THE CAUSALITY BETWEEN CRUDE OIL AND GOLD MARKETS IN RUSSIA

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PREFACE

This research presents "The causality between crude oil and gold markets in Russia." It is mainly focus on crude oil and gold relationships in the pre-crisis, crisis and post-crisis periods. The commodities play a significance role in our daily life as it is very common goods in part of our live. Commodity market is traded every day and it lead to an up and down of a country's economy around the world.

Crude oil and gold markets is selected in this research to further study their relationships. This is because these two commodities have significant importance to a country and some industry. For instance, crude oil is used as fuel for various kinds of machines and production, while gold used as an international reserve to preserve the value of the country's currency. The relationships between these two commodities are often examined in detail to establish the price of each other, where the price of gold may partially depends on crude oil price or vice versa.

In order to better understanding on the relationship between crude oil and gold markets, it is necessity to review the past study of the researchers from other countries in a time-varying. This would better enhance the knowledge regarding the role and function of these two commodities toward the economy in a country.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
AR	Autoregressive
COP	Crude Oil Price
COR	Crude Oil Return
EIA	Energy Information Administration
GARCH	Generalized AutoRegressive Conditional Heteroskedasticity
GDP	Gross Domestic Product
GP	Gold Price
GR	Gold Return
JJ	Johansen-Juselius
LBMA	London Bullion Market Association
MA	Moving Average
OPEC	Organization of Petroleum Exporting Countries
S.E	Standard Error
SIC	Schwarz Information Criteria
U.S.	United States
VAR	Vector Autoregressive
VDC	Variance Decomposition
VEC	Vector Error-Correction

ABSTRACT

This research examines causality between crude oil and gold markets in Russia from January 2001 to December 2014. The sample period is separated to become the pre-crisis, crisis and post-crisis periods. Granger causality test, impulse response function and variance decomposition are employed for each sub-period. Empirical result provides two findings. First, gold price has positive response to crude oil price movement in the pre-crisis period, while negative response appeared during the crisis and post-crisis periods. This indicates that gold is acted as effective hedging tool before the crisis, while it is acted as safe haven asset during and after the crisis. Second, information flow is found to be occurred from crude oil market to gold market in the crisis and post-crisis periods. This study suggests that crude oil-exporting countries should use gold as a tool to hedge against inflation in the pre-crisis period. In the subsequent periods, they need to turn gold to be a tool to preserve their portfolio value. Furthermore, investors should emphasize on the use of information about crude oil price movement to set their hedging strategies during the crisis and post-crisis periods.

CHAPTER 1: INTRODUCTION

1.0 Overview

This chapter provides general background of interaction between crude oil and gold markets. Subsequently, important feature and function of two commodity markets in the economy are highlighted. The current issues of the crude oil price movement and reaction of gold price in the Russia motivate us to conduct this research. In addition, research questions are form to center our research. Meanwhile, several research objectives are list out to determine the goal that we obtain from the research. The contribution of this research is discuss at the end of this chapter which followed by outline of study.

1.1 Background of Crude Oil and Gold Markets

Trend of market interconnectivity of commodity field, especially the connection between crude oil and gold markets is highlighted in the Russia economy. Crude oil and gold are important representatives of the large commodity markets and play an important role in the Russia economy. Connection between crude oil and gold first appeared in history when producers of the Middle East demanded gold in exchange for crude oil (Simakova, 2011). The prices of these two commodities are not completely driven by the supply and demand forces in the market. This statement

is supported by Zhang and Wei (2010), where the prices of crude oil and gold can be affected through financial features and interaction between each other.

Crude oil is the most important commodity in Russia because it provides energy resources to other industries that needed oil to burn in their operation. Oil and gas industry are the core industries of Russia economy, as it generate approximately one-quarter of the Gross Domestic Product (GDP) and over two-thirds of the export revenue for their federal budget ("Launching new fuel", 2015).

In 2014, Russia expanded their oil revenue by increasing 10 million tons of oil supplies to China, Japan and South Korea, which lead the proportion of oil exports to Asia increased from 7.2 percent to 8.7 percent (Kuchma, 2015). This export expansion put oil export at the top of the Russia's export product groups. Workman (2015) reported that oil overall exports $288,361.702 million occupied the 58.6 percent of the total Russian exports in 2014. Russia reacted effectively to this current oil trend because it intended to retain their leading positions in the oil industry.

Gold also play an important role in the Russia economy as its function as a safe haven asset and hedging instrument. Gold basically performing in the economy through these two functions. Safe haven always refer to protection of the increasing risk in the financial market, while hedge focus on the protection against purchasing power risk. Skoyles (2013) mentioned that the main difference between safe haven and hedge is the length of the effect. The important feature of the hedge is its ability to perform on average, which is different from the safe haven feature that can only perform in the certain periods.

In 2014, Russia replaced United States to become the third largest gold producer in the world (Cammarosano, 2014). However, Russia still imported and purchased gold from the market to boost up their reserves. In June 2014, Russia purchased additional 500,000 ounces of gold into its reserves. This is because Russia aimed to create a safety net for their economy to minimize the impact from sanction of the United States ("Russia builds up gold reserves", 2015). According to Kurapovna (2015), this is not the first time Russia used the gold standard to cure their economic problems because the same action is taken previously during May 2000. Therefore, the role of gold as a hedge and safe haven is shown to be important for the Russia economy.

1.2 Relationship between Crude Oil and Gold Markets

There is a connection between crude oil and gold markets. The rising oil price caused the gold price increasing in the economy, and subsequently raised inflation in the country. Investors generally use gold as a hedging instrument because it is able to maintain purchasing power in the short term and long term. Hence, gold is suitable as an inflation hedge when the oil price suffers from unfavorable movement. Cheng, Su and Tzou (2009) stated that a rise in oil price place upward pressure on inflation and this raised the appeal of gold as an investment asset to hedge against inflation. The World Gold Council indicated that apart from gold's safe haven attribute, inflationary pressures in many areas of world maintained significant even though the crude oil price dropped. Therefore, gold is being used as an inflation hedge due to its real value differ in short term and the purchasing power stable across countries.

There is a common belief that gold is a safe haven asset to secure the increasing risk in downward extreme market movement. Gold is perceived as a commodity and monetary assets couple with no credit risks since global gold market is easy to access and gold is a highly liquid investable asset. Sari, Hammoudeh and Soytas (2010) stated that oil and gold are always mixed together to diversify investor's portfolio. In the case of market downturns, investors used gold as safe haven to lower their exposure to losses. Therefore, gold is crucial for investors to maintain their portfolio value.

In addition, crude oil and gold prices react to each other through the export revenue channel. Basic part of the international reserve portfolio in the countries comprised of gold. Oil-exporting countries such as Russia, Saudi Arabia, etc. usually invest in gold market to diversify their market risk. Reboredo (2013) found that the crude oil price could influence the gold price through export revenue channel. Increasing in the oil revenue boost up the gold market investment thus causes crude oil and gold prices having positive movement. This would be the reason that oil-exporting countries holding gold as assets of their international reserve portfolio.

