THE IMPACT OF OIL RETURN ON THE CHANGES OF REAL EXCHANGE RATE DURING CRISES: INTERNATIONAL TRADE IN CHINA

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DECLARATION

We hereby declare that:

(1) This undergraduate research project is the end result of our own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

(2) No portion of this research project has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) Equal contribution has been made by each group member in completing the research project.

(4) The word count of this research report is 8061.

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ADF	Augmented Dickey-Fuller
ARCH	Autoregressive Conditional Heteroscedasticity
CNYUSD	Chinese Yuan against United States Dollars
DCC-MGARCH	Dynamic Conditional Correlation- Multivariate Generalized Autoregressive Conditional Heteroscedasticity
EGARCH	Exponential Generalized Autoregressive Conditional Heteroscedasticity
EMBI	Emerging Markets Bond Index
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GDP	Gross Domestic Production
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square
OPEC	Organization of the Petroleum Exporting Countries
RBF	Reserve Bank of Fiji
SIC	Schwarz Criterion
TGARCH	Threshold Generalized Autoregressive Conditional Heteroscedasticity
UK	United Kingdom
US	United States
USD	United States Dollars
VAR	Vector Autoregressive Model
WTI	West Texas Intermediate

ABSTRACT

This study examines the impact of oil returns on the changes of the real exchange rate in China over three sub-periods of crisis which are energy crisis, financial crisis and oil crisis. The daily data of WTI crude oil prices and real exchange rate of Chinese against U.S. Dollar are collected from January 2000 to December 2015. The estimations of GARCH specifications have been employed to capture the risk and asymmetric effects for the changes of real exchange rate CNYUSD over three sub-periods. The empirical results provide two findings. First, the oil returns influence on the changes of real exchange rate CNYUSD can be sustained by taking asymmetric effect into account over three sub-periods of crisis. Second, the oil returns are unable to sustain in influencing the changes of real exchange rates CNYUSD over three sub-periods of crisis. Therefore, oil producers and investors should consider asymmetric effects to predict the exchange rate based on price movement of crude oil.

CHAPTER 1: INTRODUCTION

1.1 Importance of Impact of Oil Returns on the Changes of Real Exchange Rate

In this era of globalization, the relationship between crude oil prices and real exchange rates has received a concern among oil producers and investors. Therefore, the changes of crude oil prices in international market are the significant element to influence the oil producers' and investors' decisions.

For oil producers' aspect, the understanding on the impact of oil returns on the changes of real exchange rate is important for setting selling prices. For example, high oil prices tend to increase the production cost of companies. Therefore, the selling prices of products increases due to higher input costs and leads to high inflation. This reduces the consumers' purchasing power. The economic growth depresses due to the low consumption on oil. Hence, the demand of domestic currency decreases in the country and the currency tends to depreciate. Therefore, oil producers should adjust the selling prices based on the exchange rate at particular time.

For investors' aspect, the information of oil-exchange rate relationship can be used to improve their trading efficiency in foreign exchange markets. The plunging of the global oil prices influences the real exchange rates for the energy-based export countries' currency depreciated. For example, the declining of the global crude oil price tends to increase the cost of oil production and subsequently the capacity of oil exported decreases. Therefore, the demand of domestic currency fall down and the currency depreciated. While in the oil importer countries, China as an example, the increasing of global oil price reduces the demand of oil. This is because the buyers are unaffordable with higher oil prices. The oil production dropped as a result from declining in oil imported. Consequently, the country's economic growth is slowdown and leads to the value of currency to be depreciated. As a conclusion, investors' confidence decrease and they withdraw their funds from the country in order to protect their benefits.

1.2 Background of Study

China is an important role in the global crude oil market. Table 1.1 shows that China is the largest crude oil importer in the world. This is the first motivation of us to study the impact of crude oil prices in China. Second, China's economic grew by 6.9 per cent in 2015 that marked as its slowest growth in nearest 25 years but they still highly demand on oil. Therefore, China is emphasized in this study.

Moreover, we use West Texas Intermediate (WTI) crude oil price in our study because it is widely used as oil pricing benchmark in international. As China is the largest oil importer, it will emerge a lot of currencies exchanged while dealing with oil exporter countries. The U.S. Dollar is currency benchmark due its currency mostly traded in transactions. Instead of nominal exchange rates, the real exchange rates are the adjusted the nominal rate for differences such as inflation in price levels. Subsequently, the real exchange rates of Chinese Yuan against U.S. Dollars are chosen in our study.

Table 1.1: List of Crude Oil Importing Countries in 2015

Rank	**Importer**	**Amount of Crude Oil Imports (U.S. Dollars in Billion)**
1	China	134.3
2	United States	132.6
3	India	72.3
4	South Korea	55.1
5	Japan	45

Source: The World Factbook (2016)

1.3 Problem Statement

Figure 1.1 shows there is high volatility of oil returns over three sub-periods of crisis which are energy crisis, financial crisis and oil crisis. The changes of real exchange rate become volatile after 2006.

2000/2003 Energy Crisis

There was a high volatility of oil returns during the energy crisis in China. In 2000, OPEC had reduced oil production therefore the demand of oil in the international market exceeds supply (Belaunde, 2001). Oil prices increased due to over-demand in oil and the energy crisis happened. However, the volatility of the changes in real exchange rates was low and stable. The reason behind was China's government fixed their exchange rate with U.S. Dollar from 1995 to 2005. In addition, agricultural was the main sector of China to influence their economy in this period. As a consequence, a high volatility of oil returns was not the significant element that affected the changes of real exchange rate of China during the 2000/2003 energy crisis.

2008/2009 Financial Crisis

Financial crisis arises due to volume of mortgage loans and loan default rates increased. The real exchange rates volatility was high at the beginning of the financial crisis and turned to low towards the end of crisis. As observed in figure 1.1, the oil return volatility is the highest among the energy crisis, financial crisis and oil crisis. In August 2008, the Organization for Economic Co-operation and Development (OECD) countries suddenly halted in the demand of oil. For example, crude oil prices reached a high record of US$147 per barrel in July 2008 and had fallen rapidly to US$35 per barrel in the mid of 2009 (Oil Prices Trends, 2010). The decline in oil demanded by OECD countries caused the crude oil prices to be dropped. However, China highly demanded on oil at the end of 2008 due to its economic was transformed to industrialization based.

