

# Essays on oil price fluctuations, financial markets and international trade

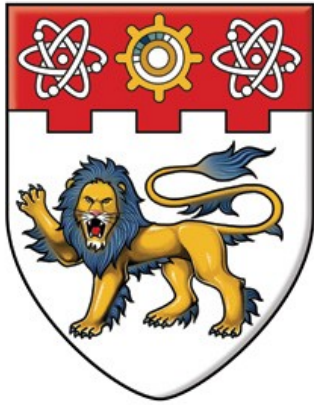
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Essays on Oil Price Fluctuations,  
Financial Markets and International Trade

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SCHOOL OF HUMANITIES AND SOCIAL SCIENCES

2013

Essays on Oil Price Fluctuations,  
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SCHOOL OF HUMANITIES AND SOCIAL SCIENCES

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2013

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*I dedicate this thesis to my grandparents, my parents, my foster-father (my father's brother), and my little sister for their endless support and unconditional love. I love you all and really, no words can describe the wonderful things you bring to my life since my birth and how much I love you. This thesis is also dedicated to my husband, Anh Tu Le, whom I can never thank enough for his endless love and support till the very end of my thesis submission.*

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# **EXECUTIVE SUMMARY**

This thesis consists of three self-contained essays on oil price fluctuations, financial markets and international trade.

The first essay investigates the impact of oil price fluctuations on gold market returns using monthly data from May 1994 to April 2011. A structural vector autoregressive approach is employed to examine the dynamics between oil price shocks and gold returns. Various oil price proxies are used in the empirical examination to capture potential nonlinearities in the dynamics between oil price shocks and gold returns. Oil price shocks appear to have a statistically significant and positive impact on real gold returns contemporaneously. The impact is found to be symmetric but nonlinear. These findings imply that observing oil price fluctuations can help predict movements in gold price, which would significantly help monetary authorities and policymakers in monitoring the price of major commodities, as well as investors and managers in optimizing portfolios.

The second essay applies the bounds testing approach to cointegration to the sampling period from Jan-1986 to Dec-2011 to investigate the relationships between the prices of two strategic commodities (oil and gold) and the macro-financial variables (interest rate, exchange rate and stock price). Japan – a major oil-consuming-and-importing as well as gold-holding-and-exporting country is selected as the case study. The findings of this study could help the Japanese monetary authority in conducting monetary policy, market participants and investors of Japanese yen in building their optimal portfolios as well as have the potential for significant impact in further research.

The third essay aims to examine whether a large part of the variability of trade balances and their oil and non-oil components is associated with oil price fluctuations. The long-run

causality running from oil price to overall, oil and non-oil trade balances and their short-run dynamics are investigated by applying the Toda-Yamamoto's 1995 (TY) causality approach and generalized impulse response functions (IRFs), respectively to the monthly data spanning from January 1999 to November 2011. Three Asian economies that represent three distinct characteristics in terms of oil are chosen and examined: Malaysia as an oil exporter, Singapore as an oil refinery and Japan as an oil importer. The stability of the causality is also checked and the estimated impulse responses across different periods are examined. The results have implications for both policy makers and economic modeling of the impact of oil price shocks.

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## **LIST OF ACRONYMS**

ADF: augmented Dickey–Fuller

AIC: Akaike Information Criteria

ARDL: autoregressive distributed lag

CPI: consumer price index

CUSUM: cumulative sum

CUSUM-sq: cumulative sum squared

DSGE: dynamic stochastic general equilibrium

EIA: Energy Information Administration

GARCH: generalized autoregressive conditional heteroskedasticity

GDP: gross domestic product

GH: Gregory-Hansen

IMF: International Monetary Fund

IRF: impulse response function

KPSS: Kwiatkowski–Phillips–Schmidt–Shin

LIBOR: London Interbank Offered Rate

MSCI: Morgan Stanley Capital International

OLS: ordinary least squares

OPEC: Organization of the Petroleum Exporting Countries

PP: Phillips–Perron

SBC: Schwarz Bayesian Criterion

SIC: Schwarz information criterion

TY: Toda-Yamamoto

UECM: unrestricted error correction model

VAR: vector autoregression

VECM: vector error correction model

VDC: variance decomposition

WTI: West Texas Intermediate

ZA: Zivot-Andrews

## INTRODUCTION

Trend of market interconnectivity in the world economy is noticeable in the commodity field, with oil and gold as the most important representatives. These two commodities are the world's most strategic commodities and have received much attention recently, owing partly to the surge in their prices and the increase in their economic applications. Crude oil is the world's most commonly traded commodity, and its price is the most volatile in the commodity market (Regnier, 2007). Meanwhile, gold is considered the leader in the precious-metals market as increases in its price appear to lead to parallel movements in the prices of other precious metals (Sari et al., 2010).

Investors in advanced and emerging markets often switch between oil and gold or combine them to diversify their portfolios (Soytas et al., 2009). Monetary authorities or central banks often watch gold prices to determine whether their monetary policy is on course (Lastrapes, and Selgin, 1996). If oil prices influence gold prices, observing oil price movements may therefore help policymakers to predict gold prices and employ an appropriate economic policy. Investigating the relationship between oil and gold price returns would provide clues to investors about where to put their investment dollars. Last but not least, such discussions of the topic are crucial for investors, traders, policymakers and producers when they play catch up with each other and experience feedback relationships with oil price shocks.

The aforementioned descriptions of oil and gold price movements justify the economic importance of investigating the relationship between the prices of these two commodities, particularly the impact of oil price shocks on gold price returns. Despite this, the literature on the oil–gold price relationship is sparse as most existing research has focused on the relations of these commodities to macroeconomic performances. Thereby, existing literature has not provided much insight into the directional relationships between oil and gold prices and how



they are related to each other. Further, it is the lack of statistical evidence showing long run and stable relationships between the two typical large commodity markets, given their similar price trends. Last but not least, very few studies examine whether the oil price-gold price relationship is lead or lag, linear or nonlinear, symmetric or asymmetric. The first essay of this study aims to fill in these gaps in the research.

The special features of oil and gold would also make one expect fluctuations in the prices of the two commodities to have implications for movements in financial variables. Relevant studies are yet relatively scarce (e.g., Hammoudeh et al., 2009; Baur, 2011; Bhar and Hammoudeh, 2011). In spite of this relative neglect in literature, it could be misleading to conclude a lack of interest in this question. From the perspective of monetary authorities, the seeming causation or correlation between strategic commodities and financial variables provides a rationale for analyzing the relationship between commodity prices and performance of critical financial indicators in economy. First, since commodities are the primary inputs to many manufactured goods and some are important to services, commodity prices are expected to have a direct influence on the general price level. Second, since the prices of most commodities including oil and gold are determined in markets with efficient information, they reflect demand or supply shock more rapidly than do the prices of manufactured goods and services. Third, since strategic commodities such as oil and gold are the most traded commodities, they are prone to speculations by financial market players such as hedge funds and day traders. As a result, speculative behaviors in commodity prices may have implications for the general price level (Bhar and Hammoudeh, 2011). In this respect, monetary authorities are advised to achieve stability in commodity prices as this may lead to the general price stability (Gagner, 1989). Even though monetary authorities cannot intervene in the commodity price formation process, signals from the commodity prices, such as those

in oil and gold markets, may contain useful information for monetary authorities in managing their price stability policies.

Results from studies in this area would also be of interest to commodity-consuming and trading nations, portfolio managers, traders and investors to develop an understanding of the interrelationships between commodity prices and economic and financial variables. The second essay in this study focuses on the prices of oil and gold, which are critical commodities to an overall economy and are widely traded on commodity exchanges. These commodities are also traded on the world markets, spanning different areas of activity within an economy and have different characteristics in terms of industrial use, investment appeal and hedging strategies. The results are expected to provide relevant information to policy makers who are responsible for the impact of commodities' price fluctuation on interest rate and exchange rates. The findings will also be informative to traders and investors interested in hedging. They will also be useful for market participants keen on switching between commodities and stocks, and for portfolio managers interested in whether to use commodities to diversify away stock market risk in their portfolios.

The third essay examines the relationship between oil as the representative international commodity and trade balances. Trade has been a key engine for economic growth while oil is the most traded commodity in the world. High and rising trade deficit, however, hinders economic growth. Given the importance of oil as an internationally traded commodity and the volatility of its price, oil price shocks could explain the emergence of large trade imbalances across the globe.

A number of economic studies have investigated the macroeconomic impacts of oil price shocks, especially in oil-importing countries with a focus on the responses of real economic growth and consumer price inflation (see, e.g. Barsky and Kilian, 2004 and Hamilton, 2005

for recent reviews). Fewer studies, however, were conducted on the trade channel of the transmission of oil price shocks to an economy. Notable studies are Backus and Crucini (2000), Kilian et al. (2009), and Bodenstein et al. (2011); out of which, Kilian et al. (2009) provides the most comprehensive analysis of the effects of oil price shocks on external balances.

It is a common premise in policy discussion that oil price shocks would have large and often negative effects on external accounts including trade balance. When oil prices surge, countries are forced to borrow from abroad to offset adverse terms-of-trade shocks. There are some doubts that international risk sharing is not enough, implying that the ensuing imbalances may not be large enough to effectively cushion the domestic impact of oil price shocks (Kilian et al., 2009). It is thus of crucial importance from both policy and theoretical points of view to examine the impact of oil price shocks on trade balances. This is explored in the third essay, which could render theoretical and policy implications.

## **1. ESSAY ONE: OIL PRICE SHOCKS AND GOLD RETURNS**

### **1.1. INTRODUCTION**

A cursory analysis of oil and gold prices in nominal and real terms is presented in Figures 1.1a and 1.1b, respectively. It shows that there is a clear co-movement between the prices of the two strategic commodities, both in nominal and real terms. This study aims to examine and estimate the effects of oil price shocks on real gold market returns to establish whether this co-movement arises from the effect that oil price shocks have on gold prices or whether they are merely correlated. Specifically, it attempts to address the following questions. Is there a stable long-run relationship between oil price and gold price? Do oil

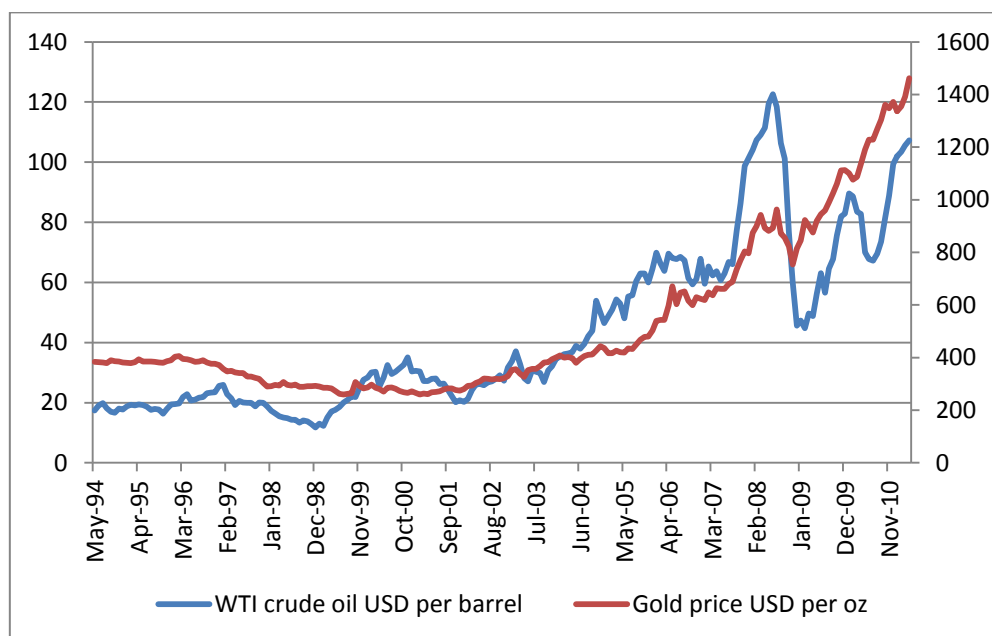
price shocks impact gold returns? Is the impact negative or positive, weak or strong, symmetric or asymmetric, linear or nonlinear?

The study described in this essay is one of very few to have examined the oil–gold price relationship. In particular, it explores the effects of oil price shocks on global real gold returns over the period May 1994 through April 2011. Several oil price proxies are employed in the empirical examination that have not been used before in research in this area, in order to explore the nonlinear and asymmetric effects of oil price changes on gold returns.

