ESSAYS ON IDENTIFYING OIL PRICE SHOCKS AND ITS DYNAMIC IMPACTS ON MACRO ECONOMY: EVIDENCE FROM CHINA

by

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A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics

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ABSTRACT

The famous energy crisis of 1973-1974 initially inspired a lot of studies on the influence of increasing oil prices in the macro economy in the United States. Many scholars attribute the major recessions, high inflation and slumping economic growth to soaring oil prices. However, after that, the association between higher oil prices and unsatisfying economic performance was weakened by the evidence that subsequent oil prices shocks with comparable magnitudes as that of 1970s did not lead to declining GDP and rising inflationary pressure; instead, both magnitudes remain relatively stable. This phenomenon which is contrary to our prior impressions could be the result of changing behavior of firms and households responding to fluctuations in the market of oil. Also, it inspires a deeper and closer look at the different types of oil price shocks, which gives rise to the following interesting questions. Are oil price shocks alike? If not, do they have different impacts on the evolution of oil prices? Do major macroeconomic variables in other countries, like China, experience the same response patterns in respect to various underlying oil price shocks as the United States? Is China responsible for the soaring price of oil in 2008? Furthermore, the unexpected oil price declines since 1990s provide us with the opportunity to explore the question, is the relationship between economic behavior and real oil price symmetric in China's situation?

The three essays in this dissertation investigate two main topics about oil price shocks. One topic attempts to identify oil price shocks from different resources and the other studies the dynamic influences of oil price shocks in the macroeconomy of

China. The first essay attempts to disaggregate oil price shocks into six types while the second essay analyzes the behavior of major economic indicators in China in reaction to the variety of oil price shocks. The third essay focuses on testing whether the effect of oil price increases or decreases is symmetric in China.

In the first essay, I estimate a Structural VAR model to decompose shocks of oil price into six components: oil supply shocks, global demand shocks for all industrial commodities, U.S. money supply shocks, China's money supply shocks, China's real effective exchange rate shocks and shocks in oil specific demand. This disaggregation of oil price shocks endeavors to characterize the relative importance on the evolution path of oil prices from different perspectives: supply side, demand side, precautionary concern and monetary policy in both of the U.S. and China. The evidence in this study shows that, at any specific time, real oil price responds to a combination of structural shocks that change over time. Furthermore, different types of shocks behave differently in affecting oil price fluctuations. Actually, oil-specific demand shocks and China's effective exchange rate shocks make the largest contribution to the fluctuations of oil price. While money supply shocks in U.S., money supply shocks in China and shocks in global aggregate demand cause relatively large impacts on oil price, oil supply shocks make little contribution to the dynamics of oil price.

The second essay analyses the impulse response patterns of the major macroeconomic variables in China w.r.t. the disentangled oil price shocks obtained in the first essay. The results show that the influence of oil price changes in China's economy is majorly transmitted through the demand channel and the monetary policy channel. Specifically, positive oil supply shocks bring little impact on the majority of

China's macroeconomic indicators. An unexpected increase in global aggregate demand has very limited impact on China's real consumption, real investment and real export. But, it has significant and positive impact on China's real import, China's value added and one year lending rate. Besides, positive innovations in U.S. money supply M2 causes little or small impact on most of China's major economic indicators while positive China's money supply shocks can possess a relatively large influence in real consumption and one year lending rate in China, although the effect is statistically insignificant for most of the projection period. At the meantime, positive shocks in China's real effective exchange rate or an appreciation in RMB can have significant impact on the majority of China's macroeconomic indicators. However, positive shocks in oil specific demand can only possess a small positive impact on China's one year lending rate with partially statistical significance.

By extending the method proposed by Kilian and Vigfusson (2011), the third essay investigates whether the influence of oil price fluctuations in China's macroeconomy is symmetric. The result reveals that the influences of oil price changes in major economic indicators of China are symmetric. This finding is reasonable, considering the more and more flexible exchange rate policy and the reform of interest rate marketization in China, which greatly reduces the frictions in the markets and smooths the capital and labor transferring among different sectors.

Chapter 1

DECOMPOSITION OF OIL PRICE SHOCKS-A STRUCTURAL VAR APPROACH

1.1 Introduction

1.1.1 Motivation

In the past decade, there continues to be considerable interest in the effect of oil price shocks on the major economies' performances. Kilian (2009), Peersman and Van Robays (2009) and Marko Melolinna (2012) all point out the relationship between macro economies and oil prices depends substantially on the underlying sources of the oil price disturbances. Therefore, not only to scholars but also to policy makers, identifying and quantifying possible origins of oil price fluctuations are of great importance.

Figure D.1 in Appendix D illustrates the major oil related events and the quarter over quarter real WTI oil price dynamics in the United States from 1959 to 2014, in contrast to the trend of quarter over quarter real GDP growth. The starting point of 1959 is chosen because the PCE index is only available after 1959. Considering oil is used as both an intermediate and final consumption good, using Producer Price Index (PPI) or Consumer Price Index (CPI) alone to deflate the WTI oil price may not be broad enough. So I construct the geometric average of the

Personal Consumption Expenditure Index (PCE) and PPI[1] as a deflator. By dividing the WTI oil price by this geometric average of the PCE index and PPI, I get the real price of oil. From Figure D.1 in Appendix D, one of the most striking facts we can see is that since the 1990s, the U.S. economy does not suffer serious declines in terms of real GDP growth following major increases in the price of oil, except for the depression after the Persian Gulf Crisis in 1990-1991. Also, it seems that events of different categories have different influences in the evolution of oil prices. For instance, both OPEC production reductions in 1999 and 2009 are followed by a sharp oil price increase, while a slump in oil price occurs after the Asian financial crisis in 1997 and the global financial collapse in 2008. There are numerous reasons behind the new oil price-real GDP relationship. Firms and households may respond to oil price changes with rational expectations and this changing behavior may play a role in this new oil price-real GDP relationship. Besides, different sources of disturbances which underlie the seemingly identical soaring prices may have distinct impacts on the economy. For instance, if oil price increases are primarily due to the strong demand for crude oil rather than oil supply disruptions or some other reason, these increases could probably lead to a booming economy instead of recessions.

Figure D.2 in Appendix D compares the quarter over quarter real WTI oil prices dynamics with the trend of inflation rate in the same time period described above. Here the inflation rate is obtained by calculating the growth rate of U.S. CPI. We can tell from Figure D.2 in Appendix D that U.S. inflation becomes more stable in

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[1] The PPI has a 1982 base while the PCE index has a base year of 2009. So I convert the PPI to a 2009 base by dividing every monthly value of the PPI by the 2009 monthly average and then multiplying by 100.

response to oil price fluctuations after the 1990s. It seems that the inflationary pressure brought about by oil price increases is not as intense as what most researchers have predicted.

In Appendix D, both Figure D.1 and Figure D.2 show an obvious change of response patterns of real GDP growth and inflation following major oil price fluctuations. Before the 1990s, the responses of real GDP and inflation w.r.t. oil price changes are volatile and violent. However, after the 1990s, the responses become stable and mild. In other words, the influence of oil price shocks in inflation and real GDP growth seems less significant than it was in earlier period. For example, during the real oil price increases of 150.96% in 1973Q1-1974Q1 and of 103.72% in 1979Q1-1980Q1, real GDP declined by 2.56% and 2.18% respectively in the following next year. On the other hand, real GDP dropped by 0.47% when the oil price jumped by 72.88% in 1990Q2-1990Q4 and dropped by 0.28% following the price jump of 111.79% in 1999Q1-2000Q1. Also, the CPI increased by 9.91% and by 14.21% respectively when oil prices jumped in 1973Q1-1974Q1 and 1979Q1-1980Q1. On the contrary, the CPI grows by 3.45% and by 3.26% respectively when oil prices increased in 1990Q2-1990Q4 and 1999Q1-2000Q1. From Figure D.1 and Figure D.2, it seems that oil price fluctuations before 1990s are mainly due to oil supply side shocks while oil price changes after that are mainly from combinations of factors other than supply side shocks. What are these factors and do they play different roles in affecting the world oil price fluctuation? Especially, does China also contribute to the world oil price evolution? Further, understanding the reasons behind oil price dynamics and knowing the magnitudes of its impacts on oil prices are of great importance before making appropriate policy.

Inspired by this, the motivation of this chapter is to discover and quantify the important sources of variations in oil prices. This will pave the way to the analysis in Chapter 2, which focuses on the response patterns of major macroeconomic indicators in China with respect to different types of oil shocks.

As a reference, I plot the relationships between quarter over quarter real WTI oil price and quarter over quarter China's growth rate of industrial value added as well as China's inflation in Figure E.1 and Figure E.2 in Appendix E, respectively. The real WTI oil price is again calculated by dividing WTI oil price by the constructed index, which is the geometric average of PCE Index and PPI. China's inflation rate is calculated as the growth rate of China's CPI. Because of the unavailability of China's macro data before 1990s, I can not compare the response patterns of major macro factors directly between U.S. and China across the same time period. Generally speaking, starting from 1997, both Figure E.1 and Figure E.2 in Appendix E do not show obvious change in the response patterns of China's growth rate of value added and China's inflation with respect to oil price changes. However, we can see from both Figure E.1 and Figure E.2 that the series of China's inflation and growth rate of China's value added are highly correlated with the real WTI oil prices changes. Actually, the correlation coefficient between China's inflation and the growth in WTI real oil price from 1997 to 2014 is 38.18%, while the correlation coefficient between growth in China's value added and growth in WTI real oil price is 39.38%. This means fluctuations in the real world oil price can probably have important impacts on China's macroeconomy through certain transmission mechanisms.

1.1.2 **Contribution**

The study in this chapter makes two major contributions to the previous literature. First, I use U.S.M2 to capture the far-reaching influence of U.S. monetary policy in the world oil market, which is not tested in this manner in most of the existing studies. Besides, in order to answer the question proposed by many researchers that whether China was responsible for the major oil price surges since the 1990s, I also include China's money supply and China's real effective exchange rate to examine China's influence in the global oil market. The inclusion of the above variables can further differentiate the sources of the world oil price fluctuations and help in fully understanding the world oil price behavior.

Second, this study covers the most recent oil price shocks using the latest monthly data, which can provide up to date information with high frequency. For example, the big price jump after the Arab Spring in 2010 and the moderate decline after the European Economic Crisis that began in late 2009 are both incorporated in the study of this chapter.

1.1.3 **Organization**

Chapter 1 is arranged as follows: Section 1.1 introduces the motivation and the major contributions of the study implemented in this chapter. Section 1.2 reviews the development of the relevant theoretical and empirical literatures on the disaggregation of oil price shocks and its impacts on the dynamics of oil prices. Section 1.3 discusses the data as well as the empirical method employed in Chapter 1. The results are presented in Section 1.4.

1.2 Literature Review

The literature on the causes of oil price fluctuations began to evolve after the 1973 oil crisis. The initial belief about the causes of oil price fluctuations is that historical oil price shocks are primarily caused by physical oil supply disruptions, which is primarily associated with major wars or major policy changes in the organization of oil producing countries. Examples of these types of supply shocks include the sharp spikes in oil prices after the OPEC oil embargo in 1973, after the Iran–Iraq War in 1979-1980, after 1985 when Saudi Arab abandoned its role as a leading producer and after 1990 when the Kuwait was invaded. Hamilton (1985, 1996, 2009) supports the conventional view that historical oil price shocks are mainly brought about by significant disturbances in crude oil production, most of which are due to exogenous geopolitical events.

However, after a closer looking at the seemingly identical political events in the Middle East, many observers began to cast doubt on the traditional oil supply shock view and shifted their interest to the demand side. Barsky and Kilian point out that the magnitude and the patterns of the subsequent changes in oil prices after these major events vary differently. Actually, the periods following Iranian revolution of 1978-79, the oil output reduction of OPEC in 1999 and the war in 2001 all are characterized by a relatively small change in price, compared to similar previous oil events. The role of worldwide demand for oil is becoming more and more essential in understanding oil prices and this view is popular among mainstream economists. Bernanke, Gertler and Watson (1997), Li and Ni (2002), Johns, Leiby and Paik (2004), Kilian (2009) all state the importance of demand pressure in driving oil prices. The oil prices decrease in 1997, along with oil price increases in 2003 and 2008 are all widely regarded as evidence in favor of the increasing popular viewpoint that oil supply shocks are playing a less important role than before in determining oil price dynamics. However, contrary to this assertion, a recent study, Chai et al. (2011) finds that world oil prices are responding more sensitively to oil supply shocks with a shorter influence period by using a BVAR-TVP (Time Varying Parameter) model.

While many studies try to attribute the oil price increases in 2003-2008 to increasing aggregate demand in major Asian emerging countries, another popular view attributes price increases to the increased financialization of oil futures markets in the United States. This view stresses that speculation has become a primary driving force in determining spot oil prices. Fattouh, Kilian and Mahadeva (2012) identify six stratifications in theory to review the impact of speculation on the dynamics of oil prices and they find that no obvious evidence supports the significance of speculation in oil price shocks after 2003. On the contrary, strong evidence emerges to show economic fundamentals actually drive these shocks in spot oil prices.

Unlike previous studies examining oil price shocks and their dynamic effects without quantifying the types of shocks based on various underlying causes, Kilian (2009) uses a Structural VAR model to factor the real oil price shocks into three components: shocks in oil supply, shocks in aggregate demand for all industrial commodities and oil specific demand shocks, such as precautionary demand shocks. After successful identification, he also quantifies these shocks and examines different impact patterns of the various shocks on oil prices. He claims that oil price increases due to an increasing aggregate demand displays a sustained pattern whereas oil price increases based on precautionary needs for crude oil in the future elicits a prompt and persistent response and disturbances in oil production lead to a transient and small increase in oil price. Actually, Kilian further decomposes world oil production changes into shocks in oil supply due to exogenous Middle East political events and other oil supply shocks. However, the identification does not alter the major conclusions.

Following his creative way to disentangle oil price shocks into specific types, researchers began to explore the underlying sources of oil price disturbances. Peersman and Stevens (2010) question the exogeneity of oil price shocks and develop a DSGE model endogenizing the oil sector to examine the relative importance of oil price disturbances originated from different sources in accounting for the formation of oil prices. They divide supply side shocks into oil mark-up and oil investment shocks and find that more than half of the oil price volatility can be explained by disturbances from supply side shocks caused primarily by inefficient market power transitions among oil companies while oil specific demand shocks based on precautionary concerns are shown to be the second important factor in driving up oil prices. Their results support the claims that oil price shocks are not similar to each other. Robays (2012) uses a threshold vector autoregressive model (TVAR) to value the influence of oil shocks with different degree of uncertainty. Following Kilian's classification of oil market shocks, he finds that the influences of demand and supply shocks in oil prices differ substantially and these influences are stronger when the degree of uncertainty in the macroeconomy is higher. Apergis and Miller (2009) also disentangle oil price shocks using a very similar approach as Kilian's.

Besides classical classification of oil price shocks into demand side and supply side, economists also identify other sources of oil price disturbances. Since the U.S. dollar denominates the trading of crude oil, the role of the dollar in oil price movements becomes a concern. Theoretically, oil prices are negatively related to the value of U.S. dollar. A weakening dollar due to the increasing currency reserves is blamed by researchers for oil price increases in the 1970s and the most recent oil price surges. A study from the IMF (2008a) finds that the nominal dollar exchange rate has a significant effect on both short-run and long-run crude oil prices. In detail, they claim that an increase of about 1% for the oil price results in a response to a 1% decrease in the dollar's value. Although Kesicki (2009) points out that this conclusion is limited to the specific episode, the IMF study does shed light on the importance of including the effect of the U.S. dollar as a factor that influences the oil price movements. Erceg, Guerrieri and Kamin (2011) use a multi-country SIGMA model to assess to what extent the "dollar bloc" played a role in the increase in oil prices that occurred in mid-2008. Li and Zhao (2011) point out the response of oil price to shocks in demand side is incompatible with Kilian's conclusion when the sample is expanded, thus motivating them to further decompose the oil price shocks by adding the factor of US dollar liquidity. Their results also show the importance of US dollar liquidity in explaining the impact of demand side shocks on oil price changes. Chai et al. (2011) also point out that the effect of the U.S. dollar index in affecting oil prices is increasing over time.

Similar to Kilian's measurement of global economic activity, the Baltic Dry Cargo Index is also used by many practitioners. Also, other measures are also proposed to capture global economic activity. Krichene (2002) employs real global GDP as a proxy for world economic activity. Cunado and Gracia (2003) use the Industrial Production Index to investigate the influence of oil price shocks. Melolinna (2012) proposes an alternative coincident oil demand indicator to capture the direct impact of oil demand pressures. Although Kilian's measure is not free of shortcomings, it is a common practice to use Kilian's real economic activity index in recent oil price related studies.

Based on the above literature, I include world crude oil production, global economic activity index and the world price of oil in the model of oil price decomposition in Chapter 1. Besides, different to most of the previous research that mainly employs the exchange rate as an indicator of U.S. monetary policy, I use a direct characterization-"M2" to explore the possible influence of U.S. monetary policy in the development of global oil prices. Further, I include both M2 and real effective exchange rate in China as two major indicators of the Chinese monetary policy to study the possible China's effect on world oil prices. Details about the model specifications are discussed in the next section.

1.3 Data and Methodology

1.3.1 Data Sources

The data set used in Chapter 1 is composed of six variables: the growth rate of world oil production, the level of the world real economic activity index proposed by Kilian, the growth rate of U.S. real M2, the growth rate of China's real M2, the growth rate of China's effective exchange rate and the growth rate of oil price. Specifically, China's real effective exchange rate is defined as the currency value of RMB against a basket of other currencies. All data are measured in monthly frequency and cover the period of June 1996-Dec 2014. This period was chosen as a result of data availability of the world oil production. The data of world oil production is represented by total world oil supply from U.S. EIA. The world real economic activity index is proposed in Kilian (2009) and can be found at his website. The data series of real U.S. M2 is obtained from FRED (Federal Reserve Economic Data-St. Louis). China's M2 and China's CPI can be found from China's Bureau of Statistics and this nominal M2 is deflated by China's CPI in order to get China's real M2. China's real broad effective exchange rate is also available from FRED. The real price of oil is obtained by deflating nominal WTI oil price, which is also provided by FRED. The WTI oil price is widely used by researchers as a measurement of global oil price. Instead of using CPI or PPI directly, the deflator I use to obtain the real price of oil is the geometric average of PCE index and PPI, which measures the oil price fluctuations. Considering the fact that not only oil is an intermediate good, but also oil is a final consumption good, it is more appropriate to use this constructed index to obtain the real oil price. The constructed index has a base year of 2009. The data of PCE index and PPI can be found in the database of FRED. So, all data series are expressed in real terms. Specifically, the real economic activity index and real U.S. M2 are deflated by U.S. CPI. China's real M2 is deflated by China' s CPI while effective exchange rate is determined as weighted averages of bilateral exchange rates adjusted by relative CPI. The real price of oil is deflated by the geometric average of PCE index and PPI, which is a better characterization of price changes in world crude oil.

Besides, the seasonality issue is also considered before I fit the data into the model. Actually, there is no obvious seasonality issue in global oil production and economic activity index. This statement can be defended as following. First of all, by conducting a seasonality check using X-12 census method, the statistics show that there is no seasonality issue for world oil production. Besides, although U.S. refineries would lower production as they undertake seasonal maintenance; normally the entire world oil production shows no evidence of seasonality. Secondly, the world real economic activity index adopted in Kilian (2008) is detrended by construction, so there should be no seasonality issue for this index. In the meanwhile, U.S. real M2 is already seasonally adjusted in the original data, so I only need to use census X-12 method to test the seasonality issue of China's real M2, China's effective exchange rate and the oil price. The test results show that there is no seasonality issue found in real oil price data. So Census X-12 method is adopted to adjust the seasonality issue of China's real money supply and effective exchange rate.

Then, all data series are expressed in real term without seasonality issues. Finally, except the index of real economic activity, all variables are expressed as log first difference in order to get the growth rate transformation and achieve the stationarity. The plots of these data series used in Chapter 1 are summarized in Figure A.1 to Figure A.6 in Appendix A.

1.3.2 **Methodology**

In this chapter, I use a structural vector autoregression model to disentangle oil price shocks in to six components: shocks in oil supply, shocks in global aggregate demand, U.S. money supply shocks, China money supply shocks, China real effective exchange rate shocks and the demand shocks related to global crude oil market[2]. Five

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[2] I do not include a measure of inventories in this model. The reasons are as following:

(1) The data for global oil inventory is not readily available. Even if the data is available, the quantification of the effect of inventory shock heavily depends on the data quality. Besides, the impact of this forward-looking oil stock behavior related with speculation is difficult to be identified in the standard model because speculators may respond to information that is not available to the modeler.

(2) The oil-specific demand shocks can mainly reflect changes in inventory practice and speculative activities.

major factors that would influence world oil price are considered: oil supply, global aggregate demand, U.S. money supply, money supply in China and real effective exchange rate in China. No direct variable is selected to represent oil–specific demand or precautionary demand. However, oil-specific demand shock is "other" type of shock that can be obtained by factoring out those five different underlying sources from oil price variable. The model used in Chapter 1 is defined as following:

$$A_0 z_t = \alpha + \sum_{i=1}^{7} A_i z_{t-i} + \varepsilon_t \quad (1)$$

$z_t = (\Delta prod_t, rea_t, \Delta M2A_t, \Delta M2C_t, \Delta EXC_t, \Delta rpo_t)'$, which denotes a series of monthly data. $\Delta prod_t$ is the growth rate in global crude oil production. rea_t is the real economic activity index adopted in Kilian (2009). This index is based on dry cargo single voyage ocean freight rates and is defined to account for "the demand for industrial commodities driven by the global business cycle," according to Kilian (2009). $\Delta M2A_t$ is the growth rate of real U.S. M2 while $\Delta M2C_t$ is the growth rate of real M2 in China. ΔEXC_t is the return or growth rate of China's real effective exchange rate. Δrpo_t is the growth rate of real price of oil. ε_t denotes the mutually uncorrelated structural innovations. The lag order 7 in this structural VAR model (1) is chosen based on the following considerations. Although the optimal lag order indicated by AIC is 2, I test the order up to lag 24 to compromise between optimal lags and autocorrelation patterns. Among those lags which pass the regression diagnostic checks, I found that no obvious informational gain is shown after lag 7. So 7 lags are chosen in the final regression model (1). Specifically, the result of residual serial correlation test is summarized in Table J.1 to Table J.6 in Appendix J. From Table J.1 to Table J.6, it can be concluded that the final model is free of residual serial correlation issue. By multiplying A_0^{-1}, the reduced form errors e_t can be expressed as: $e_t = A_0^{-1}\varepsilon_t$, where

$$e_t = \begin{pmatrix} e_t^{\Delta prod} \\ e_t^{rea} \\ e_t^{\Delta M2A} \\ e_t^{\Delta M2C} \\ e_t^{\Delta EXC} \\ e_t^{\Delta rpo} \end{pmatrix} = \begin{pmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{pmatrix} \begin{pmatrix} \varepsilon_t^{\text{oil supply shock}} \\ \varepsilon_t^{\text{aggregate demand shock}} \\ \varepsilon_t^{\text{U.S.money supply shock}} \\ \varepsilon_t^{\text{China money supply shock}} \\ \varepsilon_t^{\text{China exchange rate shock}} \\ \varepsilon_t^{\text{oil-specific demand shock}} \end{pmatrix}$$

The restriction on A_0^{-1} is as follows: oil supply variable would not react to the demand for global industrial commodity, monetary policy, and crude oil specific demand in the same month. This restriction is reasonable due to not only the uncertainty in both crude oil industry and monetary policy, but also the high adjustment cost of oil production, although technically crude oil supply can be increased quickly.

World real economic activity would not react to oil specific demand shocks in a very short period. This assumption is justified by the fact that global real economic activity responds very slowly to the major oil price changes in history. Also, global economic activity would not react to U.S. or Chinese monetary policy within the same month. This restriction is confirmed by the evidence that the speed of expanding the money supply in the United States or China is not fast enough to revive global economic activity.

U.S. money supply would not respond to oil price increase due to innovations in China's money supply or shocks in real effective exchange rate of China in the same month. Also, oil specific demand shocks would not influence money supply in U.S.. These restrictions are supported by the fact that money supply was exploding in

China between Jan 2005 and Oct 2008, while money supply in U.S. was rather stagnated. Also, it's unlikely that U.S. money supply would respond to the innovations in China's exchange rate within the same month due to the uncertainty in policy. In the meanwhile, U.S. money supply does not respond to oil price changes due to speculation considering the uncertainty in world oil market.

Considering consistency in monetary policy and uncertainty in world oil market, China's money supply would not respond to shocks in China's real effective exchange rate and oil specific demand within the same month. Besides, within the same month, China's real effective exchange rate would not affect oil specific demand shocks. This is due to exchange rate regime that China is currently adopting. Since 2005, China has adopted "Managed Floating Exchange Rate". As long as the changes of exchange rate are within certain range, China's central bank will not intervene in the money market frequently, thus changes in effective exchange rate would possess no impact on money supply in short term. Furthermore, float in exchange rate itself can offset the short-term impact of uncertainty on China's macroeconomy. Thus, I assume China's money supply would not respond to shocks in China's exchange rate.

Lastly, shocks in world oil price that can not be explained using global aggregate demand, oil supply, U.S. money supply, China's money supply, and China's effective exchange rate will be attributed to the specific fluctuations in precautionary oil demand caused by expectation in uncertainty of oil supply.

Different from Kilian's scheme, the identification design used here allows me to further refine the underlying factors, such as China's factor, that may have impacts on world oil price evolution.

1.4 Empirical Results

1.4.1 **Unit Root Test**

Prior to fit the data into the SVAR model, I test the stationarity of each time series. The data plots of each variable in its original form, log form and first difference form are shown in Appendix A.1. It's well known that ADF test has low power when span of data is short. For this reason, I also include KPSS and PP tests to improve the precision of test results. The unit root test results are displayed in Table H.1 in Appendix H. From Table H.1 in Appendix H, we conclude that all six variables except real economic activity index are I(1) processes and real economic activity index itself is I(0) process. As a result, all those five variables are first differenced to achieve stationarity. Further, because those five variables are all I(1) processes, Engle-Granger residual based cointegration analysis are conducted among those five variables in order to check whether the cointegration relationship exists. The test results are displayed in Table I.1 in Appendix I, which demonstrates that there is no cointegration among those time series. Finally, the variables except real economic activity index are first differenced to fit the SVAR model in Chapter 1.

1.4.2 **Impact Analysis of Structural Shocks on Oil Price Evolution**

After performing the unit root test for each time series, I use a SVAR approach to disentangle oil shocks in six types: aggregate demand shocks, oil supply shocks, U.S. money supply shocks, China's money supply shocks, China's real effective exchange rate shock and oil-specific demand shocks. Figure 1.1 characterizes the development path of these six different structural shocks from 1997 to 2014. In order to make it more readable, each structural shock series is expressed as annual average[3].

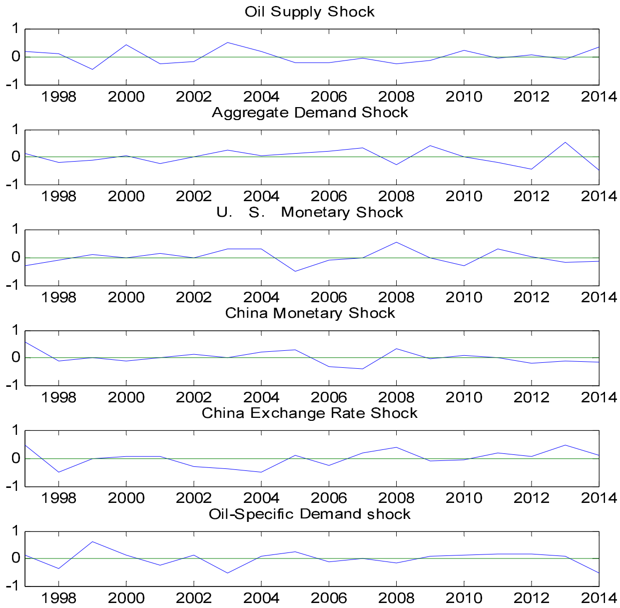

Figure 1.1: Historical Evolutions of the Structural Shocks: 1997-2014

From Figure 1.1, I can tell that oil price reacts to a combination of structural shocks that change over time. During the year of 2008, there is a small reduction in world oil supply, which is associated with the cutoff of oil production in Venezuela and Nigeria during the first half year of 2008. However, U.S. money supply has an obvious jump during that period. Both global aggregate demand and oil specific

[3] Actually, the structural shocks in Figure 1.1 are expressed as annual average in order to improve the readability. I followed the same way as what has been done in Kilian (2008).

demand decline to certain degree while China's money supply and effective exchange rate increase at that time. The decline of aggregate demand in 2008 is not surprising. Actually, in the first half of 2008, total global demand is very strong. However, in the second half, due to the financial crisis and the following economic recession, worldwide economic activity is adversely affected. As a result, a drop in global aggregate demand is shown in Figure 1.1. Regarding to the declining precautionary demand that is specific to world oil market, the same reason is revealed. It's widely believed that speculation on the future oil price overshot oil price during the first six months in 2008 and undershot oil price in the remaining months in 2008. Daily trading in oil future approached fifteen times of daily global oil production, which is the evidence of financialization of the oil market and related speculative activities. Although speculation spread over the oil market due to the strong global aggregate demand in the first half of 2008, financial crisis afterwards drives down the expectation. In summary, for the year of 2008, there are evidences of reduction in oil supply, increases in U.S. money supply, money supply in China and effective exchange rate. Therefore, a price spike of oil is observed around the end of the second quarter in 2008 while a deep drop is seen in the last quarter in 2008. Another example is the oil price collapse in 1998. Actually, no obvious impact of oil supply is shown at that time, but decline in global aggregate demand is observed. This is consistent with the fact that Asian financial crisis brings a halt to the rapid growth of Asian economies, which heavily affected people's confidence in the future economy. In the meantime, China's money supply and real effective exchange rate fall significantly. These examples demonstrate that model (1) can well disentangle and capture the different types of oil shocks in history. Besides, it shows that oil prices respond to a combination of underlying shocks. Also, it can provide evidence which may support or disprove the popular view that China is responsible for the oil price increase in 2008. In order to make a final judgment on this issue, further studies need to be conducted. However, it can be concluded from Figure 1.1 that quantifying different types of structural shocks is essential to determine the relative importance of underlying sources of disturbances in driving oil price up and down.

Figure F.1 in Appendix F demonstrates the impulse response patterns of world crude oil production, world real economic activity, U.S. money supply M2, China's money supply M2, China's effective exchange rate and the real oil price to structural shocks at one standard deviation. The structural shocks are devised to be positive innovations, which is consistent with normal convention. Also, a bootstrap method is adopted to construct the 95% and 68% confidence intervals. The actual directions of oil price responses (after a certain number of months) regarding to those positive shocks are summarized in Table 1.1.

Table 1.1: Chapter One-Summary of the Signs of the Impulse Responses of Oil Prices.

