy that should be considered by economists, traders, financial and market analysts, and policy makers.

Oil supply, aggregate demand, and oil-specific demand shocks may lead to the appreciation or depreciation of real exchange rates, as discussed in the previous sections. Thus, it is important to understand the implications of real exchange rates' movements. The depreciation of real exchange rates has positive and negative impacts on the economy. By exploring some of the negative consequences, we find that a weak value of exchange rate yields a lower international purchasing power for the citizens of G7 countries. Additionally, the depreciation of real exchange rates indicates lower returns of G7 assets, and this in turn discourages foreign investors to hold G7 assets.

On the other hand, the depreciation of real exchange rates may become a key engine to stimulate economic activity via higher prices of foreign goods relative to domestic goods. This, in turn, raises the international competitiveness of domestic goods leading to a reallocation from spending on foreign goods to domestic goods. This would be reflected not only in a reduction in the trade deficit, but also in a reduction in the unemployment rate to meet the strong demand for exported goods in international markets.

The empirical evidence indicates that four countries of the G7 do not react to real exchange rate fluctuations. This suggests the essential role of policy coordination between G7 countries in order to stabilize real exchange rates. Direct market intervention in the foreign exchange market would be a useful tool to stabilize exchange rate movements by monetary authorities of each of the G7 countries.

To prevent the negative implications of exchange rate movements on the world economy, the International Monetary Fund (IMF) and the World Trade Organization (WTO) could implement some policies. Because some countries intend to undervalue their currencies in order to stimulate their economies via raising net exports, the IMF could identify and evaluate the implemented monetary policies by central banks. The WTO could set some rules to prevent trade competition as suggested by Dupuy (2008). It is essential to emphasize that it would be necessary for these policies to fit in with the objectives of the IMF and WTO.

2.8 Robustness Check

It is important to note that our results are robust to alternative oil prices. In particular, we use the producer price index (PPI) of petroleum and West Texas Intermediate (WTI) of crude oil as alternative oil prices and find that using different oil prices does not change the conclusions of this paper. The detailed results are shown in the appendices.

For the case of the UK, using the WTI crude oil prices, the tests of structural breaks confirm the existence of a stable relationship between structural oil price shocks and real exchange rate. The impulse response function analysis shows that the appreciation of the real exchange rate is associated with oil supply and aggregate demand shocks, whereas oil-specific demand shocks lead to the depreciation of the real exchange rate over the 12-month period. Using WTI oil prices, we find that the monetary authority only responds to the aggregate demand, oil specific demand and real exchange rate shocks by raising the policy interest rate.

2.9 Conclusion

The main objective of this paper is to assess the essential role of different oil price shocks on the variation of G7 real exchange rates. To achieve this objective, we derive the oil supply and demand shocks following Kilian (2009) and investigate the response of real exchange rate to these shocks using monthly data spanning form 1980:01 to 2014:07.

We find evidence suggesting the essential role of oil structural shocks in capturing the movements of real exchange rate. In other words, the results indicate that aggregate demand and oil-specific demand shocks are associated with the depreciation of real exchange rates for oil-importing countries. Oil supply shocks impact real exchange rates of oil importing countries negatively. For the case of Canada, a net-oil exporting country, we find that only aggregate demand shocks are associated with the appreciation of the real exchange rate.

For the UK, we find an unstable relationship between oil shocks and real exchange rate. Results prior to the estimated break date indicate the real exchange rate depreciation (appreciation) is associated with oil supply (aggregate demand and oil specific demand) shocks. on the other hand, we find that results after the estimated break date indicate the real exchange rate depreciation (appreciation) is associated with specific demand (oil supply and aggregate demand) shocks.

Furthermore, the obtained results from the forecast error variance decomposition illustrate the relative importance of the structural oil shocks in explaining the variations of the real exchange rate. In essence, we find oil-specific demand shocks to be the most important shocks contributing to the explanation of the movements of real exchange rate, whereas the oil supply shocks are the least important shocks. The findings of this paper have essential implications for governmental policy makers, traders, economists, and analysts as discussed in section 2.6.

Due to the ongoing debate regarding the role of monetary policy role in responding to oil price shocks, we explore whether monetary policy responds to oil price shocks or not. We find evidence indicating that monetary authorities of G7 countries do not respond to oil supply shocks, as suggested by Hamilton and Herrera (2004). Conversely, we find evidence suggesting that only the central banks of Japan, the UK, and US react to demand shocks; this finding is in line with the finding of Lewis and Kilian (2011).

Additionally, we find evidence showing that only the monetary authorities of Italy, Japan, and the US react to changes in real exchange rates. This finding is consistent with the results of Glick and Leduc (2013) and Halvorsen (2014).

Chapter 3 - The Effects of Oil Shocks on the Economy of Saudi Arabia

3.1 Introduction

Hamilton (1983) was a pioneering contribution showing the crucial impacts of the 1970s oil shocks on economic activity. Hamilton (1983) examines the effects of oil price shocks on the U.S. economy using a vector autoregressive (VAR) model. He not only finds a negative relationship between oil shocks and GDP growth but also finds that seven out of eight of U.S postwar recessions were preceded by oil shocks. His seminal work motivated much of the literature focusing on the effects of oil shocks on various economic activities, such as output, (Hamilton 1983,1996, 2003; Mork, 1989; Hooker, 1996; Kilian 2008a), inflation (Barsky & Kilian, 2002; Bachmeier & Cha, 2011), financial markets (Bachmeier, 2008; Kilian & Park, 2009), exchange rates (Amano & Norden 1998; Chen & Chen, 2007; Jahan-Parvar & Mohammadi, 2012), monetary policy (Bernanke et al., 1997; Hamilton & Herrera, 2004), fiscal policy (El Anshasy & Bradley, 2012), trade balance (Le & Chang, 2013), terms of trade (Backus & Crucini, 2000), employment (Davis & Haltiwanger, 2001), and industry-level output (Lee & Ni, 2002) for both developed and developing countries. Kilian (2008b) provides a comprehensive literature review regarding the consequences of oil shocks on economic activity.

The literature contains a fair amount of research on the effects of oil price shocks in oil-producing countries, such as Algeria (Bouchaour and Al-Zeaud, 2012), Canada (Kilian, 2008a), Russia (Ito, 2010; Fang & You, 2014), Mexico (Cantore et al., 2012), Norway (Baumeister et al., 2010), and Venezuela (Mendoza & Vera, 2010). However, Saudi Arabia, which is a major oil producing country in the world, has not received much attention. The academic literature examining the effects of oil price shocks on the Saudi economy is scarce. There are a limited number of studies focusing on the effects of oil price shocks on the Saudi stock market, exchange rate, and inflation. Jahan-Parvar and Mohammadi (2008) explore the influential role of oil prices on real exchange rates for oil-producing countries, including Saudi Arabia, and find that higher oil prices lead to the appreciation of the real exchange rates in those countries; in other words, they find evidence consistent with the Dutch disease hypothesis. Likewise, other studies, such as Arouri et al. (2011), look into the potential effects of oil price shocks on stock markets in GCC countries, including Saudi Arabia, and conclude that oil prices affect the Saudi stock market positively. Other studies, such as Federal Reserve Bank of Dallas (2000), report that a decline in oil prices by $1 leads to a decline in Saudi oil revenue by $2.5 billion every year. Furthermore, Aleisa and Dibooglu (2002) document that Saudi Arabia's role in the oil market influences world inflation and that, in turn, is transmitted to the inflation of Saudi Arabia through import channels.

Most prior research has focused on the effects of oil supply shocks on world economies, including the Saudi economy. Kilian (2009) constructs new oil shocks to differentiate between oil supply shocks and oil demand shocks. Kilian (2009) addresses the endogeneity of oil prices and supports the idea of differential effects of oil shocks depending on the source of these shocks. He argues that spikes of oil prices after 2003 did not cause any major recessions, and these surges in oil prices were mainly driven by higher global economic growth that lead to higher global demand for oil. Additionally, he argues that aggregate demand shocks have the largest effects compared to oil-specific demand shocks and oil supply shocks. Several studies apply Kilian's (2009) methodology to investigate the differential effects of oil shocks on stock markets (Kilian &Park, 2009), monetary policy (Kilian & Lewis, 2011), and external balances (Kilian et al., 2009).

This essay examines the differential effects of oil price shocks on the economic activity of Saudi Arabia. In other words, we follow Kilian (2009) by identifying oil supply and demand shocks to investigate the response of industrial production, inflation, and the nominal exchange rate to an oil supply shock, an aggregate oil demand shock, and an oil-specific demand shock.

The remainder of this essay is organized in the following manner. The next section provides data descriptions, while section 3.3 discusses the methodology. Section 3.4 provides empirical findings, and section 3.5 contains the conclusions.

3.2 Data

Our dataset consists of industrial production, the consumer price index, nominal effective exchange rate, world crude oil production, Producer Price Index (PPI) for petroleum as a measure for world oil prices, and global real economic activity. The dataset contains monthly observations ranging from 1980:02 to 2014:02 and are obtained from a variety of sources. The data for industrial production, nominal effective exchange rate, and the consumer price index for Saudi Arabia are downloaded from the International Financial Statistics and IMF databases. The Producer Price Index (PPI) for petroleum, global economic activity index, and global crude oil production are obtained from the websites of the Bureau of Labor Statistics (BLS), the webpage of Lutz Kilian, and the U.S. Energy Information Administration (EIA), respectively. Hereafter, $Prod_t, REA_t, OP_t, IP_t, CPI_t, and\ NER_t$ denote global crude oil production, real economic activity index, real oil price, industrial production, consumer price index, and nominal effective exchange rate at time t, respectively. It is also important to emphasize that all variables, except REA, are expressed in log form.

3.3 Empirical Methodology

3.3.1 Unit Root Tests

The initial step of our analysis involves ascertaining the stationarity of economic variables. To do so, we rely on standard unit root tests, the Augmented Dickey-Fuller (1979) and Phillips Perron (1988) tests. The results[18] are presented in tables 3.1 and 3.2 and show that both tests confirm the nonstationary of economic variables in their levels but not in their first differences. This means that all the variables are integrated of order 1, I (1).

3.3.2 The Structural Vector Autoregressive (SVAR) Model

To examine the consequences of various oil price shocks, we largely adopt the methodology of Kilian (2009), Kilian and Park (2009), and Kilian et al. (2009). We follow a two-stage approach. In the first stage, we identify the oil supply, oil-specific demand, and aggregate demand shocks using a recursive identification scheme. The second stage consists of conditioning the macroeconomic variables on the shocks identified in the first stage.

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[18] The unit root tests were done in R (version 3.1.2) using functions ur.df, ur.pp, and ur.kpss from package urca (version 1.2-8).

Table 3.1 Augmented Dickey Fuller (1979) Test.

	Level Data			First Difference Data		
Variable	None	Trend	Drift	None	Trend	Drift
Oil	-0.287	-5.4953	-4.2819	-16.5982	-16.5661	-16.5815
REA	-4.0082	-4.1847	-4.0469	-14.9552	-14.9262	-14.9411
Prod	-0.4722	-6.4911	-3.2578	-14.6424	-14.6113	-14.6262
IP	-0.2271	-3.3315	-2.3948	-14.4696	-14.4521	-14.4518
CPI	3.9601	0.8031	3.5037	-11.1168	-12.4434	-11.7303
NEER	-0.5404	-1.9604	-1.696	-12.9393	-12.9223	-12.9383

Note: The 5% critical values are for None=-1.95, Trend= -3.43, and Drift=-2.88.

Table 3.2 Phillips and Perron (1981) Test

	Level		First Difference Data	
Variable	Trend	Drift	Trend	Drift
Oil	-6.2295	-4.6509	-27.7303	-27.7528
REA	-3.3858	-3.2629	-14.2844	-14.3072
Prod	-5.4058	-2.5172	-17.1978	-17.2187
IP	-3.3126	-2.407	-23.1297	-23.1274
CPI	1.5369	4.3829	-18.1283	-17.6389
NEER	-1.846	-1.4769	-14.4308	-14.4495

Note: The 5% critical values are for constant =-2.87 and Trend= -3.42.

In the first stage, we specify the Vector Autoregressive (VAR) model[19] as given by equation (3.1),

$$A_0 Y_t = A(L) Y_{t-1} + u_t \qquad (3.1)$$

[19] The parameter estimates of the VAR model are attached in the appendix.

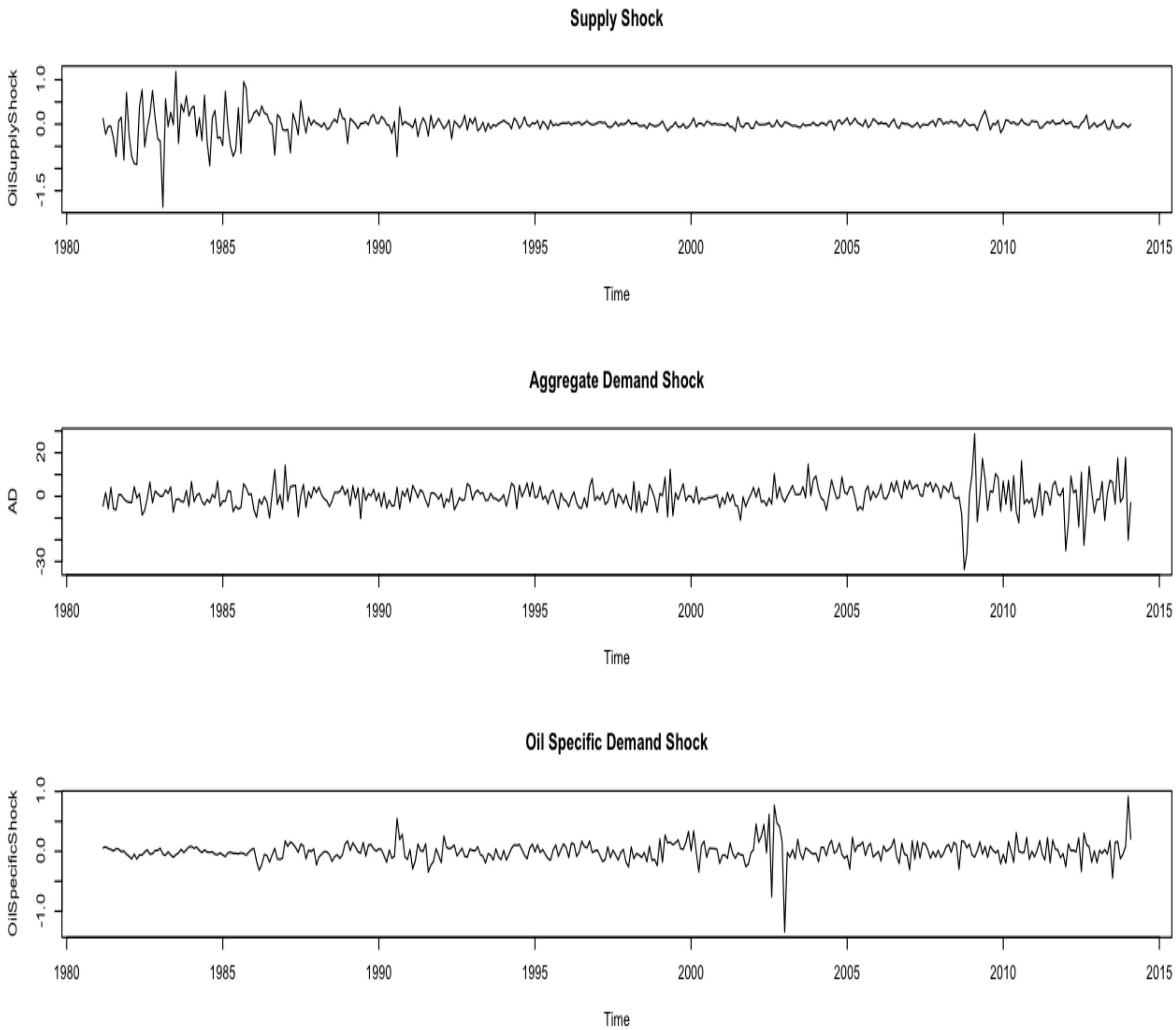
where Y_t includes percent change of global oil production, real economic activity index, and real world oil prices. The lag length is chosen based on the Akaike Information Criterion (AIC) and equals 12; this lag length is much shorter than 24 used by Kilian and Park (2009). However, we follow Kilian (2009) and Kilian et al. (2009) in identifying oil supply shocks, aggregate demand shocks, and oil-specific demand shocks based on a recursive (Cholesky) scheme in which global crude oil production is the most exogenous variable and the real oil price variable is the most endogenous one, as shown in matrix (3.2).

$$e_t = \begin{bmatrix} e_{1t}^{Prod} \\ e_{2t}^{REA} \\ e_{3t}^{OP} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} \varepsilon_{1t}^{Oil\ supply\ Shock} \\ \varepsilon_{2t}^{Aggregate\ Demand\ Shock} \\ \varepsilon_{3t}^{Oil\ specific\ demand\ Shock} \end{bmatrix} \quad (3.2)$$

Note that the vector $\widehat{\varepsilon_t} = [\varepsilon_{1t}^{oil\ supply\ shock}, \varepsilon_{2t}^{Agg.demand\ shock}, \varepsilon_{3t}^{oil\ specific\ demand\ shock}]$ is the vector of oil supply shocks, aggregate demand shocks, and oil-specific demand shocks; Figure 3.1 shows the plots of these shocks.

It is also worth noting that Kilian indicates that oil supply shocks measure the availability of crude oil, referring to the unpredictable changes in crude oil production. Aggregate oil demand shock measures the global business cycle, referring to the unpredictable changes in real economic activity that cannot be explained by supply shocks. Oil-specific demand shocks measure changes in the demand for oil that is driven by precautionary motives and refers to the unpredictable changes in the real price of oil that cannot be explained by a supply shock or an aggregate demand shock.

Figure 3.1 Structural Shocks Decomposition



After identifying the various oil shocks, we examine the effect of various oil shocks on macroeconomic variables by conditioning the identified oil shocks on the economic variable of interest, e_{4t}^{Econ}, recursively, as shown in matrix (3.3).

$$e_t = \begin{bmatrix} e_{1t}^{Prod} \\ e_{2t}^{REA} \\ e_{3t}^{OP} \\ e_{4t}^{Econ} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} \varepsilon_{1t}^{Oil\ supply\ Shock} \\ \varepsilon_{2t}^{Aggregate\ Demand\ Shock} \\ \varepsilon_{3t}^{Oil\ specific\ demand\ Shock} \\ \varepsilon_{4t}^{Other\ Econ\ Shocks} \end{bmatrix} \quad (3.3)$$

After estimating the structural VAR model given by (3.3), we calculate and analyze the impulse response functions (IRF) with a one-standard deviation bands.

3.4 Empirical Findings

Figure 3.2 displays the plotted impulse responses with a one-standard deviation bands. These impulses show the reactions of economic activity, inflation, and the nominal exchange rate to the oil supply shock, aggregate demand shock, and oil-specific demand shock.

The industrial production responds positively to oil supply and aggregate demand shocks and swings over time period. In other words, we find that the industrial production responds positively to oil supply shocks immediately until the third months when starts fluctuating till the end of the period; likewise, it fluctuates overtime period due to aggregate demand shock. On the other hand, we find that the industrial production responds negatively to oil-specific demand shock immediately until the third month when it starts to increase and continues increasing over the remaining time period.