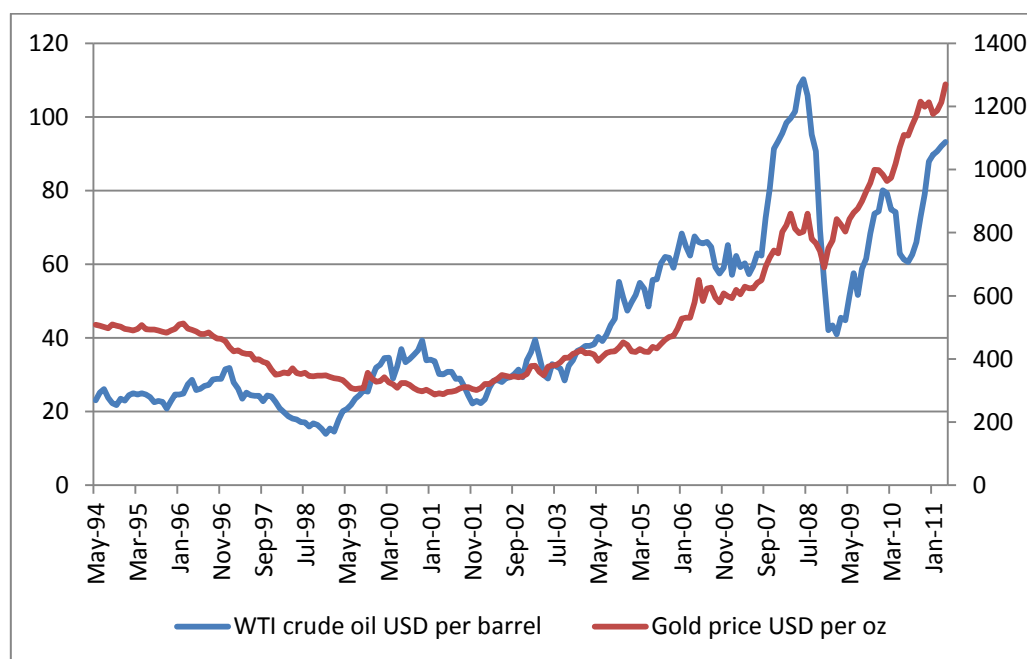
First, the Gregory–Hansen (1996) cointegration procedure is employed. It accounts for a structural break in the data. Given the volatility of the global markets, indicators and oil prices, it is important to test whether parameters of the system are stable. This issue is specifically considered in the study by Hansen (1992), which tested for parameter stability. The test results suggest that parameters are stable for the gold–oil price relationship in the system, controlling for common factors. The Gregory–Hansen test results show no cointegration between the variables in the system.

Second, a multivariate vector autoregressive (VAR) analysis is performed with linear and nonlinear transformations of oil price changes. Linear oil price shock is defined as the percentage changes in the real price of oil, while nonlinear measures of real oil price shocks are scaled real oil price shock as defined by Lee et al. (1995) and net oil price as defined by Hamilton (1996). Estimated impulse response function (IRF) analysis indicates that oil price shocks have a statistically significant and positive impact on real gold returns within one month of the shock. It also shows that the net oil price measure may not have a statistically significant impact on real gold returns as linear and scaled real oil price measures.

**Figure 1.1a: Oil and gold nominal prices**



**Figure 1.1b: Oil and gold real prices**



Note: The two figures are plotted using the monthly data on West Texas Intermediate crude-oil spot price (quoted in US dollars) acquired from the US Energy Information Administration at [http://www.eia.gov/dnav/pet/pet\\_pri\\_spt\\_s1\\_d.htm](http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm) and the monthly average of the London afternoon (p.m.) fix obtained from the World Gold Council at [http://www.gold.org/investment/statistics/gold\\_price\\_chart/](http://www.gold.org/investment/statistics/gold_price_chart/). The real prices of oil and gold are calculated by deflating the seasonally adjusted nominal prices using the monthly US consumer price level obtained from the IMF International Financial Statistics.

Third, linear and scaled real oil price transformed into positive and negative real oil price changes are used to determine asymmetric effects of real oil price change, as in Mork (1989). The test for asymmetry is carried out using a conventional Chi-square test of the null hypothesis that the coefficients of positive and negative oil price shocks in the VAR are equal to each other at each lag. The obtained results suggest that the data do not provide enough evidence to against the null hypothesis of symmetry for both linear and scaled real oil price measures.

Finally, a variance decomposition (VDC) analysis is carried out based on the structural VAR model. The median result indicates that oil price shocks account for a statistically significant 1.67% of the volatility in real gold returns. This suggests that the contribution of oil price shocks to variability in real gold returns is greater than that of global industrial production but smaller than those of the remaining variables in the baseline model. Specifically, this study finds that changes in the US dollar index make the most significant contribution to variations in real gold returns, with a median contribution of 17.42%, and the findings are not sensitive to the use of different oil price series in the VAR models.

The remainder of this study is organized as follows. Section 2 discusses the main channels through which oil price shocks may impact and/or relate to gold prices, with evidence from the literature. Section 3 describes the data and variables in the model. Section 4 presents the econometric methodology employed in the study. Section 5 reports and interprets the empirical results, and Section 6 concludes.

## **1.2. BACKGROUND AND LITERATURE REVIEW**

The plots of oil and gold prices in nominal and real terms in Figure 1a and b show that there was a very high positive correlation between the prices of oil and gold. This brings up the important question of causation: Were gold prices driven by oil prices, or were the two commodity prices driven up by other forces acting on each with similar effects? The next paragraphs discuss the two alternative arguments in order to explain for the observed co-movement of oil and gold prices.

The first argument proposes a unidirectional causal relationship running from the oil price to the gold price. Oil is often considered the leader in commodity markets, where a change in oil price affects the prices of other commodities, including that of gold. This implies that changes in the gold price may be monitored by observing movements in the oil price, through several factors.

First, high oil prices driven by supply concerns are often thought to be bad for the economy, adversely affecting growth and hence pushing down stock prices (Kilian, 2009). Compared to studies on how oil price shocks impact the real economy, only a few number of works have examined the effects of oil price shocks on the stock market; however, some studies have addressed the negative relationship between oil price shocks and stock market performance. For instance, Jones and Kaul (1996), who conduct the first study in this area, found that oil price increases in the post-war period had a significantly detrimental effect on aggregate stock returns. Sadorsky (1999) reports that oil price increases have significantly negative impacts on US stocks and that the magnitude of the effect may have increased since the mid-1980s. Ciner (2001) and Park and Ratti (2008) also conclude that a statistically significant relationship exists between oil price shocks and real stock returns and, further, state that the connection between these two variables is nonlinear. Since stock investments are no longer as

profitable as in the past, as a consequence of rising oil prices, investors tend to look to gold as an alternative asset. Such a scenario is observed during the 1970s when oil cartels reduced oil output and a surge in oil price resulted. The role of gold as a hedge for stocks, defined by Baur and Lucey (2010) as a security that is uncorrelated with stocks on average, and/or a safe haven in a market crash, is also addressed in the literature, though very scarcely. For instance, Baur and Lucey (2010) study constant and time-varying relations between stock and bond returns of countries such as the US, UK and Germany and gold returns to investigate whether gold is a hedge and/or a safe haven. They find that gold is a hedge against stocks on average and a safe haven in extreme stock market conditions. Gold is, however, neither a safe haven for bonds nor a bond hedge. Baur and McDermott (2010) examine the role of gold in the global financial system. Their study tests the hypothesis that gold represents a safe haven against stocks of major emerging and developing countries. A descriptive and econometric analysis for a sample spanning 1979 to 2009 in their study shows that gold is both a hedge and a safe haven for major European stock markets and the US but not for Australia, Canada, Japan and large emerging markets such as Brazil, Russia, India and China. Looking at specific crisis periods, the study also finds that gold is a strong safe haven for most developed markets during the peak of the recent financial crisis.

Second, the impact of oil prices on gold prices could be established through the export revenue channel (Melvin and Sultan, 1990). In order to disperse market risk and maintain commodity value, dominant oil-exporting countries use high revenues from oil sales to invest in gold. Since several countries including oil producers retain gold as an asset in their international reserve portfolios, rising oil prices (and hence oil revenues) may have implications for increases in gold prices. This holds true as long as gold accounts for a significant portion of the asset portfolio of oil exporters and if these exporters purchase gold in line with their rising oil revenues. Therefore, the expansion of oil revenues enhances gold



market investment, and this causes oil price and gold price levels to trend upward together. In such a scenario, an oil price increase leads to a rise in demand for (and hence the price of) gold.

Third, inflation seems to be the most common channel for explaining the relationship between oil and gold markets. According to this, a rise in crude-oil prices leads to an increase in the general price level (e.g., Hunt, 2006; Hooker, 2002). When the general price level goes up, the demand for gold, which is renowned as an effective tool to hedge against inflation, will increase. Hence, inflation, which is strengthened by high oil prices, causes an increase in demand for gold and thus leads to a rise in the gold price (Pindyck and Rotemberg, 1990). On the other hand, when the gold price fluctuates owing to changes in demand for jewelry, or if it is hoarded as a reserve currency and/or used as an investment asset, it is unlikely to have any relation to oil returns (Sari et al., 2010).

The second argument argues that the oil price and the gold price are only correlated. This argument reminds us of a common saying in sciences and statistics that “correlation does not imply causation”, which means that a similar pattern observed between movements of two variables does not necessarily imply that one causes the other. In this regard, the fact that prices of oil and gold move in sync is not because one influences the other, but because they are correlated to the movement of the long-term driving factors.

First, both oil and gold have been priced in US dollars since 1975 when the Organization of the Petroleum Exporting Countries officially agreed to sell its oil exclusively for US dollars. Therefore, dollar volatility may cause the international prices of crude oil and gold to move in the same direction. For instance, continuous depreciation of the dollar might force a volatile boost in crude-oil and gold prices. In theory, a negative relationship between the value of the dollar and dollar prices of commodities such as oil and gold may be explained by the law of

one price for tradable goods. According to this, a decline in the value of the dollar must be outweighed by an increase in the goods' dollar prices and/or a fall in their foreign-currency prices to ensure the same price when being measured in dollars. Moreover, as many commodities are priced in dollars in international markets, a fall in the value of the dollar may raise the purchasing power and commodity demand of foreign consumers while reducing the returns of foreign commodity suppliers and potentially their supplies. The price impact of shifts in demand and supply of commodities may be particularly large if the demand or supply of commodities is relatively price inelastic, which is generally believed to be the case for many commodities and especially crude oil (e.g., Hamilton, 2008). Sari et al. (2010) find that, during expected inflation time, when the US dollar weakens against other major currencies, particularly the euro, investors move from dollar-denominated soft assets to dollar-denominated physical assets. Zhang and Wei (2010) also present evidence of high correlations between the US dollar exchange rate and the prices of oil and gold, and of Granger causality running from the US dollar index to price changes of both commodities.

Second, interest rates could also be a factor influencing the relationship between oil and gold markets. Indeed, the surge in commodity prices has been shown in a number of studies in this area to coincide with relatively low real interest rates in general and a substantial decline in the value of the US dollar (e.g., International Monetary Fund, 2008; Krichene, 2008). Specifically, for the gold price–interest rate relationship, even though existing literature is relatively scarce, results from these studies appear to support the critical role of interest rates in influencing the price of gold (e.g., Koutsoyiannis, 1983; Fortune, 1987; Cai et al., 2001). The logic is simply that, during periods when nominal interest rates on short and safe financial assets are low, people tend to respond by purchasing commodities such as gold even though it has some storage cost. Regarding the connection between oil price and interest rates, one basic theory stipulates that increasing interest rates raises consumers' and

manufacturers' costs, which in turn reduce the amount of time and money people spend in their cars. Fewer people on the road mean a lower demand for oil, which can cause oil prices to drop. Thus, in this regard, there might be an "inverse correlation," where one thing rises and the other drops. Frankel (2006), Hotelling (1931) and Working (1949) point out that the real interest rate represents the opportunity cost of oil extraction and storage. A lower interest rate results in reduced production and increased storage, and a higher interest rate has the opposite impact. If these theories are correct, the inverse relationship between oil price and interest rate is enhanced. Frankel (2006), using linear bivariate regression models estimated by ordinary least squares (OLS), finds an inverse correlation between the real interest rate and real oil price, although such a relationship is not supported by the data from the 1980s onward. Akram (2009) shows that commodity prices generally, and oil prices in particular, increase with negative movements in US real interest rates. Further, these real interest rate innovations account for a substantial portion of the forecast error variance in commodity prices.

However, it may be argued that, when interest rates drop, consumers and companies are able to borrow and spend money more freely, which drives up the demand for oil and hence the price of oil. In fact, evidence on the empirical relationship between interest rates and commodity prices in general, and between interest rates and oil in particular, is mixed. Gracia (2006) shows evidence that the serial correlation of US dollar interest rates with crude-oil prices from January 1970 to December 1989 is over 90%, whereas the same metric from January 1992 to January 2006 is -57%. Frankel and Rose (2009) are unable to confirm a statistically significant inverse relationship between the real oil price and real interest rate. Alquist et al. (2011) find no statistically significant relationship between the real interest rate and real oil price either. Overall, the major shortcoming, which may explain the mixed findings in the literature, is that in investigating the relationship between interest rates and

commodity prices it is essential to control for the effects of macroeconomic activity, exchange rates and other possible determinants of commodity prices. Further, it may be argued that any such relationship is likely to be shock dependent. For example, shocks that increase future commodity prices, such as higher economic growth, may also lead to higher interest rates (Svensson, 2006). Thus, a positive relationship between interest rates and commodity prices may emerge owing to simultaneity bias if interest rates are not treated as endogenous variables.