2014/2015 Oil Crisis

There was a high volatility of oil returns and real exchange rates during the oil crisis. In 2015, Saudi Arabia and Iraq pumped the oil production in the international commodities market (E.L., 2014). Global oil prices influenced to be decreased due to oil over supplied in the international oil market (Krauss, 2016). In 2015, China’s government has increased 8.8 per cent in oil import capacity compared to 2014 (W.HSU, 2015). Oil reserves inventories increased as China’s government focused energy consumption in industries (Spegele, 2016). However, China’s economic growth plunged from 7 per cent to 6 per cent as in term of trade balance that import exceeds export (Shaffer, 2016). China’s stock market had fallen by 30 per cent and investors had lost their confidence on Chinese Yuan, hence the real exchange rates were high volatile (Wilson, Gurden, Jinks, & Bull, 2015).

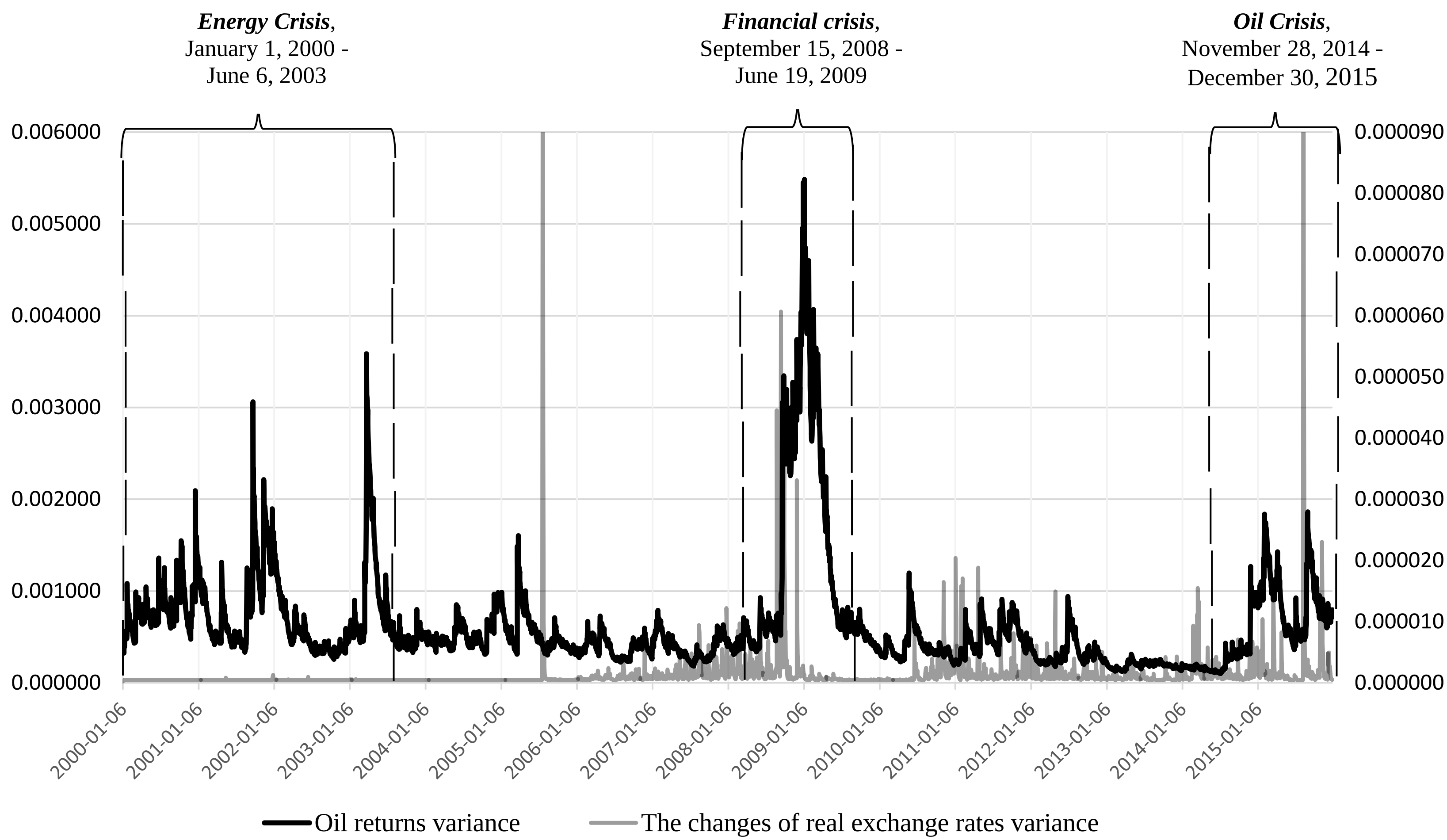

Figure 1.1: Conditional variance for oil returns and the changes of real exchange rate in China, Jan 2000 to Dec 2015

1.4 Research Questions

i. Does the impact of oil returns on the changes of real exchange rate can be sustained in China over 2000/2003 Energy Crisis, 2008/2009 Financial Crisis and 2014/2015 Oil Crisis by considering the risk on real exchange rates?

ii. Does the impact of oil returns on the changes of real exchange rate can be sustained in China over 2000/2003 Energy Crisis, 2008/2009 Financial Crisis and 2014/2015 Oil Crisis by considering the asymmetric effect on real exchange rates?

1.5 Research Objectives

i. To examine the impact of oil returns on the changes of real exchange rate in China over 2000/2003 Energy Crisis, 2008/2009 Financial Crisis and 2014/2015 Oil Crisis, respectively when the risk on real exchange rates is take into account.

ii. To examine the impact of oil returns on the changes of real exchange rate in China over 2000/2003 Energy Crisis, 2008/2009 Financial Crisis and 2014/2015 Oil Crisis, respectively when the asymmetric effect on real exchange rates is take into account.

1.6 Significance of Study

The findings of this study can assist oil producers to set selling prices of oil products by considering the risk of real exchange rate CNYUSD. The fluctuation in real exchange rates tends to increase their input costs and production costs. Therefore, they should set a higher price for oil products when risk of real exchange rate taken into account. They also need to determine the impact between oil returns and the changes of real exchange rate CNYUSD during crisis period. There is a negative impact of oil returns on the changes of real exchange rate in oil importing countries. When oil prices decreased, the value of currency appreciated due to the economy grow.

Furthermore, investors can use the information of oil returns as a tool to predict the movement of Chinese Yuan against U.S. Dollars in their investment decisions. For example, when oil prices decrease, the real exchange rate will be appreciated. Therefore, investors can diversify their risk in foreign exchange market.