On the other hand, gold price can affect oil price through producers' expectation. One of the functions of gold is to anticipate future inflation in the economy. Hence, when the supply and demand of gold encounter changes in the market, subsequently oil market reacts to this information. This is because proliferation demand of gold leads to increase in expected inflation of oil exporter, thus they mark up the price of oil. This is supported by Malliaris and Malliaris (2011), which suggested that appreciated gold price would be one of the signals for inflationary expectation. Therefore, it will deliver information to major oil exporters to boost up the price of oil to maintain their future revenue.

1.3 Problem Statement

The upturn of oil price boosted up Russia's inflation and the reaction of gold price was the issue before 2008 financial crisis. High oil price was one of the reasons that caused the real inflation rate to be higher than expected inflation rate. Inflation rate in Russia was 9 percent in 2007 higher than the initial forecast of 8 percent in 2006 ("Inflation in Russia", 2007). Hence, investors increased demand of gold in market to insure against inflation. Ito (2008) found that 1 percent increase in oil price contribute to 0.25 percent increase in real GDP growth, while inflation increase by 0.36 percent. Pindyck and Rotemberg (1990) stated that higher oil price strengthened the inflation in the economy, thus lead to a rise in demand for gold. This effect would increase the gold price in the market. As illustrated in Figure 1, crude oil and gold prices have an increasing trend in the pre-crisis period.

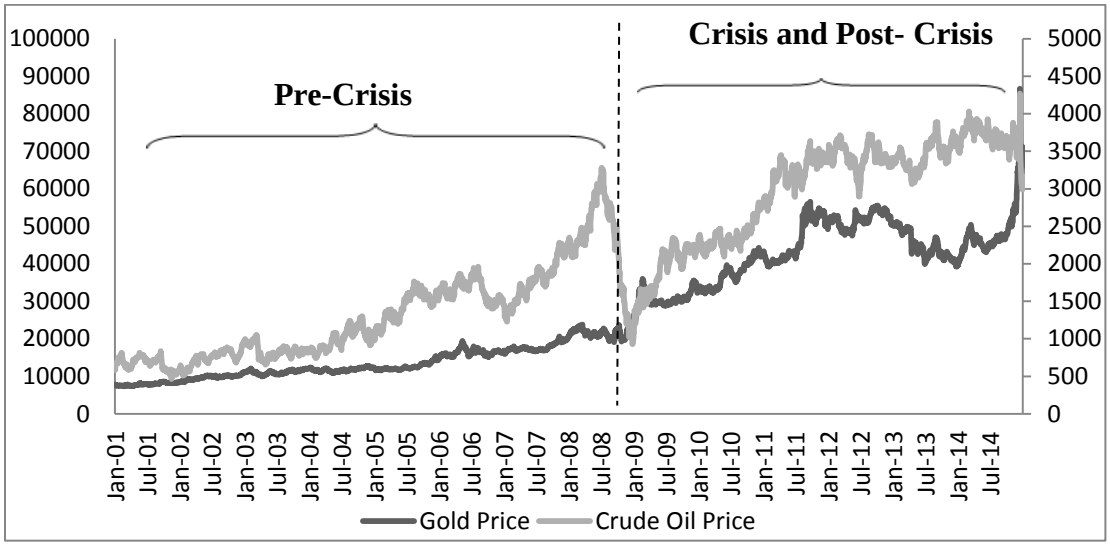

Figure 1: Daily Gold price per troy ounces (Ruble ₽) and Daily Crude Oil price per barrels (Ruble ₽) from January 1, 2001 to December 31, 2014.

Source: London Bullion Market Association (LBMA) and U.S. Energy Information Administration, Year 2014.

In June 2014, Russia crude oil price fell due to its demand decreased in other countries. The reason is United States keep on increasing the supply of shale oil to market. This leads to oversupply in oil market and Organization of Petroleum Exporting Countries (OPEC) did not reduce their oil production because intend to maintain its competitive advantage and market share. Low price strategy used by OPEC caused Russia to lose their Fiscal breakeven oil price which is $105 per barrel. Hence, it weakened Russia economy in second half of 2014 because oil-exporting is the main income for their economies. Russia export revenue consists of around 70 percent from oil and gas exports. For every descent of dollar in oil price, Russia will lose about $2 billion of their oil export revenues (Bowler, 2015). This would cause oil exporter in Russia to consume more gold to safeguard their revenue.

Based on World Bank, on June 1, 2014, crude oil price stands at $111.87 per barrel and Ruble stands at 34.97 per U.S. dollar. On December 30, 2014 crude oil price dropped to $62.87 per barrel and Ruble dropped to 59.17 per U.S dollar (Khlebnikov, 2014). This indicates that there is positive relationship between crude oil price and Russia currency. As Russia economy declines, investor tends to sell Ruble and hold other stable assets such as gold, silver, etc. According to International Monetary Fund, Russia gold reserve had increased from $41715 million in January to $46089 million in December 2014. The reason Russia government boost up their gold reserve is to back up their home currency and diversify the international reserves to prepare for catastrophic oil sink in their economy.

Russia had been chosen for this research to investigate the causality of crude oil and gold prices during the pre-crisis, crisis and post-crisis periods. Financial crisis could render negative impact towards particular participants who trades with these two commodities in Russia. Since Russia economy was heavily rely on the crude oil-exporting revenue and gold to support their home currency. Thus, the pre-crisis, crisis and post-crisis periods will directly influence the movement and relationships of the

crude oil and gold prices in Russia. Jena and Goyari (2010) stated that unexpected global factors will affect the real relationship between crude oil and gold markets. Figure 1 indicated that there is a positive relationship between two commodities from pre-crisis to post-crisis periods in Russia. However, it relationship had turn into negative in August 2014.

1.4 Research Questions

I. Is gold a hedge or safe haven against crude oil price movements?

II. How information spilled over between crude oil and gold markets during the pre-crisis, crisis and post-crisis periods?

1.5 Research Objectives

I. To determine whether gold is a hedge or safe haven against crude oil price movements.

II. To investigate information flow between crude oil and gold markets during the periods of pre-crisis, crisis and post-crisis.

1.6 Significance of the Study

This research provides information about dynamic relationship between crude oil and gold markets by determining the attribute of gold as a hedge or safe haven asset against oil price movements. The distinctive attribute of gold will benefit crude oil-exporting countries by reducing the risk of oil price changes in the economy. Theoretically, crude oil-exporting countries tend to use gold as a tool to hedge against inflation. Meanwhile, they also include gold in their international reserve portfolio to maintain the purchasing power of their revenue. The findings of this research also assist crude oil-exporting countries to react effectively towards the fluctuation of oil price movement through buying, holding and selling gold.