This positive response to oil supply shock is consistent with the view that contractions of oil supply would lead to an increase in oil prices. Therefore, the oil revenue for countries, such as Saudi Arabia, that depend heavily on oil would increase and affect economic growth positively through the increase in aggregate demand. Saudi Arabia gained from the energy crises in 1973 and 1979, caused by the Arab-Israel War and Iranian revolution, respectively, and spent most of the oil revenues on a large development effort.

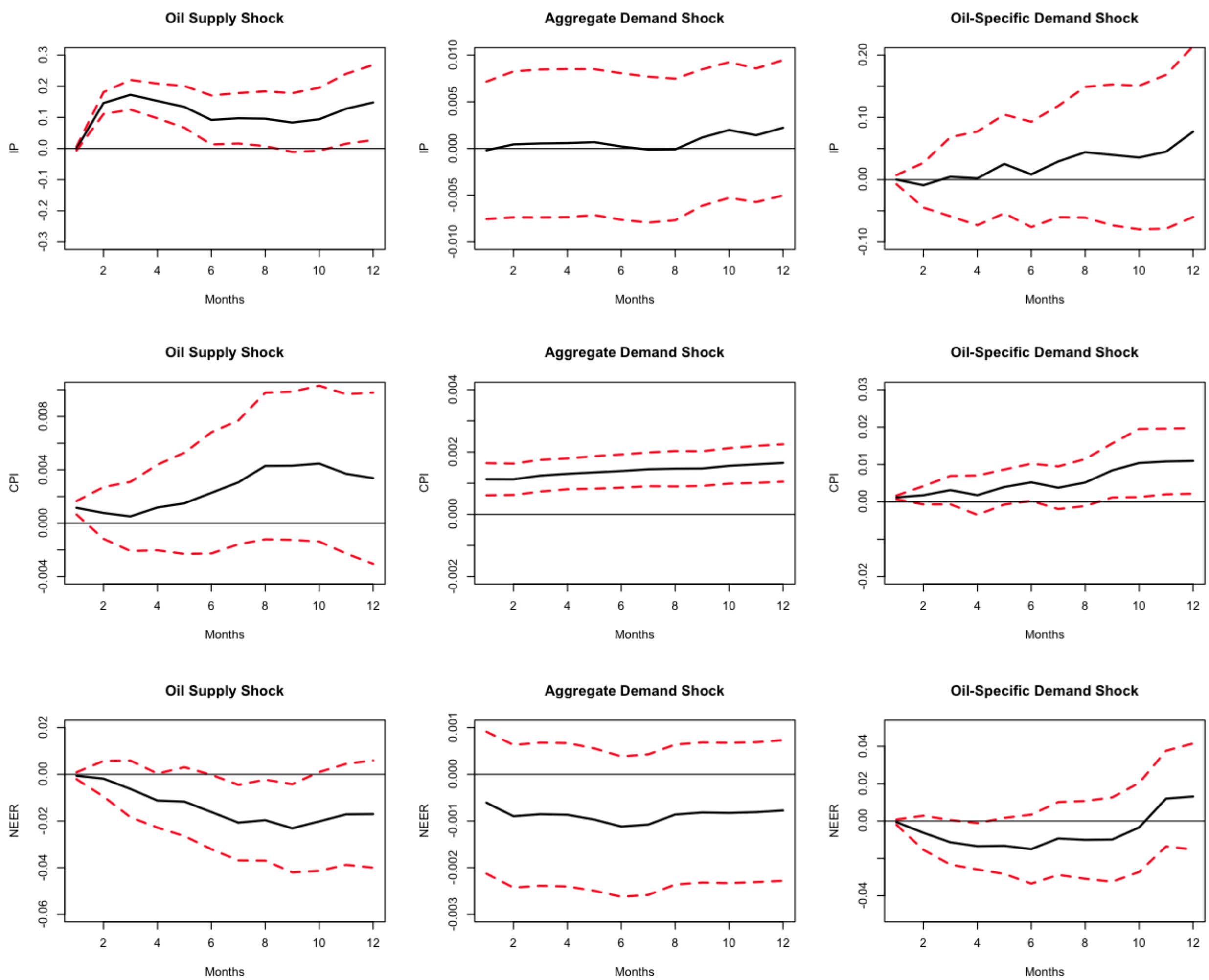
Likewise, an unanticipated increase in global real economic activity would lead to a temporary increase in the real price of oil. Thus, the oil revenues will increase and that will positively affect the economic growth through aggregate demand.

Regarding the response of inflation to structural oil shocks, the plotted impulses indicate that the impact of an unpredictable supply disruption on inflation is negative until the third month when starts to rise over the remaining period. The economic intuition behind the result of the IRF is that the oil supply contractions cause a small temporary reduction in aggregate demand due to a decrease in oil exports. Thus, the response of inflation to the supply shock would be negative in the case of Saudi Arabia.

On the other hand, the impact of aggregate demand and oil specific demand shocks on inflation is positive. In other words, we find inflation increases immediately and continue increasing over time horizon. A plausible explanation is that an unanticipated aggregate demand expansion of real global economic activity will increase real oil prices. Therefore, oil revenue will increase and lead to an increase in government spending on development. As a result, the aggregate demand would increase and cause inflation to increase; similar analysis applies for oil-specific demand shocks.

The fall of nominal exchange rate is associated with all structural oil shocks, which is unexpected by economic theory. In other words, we expect oil shocks to lead to the appreciation of oil-producing currencies, such as Saudi Arabia's; Jahan-Parvar and Mohammadi (2008) confirm the validity of "Dutch Disease Hypothesis." However, we find evidence suggesting the depreciation of nominal exchange rate as results of oil supply and demand shocks. This might be due to an increase in real oil prices, which decrease the competitiveness of Saudi exports in the global market. Therefore, the Saudi exchange rate will depreciate.

Figure 3.2 Impulse Responses of Macro Variables to Structural Oil Shocks.



Note: The horzintal axis represents time horizon "Months."

3.5 Conclusion

The objective of this paper is to empirically investigate the different effects of oil price shocks on the economic activity of Saudi Arabia. This paper utilized the measures of oil shocks initiated by Kilian (2009). The methodology of Kilian (2009), Kilian and Park (2009), and Kilian et al. (2009) was applied to examine the consequences of various oil shocks.

The estimated impulse response functions with a one-standard deviation bands indicated that the impacts of the three shocks varied. The impacts of oil supply and aggregate demand shocks have positive and immediate impacts whereas oil specific demand shocks are associated with lower industrial production level.

On the other hand, we find evidence suggesting the fall of inflation due to oil supply shocks; however, the aggregate demand shock and the oil-specific demand shock had positive and impacts on inflation.

We also found that the oil supply shock and demand shocks are associated with the depreciation of nominal exchange rates over time horizon.

An anticipated increase of oil prices, whether caused by an oil supply shock or demand shocks, will lead to an increase in oil revenue. Consequently, government spending will increase. That, in turn, will push aggregate demand up and increase IP growth and inflation in Saudi Arabia.

The results of this paper are useful for policymakers, especially in Saudi Arabia, in formulating monetary policy. Monetary policymakers may adopt inflation targeting to control the rise in inflation. Therefore, the central bank may lower or raise interest rates in order to reach the target inflation, and this may increase the stability of the economy. An important advantage of inflation targeting is that it combines two elements: a response of economic shocks in the short run, and an accurate numerical target for inflation in the medium term.

For future research, it is important to investigate the effect of the three shocks on other economic sectors, such as labor markets, the stocks and bonds market, and the international trade markets. This type of research will help policymakers in formulating sound fiscal and monetary policies.

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Appendix A - Additional Results

The following tables are the reduced form VEC model estimates for chapter 1. These estimates are for 13 countries. It is important to note that O, Y, M, EX denote the price of oil, the domestic output relative to foreign output, the domestic money supply relative to foreign money supply, and the US dollar exchange rate relative to foreign currency.

Table A.1 Parameter estimates of Reduced Form VEC Model for Australia

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.045	0.024	-0.0004	0.001	-0.006**	0.0020	-0.025	0.0084
Intercept	0.213.	0.107	0.001	0.01	0.019*	0.0090	0.111	0.0371
O-1	0.055	0.106	-0.004	0.01	0.008	0.0089	-0.038	0.0367
Y-1	2.991	1.992	-0.046	0.10	0.151	0.1660	0.186	0.6857
M-1	-0.963	1.147	0.093	0.06	0.474	0.0956	-0.248	0.3948
EX-1	0.904*	0.284	0.038**	0.015	-0.05**	0.0237	0.332	0.0979
O-2	-0.265**	0.102	0.008	0.0054	0.021**	0.0085	-0.072**	0.0351
Y-2	2.195	1.931	0.1341	0.1020	0.117	0.1609	0.35	0.6646
M-2	-1.013	1.146	0.006	0.0064	0.0605	0.0955	-0.307	0.3944
EX-2	-0.043	0.301	-0.005	-0.0052	0.0159***	0.0251	0.009	0.1036

*, (**), and *** denote 1%, 5%, and 10% significance levels respectively.

Table A.2 Parameter estimates of Reduced Form VEC Model for Canada

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.08	0.0472.	0.0001	3.6e-05**	-7.50E-05	5.4e-05	0.0002	0.0051
Intercept	8.33	4.4506	0.01	0.0034	0.006	0.0051	-0.015	0.0159
O -1	0.152	0.1127	-0.0002	8.5e-05**	-8.70E-05	0.0001	0.0002	0.0004
Y-1	-151.91	127.0885	-0.02	0.0963	0.001	0.1468	-0.25	0.4529
M -1	18.96	86.1712	-0.11	0.0653	0.44	0.0995***	0.46	0.3071
EX -1	34.52	31.3276	0.04	0.0237	-0.08	0.0362*	0.28	0.1116*
O -2	-0.58	0.1159	0.0001	8.8e-05	0.0003	0.0001*	-0.002	0.0004***
Y -2	29.34	124.0988	0.118	0.0940	-0.151	0.1433	-0.503	0.4423
M -2	24.42	95.4914	0.1	0.0723	-0.03	0.1103	-0.18	0.3403
EX -2	101.18	32.0141**	0.01	0.0243	-0.05	0.0370	0.23	0.1141
O-3	-0.2	0.1363	3.4e-05	0.0001	0.0002	0.0002	-0.001	0.0005.
Y -3	108.45	120.9941	-0.06	0.0917	-0.14	0.1397	0.33	0.4312
M -3	-68.15	79.5664	-0.06	0.0603	0.15	0.0919.	-0.31	0.2836
EX -3	70.085	32.7287*	0.001	0.0248	-0.056	0.0378	0.157	0.1166

Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table A.3 Parameter estimates of Reduced Form VEC Model for Chile

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.03	(0.01)*	-0.01	(0.003)***	0.009	(0.001)***	-0.0004	0.005
Intercept	0.442	(0.20)*	0.12	(0.03)***	-0.09	(0.02)***	0.01	0.06
O -1	0.1	0.11	0.016	0.02	-0.02	0.01	-0.001	0.03
Y -1	0.131	0.34	-0.69	(0.06)***	0.004	0.03	-0.21	(0.11).
M -1	-0.24	0.98	0.32	(0.17).	0.35	(0.10)**	0.5	0.31
E -1	1.05	(0.33)**	-0.08	0.05	-0.11	(0.03)**	0.24	(0.10)*
O -2	-0.23	(0.10)*	0.02	0.01	0.01	0.01	-0.03	0.03
Y -2	0.245	0.39	-0.65	(0.06)***	-0.01	0.04	-0.01	0.12
M -2	1.44	0.98	0.36	(0.17)*	0.12	0.1	0.16	0.31
E -2	0.2	0.35	-0.1	(0.06).	-0.06	(0.03).	-0.01	0.11
O -3	0.23	(0.10)*	0.03	(0.01)*	-0.02	(0.01)*	-0.004	0.033
Y -3	-0.18	0.34	-0.78	(0.06)***	-0.01	0.03	0.12	0.11
M -3	0.42	0.91	0.27	(0.16).	0.16	(0.09).	-0.33	0.29
E -3	-0.08	0.34	-0.1	(0.06).	-0.011	0.03	0.011	0.11

Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table A.4 Parameter estimates of Reduced Form VEC Model for Denmark

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.096	0.0558.	0.0001	0.0001	0.0004	0.0002.	0.0004	0.0003.
Intercept	30.475	17.2202.	-0.03	0.0352	-0.118	0.0633.	-0.105	0.1054
oil -1	0.266	0.1097	-0.0007	0.0002	-0.001	0.0004.	-3.3e-05	0.0007
Y-1	-31.334	54.0860	-0.508	0.1106**	0.104	0.1989	-0.212	0.3311
M-1	-15.964	27.6189	0.009	0.0565	0.486	0.1016***	-0.149	0.1691
E-1	2.08	18.7505	0.019	0.0384	0.119	0.0690.	0.203	0.1148.
Oil-2	-0.38	0.1121**	-0.001	0.0002*	0.0005	0.0004	-0.002	0.0007*
Y-2	12.622	54.4024	-0.369	0.1113*	0.34	0.2001.	-0.141	0.3331
M-2	-6.397	29.8404	0.06	0.0610	-0.125	0.1097	0.009	0.1827
E-2	0.413	18.7707	0.019	0.0384	-0.051	0.0690	-0.031	0.1149
Oil-3	0.018	0.1267	3.4e-07	0.0003	-0.0004	0.0005	-0.001	0.0008
Y-3	-14.861	53.3932	-0.452	0.1092***	0.276	0.1964	0.031	0.3269
M-3	31.32	30.1125	0.018	0.0616	0.017	0.1107	-0.073	0.1844
E-3	-9.622	18.5702	0.007	0.0380	-0.167	0.0683*	0.18	0.1137
Oil-4	-0.151	0.1173	-0.0002	0.0002	0.0001	0.0004	-0.001	0.0007
Y-4	63.056	53.8579	0.301	0.1102**	0.325	0.1981	-0.054	0.3298
M-4	3.881	31.7785	-0.007	0.0650	-0.364	0.1169**	0.084	0.1946
E-4	-13.575	19.2179	0.002	0.0393	0.033	0.0707	-0.079	0.1177
Oil-5	-0.163	0.1169	-0.0002	0.0002	-0.0003	0.0004	0.0005	0.0007
Y-5	91.727	48.7355.	-0.058	0.0997	0.229	0.1792	0.14	0.2984
M-5	-13.217	28.5005	0.015	0.0583	0.218	0.1048*	0.008	0.1745
E-5	17.866	18.7081	0.019	0.0383	-0.001	0.0688	-0.13	0.1145

Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table A.5 Parameter estimates of Reduced Form VEC Model for Japan

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT1	-0.295	0.0781	-2.1e-05	0.0001	0.0003***	0.0003	0.0002	0.0005
ECT2	-7.422	14.1819	-0.03	0.0237	0.065***	0.0130	-0.0645	0.0964
Intercept	62.147	16.0085	-0.02	0.0267	-0.0168	0.0146	-0.0993	0.1088
O-1	0.432	0.0995	-6.7e-05	0.0002	-0.0002*	9.1e-05	5.5e-05	0.0007
Y-1	-109.732.	61.0393	-0.085	0.1018	-0.028	0.0558	-0.2023	0.4150
M-1	131.177	102.9991	0.481	0.1718**	0.365***	0.0941	-0.9576	0.7002
EX-1	8.745	14.1358	-0.012	0.0236	0.021	0.0129	0.2187	0.0961
O-2	-0.227	0.1055	0.0002	0.0002	3.9e-05	9.6e-05	0.0005	0.0007
Y-2	-61.563	59.6785	0.102	0.0995	0.087	0.0545	0.6974.	0.4057
M-2	-60.622	101.4049	0.003	0.1691	0.088	0.0927	0.7735	0.6894
EX-2	-9.508	13.6978	-0.009	0.0228	-0.015	0.0125	-0.2172*	0.0931

*, (**), and *** denote 1%, 5%, and 10% significance levels respectively.

Table A.6 Parameter estimates of Reduced Form VEC Model for Mexico

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.019	0.0294	-7.4e-05	6.0e-05	-0.0002	6.6e-05***	0.0004	0.0002
Intercept	13.999	18.4974	0.047	0.0380	0.144	0.0416**	-0.236	0.1435
O-1	0.245	0.1098*	-0.0001	0.0002	0.0002	0.0002	0.001	0.0009
Y-1	-8.114	55.0684	-0.537	0.1132**	-0.048	0.1238	0.22	0.4273
M-1	15.403	48.7758	0.147	0.1003	0.58	0.1096***	1.013	0.3785**
EX-1	-7.465	14.4011	-0.154	0.0296	-0.019	0.0324	0.24	0.1117*
O-2	-0.478	0.1121**	-0.0002	0.0002	7.8e-05	0.0003	-0.002	0.0009**
Y-2	-7.68	54.9032	-0.187	0.1129	-0.11	0.1234	-0.272	0.4260
M-2	0.654	54.1577	-0.009	0.1113	0.15	0.1217	0.364	0.4202
EX-2	9.467	16.5093	-0.06	0.0339	-0.053	0.0371	0.002	0.1281
O-3	-0.037	0.1253	7.1e-05	0.0003	-0.0002	0.0003	-0.001	0.0010
Y-3	-6.378	53.3628	-0.273	0.1097*	-0.246	0.1199*	-0.316	0.4141
M-3	-47.05	53.1165	-0.036	0.1092	0.009	0.1194	-1.445	0.4122***
EX-3	-2.165	15.0388	-0.047	0.0309	0.003	0.0338	0.275	0.1167*
O-4	-0.225	0.1165.	-0.0002	0.0002	0.0002	0.0003	-0.0002	0.0009
Y-4	53.577	51.4371	0.379	0.1057***	-0.301	0.1156*	0.174	0.3991
M-4	5.876	56.5628	-0.072	0.1163	-0.095	0.1271	1.059	0.4389*
EX-4	8.67	15.0339	0.081	0.0309*	-0.042	0.0338	-0.116	0.1167
O-5	-0.132	0.1185	-0.0002	0.0002	-0.0002	0.0003	0.0002	0.0009
Y-5	44.936	50.4254	0.073	0.1037	-0.11	0.1133	0.029	0.3913
M-5	11.363	47.0144	-0.034	0.0967	-0.086	0.1057	-0.059	0.3648
EX-5	-2.145	15.7199	0.013	0.0323	-0.008	0.0353	-0.03	0.1220

Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table A.7 Parameter estimates of Reduced Form VEC Model for New Zealand

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.076	0.0448.	-0.0004	8.1e-05***	-7e-05	0.0001	-0.0002	0.0003
Intercept	8.451	4.3663.	0.034	0.0079**	0.004	0.0100	0.018	0.0246
Oi-1	0.259	0.1150*	0.001	0.0002**	-0.0003	0.0003	0.0001	0.0006
Y -1	41.182	50.4768	-0.123	0.0913	-0.106	0.1155	-0.279	0.2843
M -1	22.906	43.7837	0.045	0.0792	0.202	0.1002*	-0.492	0.2466*
EX -1	15.463	19.2881	-0.133	0.0349***	-0.019	0.0441	0.36	0.1087**
O -2	-0.434	0.1097***	0.001	0.0002**	0.0003	0.0003	-0.002	0.0006***
Y -2	-3.639	43.8793	-0.327	0.0794***	0.077	0.1004	-0.303	0.2472
M -2	4.587	45.0609	0.106	0.0815	0.156	0.1031	0.166	0.2538
EX -2	37.396	19.9434.	-0.054	0.0361	-0.017	0.0456	-0.0003	0.1123
O -3	0.112	0.1241	0.0003	0.0002	0.0001	0.0003	-0.0003	0.0007
Y -3	-27.795	44.5021	-0.034	0.0805	-0.033	0.1018	-0.201	0.2507
M -3	51.678	43.0596	-0.021	0.0779	0.131	0.0985	-0.061	0.2426
EX -3	-27.262	19.2131	-0.049	0.0348	-0.008	0.0440	0.01	0.1082

Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table A.8 Parameter estimates of Reduced Form VEC Model for Norway

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.095	0.0449*	0.001	0.0001***	-0.0001	8e-05	-0.001	0.0003.
Intercept	16.004	7.2225*	-0.095	0.0235***	0.014	0.0129	0.082	0.0426.
O-1	0.188	0.1174	-1.4e-06	0.0004	-2.0e-05	0.0002	0.0005	0.0007
Y-1	-34.531	32.9880	-0.479	0.1072***	0.027	0.0590	-0.139	0.1943
M-1	-65.402	59.5532	-0.013	0.1935	0.53	0.1066***	-0.327	0.3509
EX-1	18.305	19.9651	0.067	0.0649	-0.005	0.0357	0.102	0.1176
O-2	-0.474	0.1161***	-0.0004	0.0004	0.0002	0.0002	-0.003	0.0007***
Y-2	12.209	33.7851	-0.309	0.1098**	0.038	0.0605	-0.042	0.1990
M-2	26.192	65.6788	-0.003	0.2134	-0.023	0.1175	-0.074	0.3869
EX-2	0.499	19.0611	-0.07	0.0619	-0.023	0.0341	-0.0003	0.1123
O-3	-0.031	0.1286	-0.0002	0.0004	0.0002	0.0002	-0.0003	0.0008
Y-3	16.656	34.1128	-0.259	0.1109*	0.05	0.0611	-0.01	0.2010
M-3	-93.154	65.2892	-0.08	0.2122	0.054	0.1168	-0.556	0.3847
EX-3	9.788	18.9821	0.039	0.0617	-0.003	0.0340	0.154	0.1118
O-4	-0.237	0.1230.	-0.0002	0.0004	-0.0002	0.0002	-0.001	0.0007
Y-4	66.569	32.7579*	0.439	0.1065***	0.081	0.0586	-0.054	0.1930
M-4	89.967	66.1513	-0.025	0.2150	-0.133	0.1184	0.637	0.3897
EX-4	2.222	18.7858	-0.014	0.0611	-0.009	0.0336	-0.073	0.1107
O-5	-0.219	0.1278.	-0.0002	0.0004	0.0002	0.0002	0.001	0.0008
Y-5	41.934	29.3775	0.325	0.0955**	0.003	0.0526	-0.037	0.1731
M-5	-14.256	60.0952	-0.198	0.1953	0.152	0.1076	0.395	0.3541
EX-5	27.209	18.9059	-0.002	0.0614	-0.004	0.0338	-0.083	0.1114

Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table A.9 Parameter estimates of Reduced Form VEC Model for South Africa

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.394	0.1309**	0.001	0.0005*	-0.0003	0.0003	-0.004	0.0010***
Intercept	67.511	22.1822**	-0.161	0.0779	0.061	0.0530	0.665	0.1743***
oil -1	33.98	10.5443**	-0.071	0.0370.	0.027	0.0252	0.306	0.0829***
Y-1	0.549	0.1451***	-8.8e-05	0.0005	1.5e-05	0.0003	0.003	0.0011**
M-1	-61.035	33.2829.	-0.451	0.1169***	-0.097	0.0795	-0.429	0.2616
E-1	-23.02	45.7396	0.256	0.1607	0.271	0.1092*	-0.142	0.3595
Oil-2	-30.054	13.5100*	0.002	0.0475	0.029	0.0323	0.114	0.1062
Y-2	-0.272	0.1467.	-0.001	0.0005*	0.0004	0.0004	-0.001	0.0012
M-2	-19.391	32.4663	-0.204	0.1140.	-0.161	0.0775*	-0.065	0.2552
E-2	8.298	47.3068	-0.391	0.1662*	-0.002	0.1130	0.367	0.3718
Oil-3	24.058	13.8116.	0.049	0.0485	-0.028	0.0330	-0.029	0.1086
Y-3	0.038	0.1477	-0.0003	0.0005	0.0002	0.0004	0.002	0.0012.
M-3	-8.643	31.1768	-0.146	0.1095	-0.182	0.0745	0.059	0.2450
E-3	-47.077	48.0392	0.126	0.1687	0.14	0.1147	-0.358	0.3776
Oil-4	1.438	13.7635	-0.043	0.0483	-0.015	0.0329	0.12	0.1082
Y-4	-0.078	0.1315	-0.0002	0.0005	0.0002	0.0003	-0.001	0.0010
M-4	35.661	29.9677	0.602	0.1053***	-0.16	0.0716*	0.127	0.2355
E-4	-18.069	48.5200	-0.176	0.1704	0.135	0.1159	0.286	0.3813
Oil-5	5.39	13.5952	0.043	0.0478	-0.034	0.0325	0.045	0.1069
Y-5	-0.082	0.1318	-0.001	0.0005	0.0001	0.0003	0.002	0.0010*
M-5	20.099	29.2843	0.321	0.1029**	-0.082	0.0699	0.09	0.2302
E-5	72.544	44.4751	0.148	0.1562	0.025	0.1062	-0.072	0.3495

Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table A.10 Parameter estimates of Reduced Form VEC Model for South Korea

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.041	0.0729	-0.001	0.0002***	0.0002	9.7e-05*	0.0002	0.0005
Intercept	-11.578	25.2991	-0.277	0.0662***	0.046	0.0338	-0.04	0.1805
oil -1	38.674	60.9197	0.029	0.1594	-0.39	0.0814***	-1.156	0.4345**
Y-1	0.228	0.1319.	0.001	0.0003***	-0.0001	0.0002	-0.001	0.0009
M-1	12.12	38.2196	-0.181	0.1000.	-0.082	0.0511	0.371	0.2726
E-1	68.709	71.6483	0.401	0.1874*	0.152	0.0958	-0.798	0.5111
Oil-2	-5.664	16.1464	-0.188	0.0422***	0.002	0.0216	0.512	0.1152***
Y-2	-0.547	0.1334***	0.001	0.0003.	0.0001	0.0002	-0.002	0.0010*
M-2	40.029	31.2578	-0.071	0.0818	0.03	0.0418	0.345	0.2230
E-2	6.484	72.9561	-0.147	0.1909	0.041	0.0975	0.056	0.5204
Oil-3	33.295	17.4510.	-0.041	0.0457	0.035	0.0233	-0.09	0.1245
Y-3	-0.087	0.1396	0.001	0.0004*	0.0002	0.0002	-0.001	0.0010
M-3	12.176	29.2810	-0.166	0.0766*	0.03	0.0391	0.228	0.2089
E-3	-27.207	72.6055	0.264	0.1900	0.043	0.0971	-0.645	0.5179
Oil-4	-0.283	17.9181	-0.148	0.0469**	0.021	0.0240	0.381	0.1278**
Y-4	-0.231	0.1242.	0.0003	0.0003	-1.6e-05	0.0002	-0.002	0.0009*
M-4	26.165	27.9488	0.711	0.0731***	0.013	0.0374	0.197	0.1994
E-4	115.384	71.3410	0.048	0.1866	-0.112	0.0954	-0.023	0.5089
Oil-5	20.573	18.0828	0.031	0.0473	0.027	0.0242	-0.038	0.1290
Y-5	-0.258	0.1259*	-6.4e-05	0.0003	0.0002	0.0002	-0.001	0.0009
M-5	36.547	38.8811	0.137	0.1017	0.075	0.0520	0.007	0.2773
E-5	-61.075	69.8915	-0.092	0.1828	0.035	0.0934	-0.559	0.4985

Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table A.11 Parameter estimates of Reduced Form VEC Model for Switzerland

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT1	-0.338***	0.0892	-0.0002*	8.0e-05	0.0003**	0.0001	0	0.0006
ECT2	-0.975	11.1073	-0.003	0.0100	0.057***	0.0128	-0.015	0.0715
ECT3	36.347**	12.8853	0.007	0.0116	-0.066***	0.0149	0.088	0.0830
Intercept	29.182***	7.7185	0.016*	0.0069	-0.029**	0.0089	-0.005	0.0497
O-1	0.43***	0.1041	-4.6e-05	9.3e-05	-8.9e-05	0.0001	0.0004	0.0007
Y-1	-245.271*	111.0186	0.149	0.0995	0.006	0.1281	-0.109	0.7151
M-1	62.145	80.7312	-0.009	0.0724	0.317***	0.0932	-0.865.	0.5200
EX-1	-0.943	16.2443	-0.012	0.0146	0.031.	0.0187	0.187.	0.1046
O-2	-0.246*	0.1074	8.5e-05	9.6e-05	3.6e-05	0.0001	-0.001	0.0007
Y-2	-24.328	114.4287	0.093	0.1026	-0.454***	0.1320	-0.058	0.7371
M-2	-39.725	79.3829	0.032	0.0712	0.112	0.0916	0.269	0.5113
EX-2	-6.183	16.0033	-0.0005	0.0143	-0.002	0.0185	-0.095	0.1031

*, (**), and *** denote 1%, 5%, and 10% significance levels respectively.

Table A.12 Parameter estimates of Reduced Form VEC Model for Sweden

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.016	0.0087.	1.7e-05	1.8e-05	7.6e-05	2.2e-05***	2.4e-06	5.6e-05
Intercept	25.357	13.1119.	-0.024	0.0273	-0.115	0.0333***	0.005	0.0844
oil -1	0.169	0.1165	-0.0004	0.0002	-0.0002	0.0003	-0.001	0.0007
Y-1	-73.164	56.7509	-0.358	0.1184**	0.217	0.1443	-0.44	0.3651
M-1	-3.345	40.6808	-0.114	0.0848	0.284	0.1034**	-0.147	0.2617
E-1	0.119	19.2607	0.033	0.0402	0.122	0.0490*	0.193	0.1239
Oil-2	-0.509	0.1134***	-0.0001	0.0002	0.001	0.0003.	-0.002	0.0007
Y-2	-157.12	55.6863**	-0.087	0.1161	0.295	0.1416*	-1.004	0.3583**
M-2	-63.111	42.8475	0.149	0.0894.	0.093	0.1089	-0.007	0.2757
E-2	-20.597	19.1992	0.103	0.0400*	0.006	0.0488	-0.146	0.1235
Oil-3	-0.229	0.1270.	-0.0001	0.0003	0.0003	0.0003	-0.002	0.0008**
Y-3	-132.437	51.6391*	-0.125	0.1077	0.243	0.1313.	-1.025	0.3322**
M-3	-110.342	42.9772*	0.034	0.0896	0.216	0.1093.	-0.655	0.2765*
E-3	0.705	18.0579	0.03	0.0377	-0.017	0.0459	0.165	0.1162
Oil-4	-0.249	0.1246*	0.0002	0.0003	9.9e-05	0.0003	-0.002	0.0008.
Y-4	-113.838	48.8826*	0.827	0.1020***	0.208	0.1243.	-1.033	0.3145**
M-4	107.075	43.9645*	-0.047	0.0917	-0.088	0.1118	0.014	0.2828
E-4	19.828	17.7388	-0.034	0.0370	0.032	0.0451	0.03	0.1141
Oil-5	-0.349	0.1284**	0.0003	0.0003	0.001	0.0003*	-0.0004	0.0008
Y-5	-88.8	52.0816.	0.264	0.1086*	0.142	0.1324	-0.522	0.3351
M-5	-42.013	43.0078	-0.05	0.0897	0.231	0.1093*	0.466	0.2767.
E-5	7.602	17.1471	0.073	0.0358*	-0.032	0.0436	-0.06	0.1103

Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table A.13 Parameter estimates of Reduced Form VEC Model for the UK

	O Equation		Y Equation		M Equation		EX Equation	
	Estimates	St.d	Estimates	St.d	Estimates	St.d	Estimates	St.d
ECT	-0.013	0.0195	-0.002	0.0008**	0.004	0.0020*	0.01	0.0055.
Intercept	0.03	0.0247	0.004	0.0010***	-0.005	0.0026*	-0.008	0.0070
Oil -1	0.258	0.1113*	-0.007	0.0044	-0.007	0.0116	0.023	0.0314
Y -1	-3.777	2.5732	-0.004	0.1012	-0.366	0.2672	-0.963	0.7273
M -1	-1.214	1.0153	0.039	0.0399	0.36	0.1054***	-0.324	0.2870
E -1	0.356	0.3853	-0.008	0.0152	0.01	0.0400	0.307	0.1089**
Oil -2	-0.377	0.1111**	0.003	0.0044	-0.014	0.0115	-0.103	0.0314**
Y -2	0.033	2.3975	0.245	0.0943*	0.081	0.2490	0.448	0.6777
M -2	1.084	1.0797	-0.016	0.0425	0.18	0.1121	0.09	0.3052
E -2	-0.12	0.3833	-0.01	0.0151	-0.019	0.0398	-0.114	0.1084
Oil -3	0.161	0.1168	0.003	0.0046	-0.005	0.0121	-0.022	0.0330
Y -3	2.372	2.4979	-0.128	0.0983	0.384	0.2594	-0.572	0.7060
M -3	0.607	0.9252	0.082	0.0364*	-0.033	0.0961	-0.272	0.2615
E -3	-0.061	0.3629	-0.016	0.0143	0.015	0.0377	0.073	0.1026

Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

The following tables are the OLS parameter estimates for the following models, presented in chapter 1.

Model I: $e_t = (m_t - m_t^*) - \beta(y_t - y_t^*)$

Model I: $e_t = (m_t - m_t^*) - \beta(y_t - y_t^*) - \delta Oil$

Table A.14 OLS Estimates of the Monetary Models

	Model I			Model II			
	α	β output	γ money	α	βoutput	γmoney	δ oil
Australia	-0.11**	-3.02**	0.24**	-0.80	-2.10**	0.37**	0.15**
	(-5.04)	(-7.04)	(3.13)	(-4.61)	(-4.52)	(4.64)	(4.00)
Canada	-0.05**	-4.17**	-1.11	-0.25**	-2.53**	-0.42**	0.002**
	(-3.99)	(-12.14)	(-13.62)	(-6.88)	(-6.06)	(-3.02)	(5.71)
Chile	-6.22**	-1.15**	0.61**	6.12**	-1.27**	0.62**	-0.02
	(340.17)	(-7.23)	(15.31)	(-48.79)	(-5.81)	(13.97)	(-0.80)
Denmark	-1.69**	0.60**	-0.47**	-1.90**	-0.09	-0.31**	0.002**
	(-75.57)	(5.29)	(-4.57)	(-40.65)	(-0.54)	(-3.23)	(5.07)
Japan	-4.59**	0.40	0.22	-4.90**	0.52**	-0.24	0.004**
	(-206.41)	(1.79)	(2.05)	(-55.73)	(2.41)	(-1.43)	(3.58)
Mexico	-2.53**	-2.45**	0.60**	-2.62**	-2.15**	0.63**	0.001**
	(-153.81)	(-7.57)	(65.42)	(-70.13)	(-6.46)	(50.29)	(2.70)
New Zealand	-0.30**	-3.29**	-0.11**	-0.50**	-2.21**	0.07	0.002**
	(-16.60)	(-10.15)	(-2.11)	(11.05)	(-5.93)	(1.11)	(4.763)
Norway	-1.84**	0.77**	-0.29**	-2.12**	0.05	0.29**	0.003**
	(-104.123)	(2.86)	(-4.34)	(-57.49)	(0.24)	(3.31)	(8.29)
South Africa	-2.12**	1.14**	0.69**	-2.40**	0.64**	0.81**	0.003**
	(-70.63)	(6.21)	(27.47)	(-17.48)	(2.10)	(12.28)	(2.05)
South Korea	-6.98**	-0.31	0.32**	-6.96**	-0.37	0.33**	-0.0002
	(-299.28)	(-1.87)	(5.25)	(-100.84)	(-1.46)	(4.45)	(-0.28)
Sweden	-1.96**	-0.87**	-0.11	-2.02**	-0.92**	-0.01	0.001
	(-117.77)	(-4.75)	(-0.73)	(-82.44)	(-5.25)	(-0.11)	(3.42)
Switzerland	-0.63**	0.14	-0.45**	-0.63**	0.14	-0.45**	0.006**
	(-13.28)	(1.06)	(-3.20)	(-13.28)	(1.06)	(-3.20)	(11.74)
UK	0.54**	-1.81**	-0.23**	0.28**	-1.58**	-0.08	0.05**
	(32.76)	(-4.82)	(-4.10)	(3.63)	(-4.35)	(-1.25)	(3.40)

** indicates 5% significance level.

The following tables and figures are for chapter 2.

The following tables present the reduced form VAR parameter estimates for G7 countries discussed in chapter 2. It is also important to note that $\Delta\, Prod_t$, $\Delta\, GIP_t$, $\Delta\, Oil_t$, and $\Delta\, REER_t$ denote the percent change in global oil production, the percent change in global industrial production, the percent change in oil price, and the percent change in real exchange rate respectively.