1.7 Chapter Layout

Chapter 2 shows literature review for the positive and negative impacts of oil prices on exchange rates with or without crises. Chapter 3 shows the data and methodology. Thus, chapter 4 reports the empirical results. Lastly chapter 5 shows the major findings, implications and recommendations for future researches.

CHAPTER 2: LITERATURE REVIEW

2.1 Positive Impact of Oil Prices on Exchange Rates

Initially from the past findings, Amano and Van Norden (1998) applied cointegration and error correction models to look into the linkage of between real effective exchange rate of U.S. Dollar and global oil price. By using the monthly data during the period 1972 February to 1993 January, they suggest that there is a positive relationship between two variables in the United States. Therefore, an increase of 1 per cent in global oil price would influence an increase of 0.51 per cent in Dollar value during the long run.

Huang and Gou (2006) had implemented the four-dimensional version of structural vector autoregressive (VAR) model on China's market with real adjusted oil prices, real effective exchange rates, relative industrial production and relative consumer price index variable. Their findings showed that there were weak effects of real price shocks on exchange rates in the long run. They indicated that this effect was caused by China's decreased in dependence on imported oil than its trading partners. This was also due to the implementation of strict regulation by China in local energy markets.

Furthermore, Narayan, Narayan and Prasad (2008) used generalized autoregressive conditional heteroscedasticity (GARCH) and exponential GARCH (EGARCH) models. Their results showed that oil prices had a significant positive impact to an increase in value of the Fijian Dollar against the U.S. Dollar. More specifically a 10 per cent increase in oil prices led to 0.2 per cent appreciation of the Fijian Dollar. Their findings also indicated that following increase in oil price, would boost up the inflation rate as well as gross domestic production (GDP) due to the Reserve Bank of Fiji (RBF) raised the interest rates in Fiji.

Oriavwote and Eriemo (2012) investigated the impact of the real oil prices towards the real exchange rates in Nigeria by using vector autoregressive (VAR) & GARCH models. Based on the sample from 1980 to 2010, their findings from unit root and Granger causality test suggested that the validity of causal relationship between the studied variables during the long run. By using the GARCH test, the result suggested that there was significant persistence of volatility between the real oil prices and the real exchange rates.

Tiwari, Mutascu, and Albulescum (2013) used the wavelet correlation, covariance model and the wavelet cross-correlation model to investigate the influence of the international oil prices to the real exchange rates in Romania from 1986 to 2009. By using Durbin Watson test, the results showed a significant impact of the oil prices on the real effective exchange rates in Romania. However, the VAR and one-shot Granger causality approach showed there was no relationship between these two variables in the long run. However, there was a solid evidence to prove the causality in short run while oil prices had significant impact on real effective exchange rates.

In addition, Kin and Courage (2014) also performed GARCH model to examine the linkage of oil prices on the nominal exchange rate in South African. Their study also shows that oil prices had a significant impact on the exchange rates from 1994 to 2014 in South African.

Besides, Shahbaz, Tiwari and Tahir (2015) used the cross-wavelet analysis to investigate the linkage existing between oil price shock and exchange rates in Pakistan by covering monthly series data from 1986 to 2009. They found that the both variables were co-integrated in long run. Besides, causality and reverse causal relationship also were verified in their findings.

Pershina, Molerob, and Graciab (2015) used a VAR model. The data were collected by daily basis for oil prices, nominal exchange rates and short term interbank interest rates from 2003 to 2014. Their study investigated the impact of oil prices on exchange rates in several oil importing countries. Based on their findings, they suggested that during short-run oil shock, the three local currencies appreciate against the U.S. Dollar. Overall, the result suggested that the oil shock had positive effect on Pula currency of Botswanan, but there is a slightly positive effect in the case of Kenyan. For the Tanzanian shilling, there was no fluctuation of the currency.

2.2 Negative Impact of Oil Prices on Exchange Rates

Lizardo and Mollick (2009) used a VAR model and generalized impulse response function to study in U.S., Canada and Mexico. They identified the increase in oil prices had negatively associated with U.S. Dollar in relative with U.S., Canada, Mexico and Russia during 1970 to 2008. The reason was the import of oil by U.S. and other oil import countries during the oil shock leading the increase of supply in foreign exchange market and causing the value of USD depreciated.

Besides, Uddin, Tiwari, Arouri and Teulon (2013) used continuous wavelet transform, Cross wavelet transform and Wavelet coherency. They investigated the oil price volatility might cause the depreciation of Japanese Yen against USD in 1983 to 2013. This was because Japanese economy depended on consumption of oil that the fluctuation of oil price could drive the Japanese Yen downwards.

In addition, Ogundipe, Ojeaga and Ogundipe (2014) used vector error correction model, augmented Dicky Fuller, Johanson test and Phillips perron test and identified oil price movement have contributed enormously negative effect on real exchange rate in Nigeria during 1970 to 2011. This is because one of the massive oil exporters contributed 95 per cent and 83 per cent of its budgetary allocation and oil price movement are the important factor to determined Nigeria exchange rate.

Basher, Haug and Sadorsky (2016) used Markov-switching model, augmented Dicky Fullet test, Lagrange multiplier test and studied in Brazil, Mexico and UK. They found that oil price shocks have a negative impact on Brazil, UK and Mexico's real exchange rates during 1995 to 2010. The reason behind the impact for the oil shock was the main key that affecting exchange rate of oil imports countries.

Furthermore, Chen, Liu, Wang and Zhu (2016) used the structural VAR model, unit root tests and co-integration tests to identify the high oil prices driven by the aggregate demand shocks can effectively depreciate the U.S. dollar against the currencies for 7 out of 16 chosen OECD countries. The volume of trading by US declined due to a high oil demand and depreciation of U.S. dollar in relative with other oil exporting countries during oil demand shocks.

2.3 Positive Impact of Oil Prices on Exchange Rates during Crises

Turhan, Hacihasanoglu, and Soytas (2013) applied VAR and generalized impulse response analyses on daily data to explain how oil prices influenced on selected EMBI countries exchange rates against U.S. Dollar between 2003 and 2010. Their findings implied that oil prices had impact positively on EMBI countries exchange rates during the sample periods. Therefore, they indicated that the impact of oil prices on exchange rate became more significant during the 2008 financial crisis. This showed that increase in oil prices created a positive sentiment for investing in emerging economies, as they were expected to grow faster than the developed.

Moreover, Brayek, Sebai, and Naoui (2015) studied on the possible impact and interdependence between oil prices and exchange rates during the global financial crisis. The dynamic conditional correlation approach (DCC-MGARCH) had been employed and the results showed that there was a significant impact between dependence of several pairs of foreign exchange markets and oil prices during the crisis.