In addition, this research will make a contribution to investors through understanding the behavior of information flow between crude oil and gold markets. The expected and unexpected volume of information flow significantly affects the general level of volatility despite of positive or negative information. Hence, it is crucial for investors to understand volatility transmission mechanism between these two commodities during pre- crisis, crisis and post- crisis periods. The distinct behaviors across different periods may yield a deep understanding of market linkage to the investors. This will definitely help investors to make an appropriate decision making in cross hedging market by using crude oil and gold under different economic conditions.

1.7 Chapter Layout

This research consists of five chapters and the remaining chapters organized as follow:

In the chapter 2, we discuss the findings of past researchers. Furthermore, we review how past researchers did their research and what the relevant theories they used in their research.

In the chapter 3, the scope of study, data collection methods, sources of data, and the method of data analysis are carried out to conduct this research. It is mainly focused on the preparation work before heading to the data analysis part.

In the chapter 4, we generate and analyse the data provided in the previous chapter. After that, statistical results are presented in the form of table. Subsequently, justification that leads to the major finding of our research also provided in this chapter. .

In the final chapter, summary of the entire research will be formed and highlighted. Furthermore, implications of research also will be stated and discussed. At the end of the chapter, recommendation will be suggested in order to assist practitioners and future researchers.

1.8 Conclusion

In short, this chapter provides a basic understanding of crude oil and gold markets. After that, problem related to crude oil and gold prices issues in Russia are also discussed in this chapter. The objectives of this research are to study the functions of gold against crude oil price movement and information flows in both markets during the periods of pre-crisis, crisis and post- crisis. Past literatures will be discussed and reviewed in the next chapter

CHAPTER 2: LITERATURE REVIEW

2.0 Overview

In this chapter, relationships between crude oil and gold markets are further discuss through reviewing the studied of past researchers in different countries and different periods by using different methodologies.

2.1 Channels between Crude Oil and Gold Prices

2.1.1 Inflation Channel

Generally, crude oil and gold prices react to each other through inflation channel. Most of the studies explained their relationships through this channel (Hooker, 2002; Ciner, Gurdgiew & Luccey, 2012). Crude oil and gold act as important commodities in international trading and both commodities are correlated with each other. Narayan, Narayan and Zheng (2010) studied the relationship between crude oil and gold markets by using cointegration test. Their result showed that crude oil price tends to increase the general price and subsequently creates inflationary pressures to the economy.

Lee, Huang, and Yang (2012) suggested that inflation and crude oil price are seeemed to have a causal relationship. Increasing oil price leads to high inflation in the economy, thereby leads to the rise in the gold price and gold investment. Sujit and Kumar (2011) also supported that higher crude oil price leads to inflation happened and subsequently caused the gold price increased. Therefore, it is a significant relationship between inflation, crude oil price and gold price in the economy.

The empirical result from Hooker (2002) by using Philips curve framework reported that higher crude oil price would downturn the economic growth and caused an inflationary pressure. When the inflation happened, it would reduce asset price and investors would purchase gold as an alternative asset to store their wealth. Thus, gold price increased due to higher gold investment demand. Besides that, Zhang and Wei (2010) used cointegration test to examine the cointegration and causality relationship between the prices of these two commodities. The results showed that increasing in crude oil price led to gold price increase. This is because gold can be used to resist inflation and it caused increasing demand of gold.

2.1.2 Export Revenue Channel

Capie, Mills and Wood (2005) found that oil exporter used gold to stabilize their purchasing power due to unstable oil price in global market. When oil-exporting countries revenue increases, they tend to invest in gold market for diversify their risk portfolios (Narayan et al., 2010). The empirical evidence showed that there is linkage between crude oil and gold prices. These two commodities markets are affected by various macroeconomic factors such as exchange rate, inflation, etc. Oil exporter used gold to preserve their purchasing power and hold gold as their international reserve portfolio.

Le and Chang (2012) studied dynamic effects between crude oil price shocks and gold return by using autoregressive model. The result showed that crude oil and gold prices relationship is established through export revenue channel. This is similar with the study of Simakova (2011) which indicated that oil revenue increased from oil export boosted up demand of gold in the market. This is because oil-exporting countries tend to purchase gold to maintain their assets value and diversify their market risk through holding adequate gold reserve in their portfolio.

Zhang and Wei (2010) employed Granger causality test to investigate crude oil and gold prices interaction. The impact of crude oil price had driven the gold price changes in the economy. Their result also supported both of these commodity react to each other through exported revenue channel. When the revenue of oil exporter increased from oil sales, they used a portion of revenue to invest in gold market to disperse market risk. Ewing and Malik (2013) used GARCH models and found that there are significant transmissions of volatility between crude oil and gold markets.

2.2 Role of Gold against Oil Price Movement

2.2.1 Gold as a Safe Haven

Regnier (2007) found that crude oil is the most common commodities traded in the world, and it is the most volatile in the commodity markets. Sari et al. (2010) stated that gold is the leader in the precious metals market and its price changes would lead the price of other precious metals into same direction. This study is similar with the empirical result of Hood and Malik (2013) which stated that gold is a type of metal that can retain its value during wars, crisis period, and national policy

changes. Therefore, gold is considered as a safe haven assets against crude oil price movement.

Generally, high crude oil price would influence the price movement of other asset. Hence, investors selected gold as their alternative investment because gold is a safe haven asset that investors would purchase to safeguard against uncertainty of the crude oil price. This is supported by Ciner, Gurdgiev and Lucey (2012) which found that gold does not co-move with other commodity assets during market turbulence due to its safe haven attributes. This also indicates that gold is able to provide assurance to investors in the event of an economic downturn and also avoid the increasing risk in the financial market. Simakova (2011) stated that gold is an effective safe haven assets that highly demanded by individual investors, government and institutional to protect against uncertainty event. Gold is used as a safe haven asset for most developed markets during market instability especially for financial crisis period. Therefore, this indicated that crude oil price movement may cause a pricing signal to the gold market.

For those oil-exporting countries, they hold gold as a safe haven in their international reserves portfolio (Reboredo, 2013). This would help them to preserve the value of their portfolios. Hence, oil-exporting countries would tend to increase investment in gold, thus lead to the gold price in the market to boost up. Capie et al. (2005) reported that crude oil and gold are linked to each other through US dollar. This finding showed that investors used gold as safe haven assets in the case of US dollar weakened against other currencies, thereby lead to the increase in the gold price as well. At the same times, when US dollar depreciates, oil-exporting countries would mark-up the crude oil price to protect their revenue.

2.2.2 Gold as a Hedging Tool

Gold is a liquid metal and the only commodity that functioned as money in financial and international transaction over the years. Adrangi, Chatrath, and Raffiee (2003) suggested gold as a hedging tool against inflation. Inflation hedge is an investment that able to provide protection against the declined value of a currency. McCown and Zimmerman (2006) found that gold is able to hedge against inflation and has no market risk due to its zero beta characteristics. Unlike most commodities, gold is universally acceptable, durable, easily authenticated and relatively transportable (Beckmann & Czudaj, 2013).