Empirical evidence from several studies suggests that oil price shocks affect gold returns. For instance, Sari et al. (2010) explore directional relationships between spot prices of four precious metals (gold, silver, platinum and palladium), oil and USD/euro exchange rate and found a weak and asymmetric relationship between oil and gold price returns. Specifically, gold returns account little for oil returns while oil returns account for 1.7% of gold returns. On examining the long-term causal and lead-and-lag relationship between oil and gold markets, Zhang and Wei (2010) report a significant cointegrating relationship between the price returns of the two commodities. Results indicate that percentage changes of crude-oil price returns significantly and linearly Granger-cause the percentage change of gold price returns. Further, at a 10% level, there is no significant nonlinear Granger causality between the two markets, implying that their interactive mechanism is fairly direct.

However, Soytaş et al. (2009), in their study of the case of Turkey, show that global oil price has no predictive power over the prices of precious metals, including that of gold in Turkey. In reality, the situation can become even more complicated, as it can be observed that the oil–gold price relationship is not stable over time. For instance, during the 1970s, the price of oil may have had a much larger influence on that of gold than it has now.

Besides the abovementioned shortcomings and the small number of studies focusing on oil–gold price relationships, another major limitation of existing literature in this area is that nonlinearities and asymmetries of the impact of oil price shocks on gold returns appear to have been neglected. This study thus aims to fill these gaps.

### **1.3. VARIABLES AND DATA**

#### **1.3.1. Variables and data description**

A multivariate VAR approach is used to examine the impact of oil price shocks on real gold returns. It captures the complexities of the dynamic relationships between these two variables and others including the US dollar value index, world short-term interest rate, global equity index, world price level and world income. All these variables are believed to influence the connections between oil price shocks and real gold returns. The multivariate VAR analysis is conducted on a monthly sample from May 1994 to April 2011, inclusive of 204 observations for each series.

The choice of time period and data frequency is subject to the availability of all data required for the variables in the baseline model. The West Texas Intermediate (WTI) crude-oil price is chosen as the representative world oil price. The original WTI crude-oil spot price (quoted in US dollars) is acquired from the US Energy Information Administration. The gold price selected for evaluation is the monthly average of the London afternoon (p.m.) fix obtained from the World Gold Council. Nominal world oil and gold prices are seasonally adjusted before being deflated using the monthly US consumer price level obtained from the IMF International Financial Statistics.

The US dollar index is obtained from International Financial Statistics. This index is a measure of the value of the US dollar relative to a basket of foreign currencies including the euro, Japanese yen, pound sterling, Canadian dollar, Swedish krona and Swiss franc. A rise in the index means that the value of the US dollar is strengthened compared to other major currencies. The world commodity price index (2005 = 100), obtained from the IMF, is chosen as a proxy for the world price level. The inclusion of a commodity price index as a proxy for inflationary expectations in the VAR system, proposed by Gordon and Leeper (1994) and Christiano et al. (1996), has been extensively used in the VAR literature. This is because commodities are used as inputs of production in many industries; their price surge is expected to alter the cost structure of many industries and, hence, create high prices that can heat up an economy's inflation rates.

The annualized three-month US dollar London Interbank Offered Rate (LIBOR), average monthly rates, obtained from the British Bankers' Association, is selected as a proxy for the world interest rate. The use of LIBOR assumes that, because of increased financial market integration, there is growing convergence of global capital costs (Shafik and Jalali, 1991). Further, the LIBOR is used as a benchmark interest rate measure by international organizations and commercial banks when they give loans to developing countries. For instance, this measure is used in the World Economic Outlook survey (International Monetary Fund, 1993) as a proxy for real cost of borrowing for developing economies.

The Morgan Stanley Capital International All Country World Investable Market Index (MSCI ACWI IMI), which covers over 9,000 securities across large, mid and small cap size segments and across style and sector segments in 45 developed and emerging markets, is selected as a proxy for the global equity index. MSCI is used instead of S&P500 because

world commodity prices tend to interact with the global financial variables via the world economy and not just the US economy (Bhar and Hammoudeh, 2011).

The world industrial production index (2000 = 100), seasonally and working-day adjusted, obtained from Datastream from the CPB Netherlands Bureau for Economic Policy Analysis is selected as a proxy for world income. This is because the data on global gross domestic product (GDP) are not available at monthly frequencies and the choice of industrial production index as a proxy for GDP or income is common in the literature.

Most of the data are seasonally adjusted, except world industrial production, which is already adjusted. The natural logarithms of all seasonally adjusted data are then taken to stabilize the data variability.

For simplicity, the following notation is employed throughout unless otherwise stated:

*goldp*: gold price

*op*: oil price

*usdi*: US dollar index

*libor*: annualized three-month US dollar LIBOR interest rate

*wpi*: world commodity price index

*gei*: global equity index

*wip*: world industrial production

$\Delta$ : first difference

*ln*: natural log transformation

### 1.3.2. Nonlinear transformation of oil price variables

A number of studies have shown that oil price fluctuations have asymmetric effects on macroeconomic variables and gold price (e.g., Wang and Lee, 2011; Sari et al., 2010; Hooker, 2002). There is also empirical evidence on the nonlinear feedbacks between the price of oil and commodity prices (e.g., Nazlioglu, 2011). This study thus employs seven proxies for oil price shocks to model the nonlinearities and asymmetries between the impact of oil price increases and decreases on gold returns, as follows.

Proxy 1 is the monthly growth rate of oil prices, defined as:

$$\Delta op_t = \ln op_t - \ln op_{t-1} \quad [\text{Eq. 1.1}]$$

Proxy 2 considers only increases in oil prices ( $\Delta op_t^+$ ) and is defined as:

$$\Delta op_t^+ = \max(0, \Delta op_t) \quad [\text{Eq. 1.2}]$$

Proxy 3 considers only decreases in oil prices ( $\Delta op_t^-$ ) and is defined as:

$$\Delta op_t^- = \min(0, \Delta op_t) \quad [\text{Eq. 1.3}]$$

Proxy 4 is the net oil price measure ( $netop_t$ ), constructed as the percentage increase in the previous year's monthly high price if that is positive, and zero otherwise:

$$netop_t = \max[0, \ln op_t - \max(\ln op_{t-1}, \ln op_{t-2}, \ln op_{t-3}, \dots, \ln op_{t-12})] \quad [\text{Eq. 1.4}]$$

This proxy is proposed by Hamilton (1996), who argues that, as most increases in oil price since 1986 have been immediately followed by even larger decreases, they are corrections to the prior declines rather than increases resulting from a stable environment. He suggests that to measure correctly the effect of oil price increases it is more appropriate to compare the



current price of oil with its position over the previous year rather than during the previous month alone. Hamilton refers to this net oil price measure as the maximum value of the oil price observed during the preceding year.

Proxy 5 is the scaled oil price ( $\Delta op_t/\sigma_t$ ) suggested by Lee et al. (1995). This transformation of oil price changes has gained popularity in the macroeconomics literature. Taking into account volatility, the impact of oil price shocks is crucial both to investors and policymakers, particularly in the context of the large oil price swings of recent decades. Pindyck (2004) asserts that, if oil price volatility persists, both producers and consumers may be exposed to substantial risk via uncontrolled increases in inventory, transportation and production costs. Arouri et al. (2012) point out that oil price volatility provides information on the risk and behavior of financial asset returns in response to oil shocks. Some studies suggest that crude-oil price volatility has been substantially higher since the mid-1980s than that of other energy products (e.g., Plourde and Watkins, 1998; Regnier, 2007). Further, it is shown that the out-of-sample forecasts of a simple generalized autoregressive conditional heteroskedasticity (GARCH) model are superior to models with higher complexity, including bivariate GARCH (see, e.g., Sadorsky, 2006). All these factors justified the construction of the volatility-adjusted oil price (scaled oil price) with a GARCH(1,1) model in this study.

Specifically, a GARCH(1,1) model with the following conditional mean equation is estimated:

$$\Delta op_t = \phi_0 + \sum_{i=1}^{12} \phi_1 \Delta op_{t-i} + a_t \quad [\text{Eq. 1.5}]$$

in which  $a_t = \sigma_t \varepsilon_t$ , where  $\varepsilon_t \sim \text{NID}(0,1)$ , and the conditional variance equation:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \gamma_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad [\text{Eq. 1.6}]$$

The GARCH(1,1) model generates volatility forecasts as a weighted average of the constant long-run or average variance ( $\alpha_0$ ), the previous forecasting variance ( $\sigma_{t-1}^2$ ) and previous volatility reflecting squared “news” about the return ( $a_{t-1}^2$ ). In particular, as the return series is unexpectedly large in either the upward or the downward direction, the GARCH specification captures the well-known volatility clustering effect (Kang et al., 2009). Note here that, since monthly data are used, the inclusion of 12 lags in the conditional mean equation is needed in order to be consistent with the measure.

The volatility-adjusted oil price (or scaled oil price) is:

$$sop_t = \Delta op_t / \sigma_t \quad [\text{Eq. 1.7}]$$

Proxy 6 is the scaled oil price increases ( $sop_t^+$ ), computed as:

$$sop_t^+ = \max(0, sop_t) \quad [\text{Eq. 1.8}]$$

Proxy 7 is the scaled oil price decreases ( $sop_t^-$ ), computed as:

$$sop_t^- = \min(0, sop_t) \quad [\text{Eq. 1.9}]$$

Table 1.1 reports the correlations among the seven oil price proxies. It shows clearly that monthly percentage changes of oil price, i.e.,  $\Delta op_t$ , is highly correlated with the other five oil price proxies (above 0.8), with the sole exception of  $netop_t$ , where the correlation is just above 0.5. Both  $\Delta op_t^+$  and  $\Delta op_t^-$  are highly correlated with  $\Delta op_t$  (0.83 and 0.86, respectively), and both  $sop_t^+$  and  $sop_t^-$  are highly correlated with  $sop_t$  (0.84 and 0.85, respectively). There appears to be an equal dispersion between percentage increases and decreases of oil prices. Figure 1.2 plots various oil price proxies. From the graph, it can be

seen that  $\Delta op_t^-$  is the difference between  $\Delta op_t$  and  $\Delta op_t^+$ . Moreover,  $sop_t^-$  is the difference between  $sop_t$  and  $sop_t^+$ .

**Table 1.1: Correlation of monthly oil prices  $\Delta op_t$  with alternative oil price proxies**

	$\Delta op_t$	$\Delta op_t^+$	$\Delta op_t^-$	$netop_t$	$sop_t$	$sop_t^+$	$sop_t^-$
$\Delta op_t$	1.000						
$\Delta op_t^+$	0.829***	1.000					
$\Delta op_t^-$	0.856***	0.420***	1.000				
$netop_t$	0.540***	0.654***	0.272***	1.000			
$sop_t$	0.981***	0.828***	0.826***	0.550***	1.000		
$sop_t^+$	0.818***	0.981***	0.419***	0.659***	0.839***	1.000	
$sop_t^-$	0.842***	0.432***	0.967***	0.279***	0.853***	0.431***	1.000

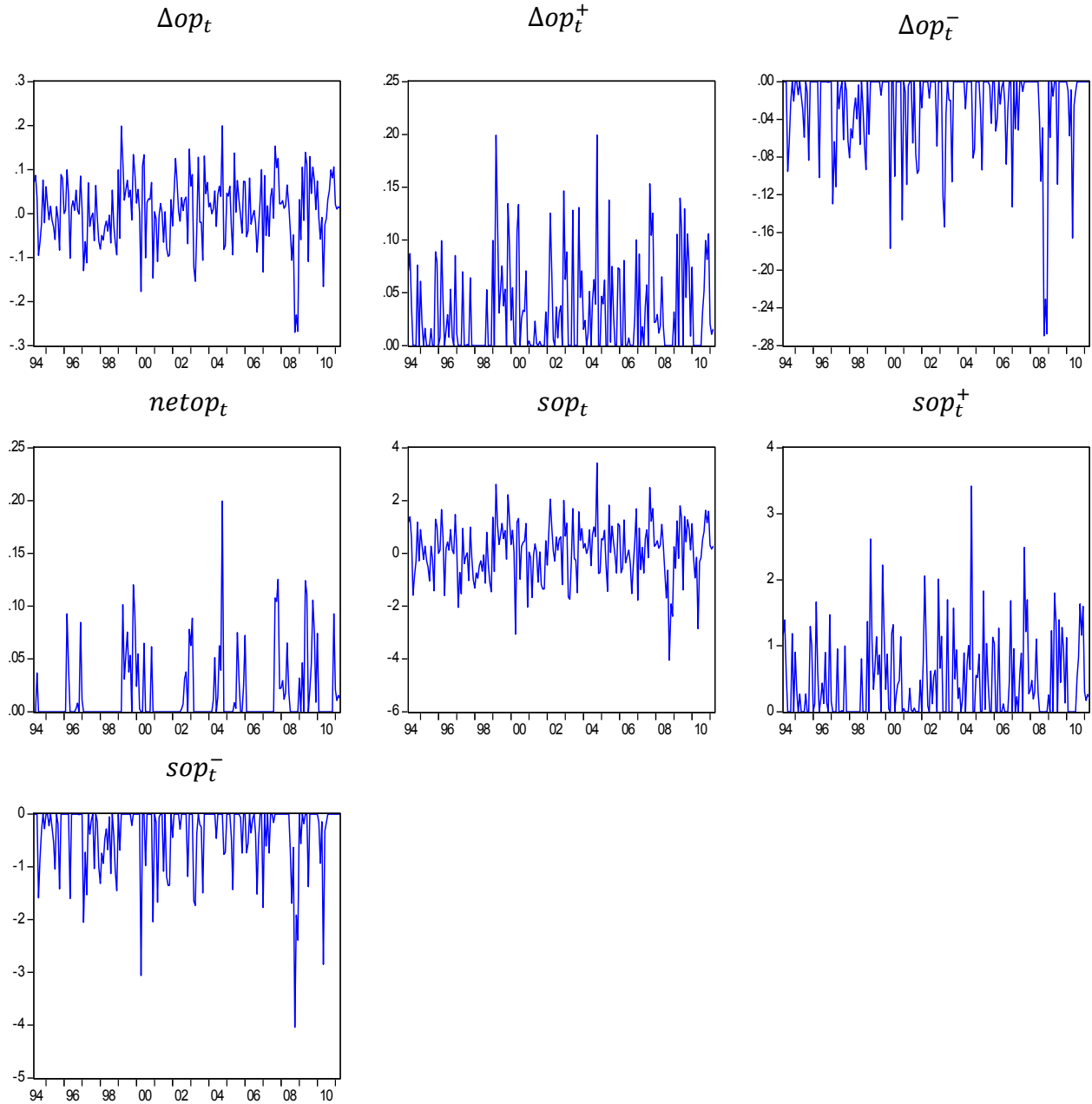
Note: Note: \*, \*\* and \*\*\* denote significance at 10%, 5% and 1%, respectively.