On the other hand, Kose and Baimaganbetov (2015) also implemented a structural VAR model to capture the asymmetric effects of oil prices volatility towards the inflation and real exchange rates in the case of Kazakhstan during the global financial crisis. Their findings suggested that oil price shock had minor positive relationship towards the real exchange rates and explained by Dutch Disease Theory. Dutch Disease Theory existed when rapidly increase in oil production led to increase in the value of currency and worsening manufacturing and agriculture sectors follow by the slowdown of economic growth.

Nusair and Kisswani (2016) conducted their study in the cases of Malaysia, Indonesia, Thailand, Singapore, Philippines and Korea on the long run relationship between real exchange rates and oil prices during crisis. By applying the Engle Granger co-integration and Gregory Hansen co-integration tests, they indicated the finding of the bi-directional causality relationship in Malaysia, Indonesia as well as Thailand; the uni-directional causality relationship from exchange rates to oil prices in Singapore, Philippines as well as Korea during the three break-down periods namely oil prices structural break down in 1978, Plaza Accord event in 1985 and Asian financial crisis in 1997. However, there is no significant causality relationship in Japan for the both direct effects during these periods.

2.4 Negative Impact of Oil Prices on Exchange Rates during Crises

Goel and Sharma (2015) used F-test to identify the negative impact of oil prices on real exchange rate during global financial crisis in India. During global financial crisis, the impact of oil price shock on Indian Rupee was relatively high due to India is an importing country.

Blokhina, Karpenko and Guirinskiy (2016) implemented F-test, T-test and Auto regression model to investigate the long-run relationship between oil prices and exchange rate in Russia during financial crisis. The reason was the Russian Ruble rates which were strongly related with oil prices during financial crisis.

2.5 Conclusion

Table 2.1 summarizes the past findings for the impact of oil prices on exchange rates.

Table 2.1: The Summary of Impact of Oil Prices on Exchange Rates

Authors	Countries	Periods	Methods	Findings
Amano & Van Norden (1998)	United States	1972 Feb-1993 Jan	Co-integration & error correction models	P
Huang & Gou (2006)	China	1990 Jan-2005 Nov	SVAR model	P
Narayan, Narayan & Prasad (2008)	Fiji	2000 Jan-2006 Dec	GARCH and EGARCH models	P
Lizardo & Mollick (2009)	US, Canada, Mexico	1946 Jan-2008 Jan	Markov-switching model, ADF test, VAR model and generalized impulse response function	N
Oriavwote & Eriemo (2012)	Nigeria	1980 Jan-2010 Feb	GARCH test & Unit root test	P
Tiwari, Mutascu, & Albulescum (2013)	Romania	1986 Feb-2009 Mar	Wavelet correlation and covariance model & the Wavelet cross-correlation model	P

Table 2.1 (Continued)

Uddin, Tiwari, Arouri & Teulon (2013)	Japan	1983 July-2013 May	Continuous wavelet transform, Cross wavelet transform & Wavelet coherency	N
Kin & Courage (2014)	South African	1994 Jan-2012 Dec	GARCH model	P
Ogundipe, Ojeaga & Ogundipe (2014)	Nigeria	1970 Jan-2011 Dec	Vector error correction model, ADF test, Johanson test	N
Shahbaza, Tiwarib & Tahir (2015)	Pakistan	1986 Feb-2009 Mar	Cross-wavelet analysis	P
Pershina, Molerob, & Graciab (2015)	Botswana, Kenya, Tanzania	2003 Jan-2014 July	VAR model	P
Basher, Haug & Sadorsky (2016)	Brazil, Mexico, UK	1995 Feb-2010 Fen	Markov-switching model, ADF test	N
Chen, Liu, Wang & Zhu (2016)	Australia, Canada, Czech Republic, Denmark, Hungary, Iceland, Japan, Korea, Mexico, New Zealand, Norway, Poland, Sweden, Switzerland, Turkey, United Kingdom, Canada, Norway, Mexico	1990 Jan-2014 Dec	Structural VAR model ,unit root tests & co-integration tests	N

Table 2.1 (Continued)

During Crises

Turhan, Hacihasanoglu, & Soytas (2013)	Brazil, Indonesia, Mexico, Philippines, SouthAfrica Russia, Peru, Poland Turkey	2003 Mar-2010 Feb	Unit root test and VAR model	P
Brayek, Sebai, & Naoui (2015)	Oil exporting countries	2000 Jan-2014 April	ARCH model, GARCH model & DCC-MGARCH model	P
Kose & Baimaganbetov (2015)	Kazakhstan	2000 Jan-2013 Dec	SVAR Model & ARCH model	P
Goel & Sharma (2015)	India	2001 Jan-2013 Sept	F-statistic	N
Nusair & Kisswani (2016)	Japan, Philippine, Malaysia, Thailand, Singapore, Indonesia, Korea	1973 Feb-2011 Feb	Engle–Granger, Gregory–Hansen, unit root test & co-integration	P
Blokhina, Karpenko & Guirinskiy (2016)	Russia	2000 Jan-2016 Jan	F-test, T-test and Auto regression model	N

Notes: P represents positive impact of oil prices on exchange rates. N represents negative impact of oil prices on exchange rates.

CHAPTER 3: DATA AND METHODOLOGY

3.1 Data

In this study, the daily data for West Texas Intermediate (WTI) crude oil price per barrel and real exchange rates of Chinese Yuan against US Dollars (CNYUSD) are used. The sample period is from January 1, 2000 to December 31, 2015 with 1314 observations. To examine the impact of oil return on real exchange rate, the sample period of both series is separated into three periods, namely energy crisis (January 1, 2000-June 6, 2003), financial crisis (September 15, 2008-June 19, 2009) and oil crisis (November 28, 2014-Decemmber 30, 2015), respectively. Furthermore, the data are obtained from FRED Economics Data. We transform the data to first difference in natural logarithmic form to reduce variation and achieve stationary of the variables. It can be computed by using Equations (1) and (2).

$$coil_t = log\left(\frac{oil_t}{oil_{t-1}}\right) \tag{1}$$

$$cer_t = log\left(\frac{er_t}{er_{t-1}}\right) \tag{2}$$

where,

$coil_t$ = daily returns of WTI crude oil price per barrel
cer_t = daily changes of the real exchange CNYUSD
log = natural logarithmic form
oil_t = WTI crude oil prices at a particular time
er_t = real exchange rate CNYUSD at a particular time
oil_{t-1}= WTI crude oil prices at a preceding time
er_{t-1} = real exchange rate CNYUSD at a preceding time

3.2 Methodology

3.2.1 Unit Root Test

Unit Root test is used to check whether there are stationary or non-stationary effects on time series data. A stationary time series data indicate that a current time data does not affect by past data and vice versa. Next, the stationary of the variables is examined by using Augmented Dickey-Fuller (ADF) test. Augmented Dickey-Fuller (ADF) was further developed by the Dickey-Fuller (1981), in order to examine whether the series data are stationary.