In another studied by Cheng et al. (2009), gold is a store of value to resist inflation. Gold has good nature to against inflation during higher crude oil price intensified the inflation. Gold as an effective tool to hedge against inflation due to the gold value is stable. Positive correlation between expected inflation and gold price are proven by Beckmann and Czudaj (2013), when expected inflation increased, investors tend to purchase more gold to hedge against the depreciation of currency. In the long run and short run, gold investment had been judged as a reliable hedge against inflation.

Narayan et al. (2010) investigated the long-run relationship between crude oil and gold prices at different growth stages. The results showed that crude oil and gold could be mutually used to forecast prices. Investors used gold as hedging tools to resist inflation and hedge against expected decline in the value of currency when their future expected inflation is rising. This is supported by the studied of Blose (2010) which gold price and expected inflation are interrelated in the economy. This indicated that gold could be used as an effective hedging tools against inflation that caused by unfavorable crude oil price movement in the economic.

2.3 Crude Oil and Gold Prices Relationship during Pre-Crisis and Post-Crisis.

The relationship between crude oil and gold prices are varying in different maturities. In pre- crisis period, Zhang and Wei (2010) studied the relationship between these two commodities by using cointegration test. The empirical result shows that both commodities are highly correlated with the correlation coefficient 0.9295 from 2000 to 2008. Due to the global inflation and US dollar depreciation in 2002, crude oil and gold prices keep increasing until the first half of 2008. Bhar and Malliaris (2011) also found that crude oil and gold had similar price pattern. This is because increase in crude oil price lead investors to consume more gold in order to safeguard themselves from the future crisis.

Chang, Huang and Chin (2013) used Granger causality test to study the crude oil and gold prices relationship from 2007 to 2011. The results indicated that there was short-term interaction between the prices of these two commodities. Bampinas and Panagiotidis (2015) examined the causal relationship between crude oil and gold prices at different maturities by employing linear and nonlinear Granger causality. Their evidence indicated that bidirectional nonlinear causality relationships occur between these two commodities in the post-crisis period. Demand and supply forces are incompletely determine the prices of gold and crude oil markets, but also affected by the interaction of others commodity markets. Tang and Xiong (2010) stated that non-energy commodities future prices would became highly correlated with oil after 2004 due to the financialization process. This process allow trader to exchange crude oil, gold and others commodity in the market through financial instrument. Therefore, crude oil and gold markets became highly correlated in the crisis and post-crisis periods.

2.4 Conclusion

After reviewing several relevant past studies by previous researchers, summarizing result regarding the crude oil and gold markets interaction are shown at the end of this chapter. All of the evidences provided were plausible enough for the direction of this research. This research is focus on the investigation of causal relationship between crude oil and gold markets. Therefore, various methodologies will be employed in following chapter to investigate the objectives of the research.

Table 2.1 Summarized of the Previous Research

Author	Journal Title	Country	Period	Method	Result
Wan-Hsiu Cheng, Jung-Bin Su, and Yi-Pin Tzou (2009)	Value-at-Risk Forecasts in Gold Market Under Oil Shocks	-	April 1998 – July2006	Autoregressive Conditional Jump Intensity (ARJI) model BHK-PGARCH model GARCH model	Oil → Gold
Paresh Kumar Narayan, Seema Narayan, and Xinwei Zheng (2010)	Gold and oil futures markets: Are markets efficient?	United States	1963–2008	Cointegration tests, Dickey–Fuller test, Engle and Granger test, Phillip and Perron unit root test, Gregory and Hansen test for cointegration	Oil → Gold
Yue-Jun Zhang and Yi-MingWei (2010)	The crude oil market and the gold market: Evidence for cointegration,causality and price discovery	-	January 2000 - March 2008	GARCH model, Granger causality test Cointegration test	Oil → Gold
Youngho Chang and Thai-Ha Le (2011)	Oil and gold prices: Correlation or causation?	-	Jan 1986 – April 2011	Granger causality, Cointegration tests	Oil → Gold
K. S. Sujit and B. Rajesh Kumar (2011)	Study on dynamic relationship among gold price, oil price, exchange rate and stock market returns	Germany, Japan, Taiwan and China	January 1998 - June 2011	Vector Autoregression (VAR), Granger causality tests, Augmented Dickey-Fuller (ADF) and Phillips-Perron(PP) tests	Gold → Oil
Yen-Hsien Lee, Ya-Ling Huang, and Hao-Jang Yang (2012)	The asymmetric long-run relationship between crude oil and gold futures	-	May 1994 – November 2008	Cointegration test of Enders and Granger, TECM-GARCH with GED, Unit root tests	Oil → Gold
Bradley T. Ewing and Farooq Malik (2013)	Volatility transmission between gold and oil futures under structural breaks	-	July 1993 – June 2010	GARCH models	Oil → Gold
Juan C. Reboredo (2013)	Is gold a hedge or safe haven against oil price movements	Turkey	January 2000 - September 2011	Copula models marginal models	Oil → Gold

CHAPTER 3: METHODOLOGY

3.0 Overview

In this chapter, data collection of this research is clearly stated and described. Short-run dynamic analysis in this research is being used to examine the causal relationship between crude oil and gold prices in the pre-crisis, crisis and post-crisis periods. Subsequently, various methodologies are explained to conduct the analysis.

3.1 Data Collection

Daily data of crude oil and gold prices are collected from U.S. Energy Information Administration (EIA) for crude oil price (COP) and London Bullion Market Association (LBMA) for gold price (GP). All the data are converted into natural logarithmic form to reduce the variation of series.

The Urals crude oil price is chosen as the representative of the Russia oil price. Urals oil is a reference and benchmark for the pricing of the major Russia export oil. The daily Urals crude oil price (quoted in Rubles per barrels) is obtained from the U.S. Energy Information Administration (EIA). The daily crude oil price is divided into two periods which are pre-crisis period from January 2001 to October 2008 inclusive

of 2045 observations, and crisis and post-crisis periods from November 2008 to December 2014 inclusive of 1608 observations.

The daily gold price (quoted in Ruble per troy ounce) are obtained from the London Bullion Market Association (LBMA), which is the association that is responsible to ensure the gold and silver markets run efficiently in the membership country. The sample period of daily gold price is separate to two sub-periods which is similar with the daily crude oil price.

3.2 Unit Root Test

According to Granger and Newbold (1974), the results have to be stationary to avoid spurious result from appearing in the regression model. When the result has a high R^2 and t-statistics, it is considered as a non-significance result. However, Augmented Dickey Fuller (ADF) Test would be chosen to deal with larger and complicated set of time series data.

3.3 Augmented Dickey-Fuller Test

Augmented Dickey-Fuller (ADF) test examine whether the time series for both variables are stationary or non-stationary in regression model. Dickey and Fuller (1979) suggested that augmented version of Dickey-Fuller test can eliminate autocorrelation problems. In addition, Augmented Dickey-Fuller (ADF) model is

classified into two models, which is intercept without trend and also with intercept and trend. Both models are stated as Equations (1) and (2).