Table A.15 Parameter estimates of Reduced Form VAR Model for Canada

	Dependent variable			
	Oil Production	GIP	Oil Price	REER
	(1)	(2)	(3)	(4)
$\Delta\, Prod_{t-1}$	-0.004	-0.322	-0.276	-0.008
	(0.049)	(1.440)	(0.209)	(0.046)
$\Delta\, GIP_{t-1}$	-0.0003	0.166***	0.004	0.002
	0.002)	(0.049)	(0.007)	(0.002)
$\Delta\, Oil_{t-1}$	0.013	1.074***	0.486***	0.001
	(0.012)	(0.345)	(0.050)	(0.011)
$\Delta\, REER_{t-1}$	0.015	3.099**	0.310	0.207***
	(0.053)	(1.548)	(0.225)	(0.050)
$\Delta\, Prod_{t-2}$	-0.043	-0.266	0.197	-0.021
	(0.049)	(1.438)	(0.209)	(0.046)
$\Delta\, GIP_{t-2}$	0.001	0.213***	0.002	0.002
	(0.002)	(0.048)	(0.007)	(0.002)
$\Delta\, Oil_{t-2}$	-0.005	0.049	-0.114**	0.00003
	(0.013)	(0.380)	(0.055)	(0.012)
$\Delta\, REER_{t-2}$	0.023	3.398**	0.401*	-0.013
	(0.055)	(1.588)	(0.231)	(0.051)
$\Delta\, Prod_{t-3}$	-0.117**	-1.480	-0.453**	0.013
	(0.049)	(1.438)	(0.209)	(0.046)
$\Delta\, GIP_{t-3}$	0.003*	0.193***	0.007	-0.004**
	(0.002)	(0.048)	(0.007)	(0.002)
$\Delta\, Oil_{t-3}$	-0.001	0.066	-0.081	0.020*
	(0.012)	(0.348)	(0.051)	(0.011)
$\Delta\, REER_{t-3}$	-0.094*	2.797*	-0.262	0.035
	(0.054)	(1.576)	(0.229)	(0.051)
Constant	0.001	0.051**	0.001	-0.00000
	(0.001)	(0.023)	(0.003)	(0.001)
Observations	411	411	411	411
R^2	0.034	0.322	0.244	0.074
F(12; 398)	1.180	15.768***	10.682***	2.633***

Note: numbers in parentheses are p-values; *p<0.1; **p<0.05; ***p<0.01

Table A.16 Parameter estimates of Reduced Form VAR Model for France

	Dependent variable			
	Oil Production	GIP	Oil Price	REER
	(1)	(2)	(3)	(4)
$\Delta\ Prod_{t-1}$	-0.013	-0.125	-0.297	-0.009
	(0.050)	(1.471)	(0.225)	(0.025)
$\Delta\ GIP_{t-1}$	-0.001	0.189***	0.007	-0.001
	(0.002)	(0.050)	(0.008)	(0.001)
$\Delta\ Oil_{t-1}$	0.011	1.194***	0.464***	0.003
	(0.011)	(0.339)	(0.052)	(0.006)
$\Delta\ REER_{t-1}$	-0.119	3.877	0.789*	0.244***
	(0.101)	(2.970)	(0.455)	(0.051)
$\Delta\ Prod_{t-2}$	-0.047	-0.014	0.068	0.001
	(0.050)	(1.469)	(0.225)	(0.025)
$\Delta\ GIP_{t-2}$	0.001	0.224***	0.002	0.0004
	(0.002)	(0.049)	(0.008)	(0.001)
$\Delta\ Oil_{t-2}$	-0.004	0.073	-0.088	0.008
	(0.013)	(0.372)	(0.057)	(0.006)
$\Delta\ REER_{t-2}$	-0.040	0.134	-0.640	-0.078
	(0.104)	(3.065)	(0.470)	(0.053)
$\Delta\ Prod_{t-3}$	-0.118**	-1.213	-0.538**	0.053**
	(0.050)	(1.465)	(0.224)	(0.025)
$\Delta\ GIP_{t-3}$	0.003*	0.200***	0.005	-0.0005
	(0.002)	(0.049)	(0.008)	(0.001)
$\Delta\ Oil_{t-3}$	-0.004	0.132	-0.078	-0.002
	(0.012)	(0.343)	(0.053)	(0.006)
$\Delta\ REER_{t-3}$	0.012	3.403	-0.452	0.102**
	(0.101)	(2.974)	(0.456)	(0.051)
Constant	0.001	0.047**	0.001	-0.0003
	(0.001)	(0.023)	(0.004)	(0.0004)
Observations	411	411	411	411
R^2	0.033	0.301	0.214	0.081
F(12; 398)	1.140	14.300***	9.017***	2.931***

Note: numbers in parentheses are p-values; *p<0.1; **p<0.05; ***p<0.01

Table A.17 Parameter estimates of Reduced Form VAR Model for Germany

	Dependent variable			
	Oil Production	GIP	Oil Price	REER
	(1)	(2)	(3)	(4)
$\Delta\, Prod_{t-1}$	-0.006	-0.277	-0.313	0.017
	(0.050)	(1.462)	(0.225)	(0.028)
$\Delta\, GIP_{t-1}$	-0.001	0.193***	0.009	-0.0003
	(0.002)	(0.050)	(0.008)	(0.001)
$\Delta\, Oil_{t-1}$	0.013	1.213***	0.470***	-0.003
	(0.011)	(0.338)	(0.052)	(0.007)
$\Delta\, REER_{t-1}$	-0.030	4.050	0.839**	0.268***
	(0.092)	(2.698)	(0.416)	(0.052)
$\Delta\, Prod_{t-2}$	-0.040	-0.175	0.049	0.046
	(0.050)	(1.459)	(0.225)	(0.028)
$\Delta\, GIP_{t-2}$	0.001	0.221***	-0.0002	0.0003
	(0.002)	(0.050)	(0.008)	(0.001)
$\Delta\, Oil_{t-2}$	-0.004	0.073	-0.086	0.004
	(0.013)	(0.369)	(0.057)	(0.007)
$\Delta\, REER_{t-2}$	0.039	-0.145	-0.739*	-0.061
	(0.095)	(2.804)	(0.432)	(0.054)
$\Delta\, Prod_{t-3}$	-0.116**	-1.472	-0.509**	0.007
	(0.050)	(1.463)	(0.225)	(0.028)
$\Delta\, GIP_{t-3}$	0.003*	0.207***	0.005	-0.001
	(0.002)	(0.049)	(0.008)	(0.001)
$\Delta\, Oil_{t-3}$	-0.004	0.174	-0.077	-0.004
	(0.012)	(0.340)	(0.052)	(0.007)
$\Delta\, REER_{t-3}$	0.029	3.901	-0.251	0.025
	(0.092)	(2.710)	(0.417)	(0.052)
Constant	0.001	0.047**	0.001	-0.0003
	(0.001)	(0.023)	(0.004)	(0.0004)
Observations	411	411	411	411
R^2	0.030	0.304	0.216	0.083
F(12; 398)	1.016	14.458***	9.149***	2.988***

Note: numbers in parentheses are p-values; *p<0.1; **p<0.05; ***p<0.01

Table A.18 Parameter estimates of Reduced Form VAR Model for Italy

	Dependent variable			
	Oil Production	GIP	Oil Price	REER
	(1)	(2)	(3)	(4)
$\Delta\ Prod_{t-1}$	-0.007	-0.376	-0.308	0.003
	(0.050)	(1.466)	(0.226)	(0.034)
$\Delta\ GIP_{t-1}$	-0.001	0.183***	0.005	0.0004
	(0.002)	(0.050)	(0.008)	(0.001)
$\Delta\ Oil_{t-1}$	0.012	1.122***	0.468***	-0.002
	(0.011)	(0.337)	(0.052)	(0.008)
$\Delta\ REER_{t-1}$	-0.036	0.435	0.092	0.358***
	(0.073)	(2.162)	(0.334)	(0.050)
$\Delta\ Prod_{t-2}$	-0.040	-0.048	0.092	0.029
	(0.050)	(1.463)	(0.226)	(0.034)
$\Delta\ GIP_{t-2}$	0.001	0.226***	0.0002	0.002
	(0.002)	(0.049)	(0.008)	(0.001)
$\Delta\ Oil_{t-2}$	-0.003	0.162	-0.072	-0.009
	(0.013)	(0.369)	(0.057)	(0.009)
$\Delta\ REER_{t-2}$	0.053	2.178	0.098	-0.211***
	(0.076)	(2.239)	(0.346)	(0.052)
$\Delta\ Prod_{t-3}$	-0.116**	-1.154	-0.508**	0.037
	(0.050)	(1.463)	(0.226)	(0.034)
$\Delta\ GIP_{t-3}$	0.003*	0.204***	0.009	-0.003***
	(0.002)	(0.049)	(0.008)	(0.001)
$\Delta\ Oil_{t-3}$	-0.006	0.153	-0.082	0.013
	(0.012)	(0.340)	(0.053)	(0.008)
$\Delta\ REER_{t-3}$	-0.022	2.949	-0.028	0.193***
	(0.073)	(2.152)	(0.332)	(0.050)
Constant	0.001	0.044*	0.001	0.0002
	(0.001)	(0.023)	(0.004)	(0.001)
Observations	411	411	411	411
R^2	0.030	0.304	0.217	0.157
F(12; 398)	1.020	14.474***	9.202***	6.195***

Note: numbers in parentheses are p-values; *p<0.1; **p<0.05; ***p<0.01

Table A.19 Parameter estimates of Reduced Form VAR Model for Japan

	Dependent variable			
	Oil Production	GIP	Oil Price	REER
	(1)	(2)	(3)	(4)
$\Delta\, Prod_{t-1}$	-0.008	-0.117	-0.294	0.021
	(0.050)	(1.450)	(0.236)	(0.078)
$\Delta\, GIP_{t-1}$	-0.0003	0.179***	0.010	-0.003
	(0.002)	(0.050)	(0.008)	(0.003)
$\Delta\, Oil_{t-1}$	0.013	1.057***	0.453***	-0.003
	(0.012)	(0.340)	(0.055)	(0.018)
$\Delta\, REER_{t-1}$	0.029	-0.682	-0.161	0.284***
	(0.035)	(1.021)	(0.166)	(0.055)
$\Delta\, Prod_{t-2}$	-0.045	-0.148	0.152	0.012
	(0.050)	(1.446)	(0.235)	(0.078)
$\Delta\, GIP_{t-2}$	0.001	0.220***	0.001	0.001
	(0.002)	(0.049)	(0.008)	(0.003)
$\Delta\, Oil_{t-2}$	-0.003	0.082	-0.059	-0.013
	(0.013)	(0.371)	(0.060)	(0.020)
$\Delta\, REER_{t-2}$	0.021	-1.570	-0.047	-0.061
	(0.036)	(1.054)	(0.171)	(0.057)
$\Delta\, Prod_{t-3}$	-0.119**	-1.370	-0.403*	-0.033
	(0.049)	(1.445)	(0.235)	(0.078)
$\Delta\, GIP_{t-3}$	0.003*	0.199***	0.003	0.003
	(0.002)	(0.048)	(0.008)	(0.003)
$\Delta\, Oil_{t-3}$	-0.004	0.151	-0.103*	0.016
	(0.012)	(0.342)	(0.056)	(0.018)
$\Delta\, REER_{t-3}$	0.005	0.178	-0.072	0.075
	(0.035)	(1.025)	(0.167)	(0.055)
Constant	0.001	0.048**	0.001	0.0001
	(0.001)	(0.023)	(0.004)	(0.001)
Observations	411	411	411	411
R^2	0.030	0.315	0.233	0.092
F(12; 398)	1.025	15.266***	10.073***	3.342***

Note: numbers in parentheses are p-values; *p<0.1; **p<0.05; ***p<0.01

Table A.20 Parameter estimates of Reduced Form VAR Model for the UK

	Dependent variable			
	Oil Production	GIP	Oil Price	REER
	(1)	(2)	(3)	(4)
$\Delta\, Prod_{t-1}$	-0.005	-0.655	-0.286	-0.022
	(0.050)	(1.454)	(0.223)	(0.053)
$\Delta\, GIP_{t-1}$	-0.001	0.178***	0.001	0.004**
	(0.002)	(0.050)	(0.008)	(0.002)
$\Delta\, Oil_{t-1}$	0.011	1.138***	0.439***	0.015
	(0.011)	(0.334)	(0.051)	(0.012)
$\Delta\, REER_{t-1}$	0.004	5.245***	0.603***	0.304***
	(0.048)	(1.407)	(0.216)	(0.051)
$\Delta\, Prod_{t-2}$	-0.046	-0.208	0.053	0.030
	(0.050)	(1.451)	(0.223)	(0.053)
$\Delta\, GIP_{t-2}$	0.001	0.211***	-0.001	0.001
	(0.002)	(0.049)	(0.008)	(0.002)
$\Delta\, Oil_{t-2}$	-0.004	0.074	-0.066	-0.008
	(0.012)	(0.365)	(0.056)	(0.013)
$\Delta\, REER_{t-2}$	0.030	-0.523	-0.001	-0.092*
	(0.051)	(1.499)	(0.230)	(0.054)
$\Delta\, Prod_{t-3}$	-0.118**	-1.430	-0.412*	-0.043
	(0.050)	(1.449)	(0.223)	(0.053)
$\Delta\, GIP_{t-3}$	0.003*	0.198***	0.006	0.001
	(0.002)	(0.049)	(0.007)	(0.002)
$\Delta\, Oil_{t-3}$	-0.006	0.121	-0.064	-0.009
	(0.012)	(0.337)	(0.052)	(0.012)
$\Delta\, REER_{t-3}$	0.006	-0.469	-0.200	0.053
	(0.049)	(1.430)	(0.220)	(0.052)
Constant	0.001	0.048**	0.002	-0.001
	(0.001)	(0.023)	(0.004)	(0.001)
Observations	411	411	411	411
R^2	0.029	0.315	0.192	0.123
F(12; 398)	1.001	15.271***	7.900***	4.669***

Note: numbers in parentheses are p-values; *p<0.1; **p<0.05; ***p<0.01

Table A.21 Parameter estimates of Reduced Form VAR Model for the US

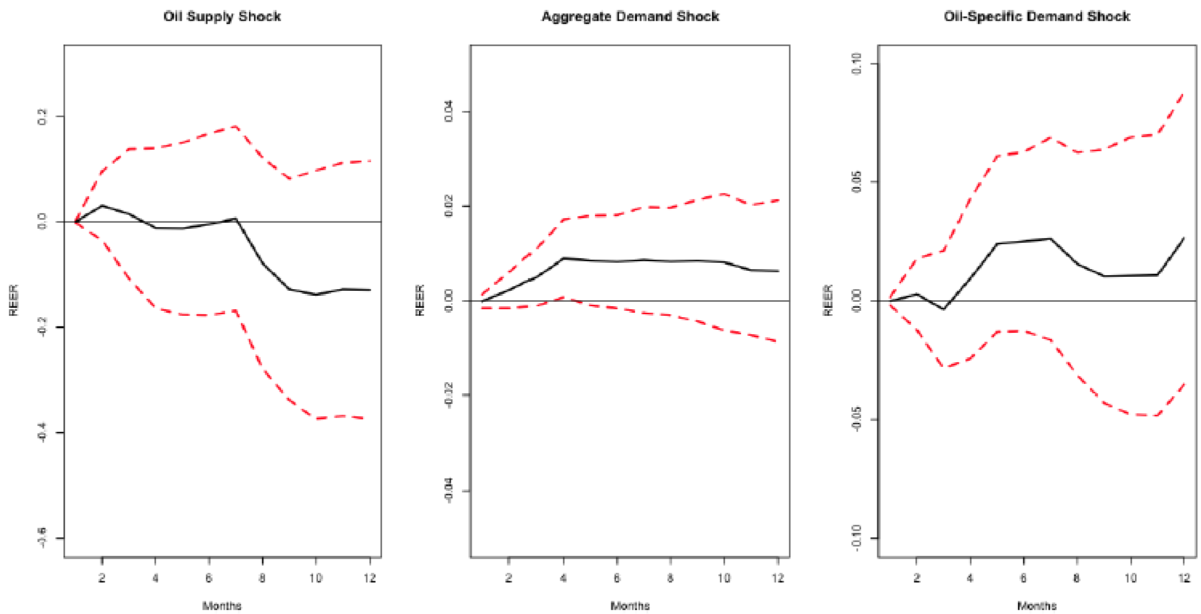
	Dependent variable			
	Oil Production	GIP	Oil Price	REER
	(1)	(2)	(3)	(4)
$\Delta\ Prod_{t-1}$	-0.001	-0.191	-0.236	-0.021
	(0.050)	(1.455)	(0.215)	(0.045)
$\Delta\ GIP_{t-1}$	-0.001	0.178***	0.009	-0.001
	(0.002)	(0.050)	(0.007)	(0.002)
$\Delta\ Oil_{t-1}$	0.011	1.192***	0.483***	-0.001
	(0.012)	(0.343)	(0.051)	(0.011)
$\Delta\ REER_{t-1}$	0.085	-1.610	-0.374	0.368***
	(0.056)	(1.639)	(0.243)	(0.050)
$\Delta\ Prod_{t-2}$	-0.041	-0.095	0.188	-0.062
	(0.049)	(1.449)	(0.214)	(0.045)
$\Delta\ GIP_{t-2}$	0.001	0.216***	0.004	-0.002*
	(0.002)	(0.049)	(0.007)	(0.002)
$\Delta\ Oil_{t-2}$	-0.003	0.088	-0.087	-0.004
	(0.013)	(0.378)	(0.056)	(0.012)
$\Delta\ REER_{t-2}$	-0.100*	-1.589	-0.008	-0.138***
	(0.058)	(1.713)	(0.254)	(0.053)
$\Delta\ Prod_{t-3}$	-0.116**	-1.621	-0.454**	-0.039
	(0.049)	(1.451)	(0.215)	(0.045)
$\Delta\ GIP_{t-3}$	0.003*	0.190***	0.002	0.002
	(0.002)	(0.049)	(0.007)	(0.001)
$\Delta\ Oil_{t-3}$	-0.004	0.134	-0.078	-0.006
	(0.012)	(0.347)	(0.051)	(0.011)
$\Delta\ REER_{t-3}$	0.033	-1.788	0.131	0.046
	(0.056)	(1.630)	(0.241)	(0.050)
Constant	0.001	0.048**	0.0004	0.0002
	(0.001)	(0.023)	(0.003)	(0.001)
Observations	411	411	411	411
R^2	0.036	0.313	0.245	0.146
F(12; 398)	1.237	15.109***	10.777***	5.669***

Note: numbers in parentheses are p-values; *p<0.1; **p<0.05; ***p<0.01

The following results are based on the oil prices measured by the price producer index for petroleum. Figures A.1 – A.4 present the impulse response functions with 95% confidence intervals. It is obvious that these impulses are similar to the ones plotted in Chapter 2.