	ε_1	ε_2	ε_3	ε_4	ε_5	ε_6
sign	-	+	+	-	-	+

Notes: The sign indicates how oil price responds to all types of positive shocks. ε_1- ε_6 are oil supply shock, aggregate demand shock, U.S. money supply shock, China money supply shock, China real effective exchange rate shock and oil-specific demand shock, respectively.

Thus, it can be seen from Table 1.1 that, besides oil supply shock, China's money supply shock and China's effective exchange rate shock, oil price reacts to the other three types of shocks positively. The positive shocks of a variable means shocks that tend to increase the variable of interest by certain amount. The explanations of the signs are straightforward. Expansion in oil production or positive oil supply shocks tend to lower real price of oil while increase in precautionary oil demand or global aggregate demand are likely to drive oil price up. Also, increase or positive shock in U.S. money supply will bring about pressure in dollar depreciation, resulting in a rising real price of oil. Besides, positive shocks or increase in effective exchange rate means appreciation in RMB, thus less export and corresponding decrease in demand of oil, which may also drive down the price of oil.

The negative responses of oi prices with respect to positive shocks in China's moneys supply seem counterintuitive at the first glance, however, it is reasonable after further consideration. Generally, an increase in money supply would stimulate the economy by adding investment in the manufacturing sector and the expansion in the manufacturing sector can finally bring a higher demand in oil. But, this is not aligned with China's experience. Actually, China's increase in money supply does not stimulate but rather reduce the investment in the manufacturing sector. This can be explained in the following aspects. Firstly, since 1990s, overinvestment has emerged in almost every traditional area of manufacturing. The lower return as a result of overproduction impedes the additional investment in the manufacturing sector in the subsequent years. At the same time, because of the lack of knowledge and advanced equipment, even though the interest rate becomes lower due to the increase in money supply, it cannot effectively stimulate the investment in the rising high-tech manufacturing which could generate high profit. Secondly, since 1998, Chinese real estate price has been facing a rapid growing[4]. Sustained expansion in money supply stimulates the growth in credit, which provides a solid foundation to the development of the market of real estate, which requires less input of oil. As a consequence, the real estate market absorbed a substantial portion of the money supply increase, which could have been reinvested in the manufacturing sector. Thus, more and more capital switched from the manufacturing sector to the market of real estate due to the much higher profit margin. As a result, the demand in oil is actually injured by the money supply increase. Besides, China's stock market has also absorbed a substantial amount of money supply in recent decades. In 2010, the total market capitalization in domestic stock market is 26.5 trillion RMB. By contrast, the total market capitalization is only 347.4 billion in 1993. Actually, the capability of absorbing money in stock market is much higher than the real estate market, in terms of the total amount. So, the significant development in both real estate market and equity market in China contribute to take in the excessive money supply. No matter it is stock market or real estate market, the occupied money in either market can not be withdrawn quickly and utilized by other areas which have substantial demand for oil, such as the manufacturing factor. Based on those above reasons, , it is not unusual to observe that an increase in China's money supply can lead to a decrease in oil demand thus a lower world oil price.

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[4] Since 1998, China begins to implement the housing marketization reform. Before 1998, China had a welfare real estate policy that employees could get apartment ownership from their employers for free, based on the employees' tenure and position. After 1998, as the Chinese economy changes from the past socialism structure to the market economy structure, the real estate market became commercialized such that employees would have to purchase their apartment ownership using their own money. From 1998 to 2008, the average housing price has increased by 230%.

The initial negative impact of an increase in U.S. money supply on the oil price, which is shown in Figure F.1 in Appendix F, is not a contradiction to my above findings. Sometimes, the feedback of the general price level (including commodities prices) to an expansionary monetary policy shock could be negative initially, although this feedback will turn positive very soon. This phenomenon is referred to as "Price Puzzle"[5] of monetary policy. One possible explanation is as following: Under certain circumstances, Federal Reserve systematically responds to signals of deflation by expanding money supply, but this expansionary monetary policy is not strong enough to avoid the subsequent deflation. Thus, an initial negative response of oil price with respect to increase in U.S. money supply is observed. Besides, this initial inverse relationship can also be explained by Keynes' money liquidity preference theory. Public may desire to hold cash due to the transaction motive, the precautionary motive and the speculative motive. If increase in money supply is used to satisfy people's increasing demand for liquidity, it will not lead to the price increase of commodities. Further, if the demand for liquidity is big enough, it can even result in a decrease in price of commodities due to a reduction in consumption. In fact, it's observed that increase in U.S. money supply in recent years does not result in higher inflation, but ends up with lower inflation. At the same time, there is a rapid growth of high liquidity assets existing in private sector, such as short-term government bond.

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[5] The discussions on the issue of "Prize Puzzle" are inconclusive. Some believes that it is a sign of a problem with the empirical model (Sims (1992)). Some asserts that even if correcting for the model specifications, the "Prize Puzzle" was still there. (Ziaei (2012)). Besides, others claim that "Prize Puzzle" is a genuine phenomenon and it depends on how closely the data from a given time period conform to determinacy or indeterminacy. (Dueker (2006)).

From Figure F.1 in Appendix F, we can see that although all variables respond to their own positive shocks on impact, they behave differently in response to other structural shocks. Specifically, an unanticipated positive innovation of global oil supply brings a persistent increase in worldwide oil production. In the meanwhile, it leads a trivial growth in global real economic activity in the following five months upon impact. After that, this impact becomes negative but with no statistical significance. At the meantime, U.S. M2 responds negatively to a positive oil supply shock within the entire horizon, although the impact dies out quickly and is insignificant for the entire horizon. Similarly, the response of China's money supply M2 to this increase in oil supply is negative and insignificant. Increases in oil supply possess a positive influence in effective exchange rate with no statistical significance. Not surprisingly, this positive oil supply shock or unexpected increase in oil supply triggers a significant decrease in real oil price for most of the horizons, although a partial reversal in trend is observed around the third month upon impact.

An unanticipated aggregate demand increase or a positive aggregate demand shock triggers an increase in world oil production. Not surprisingly, the unexpected increase in global aggregate demand causes a highly significant and persistent increase in global real economic activity upon impact. However, the U.S. money supply M2 responds negatively to this unexpected increase in global aggregate demand and this negative effect continues for the entire period with significant statistical inference. China's money supply M2 behaves in the similar way as U.S. money supply, but the magnitude of the response is smaller and the impact is insignificant for most of the horizons. Besides, an increase in aggregate demand possesses a positive effect on China's exchange rate upon impact. Then this impact becomes negative after the fourth month and turns positive again around the tenth month. However, the impact is insignificant for the entire horizon. As expected, the real oil price is positively and significantly affected by a positive aggregate demand shock for the entire period.

A positive innovation in the U.S. money supply M2 temporarily reduces oil production for about five months with no statistical significance. After that, an increase in oil production is followed but with no statistical significance. In the meanwhile, the increase in the U.S. money supply brings a limited reduction in global real economic activity for the first three months with partial statistical significance. One reason is that the increase in U.S. money supply would make dollar depreciate against the currencies of its major trade partners. This depreciation in dollar can hinder U.S. imports, which can reduce international trade activity for a short time period. However, later on, the positive U.S. monetary shock brings a positive and persistent increase in the real economic activity, which is statistically significant. Unsurprisingly, positive U.S. monetary shock induces a significant and consistent increase on the U.S. money supply. Besides, this positive shock in U.S. money supply also introduces a positive and significant impact on money supply in China. Also, the unexpected increase in U.S. money supply has a small positive[6] effect on China's effective exchange rate at the first two months, and then the effect becomes negative until the end of the entire horizon. But the effect is only statistically significant for a very short period. Increase in U.S. money supply at first drives down the real price of oil, but

[6] China's real effective exchange rate is defined as the currency value of RMB against a basket of other currencies. The higher the number, the more valuable the RMB is. So here, an increase in U.S. money supply brings about an increase in China's real effective exchange rate, thus an appreciation in RMB.

then the effect becomes positive with statistical significance. The initial short-lived negative effect of U.S. money supply on oil price can happen due to the "price puzzle" of monetary policy. Although the "Price Puzzle" is commonly referred to the fact that expansionary monetary policy can possess a negative influence in the general price index, the impact of increasing money supply on commodities price, such as oil, is similar. Further, although it is not agreed upon the reasons underlying the "price puzzle", one possible reason supported by Balke and Emery (1994), is that Fed's expansion in money supply is not strong enough to avoid the subsequent deflation. Another explanation behind this phenomenon may rely on people's increasing demand for liquidity. If the demand for liquidity is high enough, it can even lead to a decrease in consumption and a corresponding drop down in commodities price. But this relationship is reversed quickly and a positive impact of the increase in money supply on real oil price is observed for the remaining period. Based on the results, the impact of U.S. money supply on oil price is persistent.

Regarding to the positive shocks in China's money supply, oil production has very little response during the entire horizon. Global economic activity responds to an unexpected increase in China's money supply negatively for the most horizons but only with statistical significance for a very short period. Besides, the U.S. money supply responds to the unexpected increase in China's money supply positively without statistical significance. Also, it's expected to see a significant increase in China's M2 with regard to the positive innovations of China's money supply. Meanwhile, China's effective exchange rate responds to the unexpected increase in China's money supply negatively, although this effect is mild and has no statistical significance for most of the period. Besides, it is not a surprise to see that an increase in China's money supply leads to a persistent decrease in the real price of oil. The inverse relationship between China's money supply and the real world oil price can be explained that an increase in China's money supply can be substantially absorbed by the stock market and the real estate market in China, rather than investment in manufacturing. Furthermore, the high profit margin can even attract more and more capital to flow from manufacturing into the real estate market and the stock market, which requires less input of oil. Thus, increase in money supply would not necessarily increase the demand for oil or can even lead to a decrease in oil demand. As a result, it can be observed that world oil price decreases when China's money supply increases.

Another shock from China, the positive effective exchange rate shock possesses a positive influence in world oil production during the first two months. The possible explanation is that appreciation in RMB would increase China's demand in imported oil, thus a corresponding increase in world oil production. Afterwards, the effect turns negative but is insignificant for most of the horizons. However, a positive shock in China's exchange rate has a negative and significant impact on global real economic activity. This can be explained by the fact that the appreciation in RMB will greatly affect China's export, which is an important component or indicator of global economic activity. Besides, money supply in U.S. and money supply in China have positive responses with respect to an unexpected increase in China's exchange rate. Appreciation of RMB could make the Chinese government increase its money supply in order to stabilize its currency value. At the same time, U.S. government would increase its money supply to further advance the appreciation of RMB, which is beneficial to improve U.S. balance of international payments. As expected, China's exchange rate responds to its own positive shocks significantly. Also, appreciation in

RMB brought by positive innovations in China's effective exchange rate possesses a negative and significant effect on the oil price for the entire horizon. One possible explanation is that although appreciation in RMB can increase China's demand in imported oil on one hand, this appreciation can greatly depress China's export, thus corresponding demand in oil on the other hand. Further, the former positive effect on demand of oil is stronger in the short run while the latter negative effect on demand of oil is stronger in the long run, which can be evidenced that the impulse response of global oil production with respect to positive China's exchange rate shock is positive at the first two months and is negative for the rest of the projection period. As a result, in the short run, the negative impact of a positive exchange rate shock on real oil price is mainly because of the increase of world oil production. At the meanwhile, in the long run, the negative response of world oil price with respect to a positive China's exchange rate shock is majorly because of the sluggish demand in oil.

Finally, a positive innovation to oil specific demand has a negative influence in world oil production for the first two months and then this impact becomes positive and diminishes quickly for the rest of the period. However, an increase in oil demand leads an increase in global economic activity in the first four months and then the effect dies out very fast with no significance. One reason is that a positive oil-specific demand shock represents an increase in oil demand due to the expectation of the instability of future supply. This increase in oil demand will be reflected in the increase of world economic activities through inventory practice and other speculative activities. Besides, an increase in oil specific demand has a negative influence in the U.S. money supply. Similarly, the negative effect is also observed w.r.t. China's money supply. Increase in oil-specific demand will boost oil price, which can bring an inflation pressure in the economy. As a result, central bank in U.S. and China will implement a stringent monetary policy to react against the possible inflation in the future. Also, there is no significant impact of an increase in oil specific demand on China's effective exchange rate. Nevertheless, it has an immediate and long lasting positive influence in the real oil price. The magnitude of the effect keeps relatively stable around a certain level.

By summarizing the results demonstrated in Figure F.1 in Appendix F, I find the following interesting findings. First, positive innovation in global oil supply are not an important driver in oil price fluctuations, comparing to the significant and persistent impact of positive aggregate demand shocks on world oil price. The finding is aligned with the popular view that it is the demand rather than supply, which dominates the trend of global oil prices. My results approve their assertions that a shortage of oil production in one region can trigger production expansion elsewhere, thus oil production would not impact the price trend of oil.

Second, an increase in the U.S. money supply has a long-lived but lagged positive influence in the real oil price. The reason is as following: although an increase in U.S. money supply will finally bring a higher oil price in the global oil market, the impact of a positive U.S. money supply shock on world oil price can be negative at the initial response stage. One possible underlying reason is that Federal Reserve systematically responds to signals of deflation by expanding money supply, but this expansionary monetary policy is not strong enough to avoid the subsequent deflation. This can result in the initial negative relationship between money supply and oil price, which is called the "price puzzle" of monetary policy. Besides, people's high demand for liquidity not only can absorb the increased money from central bank, but also can absorb the money which could have been used for consumption. As a result, the demand for oil goes down and the corresponding oil price decreases.

Third, both China's positive money supply shocks and positive effective exchange rate shocks demonstrate negative impact on the real price of oil with statistical significance. Although many researchers claimed that China should be responsible for the recent oil price increase in 2008, no strong statistical evidence is found to support this view, at least from China's money supply and exchange rate policy side. On one hand, although a large positive shock in money supply is observed in 2008 from Figure 1.1, the effect of money supply in China on the world oil price is negative rather than positive, according to the impulse response analysis results in Section 1.4.2. Actually, from the impulse response analysis, positive China's money supply shocks bring very significant negative impact on world oil price. So if we observe China's central bank implemented expansionary monetary policy to stimulate the economy in 2008 as described in Figure 1.1, this should bring negative influence rather than positive influence in world oil price. Then the expansionary policy in China, which is regarded by many researchers as one of the reasons to stimulate Chinese economy, should not be responsible for the world oil price increase in 2008. Meanwhile, positive innovations in real effective exchange rate are seen around 2008, which should bring a decrease, rather than an increase in the world oil price based on the impact analysis results. As a result, my conclusion is that although China may have an impact on world oil price through certain transmission mechanisms, China's money supply policy and exchange rate policy in 2008 should definitely not be responsible for the oil price increase in 2008.

Finally, a surge in precautionary oil demand has the biggest impact on soaring oil prices. This result is consistent with what has been found from Kilian (2008) and reflects the importance of expectation about future oil supply in triggering the upward movement in world oil prices.

In conclusion, impulse response analysis results in Figure F.1 in Appendix F suggest that all shocks except oil supply shock can be the major drivers behind oil price fluctuations. In order to investigate and further justify the relative importance of different factors behind the changes of real oil prices, I conduct historical decompositions analysis in the next step.

Figure 1.2 displays the cumulative contribution of each structural shock to the development of oil price in monthly frequency. It is calculated by cross-multiply the effect of a specific shock on the real oil price with the structural shock in study. Specifically, the effect of a given shock on the real oil price is represented by the impulse response of oil price with respect to that specific shock.

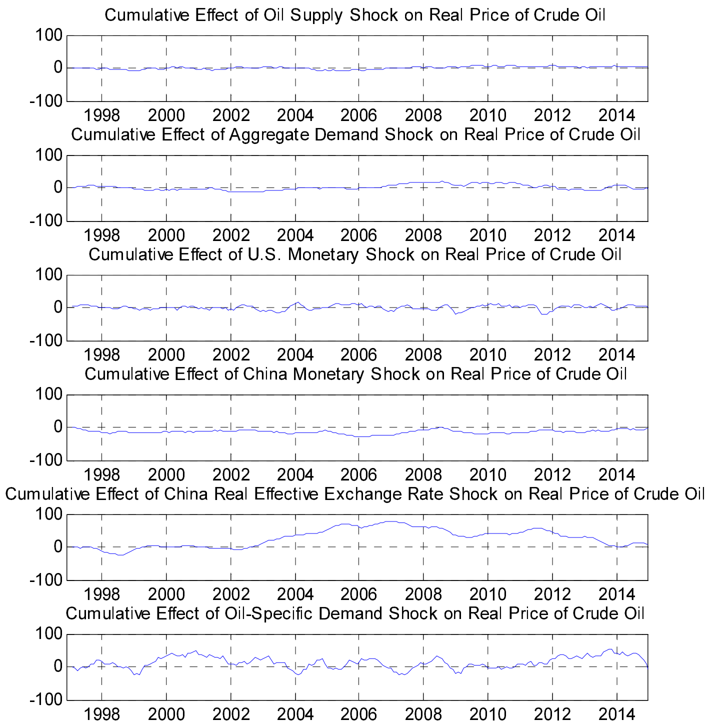

Figure 1.2: Historical Decomposition of Oil Price Shocks: 1996m11-2014m12

In summary, oil-specific demand shocks and China's effective exchange rate shocks make the largest contribution to the fluctuations of oil price. Although U.S. money supply can have a direct impact on real oil price because oil price is denominated in U.S. dollars, the effect is not necessarily larger than that of China's real effective exchange rate. On one hand, due to the "prize puzzle" explained in Section 1.4.2, increase in U.S. money may not necessarily increase the oil price as expected. On the other hand, depreciation in RMB would greatly impact China's export, thus stimulating the demand of oil. The big influence of China's effective exchange rate in world oil price can be true, especially considering China's contribution in global oil consumption in the studying period. While U.S. money supply shocks, China's money supply shocks and global aggregate demand shocks cause relatively large impacts on the real oil price, oil supply shocks make little contribution to the dynamics of real oil price. While the cumulative impacts of other types of shocks are relatively stable, oil-specific demand shocks and China's real effective exchange rate shocks are relatively volatile. Thus, the results reveal that structural shocks are not alike in the relative significance in contributing to the evolution of oil price. Also, these results show that China's factor, such as exchange rate policy, contributes to the trend of world oil price after 2002, although it is not the reason behind the world oil price increase in 2008.

The specification of this model is not perfect, but it is based on sound theoretical foundation. First of all, it captures most of the fundamental factors in driving oil price evolution, such as oil production, global aggregate demand and U.S. money supply. All these factors are commonly used and accepted in the previous literatures. Besides, I include China's money supply and China's real effective exchange rate to further study China's possible effect on the world oil production. Thus, almost every possible factor behind oil price evolution is included in the model. Oil inventory variable is not included in the model specification due to data unavailability, but oil-specific demand shocks associated with expectation in future oil market can largely capture the precautionary demand shocks in oil inventory, which can mitigate the concern of not include oil inventory variable in the model. Secondly, the rationale behind the coefficient restriction matrix, which is crucial to identify different types of oil shocks, is well defined and can stand up to scrutiny. Besides, the results that oil-specific demand shocks and China's real effective exchange rate shocks make relatively largest contribution to the oil price fluctuation is possible and reasonable when considering the study period in this chapter. The study mainly focuses on post 1997 era when other factors besides oil supply and demand begin to emerge and behave actively in the world oil market, such as China's growth and oil speculation. Based on all above reasons, the model specifications and results are reliable.

Chapter 2

IMPACTS OF OIL PRICE SHOCKS ON CHINA'S MACROECONOMY-LINEAR REGRESSION AND IMPULSE RESPONSE ANALYSIS

2.1 Introduction

2.1.1 Motivation

In theory, there are various transmission channels where an oil price shock can impinge on the macroeconomy. The first channel, which is widely accepted by economists, is the supply channel. Based on the "cost-push" type of view, oil price increases will switch firms' attention towards less energy intensive production, resulting in a corresponding reallocation of available capital and labor resources. The cut in utilization of existing capital and labor eventually creates a consequence of output decline due to an initially upward shifting aggregate supply curve. Lilien (1982), Davis (1987) and Loungani (1986) all emphasize this type of "dispersion hypothesis" in affecting the U.S. economy.

As a counterpart of the supply channel, the demand channel focuses on the influence of an oil price shock in the aggregate demand. The direction and magnitude of the impact depends on the countries' net imports of oil. A net exporting country will benefit from an oil price increase, and thus stimulating aggregate demand in its homeland while the net importing country will experience the opposite.

However, considerable evidence refutes the above hypothesis, which indicates the characterization is too simple and overlooks other alternatives. Therefore, a new generation of theoretical transmission channels has emerged. One of these alternative channels emphasizes the role of monetary policy. On one hand, oil price growth lowers real money balances and produces corresponding recessions, as a result of inflation brought about by increasing prices. On the other hand, contractionary monetary policy implemented to react against inflationary pressure can further aggravate the decline in the real output.

The two other channels that depress the role of the oil price in accelerating economic downturn pay special attention to the relative price changes and oil price volatility. The former channel believes that relative factor price changes cause specialized labor and capital shifting between sectors while the latter channel affects the economy by postponing agents' investment in face of uncertainty in the future.

The conclusion in which channels take major effect in transmitting oil price shocks to macroeconomy seems indecisive and evidences across different countries are mainly from OECD countries. Actually, different channels operate with different strengths across different countries. The supply channel or input cost channel may be more important in developing countries than developed countries, because production in developing countries is relatively more energy intensive. In the meanwhile, the demand channel may also play a more important role in developing countries as a result of larger weight of fuel and food in the consumption bucket. Besides, depending on what kind of central banks they have and how developed the financial markets are, monetary policy channel and other channels could have different importance in the oil price transmission process. Inspired by this fact, I will explore the transmission mechanism of oil price shocks on the macroeconomy in China. Thus, the main task in Chapter 2 is to find the answers to those following questions: what transmission channels of oil price shocks are more important than others in China? Do China's major macroeconomic variables have different response patterns in respect to different underlying oil price shocks? Are there any differences between China and other major developed countries, including U.S., in the response patterns?

2.1.2 Background of China's Energy Market

According to IMF, after an average of 10% real GDP growth rate from 2000 to 2010, China still keeps growing at 7.7% in 2011. Meanwhile, China was the 2nd largest oil importing country and the largest energy consumer since 2009, according to EIA. Besides, China is the largest coal consumer and producer. The giant energy demand brought by soaring economic growth attracts the attention of people worldwide.

Actually, back to the 1990s, this country was still a net oil exporter. However, China became the 2nd largest oil consumer since 2009. Although China endeavors to diversify its energy supplies, renewable resources constitute a marginal share of total energy consumption mix. Oil makes up 19% of total energy consumption while coal meets the majority of needs, which is about 70%. Economic growth, power generation, transitions in transportation sector, as well as oil refining capabilities all contribute to the surging demand for oil.

Unlike most of the developed countries, where oil prices fluctuate freely without government control, China has its unique oil pricing system and deserves our special attention. Actually, domestic oil product prices are lower than that in the global market. The producer price of crude oil in China experiences four major stages of development. Before 1981, oil prices were under the tight control of central and state governments. During the period from 1981 to 1994, the government initiated dual-track pricing mechanism, in which scarce commodities, such as oil products, are sold by Ministry of Petroleum at quota price; otherwise, production beyond the quota can be sold at much higher market prices. Regulated by the pricing mechanism, crude oil prices were substantially under government's control. Between 1994 and 1998, dual-track pricing was obsolete and prices under state control returned. Since 1998, central government in China tries its best to set domestic oil prices in accordance to the global market by deregulating oil pricing system step by step. In 1998, after adopting the new pricing mechanism, the monthly oil price was set by the average of prices last month in major world oil markets. However, China national oil corporations, such as SinoPec and PetroChina, had to sell petroleum products following the guided prices regulated by the National Development and Reform Commission, allowing for a range of fluctuation within 5% on the retail price. In 2000, the oil pricing was changed to be determined according to the average closing prices last month of Singapore future market. Shortly after that, the pricing mechanism was revised again to turn to a weighted average price of last month incorporating New York, Rotterdam and Singapore future markets. In 2009, China imposed a fuel tax and launched a reform of oil pricing system in order to tie domestic retail prices of oil products closer to the world oil market. The current oil product pricing regime allows National Development and Reform Commission (NDRC), which is the primary regulatory authority in China's energy sector, to adjust retail prices when the moving average of imported crude oil prices jumps outside of a 4% range within 22 consecutive working days for diesel and gasoline (IEA, 2013).

The special pricing mechanism may help to explain why Chinese economic growth seems insensitive to world oil price shocks for a long time. However, the implementation of this pricing mechanism causes other disturbances. When NDRC does not raise downstream fuel prices at the same rate at the time of increasing crude oil prices worldwide, downstream refiners will suffer profit losses and they are induced to increase their fuel product export, rather than supplementing the domestic market. This in turn will put pressure on the leading authorities to raise domestic prices or ease taxes. Actually, for the sake of better matching up with world oil prices, NDRC increased retail oil prices twice at the beginning of 2012 and cut prices three times by about 14 percent in mid-2012.

Consequently, international oil price shocks will inevitably have their impacts on many aspects of China's economy through a variety of transmission channels, although price control policy may have certain effect in isolating the impact of global oil price. Actually, Chinese government's price control is majorly concentrated on the downstream oil consumption products, such as gasoline and etc. So the price control may insulate the influence of world oil price[7] fluctuation in the macroeconomy in China at certain degree through the transmission channel of CPI, however, the impact of world oil price shock can transmit through other channels, such as PPI. World oil price increase can also discourage investment in energy sector as well as other growth-promoting spending, resulting in a sluggish economic development. Actually, oil refinery firms not only produce oil product for consumption, such as gasoline, but also produce chemical products which are very important raw materials for firms who

[7] The data on the effective oil price in China is unavailable. Although the world oil price is not an effective oil price in China, it does affect the China's economy indirectly because oil pricing in China is still based on the average price of major world oil markets. Besides, the existing literatures on the influence of oil price shocks in China's economy all adopt the measure of world oil price.

produce synthetic materials, like Polyvinylchloride(PVC), rubber and fiber. For the former product, when the world crude oil price increases, oil refinery companies may suffer profit loss due to domestic price control on the oil consumption product. But they can get subsidy from government as compensation. However, the prices of the latter products are largely affected by world oil market. So the pressure of rising crude oil price that oil refinery firm faces can be easily transmitted to the downstream firms and finally to the price of industrial product. In the meanwhile, rising oil price may increase the production cost of exporters. Besides, although capital control has been loosened a lot since 1990s, it is an essential factor in stabilizing China's financial system in the previous development. So the capital control policy may help limiting capital getting into or getting out of China freely to some extent when world oil price changes. Also, the impact of oil price could be transmitted through the channel of monetary policy. Furthermore, stringent monetary policy in reaction to increasing price of oil may aggravate the ongoing economic recession.

2.1.3 **Contribution**

The research in Chapter 2 endeavors to contribute to previous literature in the following aspects. First, this paper is the first to assess the response patterns of different oil price shocks on China's macroeconomy. Previous literatures are mainly focusing on the effect of real oil prices on China's macroeconomy while not stratify the underlying sources of oil price shocks. Also, the results obtained in China would contribute to the existing literature on comparing the influences of various oil price shocks in different countries.

Second, most of the existing literatures about oil price shocks on macroeconomy in China use data at quarterly frequency. Here, by using monthly data instead of quarterly data, I can capture the effect of different shocks on China's economic activity more timely and more realistically.

2.1.4 Organization

Chapter 2 is arranged in the following way: Section 2.1 points out the motivation and contributions of the study carried out in Chapter 2. Section 2.2 retrospects the development of the relevant literature about the influences of oil price shocks in major economies, including the United States and China. Section 2.3 talks about the methodology and data employed in Chapter 2. The empirical results are shown in Section 2.4.

2.2 Literature Review

2.2.1 Oil Price Shocks on U.S. Economy

Following the oil price increase that occurred between 1973 and 1974, a strand of empirical literatures begin to emphasize the influence of oil supply shocks in the macroeconomy, which is regarded as permanent due to the non-renewable property of oil as a kind of natural resource. This permanent oil price shock assumption underlies the studies both by Rasche and Tatom (1977) and Bruno and Sachs (1982). Although people keep finding more oil reserves and developing new oil technology in the past decade, oil is still considered as a natural resource with limited stock in the world.

Hamilton (1983) proposes and tests three hypotheses of possible explanations to the phenomenon that recessions are preceded with drastic oil price increases since World War II. They are stated as following: First, the correlation between oil price increase and the subsequent recessions are purely a coincidence. Second, certain endogenous variables underlie the economic downturns and the oil price increases. By employing Sim's (1980) six-variable VAR model specification and a series of Granger-causality tests, Hamilton rejects the first two explanations and thus supports his last hypothesis that oil price increase is an important factor to certain recessions in the U.S. before 1973. His inclusion of oil price shocks in the framework of "Real Business Cycle" model further supplements Rasche and Tatom's study and shifts the popular view of what world oil market has experienced after 1970s from an permanent accelerating scarcity standpoint into a temporary unstable geopolitical power in oil production countries, which is held up by Burbidge & Harrison (1984), Griffin (1985), Jones (1991) and Watkins (1992).

Followed the work by Hamilton (1983), Gisser & Goodwin (1986) further confirm that oil price shocks contribute to certain macroeconomic variables. Moreover, they conclude that there is a stable influence pattern of oil shocks on the economy before and after 1973, which is contrary to the general impression of the advent of the new era of OPEC.

With many empirical evidences of impacts of oil price shocks on the macroeconomy, another strand of research focus on the attribution issue of oil price shocks. They try to figure out not only whether or not but also to what extent, recessions are caused by oil price shocks, monetary policies or some other factors.

Romer & Romer (1989) adopt the "narrative approach" pioneered by Friedman and Schwartz to investigate the relationship between real business cycle and monetary policy during the period of post-World War II. By identifying the historical monetary policy using this approach, Romers make the conclusion that six of the eight postwar recessions are caused by the Fed's monetary contractions to combat "excessive" inflations, which blurs and even negates the significance of oil price shocks in influencing the U.S. economy post the Second World War.

On the ground of the analysis of Hamilton (1983) and Romer & Romer (1989), Dotsey & Reid (1992) reexamine the issue of whether oil price shocks or monetary implementations should be responsible for the postwar economic performance in the United States. First, they add oil prices in Romers' analysis and find out that the inclusion of oil prices leads to the insignificance of monetary policy. Then they modify Hamilton's model by using interest rates as a proxy for monetary policy and finally, they argue that both oil prices and monetary policy are the driving forces towards the subsequent dynamics in real economic activity.

The empirical evidence (Ferderer (1992) & Lee, Ni, and Ratti (1995)) that oil prices have less explaining power to account for the movements of the majority of the U.S. macroeconomic indicators after 1985 has elicited a wave of discussion on a number of possible conjectures. However, the outcome obtained in Hooker (1996) explicitly demonstrate that neither the linearity assumption in the relationship between output and oil price nor the symmetric specification in the response pattern of major economic indicators to price shocks of oil is convincingly supported.