Model with constant and without trend:

$$\Delta lnY_t = \mu + \delta Y_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta Y_{t-1} + \varepsilon_i \quad (1)$$

Model with constant and with trend:

$$\Delta lnY_{t-1} = \mu + \beta_t + \delta Y_{t-1} + \sum_{i=1}^{k} a_i \Delta Y_{t-1} + \varepsilon_i \quad (2)$$

Where, ΔlnY_t is first difference for daily prices in natural logarithmic form at specific times, ΔlnY_{t-1} is first difference for daily prices in natural logarithmic form at previous times, μ is the intercept form, βt, is regressed by the independent variables which include the trend variable, δY_{t-1} is lagged level, $\Sigma \alpha_i \Delta Y_{t-1}$ is the total of lagged changes in variables, *t* is time trend, ε_1 is error term.

The rejection on the null hypothesis of both crude oil and gold prices displayed stationary because t-statistic is greater than critical value at significance level. Otherwise, do not reject null hypothesis. This is because this augmented version includes extra lagged terms of the dependent variable in Equation (1) and (2). The Akaike Information Criterion (AIC) or Schwarz Information Criteria (SIC) are used to determine the optimal lag length.

Equations (3) and (4) showed that daily prices of crude oil and gold are choose to transform to daily change in logarithmic prices (Rt) in order to achieve the stationary of a series.

$$COR_t = l_n \frac{COP_t}{COP_{t-1}} \quad (3)$$

$$GR_t = l_n \frac{GP_t}{GP_{t-1}} \quad (4)$$

Where, ln is a natural logarithm, COR_t is crude oil return, GR_t is gold return, COP_t is crude oil price, GP_t is gold price,COR_{t-1} is previous crude oil return, GP_{t-1} is previous gold return.

3.4 Johansen-Juselius Cointegration Test

According to Johansen and Juselius (1990), cointegration test was conducted to explore the existence of cointegrations between crude oil and gold returns for pre, crisis and post-crisis periods. Johansen-Juselius (JJ) test developed a maximum likelihood estimation procedure based on the reduced rank regression method. There are two regression procedures to describe the JJ cointegration test. Next, to estimate the cointegration vector, the short-term dynamic of the system would be taken into consideration.

There are two types of test statistics that are involved in JJ test, which are trace (Equation (5)) and Maximum eigenvalue (Equation (6)). Both equations are written as below.

$$J_{trace\ (r)} = -T \sum_{i=r+1}^{n} ln(1 - \hat{\lambda}_i) \quad (5)$$

$$J_{\max(r)} = -T * In\left(1 - \widehat{\lambda_{r+1}}\right) \quad (6)$$

Where

r is number of cointegrating vector,

T is number of observation,

λ_{r+1} is largest estimated eigen value at *r-1*,

n is number of variables for $r = 0, 1, \ldots n - 1$, and

λ_i is largest canonical correlation,

r+1 is alternative of cointegration relation for r= 0, 1, 2n-1.

Johansen and Juselius (1990) stated that λ_{max} test is more often selected since Maximum eigenvalue test statistic can identify the number of cointegrating vector (*r*), thus *r* is more precise than trace test statistic. This is because there have only two answer involved in the Maximum eigenvalue either r=1 or r=2.

3.5 Vector Autoregressive Model (VAR)

This model is an extension of an autoregressive (AR) model by adding multiple variables. The VAR formed by using the stationary series and all series were treated as endogenous in model to capture the dynamic effect. The model expresses each variable depends on its own lag and other variables' lag. Besides, VAR is a simultaneous model where two series can be treated as endogenous variable to explain the dynamic effect. The order (p) of VAR is identified by using Schwarz Information Criteria (SIC). The simple estimated VAR model is written as Equations (7) and (8).

$$Crude\ Oil\ Return = \beta_1 - \beta_2 x_t + \gamma_1 y_{t-1} + \gamma_2 x_{t-1} + u_{yt} \quad (7)$$

$$Gold\ Return \quad = \beta_{10} - \beta_{11} y_t + \gamma_{10} y_{t-1} + \gamma_{11} x_{t-1} + u_{xt} \quad (8)$$

Where, $u_{yt}\ and\ u_{xt}$ is an uncorrelated white-noise error term.

These equations are not reduced-form equation since y_t has a contemporaneous impact on x_t (given by$-\beta_{11}$), and x_t has a contemporaneous impact on y_t (given by$-\beta_2$).

3.6 Granger Causality Test

Granger causality test is used to measure the causal direction between crude oil and gold returns. The function of this test is to determine whether one variable is useful in forecasting another. According to Granger (1969), Granger causality test can be conducted in Vector autoregressive (VAR) model to capture the short-run causal relationship between two variables. Granger causality test is used to detect the lags of the variable whether Granger-cause to other variable by using VAR model. The null hypothesis for all lags of the variable can be excluded from each equation in VAR model.

The Granger causality test for the case of two stationary variables, pass values of gold return (GR_t) and crude oil return (COR_t) involves as a first step estimation of the VAR model (Equation (9) and (10)).

$$\Delta GR_t = \beta_1 + \sum_{i=1}^{n} \beta_i \Delta COR_{t-i} + \sum_{j=1}^{m} \gamma_j \, \Delta GR_{t-j} + e_{1t} \quad (9)$$

$$\Delta COR_t = \beta_2 + \sum_{i=1}^{n} \theta_{i\Delta} COR_{t-i} + \sum_{j=1}^{m} \delta_j \, \Delta GR_{t-j} + e_{2t} \quad (10)$$

Where

ΔGRt is pass values of gold return,

ΔCOR_t is pass value of crude oil return,

$e_{1t}\ and\ e_{2t}$ is error term.

F statistics (Equation (11)) for the normal Wald test on coefficient restrictions given by:

$$F = \frac{(SSE_R - SSE_U)/(k_U - k_R)}{SSE_U/(n - k_U - 1)} \qquad (11)$$

Where

SSE_R = sum of squared residuals with regression of restricted,

SSE_U = sum of squared residuals with regression of unrestricted,

k_U = number of regression of unrestricted,

k_R = number of regression of restricted, and

n = number of observation.

Rejection of null hypothesis when Wald-F test statistics (Equation (11)) is higher than critical value from F distribution$(F_{\sigma,(K_U-K_R),(n-k_U-1)})$, therefore this indicates that Granger causality exist between gold and crude oil markets.