The ADF test is used to capture the inefficiency in DF test such as DF regression model does not take dynamic effect into account. So, the regression model of these unit root tests carries in two different ways. The first model including a constant term and the second model comprised a constant term and time trend. Both models are written as Equations (3), (4), (5) and (6). In addition, the null hypothesis stated that β_2 is non-stationary which means that the series data has the unit root. We tend to reject the null hypothesis if the series is stationary in three sub-periods. The result shows that the CNYUSD and oil prices are stationary at the level.

Augmented Dickey-Fuller equation with intercept:

$$cer_t = \beta_1 + \beta_2\, cer_{t-1} + \sum_{i=1}^{k} \alpha_i\, cer_{t-1} + \varepsilon_t \tag{3}$$

$$coil_t = \beta_1 + \beta_2\, coil_{t-1} + \sum_{i=1}^{k} \alpha_i\, coil_{t-1} + \varepsilon_t \tag{4}$$

Augmented Dickey-Fuller equation with intercept and trend:

$$cer_t = \beta_1 + \delta_t + \beta_2\, cer_{t-1} + \sum_{i=1}^{k} \alpha_i\, cer_{t-1} + \varepsilon_t \tag{5}$$

$$coil_t = \beta_1 + \delta_t + \beta_2\, coil_{t-1} + \sum_{i=1}^{k} \alpha_i\, coil_{t-1} + \varepsilon_t \tag{6}$$

where,

cer_t = daily changes for the real exchange CNYUSD

$coil_t$ = daily returns of WTI crude oil price per barrel

cer_{t-1} = daily changes for the real exchange of CNYUSD at a preceding time

$coil_{t-1}$ = daily returns of WTI crude oil price per barrel at a preceding time

β_1 = intercept

δ_t = time trend

ε_t = error terms

3.2.2 Ordinary Least Square

Ordinary least square (OLS) is used to detect whether the residuals suffer from the autocorrelation problem and ARCH effects. The OLS regression model is written as below:

$$cer_t = \beta_1 + \beta_2 \, coil_t + \varepsilon_t \qquad (7)$$

where,

β_1= intercept

ε_t = error terms

By examine whether the model is adequate, we need to ensure the regression model is linear and no econometric problems. The F-statistic test is employed to determine whether the model is significant. Thus, Jarque-Bera test is used to examine whether the error terms are normally distributed. Furthermore, the Breush-Godfrey serial correlation LM test and heteroscedasticity test have been carried out to examine the model whether has autocorrelation and heteroscedascity problem.

3.2.3 Estimations on the GARCH Specifications

Autoregressive Conditional Heteroscedasticity (ARCH (*q*)) model is developed by Engle (1982). Volatility clustering is a phenomenon that commonly happened in economic time series. Mandelbrot (1963) defines that volatility clustering is that large changes tend to be followed by large changes, and small changes tend to be followed by small changes. Therefore, the variance of daily percentage price change in the real exchange rates CNYUSD can be captured by using this model.

Generalized Autoregressive Conditional Heteroscedasticity (GARCH (*p*,*q*)) model is developed by Bollerslev (1986). The GARCH model is used to capture thr volatility with fewer parameters than the ARCH model. Therefore, GARCH model can reduce the possibility of suffering from multicollinearity between the estimators as included lesser parameter (lag term) compared with ARCH model. Specifically, the sum of coefficient ARCH term and GARCH term are less than one and it must be positive sign, implying that the volatility persistence is stable. The conditional mean equation is written in Equation (8) while conditional variance equation is written in Equation (9).

$$cer_t = \psi + \theta coil_t + \varepsilon_t \quad (8)$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i} + \sum_{j=1}^{p} \beta_j \sigma^2{}_{t-j} \quad (9)$$

where,

ψ, ω = intercept

ε_t = error term

$\omega > 0$

$0 < \alpha_i < 1$

$0 < \beta_j < 1$

$0 < \alpha_i + \beta_j < 1$

p = the lags order of GARCH term

q = the lags order of ARCH term

α_i = the coefficient of ARCH term at a particular time

β_j = the coefficient of GARCH term at a particular time

GARCH model fails to be used in capturing the relationship between risk and expected return. Therefore, we incorporate the conditional variance in to Equation (10). The GARCH model will become GARCH in mean. The conditional mean equation is written in Equation (10) while conditional variance equation is written in Equation (11).

$$cer_t = \psi + \theta coil_t + \delta \log(\sigma^2_t) + \varepsilon_t \tag{10}$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i} + \sum_{j=1}^{p} \beta_j \sigma^2_{t-j} \tag{11}$$

where,

$\log(\sigma^2_t)$ = the variance of CNYUSD on itself at a particular time in natural logarithmic form

Threshold GARCH (TGARCH) model is used to capture the bad news and good news effect by including threshold term in GARCH model. This model is developed by Zakoian (1994). The sign on the parameter of ς is expected to be positive, indicating that bad news has the larger impact on the volatility of returns. In the Equation (12), $d_{t-h} = 1$ if $\varepsilon_{t-h} < 0$, otherwise $d_{t-h} = 0$. The following is the variance equation for the TGARCH model.