### 1.3.3. Time-series properties

To examine the order of integration of the variables, the time-series properties of the variables in the models are first checked by performing several unit root tests, namely augmented Dickey–Fuller (ADF) (Dickey and Fuller, 1981), Phillips–Perron (Phillips and Perron, 1988) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) (Kwiatkowski et al., 1992)–with constant and trend on levels and first differences of all the logged series, including oil price, gold price, US dollar index, world interest rate, world price level, global equity index, world industrial production index and the seven oil price proxies. The null of KPSS, namely stationarity, differs from the null of ADF, which is non-stationarity, and so it provides a cross-check at 1%, 5% and 10% levels of significance.

**Figure 1.2: Different oil price measures**

Note: The figures present the graphs of the seven oil price proxies, respectively:  $\Delta op_t$ ,  $\Delta op_t^+$ ,  $\Delta op_t^-$ ,  $netop_t$ ,  $sop_t$ ,  $sop_t^+$  and  $sop_t^-$ .



A break in the deterministic trend affects the outcome of unit root tests, and several studies have found that the conventional unit root tests fail to reject the unit root hypothesis for series that are actually trend stationary with a structural break. Work by Zivot and Andrews (1992) provides methods that treat the occurrence of the break date as unknown. Hence, the present study also employed the Zivot–Andrews test (allowing for a single break in both intercept and trend) to account for an endogenous structural break in the data series.

To test for a unit root against the alternative of trend stationary process with a structural break, the following regression is used:

$$y_t = \mu + \theta DU_t(\tau_b) + \beta t + \gamma DT_t(\tau_b) + \alpha y_{t-1} + \sum_{i=1}^k \varphi_i \Delta y_{t-i} + \varepsilon_t \quad [\text{Eq. 1.10}]$$

where  $DU_t(\tau_b) = 1$  if  $t > \tau_b$ , and 0 otherwise, and  $DT_t(\tau_b) = t - \tau_b$  for  $t > \tau_b$ , and 0 otherwise. Here,  $\Delta$  is the first-difference operator, and  $\varepsilon_t$  is a white-noise disturbance term with variance  $\sigma^2$ ;  $DU_t$  is a sustained dummy variable that captures a shift in the intercept, and  $DT_t$  represents a shift in the trend occurring at time  $\tau_b$ .

The model accommodates the possibility of a change in the intercept as well as a broken trend. The breakpoint is estimated by the OLS for  $t = 2, 3 \dots T-1$ , and the breakpoint  $\tau_b$  is selected by the minimum t-stat ( $t_{\hat{\alpha}}$ ) on the coefficient of the autoregressive variable. Here,  $t_{\hat{\alpha}}$  is the one-sided t-stat for testing  $\alpha = 1$  in the model. The lag length  $k$  is determined using the general to specific approach adopted by Perron (1989). The null of a unit root is rejected if  $t_{\hat{\alpha}} < k_{inf,\alpha}$ , where  $k_{inf,\alpha}$  denotes the size  $\alpha$  left-tail critical value.

**Table 1.2a: Results of Unit root tests without a structural break (in log level)**

	ADF	PP	KPSS
Intercept and trend			
Oil price	-2.826 (1)	-2.898	0.164**
Gold price	-0.813 (0)	-0.799	0.442***
US dollar index	-1.605 (1)	-1.479	0.330***
LIBOR	-1.461 (4)	-1.212	0.124*
World industrial production	-4.067*** (3)	-2.765	0.076
World commodity price index	-1.995 (1)	-2.014	0.301***
MSCI global equity index	-2.570 (3)	-2.395	0.093

Note: \*, \*\* and \*\*\* denote significance at 10%, 5% and 1%, respectively. Numbers in all the parentheses are lag orders to include in equations. With trend, critical values for ADF, PP, and KPSS tests are respectively: at 1% = -3.99, -3.99, and 0.22; at 5% = -3.42, -3.43, and 0.15; at 10% = -3.14, -3.14, and 0.12.

Tables 1.2a and 1.2b present the outcomes of three unit root tests as described above without a structural break. The results show that, at 5% significance level, the data do not provide enough evidence to against the null hypothesis of nonstationarity at the log levels of variables but do not provide enough evidence to accept this null hypothesis at the first log differences of variables. Considering the fact that the three unit root tests do not account for a structural break, as stated above, the Zivot–Andrews test is employed, with constant and trend, and without trend, and the results are reported in Table 1.3a and 1.3b. Both suggest that, at conventional levels, all the logged series are non-stationary while their first differences and the oil price proxies are stationary. It is accepted that in log levels all the variables are  $I(1)$  processes, and that in first log differences, all of the variables and seven oil price proxies are  $I(0)$  processes.

**Table 1.2b: Results of Unit root tests without a structural break**

	ADF	PP	KPSS
Intercept and trend			
$\Delta op_t$	-11.805*** (0)	-12.002***	0.029
$\Delta op_t^+$	-12.811*** (0)	-12.872***	0.035
$\Delta op_t^-$	-10.701*** (0)	-10.846***	0.032
$netop_t$	-10.269*** (0)	-10.358***	0.033
$sop_t$	-12.350*** (0)	-12.514***	0.033
$sop_t^+$	-13.413*** (0)	-13.426***	0.033
$sop_t^-$	-12.187*** (0)	-12.321***	0.033
Gold price	-14.694*** (0)	-14.695***	0.046
US dollar index	-11.234*** (0)	-11.234***	0.068
LIBOR	-4.996*** (3)	-9.203***	0.101
World industrial production	-4.988*** (1)	-8.823***	0.035
World commodity price index	-10.308*** (0)	-10.673***	0.034
MSCI global equity index	-11.288*** (0)	-11.481***	0.053

Note: The three tests are performed on seven proxies for oil price shocks and first differences of other logged variables. \*, \*\* and \*\*\* denote significance at 10%, 5% and 1%, respectively. Numbers in all the parentheses are lag orders to include in equations. With trend, critical values for ADF, PP, and KPSS tests are respectively: at 1% = -3.99, -3.99, and 0.22; at 5% = -3.42, -3.43, and 0.15; at 10% = -3.14, -3.14, and 0.12.

**Table 1.3a: Results of Zivot-Andrews unit root test (in log level)**

	[k]	t-statistics	Break point
Intercept and trend			
Oil price	2	-4.529	2008M10
Gold price	0	-3.842	2005M08
US dollar index	1	-3.661	2002M03
LIBOR	4	-2.973	2004M05
World industrial production	4	-4.131	2008M08
World commodity price index	3	-4.153	2008M10
MSCI global equity index	3	-3.456	2003M04

Note: \*, \*\* and \*\*\* denote significance at 10%, 5% and 1%, respectively. The critical values for Zivot and Andrews test (with intercept and trend) are: -5.57, -5.08 and -4.82 at 1%, 5% and 10% significance levels, respectively.



**Table 1.3b: Results of Zivot-Andrews unit root test**

	[k]	t-statistics	Break point
Intercept and trend			
$\Delta op_t$	1	-7.299***	2001M12
$\Delta op_t^+$	0	-11.901***	2002M02
$\Delta op_t^-$	1	-7.484***	2008M08
$netop_t$	0	-9.357***	2007M09
$sop_t$	1	-7.474***	2001M12
$sop_t^+$	0	-12.365***	2002M02
$sop_t^-$	1	-7.675***	2008M08
Gold price	1	-10.140***	2008M04
US dollar index	0	-9.893***	2008M08
LIBOR	3	-6.015***	2008M11
World industrial production	3	-4.957*	2008M03
World commodity price index	1	-7.509***	2008M08
MSCI global equity index	2	-5.541**	2007M11

Note: The three tests are performed on seven proxies for oil price shocks and first differences of other logged variables. \*, \*\* and \*\*\* denote significance at 10%, 5% and 1%, respectively. The critical values for Zivot and Andrews test (with intercept and trend) are: -5.57, -5.08 and -4.82 at 1%, 5% and 10% significance levels, respectively.

## **1.4. ECONOMETRIC METHOD**

### **1.4.1. The Gregory–Hansen cointegration analysis**

Since all the variables in log level each contain a unit root, this study employs the cointegration testing procedure by Gregory and Hansen (1996) for the existence of common stochastic trend. Various methods have been proposed to analyze empirically the long-run relationships and dynamic interactions between time-series variables. The two-step procedure of Engle and Granger (1987) and the full information maximum likelihood-based approach of Johansen (1988) and Johansen and Juselius (1990) are the most widely used techniques. However, the cointegration frameworks in these studies have limitations. These can arise because major economic events may affect the data-generating process. In the presence of structural breaks, tests for the null hypothesis of cointegration are severely oversized because there is a tendency of rejecting the null hypothesis despite one with stable cointegrating parameters. The presence of structural breaks leads to inefficient estimation and hence lower testing power (Gregory et al., 1996). The sensitivity of the outcome of the tests to structural breaks has been documented in several studies (e.g., Wu, 1998; Lau and Baharumshah, 2003). Thus, this study employed the Gregory–Hansen tests for cointegration to account for the possible presence of an endogenous structural break.

The Gregory–Hansen tests for threshold cointegration explicitly incorporate a break in the cointegrating relationship. The Gregory–Hansen statistics can be seen as a multivariate extension of the endogenous break univariate approach and enabled us to test for cointegration by taking into account a breaking cointegrated relationship under the alternative. The cointegration procedure consists of two steps.

First, the instability of the long-run relationship between the variables in the model is tested. To this end, Hansen's (1992) linearity (instability) test is performed to determine whether the

cointegrating relationship has been subject to a structural change. Specifically, the  $L_C$  test proposed in Hansen (1992) is employed to verify whether the long-run relationship between the variables in the model is subject to a break. The  $L_C$  statistic is recommended when the likelihood of parameter variation is relatively constant throughout the sample.

Table 1.4 lists the test statistics  $L_C$ . The results suggest that, when gold price and labor are used as dependent variables, there is insufficient evidence to accept the null of stability in these two long-run equations, since the two test statistics are significant at the 5% level. Meanwhile, the remaining equations are stable. The findings, however, change slightly if the test results are considered at 1% significance level. Specifically, most of the long-run relationships are stable at the 1% level, including the gold price equation. The only exception is the labor equation. Since there is not enough evidence to against the null hypothesis of no sudden shift in regime for most of the equations, it may be concluded that at the 1% level strong evidence exists that parameters are stable for the oil–gold price relationship, controlling for common factors affecting both the commodities' prices.

Second, cointegration tests are conducted in which a break in the long-run equation is allowed, following the approach suggested by Gregory and Hansen (1996). The advantage of this test is the ability to treat the issue of a break (which can be determined endogenously) and cointegration together. The Gregory–Hansen test enables to assess whether the cointegration among the variables of interest holds over a first period of time and then, in a priori unknown period  $T_b$  (the timing of the change point), shifts to another long-run relationship.

**Table 1.4: Hansen (1992) Instability test results**

Dependent variable	$L_C$ test statistic	p-value
Oil price	0.940*	0.072
Gold price	1.347**	0.013
USD index	0.759	0.159
LIBOR	3.162***	< 0.01
World commodity price index	0.863	0.101
MSCI global equity index	0.906*	0.084
World industrial production	1.014*	0.052

Note: \*, \*\* and \*\*\* denote significance, i.e. rejection of the null hypothesis of stability at 10%, 5% and 1% levels, respectively.  $L_C$  tests are performed by Eviews 7. This study uses C and @TREND as deterministic regressors, and automatic lag selection with a Schwarz information criterion (SIC) with an automatic observation-based max lag.