3.7 Impulse Response Function

Impulse response function is the response of any variable reaction to some external effect. Impulse means the output of the dynamic system presented with a brief input signal. Impulse response function is determinant of endogenous variable into the innovation identified with a specific variable and describes the dynamics of the VAR and VEC structure. Additional new information to any variable of the system will deliver a shock to the variable itself and other variable. By comparing with Granger-causality, impulse response function provides more complete information between the variables and more understanding towards the reaction of one variable due to the movement in other variable. In addition, impulse response function is generally used to out sample the study to capture future interactions between the selected variables.

$$y(m) = b_i x(m) + b_{ii} x(m-1) + \cdots + b_N x(m-n)$$

$$= \sum_{i=0}^{N} b_i \cdot x(m-i) \qquad (12)$$

Where

$x(m)$ is input signal,

$y(m)$ is output signal,

n is filter order,

b_i is value of impulse response at the ith instant for $0 \leq i \leq n$ of an *n*th-order filter.

3.8 Variance Decomposition

The variance decomposition (VDC) is used to examine proportion of explanation in a sequence due to own shocks versus other variable shocks. It can be described as effect of shock variance for both variables. VDC shows that the proportion of variability of Y can be explained by X and which proportion should be attributed to other factors. In addition, VDC can be used to predict the variables that contribute a certain percentages of the variance due to change in certain variables in the VAR system.

Assuming moving average (MA) representation stationary VAR (p) process with being the order of the VAR (Equation (13)) as follows:

$$X_t = CD_t \sum_{t=0}^{\infty} \emptyset_i \, w_{t-i} \qquad (13)$$

Where

X_t is (K x1) endogenous variables,

$\emptyset_i$is ith (KxK) MA coefficient matric,

w_t is (Kx1) vector of orthogonal white noise innovation all with a unit variance,

C is (KxM) coefficients matrix corresponding to the deterministic term represented by (Mx1) matrix D_t.

Process for the h-step forecast error (Equation (14)).

$$X_{t+h} - Xt(h) \sum_{t-0}^{h-1} \emptyset_i \, w_{t+h-i} \qquad (14)$$

Where

$Xt(h)$ is the optimal h-step at period t forX_{t+h},

$\emptyset_0 \varepsilon_{t+1}$ is One-step-ahead the forecast error,

w_t is the forecast errors term.

3.9 Conclusion

In a nutshell, this chapter provides brief introduction toward models, data and methods that employed in this research. There are five empirical test used to examine the causality between crude oil and gold markets in Russia. Augmented Dickey-Fuller unit root test, Johansen-Juselius cointegration test, Granger causality test , impulse responses function and variance decomposition are carries out under different purposes and assumptions to generate unbiased results. The empirical result would be discussed in the following chapter.

CHAPTER 4: Empirical Results

4.0 Overview

This chapter presents the empirical result of econometric methods as proposed in previous chapter. Five empirical tests are carries out in this chapter to answer the research questions. Subsequently, the results of each sub-period are compare with each other to identify the causality between crude oil and gold prices in difference periods.

4.1 Unit Root Test

Table 4.1 Result of Augmented Dickey-Fuller Unit Root Test.

	Panel A		Panel B	
Variables	Level	First Difference	Level	First Difference
Oil Price	-1.5640	-44.6592***	-2.0098	-40.4059***
	(1)	(1)	(1)	(1)
Gold Price	-0.9793	-45.9396***	-2.3708	-39.2927***
	(1)	(1)	(1)	(1)

Notes: Panel A denotes as the pre-crisis period. Panel B denotes as the crisis and post-crisis periods. *** denotes rejection of the null hypothesis at 1% significance level. Parentheses presented the optimal lag length. The form of daily price in both markets is natural logarithmic form.

Table 4.1 shows the result of Augmented Dickey-Fuller (ADF) test for crude oil and gold prices in Panels A and B. The result indicates that accepted null

hypothesis of both crude oil and gold prices have a unit root exist in level form. Moreover, both variables reject the null hypothesis at the 1 percent significance level in first difference. In conclusion, the ADF test result has indicated that crude oil and gold prices have a stationary in the first difference while non-stationary in the level form.

4.2 Johansen-Juselius Cointegration Test

Table 4.2 Johansen-Juselius Cointegration Test

	Panel A				Panel B			
	Test Statistic		Critical Value (5%)		Test statistic		Critical Value (5%)	
H_0	Trace	Max-E	Trace	Max-E	Trace	Max-E	Trace	Max-E
r = 0	14.71	13.49	15.49	14.26	13.66	8.76	15.49	14.26
r = 1	1.21	1.21	3.84	3.84	4.89*	4.89*	3.84	3.84

Notes: Panel A denotes as the pre-crisis period. Panel B denotes as the crisis and post-crisis periods. Max-E is Maximum eigenvalue. r =number of cointegrating vectors. * denotes rejection of the hypothesis at the 5% level. The lag length is chosen by using SC. Optimal lag length is 1 for the sample period.

Since both daily prices exhibit same concerted integrated order of one, Table 4.2 shows the results of Johansen-Juselius cointegration test for crude oil and gold prices in Panels A and B. For Panel A, the trace statistics of 14.71 shows that null hypothesis of no cointegrating vector is not rejected at the 5 percent significance level because its value less than critical value of 15.49. Meanwhile, the Maximum eigenvalue provides similar result which is rejects null hypothesis at the 5 percent significance level.

Furthermore, reject of null hypothesis when the trace statistics of 13.66 less than the critical value of 15.49 at the 5 percent significance level. Meanwhile, Maximum eigenvalue also provides similar result in Panel B. In a short conclusion, Trace and Maximum eigenvalue is not cointegrating vector. Therefore, the result indicates that Trace and Maximum eigenvalue test shows that there is no long run relationship exists between crude oil and gold prices in Panels A and B.

4.3 Granger Causality Test

Table 4.3 Granger Causality Test

	Panel A		**Panel B**	
Null hypothesis	F-statistic	Probability	F-statistic	Probability
GR does not Granger cause COR	1.4654	0.2262	1.2479	0.2641
COR does not Granger cause GR	3.7027	0.0545*	5.3584	0.0207**

Notes: Panel A denotes as the pre-crisis period. Panel B denotes as the crisis and post-crisis periods. *, ** and *** denotes rejection of the hypothesis at significance level 10%, 5% and 1% respectively. GR represents gold price and COR represents crude oil price.

Table 4.3 shows the result of Granger causality test for crude oil and gold returns in Panels A and B. For Panels A and B, the probability of 0.2262 and 0.2641 shows that the null hypothesis is not rejected at significance level. Therefore, this result indicates that gold return does not Granger causes crude oil return. On the other hand, the null hypothesis crude oil return is found to be Granger causes gold return because its probability of 0.0545 is lower than the 10 percent level in Panel A.

Next, the null hypothesis is rejected when the probability of 0.0207 is lower than the 5 percent level in Panel B. Hence, crude oil return Granger cause gold return in Panels A and B but Panel B results is more significance than Panel A. From the Tables 4.3 result shows that no bidirectional between two returns. There is only one direction, which is crude oil return Granger cause gold return in both Panels. The results indicated that the signal of crude oil return Granger cause gold return, it means the past values of crude oil price should contain information that helps to predict gold return above and beyond the information contained in past value of gold return alone.