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i} + \sum_{h=1}^{u} \varsigma_h \varepsilon_{t-h} d_{t-h} + \sum_{j=1}^{p} \beta_j \sigma^2_{t-j} \tag{12}$$

Exponential GARCH (EGARCH) model is developed by Nelson (1991). This model is used to capture the asymmetric effects of the CNYUSD shock on volatility. This is captured by the parameter of ζ in the equation (13). Negative sign on the parameter indicates that negative shock has high volatility of CNYUSD than positive shock, vice versa. Besides, the coefficient of volatility persistence, Ω must less than 1, and the sign of this parameter in this model can be either positive or negative. The mean equation for the EGARCH and the EGARCH-M models are similar with the GARCH and the

GARCH-M models. However, the variance equation for the EGARCH and the EGARCH-M models are computed as follows:

$$log\ (\sigma^2) = \omega + \sum_{i=1}^{q} \alpha_i \left|\frac{\varepsilon_{t-q}}{\sigma_{t-p}}\right| + \zeta \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \sum_{j=1}^{p} \Omega_j\ log\ (\sigma^2{}_{t-p}) \qquad (13)$$

where,

ω = intercept

α_i = the coefficient of ARCH term at particular time

ζ = the coefficient of asymmetric effect

Ω_j = the coefficient of volatility persistence at a particular time

CHAPTER 4: EMPIRICAL RESULTS

4.1 Unit Root Tests and Simple OLS Regression

The unit root tests and OLS regression model for the impact of WTI crude oil prices on the real exchange rate of CNYUSD are carried out. First, the Augmented Dickey-Fuller (ADF) test is performed to verify the data are stationary or non-stationary. There are two models being employed which are with time trend and without time trend. The results stated that exchange rates and oil prices are stationary in both models over the three sub-periods of crisis. The results are reported in Table 4.1.

Table 4.1: The Result of ADF Unit Root Test

	Energy Crisis		**Financial Crisis**		**Oil Crisis**	
	cer_t	$coil_t$	cer_t	$coil_t$	cer_t	$coil_t$
Constant	-15.3031(15)***	-14.7302(13)***	-10.3524(5)***	-20.2852(1)***	-10.4687(7)***	-11.3676(5)***
Constant with trend	-15.2947(15)***	-14.7199(13)***	-10.3264(5)***	-20.2300(1)***	-10.4513(7)***	-11.3438(5)***

*Notes: ***(**)* denote statistical significant at the 1%, 5%, and 10% levels, respectively.*

The result of Jarque-Bera test indicated that the model is fulfilled normality assumption. Therefore, we proceed to the OLS regression which is used to examine the autocorrelation problems and ARCH effects on residuals. However, OLS regression models unable to provide a sufficient result as the models are suffering from serial autocorrelation and ARCH effects over the three sub-periods of crisis. In next section, the GARCH and EGARCH models are used to remedy the ARCH effect. The results are reported in Table 4.2.

Table 4.2: The Result of OLS Regression

	Energy crisis	**Financial crisis**	**Oil crisis**
β_1	-3.41 X 10^{-7}	-1.69 X 10^{-5}	0.0002*
	(3.36 X 10^{-6})	(9.53 X 10^{-5})	(0.0001)
$coil_t$	-0.0002	-0.0045**	-0.0082**
	(0.0001)	(0.0018)	(0.0036)
F-statistic(p-value)	2.0032	6.1818**	5.1058**
Descriptive statistics			
Mean	-4.76 X 10^{-23}	1.65 X 10^{-20}	3.69 X 10^{-20}
Standard Deviation	9.52 X 10^{-05}	0.001309	0.001756
Skewness	0.344949	1.541844	4.327442
Kurtosis	63.39273	24.46373	43.53241
Jarque-Bera	129799.4***	3722.423***	19325.06***
Autocorrelation			
k (lag length)	*Q-statistic*	*Q-statistic*	*Q-statistic*
1	154.6308***	19.9504***	14.9082***
Heteroscedasticity			
	Q-statistic	*Q-statistic*	*Q-statistic*
ARCH-LM(1)	197.7579***	17.1346***	197.7579***

*Notes: The standard errors are reported in parenthesis. ***(**)* denote statistical significant at the 1%, 5%, and 10% levels, respectively.*

4.2 The Impact of Oil Returns on the Changes of Real Exchange Rate with and without Considering Volatility of Real Exchange Rate

Based on the diagnostic results of the Ljung-Box Q-statistics, the residuals are serially independent which indicated that all models in three sub-periods of the crisis are not suffering from autocorrelation problems. In addition, the models are free of heteroscedasticity problems by referring to the result of ARCH-LM test over the three crises. Therefore, all models are adequate. In the following interpretations, the model in each sub-period of crisis with lower SIC is used.

In the energy crisis, the mean equation of the GARCH (1,1) and GARCH (1,1)-M models are statistically insignificant, revealing that oil price returns have no impact on the changes of real exchange rate. The main reason is that agriculture was the significant sector to influence the China's economic and thus the exchange rate will not be affected by the volatility of oil. However, by adding the volatility term of δ in GARCH (1,1)-M model, the impact of oil price returns on the changes of CNYUSD still remain unchanged. This is due to the volatility term is insignificant in the model, implying that the volatility of exchange rate has no impact on exchange rate itself. Third, the estimated coefficients of ARCH (0.1439) and GARCH (0.6648) terms in variance equation are statistically significant at the one per cent level in GARCH (1,1) model. The volatility persistence of 0.8086 for real exchange rate is relatively high which measured by the sum of ARCH and GARCH coefficients. This indicates the shocks to exchange rate volatility have more persistent.

During the global financial crisis, the results report that the mean equation for the ARCH (1) and the Threshold (1) ARCH (2)-M models are statistically significant at the one per cent level. This implies that oil price returns have negative impact on the changes of real exchange rate. There is 10 per cent increase in WTI crude oil price returns, on average, the changes of CNYUSD will decrease by 0.0324 per cent, ceteris paribus. The result is statistically significant at the one per cent level in volatility term, suggesting that the exchange rate volatility has positive impact on exchange rate itself. In the same time, there is less negative impact of oil price returns on the changes of real exchange rate in Threshold (1) ARCH (2)-M model as compared to ARCH (1) model due to the positive sign of volatility term. The exchange rate volatility is important because there is over debt burden of corporates during financial. In the variance equation, the threshold term of ς for Threshold (1) ARCH (2)-M model is statistically significant at ten per cent level. This suggests that bad news have larger effect than good news. Moreover, the ARCH term with lag 1 order is statistically insignificant. Indeed, the ARCH term at lag 2 is statistically significant at the one per cent level.

In the oil crisis, the results state that the mean equations for ARCH (3) and ARCH (3)-M models are statistically significant at level of 5 per cent. Oil returns have negative impact on the changes of real exchange rate. However, the ARCH term in variance equation for ARCH (3)-M model is statistically insignificant. Moreover, the risk of real exchange rate in oil crisis is the volatility of oil prices and it is statistically insignificant. The reason is Chinese oil enterprise had signed the oil trading agreement with the Mexico oil company (Powell, 2014). Therefore, the movement of oil prices will not affect the real exchange rates CNYUSD.