Three models are employed corresponding to the three assumptions concerning the nature of the shift in the cointegrating vector: the level shift model (C), the level shift with trend model (C/T) and the regime shift model (C/S). To model the structural change, the step dummy variable is defined as  $D_t(T_b)$  as:  $D_t(T_b) = 1$  if  $t > T_b$ , where  $1(.)$  denotes the indicator function, and  $D_t(T_b) = 0$  otherwise. The three models, C, C/T and C/S, representing the general long-run relationship are respectively defined as follows:

$$y_t = \mu + \theta D_t(T_b) + \alpha' x_t + u_t \quad [\text{Eq. 1.11}]$$

$$y_t = \mu + \theta D_t(T_b) + \alpha' x_t + \beta t + u_t \quad [\text{Eq. 1.12}]$$

$$y_t = \mu + \theta D_t(T_b) + \alpha' x_t + \delta' x_t D_t(T_b) + u_t \quad [\text{Eq. 1.13}]$$

where  $y_t$  is a scalar variable,  $x_t$  is an  $m$ -dimensional vector of explanatory variables (both  $x_t$  and  $y_t$  are supposed to be  $I(1)$ ),  $u_t$  is the disturbance term, parameters  $\mu$  and  $\theta$  measure, respectively, the intercept before the break in  $T_b$  and the shift occurring after the break, while  $\alpha$  denotes the parameters of the cointegrating vector,  $\beta$  is the trend slope before the shift and  $\delta$  is the change in the cointegrating vector after the shift.

The standard methods to test the null hypothesis of no cointegration are residual-based. OLS is employed to estimate equations (1.11), (1.12) and (1.13), and then a unit root test is applied to the regression errors (Gregory and Hansen, 1996). The time break is treated as unknown and estimated with a data-dependent method, i.e., it is computed for each break point in the interval  $[0.15T, 0.85T]$  where  $T$  denotes the sample size (Zivot and Andrews, 1992). The date of the structural break corresponds to the minimum of the unit root test statistics computed on a trimmed sample.

I thus investigate the presence of a cointegrating relationship under a structural shift between the variables in the model and computed modified versions of the cointegration ADF tests of Engle and Granger (1987), as well as modified  $Z_t$  and  $Z_\alpha$  tests of Phillips and Ouliaris (1990), i.e.,

$$ADF^* = \inf_{T_b} ADF(T_b) \quad [\text{Eq. 1.14}]$$

$$Z_t^* = \inf_{T_b} Z_t(T_b) \quad [\text{Eq. 1.15}]$$

$$Z_\alpha^* = \inf_{T_b} Z_\alpha(T_b) \quad [\text{Eq. 1.16}]$$

All three statistics obtained from the C, C/T and C/S models for comparison are listed, where the lag  $k$  is set as in Perron (1997), following a general to specific procedure.

The results of the Gregory–Hansen threshold cointegration tests are presented in Table 1.5. They indicate that there is not enough evidence to against the null of no cointegration for all equations in the model. The findings are invariant to the model specifications, i.e., C, C/T or C/S. The Gregory–Hansen cointegration test thus suggests that there is no cointegration between oil and gold prices, controlling for a number of factors, in the examined period. Given this outcome and the findings by Engle and Yoo (1987), Clements and Hendry (1995) and Hoffman and Rasche (1996) that unrestricted VAR is superior in terms of forecast variance to a restricted vector error correction model (VECM) at short horizons when the restriction is true, and by Naka and Tufte (1997) that the performance of unrestricted VARs and VECMs for impulse response analysis over a short run is nearly identical, unrestricted VARs are run as described in the following.

**Table 1.5: Gregory and Hansen (1996) Cointegration Test Results**

Dependent variable:		Oil price	Gold price	USD index	LIBOR	World commodity price index	MSCI global equity index	World industrial production
Level	ADF*	-5.721 (1)	-6.002 (4)	-5.340 (1)	-5.774 (4)	-5.331 (1)	-5.298 (6)	-6.015 (5)
shift		[1999M06]	[2005M10]	[2002M08]	[2005M10]	[1999M05]	[2001M09]	[2005M10]
C	$Z_{\alpha}^*$	-57.551	-54.754	-42.335	-51.116	-53.799	-42.172	-55.344
		[1999M06]	[2005M08]	[2002M09]	[2005M08]	[1999M05]	[2002M07]	[2002M09]
	$Z_t^*$	-5.483	-5.519	-4.863	-5.154	-5.155	-4.741	-5.463
		[1999M06]	[2005M08]	[2002M09]	[2005M08]	[1999M04]	[2002M07]	[2002M07]
Level	ADF*	-5.715 (1)	-6.011 (4)	-5.311 (1)	-5.703 (4)	-5.653 (1)	-5.778 (1)	-5.4567 (1)
shift		[1999M06]	[2005M10]	[2002M08]	[2005M10]	[2002M06]	[2002M03]	[2008M08]
with	$Z_{\alpha}^*$	-57.516	-54.663	-41.504	-42.728	-59.519	-56.992	-54.371
trend		[1999M06]	[2006M01]	[2002M09]	[2005M09]	[2002M06]	[2002M05]	[2002M05]
C/T	$Z_t^*$	-5.482	-5.523	-4.816	-4.734	-5.462	-5.575	-5.433
		[1999M06]	[2006M01]	[2002M09]	[2005M09]	[2002M06]	[2002M05]	[2002M05]
Regime	ADF*	-6.391 (1)	-7.771 (4)	-5.502 (0)	-6.582 (0)	-6.709 (0)	-5.555 (1)	-7.140 (1)
shift		[2008M03]	[2005M10]	[2005M06]	[2008M02]	[2008M04]	[2006M09]	[2002M06]
C/S	$Z_{\alpha}^*$	-67.531	-89.288	-52.923	-72.081	-76.008	-56.376	-84.488
		[2008M02]	[2005M11]	[2005M07]	[2008M02]	[2008M03]	[2002M05]	[2002M05]
	$Z_t^*$	-6.339	-7.621	-5.518	-6.599	-6.725	-5.565	-7.092
		[2008M02]	[2005M11]	[2005M07]	[2008M02]	[2008M04]	[2002M05]	[2002M05]

Note: This study conducted Gregory-Hansen cointegration test for common stochastic trend in all the seven variables. It used automatic lag selection based on AIC with max number of lags set to 6. Numbers in (.) are lag orders to include in equations. Time breaks are in [.]. Critical values for level shift, level shift with linear trend, regime shift models are based on Gregory and Hansen (1996, Table 1). None of the test statistics are statistically significant at the levels of 1%, 5% and 10%.

### 1.4.2. Structural VAR model

The empirical framework used here for investigating the complexities of the dynamic connections between oil price shocks and gold returns is a multivariate VAR approach. Since work by Darby (1992) and Hamilton (1983), VAR models have been used extensively to analyze the impact of oil price shocks on economic activity. The main advantage of this model is the ability to capture dynamic relationships between the economic variables of interest. The variables are modeled into an unrestricted VAR system. Depending on whether they are stationary in level or integrated of order one, the variables are entered in level or as first differences into the VAR system, respectively. As the results from unit root tests show that the logged variables are stationary in their first differences, they are entered as first differences into the VAR system. A VAR of order  $p$ , where  $p$  represents the number of lags, which includes  $k$  variables, has the following form:

$$Z_t = \alpha + \sum_{i=1}^p A_i \cdot Z_{t-i} + v_t \quad [\text{Eq. 1.17}]$$

where  $Z_t$  is the  $(k \times 1)$  vector of endogenous variables discussed above,  $\alpha$  is the  $(k \times 1)$  intercept vector,  $A_i$  is the  $i^{\text{th}}$   $(k \times k)$  matrix of autoregressive coefficients for  $i = 1, 2, \dots, p$ , and  $v_t$  is a  $(k \times 1)$  vector of reduced-form white-noise errors.

The VAR model has seven stationary variables, which are first log differences of: real oil price, real gold price, US dollar value index, world short-term interest rate, world commodity price level, global equity index and world industrial production. The oil price variable in VAR systems is either first log difference of world real oil prices or nonlinear transformations of real oil price changes, as described in Section 3.2. Lag length is determined based on Akaike information criterion for the various VAR specifications corresponding to different oil price proxies. To check the suitability of the models, each is



tested for the presence of autocorrelation, joint significance of the VAR coefficients at various lags, as well as the eigenvalue stability condition, that is, whether the VAR model satisfies the stability condition. As a result, all the eigenvalues lie inside the unit circle and the VAR satisfies the stability condition, the VAR coefficients are jointly significant and no autocorrelation at the lag order is observed.<sup>1</sup>

Based on the unrestricted VAR models, generalized IRFs and VDCs are estimated. An IRF measures the time profile of the effect of shocks at a given point in time on the (expected) future values of variables in a dynamical system (Pesaran and Shin, 1998). Meanwhile, the forecast-error of generalized VDC analysis reveals information about the proportion of the movements in one variable due to its “own” shocks versus shocks to the other explanatory variables. The IRF and VDC analysis is used in the study because while the Granger causality tests are extensively used in the literature for examining causality structure, they suffer from a number of limitations. First, Granger causality actually implies a correlation between the current value of one variable and the past values of others, and thus it does not necessarily mean that changes in one variable cause changes in another. Further, Granger causality may not provide the complete picture of interactions between the variables of a system as it does not show how the series respond when there is a shock in one of the variables in the system. A number of studies in the literature have used the sum of the coefficients to indicate the sign of the causality. This may produce misleading results as all dynamic effects between the equations must be taken into account. If the response function is positive for all periods, fading away to zero, then a positive sign of the causality can be assumed. But if it is positive, then negative, and then dampens down, there may not be a clear sign of causality; rather it could be said that the sign depends on the time horizon.

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<sup>1</sup>As space is limited, detailed results will be provided upon request.

It is often of interest to know the response of one variable to an impulse in another variable in a system that involves a number of other variables as well. It is also useful to investigate the impulse response relationship between two variables in a higher-dimensional system. If there is a reaction of one variable to an impulse in another variable, the latter is called causal for the former. This type of causality is examined by tracing out the impact of an exogenous shock or innovation in one of the variables on some or all of the other variables. Generalized impulse response analysis developed by Koop et al. (1996) and Pesaran and Shin (1998) is thus employed in this study. Their generalized forecast error VDC analysis, which is an analysis tool to determine the relative importance of oil price shocks in explaining the volatility of the gold price, is also used.

I use the generalized approach to forecast error VDC and impulse response analysis in favor of the more traditional orthogonalized approach. This is because, while the results of the latter are sensitive to the order of the variables in the system, the former do not have this shortcoming. Since the generalized approach is invariant to the ordering of variables in the VAR and produces one unique result, it is not subject to the orthogonality critique of Lutkenpohl (1991). The generalized approach is common in the recent literature, and therefore the specifics are not discussed here, to conserve space.

## **1.5. RESULTS AND INTERPRETATIONS**

### **1.5.1. Impact of oil price shocks on gold markets**

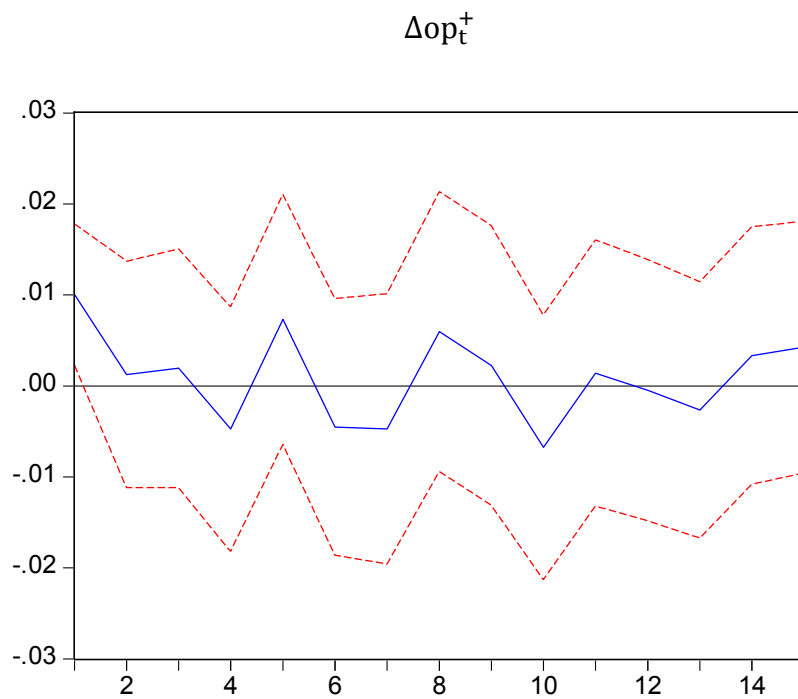
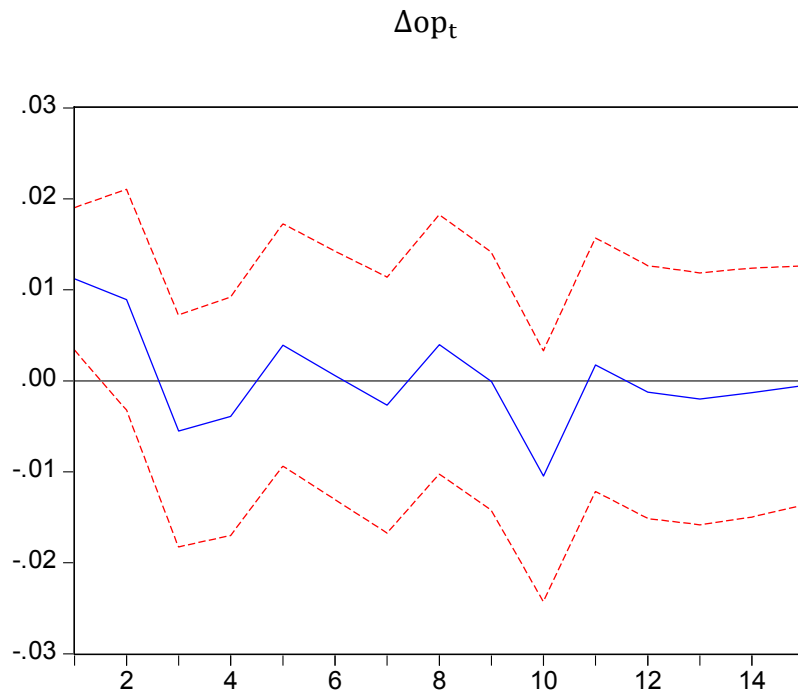
This section assesses the impact of real oil price shocks on real gold returns. To this end, this study examines the generalized IRFs of real gold returns from a one standard deviation shock to oil price measured by the linear and nonlinear transformations of oil price shocks based on the VAR model. The forecast is made considering a 15-month period. Further, the oil price is characterized by large price rises and high volatility. Besides using  $\Delta op_t$  and the nonlinear