4.4 Impulse Response Function

Panel A

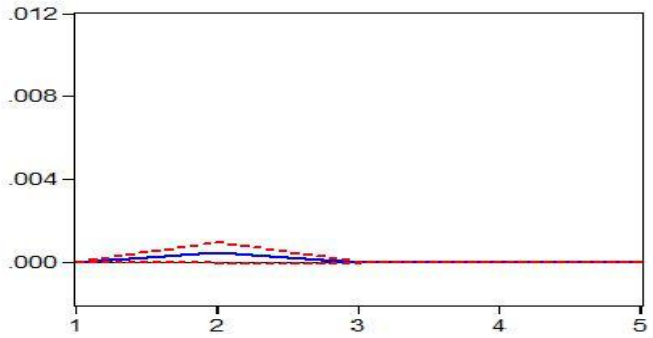

Figure 4.1 Response of gold return due to crude oil return shock.

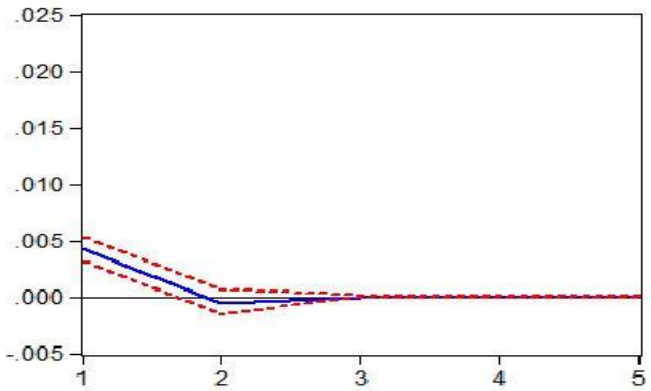

Figure 4.2 Response of crude oil return due to gold return shock.

Panel B

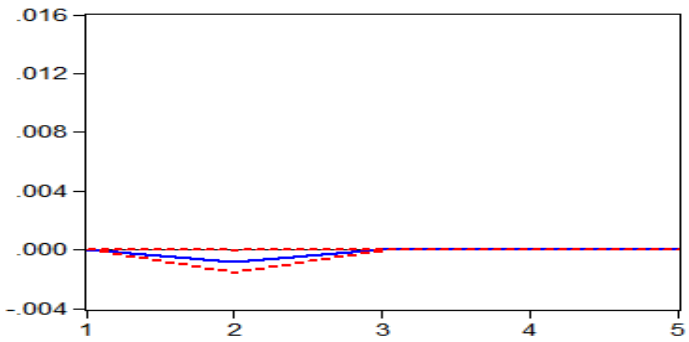

Figure 4.3 Response of gold return due to crude oil return shock.

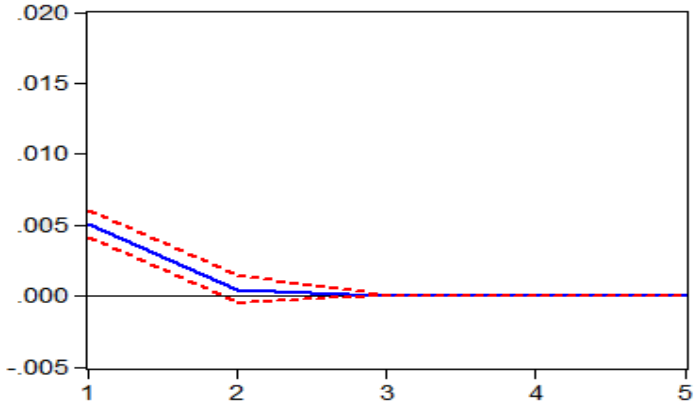

Figure 4.4 Response of crude oil return due to gold return shock.

Notes: Panel A denotes as the pre-crisis period. Panel B denotes as the crisis and post-crisis periods

Impulse responses are used to further explain the interaction between crude oil and gold markets. Besides, the impulse response function can demonstrate whether there is any strong causality relationship between crude oil and gold prices. Figures 4.1, 4.2, 4.3, and 4.4 explained the response between crude oil and gold due to the one unit of own or another variable shock.

Figures 4.1 and 4.3 indicate that there is weak response of gold return due to the unit shock of crude oil return, while figures 4.2 and 4.4 indicate that there is strong response of crude oil return due to the unit shock of gold return during Panels A and B. This figure shows that crude oil and gold response on each other only in first of three day, after that it turned to become no response.

4.5 Variance Decomposition

Table 4.4 Variance Decomposition of Crude Oil and Gold Returns in Russia

Market explained	Period (days)	By innovation in			
		S.E	Gold Return	S.E	Crude Oil Return
Panel A					
Gold Return	1	(0.00000)	100.0000	(0.00000)	**0.000000**
	2	(0.21493)	99.82056	(0.21493)	**0.179436**
	3	(0.21514)	99.82056	(0.21514)	**0.179439**
	4	(0.21514)	99.82056	(0.21514)	**0.179439**
	5	(0.21514)	99.82056	(0.21514)	**0.179439**
Crude Oil Return	1	(0.79076)	**3.327436**	(0.79067)	96.67256
	2	(0.79422)	**3.379551**	(0.79422)	96.62045
	3	(0.79426)	**3.379549**	(0.79426)	96.62045
	4	(0.79426)	**3.379549**	(0.79426)	96.62045
	5	(0.79426)	**3.379549**	(0.79426)	96.62045
Panel B					
Gold Return	1	(0.00000)	100.0000	(0.00000)	**0.000000**
	2	(0.28399)	99.66656	(0.28399)	**0.333444**
	3	(0.28430)	99.66650	(0.28430)	**0.333502**
	4	(0.28430)	99.66650	(0.28430)	**0.333503**
	5	(0.28430)	99.66650	(0.28430)	**0.333503**
Crude Oil Return	1	(1.18118)	**7.051240**	(1.18118)	92.94876
	2	(1.17271)	**7.103115**	(1.17271)	92.89689
	3	(1.17271)	**7.103102**	(1.17271)	92.89690
	4	(1.29611)	**7.103102**	(1.17271)	92.89690
	5	(1.17271)	**7.103102**	(1.17271)	92.89690

Notes: Panel A denotes as the pre-crisis period. Panel B denotes as the crisis and post-crisis periods. S.E denotes as standard error. All figures are denoted as the percentage for the forecast error variance (5 day periods) for crude oil and gold market is explained by innovations from two markets.

Variance decomposition shows the percentage information flow between the two markets in the Panels A and B. Tables 4.4 presents the variance decompositions of the 5 days periods for crude oil and gold return. Based on Table 4.4 indicates the proportion variance of the gold return can be explain by variance of crude oil return

around 0.18 percent in Panel A. The result of Panel A indicates that there is higher than 1 percent for proportion variance of the crude oil return explained by variance gold return. Meanwhile, percentage for proportion variance in gold return explained by variance crude oil return is lower than 1 percent.