Rotemberg and Woodford (1996) try to dig into the old question from a brand new perspective by adding imperfect competition in their model specifications. They accentuate that the predictions on output and real wages using oil price will be greatly improved by involving a certain degree of imperfect competition, which will change the markups over the business cycle. Besides, they make it a reality to incorporate all kinds of models, like perfectly competitive product markets, monopolistically competitive product markets and their implicit collusion model, into one model under a single specification.

BGW (1997) examines the impacts of oil price fluctuations together with systematic or endogenous monetary policies by modifying the VAR procedure proposed in Sims and Zha (1995). The empirical results conform to their claim that it is the tightening monetary policy rather than oil price changes that contribute to the effect of oil price shocks on the macroeconomy, which offers attributions to the statement that energy costs are so trivial relative to costs of total production that it cannot be accountable for the entire decline in production. (Kim & Loungani (1992) and Rotemberg & Woodford (1996)). However, Hamilton and Herrera (2004) challenges the conclusion in BGW's paper that monetary policy can be applied to eliminate any depressive effects followed by an oil price increase. They interpret their findings from two angles. First, they take the case in 1974 as an example to illustrate that whether the Fed is capable of implementing a contractionary monetary policy by increasing the Federal Funds rate up to 900 basis points to avoid economic malaise afterward remains questionable. Second, the relatively small magnitude of oil price effect that claimed in BGW's paper is mainly the result of the choice of a shorter lag length.

Darrat, Gilley and Meyer (1996) employ difference in difference of oil prices and use various lag lengths for different variables in their analysis of industrial production growth. By making these distinct changes relative to previous research, they claim that oil prices propagate through demand for oil consumption as well as monetary & fiscal policy, rather than direct shock on output. However, Hamilton (1997) comments that it is the existence of nonlinear relationship between oil prices and output growth from 1973 to 1993 instead of manipulation of lag lengths on variables that leads to a failure of finding a significant role of oil prices on the macroeconomy. Otherwise, a strong connection between the variables will be clearly shown when exploiting different measures or sample periods, all of which is refuted in the later work done in Darrat & Gilley (1997).

Although a large portion of literature agrees with the conclusion that oil price shocks greatly impact the U.S. macroeconomy, the proposition of whether oil price fluctuations contribute directly to follow-up economic breakdown remains unclear, partly in virtue of a much weaker correlation witnessed in the data extended. However, this is not the major concern in this paper, because my focus in this chapter is to see whether macroeconomic variables respond differently w.r.t. different types of oil price shock.

Barsky and Kilian (2004) emphasize that "exogenous political events in the Middle East are not the only important driving forces in the dynamics of oil price shocks." Moreover, the apparently same political events can actually play very different roles from one period to another due to the diversified oil market demand as well as the changing world-wide economic conditions. In spite of numerous agreements on the exogeneity of oil shocks since 1973 (Shapiro & Watson (1989); Rotemberg & Woodford 1996; Hamilton 2003), Kilian (2006) points out the significance in treating oil price shocks endogenous in the macroeconomic system since oil price movements also reflect changes in oil demand driven by endogenous macroeconomic conditions at each period. Because the postulated thought experiment on the effect of oil price shocks contradicts the reality when researchers allow oil price changes while keeping other economic variables constant, it is of great importance to disaggregate oil price dynamics to mutually uncorrelated structural shocks. He also stresses the concept of "precautionary demand", a potential oil price transmission channel which will trigger the oil demand through the growing uncertainty regarding oil supply in the future.

Along the similar line of his previous study (Kilian 2006), Kilian (2008, 2009) investigates the size and the sign of the exogenous oil supply shocks on the CPI inflation and U.S. GDP growth by proposing a new way to measure the exogenous oil supply shocks. His results reveal that the exogenous oil production disturbances are responsible for only a tiny portion of oil price increases and oil supply shocks has relatively little impact on the GDP growth and the CPI inflation in U.S. except for special episodes, like 1990/1991 Persian Gulf War. In the meanwhile, demand side shocks seem to be an important player in the dynamics of the macroeconomy in the U.S. The various reasons underlying oil price fluctuations provide an explanation of why recent oil price shocks fail to cause recessions. Further, Hamilton (2009a) examines the reasons and the effect of oil price run-up from 2007 to 2008. Contrary to the common view that oil price shocks are caused by oil supply disturbances, Hamilton believes that the 2007-08 oil price increase is attributed to a growing aggregate demand worldwide, especially a surge in the Chinese oil consumption. This point is also supported by Kilian (2011) using a direct measure of demand shocks. However, the influence of the oil price increase in U.S. economy based on the increasing demand appears to be no different to these oil price changes originated from the supply side. Still, Hamilton (2009b) believes that scarcity rent based on Hotelling's principle starts to determine the oncoming oil price shocks because of the increased oil demand in developing counties and the limited global production capacity.

2.2.2 Oil Price Shocks on China's Economy

As a large portion of theoretical and empirical literature focuses on the impact of oil price shocks on the macroeconomy in U.S., more researchers are paying close attention to the case in China due to its prominent economic development and influence in the world energy market. China's special political and economic regimes interest many scholars and study on China's case greatly contributes to the existing literature on this subject.

Back to 1994, Peng & Martin have already studied on the influence of the 1986 oil price shock on China's post-reform economy by using a computable general equilibrium model. It is not until the oil price shock in 2008 when people begin to notice that a great number of papers come up to talk about China's urge in crude oil.

Francois and Valerie (2009) investigate oil price shocks on China's macroeconomy adopting a factor-augmented vector auto-regression method. After estimating the model over the period from 1980 to 2006, the results of impulse response analysis show that the oil price increase possesses a positive influence in contemporaneous PPI, CPI and a delayed negative impact on the GDP, investment and consumption. The results of China agree with most of the natural oil price transmission channels that were described in earlier literature. Nevertheless, Du, He and Wei (2010) discover a positive relationship between China's GDP and world oil price, which is distinct from the results obtained on developed countries in present literature. They tentatively explain this phenomenon by relating the rising oil price with an improving external environment that is necessary for exporting to other countries which benefit from rising oil prices, such as U.S. and some European nations. While the surge in the world oil price may harm China's production cost and its GDP growth, expansion in export significantly reverses the adverse situation. As a result, an increase in the oil price finally starts an upward trend in the GDP. Both studies are not ideal without any drawback since they treat oil price shocks without exploring the underlying reasons carefully, which will obscure the distinct influences of the different oil price shocks in the macroeconomy and mislead policy makers into crossroads.

Given the fact that China is an oil importing country and has had tremendous demand for oil since 2008, some commentators predict that the price hike in oil will undoubtedly harm China's export due to the upward production cost after the oil price increases. However, data under scrutiny shows that China's export appears to benefit, rather than suffer from the rising oil prices. Ricardo et al. (2009) seeks to give their explanations to this odd phenomenon. They estimate the monthly sample period from 1992 to 2005 by using an autoregressive distributed lag (ARDL) model including the oil price, China's export and measure of competitiveness. They find that the oil price possesses a positive and significant influence in competitiveness as well as export. This confirms their conjecture that China's strong demand in oil brings oil price increase worldwide will harm itself as an oil importing country. However, this adverse effect of the oil price increase has a more severe impact on its export competitors due to China's almost infinite labor supply, which makes China an advantageous place in the international trade.

Wu, Li and Zhang (2013) use input-output analysis to study the role of price control in China in oil price transmission process. By comparing the results between China and the United States, they find that price control policy in China greatly impedes the process of transmitting oil price shocks into domestic inflation, which helps to isolate the influence of world oil price fluctuation in the Chinese macroeconomy and lead to the distortions of price adjustments, which results in a prolonged long-term inflation impact.

Despite general agreements among researchers on the great impact of China's energy demand on the world oil price (Hamilton 2009a, Kilian 2011), differences are also heard. Chen et al. (2009) focus on the examination of China's influence on world oil markets, such as the Middle-East, Europe, North American and etc., by using a technique called Directed Acyclic Graphs (DAG). The DAG technique is mainly used in the area of mathematics and computer science. In economics, it is employed to overcome the unrealistic assumption of a recursive structure in the Cholesky Decomposition. The empirical evidence reveals that China plays little role in affecting the world oil market volatility, however, fluctuations of oil prices in China are mainly affected by the OPEC and U.S. oil markets. This conclusion brings back the previous arguments and demonstrates that China has not exerted price influence on the rest of the global crude oil markets. The similar result is also obtained in Refalo (2009). Also, Mu and Ye (2011) use a VAR analysis including the world oil production, China's net oil import and world oil price to examine monthly data series from 1997 to 2010. Their findings also suggest that China's demand for oil, which is represented by China's net oil import, plays a very little role in affecting the monthly oil prices and there is no Granger causality between these two variables.

Although the soaring demand for oil in China is due to its quick development, coal and electricity remain the major sources of energy due to the fact that approximately seventy percent of China's total energy consumption comes from coal and almost eighty percent of power is generated from coal. Some effort has been paid to study the relationship between these kinds of energy and the macroeconomy in China. Yang, Xuan and Jackson (2012) try to explain the co-movement of coal and oil prices from possible aspects. The substitution between coal and oil in China partly contribute to the price correlation between coal and oil. However, due to the lack of availability of monthly data about China's electricity consumption and price, I will not include electricity as a part of my analysis.

This chapter is mainly trying to examine the different response patterns of major economic indicators in China, such as output, investment, international trade and etc., w.r.t. different oil price shocks. Details on the data selection and the model specifications are discussed in Section 2.3.

2.3 Data and Methodology

2.3.1 Data Sources

To get a comprehensive description about China's macroeconomy, I include 6 variables[8] in the regression model. I use monthly growth rate[9] of China value added of industrial production as a proxy of China's GDP growth rate. Besides, variables on growth rate of consumption, investment, one year lending rate, export and import are

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[8] Originally, I also include China's CPI and PPI in the analysis. After considering the data transparency issue especially exhibited in those two data series, I decided to exclude China's CPI and PPI in the analysis.

[9] The original data of China value added is YoY growth in monthly frequency. Then I convert the year over year growth rate into month over month growth rate by using the formula: $\mathrm{G_{MoM}} = [(1 + G_{YoY})^{\frac{1}{12}} - 1]*100$.

considered to capture the macroeconomy in China. Data series such as China's export, China's import, China's fixed assets investment, China's consumption, China's growth rate of value added of industrial production and interest rate(one year lending rate) can be available from Bloomberg database. China's total consumption data is obtained from the China National Bureau of Statistics. The data covers the period from Jan, 1997 to Dec, 2014, which is mainly determined by the time period of the availability in both China's macro variables and different types of oil price shocks disentangled in Chapter 1. Similarly, the macro variables are all stationary and free of seasonality issue. The plots of these data series used in Chapter 2 are summarized in Figure B.1 to Figure B.6 in Appendix B.

2.3.2 Methodology

In this part, I would use a simple linear regression model to study the effects of different oil price shocks on China's macroeconomy. Although there are popular views among researchers that economic variables are endogenously determined, I have the following justifications to treat the six types of structural shocks as predetermined with respect to these major macroeconomic variables in China. Actually, in spite of the fact that China is playing a more significant role in world oil market, seldom does empirical evidence indicate that China's factor has Granger caused the oil price. The assumption that oil price shocks are predetermined w.r.t. the major China's macro variables can be defended as following:

For China's value added, the assumption that $\hat{\varepsilon}_{jt}, j = 1,2,3,4,5,6$ is predetermined can be defended by the following logic: First, an innovation in oil production increase (decrease) would probably bring a growth (decline) in China's value added, which means the correlation between oil production innovations and the shocks in China's value added should be positive. At the meantime, an unexpected growth in China's value added would stimulate the global oil production, which also means the correlation between innovations in China's value added and oil production shocks should be positive. However, by correlating the autoregressive residuals of China's value added with oil supply shock $\hat{\varepsilon}_{1t}$, I find very low correlation (0.0583) at monthly frequency. That actually means neither direction of causality matters at the monthly frequency. Thus oil supply shock can be regarded as predetermined to China's value added. Second, while an expected increase in global demand may stimulate demand for China's industrial product, an increase in China's industrial production would also bring an upward trend in global demand. The correlation coefficient (0.0807) is very small, which indicates little evidence of causal linkage on both directions. As a result, global demand shock $\hat{\varepsilon}_{2t}$ can also be treated as predetermined. Besides, in one direction, a positive U.S. monetary shock may increase China's industrial production thus China's value added because of increasing demand for China's export. In another direction, increase in China's value added may induce the U.S. money authority to cut down money supply. That's because increase in value added, a proxy of GDP in China, can stimulate China's demand in import from U.S., which will make dollars flow into the U.S. In order to act against the corresponding inflation, Fed may take action to reduce money supply. The correlation coefficient between innovations in China's value added and U.S. money supply shock is -0.0483 and this small negative correlation coefficient means the negative feedback from China's value added to U.S. money supply does not matter. Furthermore, due to the fact that it's difficult for China's industrial production to respond to U.S. monetary shock at monthly frequency, it's plausible to consider the U.S. money supply shock

$\hat{\varepsilon}_{3t}$ is predetermined with respect to China's value added. Similarly, increase in China's money supply may stimulate China's industrial production while expansion in industrial production may induce China's money authority to reduce money supply in order act against the possible over production. The correlation coefficient between innovations in value added and money supply shock is -0.0853, which also means the negative feedback from value added to money supply is negligible. Moreover, it's unlikely that China's central bank will respond to the increase or decrease in industrial production within one month. So it's reasonable to assume the predetermination of innovations in China's money supply with respect to China's value added. Also, China's exchange rate shock is predetermined with respect to China's value added because China's fixed exchange rate will not adjust the changes in industrial production within one month considering China's managed floating exchange rate regime. Finally, the correlation coefficient between innovations in value added and the shocks in precautionary demand is 0.0899. An increase in value added may on one hand increase the precautionary demand in oil, on the other hand, a positive innovation in precautionary demand may retard the growth rate of value added due to the oil price increase. Hence, it's inappropriate to use the low correlation coefficient to conclude that precautionary demand shock is predetermined to China's value added. Nevertheless, according to Kilian (2009), precautionary demand represents an expected shortfall of oil supply in a shorter time horizon. Then the effect of innovations to China's value added on the precautionary demand would be negligible within a month. As a result, the assumption that precautionary demand shock is predetermined to China's value added still holds.

The analysis of predetermination of these six types of shocks with respect to other macroeconomic variables other than China's value added is along the same line. The correlation coefficients between these six types of shocks and the autoregressive residuals of the major economic indicators in China are summarized in Table 2.1.

Table 2.1: Chapter Two-Correlation Coefficients Summary.

Correlation	$\hat{\varepsilon}_{1t}$	$\hat{\varepsilon}_{2t}$	$\hat{\varepsilon}_{3t}$	$\hat{\varepsilon}_{4t}$	$\hat{\varepsilon}_{5t}$	$\hat{\varepsilon}_{6t}$
consumption	-0.0031	-0.1513*	0.0755	0.0834	0.1285	0.0552
investment	0.0054	0.0092	-0.0071	0.0883	-0.0930	0.0050
export	-0.0091	-0.0983	-0.0039	0.0644	-0.0794	-0.0403
import	0.0376	0.0042	0.0065	0.0815	-0.1086	0.0756
value added	0.0583	0.0807	-0.0483	-0.0853	-0.0930	0.1864*
lending rate	0.0213	0.1440*	-0.1128	0.0403	-0.1299	0.1490*

Notes: (1) $\hat{\varepsilon}_{1t}$-$\hat{\varepsilon}_{6t}$ denotes oil supply shock, aggregate demand shock, U.S. money supply shock, China money supply shock, China real effective exchange rate shock and oil-specific demand shock, respectively. All these structural shocks are obtained by disaggregating oil price using SVAR model in Chapter 1. (2) The correlation coefficients are calculated by correlating the autoregressive residuals of major economic indicators with these six types of monthly structural shocks $\hat{\varepsilon}_{jt}, j = 1,2,3,4,5,6$. Actually I fit each macroeconomic indicators to AR(12) process due to the fact that all those macroeconomic data series are at monthly frequency. (3) Except China's lending rate, all China's macro variables are in growth rate transformations. China's lending rate is in its first difference transformation. (4) * implies significance at 5% confidence level.

From Table 2.1, we can see that most of the correlation coefficients are very small, which indicates no causality runs from innovations of major macroeconomic variables in China to these six types of structural shocks obtained in Chapter 1. The highest correlation exists between innovations in China's value added and China's oil specific demand shocks. However, the correlation coefficient is 0.1864, which is still considered to be moderate and acceptable.

Because the structural shocks disentangled from Chapter 1 are uncorrelated, I can regress China's macro variables on each type of the structural shocks disentangled in Chapter 1 separately. Also, based on the above justifications of the predetermination for those oil price shocks, I can estimate the regression model simply use OLS method and do the impulse response analysis. Instead of using this methodology to study the influence of oil price shocks in U.S. macroeconomy as Kilian (2008) did, I employ the same methodology to study the influences of world oil price shocks in China's macroeconomy. As a result, I investigate the impulse response patterns of different structural innovations on China's major macroeconomic aggregates according to the following linear regressions:

$$chcosu_t = \alpha_{1j} + \sum_{i=0}^{12} \varphi_{1ji}\hat{\varepsilon}_{jt-i} + \mu_{1jt}, j = 1,2,3,4,5,6 \qquad (1)$$

$$chinve_t = \alpha_{2j} + \sum_{i=0}^{12} \varphi_{2ji}\hat{\varepsilon}_{jt-i} + \mu_{2jt}, j = 1,2,3,4,5,6 \qquad (2)$$

$$chexpo_t = \alpha_{3j} + \sum_{i=0}^{12} \varphi_{3ji}\hat{\varepsilon}_{jt-i} + \mu_{3jt}, j = 1,2,3,4,5,6 \qquad (3)$$

$$chimpo_t = \alpha_{4j} + \sum_{i=0}^{12} \varphi_{4ji}\hat{\varepsilon}_{jt-i} + \mu_{4jt}, j = 1,2,3,4\ 5,6 \qquad (4)$$

$$chvaad_t = \alpha_{5j} + \sum_{i=0}^{12} \varphi_{5ji}\hat{\varepsilon}_{jt-i} + \mu_{5jt}, j = 1,2,3,4,5,6 \qquad (5)$$

$$chlera_t = \alpha_{6j} + \sum_{i=0}^{12} \varphi_{6ji}\hat{\varepsilon}_{jt-i} + \mu_{6jt}, j = 1,2,3,4,5,6 \qquad (6)$$

where:

$\hat{\varepsilon}_{jt}, j = 1,2,3,4,5,6$ are disentangled monthly structural innovations obtained in Section 1.3.2.

chcosu=monthly growth rate of China's consumption expenditure, which includes not only consumption for domestic good but also part of imported goods[10]).

chinve=monthly growth rate of china fixed assets investment (excluding rural households).

chexpo=monthly growth rate of china export trade.

chimpo=monthly growth rate of china import trade.

chvaad=monthly growth rate of value added of industrial production(a proxy for china's GDP growth rate).

chlera=monthly change in china's one year lending rate (benchmark).

In the regression model, *chcosu*, *chinve*, *chexpo* and *chimpo* are all in real terms adjusted by China's CPI. Seasonality tests are also conducted on all six data series. Series *chinve*, *chexpo* and *chimpo* are seasonally adjusted by X-12 census method while *chcosu*, and *chvaad* are seasonally adjusted by Tramo/Seats method. The reason to use X-12 census method to deal with data series *chinve*, *chexpo* and *chimpo* is that these three data series do not have missing values. On the other hand, Tramo/Seats method is used to deal with data series *chcosu* and *chvaad* due to the fact that they have missing values. There is no obvious seasonality observed in data series of China's one year lending rate. So all the data series used in the regression model are free of seasonality issue. Monthly growth rate is calculated as the log difference transformation of the level data. Specifically, the data series of one year lending rate is

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[10] Because China's consumption includes part of the imports, so I cannot get a pure consumption by subtracting China's imports from China's consumption. However, it is still worth to discuss consumption and imports separately because they actually represents two different aspects of China's economy.

in the form of monthly change (using first difference transformation) instead of monthly growth rate, because interest rate itself represents the growth rate or the return rate. To capture the dynamics of China's major economic indicators, which are at monthly frequency, the number of lags is set to 12[11] months. In order to get inference in the impulse response estimates in the presence of non-normally distributed residuals, I use bootstrap method to get the confidence interval of each response estimate. In summary, all the macroeconomic data series are either in log differenced form or in first differenced form in order to achieve stationarity. So I use cumulative impulse response analysis to retrieve the impulse response patterns of the level data.

2.4 Empirical Results

2.4.1 Unit Root Test

Prior to fit data to the linear regression model (1) to (6) in Section 2.3.2, I test the stationarity of each time series. It's well known that ADF test has low power when the span of data is short. So in this part, I also include the KPSS test and the PP test to

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[11] The lag order of 12 is chosen based on the following considerations:

(1) According to the regression functions (1)-(6) described in Chapter 2, φ_{1jh} to φ_{6jh} represents the coefficients of the impulse response functions ("IRFs"). As a consequence, the lag order is chosen by the horizon of IRFs, which is 12.

(2) From the perspective of policy makers, they are more concerned about the responses at a horizon of one year.

(3) According to Hamilton and Herrera (2004), the smaller lag orders selected by AIC or BIC can not fully capture the dynamic influences of oil price changes on the macroeconomy.

check the reliability of the ADF test results. The unit root test results are reported in Table K.1 in Appendix K. From Table K.1, we conclude that all six variables are stationary. As a result, all six monthly growth/change data series can be directly substituted into model (1) to (6) in Section 2.3.2.

2.4.2 Impact Analysis of Structural Shocks on China's Macroeconomy

Figure G.1 to Figure G.6 summarize the response patterns of major macroeconomic variables in China to different oil shocks. In general, it is demonstrated that the types of shocks underlying oil price fluctuations possess different influences in the major economic variables in China.

Specifically, an unexpected increase or a positive shock in oil supply has little effect on real consumption. Besides, the response of real consumption with respect to a positive aggregate demand shock is trivial for the entire period with no statistical significance within the one standard error band. Similarly, an increase in U.S. money supply or a positive U.S. monetary shock causes little impact on China's real consumption. These results agree with my expectation that an expansion in world oil production, an increasing global aggregate demand and an increase in U.S. money supply have negligible effect on China's domestic consumption because of China's oil price regulation. Actually, the oil price control policy in China is meant to minimize the effect of crude oil price fluctuations on China's macroeconomy. By comparison, an unexpected increase in China's money supply M2 or a positive China's money supply shock displays a significant and persistent influence in China's real consumption, which is reasonable because expansionary monetary policy would stimulate aggregate domestic demand in the short term. Similarly, a positive shock in China's effective exchange rate also has a positive impact on China's real consumption with statistical significance within one standard error band. The explanation is that appreciation in RMB can stimulate domestic demand for imported goods, thus increases real consumption correspondingly. Compare to aggregate demand shock, an increase in oil specific demand possesses higher positive impact on consumption, but this effect is still insignificant.

Similar to China's real consumption, the corresponding responses of China's real investment to increases in oil supply and global aggregate demand are trivial and insignificant. However, China's real investment reacts positively and significantly to an increase in U.S. money supply M2 after about eight months upon impact. One reason may be that the expectation of increased exports due to an increase in U.S. money supply and the corresponding expansion in U.S. economy would stimulate China's domestic investment. The other reason is that an increase in U.S. money supply can bring down the interest rate in U.S. relative to the interest rate in China, which will attract international capital to flow from U.S. into China. This capital flow can provide fund for domestic investment. At the meantime, a positive shock in China's money supply has little impact on China's investment. This can also be explained by what I have discussed in Section 1.4.2. As a result of soaring price in real estate in China after 1998, increase in China's money supply is absorbed by China's real estate market substantially. The outflow of money into the real estate market can bring a positive impact on investment because investment in real estate is an essential component of fixed asset investment in China. However, China's stock market also takes in a significant portion of the money supply increase, which will have a negative influence in investment because the money flowed into the stock market can not be easily retrieved and could have been invested in real economy. So, the impact of positive shocks in China's money supply on China's investment can be trivial and insignificant. Besides, a positive shock in China's real exchange rate or appreciation in RMB has a negative influence in China's investment, though the impact is insignificant for most of the horizons. The negative relationship is reasonable because an appreciation in RMB would result in a reduction in China's export, which can greatly depress domestic investment. Compare to China's real consumption, the effect of positive oil specific demand shock on China's real investment is negative, but with no statistical significance for the entire horizon. A positive shock in oil specific demand reflects people's expectation of uncertainty in future oil supply, which can greatly depress investment today.

As a major component of China's GDP, China's export has little response to a positive crude oil supply shock. On the contrary, an increase in aggregate demand has a very small positive influence in China's export after six months upon impact. However, this positive effect is insignificant. In the meanwhile, an unanticipated increase in U.S. money supply drives China's export up a little bit only after ten months upon impact. But, an unexpected increase in China's money supply causes little impact on China's export. Unsurprisingly, a positive shock in China's real effective exchange rate or appreciation in RMB can greatly depress China's export and this influence possesses statistical significance through the entire horizon. Finally, a positive oil specific demand shock brings a small increase in China's export after three months upon impact, but this impact begins to diminish till zero. Most of the empirical results conform to my expectations. Although expansion in world oil production can lead to decreases in oil price and production cost, this oil price reduction would not have significant impact on stimulating China's export. The major reason is that export in China is labor intensive and labor cost constitutes the majority of the entire production cost. As long as the labor cost is not greatly impacted by the decrease in price of oil, the effect of a positive oil supply shock on China's export is trivial. Increase in global aggregate demand can boost China's export directly while increase in U.S. money supply firstly stimulate U.S. economy and then bring subsequent increase in China's export as a result of this expansion in U.S. economy. My explanation on why a positive money supply shock in China has no statistically significant impact on China's export is that China's export is more directly affected by exchange rate shocks or demand shocks, rather than monetary policy shocks. Increase in China's money supply would not necessarily lead to depreciation in RMB and increase in export. Actually, if money demand increases at the same time when money supply increases, there could be no impact on the currency value of RMB and export. Besides, increase in precautionary demand in oil may raise people's demand for China's export at present because of their expectation on rising future oil prices.

China's import, as the counterpart of China's export demonstrates different response patterns with respect to certain types of structural shocks. Similarly, an unexpected positive oil supply shock still has no significant impact on China's import. It only has a very small positive effect on China's import after three months upon impact and this effect quickly dies out for the rest of the period. The possible explanation is that although decrease in world oil price as a result of increase in oil supply may increase China's import of oil on one hand, on the other hand, China's import of other substitutes of oil, such as petroleum coke and LNG (liquefied natural gas), may drop significantly. Therefore, the net influence of oil supply increase in China's import may be negligible. Compared to China's export, an increase in global aggregate demand has a higher positive influence in import of China, and this effect is significant for most of the period. As we know, China is the 2nd largest trading country. When the world economy is recovering or growing, it will definitely stimulate China's export because of the improvement in the economy of its major trading counterparties. In the meanwhile, China itself is the engine of the world economy growth, so the growth in the world economy can be majorly driven by China's economy growth. Then it's not surprised to observe an increase in China's import when the world economy is growing. Further, if China makes the predominant contribution to the world economy growth compared to other countries, the positive effect of increase in global aggregate demand on China's import could be higher than the positive influence in export of China. Similar to China's export, positive shocks in China's money supply and positive shocks in U.S. money supply have little impact on China's import. The reason is that China's export or import is majorly driven by exchange rate or factors from demand side. One interesting phenomenon is that a positive real effective exchange rate shock or appreciation in RMB can bring a negative impact on China's import with statistical significance for the entire period. Or in the other way, a negative real effective exchange rate shock or depreciation in RMB can bring a positive impact on import in China. It is counterintuitive at first glance but it has the underlying reasons. Actually, when real effective exchange rate decreases, it can bring an increase in both China's export and import. The key point to understand this phenomenon is the major components of China's export and import. China's export is majorly concentrated in low and medium value added products, such as agricultural produce and clothes. Thus, when the real effective exchange rate decreases, it will greatly stimulate foreign demand in China's export as a result of lower prices. However, China's import is mainly composed of crude oil, raw materials and high-tech equipment, which are difficult to find equivalent domestic alternatives[12]. Furthermore, they are all essentials to support China's sustained economic growth, which is evidenced in my studying period. As a result, as long as the economy is keeping growing at a certain pace, it's not uncommon to observe an increase in China's import even after a negative real effective exchange rate shock or depreciation in RMB. Finally, a positive shock in oil specific demand firstly displays a small positive influence in China's import and then this impact becomes negative after eight months. However, the impact is insignificant for the entire period.

An unexpected increase in oil supply or a positive oil supply shock possesses limited influence in the level of China's value added in industrial production. Similarly, a positive U.S. monetary shock has no significant effect on China's value added. Besides, an unexpected increase in oil-market specific demand has little impact on China's value added. These insignificant empirical results conform to my expectations. Although an increase in oil supply could cause an increase in China's value added in industrial production due to the lower production cost arising from decrease in oil prices, this positive effect may not be realized due to the following considerations. First, China's special oil pricing regulation may isolate China's industrial production from the impact brought by oil supply fluctuations to certain extent. Second, coal, rather than oil, is the major source of energy consumed in the industrial production, although demand of oil in China is growing in recent years. One

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[12] According to J-curve statement, deprecation will bring a decrease in import in the long run by assuming that equivalent domestic alternatives exist. However, this assumption is not true in China.

thing needs to be clarified is that oil price regulation policy in China has some effect on insulating the influence of oil price fluctuations in the macroeconomy in China, but this effect is limited. Actually, it may block the effect of oil price fluctuations brought by disruptions in world oil production to certain degree, it cannot effectively stop oil price impact caused by other factors. In fact, oil price fluctuations due to increase in global aggregate demand or uncertainty about future oil market can also be reflected in China's stock or capital market, which will in turn affect people's expectation and corresponding production or consumption behavior. Similarly, the insignificance of a positive U.S. monetary shock on China's value added can also be explained by either the isolation effect of China's oil price regulation or the lag effect of U.S. monetary policy transmission worldwide. Again, due to the fact that coal is actually the major source of energy consumed in China's industrial production, increase in oil-market specific demand could not have a significant influence in China's value added. Meanwhile, my expectation of the responses of China value added with respect to positive innovations of global aggregate demand is confirmed. Increase in world aggregate demand causes a direct and persistent increase in China's value added, which may also reflect the fact that China's growth is the major reason behind the increase in global aggregate demand. Besides, increase in China's money supply possesses a negative influence in China's value added, but this impact is insignificant for the entire horizon. Finally, a positive shock in China's effective exchange rate possesses a persistent and negative impact on China's value added. This is expected because appreciation in RMB will greatly depress China's export, which is one important component of China's GDP.