Figure A.1 The Responses of Canadian and French Real Exchange Rates to Structural Oil Shocks

Canada



France

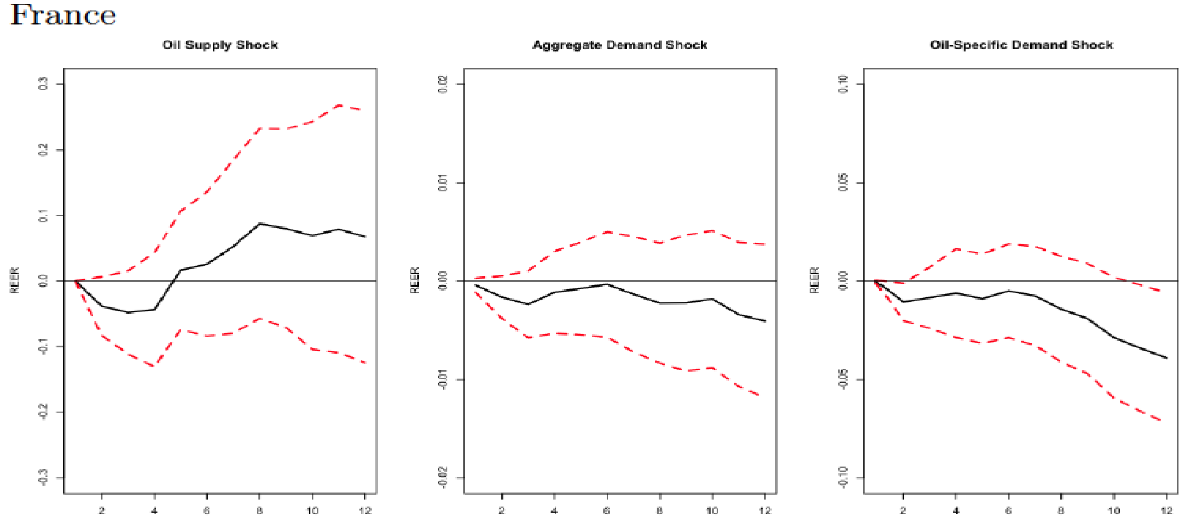
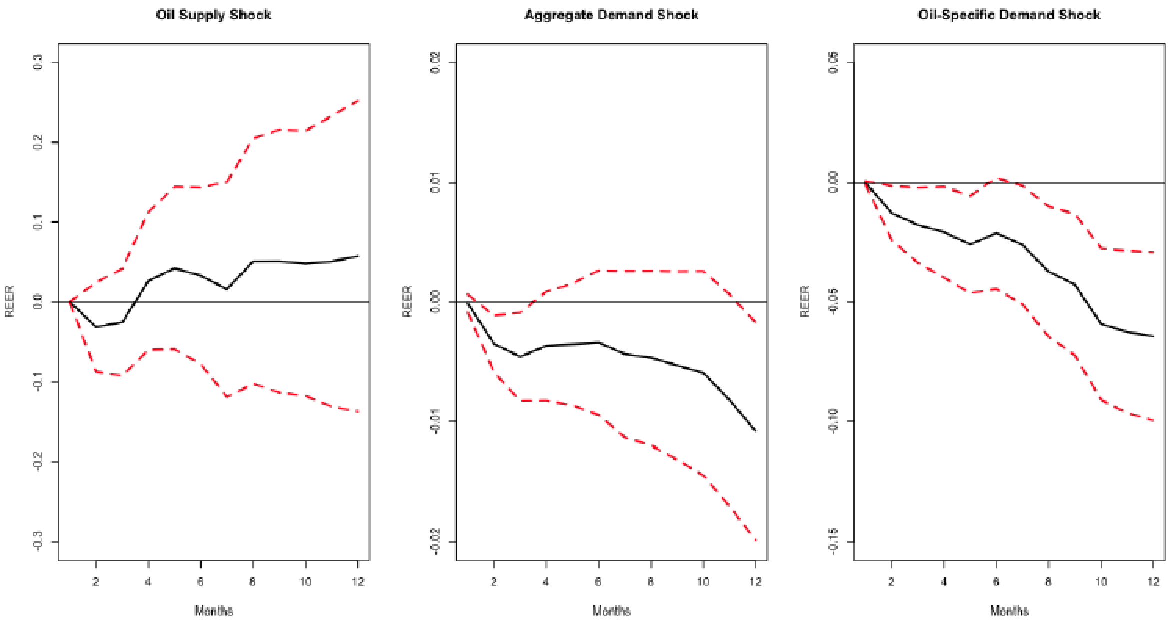


Figure A.2 The Responses of German and Italy Real Exchange Rates to Structural Oil Shocks

Germany



Italy

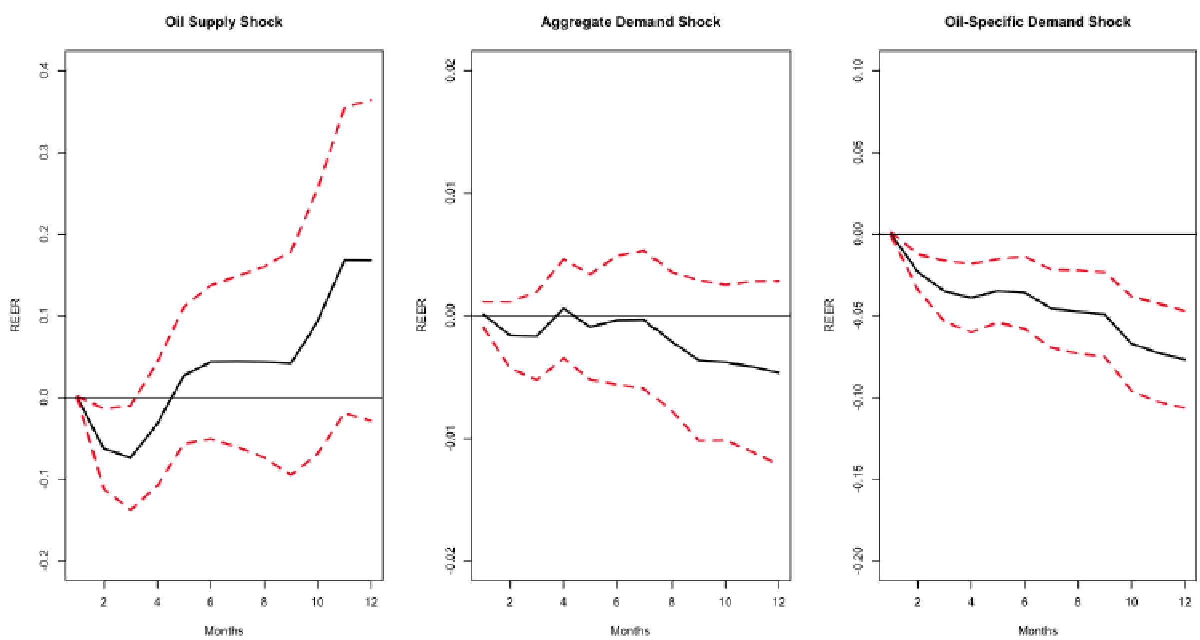
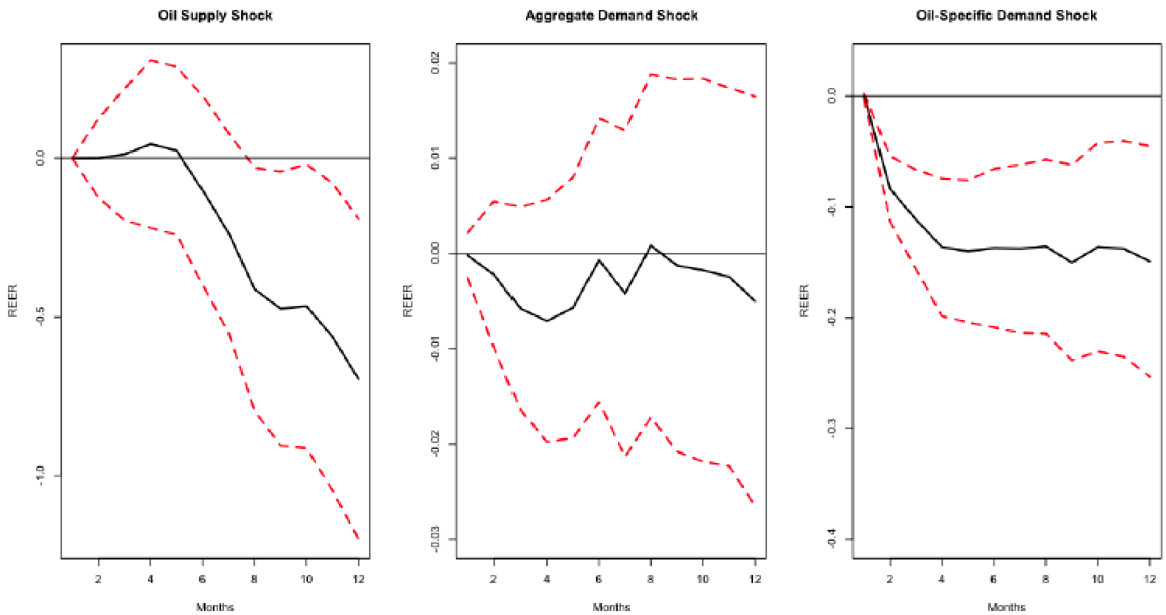


Figure A.3 The Responses of Japanese and British Real Exchange Rates to Structural Oil Shocks

Japan



UK

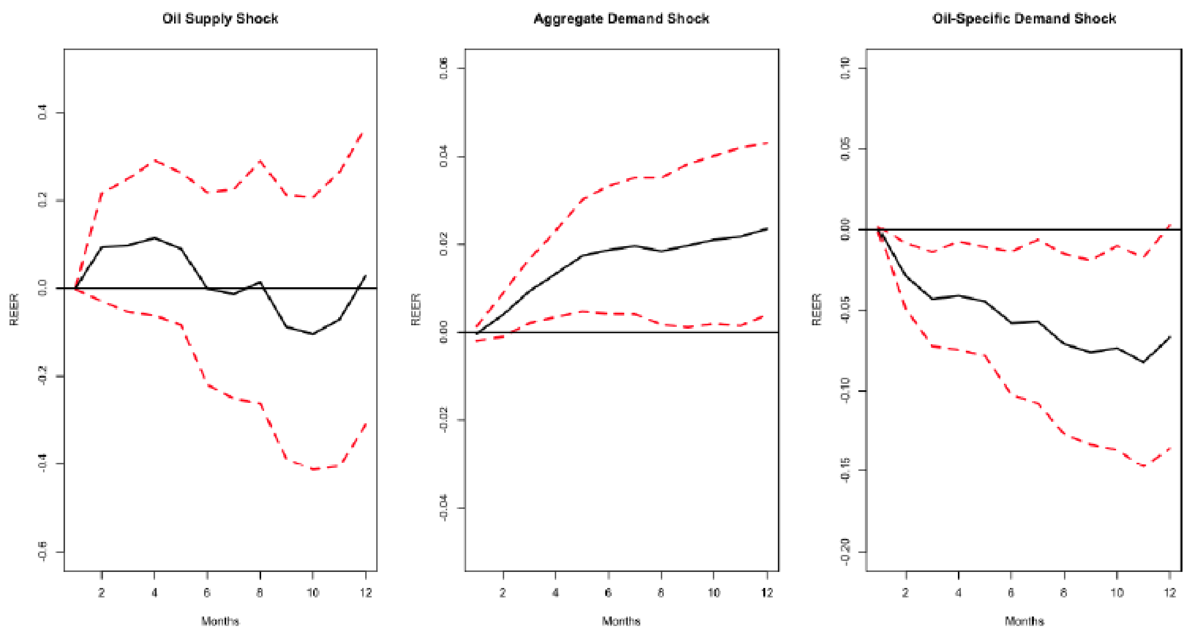


Figure A.4 The Responses of US Real Exchange Rates to Structural Oil Shocks

US

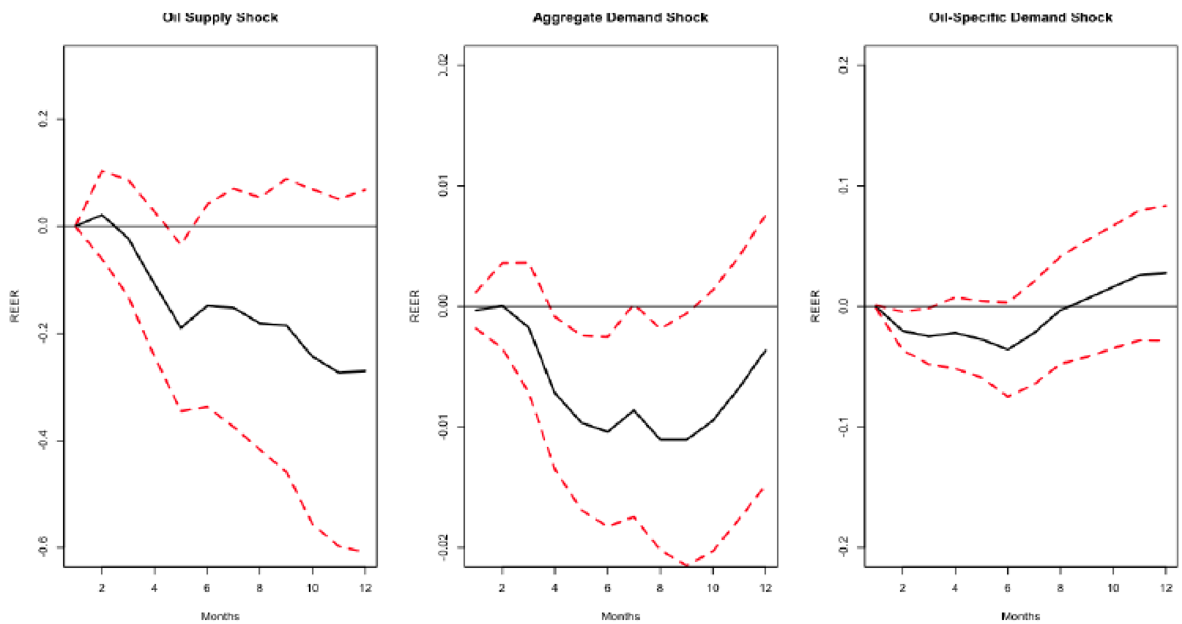


Table A.22 and A.23 summarize the structural break tests of Andrews (1993) and Andrews and Ploberger (1994). Since the structural break tests indicate unstable relationship between structural oil price shocks and British real exchange rate, we computed the impulse responses before and after the estimated break date as shown in Figure A.5. Note that Panel A shows the impulse responses for the pre-break period while Panel B shows the impulses over the post-break period. Clearly, these impulses confirm the same conclusion as the one reached in Chapter 2.

Table A.22 Structural Break Tests

	Break Date	Ave F	Sup F	Exp F
Canada	August 2007	5.24	10.16	3.08
		(0.38)	(0.52)	(0.47)
France	June 1993	5.65	13.51	3.92
		(0.31)	(0.22)	(0.26)
Germany	October 2000	5.76	10.02	3.26
		(0.29)	(0.54)	(0.41)
Italy	August 1992	3.27	10.34	1.95
		(0.79)	(0.50)	(0.82)
Japan	February 1995	3.70	7.59	2.11
		(0.70)	(0.82)	(0.79)
U.K.	September 1992	13.19**	20.69**	7.37**
		(0.003)	(0.02)	(0.02)
U.S.	April 1985	3.14	13.05	2.97
		(0.82)	(0.25)	(0.49)

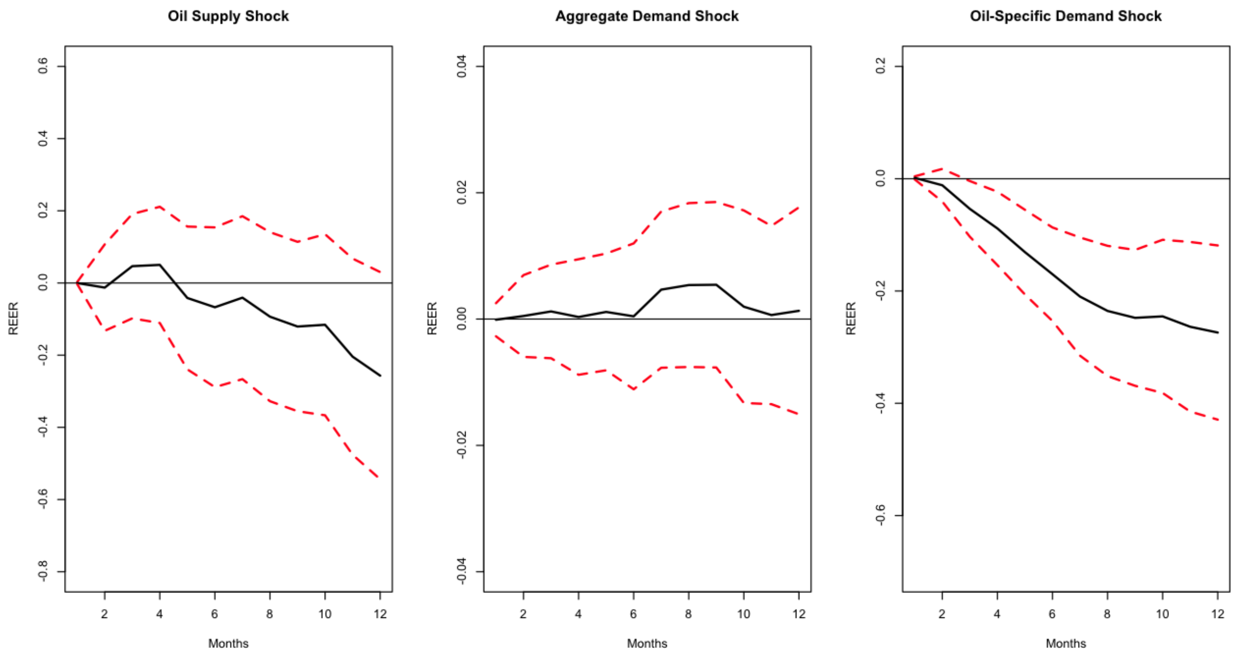
** Indicates the rejection of the null hypothesis at 5%.

Table A.23 Structural Break Tests for the UK

	Date break	Ave F	P-value	Sup F	P-value	Exp F	P-value
Pre-break date	August 1986	3.82	(0.99)	9.41	(0.95)	2.22	(0.98)
Post-break date	February 2009	5.58	(0.83)	17.77	(0.26)	5.74	(0.32)

Figure A.5 The Responses of British Real Exchange Rates to Structural Oil Shocks

Panel A



Panel B

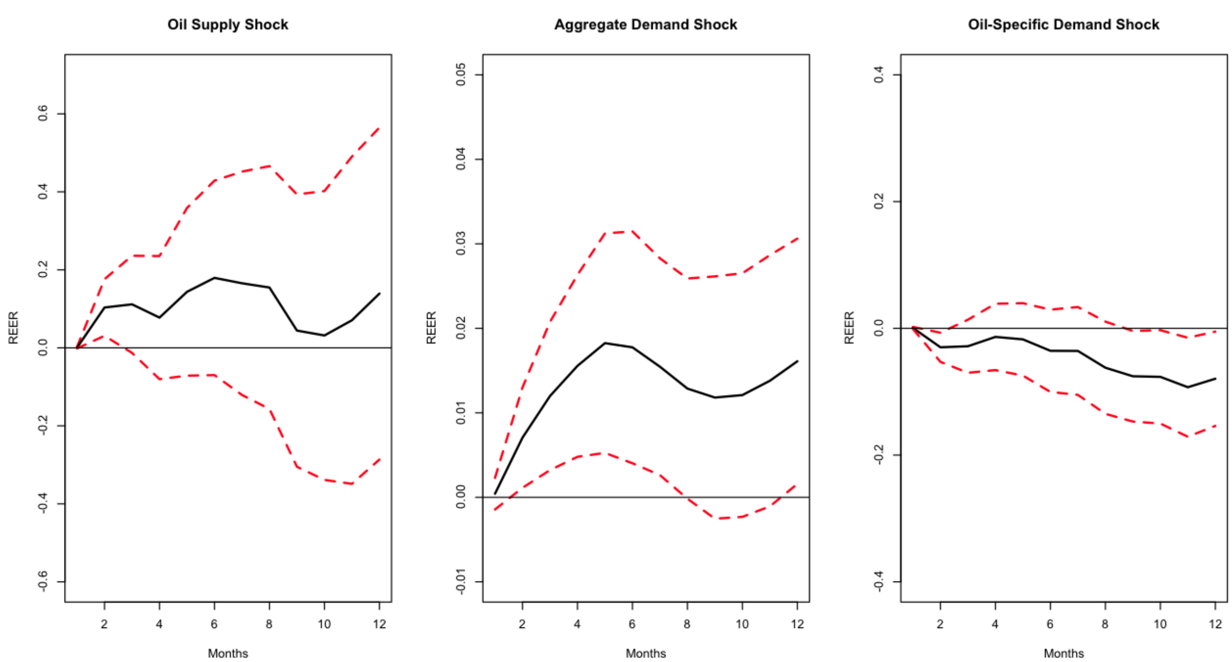


Figure A.6 illustrates how real exchange rate responds to structural oil price shocks as well as the role of energy intensity using PPI oil prices based on equation (21) in chapter 2.