transformations of real oil price, i.e.,  $netop_t$ ,  $sop_t$ , this study also employs  $\Delta op_t^+$  and  $sop_t^+$  in the belief that oil price increases may have a significant effect on the gold market, even though this might not occur for oil price decreases.

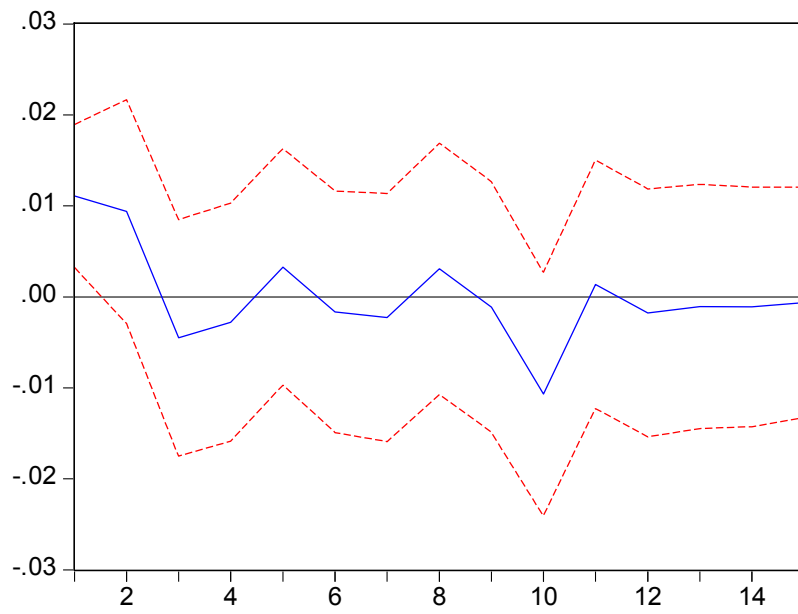
The estimated generalized IRFs of gold returns to shocks in different oil price proxies are illustrated in Figure 1.3. The results show that a one standard deviation increase in real oil price measured by all five proxies positively impacts real gold returns contemporaneously. The statistical significance of these contemporaneous impacts varies with the use of different oil price proxies. Specifically, the instantaneous impacts of scaled world real oil price shock and scaled oil price increase on real gold returns, as well as those of linear real oil price change and oil price increase, are significant, whereas that of the net oil price measure is insignificant. The statistically insignificant results obtained with the net oil price shock measure compared to linear or scaled world real oil price shocks may be due to the pattern of oil price increases and decreases in the period of study.

The results suggest that nonlinear relationships may exist between the price changes of oil and gold. Specifically, when using real oil price changes, positive oil price changes, volatility-adjusted (scaled) oil price and scaled oil price increase, evidence of the contemporaneous impact of oil price shocks on real gold returns is significant. Meanwhile, the evidence in the case of net oil price increase is insignificant. The nonlinearity of the impact of oil price shocks on gold returns contradicts the finding by Zhang and Wei (2010) that the crude-oil price change linearly impacts the volatility of gold price and the two market prices do not feature a significant nonlinear causality. The signs of instantaneous impact of oil price shocks on gold returns are all identically positive, and the same as expected in hypothesis.

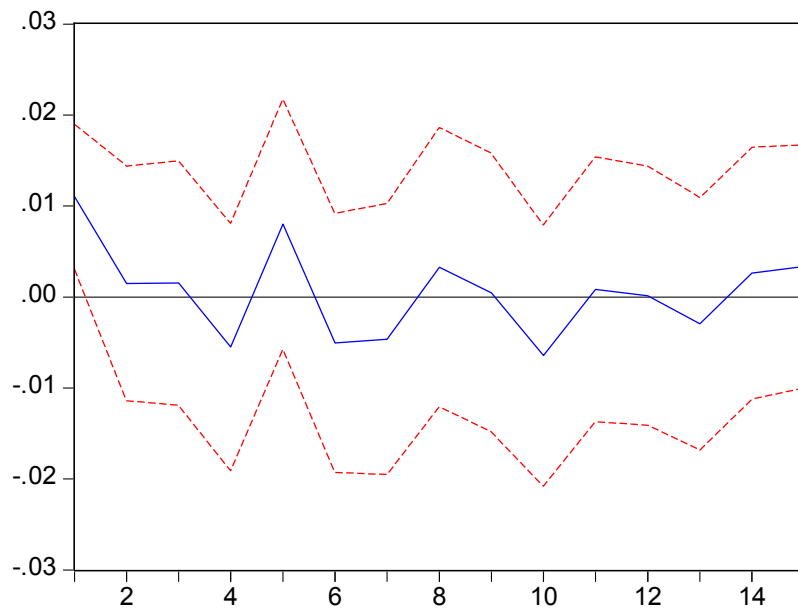
**Figure 1.3: Generalized impulse response function of gold returns to one SE shock in various transformations of oil price shocks in the seven-variable VAR model**

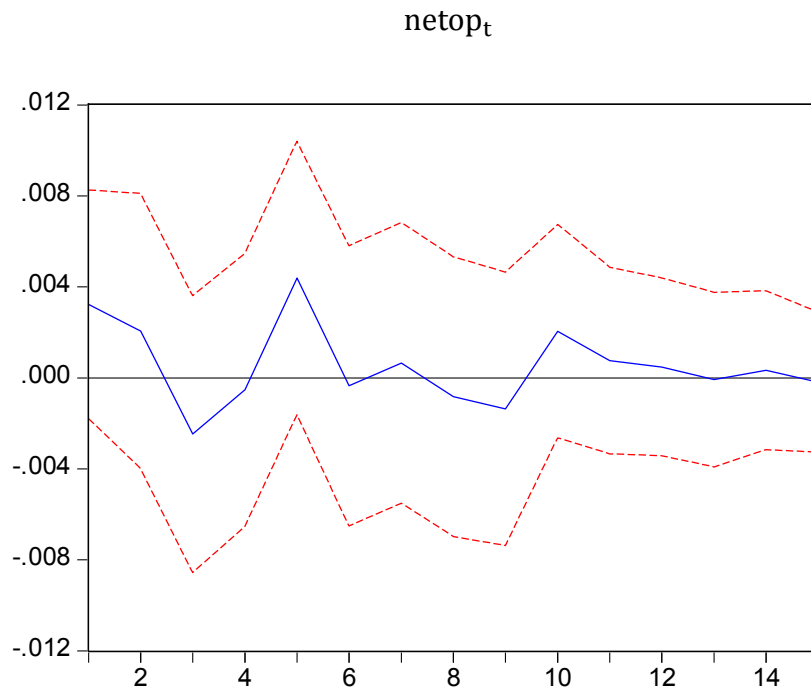


$\text{sop}_t$



$\text{sop}_t^+$





### 1.5.2. Asymmetric effects of oil price shocks

Following Lee et al. (1995) and Hamilton (1996, 2000) who find that oil price increases have a greater influence on a country's macroeconomic variables, this study investigates whether oil prices have the same asymmetric effect on gold returns. The results from the IRF analysis show that only the monthly oil price return and the volatility-adjusted (scaled) oil price change have significant impacts on the monthly gold return. To examine asymmetric effects of oil price shocks on gold returns, these two proxies of oil price shocks ( $\Delta op_t$  and  $sop_t$ ) are split into positive and negative oil price changes and entered as separate variables in estimation equations for the gold price changes as follows:

$$\Delta \ln goldp_t$$

$$\begin{aligned}
&= \varphi_0 + \sum_{i=1}^k \varphi_{1i} \cdot \Delta \ln goldp_{t-i} + \sum_{i=1}^k \varphi_{2i} \cdot \Delta op_{t-i}^+ + \sum_{i=1}^k \varphi_{3i} \cdot \Delta op_{t-i}^- + \sum_{i=1}^k \varphi_{4i} \cdot \Delta \ln usdi_{t-i} \\
&+ \sum_{i=1}^k \varphi_{5i} \cdot \Delta \ln libor_{t-i} + \sum_{i=1}^k \varphi_{6i} \cdot \Delta \ln wpi_{t-i} + \sum_{i=1}^k \varphi_{7i} \cdot \Delta \ln gei_{t-i} + \sum_{i=1}^k \varphi_{8i} \cdot \Delta \ln wip_{t-i} \\
&+ \varepsilon_t \quad [\text{Eq. 1.18}]
\end{aligned}$$

$$\Delta \ln goldp_t$$

$$\begin{aligned}
&= \varphi_0 + \sum_{i=1}^k \varphi_{1i} \cdot \Delta \ln goldp_{t-i} + \sum_{i=1}^k \varphi_{2i} \cdot sop_{t-i}^+ + \sum_{i=1}^k \varphi_{3i} \cdot sop_{t-i}^- + \sum_{i=1}^k \varphi_{4i} \cdot \Delta \ln usdi_{t-i} \\
&+ \sum_{i=1}^k \varphi_{5i} \cdot \Delta \ln libor_{t-i} + \sum_{i=1}^k \varphi_{6i} \cdot \Delta \ln wpi_{t-i} + \sum_{i=1}^k \varphi_{7i} \cdot \Delta \ln gei_{t-i} + \sum_{i=1}^k \varphi_{8i} \cdot \Delta \ln wip_{t-i} \\
&+ \varepsilon_t \quad [\text{Eq. 1.19}]
\end{aligned}$$

I construct a Wald coefficient test to examine whether the coefficients of positive and negative oil price shocks are significantly different. The null hypothesis is  $H_0: \sum_{i=1}^k \varphi_{2i} = \sum_{i=1}^k \varphi_{3i}$ . F-statistic for equation (1.18) is  $F(1,193) = 1.134$  (p-value = 0.288), and F-statistic for equation (1.19) is  $F(1,193) = 0.658$  (p-value = 0.418). The results indicate that both linear and scaled world real oil price changes have no asymmetric effects on the real world gold returns. This is contradictory to the findings by Sari et al. (2010) that the relationship between oil price return and gold return is very weak and asymmetric. This could be explained due to the inclusion of different variables in the model, different methodologies used as well as different periods covered in the study.

### **1.5.3. Variance decomposition**

The forecast error VDC enables us to determine the relative importance of oil price shocks in explaining the volatility of the gold price. Owing to its dynamic nature, VDC accounts for the share of variations in an endogenous variable resulting from other endogenous variables and the transmission to all other variables in the system (Brooks, 2008).

Table 1.6 lists the results of the forecast error VDC of real gold returns due to oil price shocks and other factors in the model. Each percentage shows how much of the unanticipated changes of real gold returns are explained by the variable over a 15-month horizon. The VDC analysis is performed based on the structural 7-variable VAR model with the linear oil price shock specification: monthly oil price growth rate.

The results indicate that, immediately after the shocks, most of the factors (except for the world industrial production) are able to explain variations in gold returns. Specifically, the monthly oil price change accounts for approximately 2.77% of the variation in the real gold price returns. Of all the variables, the role played by the US dollar index in explaining volatilities in the gold price appears to be the most significant when accounting for 22.67% of gold price variation. The contribution of oil price shocks to variability in real gold returns is smaller than those of the US dollar index and world commodity price but greater than those of the other variables. Indeed, world industrial production plays the least, insignificant, role in explaining the gold returns. Since world industrial production is a proxy for world income, this finding appears to be consistent with the finding by Levin et al. (2006) that there is no significant relationship between changes in the price of gold and changes in world income.