Besides, positive oil supply shocks have very little effect on China's one year lending rate with statistical significance for the entire horizons. That can be partly explained that China's interest rate is still under government control. So innovations in world oil production would not affect China's lending rate that much. However, positive shocks in global aggregate demand can cause positive and persistent impact on the dynamics of this one year lending rate, with statistical significance for the entire period. In most cases, increase in global aggregate demand itself indicates the strong growth in China's economy. The central bank in China can raise one year lending rate so as to prevent the overheated economy. In the meanwhile, the influence of an unanticipated increase in U.S. money supply in China's one year lending rate is slightly negative. But this negative effect is not significant for the entire period. This can be explained as following. On one hand, an unexpected increase in U.S. money supply may reduce the interest rate in U.S., which can make capital flow from U.S. to China[13] and result in corresponding inflation. On the other hand, China can lower[14] its interest rate so as to prevent the possible capital inflow and the corresponding inflation. Also, reducing interest rate can prevent possible appreciation in RMB brought by capital inflow, which China definitely does not desire. Although this

[13] Although China has stringent capital control policy, this policy is loosened step by step and it can not fully limit the capital inflow and outflow between China and other countries.

[14] The fact that China's central bank lowers the interest rate rather than increase the interest rate to act against the inflation pressure from outside can also be explained by the dilemma that China is facing now: coexistence of high inflation and inadequate aggregate demand. Considering the credit ration would cushion the increasing demand thus possible future inflation, Chinese government may lower interest rate to stimulate the current economy.

reduce in interest rate may stimulate the economy and even bring upward pressure in China's general price level later on, the impact can be cushioned by credit ration. Not surprisingly, a positive increase in China's money supply results in a persistent decrease in China's one year lending rate and this negative impact is statistically significant for most of the periods. Besides, an unexpected increase in real effective exchange rate or appreciation in RMB will depress China's export, which is a major component of China's value added. In order to mitigate the possible negative impact on China's macroeconomy, China's central bank may lower interest rate to facilitate the economic growth. Also, a positive oil specific demand shock has a positive impact on China's one year lending rate and this positive impact is significant for most of the horizons. Rising oil prices due to the expectations of uncertainty in the future would have an upward pressure on the inflation, which would probably make China's central bank increase the benchmark interest rate in order to act against this pressure.

In conclusion, the above results reveal certain important response patterns of China's major macroeconomic variables with respect to these six types of structural shocks. First, positive oil supply shocks or unexpected increase in world oil production bring little and insignificant effects on the majority of China's macroeconomic indicators. This result is consistent with what has been found in the U.S.(Kilian, 2008). That means, in another direction, world oil price increases due to oil supply disruptions would not have significant impact on the major aspects of China's economy. This is mainly due to China's oil price control policy and the regulation of China's interest rate, which can isolate the effect of global oil supply disruptions on the macroeconomy in China.

Second, the impacts of positive global aggregate demand shocks on China's economy are a little bit complicate. On one hand, an increase in global aggregate demand has very limited impact on China's real consumption, real investment and real export. The reasons underlying the limited and insignificant impacts of global aggregate demand shocks are partly due to the oil price control policy and are partly because of the gradual rising trend in labor cost which can harm China's predominant advantage in export. On the other hand, it possesses a positive and significant impact on real import in China, China's value added and one year lending rate. Further, according to Kilian (2008), increase in global aggregate demand can result in a delayed declining in U.S. real GDP. Different to U.S., positive shocks in global aggregate demand has positive and significant influence in China's value added. The significant and positive influences of aggregate demand shocks in China's import and China's value added actually reflect that strong economic growth in China is the major source of increasing global aggregate demand. In the meanwhile, the positive responses of China's one year lending rate with respect to increases in global aggregate demand demonstrate that the effect of aggregate demand shocks can be transmitted through the interest rate channel. Therefore, the impacts of aggregate demand shocks on China's macroeconomy are not consistent. With respect to different economic indicators, the impacts of oil price increases due to increases in global aggregate demand are different.

Besides, positive shocks in U.S. money supply M2 causes little or small impact on variables such as China's real consumption, real investment, export, import, China's value added and one year lending rate. The insignificant impact can be either explained by China's control policy in prices of oil related consumption and interest rate or can be explained that coal, rather than oil is the major source of energy in China. In summary, world oil price increases due to the expansion in U.S. money supply has very little impact on those six China's major economic indicators.

Positive shocks in China's money supply M2 have no significant impact on China's real investment, export, import and industrial value added. However, it can bring positive and significant impact on real consumption in China while significant and negative impact on one year lending interest in China. The insignificant impact can be explained that China's increase in money supply is mainly absorbed in real estate market, rather than production. On the contrary, increase in China's money supply M2 can stimulate domestic demand thus real consumption. As expected, increase in money supply would lead to a decrease in interest rate. So, world oil price increases due to the changes in money supply of China will have an impact on consumption and one year lending rate in China. However, it has little impact on the rest of the major economic indicators.

Positive shocks in China's real effective exchange rate or an appreciation in RMB can have an influence in most of China's macroeconomic indicators, although some of the impact is insignificant. That means world oil price increases due to depreciation in RMB can affect China's economy broadly and significantly. Finally, the impacts of positive oil market specific demand shocks on China's major macroeconomic indicators are limited and statistically insignificant.

Given the main results in Chapter 2, it can be concluded that oil price increases due to different underlying shocks can have very different impacts on China's macro economy. Further, oil price transmission channels, such as demand channel and monetary policy channel, are relatively more important than other channels in affecting China's economy. Similar to the results stated in Kilian (2008), the influences of oil supply shocks in major macroeconomic indicators are insignificant, such as China's value added. However, compared to the results in Kilian (2008), a positive aggregate demand shock possesses a persistent and positive influence in China's value added(a proxy for China's GDP) while it causes a temporary increase at first and then a steady decline in U.S. real GDP. Also, contrary to the significant impacts of positive shocks in oil specific demand on U.S. CPI and GDP, a positive oil market specific demand shock has little impact on China's value added and other major macroeconomic indicators. The above results further demonstrate that oil price shocks may have different impacts in different countries.

Chapter 3

ANALYSIS OF SYMMETRY ABOUT THE EFFECTS OF OIL PRICE SHOCKS ON CHINA'S MACROECONOMY

3.1 Introduction

3.1.1 Motivation

The shock of oil price increase has been followed by all but one post-war recession (Hamilton 1983). However, major oil price collapses since 1980s seem not to stimulate the U.S. macroeconomy. This phenomenon encourages a number of studies to address the symmetry issue in the influence of oil price shocks in macroeconomy (Mork 1989; Mory 1993; Lee et al 1996; Hamilton 1996). It's widely accepted that increasing price of oil is likely to slow the U.S. economy while falling oil prices appear to have less or even no effect to boost the economy. The asymmetric relationships between oil shocks and major macro variables may rely on adjustment costs to oil price changes or the monetary policy in reaction to oil price dynamics. Another possible explanation is the uncertainty brought by changing oil prices would amplify the negative effect when oil price increases and offset the positive effect when oil prices decreases.

But, among the papers examining the symmetry issue, most of them are on the developed countries, such as the U.S. and European countries. A relatively small number of papers focuses on the developing countries, like China. Hence, whether oil price movements have any asymmetric effect on the macroeconomy remains an open question in developing countries. Also, China's increasing demand for oil consumption and its significant reliance on oil import since 1990s make it a particularly interesting topic to investigate. Last but not the least, the Chinese government has initiated several reforms in crude oil business since 1979. The evolution of domestic oil pricing mechanisms provides a natural experiment on the relationship between the macroeconomy and oil price shocks.

Motivated by the above mentioned facts, I would like to closely examine the symmetry issue in China's special case. Is there any evidence that China's macroeconomic variables respond asymmetrically to energy price increases and decreases? What's the appropriate methodology to characterize the interaction between China's major macroeconomic variables and world oil price, allowing for the asymmetric effect if any? This chapter attempts to give tentative answers to these questions.

3.1.2 **Contribution**

The study in Chapter 3 makes several contributions to the literature. Firstly, comparing to the majority of previous studies in which the primary concern is on the developed economies, this chapter will enrich the empirical study on the symmetry issue in the developing countries. Furthermore, most of the existing papers talking about the influence of oil price shocks in China emphasize the asymmetric effect of oil prices on output and Chinese stock market. My study in Chapter 3 will extend the research on symmetry issue to other important aspects, such as, investment, export, import, interest rate in China and etc.

Secondly, I extend the methodology used by Kilian & Vigfusson (2011) to investigate the symmetry issue of oil price changes on China's macroeconomy. By simultaneously modeling China's major macroeconomic factors, the extended model can examine the symmetry issue in a more systematic way.

3.1.3 Organization

Similar to the organization of previous chapters, Chapter 3 is organized in the following way: Section 3.1 gives a brief description about the motivation and major contributions of the study in this chapter. Section 3.2 reviews the development of the relevant theoretical and empirical literatures on the study of symmetric effect of oil price shocks on the macroeconomy in the U.S. as well as other countries, including both developed economies and developing economies. Section 3.3 describes the data and empirical methods employed in Chapter 3. The results are summarized in Section 3.4.

3.2 Literature Review

The economic literature about energy prices has noted the asymmetric effect of crude oil prices on the macroeconomy for over two decades. Major oil price collapses since 1980s inspire a handful of studies on the asymmetric effects of oil price shocks on the U.S. macroeconomy (Mork 1989 and 1994, Mory 1993, Lee et al. 1995, Ferderer 1996, Hamilton 1996, Huntington 1998, Hamilton and Herrera 1999).

To characterize the asymmetric effect of oil price fluctuations, several attempts are made to build different oil price specifications, which extend Hamilton's (1983) linear methodology to non-linear methodology. Mork (1989) starts to evaluate the asymmetric effects on the macroeconomy by defining separate oil price variables that distinguish upward and downward oil price changes. Using his definition of oil price variables and data from industrialized economy, Mork and Olson (1994) conclude that the asymmetry property exists in the oil price-output relationship of the United States. Price increases of oil possess a negative and significant influence in national output while price decreases of oil exhibit no significant effect. Encouraged by the results found in Mark Hooker (1996) that neither the linear relationship proposed by Hamilton (1983) nor the asymmetric specification in oil prices proposed by Mork (1989) is consistent with the economic performance in the 1980s, Hamilton (1996) suggests another asymmetric oil price specification. He puts forward to use the "net oil price increase" over the year if the oil price at time t exceeds the previous year's maximum. When oil price at time t is less than the maximum of last year, then the net oil price increase is set as 0. Hamilton's proposition roots in his assertion that "most of the oil price increases are simply corrections of earlier declines", thus it's more appropriate to use this modification to capture the real uncertainty that oil prices changes would impose on the behavior of individuals and firms. By employing his measurements of oil price changes, Hamilton argues that the prediction on the U.S. GDP growth by oil price increases is reinforced. Followed by Hamilton's initiative, the censoring percentage changes in energy price have been a common practice in the discussion of symmetry issue of oil price shocks. Also, the perception that positive oil price shocks seem to have larger impacts on macroeconomic aggregates than negative oil price shocks is strengthened by the measurement of censored oil price changes. Nevertheless, Kilian (2011) points out the commonly used censored oil price specifications in VAR models would lead to invalid estimates and he proposes a method to correctly compute the impulse responses. According to the empirical results based on his model specification, he comes to the conclusion that the asymmetric phenomenon that is evident in most of previous literatures disappears. Also, in the same vein, to reveal the strong impact of the volatile nature of oil price shocks, Lee, Ni and Raati (1995) uses a GARCH model to study the effect of oil price changes on macroeconomy. They come to the conclusion that "the positive oil price shocks are significantly negatively correlated with real GNP growth but negative oil price shocks are not."

A strand of researchers investigates the relationship between the specification in the price of oil and the asymmetric performance. Meanwhile, some studies attempt to explore various oil price shock transmission channels that can help explaining the asymmetric responses in the economic activity. All these studies provide possible explanations to the asymmetric issue.

Hamilton (1988) proposes the adjustment cost hypothesis and he argues that asymmetry could be the result of adjustment costs to accommodate oil price changes. The cost of adjusting oil price changes plays a negative effect on economic growth no matter whether oil price is increasing or decreasing. However, falling oil price could stimulate the macroeconomy while rising price of oil could retard the economy. Therefore, falling oil price would offset the negative effect of adjustment cost while rising oil price would aggravate the negative effect of adjustment cost. As a result, oil price shocks appear to have asymmetric effect on the macroeconomy. Hamilton's explanation is supported by Loungani (1986), Davis (1987), Lee et al. (1995), but is not empirically tested.

An alternative channel that oil price shocks can account for the asymmetric response pattern is monetary policy. Oil price increases would also have significant impact on wages and thus on the overall price level in the whole economy. Then when oil price increases, inflationary fears lead monetary policy makers to increase interest rate or contract money supply, all of which would worsen the negative influence of rising oil prices in aggregate output. However, if oil price decreases, money authority gets away from trying to react against the negative oil price shocks, being afraid of the broad inflationary pressure brought by stimulating policies, such as lowering interest rate. This asymmetric response of monetary policy is possible when central bank makes inflation target as its priority. Thus, Bernanke, Gertler and Watson (1997) argue that contractionary monetary policy should be responsible for the economic downturn following rising oil prices. Moreover, Tatom (1993) point out the asymmetric effect of oil prices on U.S economic activity disappears when considering the stance of monetary authority.

In addition, several of the researchers propose alternative explanations to the asymmetric influence of oil price shocks. Ferderer (1996) offers a way to account for the asymmetry phenomenon by emphasizing uncertainty. The uncertainty for future and corresponding financial pressure brought by fluctuating oil prices could enlarge the adverse influence of oil price increases and soften the positive influence of oil price decreases at certain degree. Also, Brown and Yucel (2002) show "a strongly asymmetric response pattern of short-term interest rate to positive and negative oil price shocks." Based on their counterfactual experiments, they conclude that oil price shocks transmit asymmetric influence in GDP by means of interest rates and monetary policy cannot be the only origin of symmetry in the macroeconomy. Huntington (1998) finds that "energy prices other than oil react symmetrically to changes in oil product prices, while oil product prices respond asymmetrically to crude oil prices changes." Thus he comes to the conclusion that the observed asymmetric effects are mainly due to the adjustments within the energy sector, rather than within the rest of the economy.

However, the meanings of asymmetric relationships in crude-oil product and oil price-GDP are different. The former asymmetric relationship emphasizes the speed of the response while the latter underlines the magnitude of the response. Thus, it's unclear on how to associate asymmetric relationship in crude-oil product with asymmetric relationship in oil price-GDP. The difficulty in interpretation casts doubt on attributing the entire asymmetric responses of GDP to oil price shocks to the different adjustment speed within the oil industry.

Among those studies on the asymmetric effect of oil prices, a large number of literatures implement non-linear vector autoregressive models (Hamilton (1996), Hauntington (1998), Balke et al (2002), Rahman and Serletic (2010)). However, some other approaches are also employed to investigate the asymmetry issue. Holmes and Wang (2003) study the interaction between UK output and oil price shocks by using a Markow-Switching approach, which is also used by Clements and Krolzig (2002) to find the evidence against the conventional wisdom that recessions are more violent in affecting the U.S. economic growth than expansions. Huang, Hwang and Peng (2005) adopt the multivariate threshold model to study the impact of oil price shocks and its volatility on the economies of US, Canada and Japan.

In summary, any explanation of those above alone cannot be responsible for the entire asymmetric relationship between the aggregate economic activity and oil price changes. And the underlying reasons may vary across different time periods. Furthermore, which model is a better characterization of the influence of oil price shocks in the macroeconomy is still an unresolved question. It depends on the specific question studied in a particular economy.

Despite the mainstream of the research on the asymmetry issue is targeting at the developed countries, a series of the recent studies has shifted the focus from the developed countries to the developing economies. The primary focuses are net oil exporting countries among those literatures.

Further, Eltony and Al-Awadi (2001) find that the response pattern of the macroeconomic variables to oil price fluctuations in Kuwait is symmetric. Their results also confirm that oil price shocks have a significant influence in government expenditures. Specifically, the economy of Philippine is investigated in Raguindin and Reyes (2005). Under their asymmetric VAR model specification, their finding is that falling oil prices possess a higher influence in the macroeconomy than rising oil prices. Berument and Ceylan (2005) examine a group of North African and Middle East nations and find that the impulse response of GDP to oil price shocks is significant only for some countries. Farzanegan and Markwardt (2009) extend Berument and Ceylan's analysis by using quarterly data in Iran to explore the oil price-macroeconomy relationship. They argue that the asymmetric effect is evident in Iranian economy and they also find oil price increases has a positive influence in industrial output growth.

Besides the oil exporting countries, limited literatures focus on the oil importing countries, like China. Cong et al. (2008) investigates the relationship between the shocks of oil price and equity market in China. They find that the asymmetric assumption of oil price shocks on Chinese oil corporations' equity returns is rejected by the empirical results. Du et al. (2010) examine the relationship between the macroeconomy in China and world oil prices. They firstly employ three forms of non-linear transformations of oil prices to study the possible asymmetric influence in oil price shocks on China's macroeconomy. Their findings show that world oil price decrease has a negative influence in China's GDP growth while world oil price increase has no significant effect. Their tentative explanation is that if increases in real oil price are not caused by economic expansion in U.S. or EU, China's export thus GDP growth will not be greatly affected. However, the decrease in oil price is more likely to be associated with the depression of the economies in U.S. or EU. As a result, oil price decreases tend to reduce export, which will drive down China's GDP growth rate.

My study in Chapter 3 stands on the shoulders of former researchers on the asymmetry issue of oil price shocks on developing countries. The aim is to enrich the previous literatures on this asymmetry topic, explore the proper model specification of oil price shocks in China's case and provide explanations to the special empirical results that are obtained in this specific study.

3.3 Data and Methodology

3.3.1 Data Sources

All series employed in this chapter are monthly data. By dividing the WTI oil price by the geometric average of the PCE index and PPI, I get the real oil price. The WTI oil price, U.S. CPI and PCE index can be obtained from FRED. Besides, I also include 8 [15] macroeconomic data series in the regression model to get a full

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[15] Originally, I also include China's CPI and PPI in the analysis. After considering the data transparency issue exhibited in those two series, I decided to exclude China's CPI and PPI in the analysis. Otherwise, the result will be heavily biased by these two indicators.

understanding on whether the effect of oil price fluctuations on China's macroeconomy is symmetric or not. I use growth rate of China value added of industrial production as a proxy of China's GDP growth rate. Variables on China's real consumption, China's real investment, China's one year lending rate, China's real M2, China's real effective exchange rate, export and import are considered to describe other aspects of macroeconomy in China. Specifically, China's export, China's import, China's fixed assets investment, China's M2 supply, China's growth rate of value added of industrial production, interest rate(one year lending rate) are available from Bloomberg database. China's total consumption data is obtained from China National Bureau of Statistics. Real effective exchange rate is obtained from FRED database. Except China's one year lending rate[16], all data series in Chapter 3 are expressed in MoM (Month over Month) growth rate format. Similar to Chapter 2, all data series are free of seasonality and are expressed in real term. Since China's monthly money supply can only be obtained from Jan, 1996 and transformations need to be applied to the original series, the sample period used in Chapter 3 ranges from Feb, 1996 to Dec, 2014. The plots of these data series used in Chapter 3 are summarized in Figure C.1 to Figure C.9 in Appendix C.

[16] Because there is no economic meaning to transform interest rate in to growth rate, China's one year lending rate is first differenced in order to achieve stationarity. Real effective exchange rate together with other variables is in log difference transformations to stand for the growth rate of each variable. Specifically, the growth rate of real effective exchange rate can be interpreted as the return of the exchange rate.

3.3.2 Methodology

In this chapter, I will extend the bivariate near-VAR model proposed by Kilian and Vigfusson (2011), to study the influence of oil price changes in the macroeconomy of China. The extended model contains 8 China's major macro indicators and world oil price. This generalized model allows for both decreases and increases in price of oil to exhibit different impacts on China's major macroeconomic indicators. Besides, by including contemporaneous oil price variables and censored oil price variables in the equation system, this generalized model not only allows current oil price changes have an impact on present macroeconomic indicators but also can avoid the issue of inconsistent estimation existed in the censored oil price VAR model. The exact form of the regression model is stated as follows:

$$Oilp_t = a_{1\_0} + \sum_{i=1}^{p_1} a_{11,i}\, oilp_{t-i} + \sum_{i=1}^{p_1} a_{12,i}\, impo_{t-i} + \sum_{i=1}^{p_1} a_{13,i} expo_{t-i} + \sum_{i=1}^{p_1} a_{14,i} cons_{t-i} + \sum_{i=1}^{p_1} a_{15,i} invest_{t-i} + \sum_{i=1}^{p_1} a_{16,i} vaad_{t-i} + \sum_{i=1}^{p_1} a_{17,i} lrate_{t-i} + \sum_{i=1}^{p_1} a_{18,i} m2_{t-i} + \sum_{i=1}^{p_1} a_{19,i} exch_{t-i} + \varepsilon_{1,t} \quad (1)$$

$$Impo_t = a_{2\_0} + \sum_{i=0}^{p_2} a_{21,i}\, oilp_{t-i} + \sum_{i=0}^{p_2} a_{22,i} oilp^{+} + \sum_{i=1}^{p_2} a_{23,i}\, impo_{t-i} + \sum_{i=1}^{p_2} a_{24,i} expo_{t-i} + \sum_{i=1}^{p_2} a_{25,i} cons_{t-i} + \sum_{i=1}^{p_2} a_{26,i} invest_{t-i} + \sum_{i=1}^{p_2} a_{27,i} vaad_{t-i} + \sum_{i=1}^{p_2} a_{28,i} lrate_{t-i} + \sum_{i=1}^{p_2} a_{29,i} m2_{t-i} + \sum_{i=1}^{p_2} a_{20,i} exch_{t-i} + \varepsilon_{2,t} \quad (2)$$

$$Expo_t = a_{3\_0} + \sum_{i=0}^{p_3} a_{31,i}\, oilp_{t-i} + \sum_{i=0}^{p_3} a_{32,i} oilp^{+} + \sum_{i=1}^{p_3} a_{33,i}\, impo_{t-i} + \sum_{i=1}^{p_3} a_{34,i} expo_{t-i} + \sum_{i=1}^{p_3} a_{35,i} cons_{t-i} + \sum_{i=1}^{p_3} a_{36,i} invest_{t-i} + \sum_{i=1}^{p_3} a_{37,i} vaad_{t-i} + \sum_{i=1}^{p_3} a_{38,i} lrate_{t-i} + \sum_{i=1}^{p_3} a_{39,i} m2_{t-i} + \sum_{i=1}^{p_3} a_{30,i} exch_{t-i} + \varepsilon_{3,t} \quad (3)$$

$$Cons_t = a_{4\_0} + \sum_{i=0}^{p_4} a_{41,i}\, oilp_{t-i} + \sum_{i=0}^{p_4} a_{42,i} oilp^{+} + \sum_{i=1}^{p_4} a_{43,i}\, impo_{t-i} + \sum_{i=1}^{p_4} a_{44,i} expo_{t-i} + \sum_{i=1}^{p_4} a_{45,i} cons_{t-i} + \sum_{i=1}^{p_4} a_{46,i} invest_{t-i} + \sum_{i=1}^{p_4} a_{47,i} vaad_{t-i} + \sum_{i=1}^{p_4} a_{48,i} lrate_{t-i} + \sum_{i=1}^{p_4} a_{49,i} m2_{t-i} + \sum_{i=1}^{p_4} a_{40,i} exch_{t-i} + \varepsilon_{4,t} \quad (4)$$

$$Invest_t = a_{5\_0} + \sum_{i=0}^{p_5} a_{51,i}\, oilp_{t-i} + \sum_{i=0}^{p_5} a_{52,i} oilp^+ + \sum_{i=1}^{p_5} a_{53,i}\, impo_{t-i} + \sum_{i=1}^{p_5} a_{54,i} expo_{t-i} + \sum_{i=1}^{p_5} a_{55,i} cons_{t-i} + \sum_{i=1}^{p_5} a_{56,i} invest_{t-i} + \sum_{i=1}^{p_5} a_{57,i} vaad_{t-i} + \sum_{i=1}^{p_5} a_{58,i} lrate_{t-i} + \sum_{i=1}^{p_5} a_{59,i} m2_{t-i} + \sum_{i=1}^{p_5} a_{50,i} exch_{t-i} + \varepsilon_{5,t} \quad (5)$$

$$Vaad_t = a_{6\_0} + \sum_{i=0}^{p_6} a_{61,i}\, oilp_{t-i} + \sum_{i=0}^{p_6} a_{62,i} oilp^+ + \sum_{i=1}^{p_6} a_{63,i}\, impo_{t-i} + \sum_{i=1}^{p_6} a_{64,i} expo_{t-i} + \sum_{i=1}^{p_6} a_{65,i} cons_{t-i} + \sum_{i=1}^{p_6} a_{66,i} invest_{t-i} + \sum_{i=1}^{p_6} a_{67,i} vaad_{t-i} + \sum_{i=1}^{p_6} a_{68,i} lrate_{t-i} + \sum_{i=1}^{p_6} a_{69,i} m2_{t-i} + \sum_{i=1}^{p_6} a_{60,i} exch_{t-i} + \varepsilon_{6,t} \quad (6)$$

$$Lrate_t = a_{7\_0} + \sum_{i=0}^{p_7} a_{71,i}\, oilp_{t-i} + \sum_{i=0}^{p_7} a_{72,i} oilp^+ + \sum_{i=1}^{p_7} a_{73,i}\, impo_{t-i} + \sum_{i=1}^{p_7} a_{74,i} expo_{t-i} + \sum_{i=1}^{p_7} a_{75,i} cons_{t-i} + \sum_{i=1}^{p_7} a_{76,i} invest_{t-i} + \sum_{i=1}^{p_7} a_{77,i} vaad_{t-i} + \sum_{i=1}^{p_7} a_{78,i} lrate_{t-i} + \sum_{i=1}^{p_7} a_{79,i} m2_{t-i} + \sum_{i=1}^{p_7} a_{70,i} exch_{t-i} + \varepsilon_{7,t} \quad (7)$$

$$M2_t = a_{8\_0} + \sum_{i=0}^{p_8} a_{81,i}\, oilp_{t-i} + \sum_{i=0}^{p_8} a_{82,i} oilp^+ + \sum_{i=1}^{p_8} a_{83,i}\, impo_{t-i} + \sum_{i=1}^{p_8} a_{84,i} expo_{t-i} + \sum_{i=1}^{p_8} a_{85,i} cons_{t-i} + \sum_{i=1}^{p_8} a_{86,i} invest_{t-i} + \sum_{i=1}^{p_8} a_{87,i} vaad_{t-i} + \sum_{i=1}^{p_8} a_{88,i} lrate_{t-i} + \sum_{i=1}^{p_8} a_{89,i} m2_{t-i} + \sum_{i=1}^{p_8} a_{80,i} exch_{t-i} + \varepsilon_{8,t} \quad (8)$$

$$Exch_t = a_{9\_0} + \sum_{i=0}^{p_9} a_{91,i}\, oilp_{t-i} + \sum_{i=0}^{p_9} a_{92,i} oilp^+ + \sum_{i=1}^{p_9} a_{93,i}\, impo_{t-i} + \sum_{i=1}^{p_9} a_{94,i} expo_{t-i} + \sum_{i=1}^{p_9} a_{95,i} cons_{t-i} + \sum_{i=1}^{p_9} a_{96,i} invest_{t-i} + \sum_{i=1}^{p_9} a_{97,i} vaad_{t-i} + \sum_{i=1}^{p_9} a_{98,i} lrate_{t-i} + \sum_{i=1}^{p_9} a_{99,i} m2_{t-i} + \sum_{i=1}^{p_9} a_{90,i} exch_{t-i} + \varepsilon_{9,t} \quad (9)$$

The first equation in the model is the same as the first equation of a standard VAR model. The second to the ninth equations are non-linear regressions that include both $oilp_t$ and ${oilp_t}^+$. $oilp_t$ represents the growth rate of real oil price and the censored variable, ${oilp_t}^+$ is defined as follows:

$${oilp_t}^+ = \begin{cases} oilp_t, if\ oilp_t > 0 \\ 0, if\ oilp_t \leqslant 0, \end{cases}$$

The dependent variables from the second equation until the last equation are a set of macroeconomic indicators in China as described in Section 3.3.1. They are monthly growth rate of China's real import, real export, real consumption, real investment, value added of industrial production, real M2 and real effective exchange rate. Specifically, one year lending rate is in first differenced transformation. In this model specification, oil price increases and decreases are allowed to have a different magnitude of influence in China's macroeconomic indicators. Given the high dimension of the VAR system, I choose different lag orders for different equations in order to obtain a more parsimonious specification. In order to get more efficient estimates, the whole system is estimated by SURE, the seemingly unrelated regression estimator. Actually, the assumption that world oil price is predetermined[17] for China's macro variables ensures the consistency of OLS estimation (used in VAR lag order selection in section 3.4.2) and the efficiency of Seemingly Unrelated Regression(used in estimation in section 3.4.3). After I get the coefficient estimates of the above model, I conduct slope-based tests to explore the symmetry issue. For equation m, testing whether the transmission of oil price shock is symmetric is equivalent to testing:

$$H_0: a_{m2,0} = a_{m2,1} = a_{m2,2} = \cdots = a_{m2,P_m} = 0, where\ m = 2, \ldots 9$$

Wald test statistic is a chi-square limiting distribution with Pm+1 degrees of freedom. The null hypothesis states that the effect of oil price fluctuation is symmetric.

[17] The predeterminancy of world oil price w.r.t. China's macroeconomic aggregates is standard in the literature and is consistent with most of the empirical evidence.

3.4 Empirical Results

3.4.1 Unit Root Test

Before any estimation and tests are conducted on the model described in Section 3.3.2, Unit Root Tests are implemented on the growth rate of world oil prices and other 8 major macroeconomic indicators in China to make sure the stationarity of each data series is achieved. It's well known that ADF test has low power when the span of data is short. So similar to Section 1.4.1 and Section 2.4.1, I also include the KPSS test and the PP test to justify the precision of the test results. Test results are summarized in Table L.1 and all data series pass the tests of stationarity.

3.4.2 Lag Order Selection

After the stationarity tests, I use information criteria to help determine the optimal lag order of each equation in the model. Given the high dimension of the VAR system, it is parsimonious[18] to allow different lag order for each equation in the model described in Section 3.3.2. Under the assumption that oil price is predetermined to China's macroeconomic variables, the model described in Section 3.3.2 can be estimated consistently equation by equation using OLS method. The assumption that oil price is predetermined w.r.t. China's major economic indicators is reasonable considering the fact that monthly data is used in this model. Furthermore, taking oil price as predetermined w.r.t. the macroeconomic variables is standard in the literature. Given these above considerations, for a given value of lag order P, I estimate each

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[18] I also tried models allowing different variables enter into an equation with different lags. However, the residual serial correlation test results of these models become worse. Besides, it still does not show obvious asymmetric effect of oil prices in these models.

equation separately by OLS and get the statistics of AIC and SBC. The results are summarized in Table M.1 to Table M.9. According to AIC[19], the lag orders from equation (1) to equation (10) should be 1, 6, 3, 1, 10, 3, 1, 3 and 1, respectively. At the same time, the lag order of each equation is adjusted to make sure the model described in Section 3.3.2 is free of residual serial correlation. As a result, the final lag orders of equation (1) to equation (9) are: 1, 5, 3, 4, 7, 5, 5, 5, 4.