Figure A.6 The Responses of US Real Exchange Rates to Structural Oil Shocks

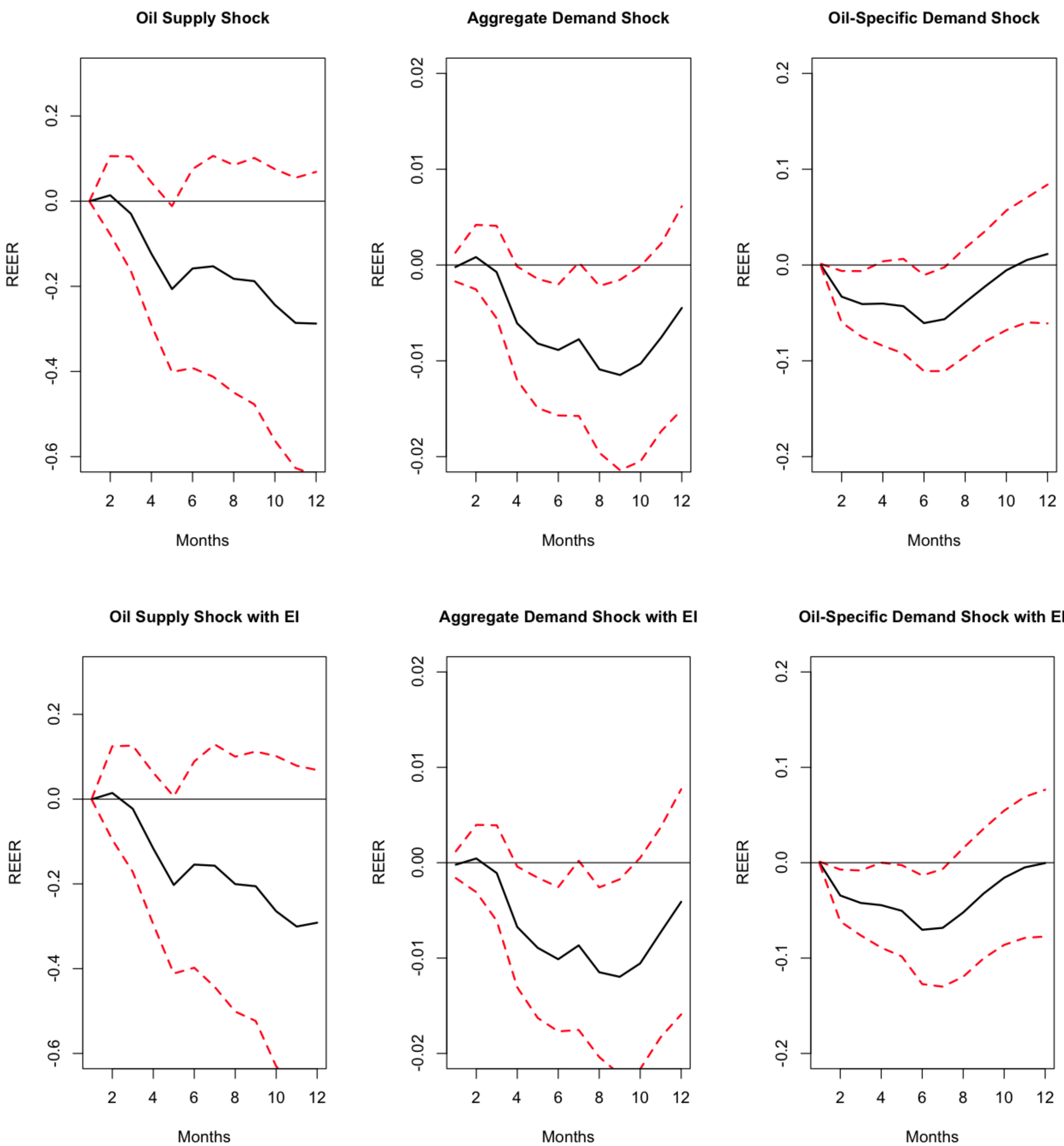


Table A.24 and A.25 present the forecast error variance decomposition for all countries; clearly the results are in line with the results documented in subsection 2.5.6 of Chapter 2.

Table A.24 Forecast Error Variance Decomposition

	Canada				France				Germany			
H	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total
1	0.0014	0.0030	0.0001	0.0010	0.0057	0.0077	0.0439	0.0574	0.0022	0.0297	0.0482	0.080
3	0.0016	0.0185	0.0106	0.0307	0.0065	0.0126	0.0484	0.0676	0.0126	0.0314	0.0498	0.0939
6	0.0016	0.0190	0.0186	0.0393	0.0182	0.0127	0.0476	0.0786	0.0069	0.0335	0.0531	0.0935
12	0.0016	0.0191	0.0190	0.0394	0.0183	0.0128	0.0476	0.0787	0.0137	0.0313	0.0521	0.0972
	Italy				Japan				US			
H	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total
1	0.0052	0.0056	0.0054	0.0626	0.00003	0.0001	0.1773	0.17743	0.000002	0.0012	0.0168	0.0180
3	0.0082	0.0124	0.0541	0.0748	0.00056	0.0032	0.1815	0.18526	0.011420	0.0281	0.0160	0.0555
6	0.0126	0.0183	0.0531	0.0841	0.00077	0.0037	0.1843	0.18877	0.018057	0.0324	0.0170	0.0674
12	0.0127	0.0184	0.0531	0.0843	0.00078	0.0037	0.1843	0.18878	0.018065	0.0325	0.0170	0.0675

Note: the reported numbers are percentage rate.

Table A.25 Forecast Error Variance Decomposition for the UK.

	Pre-Break				Post - Break			
H	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total
1	0.0012	0.0015	0.0019	0.0048	0.0072	0.0031	0.0351	0.0454
3	0.0029	0.0053	0.0021	0.0198	0.0069	0.0278	0.0320	0.0667
6	0.0124	0.0057	0.0022	0.0205	0.0078	0.0415	0.0323	0.0818
12	0.0124	0.0057	0.0022	0.0205	0.0078	0.0432	0.0323	0.0835

Tables A.26 and A.27 summarize the role of monetary policy in responding to oil structural oil price shocks and real exchange rate shocks.

Table A.26 Monetary Policy Responses to Structural Shocks

	$\widehat{\beta_1}$	$\widehat{\beta_2}$	$\widehat{\beta_3}$	$\widehat{\beta_4}$
Canada	-2.82	0.10	0.102	-2.87
	(-0.95)	(1.62)	(-0.23)	(-1.21)
France	-1.41	0.06	0.13	2.97
	(-0.68)	(1.01)	(0.58)	(0.69)
Germany	-0.61	0.03	0.12	-0.46
	(-0.85)	(0.67)	(0.78)	(-0.30)
Italy	-1.36	0.06	-0.29	-4.11*
	(-0.97)	(1.35)	(-0.79)	(-1.97)
Japan	-0.87	0.16**	0.64**	-2.15**
	(-0.68)	(4.04)	(3.83)	(-2.43)
U.S.	-1.04	0.16**	0.35***	7.32**
	(-0.83)	(4.40)	(1.71)	(3.32)

Numbers in parenthesis are t-values based on Newey-West (1987) standard errors.
*, **, *** Indicate the significance levels at 1%, 5%, and 10% respectively.

Table A.27 Monetary Policy Responses to Structural Shocks in the UK

	$\widehat{\beta_1}$	$\widehat{\beta_2}$	$\widehat{\beta_3}$	$\widehat{\beta_4}$
Pre-break date	-3.09	0.38**	0.16	2.58
	(-1.54)	(5.58)	(0.67)	(1.58)
Post-break date	0.14	0.08**	0.67**	1.99***
	(0.12)	(3.02)	(3.23)	(1.86)

Numbers in parenthesis are t-values based on Newey-West (1987) standard errors.
*, **, *** Indicate the significance levels at 1%, 5%, and 10% respectively.

The following results are based on the oil prices measured by the West Texas Intermediate oil prices. Figures A.7 – A.10 present the impulse response functions with 95% confidence intervals. It is obvious that these impulses are similar to the ones plotted in Chapter 2.

Figure A.7 The Responses of Canadian and French Real Exchange Rates to Structural Oil Shocks

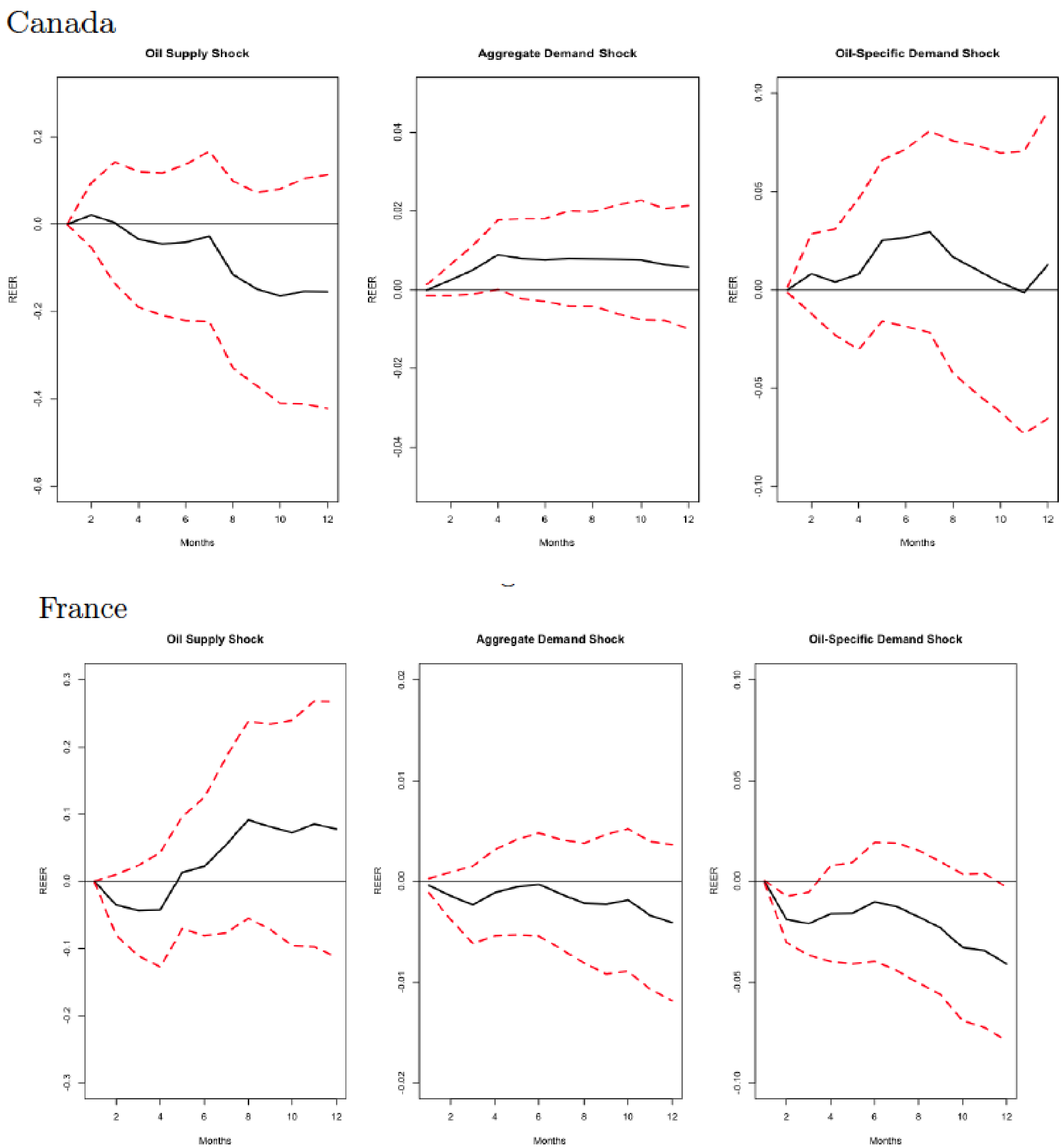
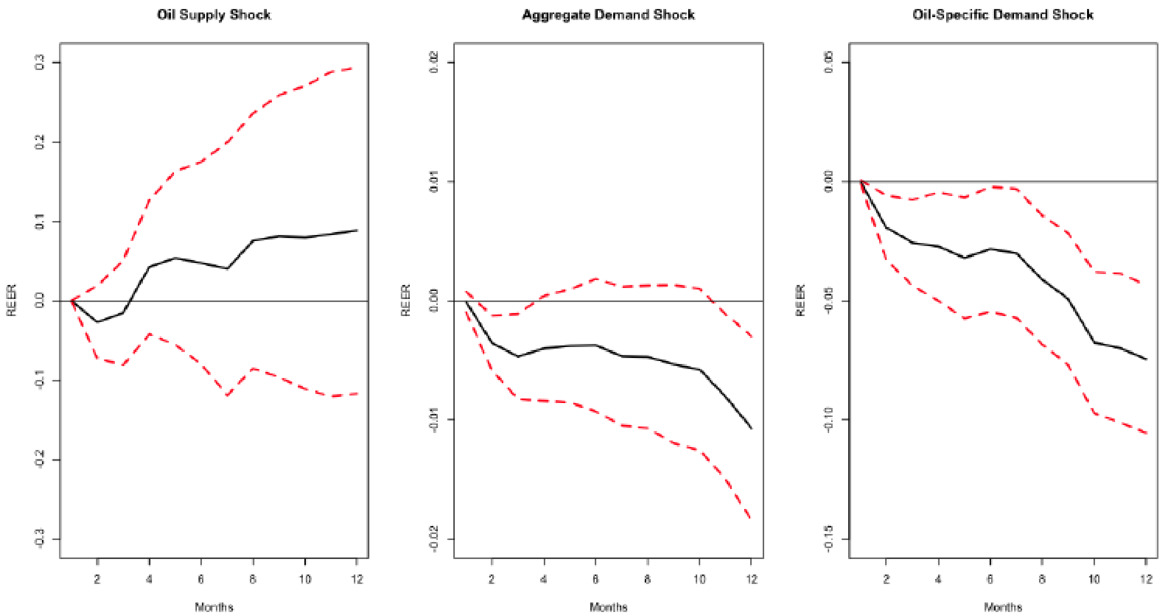


Figure A.8 The Responses of German and Italian Real Exchange Rates to Structural Oil Shocks

Germany



Italy

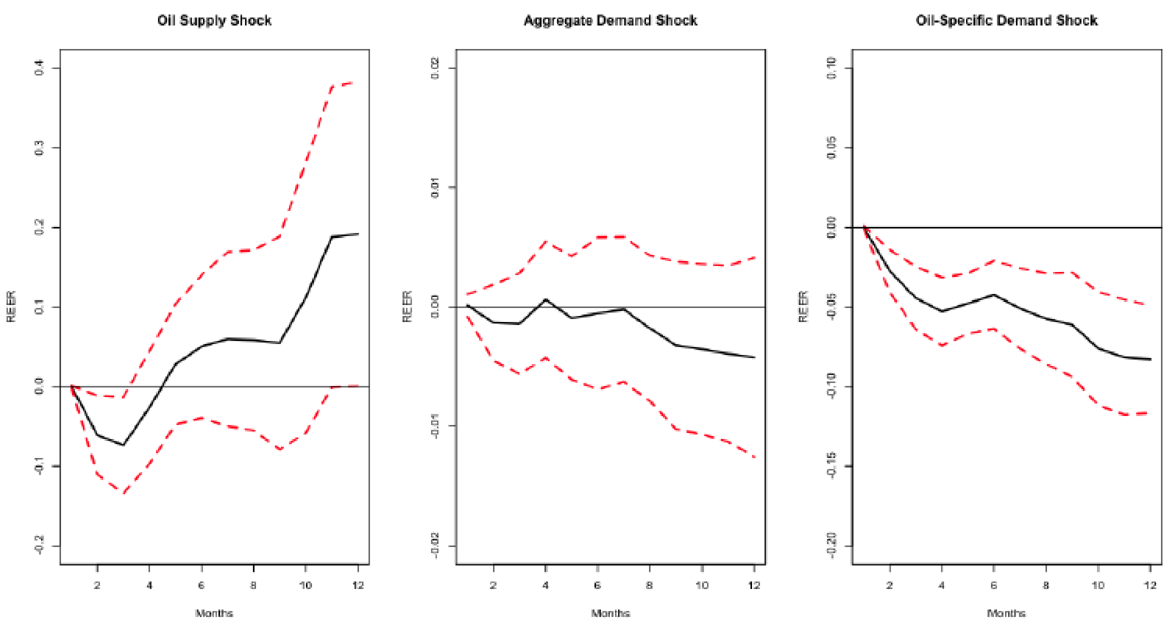
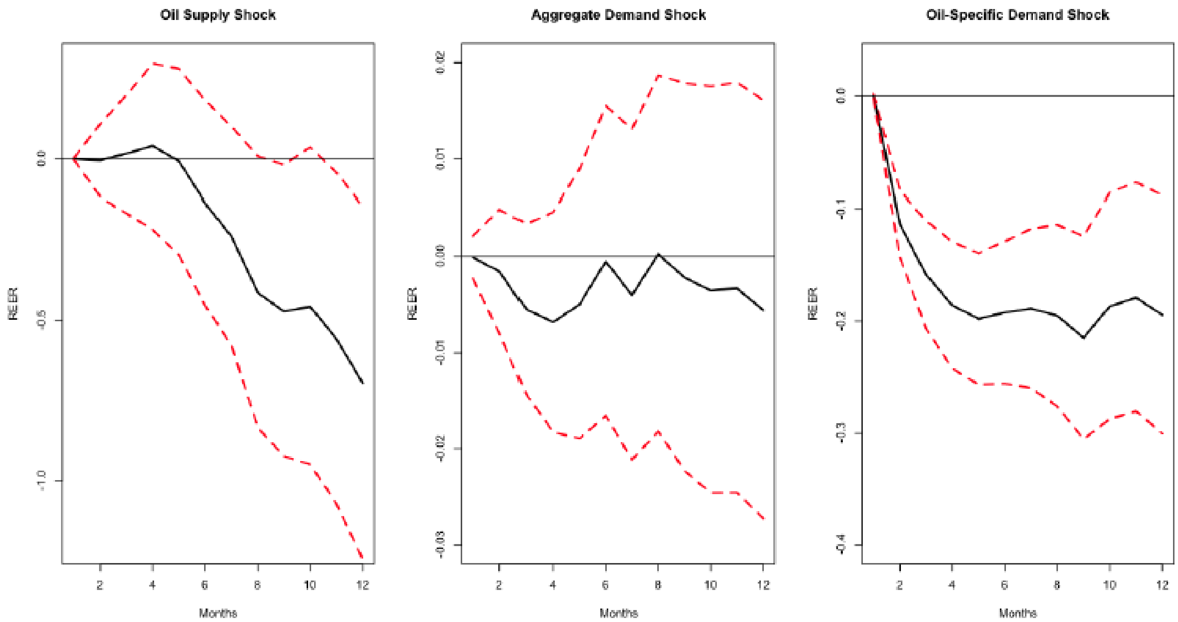


Figure A.9 The Responses of Japanese and British Real Exchange Rates to Structural Oil Shocks