In Panel B, the percentage for proportion variance of crude oil return explained by variance of gold return increased from 3.38 percent to 7.1 percent. Meanwhile, the percentage for proportion variance of gold return explained by variance of crude oil return increased slightly from 0.18 percent to 0.33 percent. Based on both Panels A and B, the results of variance decomposition are found that proportion variance of gold return has a strong information flow to explain the proportion variance in crude oil return. Variance decomposition results are consistent with the results of Granger causality as reported in Table 4.3. Investor believes gold is a valuable asset in all time, any fluctuation on crude oil price tend to affect investor's perspective on economic growth and reflected to the gold market. However any incident on the gold market will not affect the crude oil market.

4.6 Comparison between Panels A and B

Table 4.5 Comparison between Panels A and B

	Panel A		Panel B	
	Gold→Oil	**Oil → Gold**	**Gold→Oil**	**Oil → Gold**
Granger causality	No Granger cause	Granger cause	No Granger cause	Granger cause
Impulse Response	Strong responses	Positive responses	Strong responses	Negative response
Variance Decomposition	Variance proportion of gold return can be explained by crude oil return 0.18%	Variance proportion of crude oil return explained by gold return 3.38%	Variance proportion of gold return can be explained by crude oil return 0.34%	Variance proportion of crude oil return explained by gold return 7.1%

Notes: Panel A denotes as the pre-crisis. Panel B denotes as the crisis and post-crisis period.

Table 4.5 indicates that crude oil return Granger causes the gold return in Panels A and B. Based on this result we can conclude that crude oil price can be used to predict gold price in both Panels A and B. This is because the information flow of crude oil price movement influences the demand and supply of the gold, thus sends a pricing signal to the gold market.

Panel A shows that there is positive response of gold market due to the shock of crude oil return. This indicates that more gold is needed to hedge against inflation when higher crude oil price existed during the pre-crisis period. On the other hand, Panel B shows a negative response of gold market due to the shock of crude oil price. When there is declining crude oil price in the crisis and post crisis periods, market

participant holding gold is treated as a safety investment, as they believe that lower crude oil price will weaken their home currency.

The proportion variance of the crude oil return explained by gold return in Panel B (7.1%) is higher percentage than Panel A (3.38%). This is because crude oil and gold markets participant experienced the crude oil turmoil during the crisis period, thus they became sensitive towards the information spillover in this two markets, especially during crisis and post-crisis periods.

4.7 Conclusion

This chapter basically analyzes the causality between crude oil and gold returns. All the empirical results have been shown clearly in the figures and table form together with precise explanation. The results in this chapter have achieved the objectives of this research. The summary of whole research will be further discussed in the following chapter.

CHAPTER 5: CONCLUSION

5.0 Overview

This research emphasizes the causal effect between crude oil and gold prices in Russia. The findings of the entire research are summarizes in this chapter. Based on the major findings, some implications will be suggested for market participants. Lastly, several recommendations are provided for the future researchers to improve the scope of study of crude oil and gold markets.

5.1 Major Findings

Our result provides two major findings. First, our results indicated that gold is an effective hedging tool against crude oil price during the pre-crisis period, while gold can acted as an effective safe haven asset during the crisis and post-crisis periods. Second, the flow of information in crude oil market can be used to predict the gold price.

First finding shows that during the pre-crisis period, gold price has positive response to the crude oil price movement in the market. In this period, higher crude oil price cause inflation increased in the economy. Therefore, Russia considered gold as an effective hedging tool due to its stable value and able to perform well in a high inflationary period. On the contrary, gold price has negative response to the crude oil

price movement during the crisis and post crisis periods. Unfavorable movements of crude oil price encourage Russia, a major oil-exporting country to use gold as their safe haven asset to stabilize their purchasing power because gold is a safety commodity to store value. When the crude oil price falls during and after the crisis periods, Russia used gold reserve to maintain their revenue through back up their currency value.

Second finding indicates that gold price have a high response and large percentage of proportion innovation due to crude oil price movement in the pre-crisis period. This means that crude oil market can be used to predict the gold price. Most of the Russia investors believe gold is a form of stable 'money' in all time. When any spillovers information regarding the crude oil market appears, they will quickly respond in gold market to safeguard their investment. This is because investors believe that gold can protect the value of their investment goes down in the future. However, this effect became stronger in the crisis and post-crisis periods. This is because after 2008 financial crisis, crude oil price is highly fluctuate in the market, thus threaten the stability of the Russia economy. Instability of crude oil price causes an adverse impact to investors. Hence, Russia investors became more risk sensitive towards the information flow of commodity markets, especially crude oil and gold markets in the short- run because gold is able to reduce the portfolio variation cause by the crude oil market.

Last but not least, by employing different methodologies on different sample sizes in different countries, the results of our research questions are found to be consistent with the previous researchers. For instance, gold as a hedging tool (Beckmann & Czudaj, 2013) and gold as a safe haven asset (Reboredo, 2013) are found to be consistent with the first finding. While our second finding indicates that causality between crude oil and gold prices is found to be consistent with the result of Le and Chang (2012).

5.2 Implications

Different attributes of gold could have distinct implications for the market's participants. The first finding of this research is useful for oil-exporting countries to determine the gold quantity that required to holds in their international reserve portfolio in the pre-crisis, crisis and post-crisis periods. This research implies that gold is an effective hedging tool before the crisis period. However, it is act as a safe haven asset in the crisis and post-crisis periods. This indicate that during the pre-crisis period, oil-exporting countries is encouraged to store gold to hedge against inflation, whereas in the crisis and post-crisis periods, oil-exporting countries is encouraged to use gold to preserve the value of their portfolio. Therefore, the finding assists oil-exporting countries to maintain the crude oil value through holding adequate gold in their portfolio.

The second finding shows that gold market is highly responsive towards the information flow of crude oil price movement in the pre-crisis, crisis and post-crisis periods. This finding suggests investors to understand the possible consequences of their investments through anticipate the information transmission from crude oil to gold markets, especially in the crisis and post-crisis periods. Information from crude oil market affects the volatility of gold market. Information spillover between crude oil and gold markets reflect an opportunity for investors to hedge in the market, especially for those risk-adverse investors. At theoretical level, crude oil market's variance would cause a pricing signal to gold market in the short run. Investors should rely on this information to construct hedging strategies through analyzing the expected periods of buying, holding and selling gold. This mechanism would assist risk-adverse investors to reduce their portfolio risk and hedge against their portfolio to current market trend.

5.3 Recommendations

This research emphasizes the role of gold in the market in respond to the crude oil price movement. This research focuses on the crude oil and gold prices relationships through inflation and export revenue channels. However, two channels might be insufficient to fully explain the interaction between crude oil and gold markets. Other than these channels, there are other possible channels that influence the reaction of oil and gold prices react to each other. For instances, oil price fluctuation could influence the exchange rate stability and stock market movement, and consequently influence the gold market. Therefore, future researchers are encouraged to explore and identify additional related channel to further clarify the interaction between these two markets. This would strengthen the outcome of the future research.

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