3.4.3 **Slope Based Tests**

In order to investigate whether decreases and increases in price of oil have any asymmetric influence in China's macroeconomy, I conduct slope based tests for the model described in Section 3.3.2. The test results are reported in Table 3.1, which are based on the final lag orders listed in Section 3.4.2. Generally speaking, oil price changes do not show obvious asymmetric effect on China's macroeconomy.

Table 3.1: Chapter Three-Slope-based Test Results Summary.

Variable	**P-value(AIC)**
Impo(growth rate of China's real import)	0.0510
Expo(growth rate of China's real export)	0.6180
Cons(growth rate of China's real consumption expenditure)	0.9461
Invest(growth rate of China's real investment)	0.2958
Vaad(growth rate of China's value added)	0.0685
Lrate(first difference of China one year lending rate)	0.3362
M2(growth rate of China's real M2)	0.3324
Exch(growth rate of China's real effective exchange rate)	0.2346

[19] Although I calculate both AIC and BIC, I use AIC as a reference to select the lag order of each equation in the model.

Notes: (1) The numbers in the second column are the p-values of the slope based tests described in Section 3.4.3. (2) AIC denotes that the lag order in the regression is determined by Akaike Information Criterion.

As a major indicator of China's monetary policy, China's M2 responds symmetrically to crude oil price changes. Actually, it can be observed from Table 3.1 that the p-value of the slope based test is 0.332. Thus, the equation of China's real M2 described in Section 3.3.2 becomes:

$$M2_t = a_{8\_0} + \sum_{i=0}^{5} a_{81,i}\, oilp_{t-i} + \sum_{i=1}^{5} a_{83,i}\, impo_{t-i} + \sum_{i=1}^{5} a_{84,i} expo_{t-i} + \sum_{i=1}^{5} a_{85,i} cons_{t-i} + \sum_{i=1}^{5} a_{86,i} invest_{t-i} + \sum_{i=1}^{5} a_{87,i} vaad_{t-i} + \sum_{i=1}^{5} a_{88,i} lrate_{t-i} + \sum_{i=1}^{5} a_{89,i} m2_{t-i} + \sum_{i=1}^{5} a_{80,i} exch_{t-i} + \varepsilon_{8,t} \quad (8')$$

Further, a hypothesis test is conducted on equation (8'):

$$\mathrm{H}_0: a_{81,0} = a_{81,1} = \cdots = a_{81,5} = 0$$

Specifically, *oilp* is the monthly growth rate of real oil price and *M2* is the monthly growth rate of China's real money supply M2. Although the sum of the regression coefficients shows that a 1% increase/decrease of oil price growth will bring a 0.09% decrease/increase in the growth rate of China's M2, the p-value of the above hypothesis test showed in the last column of Table N.1 in Appendix N is 0.25, which indicates the oil price changes show no statistical significance in China's growth rate of real M2.

The symmetric effect of oil price changes on China's real M2 is reasonable. Rising oil price on one hand would increase the production cost and this effect can be transmitted and spread out to the price index, leading to an unavoidable inflation throughout the whole economy. Besides, this increase in crude oil price would depress the domestic demand of consumption and postpone the decisions to make an investment, all of which can contribute to a reduction in output or an economic depression. Therefore, the central bank will adopt a tightened monetary policy to suppress the inflation pressure due to the increasing oil prices. When global oil price decreases, China's central bank would possibly increase money supply to stimulate the domestic economy. Also, considering the independence of monetary policy and the central bank's priority in stabilizing the general price level, the insignificant impact of oil price changes on China's money supply is understandable.

Besides China's money supply M2, two other major instruments of monetary policy are also examined. They are real effective exchange rate and one year lending rate. Same as China's M2, the return or growth rate of effective exchange rate behaves symmetrically to oil price changes. This can be concluded by the p-value (0.235) of the slope based test results shown in Table 3.1. Although China's exchange rate is being controlled by China's central bank, the exchange rate is allowed to fluctuate within a limit around a certain rate. This fixed rate has been set according a basket of currencies in major countries. This gradually increased flexibility in the managed exchange rate mechanism actually makes the transmission of oil price shocks through exchange rate more smoothly. As a result, the symmetric effect of oil price changes on the return of China's real effective exchange rate is observed. Thus, the equation of China's real effective exchange rate described in Section 3.3.2 becomes:

$$Exch_t = a_{9\_0} + \sum_{i=0}^{4} a_{91,i}\, oilp_{t-i} + \sum_{i=1}^{4} a_{93,i}\, impo_{t-i} + \sum_{i=1}^{4} a_{94,i} expo_{t-i} + \sum_{i=1}^{4} a_{95,i} cons_{t-i} + \sum_{i=1}^{4} a_{96,i} invest_{t-i} + \sum_{i=1}^{4} a_{97,i} vaad_{t-i} + \sum_{i=1}^{4} a_{98,i} lrate_{t-i} + \sum_{i=1}^{4} a_{99,i} m2_{t-i} + \sum_{i=1}^{4} a_{90,i} exch_{t-i} + \varepsilon_{9,t} \quad (9')$$

Also, a hypothesis test is conducted on equation (9'):

$$H_0: a_{91,0} = a_{91,1} = \cdots = a_{91,4} = 0$$

Specifically, *oilp* is the monthly growth rate in oil price and *Exch* is the monthly return or growth rate of China's effective exchange rate. According to the p-value (0.76) of the joint hypothesis test results in the last column of Table N.1 in Appendix N, it is found that the return of China's real effective exchange rate is not affected by oil price changes significantly. Similar to China's M2, because of the independency of the exchange rate policy in China, China's real effective exchange rate is not sensitive to the global oil price changes. Further, based on the sum of the regression coefficients shown in Table N.1 in Appendix N, a 1% increase/decrease in the growth rate of real oil price will bring a 0.01% decrease/increase in the return of China's real effective exchange rate.

Similar to China's money supply and China's effective exchange rate, one year lending rate responds to oil price changes following a symmetric manner. This can be concluded by the p-value (0.336) of the slope based test results shown in Table 3.1. Since 1996, China's central bank has been implementing a series reforms to advance interest rate marketization. For example, China's central bank abandoned its control on Inter Bank Offered Rate in 1996. Besides, the lending rate between China's financial institutions can be freely determined by market in 2013. So it's not unusual to observe the symmetric influence of oil price changes in China's one year lending rate. The equation of China's one year lending rate described in Section 3.3.2 becomes:

$$Lrate_t = a_{7\_0} + \sum_{i=0}^{5} a_{71,i}\, oilp_{t-i} + \sum_{i=1}^{5} a_{73,i}\, impo_{t-i} + \sum_{i=1}^{5} a_{74,i} expo_{t-i} + \sum_{i=1}^{5} a_{75,i} cons_{t-i} + \sum_{i=1}^{5} a_{76,i} invest_{t-i} + \sum_{i=1}^{5} a_{77,i} vaad_{t-i} + \sum_{i=1}^{5} a_{78,i} lrate_{t-i} + \sum_{i=1}^{5} a_{79,i} m2_{t-i} + \sum_{i=1}^{5} a_{70,i} exch_{t-i} + \varepsilon_{7,t} \quad (7')$$

Further, a hypothesis test is conducted on equation (7'):

$$\mathrm{H}_0: a_{71,0} = a_{71,1} = \cdots = \varphi_{71,5} = 0$$

Specifically, *oilp* is the monthly growth rate in oil price and *Lrate* is the month over month change of China's one year lending rate. The p-value (0.00) of the joint hypothesis test in the last column of Table N.1 in Appendix N indicates that China's one year lending rate is impacted by oil price changes significantly. Further, a 1% increase/decrease in oil price growth will bring a 0.02% increase/decrease in China's one year lending rate. Compared to the insignificant effect of oil price changes on China's M2, the effect of oil price changes on China's one year lending interest is significant. This can be explained by the more and more flexible interest rate policy, compared to the relative independent monetary policy in China.

China's real export, as one of the major component of China's real GDP, reacts symmetrically to the price changes of world crude oil. The conclusion can be inferred by the p-value (0.618) of the slope based test results in Table 3.1 and this is consistent with what has been found in the recent literature, like Hu Meng and Zhang (2013). When global oil price increases, China's export may increases rather than decreases. This is due to the following aspects: First, China's special oil pricing mechanism would keep domestic oil product price stable even if global crude oil price is going upward. This action protects production cost of exporters from being driven up by the increase of global crude oil price. Compared to the competitors from other countries that produce the same products, China's exporters have comparative advantage in price and this would result in higher exports. Second, global crude oil price increases would bring in more export earnings to those countries who export oil, such as OPEC. The increase in revenue would stimulate these countries' imports from China, resulting in an increase in China's export. Meanwhile, when oil price decreases, China's export may decrease accordingly, due to the fact of less competitive advantage in prices of exports and worse outside environment in international trade. Besides, from the previous regression result that an increase/decrease in oil price will bring a decrease/increase in real effective exchange rate or a deprecation/appreciation in RMB, it's no wonder that an increase/decrease in oil price can bring an increase/decrease in export. Given the symmetric effect of oil price changes on China's real export, the equation of China's real export described in Section 3.3.2 becomes:

$$Expo_t = a_{3\_0} + \sum_{i=0}^{3} a_{31,i}\, oilp_{t-i} + \sum_{i=1}^{3} a_{33,i}\, impo_{t-i} + \sum_{i=1}^{3} a_{34,i} expo_{t-i} + \sum_{i=1}^{3} a_{35,i} cons_{t-i} + \sum_{i=1}^{3} a_{36,i} invest_{t-i} + \sum_{i=1}^{3} a_{37,i} vaad_{t-i} + \sum_{i=1}^{3} a_{38,i} lrate_{t-i} + \sum_{i=1}^{3} a_{39,i} m2_{t-i} + \sum_{i=1}^{3} a_{30,i} exch_{t-i} + \varepsilon_{3,t} \quad (3')$$

Also, the hypothesis test is conducted on equation (3'):

$$\mathrm{H}_0: a_{31,0} = a_{31,1} = \cdots a_{31,3} = 0$$

Specifically, *oilp* is the monthly growth rate of real oil price and *Expo* is the monthly growth rate of China's real export. According to the p-value (0.16) of the joint hypothesis test that is shown in the last column of Table N.1 in Appendix N, it can be inferred that China's real export is not affected by oil price changes significantly. This can be explained by the fact that oil is only one of the important inputs in production. So oil price increases would not necessarily result in an adverse impact on China's real export because of the substitution effect of other inputs, such as labor. Further, if oil price growth increases/decreases by 1%, China's real export growth will increase/decrease by 0.22%.

Similarly, China's import responds to world oil price changes in a symmetric manner, which can be concluded from the p-value (0.051) of the slope based test results in Table 3.1. Accordingly, the equation of China's real import described in Section 3.3.2 becomes:

$$Impo_t = a_{2\_0} + \sum_{i=0}^{5} a_{21,i}\, oilp_{t-i} + \sum_{i=1}^{5} a_{23,i}\, impo_{t-i} + \sum_{i=1}^{5} a_{24,i} expo_{t-i} + \sum_{i=1}^{5} a_{25,i} cons_{t-i} + \sum_{i=1}^{5} a_{26,i} invest_{t-i} + \sum_{i=1}^{5} a_{27,i} vaad_{t-i} + \sum_{i=1}^{5} a_{28,i} lrate_{t-i} + \sum_{i=1}^{5} a_{29,i} m2_{t-i} + \sum_{i=1}^{5} a_{20,i} exch_{t-i} + \varepsilon_{2,t} \quad (2')$$

Similarly, a hypothesis test is conducted on equation (2'):

$$\mathrm{H}_0: a_{21,0} = a_{21,1} = \cdots = a_{21,5} = 0$$

Specifically, *oilp* is the monthly growth rate of real oil price and *Impo* is the monthly growth rate of China's real import. According to the p-value (0.00) of the joint hypothesis test that is shown in the last column of Table N.1 in Appendix N, it can be inferred that the real import of China is impacted by oil price changes significantly. Further, if oil price growth increases/decreases by 1%, China's real import growth will increase/decrease by 0.56%. The positive relationship between real import in China and oil price changes seems counterintuitive at first glance. However, considering China's strong economic growth is the engine of the world's economy development during the study period, rising oil price itself might be a reflection of China's strong demand in import. Thus, it's not surprising to see an increase in China's real import even when oil price increases. Compared to the insignificant effect of oil price changes on China's real export, oil price changes have a significant influence in China's real import. Response of China's real export with respect to oil price changes needs reallocation of labor and capital within different sectors while response of China's real import does not. Also, oil is not the only energy resource that can be used in production for export, thus increase in oil prices can stimulate the usage of other energy. As a result, it is not unusual to observe an insignificant effect of oil price changes on China's real export while a significant effect of oil price changes on the real import in China.

Specifically, oil price changes show an symmetric influence in the growth rate of China's value added. Actually, the p-value of the slope based test is larger than 5% (0.069), which indicates the coefficients of the censored oil price variables are statistically insignificant and oil price changes have no asymmetric effect on China's growth rate of value added. This result is different from what has been obtained in other papers which employ different methods, such as Du, He and Wei (2010). However, it can be justified in the following dimensions. First, the presence of reallocation effect, one of the major explanations for the asymmetric response of real output to oil price innovations, is negligible in China. The popular view in the literature supporting the asymmetric influence of oil price in output believes that changes in oil price could result in reallocations of capital and labor within or across industrial sectors. Frictions in the markets refrains capital and labor from transferring smoothly among different sectors during reallocation, resulting in a pure loss to real output, no matter which direction oil price goes towards. So it reinforces the recessionary effect on output when oil price goes up while it offsets the expansionary effect when oil price falls down. Although the frictions in China's capital and labor markets are pervasive, the influence of its negative effect on real output is not obvious. As Edelstein and Kilian (2009) suggested, the magnitude of the negative impact of relocation effect depends on consumers' expenditure shifting in response to oil price changes. Moreover, it is generally agreed that domestic auto industry is most vulnerable to the negative reallocation effect. However, the evidence in China shows that the effect of oil price changes on automobiles purchase is very limited. That's because gasoline prices constitutes only a small proportion of the total expenditure related to auto consumptions. The oil price elasticity of auto demand in China is very small, thus the adverse effect of oil price changes on resource reallocation and then on real output is not significant.

Another major reason behind this phenomenon relies on the special gasoline pricing mechanism. As is discussed in Section 2.1.2, although China's oil pricing mechanism is becoming more and more integrated with the world crude oil market, it has certain features that can distort the relationship between global oil prices and macroeconomy in China. First, the current oil product pricing mechanism is based on the trading prices of oil products in New York, Rotterdam and Singapore markets, rather than the prices of crude oil. Considering the lag effect of changing crude oil price on oil products, the current domestic oil product price is actually a reflection of the world crude oil market in the previous periods. Second, Although China's crude oil price is adjusted according to world crude oil market; domestic oil product price is subjected to government control. So it's not unusual to see that China's National Development and Reform Commission (NDRC) may not raise domestic oil product prices or only raise the prices a little bit, in the consideration of upcoming inflation even when large increase of price in world crude oil market is observed. Meanwhile, to protect domestic oil refining industry from suffering declines in world crude oil price, NDRC will not push domestic oil product prices down. Thus, this special oil pricing mechanism in China could offset both the negative effect of increases in oil price and the positive effect of decreases in oil price on the growth rate of China's value added.

Based on the above reasons, the symmetric effect of oil price decreases and increases on the growth rate of China's value added is very likely to happen in case of China's special situation. Furthermore, according to the slope based test results shown in Table 3.1, the equation of growth rate of China's value added described in Section 3.3.2 becomes:

$$Vaad_t = a_{6\_0} + \sum_{i=0}^{5} a_{61,i}\, oilp_{t-i} + \sum_{i=1}^{5} a_{63,i}\, impo_{t-i} + \sum_{i=1}^{5} a_{64,i} expo_{t-i} + \sum_{i=1}^{5} a_{65,i} cons_{t-i} + \sum_{i=1}^{5} a_{66,i} invest_{t-i} + \sum_{i=1}^{5} a_{67,i} vaad_{t-i} + \sum_{i=1}^{5} a_{68,i} lrate_{t-i} + \sum_{i=1}^{5} a_{69,i} m2_{t-i} + \sum_{i=1}^{5} a_{60,i} exch_{t-i} + \varepsilon_{6,t} \quad (6')$$

Specifically, *oilp* is the monthly growth rate of real oil price and *Vaad* is the monthly growth rate of China's value added. Also, the lag order here is chosen by AIC. A hypothesis test is also conducted on equation (6'):

$$\mathrm{H}_0: a_{61,0} = a_{61,1} = \cdots = a_{61,5} = 0$$

As displayed in the last column of Table N.1 in Appendix N, the p-value of the joint hypothesis is 0.00, which means the growth rate of China's value added is affected by the oil price changes significantly. Furthermore, oil price increases and oil price decreases can exhibit symmetric influence in China's value added. According to the sum of the regression coefficients, if oil price increases by 1%, it can cause a 0.01% increase in the growth rate of China's value added. On the contrary, if oil price decreases by 1%, it will bring a 0.01% decrease in the growth rate of China's value added. Similarly, from the previously regression result that an increase/decrease in oil price will bring a decrease/increase in real effective exchange rate or a deprecation/appreciation, it's no wonder to understand that an increase/decrease in oil price can bring an increase/decrease in China's value added as a result of the deprecation/appreciation.

Also, oil price changes have symmetric impacts on both China's real consumption and China's real investment. This conclusion is based on the fact that the p-values of the slope based tests for China's real consumption and China's real investment are 0.946 and 0.296, respectively. The symmetric effect of oil price changes on China's real consumption and real investment is plausible. When oil price increases, real consumption will tend to shrink as a result of a reduction in disposable income. This decreasing purchasing power would possibly postpone people's consumption, thus reducing their consumption expenditure. In the meanwhile, increase in crude oil price may add to firms' costs and theirs' expectation of uncertainty, which results in a delay in investment decisions. When oil price decreases, the opposite is true. Although the negative effect of oil price increases on consumer price index can be alleviated by the oil price control policy, the consumption behavior can be greatly affected by people's rational expectation of uncertainty in oil prices. So even if there is stickiness in the oil price transmission mechanism due to the unsound market system in China, with the signal sent out by oil price changes, consumption and investment behaviors can be adjusted accordingly through rational expectations. Furthermore, the extent of the influence of oil price changes roots in the belief that whether oil price changes are transitional or not. As a result, the symmetric effect of oil price changes on China's real consumption and real investment is reasonable.

As a result, the equation of China's real consumption described in Section 3.3.2 becomes:

$$Cons_t = a_{4\_0} + \sum_{i=0}^{4} a_{41,i}\, oilp_{t-i} + \sum_{i=1}^{4} a_{43,i}\, impo_{t-i} + \sum_{i=1}^{4} a_{44,i} expo_{t-i} + \sum_{i=1}^{4} a_{45,i} cons_{t-i} + \sum_{i=1}^{4} a_{46,i} invest_{t-i} + \sum_{i=1}^{4} a_{47,i} vaad_{t-i} + \sum_{i=1}^{4} a_{48,i} lrate_{t-i} + \sum_{i=1}^{4} a_{49,i} m2_{t-i} + \sum_{i=1}^{4} a_{40,i} exch_{t-i} + \varepsilon_{4,t} \quad (4')$$

A joint hypothesis test is conducted on the equation of (4'):

$$\mathrm{H}_0: a_{41,0} = a_{41,1} = \cdots = a_{41,4} = 0$$

Specifically, *oilp* is the monthly growth rate of real oil price and *Cons* is the monthly growth rate of China's real consumption. According to the joint hypothesis test result that is shown in Table N.1 in Appendix N, the following conclusion can be obtained. Although an increase/decrease of oil price by 1% tends to increase/decrease China's real consumption expenditure by 0.01%, this influence of oil price changes in China's real consumption is not statistically significant, which can be inferred by the p-value of the joint hypothesis test (0.99). This insignificant effect of oil price changes on China's real consumption relies on the oil price control policy in China, which can isolate the adverse effect of world oil price changes on the macroeconomy in China.

Similar to China's real consumption, the equation of China's real investment described in Section 3.3.2 becomes:

$$Invest_t = a_{5\_0} + \sum_{i=0}^{7} a_{51,i}\, oilp_{t-i} + \sum_{i=1}^{7} a_{53,i}\, impo_{t-i} + \sum_{i=1}^{7} a_{54,i} expo_{t-i} + \sum_{i=1}^{7} a_{55,i} cons_{t-i} + \sum_{i=1}^{7} a_{56,i} invest_{t-i} + \sum_{i=1}^{7} a_{57,i} vaad_{t-i} + \sum_{i=1}^{7} a_{58,i} lrate_{t-i} + \sum_{i=1}^{7} a_{59,i} m2_{t-i} + \sum_{i=1}^{7} a_{50,i} exch_{t-i} + \varepsilon_{5,t} \quad (5')$$

A joint hypothesis test is conducted on equation (5'):

$$\mathrm{H}_0: a_{51,0} = a_{51,1} = \cdots a_{51,7} = 0$$

Similarly, *oilp* is the monthly growth rate of real oil price and *Invest* is the monthly growth rate of China's real investment. According to the joint hypothesis test result that is shown in Table N.1 in Appendix N, the same conclusion as that of China's real consumption can be inferred. Although a 1% increase/decrease in the oil price growth will lead to a 0.08% increase/decrease in the real investment growth, China's real investment is not affected significantly by oil price fluctuations, which can be inferred by the p-value (0.45) shown in the last column of Table N.1 in Appendix N. The explanation is the same as what has been described in the case of China's real consumption.

In a summary, the effects of oil price changes on China's major economic indicators are symmetric. This is similar to what Kilian and Vigfusson (2011) has found in their paper that there is no statistically significant evidence of asymmetry in the effect of oil price changes on CPI and GDP in U.S.. Further, China's real import, China's value added and China's one year lending rate are affected by global oil price fluctuations significantly, although no significant impacts are observed on China's real consumption, real investment, real export, real M2 and effective exchange rate. The insignificance of the influences of oil price changes in the real consumption, real investment, real export, real M2 and real effective exchange rate can be partly explained that oil is not the only major source of energy in China and can be partially attributed to the independence of China's monetary policy.

Chapter 4

CONCLUSIONS

The purpose of the dissertation is identifying different types of world oil price shocks and studying their dynamic impacts on China's macroeconomy. Besides, the symmetry issue of oil price fluctuations-whether oil price increases or decreases have the same magnitude of impact on China's major macroeconomic indicators is also investigated.

By using Structural VAR model, six major types of oil price shocks have been identified and quantified, including oil supply shocks, aggregate demand shocks, U.S. money supply shocks, China's money supply shocks, China's real effective exchange rate shocks and oil specific demand shocks. This study finds that, at any point of time, real oil price responds to a combination of structural shocks that change over time. However, different types of shocks behave differently in affecting oil price fluctuations. Specifically, positive global oil supply shocks exhibit little impact on oil price fluctuations while positive shocks in global aggregate demand possess a positive and persistent impact on world oil price. At the meantime, an increase in the U.S. money supply has a long-lived but lagged positive effect on the oil price while an increase in the money supply of China demonstrates a significant and negative impact on the oil price. The initial negative relationship between money supply in U.S. and global oil price can be explained by "price puzzle" while the inverse relationship between China's money supply and world oil price is mainly due to the special outflow of money into the real estate market during the study period in China. Besides, positive shocks in China's real effective exchange rate can drive world oil price down while positive oil specific demand shocks can push global oil price up. According to the magnitude of impact through history, oil-specific demand shocks and China's real effective exchange rate shocks make the largest contribution to the fluctuations of oil price. While U.S. money supply shocks, China's money supply shocks and global aggregate demand shocks cause relatively large impacts on the oil price, oil supply shocks make little contribution to the dynamics of real oil price. Further, no strong statistical evidence is found in this study to support the popular view that China should be responsible for the oil price increase in 2008.

After different oil price shocks are identified and quantified, the dynamic influence of oil price shocks in the major economic indicators of China are explored. The evidence demonstrates that oil price increases due to different underlying shocks can have very different impacts on the macroeconomy in China. Actually, the impact of oil price changes on the macroeconomy in China is majorly transmitted through the demand channel and the monetary policy channel. Specifically, positive oil supply shocks bring little impacts on the majority of China's macroeconomic indicators, which is consistent with most of the results that have been found in the literature. An unexpected increase in global aggregate demand has very limited impact on China's real consumption, real investment and real export. However, it has significant and positive impact on China's real import, China's value added and one year lending rate. Besides, positive innovations in U.S. money supply M2 causes little or small impact on most of China's major economic indicators. At the meantime, positive shocks in real effective exchange rate or an appreciation in RMB can have great impacts on the majority of China's macroeconomic indicators while the impacts of positive oil specific demand shocks on China's economy is very limited.

Regarding to the symmetry issue of oil price shocks on the macroeconomy in China, slope based tests are implemented. The test result shows that the influences of oil price changes in China's major economic indicators are symmetric. The symmetric effect is consistent with what has been found for U.S. macroeconomy in Kilian and Vigfusson (2001). Further, the symmetric effect of oil price changes on the macroeconomy in China is reasonable, considering the more and more flexible exchange rate and the reform of interest rate marketization, which greatly reduces the frictions in the markets and smooths the capital and labor transferring among different sectors.

A number of limitations of this study should also be mentioned. First, the model specifications in Chapter 1 are not perfect although they are based on sound economic theory. Actually, not all underlying shocks behind the oil price fluctuations are considered in the model as a result of the unavailability of the data, such as oil inventory. Second, the data quality on China's macroeconomic variables has been debated and questioned for a long time. The inconsistency between different data revisions and the intransparency of data construction both raise the question on the reliability of China's economic data. All the above limitations can cause an inaccuracy of the results that have been found in this study. At the meantime, these limitations can also provide a room for future study that could address these shortcomings.

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Appendix A

DATA PLOTS FOR VARIABLES IN CHAPTER 1

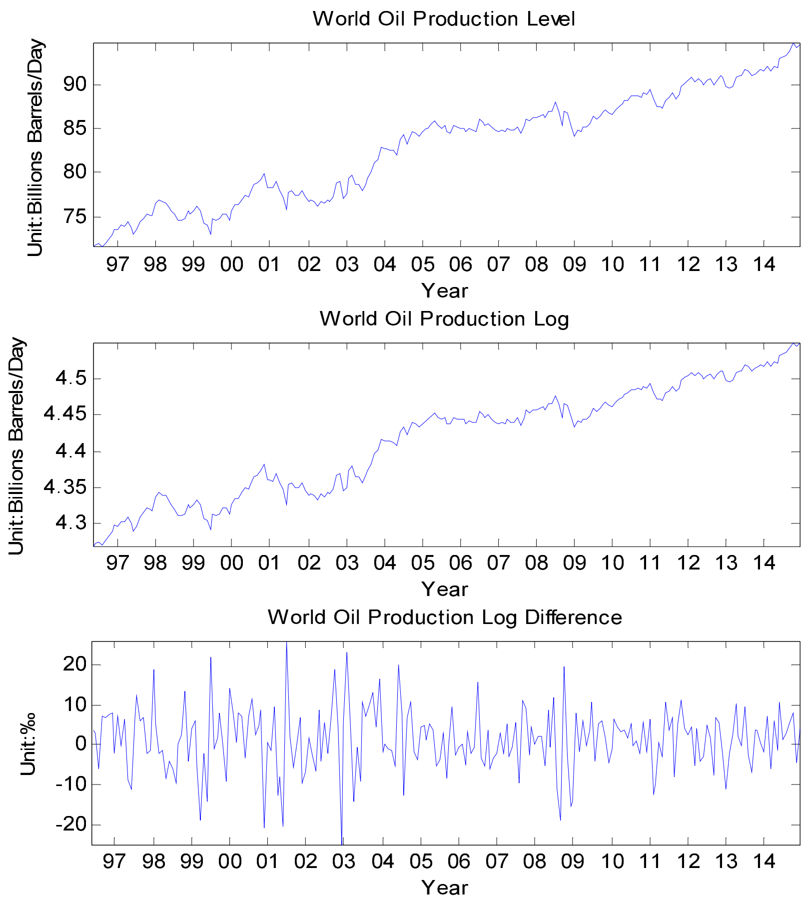


Figure A.1: Chapter One-Data Plots for Variable of World Oil Production and Its Transformations.

Notes: In Chapter 1, the variable of world oil production in level or log format ranges from 1996m5 to 2014m12 while it ranges from 1996m6 to 2014m12 in the log difference format.

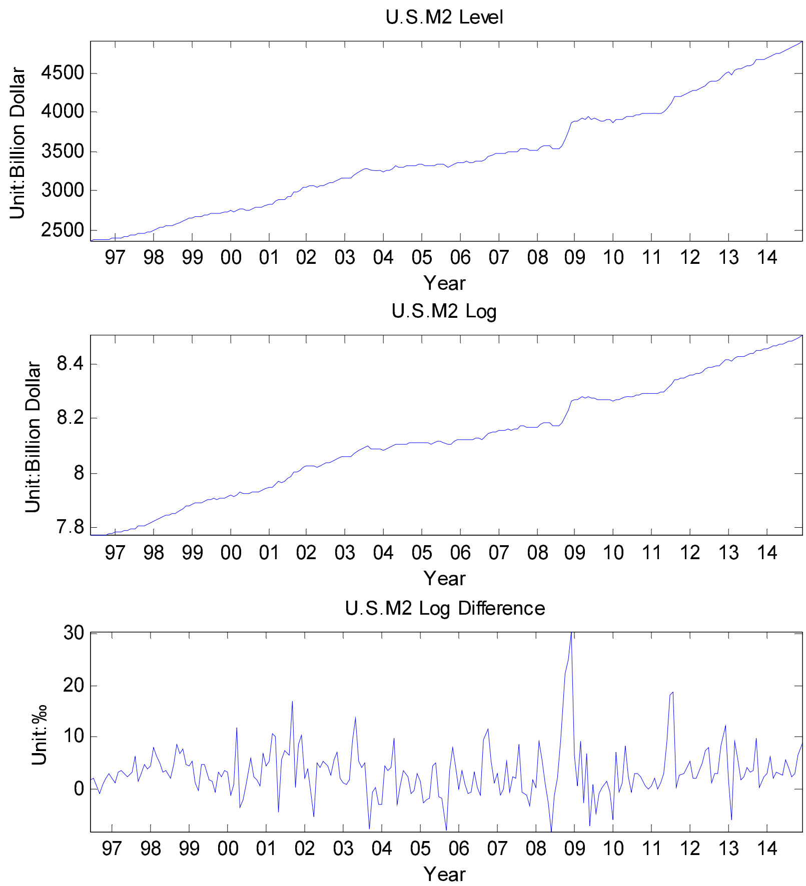


Figure A.2: Chapter One-Data Plots for Variable of U.S. Money Supply M2 and Its Transformations.

Notes: In Chapter 1, the variable of U.S. M2 in level or log format ranges from 1996m5 to 2014m12 while it ranges from 1996m6 to 2014m12 in the log difference format.