Table 4.3: The Result of GARCH Model

	Energy Crisis		Financial Crisis		Oil Crisis	
	GARCH(1, 1)	**GARCH (1, 1)-M**	**ARCH(1)**	**Threshold(1) ARCH(2)-M**	**ARCH(3)**	**ARCH(3)-M**
Conditional Mean Equation						
ψ	-2.26×10^{-6}	0.0001	3.13×10^{-6}	0.005***	0.0002	0.0071
	(3.69×10^{-6})	(0.0002)	(8.92×10^{-5})	(0.0009)	(0.0001)	(0.0005)
θ	-9.35×10^{-5}	-9.35×10^{-5}	-0.0046***	-0.0032***	-0.0105**	-0.009**
	(0.0001)	(0.0001)	(0.0017)	(0.0005)	(0.0039)	(0.0043)
δ	-	7.06×10^{-6}	-	0.0004***	-	0.0005
	-	(9.42×10^{-6})	-	(6.46×10^{-5})	-	(0.0005)
Conditional Variance Equation						
φ	1.59×10^{-9}***	1.64×10^{-9}***	1.28×10^{-6}***	3.43×10^{-7}***	2.42×10^{-6}***	2.53×10^{-6}***
	(1.02×10^{-10})	(1.0×10^{-10})	(6.5×10^{-8})	(4.94×10^{-8})	(7.07×10^{-8})	(7.74×10^{-8})
α_1	0.1439***	0.1466***	0.1763***	-0.0063	0.0894	0.1183
	(0.0185)	(0.0191)	(0.0694)	(0.0049)	(0.0607)	(0.0845)
ς	-	-	-	0.2146***	-	-
	-	-	-	(0.1213)	-	-
β	0.6648***	0.6557***	-	-	-	-
	(0.0206)	(0.0207)	-	-	-	-
α_2	-	-	-	0.6467***	0.0870***	0.0399
	-	-	-	(0.1013)	(0.0247)	(0.0382)
α_3	-	-	-	-	-0.0312***	-0.0160
	-	-	-	-	(0.00403)	(0.0301)
$\sum \alpha_{1,2,3} + \beta$	0.8087	0.8023	0.1763	0.6404	0.1452	0.1422
Schwarz criterion	-16.0180	-16.0105	-10.5075	-10.9231	-9.8322	-9.8122
Diagnostics						
Q^2-stat(1)	0.9290	0.8162	0.1730	0.0920	0.0453	0.0025
	(0.335)	(0.366)	(0.677)	(0.762)	(0.831)	(0.960)
Q^2-stat(15)	2.1933	2.2425	6.1366	2.1560	0.3170	0.2850
	(1.000)	(1.000)	(0.977)	(1.000)	(1.000)	(1.000)
Q^2-stat(30)	2.6498	2.6999	6.6908	8.0397	0.7580	0.6909
	(1.000)	(1.000)	(1.000)	(0.719)	(1.000)	(1.000)
ARCH-LM(1)	0.9246	0.8124	0.1695	0.0901	0.04463	0.00244
	(0.3363)	(0.3674)	(0.6806)	(0.7640)	(0.8327)	(0.9606)

*Notes: The standard errors are reported in parenthesis. ***(**)* denote statistical significant at the 1%, 5%, and 10% levels, respectively.*

4.3 The Impact of Oil Returns on the Changes of Real Exchange Rate with and without Asymmetric Effect on Real Exchange Rate

For the residual diagnostic checking, the Ljung-Box Q-statistic with various lags indicates that the all models over the three sub-periods of crisis are free from autocorrelation problem. Thus, the ARCH-LM test reports that the null hypothesis of no heteroscedasticity problem cannot be rejected over the three sub-periods. Therefore, the models are adequate. In the following interpretations, the model with lower SIC is used.

In the energy crisis, the EGARCH (1,1) and the EGARCH (2,1)-M models in mean equation imply that a depreciation of the Chinese Yuan against the US Dollar as resulted from an increasing in oil prices. However, the coefficient is relatively low (-0.00003) indicate that the impact of oil price returns on the changes of real exchange rate is low. Besides, the volatility term in EGARCH (2,1)-M model is statistically significant at level of one per cent. The increase in exchange rate volatility leads to a depreciation of the CNYUSD, ceteris paribus. This is because China's government had pegged their exchange rate against U.S. Dollar in order to combat with economic instability from 1995 to 2005. However, the coefficient of exchange rate volatility is relatively small that indicates exchange rate risk has low impact on exchange rate. Next going through the variance equation, the parameter of ζ is used to capture asymmetric effects on exchange rate volatility. The parameter of ζ in EGARCH (2,1)-M is statistically significant at the one per cent level, implying that negative shock is going to raise higher exchange rates volatility than positive shock. The volatility persistent term, Ω_2, is statistically significant at the one per cent level.

In the financial crisis, there is negative impact of oil price returns on the changes of real exchange rate as resulted from mean equation. The exchange rate volatility term in EGARCH (1,1)-M model is statistically significant at the one per cent level with the positive sign which has the adverse result with the energy crisis.

Thus, the exchange rate volatility increases tend to appreciate the CNYUSD. Turning to variance equation, the asymmetric term is statistically significant at the one per cent level. This implies that the negative shock influences higher exchange rates volatility than positive shock. The parameter of $\boldsymbol{\Omega}_1$ is statistically significant at the one per cent level with negative sign.

For the oil crisis period, there is negative impact of oil prices on real exchange rates as a result from mean equation. The 10 per cent increase in oil prices will influence the real exchange rates depreciated by around 0.14 per cent. Hence, the impact is the highest among the three sub-periods of crisis. The volatility of exchange rate has positive impact on exchange rate itself and statistically significant at the one per cent level. Oil crisis happened due to over supply of oil in the international oil market and this can be the one of the exchange rate risk in China. As China highly demands on oil in their production, therefore the risk of real exchange rate (oil crisis) is an important element in examine the real exchange rate. The positive sign on asymmetric term implies that the positive shock has to raise higher exchange rate volatility than negative shock. Furthermore, the volatility persistence term is also statistically significant at the one per cent level. The result of negative volatility persistence term can be illustrated from the result of the financial crisis.