Japan



UK

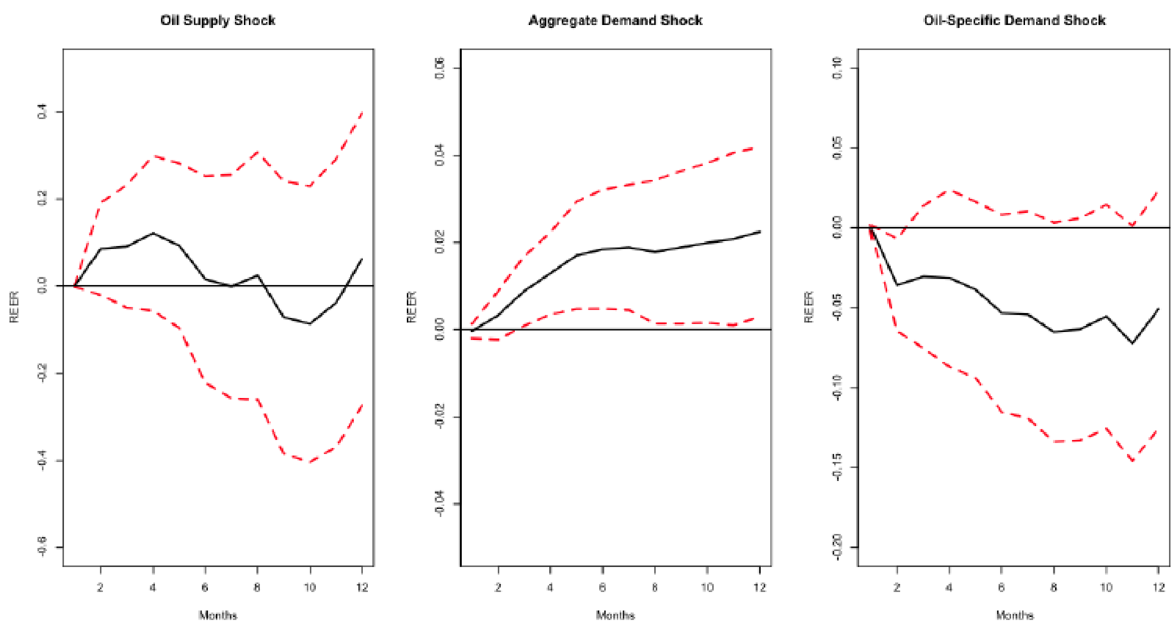


Figure A.10 The Responses of the US Real Exchange Rates to Structural Oil Shocks

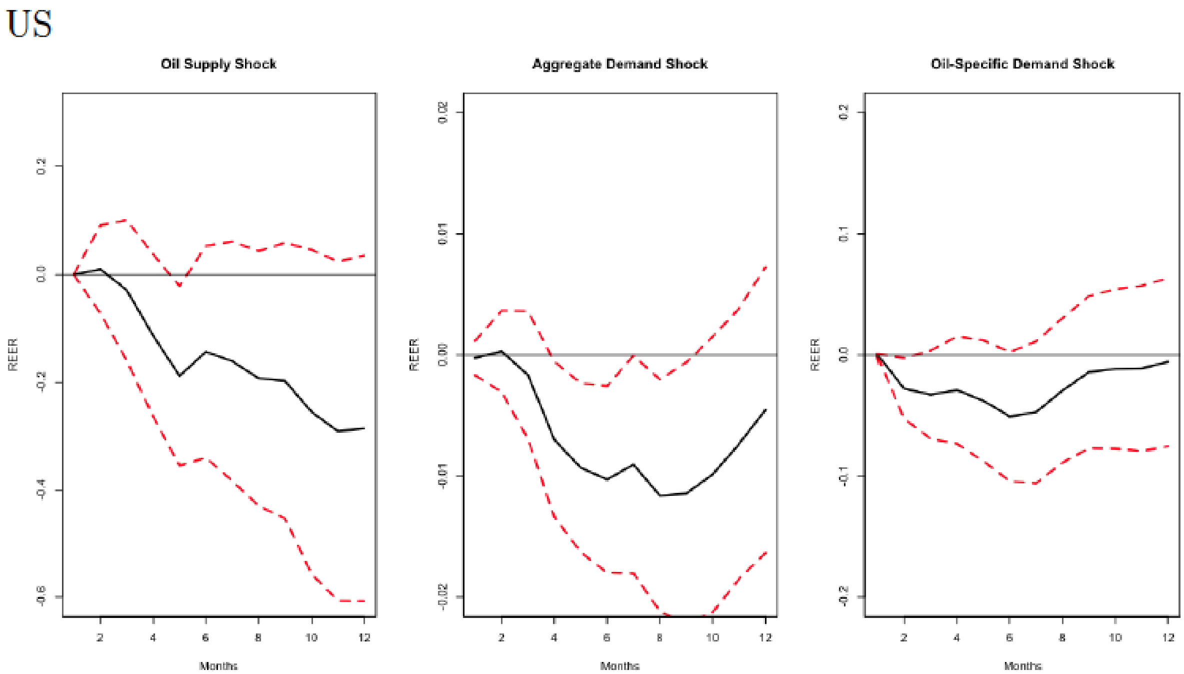


Table A.28 summarizes the structural break tests of Andrews (1993) and Andrews and Ploberger (1994). Note that all the structural break tests indicate the existence of a stable relationship between structural oil price shocks and G7 real exchange rate.

Table A.28 Structural Break Tests

	Break Date	Ave F	Sup F	Exp F
Canada	August 2007	5.79	10.62	3.26
		(0.29)	(0.47)	(0.41)
France	April 1985	2.82	9.11	1.67
		(0.88)	(0.64)	(0.89)
Germany	July 1988	3.72	6.54	2.03
		(0.69)	(0.91)	(0.79)
Italy	August 1992	3.71	10.82	2.19
		(0.69)	(0.45)	(0.74)
Japan	May 1989	3.37	7.60	2.09
		(0.77)	(0.81)	(0.77)
U.K.	February 2009	6.90	15.97	5.09
		(0.61)	(0.39)	(0.44)
U.S.	April 1985	3.14	13.05	2.97
		(0.82)	(0.25)	(0.49)

** Indicates the rejection of the null hypothesis at 5%.

Figure A.11 shows the impacts of structural oil shocks on the real exchange rates beside the impacts of energy intensity associated with structural oil shocks using West Texas Intermediate oil prices based on equation (2.21) of chapter 2.

Figure A.11 The Responses of the US Real Exchange Rates to Structural Oil Shocks

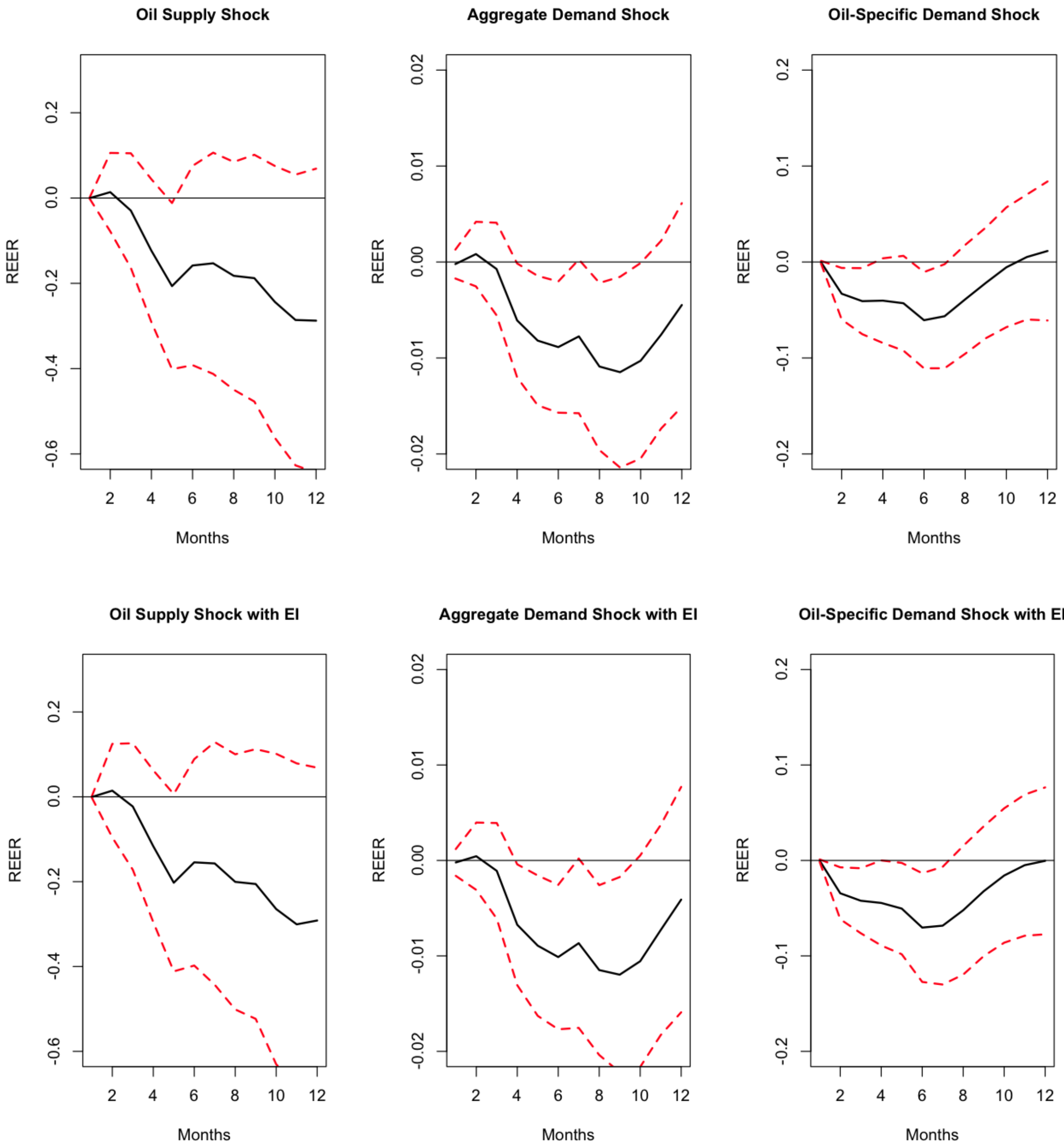


Table A.29 summarizes the contribution of each structural oil shock into the movements of G7 real exchange rates.

Table A.29 Forecast Error Variance Decomposition

	Canada				France				Germany			
H	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total
1	0.0011	0.0028	0.0013	0.0052	0.0057	0.0070	0.0354	0.0483	0.0025	0.0305	0.0380	0.0710
3	0.0016	0.0171	0.0020	0.0208	0.0064	0.0110	0.0363	0.0537	0.0131	0.0317	0.0370	0.0820
6	0.0017	0.0176	0.0097	0.0277	0.0171	0.0110	0.0356	0.0638	0.0139	0.0317	0.0376	0.0834
12	0.0017	0.0176	0.0084	0.0278	0.0172	0.0110	0.0356	0.0639	0.0139	0.0317	0.0376	0.0834
	Italy				Japan				UK			
H	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total
1	0.0045	0.0046	0.0430	0.0523	0.000008	0.000044	0.1323	0.1323	0.0067	0.0030	0.0309	0.0406
3	0.0071	0.0109	0.0502	0.0682	0.000556	0.002849	0.1469	0.1503	0.0063	0.0347	0.0282	0.0694
6	0.0110	0.0167	0.0514	0.0793	0.000764	0.003653	0.1480	0.1524	0.0064	0.0504	0.0292	0.0861
12	0.0111	0.0168	0.0515	0.0795	0.000765	0.003660	0.1480	0.1524	0.0064	0.0506	0.0291	0.0863
	US											
H	ε_t^{Sup}	ε_t^{AD}	ε_t^{D}	Total								
1	0.000001	0.0008	0.0209	0.0218								
3	0.011154	0.0281	0.0196	0.0589								
6	0.016674	0.0327	0.0225	0.0719								
12	0.016675	0.0328	0.0225	0.0720								

Note: the reported numbers are percentage rate.

Table A.30 presents the results of monetary policy role in reacting to oil shocks and real exchange rate shocks.

Table A.30 The Role of Monetary Policy

	$\widehat{\beta_1}$	$\widehat{\beta_2}$	$\widehat{\beta_3}$	$\widehat{\beta_4}$
Canada	-2.57	0.11	0.14	-3.04
	(-0.92)	(1.65)	(-0.24)	(-1.24)
France	-1.43	0.06	0.19	3.15
	(-0.68)	(1.07)	(0.89)	(0.71)
Germany	-0.54	0.02	0.06	-0.52
	(-0.95)	(0.80)	(0.44)	(-0.33)
Italy	-0.92	0.07	-0.47	-4.76**
	(-0.63)	(1.56)	(-1.16)	(-2.32)
Japan	-1.07	0.19**	0.51**	-2.18**
	(-0.83)	(3.78)	(2.67)	(-2.49)
UK	-1.34	0.18**	0.39**	2.06*
	(-0.94)	(4.78)	(2.05)	(1.79)
U.S.	-1.31	0.16**	0.27	7.17**
	(-0.83)	(4.31)	(1.44)	(3.33)

Numbers in parenthesis are t-values based on Newey-West (1987) standard errors.
*, **, *** Indicate the significance levels at 1%, 5%, and 10% respectively.

The following tables, A.31 and A.34, summarize the parameter estimates the reduced form VAR model consisting exchange rate for chapter 3. It is also important to note that $\Delta\ Prod_t, REA, \Delta oil,$ and ΔER denote the percent change in global oil production, the global economic activity index, the percent change in oil price, and the percent change in nominal exchange rate respectively.

Table A.31 The Parameter Estimates of the Reduced Form VAR with Exchange Rate

	Dependent variable			
	Oil Production	REA	Oil Price	ER
	(1)	(2)	(3)	(4)
$\Delta\ Prod_{t-1}$	0.046	-0.332	0.001	-0.005
	(0.054)	(1.277)	(0.038)	(0.003)
REA_{t-1}	0.0003	1.315***	0.003**	0.0001
	(0.002)	(0.053)	(0.002)	(0.0001)
$\Delta\ Oil_{t-1}$	-0.048	3.263**	-0.174***	-0.0005
	(0.058)	(1.392)	(0.041)	(0.003)
$\Delta\ ER_{t-1}$	-0.772	-87.350***	1.299*	0.389***
	(0.959)	(22.849)	(0.672)	(0.054)
$\Delta\ Prod_{t-2}$	-0.130**	-0.950	-0.029	-0.002
	(0.053)	(1.269)	(0.037)	(0.003)
REA_{t-2}	-0.001	-0.578***	-0.004	-0.0002
	(0.004)	(0.089)	(0.003)	(0.0002)
$\Delta\ Oil_{t-2}$	0.011	-0.043	-0.108**	-0.001
	(0.060)	(1.428)	(0.042)	(0.003)
$\Delta\ ER_{t-2}$	1.705	8.223	-0.139	-0.127**
	(1.051)	(25.048)	(0.737)	(0.059)
$\Delta\ Prod_{t-3}$	-0.304***	1.748	-0.022	0.001
	(0.053)	(1.274)	(0.037)	(0.003)
REA_{t-3}	0.0001	0.298***	0.003	0.0001
	(0.004)	(0.097)	(0.003)	(0.0002)
$\Delta\ Oil_{t-3}$	-0.001	2.886**	-0.175***	0.002
	(0.059)	(1.402)	(0.041)	(0.003)
$\Delta\ ER_{t-3}$	-2.661**	9.364	-0.034	0.100*
	(1.060)	(25.270)	(0.743)	(0.059)
$\Delta\ Prod_{t-4}$	-0.194***	0.259	-0.023	-0.006*
	(0.056)	(1.331)	(0.039)	(0.003)

Table A.32 The Parameter Estimates of the Reduced Form VAR with Exchange Rate

	Dependent variable			
	Oil Production	REA	Oil Price	ER
	(1)	(2)	(3)	(4)
REA_{t-4}	-0.0004	-0.208**	-0.005	-0.0002
	(0.004)	(0.099)	(0.003)	(0.0002)
$\Delta\ Oil_{t-4}$	0.015	1.699	-0.186***	-0.003
	(0.059)	(1.417)	(0.042)	(0.003)
$\Delta\ ER_{t-4}$	0.251	12.081	0.253	-0.054
	(1.068)	(25.446)	(0.748)	(0.060)
$\Delta\ Prod_{t-5}$	-0.099*	-0.887	-0.028	-0.003
	(0.056)	(1.340)	(0.039)	(0.003)
REA_{t-5}	-0.001	0.140	0.003	0.0004*
	(0.004)	(0.100)	(0.003)	(0.0002)
$\Delta\ Oil_{t-5}$	-0.007	1.582	-0.043	0.004
	(0.061)	(1.456)	(0.043)	(0.003)
$\Delta\ ER_{t-5}$	0.378	-60.628**	-0.270	-0.031
	(1.065)	(25.394)	(0.747)	(0.060)
$\Delta\ Prod_{t-6}$	-0.156***	0.306	-0.026	-0.001
	(0.056)	(1.332)	(0.039)	(0.003)
REA_{t-6}	0.003	0.029	0.002	-0.0001
	(0.004)	(0.101)	(0.003)	(0.0002)
$\Delta\ Oil_{t-6}$	-0.019	1.466	-0.159***	-0.002
	(0.060)	(1.434)	(0.042)	(0.003)
$\Delta\ ER_{t-6}$	-1.924*	21.917	-0.021	0.021
	(1.061)	(25.280)	(0.743)	(0.059)
$\Delta\ Prod_{t-7}$	-0.163***	-0.290	-0.019	-0.007**
	(0.056)	(1.327)	(0.039)	(0.003)
REA_{t-7}	0.0003	-0.042	-0.004	-0.00002
	(0.004)	(0.101)	(0.003)	(0.0002)
$\Delta\ Oil_{t-7}$	-0.013	2.688*	-0.150***	0.002
	(0.060)	(1.429)	(0.042)	(0.003)
$\Delta\ ER_{t-7}$	0.431	-2.216	-0.063	-0.023
	(1.060)	(25.275)	(0.743)	(0.059)

Table A.33 The Parameter Estimates of the Reduced Form VAR with Exchange Rate

	Dependent variable			
	Oil Production	REA	Oil Price	ER
	(1)	(2)	(3)	(4)
$\Delta\, Prod_{t-8}$	-0.106*	-0.906	-0.012	0.002
	(0.057)	(1.349)	(0.040)	(0.003)
REA_{t-8}	0.002	-0.119	0.0003	-0.00004
	(0.004)	(0.101)	(0.003)	(0.0002)
$\Delta\, Oil_{t-8}$	0.007	0.391	-0.091**	-0.0001
	(0.061)	(1.456)	(0.043)	(0.003)
$\Delta\, ER_{t-8}$	-0.773	9.378	0.336	0.089
	(1.054)	(25.113)	(0.739)	(0.059)
$\Delta\, Prod_{t-9}$	-0.059	-0.907	-0.010	-0.002
	(0.056)	(1.333)	(0.039)	(0.003)
REA_{t-9}	-0.007*	0.236**	0.002	0.00003
	(0.004)	(0.100)	(0.003)	(0.0002)
$\Delta\, Oil_{t-9}$	-0.029	1.123	-0.139***	0.004
	(0.060)	(1.427)	(0.042)	(0.003)
$\Delta\, ER_{t-9}$	0.422	30.911	-0.153	-0.068
	(1.054)	(25.123)	(0.739)	(0.059)
$\Delta\, Prod_{t-10}$	0.115**	0.471	-0.010	-0.004
	(0.053)	(1.258)	(0.037)	(0.003)
REA_{t-10}	0.005	-0.157	-0.001	0.00001
	(0.004)	(0.100)	(0.003)	(0.0002)
$\Delta\, Oil_{t-10}$	0.017	3.388**	-0.154***	-0.003
	(0.059)	(1.408)	(0.041)	(0.003)
$\Delta\, ER_{t-10}$	0.039	-11.929	0.203	0.064
	(1.042)	(24.832)	(0.730)	(0.058)
$\Delta\, Prod_{t-11}$	-0.045	1.294	-0.006	-0.001
	(0.053)	(1.253)	(0.037)	(0.003)
REA_{t-11}	-0.002	0.103	-0.001	-0.00004
	(0.004)	(0.094)	(0.003)	(0.0002)
$\Delta\, Oil_{t-11}$	-0.003	2.018	-0.128***	0.004
	(0.060)	(1.432)	(0.042)	(0.003)
$\Delta\, ER_{t-11}$	-1.680	-47.000*	-0.192	0.025
	(1.035)	(24.677)	(0.726)	(0.058)

Table A.34 The Parameter Estimates of the Reduced Form VAR with Exchange Rate

	Dependent variable			
	Oil Production	REA	Oil Price	ER
	(1)	(2)	(3)	(4)
$\Delta\, Prod_{t-12}$	0.004	-1.259	0.005	0.001
	(0.053)	(1.253)	(0.037)	(0.003)
REA_{t-12}	0.00001	-0.064	0.00001	0.00001
	(0.002)	(0.056)	(0.002)	(0.0001)
$\Delta\, Oil_{t-12}$	0.015	4.726***	0.695***	-0.003
	(0.060)	(1.427)	(0.042)	(0.003)
$\Delta\, ER_{t-12}$	-1.207	-2.606	0.478	-0.030
	(0.971)	(23.137)	(0.680)	(0.054)
Constant	0.004	-0.328	0.007	-0.0002
	(0.013)	(0.309)	(0.009)	(0.001)
Observations	396	396	396	396
R2	0.256	0.941	0.743	0.204
F-Statistic (df = 48; 347)	2.490***	115.293***	20.876***	1.854***

Note: numbers in parentheses are p-values; *p<0.1; **p<0.05; ***p<0.01

The following tables, A.35 and A.39, summarize the parameter estimates the reduced form VAR model consisting industrial production for chapter 3. It is also important to note that $\Delta\ Prod_t, REA, \Delta oil,$ and ΔIP denote the percent change in global oil production, the global economic activity index, the percent change in oil price, and the percent change in the industrial production respectively.