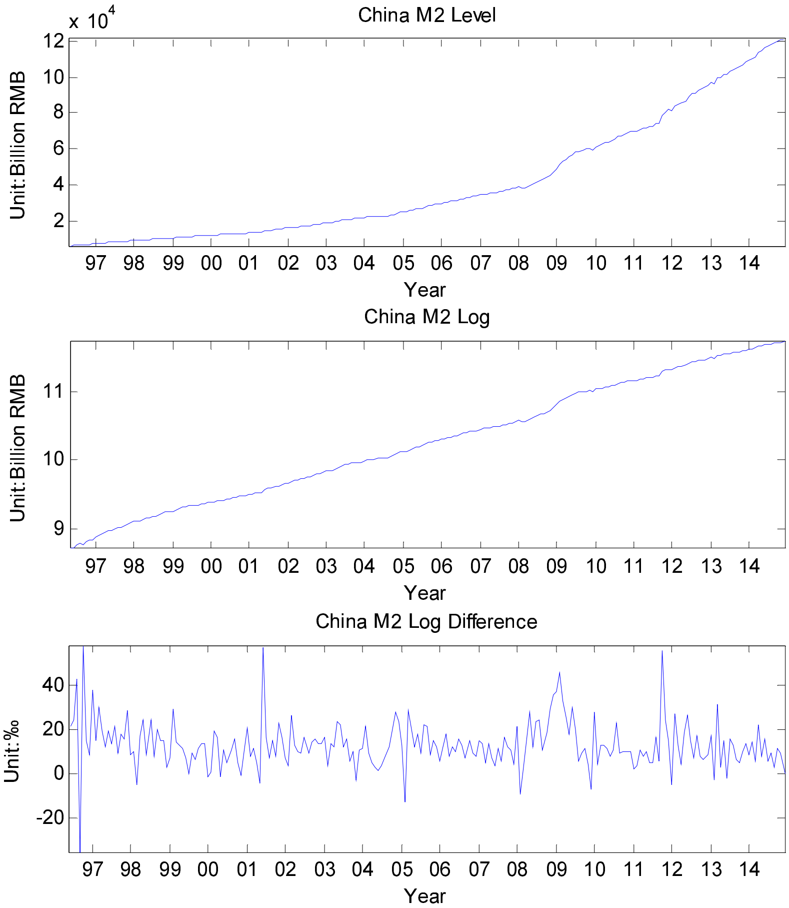


Figure A.3: Chapter One-Data Plots for Variable of China's Money Supply M2 and Its Transformations.

Notes: In Chapter 1, the variable of China's M2 in level or log format ranges from 1996m5 to 2014m12 while it ranges from 1996m6 to 2014m12 in the log difference format.

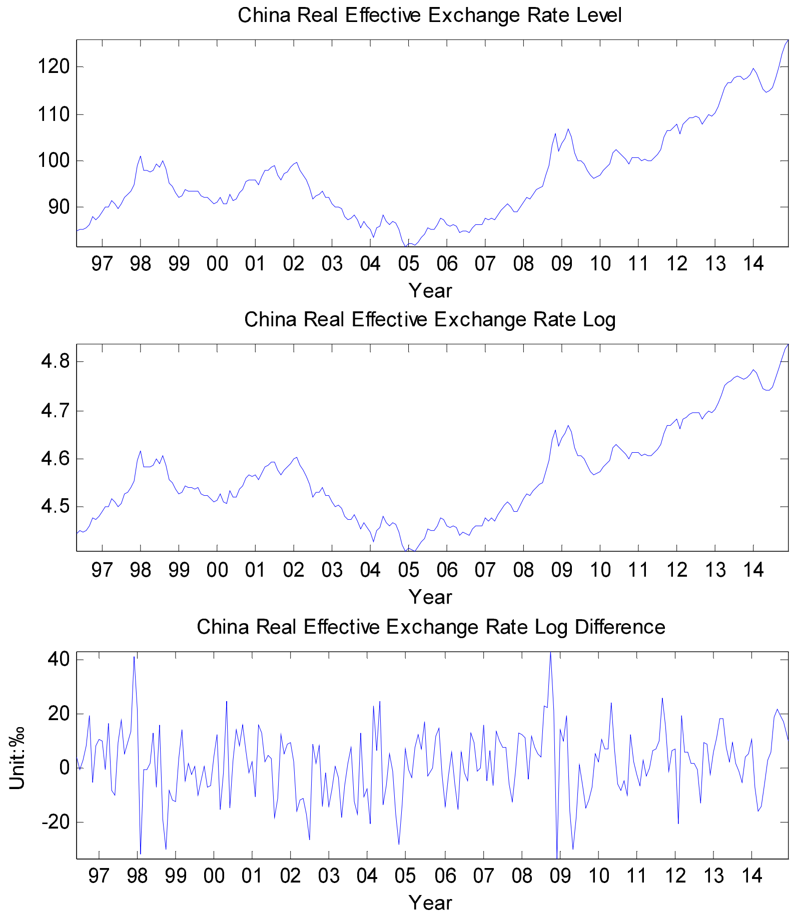


Figure A.4: Chapter One-Data Plots for Variable of China's Real Effective Exchange Rate and Its Transformations.

Notes: In Chapter 1, the variable of China's real effective exchange rate in level or log format ranges from 1996m5 to 2014m12 while it ranges from 1996m6 to 2014m12 in the log difference format.

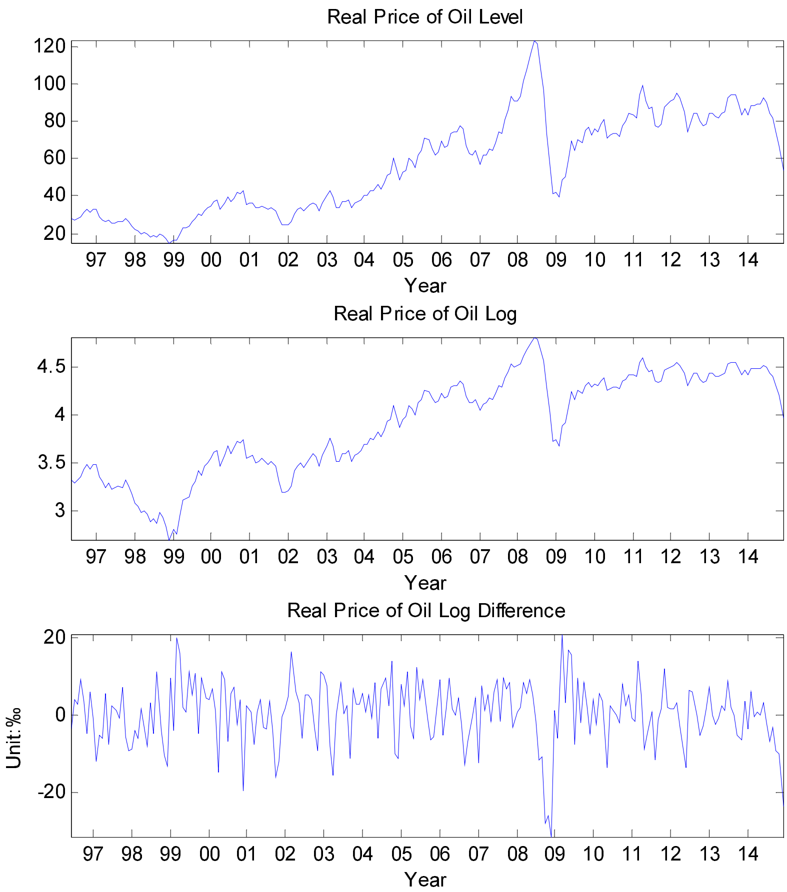


Figure A.5: Chapter One-Data Plots for Variable of Global Real Oil Price and Its Transformations.

Notes: In Chapter 1, the variable of global real oil price in level or log format ranges from 1996m5 to 2014m12 while it ranges from 1996m6 to 2014m12 in the log difference format.

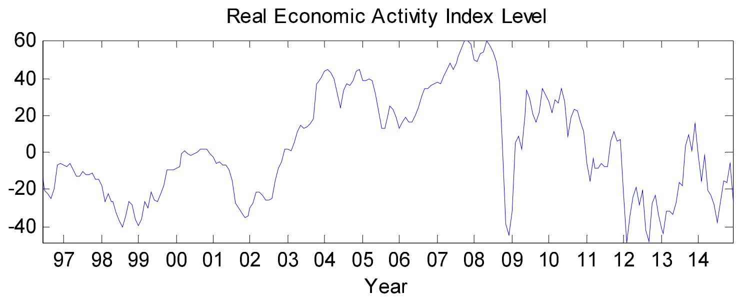


Figure A.6: Chapter One-Data Plots for Variable of Global Real Economic Activity Index.

Notes: In Chapter 1, the variable of global real economic activity index ranges from 1996m6 to 2014m12.

Appendix B

DATA PLOTS FOR VARIABLES IN CHAPTER 2

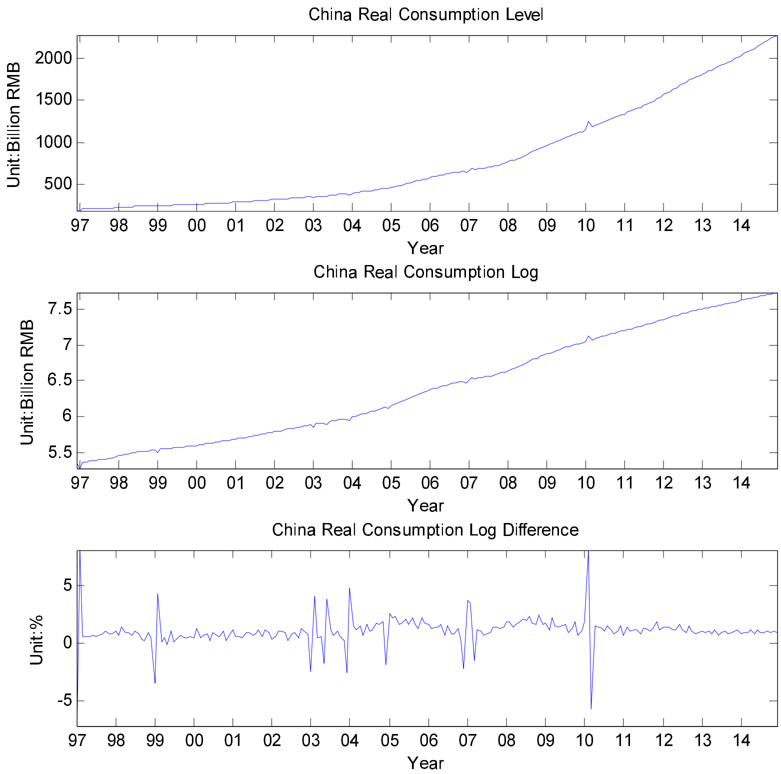


Figure B.1: Chapter Two-Data Plots for Variable of China's Real Consumption and Its Transformations.

Notes: In Chapter 2, the variable of China's real consumption in level or log format ranges from 1996m12 to 2014m12 while it ranges from 1997m1 to 2014m12 in the log difference format.

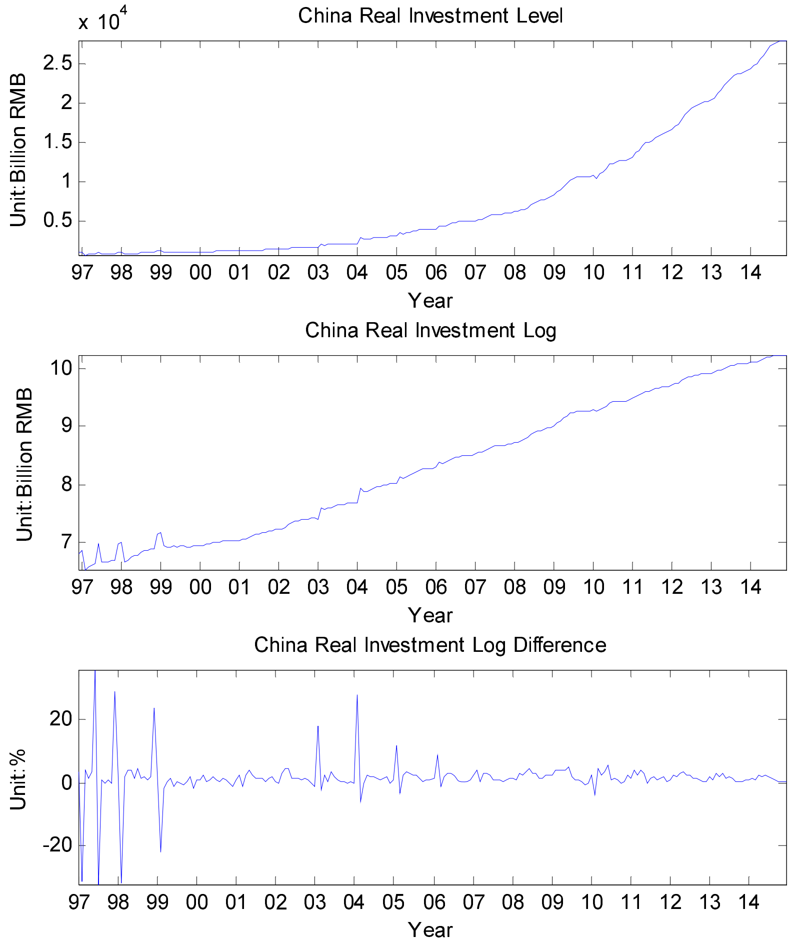


Figure B.2: Chapter Two-Data Plots for Variable of China's Real Investment and Its Transformations.

Notes: In Chapter 2, the variable of China's real investment in level or log format ranges from 1996m12 to 2014m12 while it ranges from 1997m1 to 2014m12 in the log difference format.

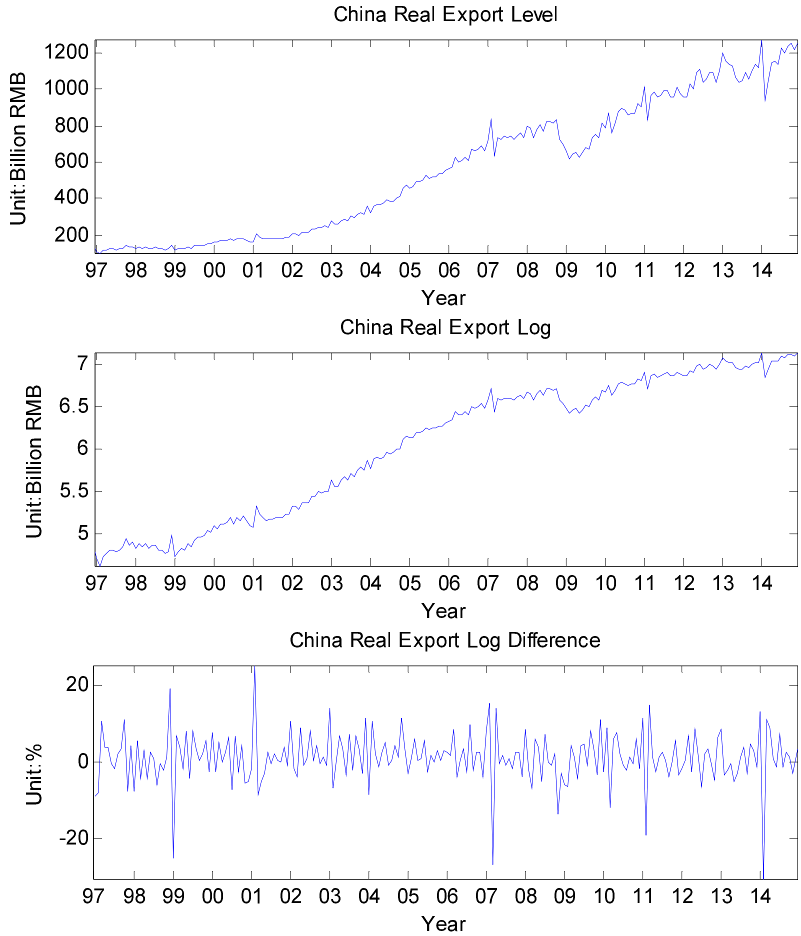


Figure B.3: Chapter Two-Data Plots for Variable of China's Real Export and Its Transformations.

Notes: In Chapter 2, the variable of China's real export in level or log format ranges from 1996m12 to 2014m12 while it ranges from 1997m1 to 2014m12 in the log difference format.

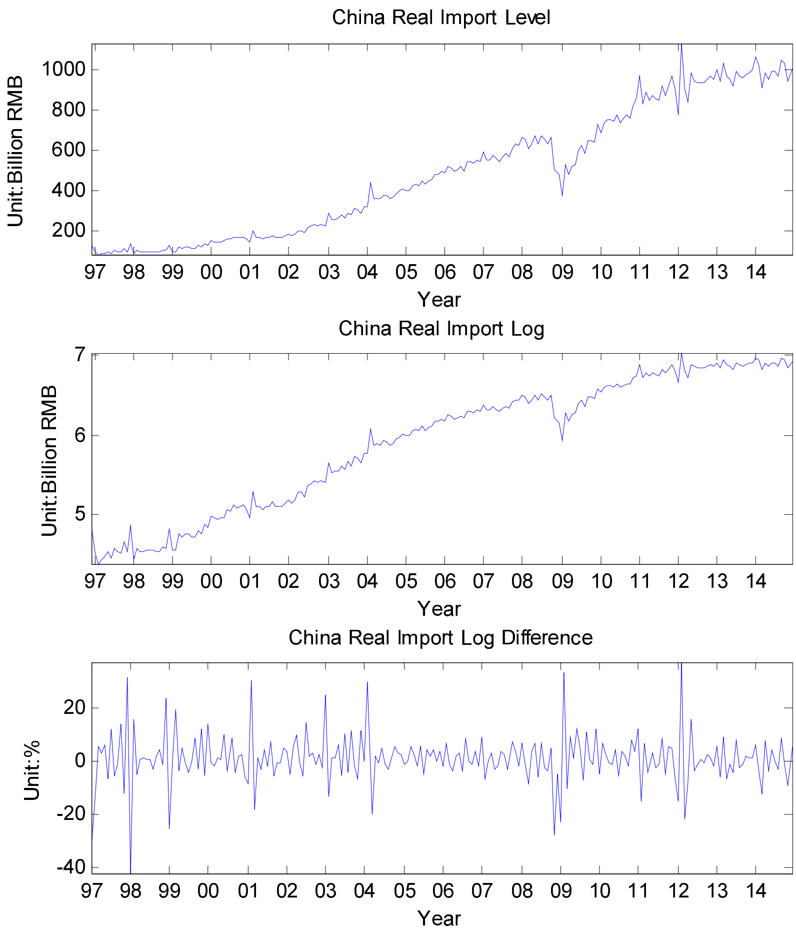


Figure B.4: Chapter Two-Data Plots for Variable of China's Real Import and Its Transformations.

Notes: In Chapter 2, the variable of China's real import in level or log format ranges from 1996m12 to 2014m12 while it ranges from 1997m1 to 2014m12 in the log difference format.

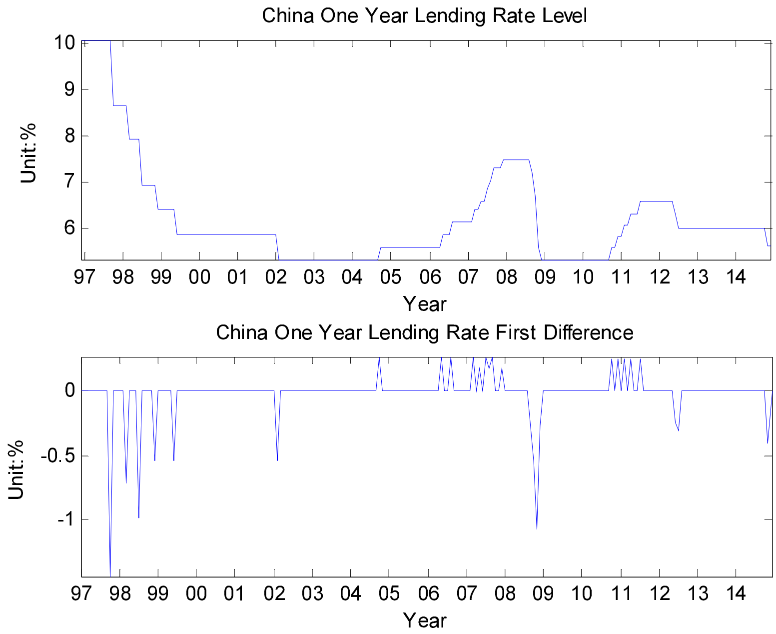


Figure B.5: Chapter Two-Data Plots for Variable of China's One Year Lending Rate and Its Transformations.

Notes: In Chapter 2, the variable of China's one year lending rate in level format ranges from 1996m12 to 2014m12 while it ranges from 1997m1 to 2014m12 in the first difference format.

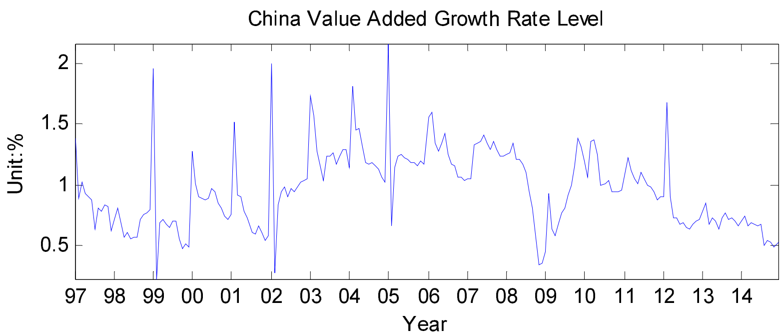


Figure B.6: Chapter Two-Data Plots for Variable of China's Value Added Growth Rate.

Notes: In Chapter 2, the variable of China's value added growth rate ranges from 1997m1 to 2014m12.

Appendix C

DATA PLOTS FOR VARIABLES IN CHAPTER 3

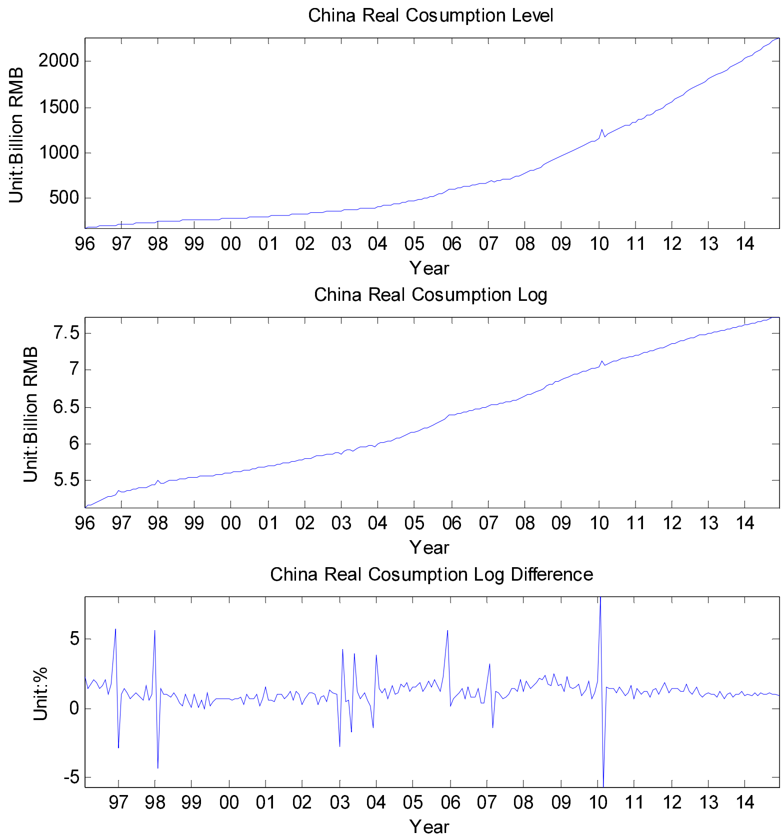


Figure C.1: Chapter Three-Data Plots for Variable of China's Real Consumption and Its Transformations.

Notes: In Chapter 3, the variable of China's real consumption in level or log format ranges from 1996m1 to 2014m12 while it ranges from 1996m2 to 2014m12 in the log difference format.

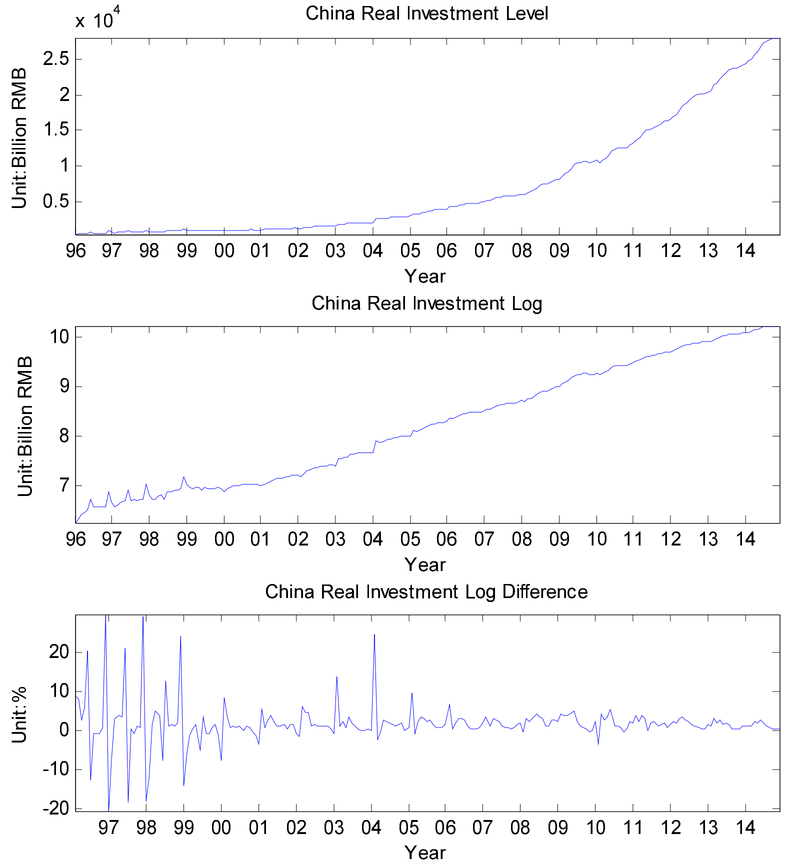


Figure C.2: Chapter Three-Data Plots for Variable of China's Real Investment and Its Transformations.

Notes: In Chapter 3, the variable of China's real investment in level or log format ranges from 1996m1 to 2014m12 while it ranges from 1996m2 to 2014m12 in the log difference format.

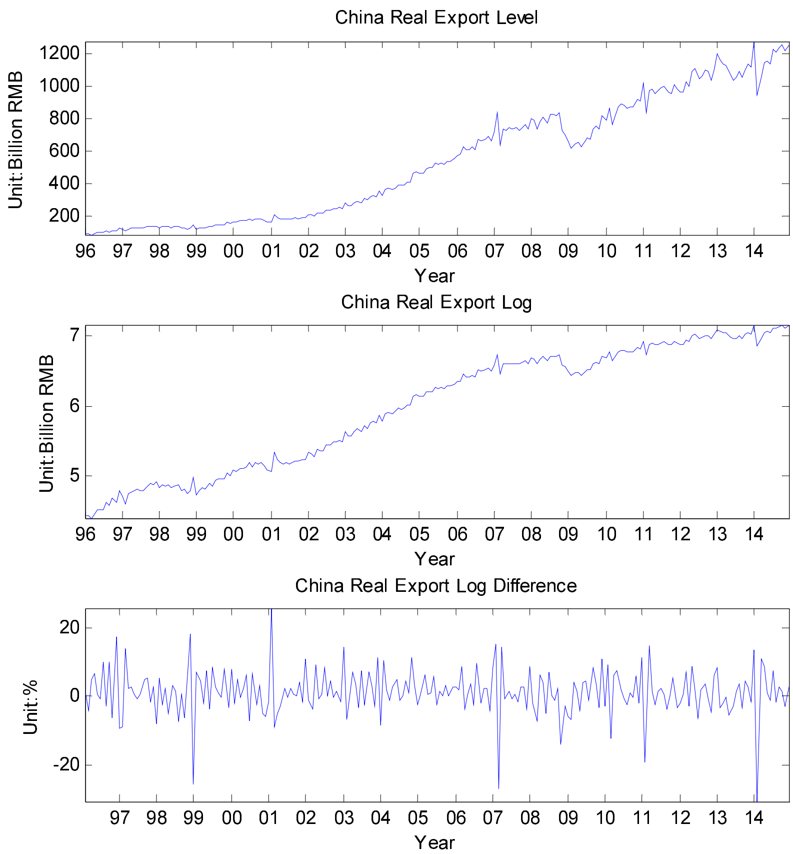


Figure C.3: Chapter Three-Data Plots for Variable of China's Real Export and Its Transformations.

Notes: In Chapter 3, the variable of China's real export in level or log format ranges from 1996m1 to 2014m12 while it ranges from 1996m2 to 2014m12 in the log difference format.

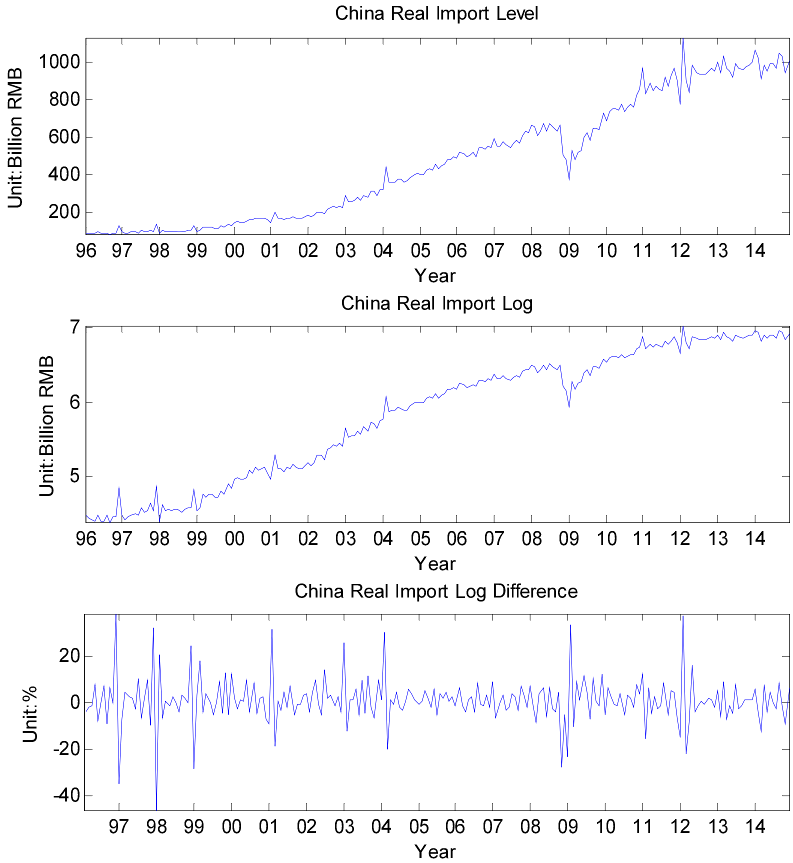


Figure C.4: Chapter Three-Data Plots for Variable of China's Real Import and Its Transformations.