**Table 1.6: Generalized variance decomposition of variance in real gold returns due to world real oil price and other aggregate shocks**

Horizon	Percentage (%) of variation in real gold returns due to shocks in					
	Oil price	USD index	LIBOR	Global equity index	World commodity price	World industrial production
0	2.765	22.655	0.446	0.540	7.947	0.000
1	3.316	20.938	01.603	2.579	8.757	0.179
2	5.191	21.219	1.575	2.725	10.362	1.129
3	5.119	21.665	1.524	3.179	10.273	2.046
4	6.268	20.651	1.455	3.169	11.404	2.044
5	5.872	21.062	2.820	3.034	10.776	3.479
6	5.707	21.878	2.782	3.219	10.660	3.376
7	8.076	20.062	2.622	2.963	13.237	6.425
8	8.147	19.716	3.869	2.980	13.270	6.320
9	7.916	19.158	4.034	5.309	12.938	6.285
10	7.469	17.720	3.746	5.169	12.203	8.395
11	7.220	17.151	3.634	5.623	11.802	8.437
12	8.424	18.526	3.677	5.487	11.888	8.058
13	8.313	18.168	4.761	5.697	11.718	8.090
14	8.366	17.882	5.057	6.046	11.512	8.269
15	9.505	17.328	5.590	5.849	13.320	8.001

Note: Generalized forecast error variance decompositions are performed on the first differences of logged variables.

The relative contributions of the variables in the system in accounting for variations in real gold returns immediately after the shocks fluctuate dramatically for the periods following the shocks. This study may thus conclude that the impacts of aggregate shocks on the gold market are non-transitory. Specifically, ten months after the shock, the oil price change explains 7.47% of the variation in the real gold price returns whilst the US dollar index, the LIBOR, global equity index, world commodity price and world industrial production explain 17.72%, 3.75%, 5.17%, 12.20% and 8.40% respectively. The results still indicate that the contribution of oil price shocks to variability in real gold returns is smaller than those of the US dollar index and world commodity price but greater than those of the other variables and this is maintained over time throughout the 15-month horizon.

Finally, this study conducts robustness checks using several oil price series. Recent events have shown that WTI can be influenced by local conditions at Cushing, Oklahoma, USA, the delivery point for WTI, e.g., stocks of crude oil in Cushing and conditions in refineries that depend heavily on WTI (Dées et al., 2008). Robustness checks are carried out using the UK Brent crude oil and the simple average of three crude-oil price measures – Petroleum WTI, Petroleum UK Brent and Petroleum Dubai – in US dollars per barrel with similar transformations. The results are not significantly different, and so this study retains the WTI oil price in US dollars in the analysis.<sup>2</sup>

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<sup>2</sup>As space is limited, detailed results on robustness checks will be provided upon request.

## 1.6. CONCLUSION

This study investigates the impact of oil price shocks on gold price returns using a multivariate structural VAR approach. Key findings are as follows. First, it appears from Gregory and Hansen's (1996) cointegration analysis that there is no cointegration among the variables of interest. This suggests that no stable, long-run, linear relationship exists between them. Second, generalized IRFs show that oil price shocks significantly and positively affect gold returns contemporaneously within one month of the shock. It also appears that the effect of oil price shocks on gold returns is nonlinear. For instance, the significant causality found with the proxy measuring percentage increase in oil prices indicates that oil price increases appear to have a greater impact on gold returns when they follow a period of lower price increases. Third, the responses of gold returns to innovations in oil price shocks appear to be instantaneous and die out quickly within a few months. This suggests that the oil–gold price relationship does not lag long. Moreover, the short optimal lag lengths in the regression equations (i.e., 1 month) confirm that the relationships between gold and oil returns as well as other variables are insignificantly lead-and-lag. In reality, as information on the oil price and other variables is readily available, other relevant markets including the gold market appear to respond quickly to movements in all the variables. Fourth, when real oil price shocks are separated into positive and negative shocks, there is insufficient evidence to assume that they have asymmetric effects on gold returns. This finding contradicts those of several studies which have shown that oil price fluctuations have asymmetric effects on macroeconomic variables and the gold price (e.g., Wang and Lee, 2011; Sari et al., 2010; Hooker, 2002). Finally, the generalized forecast error VDCs indicate that, even though the variation in gold returns is better explained by oil price shocks compared to changes in global income, it is best explained by fluctuations of the US dollar index. These findings are robust to the use of different oil price series.

## **2. ESSAY 2: DYNAMICS BETWEEN STRATEGIC COMMODITIES AND FINANCIAL VARIABLES**

### **2.1. INTRODUCTION**

Oil and gold are the strategic commodities of the world and have irreplaceable roles in the global economy. They have received considerable attention post the financial crisis of 2008 as alternative investments. Oil is the most traded commodity in the world and its price fluctuations were observed not only associated with major developments in the world economy, but also a trigger for inflation and recession. The oil price hikes in 1974 and 1979, for instance, played a critical role in slowing down the global economy, at the same time, inflation was also rising. Until lately when people believe that they are living in a lower inflation environment, recent increases in oil prices have caused concern that the good situation could be altered.

Gold, which is long considered the leader in the market of precious metals, is not only an industrial commodity but also an investment asset. Gold is commonly known as a safe haven to avoid the increased risk in financial markets and one of risk management tools in hedging and diversifying commodity portfolios. Since the gold price is often thought to rapidly adjust to changes in inflation rate, gold has the value-preserving ability. In this regard, gold has the ability to resist changes in the internal and external purchasing power of domestic currency. During times of national crisis, bank failures, war, and invasions and in case of negative interest rates, gold is considered as a solid asset and a safe haven sought by international investors. For example, in current unpredicted global financial situation, US, India and China are top three countries consuming major part of globally produced gold.

The special features of oil and gold would make one expect fluctuations in the prices of the two commodities to have implications for movements in financial variables. Despite of this, most of the studies on commodities mainly focus on the co-movements of commodities among themselves and also with macroeconomic variables. That does not necessarily address the concerns of policy makers with the high-frequency co-movements of commodities with commodity-sensitive macro-financial variables. It would be interesting and informative to relate selected individual commodity price co-movements instead of changes in an aggregated commodity index (such as the CRB indexes) to changes in financial variables. Policy makers would be concerned about the impact on sensitive financial variables due to the changes in the prices of strategic and mostly traded commodities such as oil and gold. Traders, portfolio managers and hedge fund managers would be interested in the commodity-macro-financial relationships for specific commodities to design commodity-specific hedging strategies.

As such, this study examines the dynamic relationships between the prices of oil, gold, which are two strategic commodities in the world, and the macro-financial variables in Japan as a representative case study. The financial variables focused in this study are real stock price, exchange rate and short-term interest rate, all of which are of strong interest to many monetary authorities, investors, traders and exporters.

The rest of this paper is organized as follows. The next section reviews the literature on the subject matter. Section 3 provides an overview on the relationships between oil, gold and the Japanese economy. This is to justify why Japan is chosen as the case study. Section 4 discusses the data and methodology. Section 5 presents and interprets the empirical results and discusses the policy implications. Section 6 concludes.

## 2.2. LITERATURE REVIEW

A considerable number of researches have been conducted on oil price-macroeconomy relationships. Recent studies in the field are either time series data analysis for one country (Guo and Kliesen, 2005; Breitenfellner and Crespo, 2008; Hamilton, 2011) or cross-sectional or cross-national data analysis (Cunado and Perez de Gracia, 2003, 2005; Jimenez and Sanchez, 2005; Cologni and Manera, 2008). Further, the critical role of oil in an economy would make one expect changes in oil prices to be correlated with changes in stock prices (Huang et al., 1996). Indeed, investigating the relationship between oil and stock markets has been a recent trend in the energy sector. However, in sharp contrast to the large volume of studies on the relationships between oil price and macroeconomic variables, the number of analyses on oil price-stock price interactions has been relatively fewer.

The most recent and notable studies in this field include Basher and Sadorsky (2006), Park and Ratti (2008), Kilian and Park (2009) and Lee et al. (2012). Basher and Sadorsky (2006) show that oil price changes are likely to have a greater impact on profits and stock prices in emerging economies compared to developed ones. Kilian and Park (2009) opine that the response of aggregate real stock returns is positive or negative, greatly depending on whether the increase in oil prices is driven by demand or supply shocks in the crude oil market. The negative response of stock prices to oil price shocks, often referred to in the financial press, is only found when the oil price rises due to an oil-market specific demand shock such as an increase in precautionary demand driven by fears about the future availability of crude oil. Furthermore, rises in oil prices may have adverse effects on market economies that consume oil, but has no oil production facilities while having positive effects on market economies that produce oil. Park and Ratti (2008) show that oil price shocks have a statistically significant negative impact on real stock returns in the United States and 12 European oil importing countries. Kilian and Park (2009) examine the responses of real US stock returns to oil price

shocks and also find persistent positive effects on cumulative stock returns when higher oil prices are driven by a global economic expansion. It is noticeable that several studies include short-term interest rate in the models to estimate the impact of oil price shocks on real stock returns (e.g., Sadorsky, 1999; Cong et al., 2008; Park and Ratti, 2008, Lee et al., 2012).

Besides, the role of exchange rate in explaining for movements in stock market returns is also well-known in literature (Dornbusch and Fischer, 1980; Gavin, 1989; Mishra, 2004; Yang and Doong, 2004). It is argued that the major shortcoming of literature on the stock price-exchange rate relationship is that it is mostly based on a two-variable framework, which can be misleading due to the omission of oil price as an important variable (Abdelaziz et al., 2008). The oil price could be a channel through which exchange rate and stock market impact each other. Thus, when the oil price is omitted, inferences on the long-run relationship and the causality structure of variables may not accurately reflect the influence of exchange rate on stock price.

Compared to oil, literature on the relationships between gold prices and macroeconomic variables in general and between gold prices and macro-financial variables in particular has been much sparser. Levin et al. (2006) is a notable study on the short-run and long-run determinants of price of gold based on a theoretical framework of simple economics of supply and demand. This study shows that US price level and the price of gold move together in a statistically significant long-run relationship. It also finds that short run fluctuations in the gold price are caused by political instability, financial turmoil and changes in exchange rates and real interest rates. The study demonstrates that there is a positive relationship between gold prices and changes in US inflation, nevertheless a negative relationship is found between changes in the gold price and changes in the US dollar trade-weighted exchange rate and the gold lease rate. The economic literature on gold also hints at gold playing the part of a hedge or a safe haven during crises. Jaffe (1989) shows that gold is a hedge against both

stock losses and inflation and that including gold in financial portfolios can reduce their variance, while slightly improving returns. McCown et al. (2007) argue that gold can be a hedge against stock losses and expected inflation in the long-run, but only intermittently and mostly during the seventies when inflation was especially high.

In theory, since gold is priced in the dollar, gold price fluctuations are expected to be affected by fluctuations in the exchange rate of the dollar. When the dollar depreciates, the nominal price of gold tends to rise, thus preserving the real value of gold. As a result, gold can act as a hedge against currency exposure for investors holding dollar-denominated assets. Several studies have empirically investigated gold price-exchange rate relationships (e.g., Capie et al., 2005; Levin et al., 2006; Sjaastad and Scacciallani, 1996; Sjaastad, 2008). Sjaastad (2008) finds that in the 1990s and the early years of the current century, the dollar and the yen areas appear to have become dominant in the world gold market. Accordingly, real appreciations or depreciations of the euro and the yen against the dollar have profound effects on the price of gold in all other currencies. Using the weekly data spanning from 8 January 1971 to 20 February 2004, Capie et al. (2005) show that there is a negative relationship between the US dollar and gold prices and the strength of that relationship varies over the investigation period. The results imply that gold returns can be used as a hedge against US-dollar depreciation. The study asserts that gold could serve as a hedge because it is a homogeneous asset unlike, say, property, and therefore is easily traded in a continuously open market. It acquires the attributes of an asset, owing partly to the fact that gold cannot be produced by the authorities that produce currencies. This means that those who are able to increase the supply of money and therefore, from time to time, debase its value are unable to debase the value of gold by the similar means.

The relationship between gold price and interest rate is also examined by a few studies. The results from these studies seem to ascertain the critical role of interest rate in influencing the



price of gold (e.g., Koutsoyiannis, 1983; Fortune, 1987; Cai et al., 2001). The logic is simply that during periods when nominal interest rates on short and safe financial assets are low, people tend to respond by purchasing commodities such as gold even though it does have some storage cost. The level of interest rates also affects the real cost (if financed by credit) or the opportunity cost (if financed by own funds) of investing on the gold market. A drop in interest rates reduces the acquisition cost of gold on the spot market, and thus is capable of stimulating demand for gold. Kolluri (1981) points out that a correlation does exist between the gold price and inflation rate, which can be utilized for hedging and other activities. Nevertheless, the conclusions of Mahdavi and Zhou (1997), Blose and Shieh (1995), Chan and Faff (1998) indicate that gold is not an inflation protective asset.