Table 4.4: The Result of EGARCH Model

	Energy Crisis		**Financial Crisis**		**Oil Crisis**	
	EGARCH (1, 1)	**EGARCH (2,1)-M**	**EGARCH (1, 1)**	**EGARCH (1,1)-M**	**EGARCH (2, 1)**	**EGARCH (2,2)-M**
Conditional Mean Equation						
ψ	$-4.99 \text{ X}10^{-6}$***	-0.0002***	$3.30 \text{ X } 10^{-5}$	0.0013	0.0001	0.0052***
	$(1.23 \text{ X}10^{-6})$	$(1.04 \text{ X } 10^{-5})$	$(3.51 \text{ X}10^{-5})$	(0.0011)	(0.0001)	(0.0049)
θ	-0.0007***	-0.00003***	-0.0016***	-0.0051***	-0.0141***	-0.0135***
	$(2.01 \text{ X}10^{-5})$	$(1.94 \text{ X } 10^{-5})$	(0.0003)	(0.0007)	(0.0024)	(0.0032)
δ	-	$-7.60 \text{ X } 10^{-6}$***	-	$8.75 \text{ X } 10^{-5}$***	-	0.0004***
	-	$(4.78 \text{ X } 10^{-7})$	-	$(7.50 \text{ X } 10^{-5})$	-	(0.0001)
Conditional Variance Equation						
φ	-2.6434***	-1.4746***	-19.6206***	-2.4984***	-12.1628***	-24.7663***
	(0.1431)	(0.0395)	(0.5497)	(0.6835)	(1.1026)	(1.5209)
α_1	0.6940***	0.8274***	1.2453***	0.4313***	0.6716***	0.2285***
	(0.0256)	(0.0254)	(0.1585)	(0.1212)	(0.0418)	(0.0799)
ζ	0.3303***	-0.2719***	-0.9045***	0.1485	-0.1273*	0.1464***
	(0.0372)	(0.0122)	(0.0985)	(0.1084)	(0.0657)	(0.0692)
Ω_1	0.8797***	0.0864***	-0.3440***	0.8616***	0.7498***	-0.1951***
	(0.0078)	(0.0038)	(0.0442)	(0.0459)	(0.0708)	(0.0639)
Ω_2	-	0.8636***	-	-	-0.6608***	-0.6962***
	-	(0.0036)	-	-	(0.06215)	(0.0893)
α_2	-	-	-	0.4280***	-	0.3427***
				(0.1469)		(0.1033)
$\left\|\sum \Omega_{1,2}\right\|$	0.8798	0.9500	0.3440	0.8616	0.0890	0.8913
Schwarz criterion	-16.0941	-16.6504	-10.9504	-10.8625	-9.8889	-9.8373
Diagnostics						
Q^2-stat (1)	0.0611	0.2640	0.0672	0.0258	0.0216	0.0119
	(0.805)	(0.607)	(0.796)	(0.872)	(0.883)	(0.913)
Q^2-stat (15)	4.0605	5.2643	1.1381	3.0732	0.3804	0.4212
	(0.998)	(0.990)	(1.000)	(1.000)	(1.000)	(1.000)
Q^2-stat (30)	4.7166	7.5732	10.061	6.8153	0.8539	0.9761
	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)
ARCH-LM (1)	0.0609	0.2628	0.0659	0.0253	0.0213	0.0121
	(0.8051)	(0.6082)	(0.7974)	(0.8000)	(0.8839)	(0.9125)

*Notes: The standard errors are reported in parenthesis. ***(**)* denote statistical significant at the 1%, 5%, and 10% levels, respectively.*

CHAPTER 5: CONCLUSION

5.1 Major Findings

The following finding is obtained in order to response the first research question in this study. By considering real exchange rates risk, oil returns have no impact on the changes of real exchange rate in energy crisis but there is negative impact in financial crisis and oil crisis. Furthermore, the risk on real exchange rate is only important to influence the real exchange rates itself during the financial crisis. This is because the over mortgage loan leads to financial crisis and hence the volatility in real exchange rate is significant in examine the impact of oil returns on the changes of real exchange rate CNYUSD. In addition, bad news of the real exchange rate has greater impact than good news in financial crisis. Overall, the impact of oil returns on the changes of real exchange rate cannot be sustained by considering the exchange rate volatility over three sub-periods in China.

The following finding is obtained in order to response the second research question in this study. The asymmetric effect is important in influencing the impact of oil returns on the changes of real exchange rate over three sub-periods. The results show that there is a negative impact of oil returns on the changes of real exchange rate over three sub-periods. During oil crisis, there is the largest impact among three sub-periods due to China becomes the world's largest oil importer in 2015. Thus, with asymmetric effect, the oil returns on the changes of real exchange rate can be sustained over three sub-periods in China.

Overall, we need to choose the model with lowest SIC in each sub-periods of crisis by considering both risk and asymmetric effect on real exchange rates. In energy crisis, both risk and asymmetric effect on real exchange rate are necessary taken into account in order to have a better model. However, the coefficient of risk on real exchange rates is relatively small as the government of China had fixed the exchange rate from 1995 to 2005. In financial crisis and oil crisis, the asymmetric effect of real exchange rates is only needed to be considered when choosing the model with lowest SIC. In other words, the risk on real exchange rates are not the key to be considered as the risk was captured on pre-financial crisis. However, oil prices volatility will not affect the real exchange rate CNYUSD in oil crisis as the oil trading agreement between Mexico and China.

5.2 Implications

The first finding suggests that investors can improve their investment decision in foreign exchange market towards the movement of oil prices in China during crises. There is negative impact of oil returns on the changes of real exchange rate over three sub-periods of crisis in China which influenced by asymmetric effect. Therefore, investors should consider the asymmetric effect during the investment decision making process. In financial crisis, they also have to take risk of real exchange rates into account. For example, investors should make their decision based on their behavior which are risk averse and risk taker.

The second finding suggests oil producers to set higher selling price of oil products when risk and asymmetric effect of real exchange rates is taken into account. By doing so, they can maintain their targeted profit margin. This action is suggested for the crisis periods in China.

5.3 Limitations and Recommendations

First, our study attempts to capture the impact of oil return on the changes of real exchange rate CNYUSD during crises by using one denominated currency. To achieve a better view and reliability towards the oil prices volatility influences on real exchange rate of Chinese Yuan, future researchers are recommended to consider the currencies of Chinese Yuan against Hong Kong dollars, Japanese Yen and South Korea Won as the main trading partners for China.

Second, the sample periods in our study are insufficient to capture the oil shock effect. For instance, in the oil crisis, the WTI crude oil prices and real exchange rate (CNYUSD) were obtained until the December 31, 2015. However, the oil crisis is not over. Therefore, future researchers are recommended to conduct the study after the end of oil crisis. The result will be more reliable than our study in the oil crisis.

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