Notes: In Chapter 3, the variable of China's real import in level or log format ranges from 1996m1 to 2014m12 while it ranges from 1996m2 to 2014m12 in the log difference format.

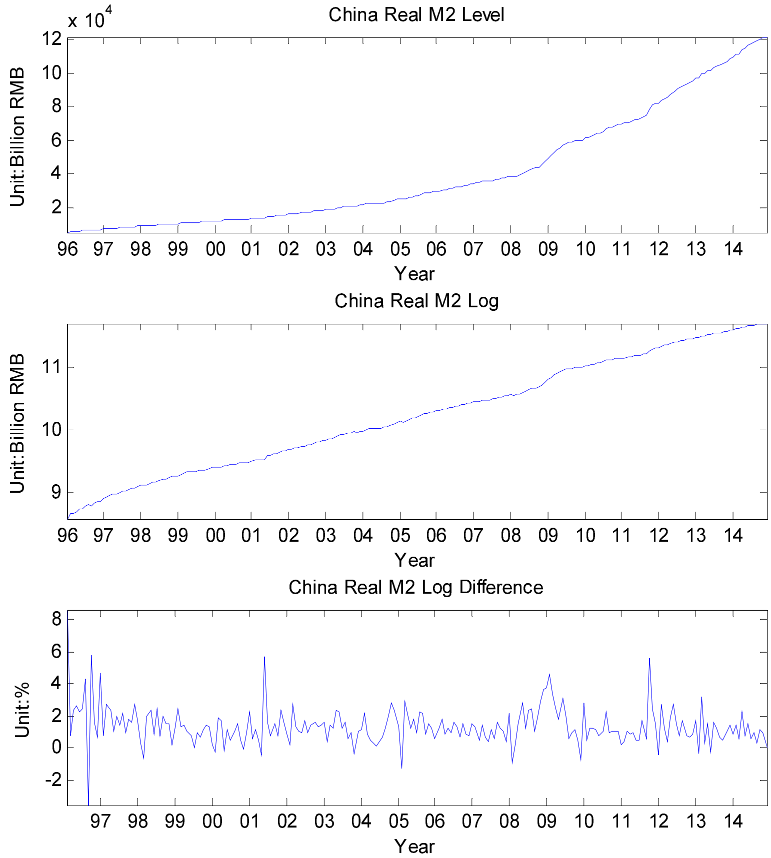


Figure C.5: Chapter Three-Data Plots for Variable of China's Real Money Supply M2 and Its Transformations.

Notes: In Chapter 3, the variable of China's real M2 in level or log format ranges from 1996m1 to 2014m12 while it ranges from 1996m2 to 2014m12 in the log difference format.

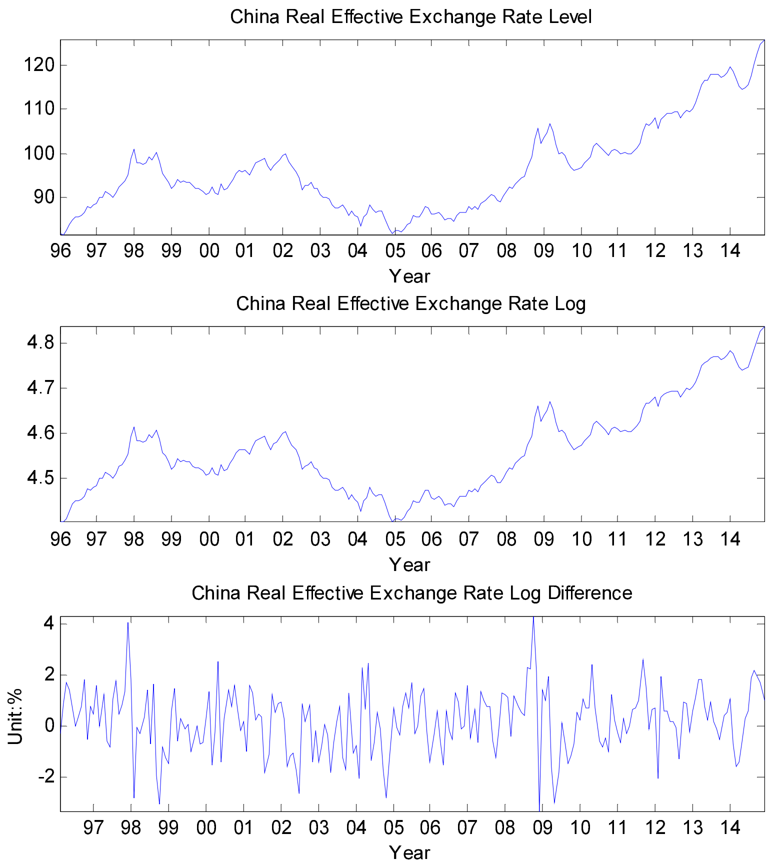


Figure C.6: Chapter Three-Data Plots for Variable of China's Real Effective Exchange Rate and Its Transformations.

Notes: In Chapter 3, the variable of China's real effective exchange rate in level or log format ranges from 1996m1 to 2014m12 while it ranges from 1996m2 to 2014m12 in the log difference format.

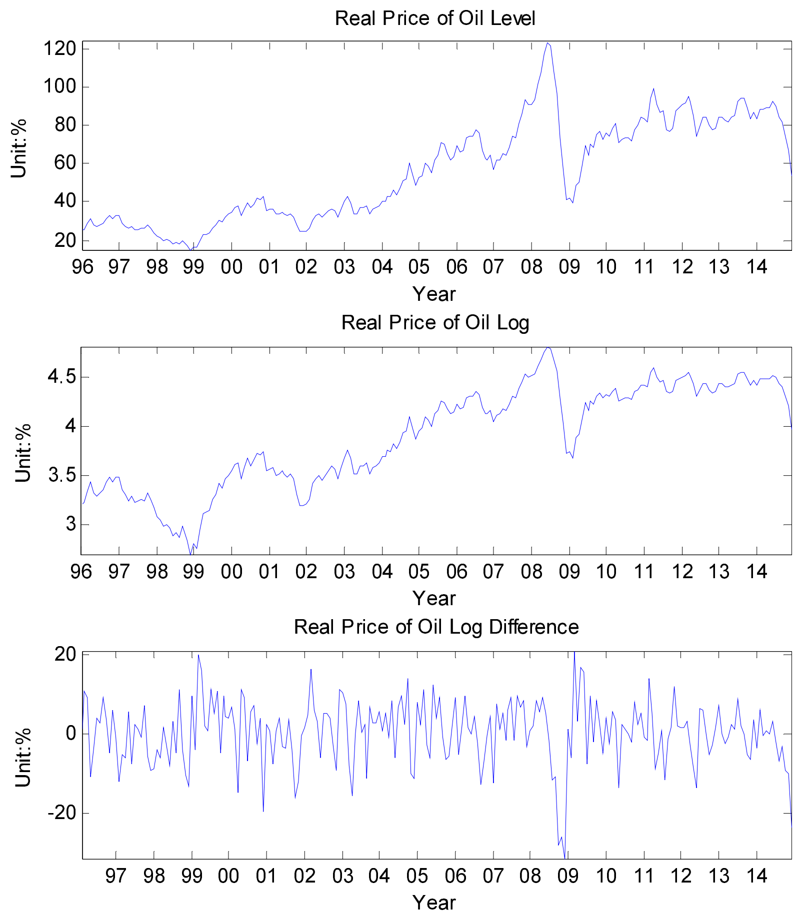


Figure C.7: Chapter Three-Data Plots for Variable of Global Real Oil Price and Its Transformations.

Notes: In Chapter 3, the variable of China's real effective exchange rate in level or log format ranges from 1996m1 to 2014m12 while it ranges from 1996m2 to 2014m12 in the log difference format.

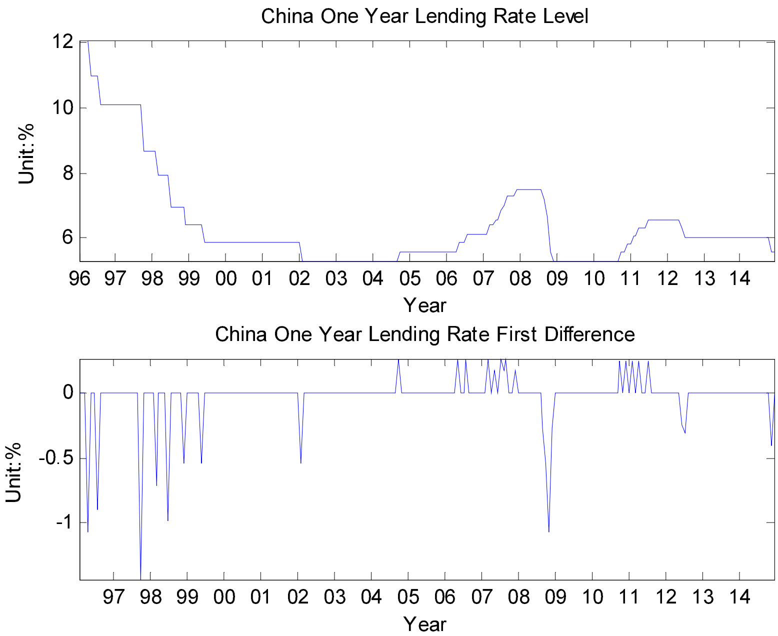


Figure C.8: Chapter Three-Data Plots for Variable of China's One Year Lending Rate and Its Transformations.

Notes: In Chapter 3, the variable of China's one year lending rate in level format ranges from 1996m1 to 2014m12 while it ranges from 1996m2 to 2014m12 in the first difference format.

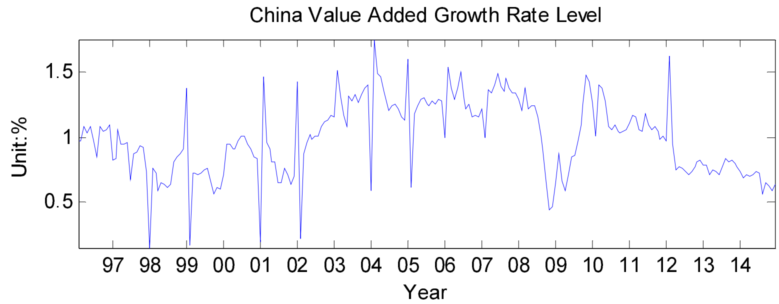


Figure C.9: Chapter Three-Data Plots for Variable of China's Value Added Growth Rate.

Notes: In Chapter 3, the variable of China's value added growth rate in level format ranges from 1996m2 to 2014m12.

Appendix D

DESCRIPTION OF MAJOR OIL EVENTS AND U.S. ECONOMY

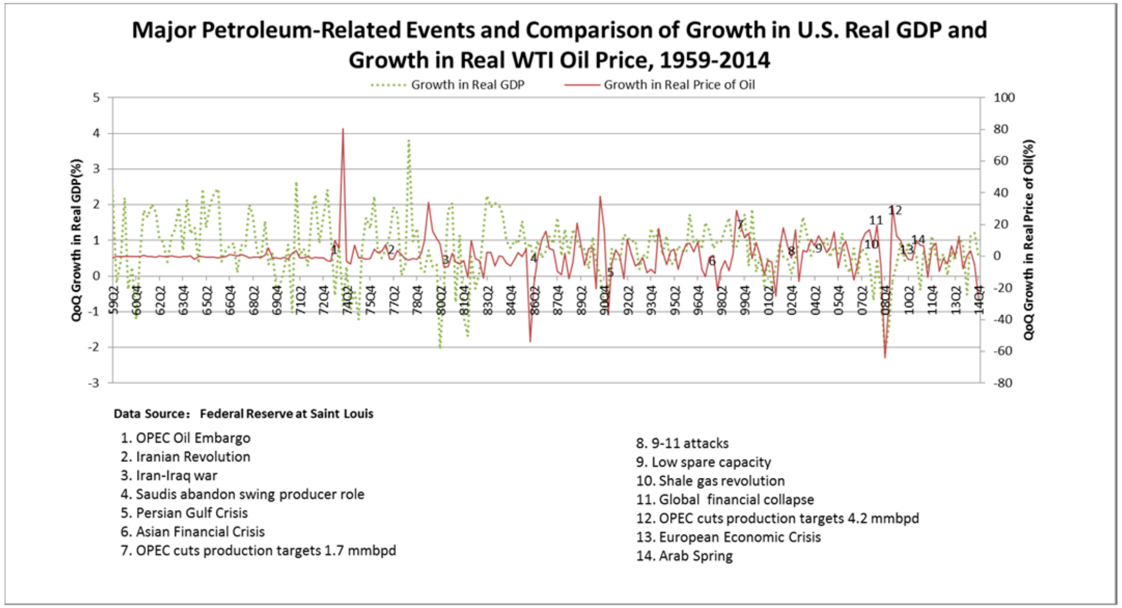


Figure D.1: Major Petroleum-related Events and Comparison of Growth in U.S. Real GDP & Growth in Real WTI Oil Price, 1959Q2-2014Q4.

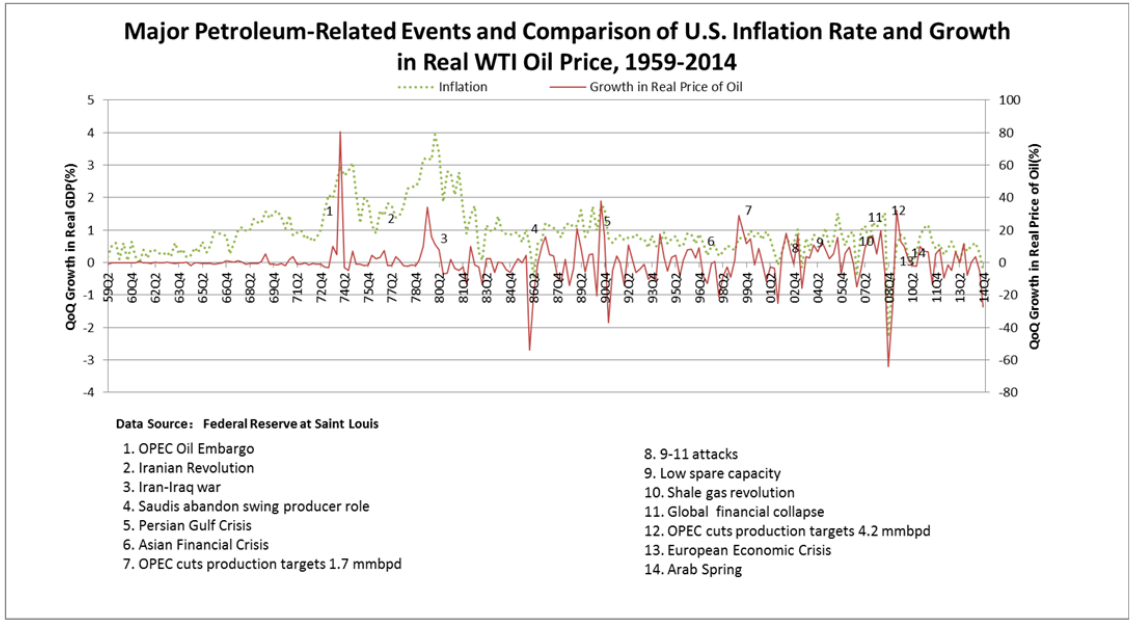


Figure D.2: Major Petroleum-related Events and Comparison of Growth in U.S. Inflation Rate & Growth in Real WTI Oil Price, 1959Q2-2014Q4.

Appendix E

DESCRIPTION OF MAJOR OIL EVENTS AND CHINA'S ECONOMY

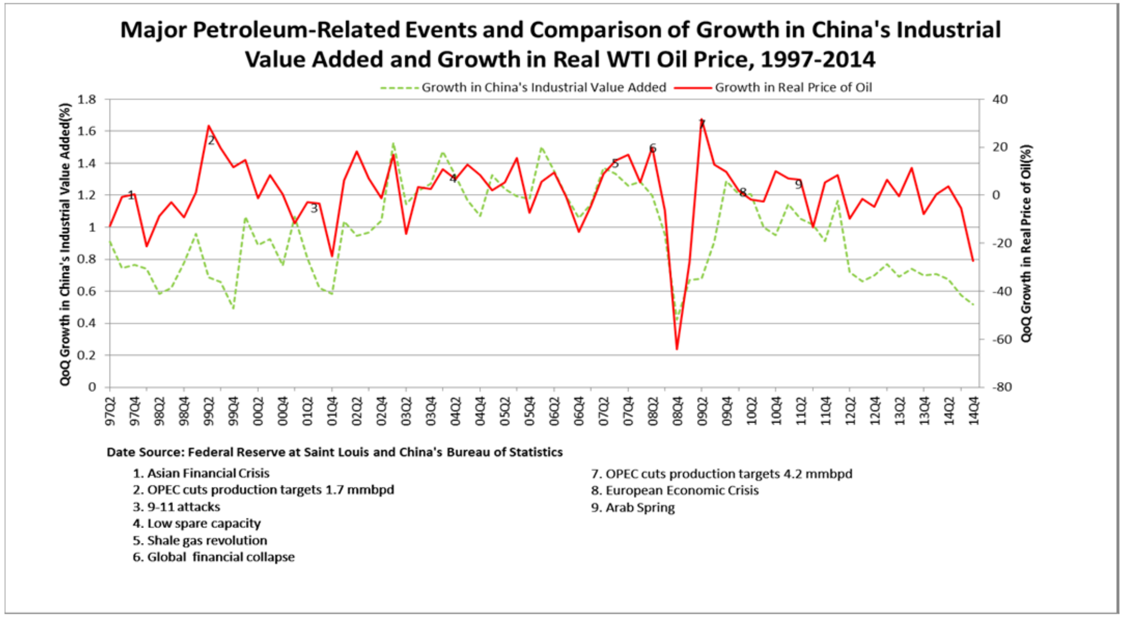


Figure E.1: Major Petroleum-related Events and Comparison of Growth in China's Value Added & Growth in Real WTI Oil Price, 1997Q2-2014Q4.

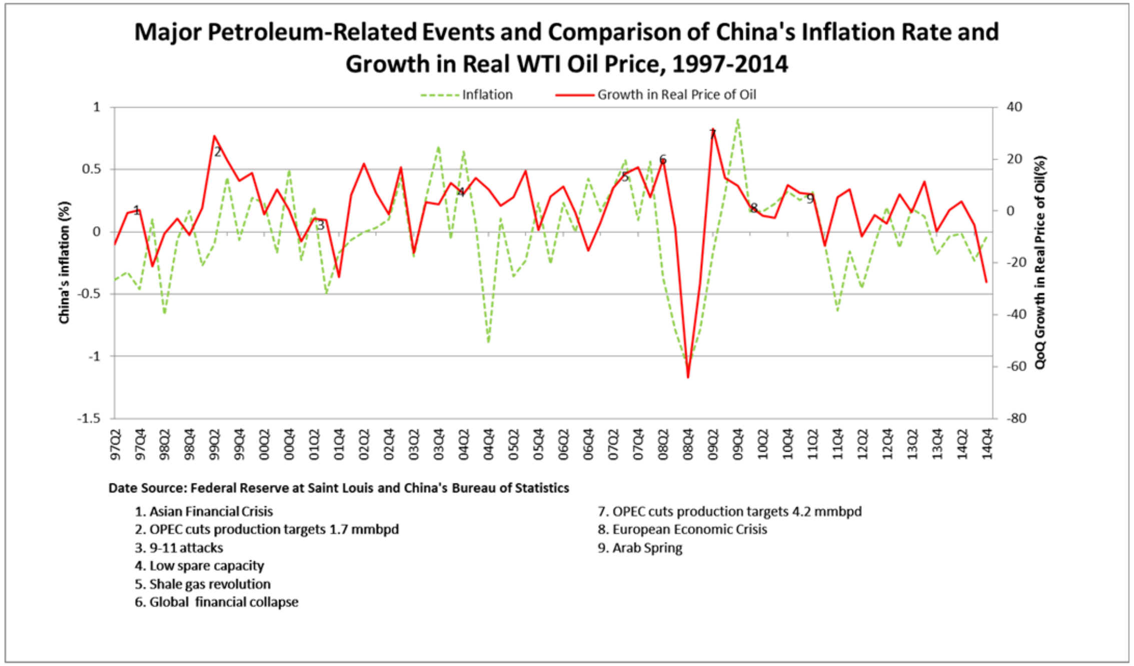


Figure E.2: Major Petroleum-related Events and Comparison of China's Inflation Rate & Growth in Real WTI Oil Price, 1997Q2-2014Q4.

Appendix F

IMPULSE RESPONSES TO STRUCTURAL SHOCKS IN CHAPTER 1

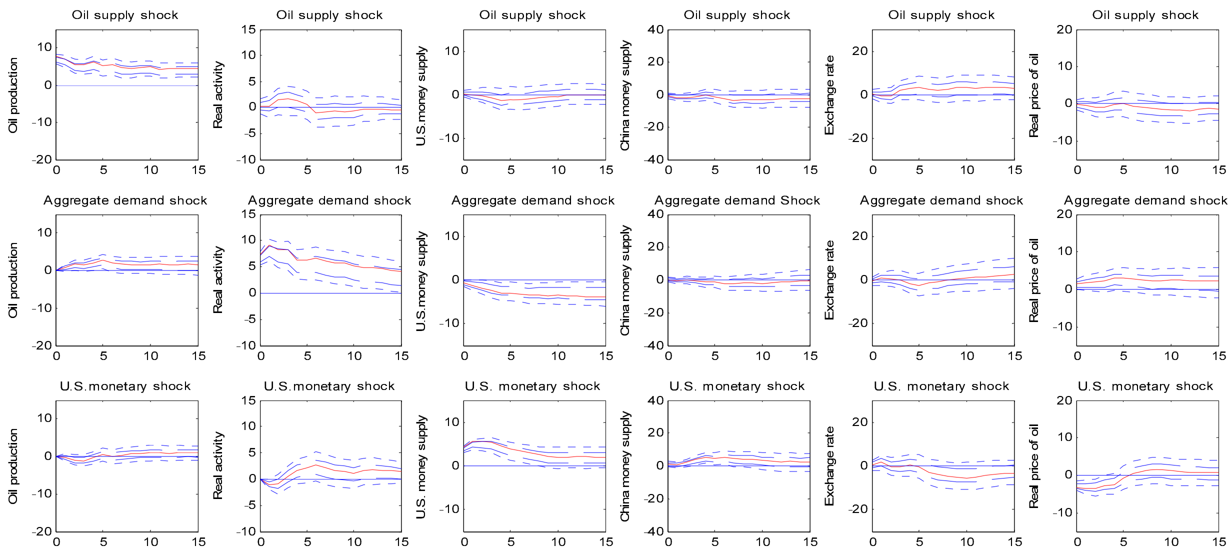
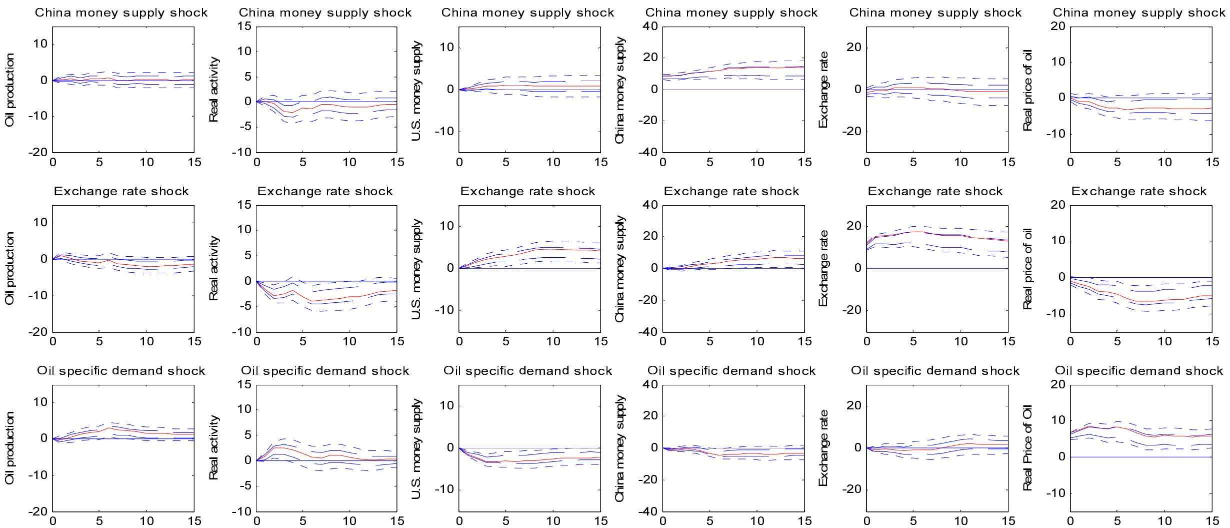


Figure F.1: Chapter One-Impulse Responses to One-Standard Deviation Structural Shocks with 95% and 68% Confidence Intervals.

Figure F.1 Continued



Note: The dotted line stands for bootstrapped 95% CI while the dashed line stands for bootstrapped 68% CI.

Appendix G

IMPULSE RESPONSES TO STRUCTURAL SHOCKS IN CHAPTER 2

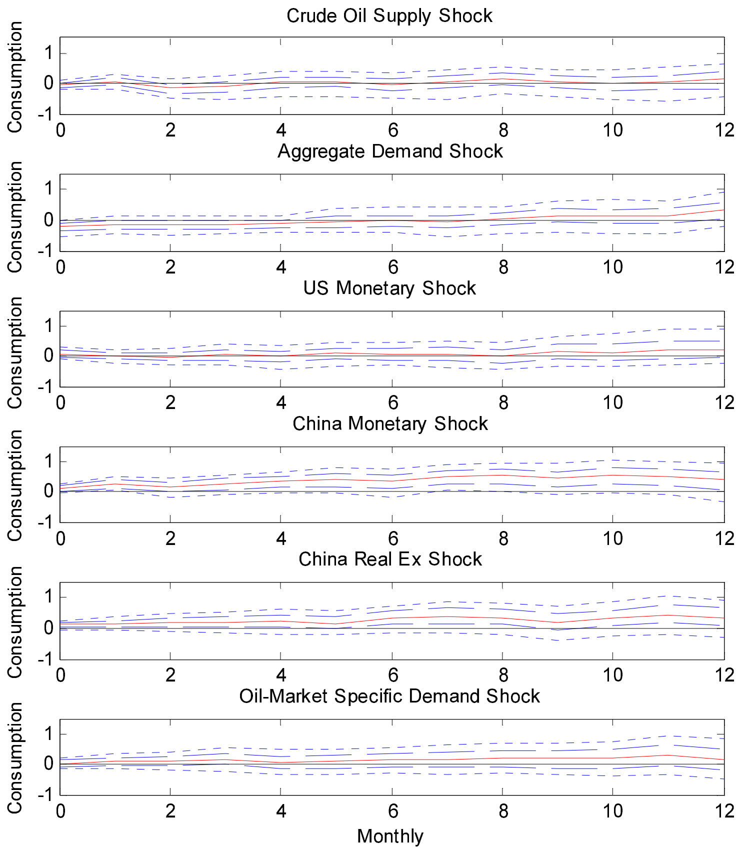


Figure G.1: Chapter Two-Impulse Responses of China's Real Consumption to Various Structural Shocks with 95% CI and 68% CI.

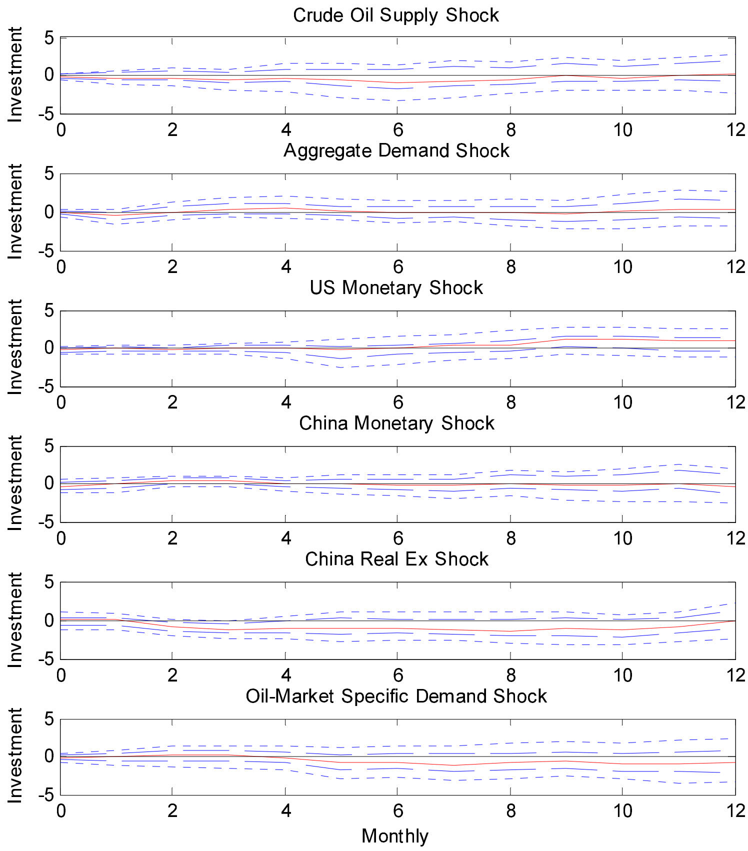


Figure G.2: Chapter Two-Impulse Responses of China's Real Investment to Various Structural Shocks with 95% CI and 68% CI.

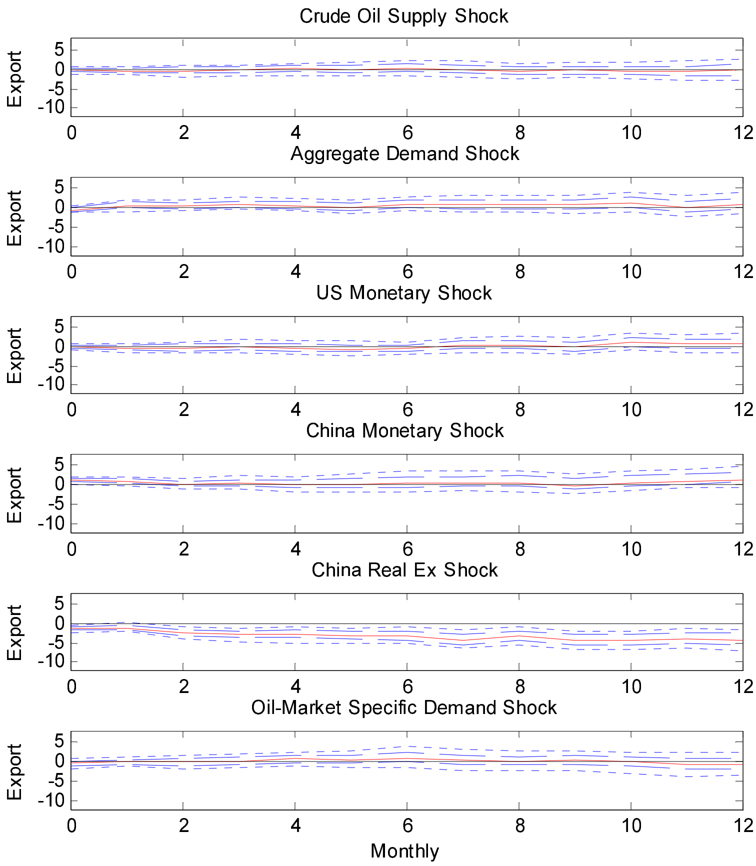


Figure G.3: Chapter Two-Impulse Responses of China's Real Export to Various Structural Shocks with 95% CI and 68% CI.