Table A.35 The Parameter Estimates of the Reduced Form VAR with IP

	Dependent variable			
	Oil Production	REA	Oil Price	IP
	(1)	(2)	(3)	(4)
$\Delta\ Prod_{t-1}$	0.059	1.140	0.006	0.060***
	(0.063)	(1.574)	(0.045)	(0.016)
REA_{t-1}	0.0005	1.354***	0.003*	0.0004
	(0.002)	(0.053)	(0.002)	(0.001)
$\Delta\ Oil_{t-1}$	-0.047	3.922***	-0.177***	0.028*
	(0.057)	(1.438)	(0.041)	(0.015)
$\Delta\ IP_{t-1}$	-0.068	-8.358	0.046	-0.150**
	(0.227)	(5.720)	(0.164)	(0.060)
$\Delta\ Prod_{t-2}$	-0.229***	-0.316	-0.023	-0.022
	(0.063)	(1.592)	(0.046)	(0.017)
REA_{t-2}	-0.0003	-0.644***	-0.004	-0.001
	(0.004)	(0.090)	(0.003)	(0.001)
$\Delta\ Oil_{t-2}$	-0.035	0.406	-0.110**	0.003
	(0.059)	(1.484)	(0.042)	(0.015)
$\Delta\ IP_{t-2}$	0.622***	0.569	-0.024	0.035
	(0.228)	(5.745)	(0.164)	(0.060)
$\Delta\ Prod_{t-3}$	-0.359***	2.275	0.001	-0.018
	(0.064)	(1.601)	(0.046)	(0.017)
REA_{t-3}	0.001	0.319***	0.003	0.0004
	(0.004)	(0.099)	(0.003)	(0.001)
$\Delta\ Oil_{t-3}$	-0.055	3.117**	-0.167***	0.016
	(0.058)	(1.460)	(0.042)	(0.015)
$\Delta\ IP_{t-3}$	0.398*	-6.398	-0.129	-0.005
	(0.229)	(5.763)	(0.165)	(0.060)
$\Delta\ Prod_{t-4}$	-0.272***	1.783	0.009	-0.023
	(0.066)	(1.663)	(0.048)	(0.017)

Table A.36 The Parameter Estimates of the Reduced Form VAR with IP

	Dependent variable			
	Oil Production	REA	Oil Price	IP
	(1)	(2)	(3)	(4)
REA_{t-4}	-0.004	-0.174*	-0.004	-0.001
	(0.004)	(0.102)	(0.003)	(0.001)
$\Delta\ Oil_{t-4}$	-0.014	1.679	-0.177***	0.004
	(0.058)	(1.468)	(0.042)	(0.015)
$\Delta\ IP_{t-4}$	0.458**	-5.712	-0.155	0.040
	(0.227)	(5.723)	(0.164)	(0.060)
$\Delta\ Prod_{t-5}$	-0.027	-1.684	-0.005	0.017
	(0.066)	(1.666)	(0.048)	(0.017)
REA_{t-5}	0.003	0.124	0.003	0.001
	(0.004)	(0.103)	(0.003)	(0.001)
$\Delta\ Oil_{t-5}$	-0.050	2.048	-0.041	0.009
	(0.060)	(1.498)	(0.043)	(0.016)
$\Delta\ IP_{t-5}$	-0.391*	11.085*	-0.205	-0.023
	(0.225)	(5.668)	(0.162)	(0.059)
$\Delta\ Prod_{t-6}$	-0.248***	1.191	-0.007	-0.029*
	(0.065)	(1.644)	(0.047)	(0.017)
REA_{t-6}	0.001	0.005	0.002	0.0004
	(0.004)	(0.103)	(0.003)	(0.001)
$\Delta\ Oil_{t-6}$	-0.032	1.132	-0.145***	0.013
	(0.058)	(1.472)	(0.042)	(0.015)
$\Delta\ IP_{t-6}$	0.644***	-1.875	-0.097	-0.027
	(0.228)	(5.732)	(0.164)	(0.060)
$\Delta\ Prod_{t-7}$	-0.186***	0.682	-0.003	0.008
	(0.066)	(1.662)	(0.048)	(0.017)
REA_{t-7}	0.001	-0.049	-0.004	-0.00002
	(0.004)	(0.103)	(0.003)	(0.001)
$\Delta\ Oil_{t-7}$	-0.047	3.031**	-0.147***	0.008
	(0.058)	(1.471)	(0.042)	(0.015)
$\Delta\ IP_{t-7}$	0.120	-3.546	-0.074	-0.053
	(0.232)	(5.844)	(0.167)	(0.061)

Table A.37 The Parameter Estimates of the Reduced Form VAR with IP

	Dependent variable			
	Oil Production	REA	Oil Price	IP
	(1)	(2)	(3)	(4)
$\Delta\, Prod_{t-8}$	-0.009	-0.224	-0.010	0.004
	(0.065)	(1.645)	(0.047)	(0.017)
REA_{t-8}	0.002	-0.114	0.001	0.001
	(0.004)	(0.103)	(0.003)	(0.001)
$\Delta\, Oil_{t-8}$	-0.001	0.174	-0.090**	0.018
	(0.059)	(1.492)	(0.043)	(0.016)
$\Delta\, IP_{t-8}$	-0.233	2.810	-0.066	0.019
	(0.231)	(5.814)	(0.166)	(0.061)
$\Delta\, Prod_{t-9}$	-0.063	-1.270	-0.021	0.029*
	(0.064)	(1.618)	(0.046)	(0.017)
REA_{t-9}	-0.009**	0.267***	0.002	-0.001
	(0.004)	(0.103)	(0.003)	(0.001)
$\Delta\, Oil_{t-9}$	-0.035	1.385	-0.141***	0.021
	(0.059)	(1.474)	(0.042)	(0.015)
$\Delta\, IP_{t-9}$	-0.024	3.798	0.030	0.034
	(0.231)	(5.822)	(0.167)	(0.061)
$\Delta\, Prod_{t-10}$	0.182***	1.239	-0.013	0.005
	(0.062)	(1.563)	(0.045)	(0.016)
REA_{t-10}	0.007*	-0.151	-0.0003	0.001
	(0.004)	(0.103)	(0.003)	(0.001)
$\Delta\, Oil_{t-10}$	-0.004	2.595*	-0.157***	0.028*
	(0.058)	(1.458)	(0.042)	(0.015)
$\Delta\, IP_{t-10}$	-0.334	-2.137	0.028	0.026
	(0.231)	(5.802)	(0.166)	(0.061)
$\Delta\, Prod_{t-11}$	0.057	1.437	-0.039	0.030*
	(0.062)	(1.555)	(0.045)	(0.016)
REA_{t-11}	-0.003	0.072	-0.001	-0.001
	(0.004)	(0.096)	(0.003)	(0.001)

Table A.38 The Parameter Estimates of the Reduced Form VAR with IP

	Dependent variable			
	Oil Production	REA	Oil Price	IP
	(1)	(2)	(3)	(4)
$\Delta\ Oil_{t-11}$	-0.002	2.547*	-0.131***	0.016
	(0.059)	(1.478)	(0.042)	(0.015)
$\Delta\ IP_{t-11}$	-0.764***	2.683	0.203	-0.266***
	(0.230)	(5.784)	(0.166)	(0.060)
$\Delta\ Prod_{t-12}$	0.068	-0.133	-0.024	-0.003
	(0.062)	(1.557)	(0.045)	(0.016)
REA_{t-12}	-0.0004	-0.058	0.0003	0.0005
	(0.002)	(0.056)	(0.002)	(0.001)
$\Delta\ Oil_{t-12}$	-0.020	4.769***	0.687***	0.036**
	(0.059)	(1.484)	(0.042)	(0.015)
$\Delta\ IP_{t-12}$	-0.237	-2.253	0.165	0.285***
	(0.232)	(5.847)	(0.167)	(0.061)
Constant	0.008	-0.306	0.006	-0.0005
	(0.013)	(0.317)	(0.009)	(0.003)
Observations	396	396	396	396
R2	0.296	0.938	0.743	0.338
F Statistic (df = 48; 347)	3.044***	108.908***	20.883***	3.697***

Note: numbers in parentheses are p-values; *p<0.1; **p<0.05; ***p<0.01

The following tables, A.39 and A.42, summarize the parameter estimates the reduced form VAR model consisting consumer price indexes for chapter 3. It is also important to note that $\Delta\, Prod_t, REA, \Delta oil,$ and ΔCPI denote the percent change in global oil production, the global economic activity index, the percent change in oil price, and the percent change in consumer price index respectively.

Table A.39 The Parameter Estimates of the Reduced Form VAR with CPI

	Dependent variable			
	Oil Production	REA	Oil Price	REER
	(1)	(2)	(3)	(4)
$\Delta\, Prod_{t-1}$	0.051	-0.147	-0.002	-0.0002
	(0.054)	(1.290)	(0.037)	(0.001)
REA_{t-1}	0.001	1.339***	0.003*	0.0001**
	(0.002)	(0.053)	(0.002)	(0.00004)
$\Delta\, Oil_{t-1}$	-0.050	3.865***	-0.178***	0.0004
	(0.059)	(1.421)	(0.041)	(0.001)
$\Delta\, CPI_{t-1}$	-1.325	117.047*	0.800	0.069
	(2.718)	(65.395)	(1.868)	(0.053)
$\Delta\, Prod_{t-2}$	-0.121**	-0.217	-0.037	0.001
	(0.053)	(1.287)	(0.037)	(0.001)
REA_{t-2}	-0.001	-0.644***	-0.004	-0.0001
	(0.004)	(0.089)	(0.003)	(0.0001)
$\Delta\, Oil_{t-2}$	-0.016	-0.153	-0.110***	-0.001
	(0.061)	(1.459)	(0.042)	(0.001)
$\Delta\, CPI_{t-2}$	-2.487	54.226	-0.239	0.044
	(2.713)	(65.262)	(1.865)	(0.053)
$\Delta\, Prod_{t-3}$	-0.283***	1.703	-0.026	0.0002
	(0.053)	(1.286)	(0.037)	(0.001)
REA_{t-3}	0.001	0.327***	0.003	0.00005
	(0.004)	(0.099)	(0.003)	(0.0001)
$\Delta\, Oil_{t-3}$	0.004	3.388**	-0.177***	0.001
	(0.060)	(1.444)	(0.041)	(0.001)
$\Delta\, CPI_{t-3}$	1.850	-19.235	2.352	0.028
	(2.719)	(65.418)	(1.869)	(0.053)
$\Delta\, Prod_{t-4}$	-0.195***	0.157	-0.024	0.001
	(0.055)	(1.334)	(0.038)	(0.001)

Table A.40 The Parameter Estimates of the Reduced Form VAR with CPI

	Dependent variable			
	Oil Production	REA	Oil Price	REER
	(1)	(2)	(3)	(4)
REA_{t-4}	-0.002	-0.187*	-0.005*	-0.00002
	(0.004)	(0.101)	(0.003)	(0.0001)
$\Delta\ Oil_{t-4}$	0.016	1.268	-0.191***	0.002
	(0.060)	(1.455)	(0.042)	(0.001)
$\Delta\ CPI_{t-4}$	-1.711	31.707	-1.998	0.086
	(2.720)	(65.435)	(1.869)	(0.053)
$\Delta\ Prod_{t-5}$	-0.062	-0.123	-0.042	0.001
	(0.056)	(1.340)	(0.038)	(0.001)
REA_{t-5}	0.001	0.139	0.003	0.00001
	(0.004)	(0.102)	(0.003)	(0.0001)
$\Delta\ Oil_{t-5}$	-0.010	1.728	-0.043	-0.0002
	(0.062)	(1.493)	(0.043)	(0.001)
$\Delta\ CPI_{t-5}$	-1.802	23.413	-0.222	0.009
	(2.727)	(65.592)	(1.874)	(0.054)
$\Delta\ Prod_{t-6}$	-0.155***	0.798	-0.031	0.001
	(0.055)	(1.330)	(0.038)	(0.001)
REA_{t-6}	0.002	-0.004	0.002	-0.00003
	(0.004)	(0.103)	(0.003)	(0.0001)
$\Delta\ Oil_{t-6}$	-0.027	1.263	-0.159***	0.0002
	(0.061)	(1.470)	(0.042)	(0.001)
$\Delta\ CPI_{t-6}$	-0.157	-37.555	-1.389	0.029
	(2.712)	(65.236)	(1.864)	(0.053)
$\Delta\ Prod_{t-7}$	-0.141**	-0.145	-0.018	0.0003
	(0.056)	(1.336)	(0.038)	(0.001)
REA_{t-7}	0.001	-0.035	-0.004	-0.00002
	(0.004)	(0.103)	(0.003)	(0.0001)
$\Delta\ Oil_{t-7}$	-0.007	2.827*	-0.148***	0.001
	(0.061)	(1.470)	(0.042)	(0.001)
$\Delta\ CPI_{t-7}$	0.466	1.598	0.874	0.029
	(2.702)	(65.010)	(1.857)	(0.053)

Table A.41 The Parameter Estimates of the Reduced Form VAR with CPI

	Dependent variable			
	Oil Production	REA	Oil Price	REER
	(1)	(2)	(3)	(4)
$\Delta\, Prod_{t-8}$	-0.055	-0.159	-0.022	0.001
	(0.056)	(1.345)	(0.038)	(0.001)
REA_{t-8}	0.001	-0.119	0.0001	0.0001
	(0.004)	(0.102)	(0.003)	(0.0001)
$\Delta\, Oil_{t-8}$	-0.007	-0.101	-0.087**	-0.001
	(0.062)	(1.492)	(0.043)	(0.001)
$\Delta\, CPI_{t-8}$	-2.231	-49.057	1.338	0.044
	(2.701)	(64.985)	(1.857)	(0.053)
$\Delta\, Prod_{t-9}$	-0.062	-0.777	-0.017	-0.0003
	(0.055)	(1.324)	(0.038)	(0.001)
REA_{t-9}	-0.007	0.262**	0.002	-0.00005
	(0.004)	(0.102)	(0.003)	(0.0001)
$\Delta\, Oil_{t-9}$	-0.024	1.242	-0.132***	-0.0004
	(0.061)	(1.468)	(0.042)	(0.001)
$\Delta\, CPI_{t-9}$	3.549	-89.247	1.780	-0.012
	(2.692)	(64.753)	(1.850)	(0.053)
$\Delta\, Prod_{t-10}$	0.143***	0.617	-0.002	0.0004
	(0.053)	(1.278)	(0.036)	(0.001)
REA_{t-10}	0.006	-0.151	-0.001	-0.00001
	(0.004)	(0.102)	(0.003)	(0.0001)
$\Delta\, Oil_{t-10}$	-0.004	2.754*	-0.151***	0.001
	(0.060)	(1.443)	(0.041)	(0.001)
$\Delta\, CPI_{t-10}$	1.132	20.056	-0.924	0.0005
	(2.693)	(64.781)	(1.851)	(0.053)
$\Delta\, Prod_{t-11}$	-0.036	1.653	-0.011	0.001
	(0.053)	(1.274)	(0.036)	(0.001)
REA_{t-11}	-0.003	0.087	-0.001	0.00000
	(0.004)	(0.096)	(0.003)	(0.0001)

Table A.42 The Parameter Estimates of the Reduced Form VAR with CPI

	Dependent Variable			
	Oil Production	REA	Oil Price	REER
	(1)	(2)	(3)	(4)
$\Delta\ Oil_{t-11}$	-0.010	2.131	-0.124***	-0.001
	(0.061)	(1.459)	(0.042)	(0.001)
$\Delta\ CPI_{t-11}$	0.485	40.908	1.010	0.067
	(2.682)	(64.522)	(1.843)	(0.053)
$\Delta\ Prod_{t-12}$	0.016	-0.703	0.007	0.001
	(0.053)	(1.274)	(0.036)	(0.001)
REA_{t-12}	-0.0003	-0.066	0.0001	0.00003
	(0.002)	(0.056)	(0.002)	(0.00005)
$\Delta\ Oil_{t-12}$	0.003	4.870***	0.693***	0.0003
	(0.061)	(1.459)	(0.042)	(0.001)
$\Delta\ CPI_{t-12}$	-2.690	-108.401*	0.851	0.071
	(2.675)	(64.364)	(1.839)	(0.053)
Constant	0.014	-0.274	0.001	0.001**
	(0.016)	(0.385)	(0.011)	(0.0003)
Observations	396	396	396	396
	0.228	0.938	0.743	0.176
F Statistic (df = 48; 347)	2.139***	108.706***	20.953***	1.548**

Note: numbers in parentheses are p-values; *p<0.1; **p<0.05; ***p<0.01