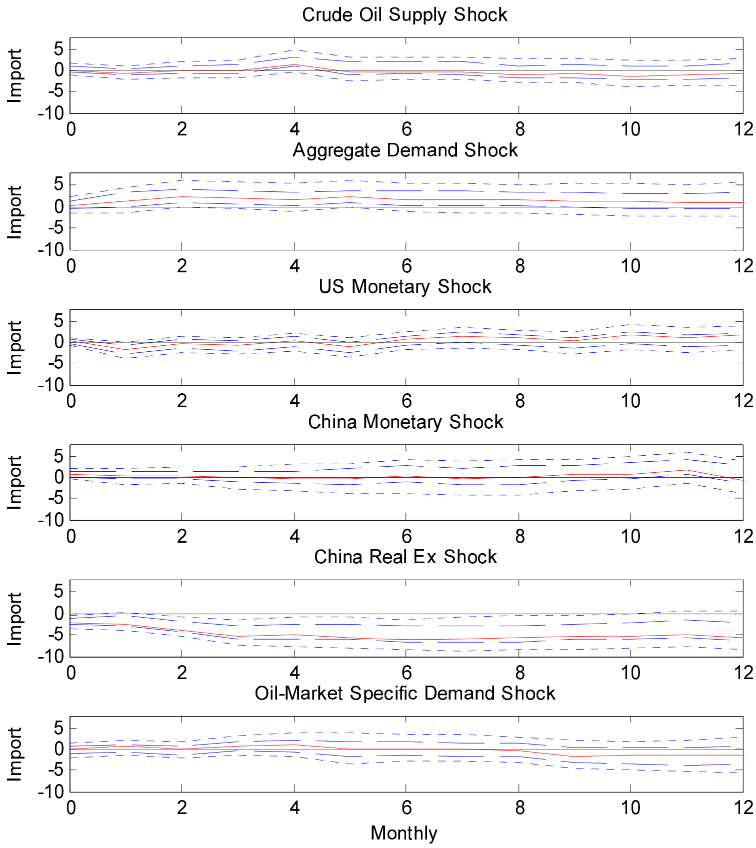


Figure G.4: Chapter Two-Impulse Responses of China's Real Import to Various Structural Shocks with 95% CI and 68% CI.

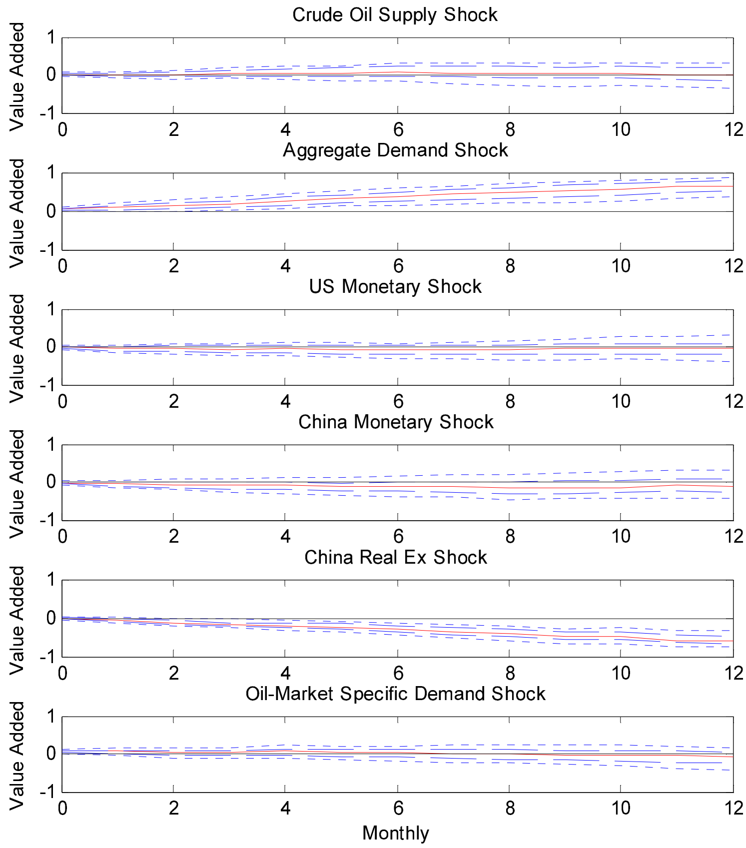


Figure G.5: Chapter Two-Impulse Responses of China's Value Added to Various Structural Shocks with 95% CI and 68% CI.

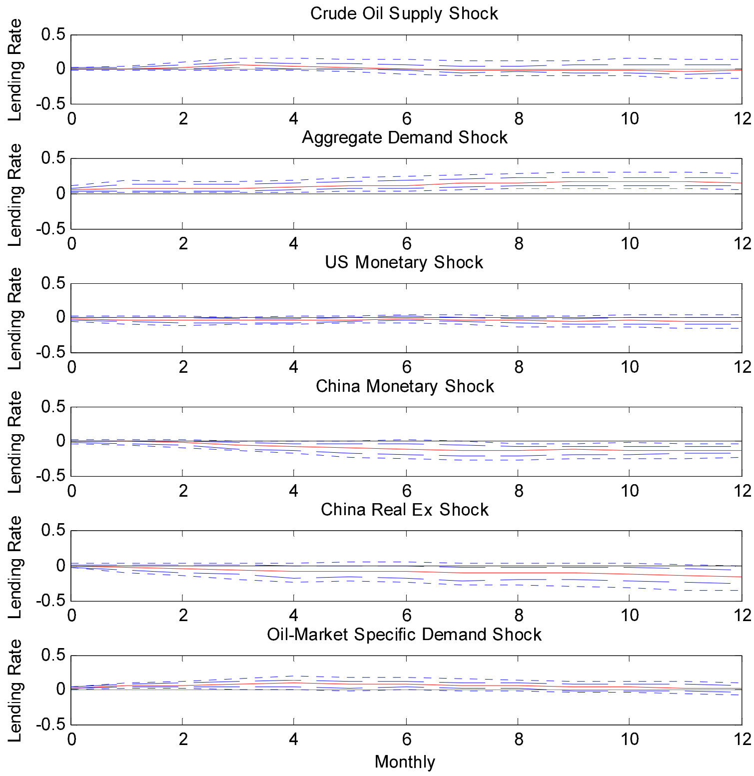


Figure G.6: Chapter Two-Impulse Responses of China's One Year Lending Rate to Various Structural Shocks with 95% CI and 68% CI.

Appendix H

STATIONARITY TEST RESULTS IN CHAPTER 1

Table H.1: Chapter One-Stationarity Test Results Summary for Variables in the Model.

Variable	ADF Test	KPSS Test	PP Test	Conclusion
Q(log form)	T -2.964 (2)	Reject the Null of TS	-3.499	I(1)
Q(log first difference: Growth Rate of Global Oil Production)	NT C -12.849[a] (1)	Not Reject the Null of LS	-15.886[a]	I(0)
I(Index of Global Real Economic Activity)	NT NC -2.209[b] (5)	Reject the Null of LS	-2.422[b]	I(0)
M2A(log form)	T -2.231 (1)	Reject the Null of TS	-1.946	I(1)
M2A(log first difference: Growth Rate of U.S. Real Money Supply)	NT C -9.649[a] (0)	Not Reject the Null of LS	-9.606[a]	I(0)
M2C(log form)	T -2.257(12)	Reject the Null of TS	-2.262	I(1)
M2C(log first difference: Growth Rate of China's Real Money Supply)	NT C -4.613[a] (11)	Not Reject the Null of LS	-15.331[a]	I(0)
EXC(log form)	NT C 0.018(1)	Reject the Null of LS	0.144	I(1)

Table H.1 Continued

EXC(log first difference : Growth Rate of China's Real Effective Exchange Rate)	NT NC -10.995[a] (0)	Not Reject the Null of LS	-11.013[a]	I(0)
P(log form)	T -2.907 (2)	Reject the Null of TS	-2.528	I(1)
P(log first difference: Growth Rate of Real Price of Oil)	NT C -11.374[a] (0)	Not Reject the Null of LS	-11.484[a]	I(0)

Notes: (1) T, NT, NC, C, TS and LS denote trend, no trend, no constant, constant, trend stationary and level stationary, respectively. (2) Numbers in parenthesis under different tests are lag orders chosen by Akaike Information Criterion (AIC). (3) a implies significance at 1% level, b implies significance at 5% level and c implies significance at 10% level. (4) Although I(Index of Global Real Economic Activity) does not pass KPSS Test, it passes both ADF Test and PP Test. So the final conclusion of I(Index of Global Real Economic Activity) is stationary.

Appendix I

ENGLE-GRANGER COINTEGRATION TEST IN CHAPTER 1

Table I.1: Chapter One-Engle-Granger Residual-Based Cointegration Analysis Results Summary.

Dependent Variable	Independent Variables	Lag Order	EG Test Statistics	Conclusion
Q(world oil production: log form)	M2A, M2C, EXC, P	0	-3.793	Q is not cointegrated with any of M2A, M2C, EXC and P or all together.
M2A(real U.S. money supply: log form)	Q, M2C, EXC, P	3	-1.438	M2A is not cointegrated with any of Q, M2C, EXC and P or all together.
M2C(real China's money supply: log form)	Q, M2A, EXC, P	0	-2.330	M2C is not cointegrated with any of Q, M2A, EXC and P or all together.
EXC(China's real effective exchange rate: log form)	Q, M2A, M2C, P	1	-2.489	EXC is not cointegrated with any of Q, M2A, M2C and P or all together.

Table I.1 Continued

P(real price of oil: log form)	Q, M2A, M2C, EXC	2	-3.813	P is not cointegrated with any of Q, M2A, M2C and EXC or all together.

Notes: (1) The critical value is -4.49, which is based on the Case 3 in Table B.9 in Hamilton (1994). (2) The lag order used in this Engle-Granger residual based cointegration analysis is chosen by AIC information criteria.

Appendix J

RESIDUAL SERIAL CORRELATION TEST IN CHAPTER 1

Table J.1: Chapter One-Residual Serial Correlation Test for the Equation of World Oil Production.

LAG	AC	PAC	Q	Prob>Q
1	-0.014	-0.014	0.040	0.841
2	-0.012	-0.012	0.073	0.964
3	0.016	0.016	0.129	0.988
4	0.006	0.006	0.136	0.998
5	0.005	0.006	0.142	1.000
6	-0.003	-0.003	0.145	1.000
7	-0.021	-0.022	0.246	1.000
8	0.020	0.019	0.332	1.000
9	-0.044	-0.046	0.765	1.000
10	-0.093	-0.099	2.744	0.987
11	0.011	0.004	2.770	0.993
12	0.106	0.111	5.381	0.944
13	-0.058	-0.057	6.161	0.940
14	0.004	0.004	6.165	0.962
15	-0.010	-0.017	6.188	0.976
16	0.030	0.028	6.394	0.983
17	-0.064	-0.070	7.361	0.978
18	-0.039	-0.038	7.723	0.983
19	-0.072	-0.088	8.947	0.974
20	0.006	-0.013	8.956	0.983
21	-0.071	-0.071	10.172	0.977
22	-0.099	-0.097	12.542	0.945
23	-0.011	-0.036	12.568	0.961
24	0.166	0.169	19.324	0.735

Table J.2: Chapter One-Residual Serial Correlation Test for the Equation of Global Economic Activity.

LAG	AC	PAC	Q	Prob>Q
1	-0.023	-0.024	0.116	0.734
2	0.021	0.022	0.216	0.897
3	-0.009	-0.009	0.236	0.972
4	-0.043	-0.045	0.636	0.959
5	-0.020	-0.022	0.722	0.982
6	-0.002	-0.002	0.724	0.994
7	-0.135	-0.145	4.855	0.678
8	0.005	-0.001	4.860	0.772
9	-0.042	-0.050	5.259	0.811
10	0.043	0.050	5.689	0.841
11	0.102	0.106	8.071	0.707
12	0.113	0.134	11.040	0.526
13	-0.039	-0.049	11.392	0.578
14	0.074	0.079	12.673	0.553
15	-0.145	-0.177	17.577	0.286
16	0.044	0.058	18.028	0.322
17	-0.080	-0.093	19.548	0.298
18	-0.042	-0.031	19.970	0.335
19	0.029	0.077	20.174	0.384
20	-0.010	-0.027	20.200	0.446
21	-0.102	-0.144	22.704	0.360
22	0.017	-0.028	22.773	0.415
23	-0.104	-0.198	25.387	0.331
24	0.107	0.117	28.218	0.251

Table J.3: Chapter One-Residual Serial Correlation Test for the Equation of U.S. Money Supply.

LAG	AC	PAC	Q	Prob>Q
1	-0.001	-0.001	0.000	0.985
2	-0.042	-0.043	0.396	0.821
3	-0.007	-0.007	0.407	0.939
4	-0.039	-0.041	0.744	0.946
5	-0.001	-0.003	0.744	0.981
6	0.055	0.052	1.427	0.964
7	0.004	0.004	1.431	0.985
8	0.011	0.014	1.458	0.993
9	0.046	0.048	1.937	0.992
10	0.003	0.008	1.939	0.997
11	0.066	0.073	2.932	0.992
12	-0.063	-0.064	3.856	0.986
13	-0.204	-0.201	13.522	0.408
14	0.115	0.115	16.618	0.277
15	0.051	0.039	17.217	0.306
16	-0.053	-0.063	17.882	0.331
17	0.096	0.087	20.070	0.271
18	-0.030	-0.028	20.290	0.317
19	-0.056	-0.035	21.049	0.334
20	-0.069	-0.086	22.184	0.331
21	-0.038	-0.042	22.529	0.370
22	-0.043	-0.036	22.969	0.404
23	-0.027	-0.051	23.152	0.452
24	-0.082	-0.080	24.787	0.417

Table J.4: Chapter One-Residual Serial Correlation Test for the Equation of China's Money Supply.

LAG	AC	PAC	Q	Prob>Q
1	-0.035	-0.035	0.262	0.609
2	0.002	0.001	0.263	0.877
3	-0.069	-0.070	1.301	0.729
4	0.045	0.039	1.746	0.782
5	-0.100	-0.099	3.957	0.556
6	-0.010	-0.024	3.978	0.680
7	0.028	0.032	4.155	0.762
8	0.056	0.040	4.856	0.773
9	0.058	0.073	5.609	0.778
10	0.039	0.041	5.953	0.819
11	0.035	0.046	6.232	0.857
12	-0.155	-0.149	11.753	0.466
13	-0.028	-0.027	11.938	0.533
14	-0.080	-0.080	13.424	0.493
15	0.061	0.042	14.302	0.503
16	-0.175	-0.179	21.529	0.159
17	-0.002	-0.061	21.530	0.204
18	0.051	0.041	22.149	0.225
19	0.051	0.008	22.774	0.247
20	-0.093	-0.067	24.828	0.208
21	0.019	0.010	24.919	0.251
22	0.058	0.087	25.729	0.264
23	-0.056	-0.038	26.497	0.278
24	-0.010	0.013	26.521	0.327

Table J.5: Chapter One-Residual Serial Correlation Test for the Equation of China's Real Effective Exchange Rate.

LAG	AC	PAC	Q	Prob>Q
1	-0.011	-0.011	0.027	0.869
2	0.005	0.005	0.033	0.984
3	0.015	0.015	0.080	0.994
4	-0.051	-0.051	0.649	0.958
5	-0.004	-0.006	0.653	0.985
6	-0.032	-0.033	0.889	0.990
7	-0.003	-0.003	0.891	0.996
8	0.172	0.175	7.622	0.471
9	0.011	0.020	7.647	0.570
10	0.025	0.025	7.794	0.649
11	0.027	0.026	7.956	0.717
12	-0.160	-0.151	13.861	0.310
13	-0.023	-0.038	13.979	0.375
14	0.071	0.084	15.160	0.367
15	0.008	0.020	15.174	0.439
16	0.031	-0.006	15.399	0.496
17	0.108	0.115	18.167	0.378
18	0.067	0.072	19.232	0.378
19	0.116	0.130	22.444	0.263
20	0.072	0.147	23.700	0.256
21	-0.014	0.006	23.747	0.306
22	0.008	-0.011	23.762	0.360
23	-0.043	-0.047	24.217	0.392
24	-0.054	-0.107	24.921	0.410

Table J.6: Chapter One-Residual Serial Correlation Test for the Equation of Real Oil Price.

LAG	AC	PAC	Q	Prob>Q
1	0.002	0.003	0.001	0.971
2	-0.012	-0.013	0.033	0.984
3	0.050	0.053	0.581	0.901
4	0.016	0.018	0.637	0.959
5	0.032	0.037	0.861	0.973
6	0.019	0.020	0.943	0.988
7	-0.095	-0.101	2.984	0.887
8	0.019	0.017	3.064	0.930
9	-0.073	-0.085	4.278	0.892
10	-0.033	-0.030	4.528	0.920
11	0.120	0.129	7.816	0.730
12	-0.050	-0.044	8.392	0.754
13	-0.173	-0.183	15.324	0.288
14	-0.011	-0.029	15.353	0.354
15	-0.135	-0.154	19.599	0.188
16	-0.080	-0.112	21.108	0.174
17	0.089	0.112	22.966	0.150
18	-0.043	-0.006	23.403	0.176
19	0.010	0.006	23.427	0.219
20	-0.016	-0.026	23.487	0.266
21	-0.019	-0.030	23.573	0.314
22	0.106	0.035	26.320	0.238
23	-0.026	-0.045	26.487	0.278
24	-0.101	-0.073	28.967	0.221

Appendix K

STATIONARITY TEST RESULTS IN CHAPTER 2

Table K.1: Chapter Two-Stationarity Test Results Summary for Variables in the Model.

Variable	ADF Test	KPSS Test	PP Test	Conclusion
CHVAAD(growth rate of China's value added)	NT C -2.885[b] (3)	Not All Accept the Null of LS	-8.069[a]	I(0)
CHLERA(original form)	NT C -2.917[b] (10)	Reject the Null of LS	-3.544 [a]	I(1)
CHLERA(first difference of China's one year lending rate)	NT NC -4.087[a] (9)	Not All Accept the Null of LS	-12.507[a]	I(0)
CHEXPO(log form)	T -0.851(2)	Reject the Null of TS	-1.726	I(1)
CHEXPO(log first difference: growth rate of China's real export)	NT C -15.973[a] (1)	Not Reject the Null of LS	-26.110[a]	I(0)
CHIMPO(log form)	T -1.206(2)	Reject the Null of TS	-3.321	I(1)
CHIMPO(log first difference: growth rate of China's real import)	NT C -15.898[a] (1)	Not Reject the Null of LS	-28.679[a]	I(0)
CHCOSU(log form)	T -2.537(8)	Reject the Null of TS	-2.496	I(1)

Table K.1 Continued

CHCOSU(log first difference: growth rate of China's real consumption expenditure)	NT C -2.497(7)	Not All Accept the Null of LS	-22.0496[a]	I(0)
CHINVE(log form)	T -3.254(13)	Reject the Null of TS	-4.096	I(1)
CHINVE(log first difference: growth rate of China's real investment)	NT C -2.847[b](12)	Not Reject the Null of LS	-19.583[a]	I(0)

Notes: (1) T, NT, NC, C, TS and LS denote trend, no trend, no constant, constant, trend stationary and level stationary, respectively. (2) Numbers in parenthesis under different tests are lag orders chosen by Akaike Information Criterion (AIC). (3) a implies significance at 1% level, b implies significance at 5% level and c implies significance at 10% level. (4) Although the growth rate of China's real consumption does not pass the ADF test when lag=7 using AIC criteria, it passes the ADF test when lag=6 using BIC criteria. Besides, it also passes PP test. So the final conclusion of the growth rate of China's real consumption is stationary. (5) Although the level of China's one year lending rate pass the ADF test and PP test, it does not pass the KPSS test. So the final conclusion of China's one year lending rate is I(1).

Appendix L

STATIONARITY TEST RESULTS IN CHAPTER 3

Table L.1: Chapter Three-Stationarity Test Results Summary for Variables in the Model.

Variable	ADF Test	KPSS Test	PP Test	Conclusion
Oilp(log form)	T -1.781(1)	Not Reject the Null of TS	-1.742	I(1)
Oilp(log first difference: growth rate of world oil price)	NT C -8.229^{a}(1)	Not Reject the Null of LS	-11.577^{a}	I(0)
Vaad(growth rate of China value added)	NT C -1.883(12)	Not All Accept the Null of LS	-7.254^{a}	I(0)
Lrate(original form)	NT C -3.115^{b} (10)	Reject the Null of LS	-4.330^{a}	I(1)
Lrate(first difference of China's one year lending rate)	NT NC -3.788^{a} (9)	Not All Accept the Null of LS	-13.340^{a}	I(0)
Expo(log form)	T -0.979(2)	Reject the Null of TS	-1.789	I(1)
Expo(log first difference: growth rate of China export)	NT C -16.554^{a} (1)	Not Reject the Null of LS	-26.906^{a}	I(0)
Impo(log form)	T -1.343 (2)	Reject the Null of TS	-3.275	I(1)

Table L.1 Continued

Impo(log first difference: growth rate of China import)	NT C -16.284^{a} (1)	Not Reject the Null of LS	-30.857^{a}	I(0)
Cons(log form)	T -2.415 (8)	Reject the Null of TS	-1.001	I(1)
Cons(log first difference: growth rate of China consumption expenditure)	NT C -2.833^{c} (7)	Not All Accept the Null of LS	-19.804^{a}	I(0)
Exch(log form)	NT C -0.248(1)	Reject the Null of TS	-0.072	I(1)
Exch(log first difference: growth rate of China real exchange rate)	NT NC -10.957^{a}(0)	Not Reject the Null of LS	-10.982^{a}	I(0)
Invest(log form)	T -2.920(12)	Reject the Null of TS	-2.256	I(1)
Invest(log first difference: growth rate of China real investment)	NT C -3.756^{a} (11)	Not Reject the Null of LS	-21.443^{a}	I(0)
M2(log form)	T -2.611(4)	Reject the Null of TS	-3.417	I(1)
M2(growth rate of China M2)	NT C -16.976^{a} (0)	Not Reject the Null of LS	-16.690^{a}	I(0)

Notes: (1) T, NT, NC, C, TS and LS denote trend, no trend, no constant, constant, trend stationary and level stationary, respectively. (2) Numbers in parenthesis under different tests are lag orders chosen by Akaike Information Criterion (AIC). (3) a implies significance at 1% level, b implies significance at 5% level and c implies significance at 10% level. (4) Although the level of China's one year lending rate pass the ADF test and PP test, it does not pass the KPSS test. So the final conclusion of China's one year lending rate is I(1).

Appendix M

LAG ORDER SELECTION IN CHAPTER 3

Table M.1: Chapter Three-Preliminary Lag Order Selection of the Function of Real Price of Oil.

Lag Order	AIC	BIC
10	1575.701	1883.271
9	1573.957	1851.100
8	1580.659	1827.392
7	1567.828	1784.141
6	1557.719	1743.613
5	1560.232	1715.708
4	1543.812	1668.868
3	1530.963	1625.600
2	1522.003	1586.221
1	1515.730*	1549.529*
optimal lag order:	**1**	**1**

Table M.2: Chapter Three-Preliminary Lag Order Selection of China's Real Import Function (2).

Lag Order	AIC	BIC
10	1517.874	1866.003
9	1523.162	1837.492
8	1523.777	1804.309
7	1512.187	1758.920
6	1497.054*	1709.988
5	1498.789	1677.923
4	1511.980	1657.316
3	1503.998	1615.534
2	1515.424	1593.162
1	1532.554	1576.492*
optimal lag order:	**6**	**1**

Table M.3: Chapter Three-Preliminary Lag Order Selection of China's Real Export Function (3).

Lag Order	**AIC**	**BIC**
10	1414.196	1762.325
9	1421.938	1736.268
8	1410.520	1691.052
7	1402.102	1648.834
6	1396.833	1609.767
5	1385.789	1564.923
4	1384.098	1529.433
3	1377.763*	1489.299
2	1379.662	1457.400
1	1401.965	1445.904*
optimal lag order:	**3**	**1**

Table M.4: Chapter Three-Preliminary Lag Order Selection of China's Real Consumption Function (4).

Lag Order	**AIC**	**BIC**
10	682.723	1030.852
9	691.801	1006.131
8	692.154	972.686
7	687.845	934.578
6	681.880	894.814
5	696.699	875.833
4	683.857	829.193
3	683.729	795.266
2	673.764	751.501
1	673.167*	717.105*
optimal lag order:	**1**	**1**

Table M.5: Chapter Three-Preliminary Lag Order Selection of China's Real Investment Function (5).

Lag Order	AIC	BIC
10	1270.984*	1619.113
9	1295.943	1610.273
8	1307.391	1587.922
7	1306.974	1553.706
6	1296.497	1509.431
5	1297.773	1476.908
4	1318.607	1463.942
3	1315.888	1427.425
2	1316.033	1393.771
1	1343.191	1387.130*
optimal lag order:	10	1

Table M.6: Chapter Three-Preliminary Lag Order Selection of China's Value Added Function (6).

Lag Order	AIC	BIC
10	-20.229	327.901
9	-22.341	291.989
8	-27.142	253.390
7	-37.970	208.763
6	-37.581	175.353
5	-41.804	137.330
4	-55.184	90.151
3	-64.498*	47.038
2	-55.416	22.322*
1	-16.401	27.537
optimal lag order:	**3**	**2**

Table M.7: Chapter Three-Preliminary Lag Order Selection of China's One Year Lending Rate Function (7).

Lag Order	AIC	BIC
10	-142.355	205.775
9	-129.788	184.543
8	-110.910	169.622
7	-119.589	127.143
6	-128.866	84.068
5	-134.636	44.499
4	-131.464	13.871
3	-138.595	-27.058
2	-135.821	-58.083
1	-145.637 *	-101.698*
optimal lag order:	**1**	**1**

Table M.8: Chapter Three-Preliminary Lag Order Selection of China's Real M2 Function (8).

Lag Order	AIC	BIC
10	617.054	965.183
9	625.641	939.971
8	620.452	900.983
7	621.076	867.809
6	617.551	830.485
5	616.929	796.064
4	604.198	749.534
3	596.548*	708.084
2	604.153	681.890
1	608.053	651.992*
optimal lag order:	**3**	**1**

Table M.9: Chapter Three-Preliminary Lag Order Selection of China's Real Effective Exchange Rate Function (9).

Lag Order	**AIC**	**BIC**
10	763.9788	1112.108
9	749.6701	1064.001
8	738.0189	1018.55
7	736.2637	982.9962
6	736.0318	948.9654
5	723.0864	902.221
4	717.6041	862.9397
3	704.9045	816.4411
2	691.8832	769.6208
1	679.1672*	723.1059*
optimal lag order:	**1**	**1**

Appendix N

REGRESSION RESULTS SUMMARY OF CHAPTER 3

Table N.1: Regression Results Summary of Chapter 3.

Lrate	Vaad	Invest	Cons	Expo	Impo	Eq.
0.01** (0.00)	0.01* (0.04)	-0.11 (0.08)	0.00 (0.95)	-0.08 (0.34)	-0.13 (0.19)	**P**
0.01* (0.01)	0.01*` (0.01)	0.01 (0.89)	-0.00 (0.83)	0.03 (0.70)	0.48*** (0.00)	**P_1**
-0.00 (0.79)	-0.01* (0.02)	0.03 (0.71)	0.01 (0.69)	0.10 (0.29)	-0.05 (0.66)	**P_2**
-0.00 (0.88)	-0.00 (0.52)	0.05 (0.53)	0.00 (0.84)	0.17 (0.06)	0.15 (0.18)	**P_3**
0.00 (0.20)	-0.00 (0.93)	0.10 (0.15)	-0.00 (0.88)	-	-0.05 (0.62)	**P_4**
-0.00 (0.19)	-0.00 (0.47)	0.05 (0.46)	-	-	0.16 (0.13)	**P_5**
-	-	-0.01 (0.86)	-	-	-	**P_6**
-	-	-0.04 (0.57)	-	-	-	**P_7**
-0.01 (0.07)	-0.01 (0.14)	0.07 (0.57)	-0.02 (0.46)	0.08 (0.59)	0.41* (0.03)	**P^{+}**
-0.01 (0.18)	-0.01 (0.08)	0.13 (0.31)	0.00 (0.98)	0.04 (0.78)	-0.46* (0.02)	**P^{+}_1**
0.00 (0.34)	0.01 (0.08)	-0.02 (0.90)	-0.01 (0.68)	-0.11 (0.48)	0.19 (0.34)	**P^{+}_2**
-0.00 (0.96)	0.01 (0.07)	0.03 (0.83)	0.02 (0.43)	-0.21 (0.17)	-0.02 (0.91)	**P^{+}_3**
-0.00 (0.87)	-0.00 (0.72)	-0.28* (0.02)	0.01 (0.84)	-	-0.01 (0.97)	**P^{+}_4**
0.00 (0.82)	0.00 (0.84)	-0.17 (0.17)	-	-	-0.40* (0.03)	**P^{+}_5**
-	-	-0.12 (0.27)	-	-	-	**P^{+}_6**
-	-	0.00 (0.97)	-	-	-	**P^{+}_7**
0.00	0.00	0.45	0.99	0.16	0.00	**P_v**

Table N.1 Continued

M2	-0.02 (0.23)	-0.02 (0.30)	-0.00 (0.84)	-0.02 (0.22)	-0.01 (0.49)	-0.02 (0.29)	-	-	0.03 (0.20)	0.02 (0.44)	0.02 (0.54)	0.04 (0.15)	0.00 (0.94)	-0.00 (0.89)	-	-	0.25
Exch	-0.02 (0.17)	0.01 (0.55)	0.01 (0.62)	0.00 (0.95)	-0.01 (0.54)	-	-	-	-0.02 (0.64)	-0.06 (0.07)	-0.02 (0.60)	-0.03 (0.31)	-0.01 (0.70)	-	-	-	0.76

Notes: (1) p-values in parentheses: * $p<0.05$, ** $p<0.01$, *** $p<0.001$. (2) The lag order in each regression is determined by AIC. (3) Specifically, the variables included in the above table are defined as following: P-The growth rate of real oil price; P_i, $i = 1,2,3,4,5,6,7$-The i-th order lag of the growth rate of real oil price; P^+- The censored oil price growth variable x_t^+, which is defined in Section 3.3.2; P^+_i-The i-th order lag of the censored oil price growth variable x_t^+. (4) "-" indicates no such item is included. (5) The "P_v" in the last column is the p-value of the joint hypothesis test.