As for the relationship between gold price and stock price, gold market is often considered as an alternative one to stock market. When the price of stock goes up, investors put more money into the stock market and thus sell their gold. This drives the gold price down. Moore (1990) conducts a study based on the data from 1970 to 1988 and shows that the gold price and the stock/bond markets have a negative correlation. This means when the stock/bond markets are declining, gold prices are rising. Büyükalvarcı (2010) confirms this finding by analyzing the effects of seven macroeconomic variables (i.e., consumer price index, money market interest rate, gold price, industrial production index, oil price, foreign exchange rate and money supply) on the Turkish stock exchange market and find that gold is an alternative investment tool for Turkish investors. When the gold price rises, Turkish investors tend to invest less in stocks, causing stock prices to fall. Hence, it might be concluded that there is a negative relationship between gold price and stock returns.

Sharma and Mahendru (2010) examine the impact of macroeconomic variables including changes in exchange rates, foreign exchange reserves, inflation rates and gold prices on stock prices in India. This study covers the period from January 2008 to January 2009 and the

results suggest that exchange rate and gold prices highly affect the stock prices. Mishra et al. (2010), however, opine that India stocks do not seem to be perceived as an alternative asset to gold even though the study finds a long-run equilibrium relation between gold prices and stock market returns in India. This study reckons that the reason for holding gold is, to a large extent, guided by the individual sentiments. The gold investing habits of Indians are strongly ingrained in the Indian Social Psyche. In India gold has been held by individuals for years and have passed hands of many generations. In addition, the equity culture in India is not as developed as in some other parts of the world.

In a different regard, gold is considered a store of value (without escalation) whereas stocks are regarded as the return on value (escalation from probable real price increase plus dividends) (Levin et al., 2006). Such a view gained attractiveness in the 19th century, thanks to the stable political climate with strong property rights and little turmoil in the US. But recent global recession has seemingly contradicted this view and investors are converging back on gold investments. Trend in stock investment has sharply declined and many stock markets in the world have crashed. Baur and Lucey (2010) and Baur and McDermott (2010) take stock of the idea of a discontinuous relation between gold and financial assets. The two functions of gold are distinguished in these studies as a hedge, which is a long-term property, and as a safe haven, which is characterized by non-positive correlations with stocks during crises. The results suggest that gold is a safe haven only in the very short-term: on average, gold-holders earn a positive return the day of an extreme negative stock return, but the gold return is likely to be negative the day after, as well as on average in the two following weeks. Baur and McDermott (2010) extend this analysis by showing that gold is a safe haven during periods of turmoil on the stock market. On reviewing the relationship between gold price and stock price variables in the United States over 1991-2001, Smith (2001) also finds a negative correlation between the two variables.

The special characteristics of strategic and most traded commodities in the world markets like oil and gold would make one expect their prices to influence and be influenced by macro-financial variables. However, the literature examining the directional relationships between such strategic commodities and macro-financial variables in a multivariate framework is not only few in number but also gives mixed signals (Pindyck and Rotemberg, 1990; Christiano et al., 1996; Awokuse and Yang, 2003). Further, these studies, for the most part, do not include all possible commodity-relevant macro-financial variables, particularly the exchange rate.

This study takes into account these deficiencies and thus aims to be a valuable addition to the scarce literature on the dynamics between strategic commodities and financial variables. In the monthly macro-financial data set, this study follows the literature and explores the individual directional relationships of oil and gold with three commodity-relevant macro-financial variables: interest rate, exchange rate and stock price that have not received much attention in the academic literature on commodities. These selected macro-financial variables are also of strong interest to monetary authorities, investors, traders and exporters. The modeling approach in this study is also different from the abovementioned studies. Methodologically, this study employs a more recent and advanced time series technique known as the autoregressive distributed lag (ARDL) approach, developed in Pesaran and Pesaran (1997) and Pesaran, Shin, and Smith (2001). This approach differs from conventional cointegration methods and overcomes the pre-cointegration biases. Last but not least, this study focuses on Japan, a very interesting case study for the subject matter, due to what follows.

### **2.3. OIL, GOLD AND THE JAPANESE ECONOMY**

Oil is the most consumed energy resource in Japan even though its annual consumption has been falling recently and its share of total energy consumption has decreased from about 80% in the 1970s to 46% in 2008 (Refer to Figure 2.1 and 2.2). Still, according to the International Energy Statistics from U.S. Energy Information Administration (EIA), Japan is the third largest net oil importer in the world, behind the US and China, as of March 2011. Japan is also the third biggest oil consumer with daily oil consumption of 4.4 million barrels in 2010. The country, however, has very limited domestic oil reserves of 44 million barrels, as of January 2011, a decline from the 58 million barrels in 2007. As a result, it had to rely heavily on oil imports to meet 45% of its energy consumption needs in 2009. Further, the 9.0 magnitude earthquake and resulting tsunami in March 2011 has adversely affected the country in general and severely damaged its energy infrastructure such as nuclear power stations, electric grid, refineries, and gas and oil-fired power plants in particular. Therefore, Japan will likely require additional energy (natural gas, oil) to provide electricity despite its declined power demand in the short term due to the destruction of homes and businesses.

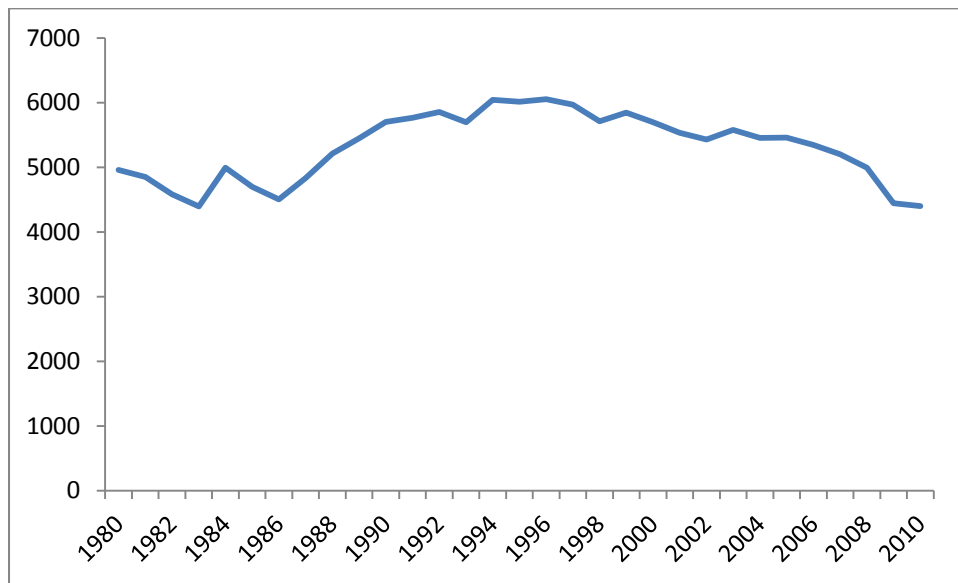
World crude oil prices, however, is expected to keep rising, partly due to an easing of the European debt crisis, an improvement of the US economy and monetary easing around the world. On the one hand, rising crude oil price will likely to have a negative effect on net oil importing economies like Japan as it causes a large deficit in the current account balance by worsening the terms of trade and lowering their purchasing power in real terms. Consequently, it could become a factor that dampens the economy in the long term. On the other hand, one may debate that if high crude oil prices are associated with expectations for an improvement in the global economy, such an improvement could be a factor that boosts the economy throughout higher exports.

In 2011, Japan posted its first annual trade deficit since 1980, that was partly driven by a jump in fuel imports. In order to promote a favorable export situation, the Bank of Japan intervene the currency markets to weaken the Japanese yen. In spite of such efforts, the economic recovery has still been relatively slow.

Japan has evolved as a major market for gold for fabrication and investment since 1974 when trading was liberalized and gold merchants were allowed to import gold freely. By 1980 the gold market in Japan was fully liberalized and obtained fast development. In March 1982, Tokyo gold exchange of Japan was set up as the only gold futures market officially approved by the Japanese government. During the early establishment period of Japan's gold market, due to the management system and the troublesome trading process, the daily trade volume was very small. With the rapid development of the economy, a large number of gold investors came in and gradually formed into a slightly influential gold trading market in the international arena. In recent years, the development of the gold market in Japan is even more active, coupled with the country's increasing economic advancement, this has turned Japan gold market to be become the major player driving the gold price fluctuations in Asia.

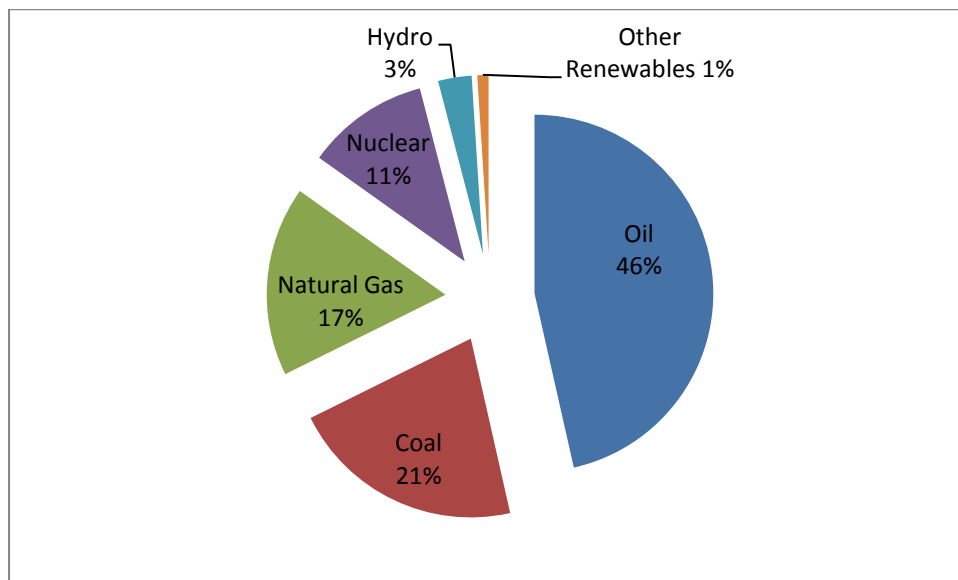
The paradox is that Japan is probably the only country that massively exports gold without being a major producer. According to a recent report by Reuters, one of the world's leading sources for business and professionals, Japan exported a total of 91 tonnes of gold and imported 13 tonnes in 2010. This results in record net exports of 78 tonnes, about a quarter of annual output from top miner China. But given the fact that Japanese households were seen holding about 1,500 tonnes of gold in 2010, the net exports may have reduced the amount to around 1,400 tonnes. There are still lots of gold in this country and net exports could hit records again.

**Figure 2.1: Japan's Oil Consumption by Year (1980-2010)**



Source: US Energy Information Administration Statistics

**Figure 2.2: Japan's Total Energy Consumption by Type (2008)**

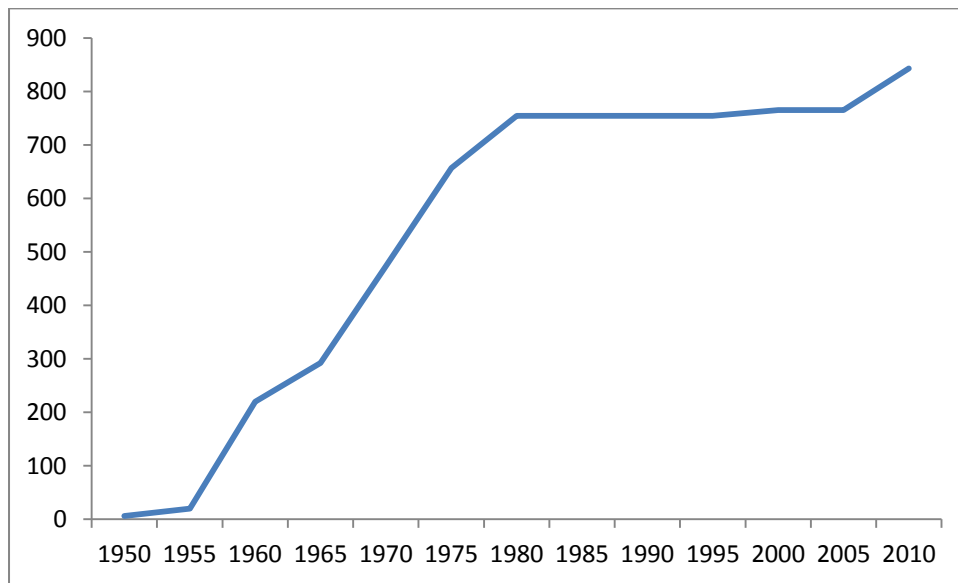


Source: US Energy Information Administration

Besides, based on IMF International Financial Statistics, Japan is always among the top gold holders in the world, latest ranked at 9th place in 2011, with increasing gold holdings from 765.2 tons of gold as of January 2011 to 843.3 tons of gold as of early July 2011. Several reasons could be used to explain for this. Traditionally, it is the Japanese culture that people harbor gold to protect against unforeseen events and only sell it when they have urgent needs. Concerns about the Japanese economy and continuing debasement of the Japanese yen may be leading Japanese diversification into gold. In this respect, gold in Japan is not so much associated with risk aversion, but more as an asset that many bought when prices languished for 30 years. The situation has recently changed, however, owing to the likely adverse impacts of the current global crisis and the earthquake and tsunami hitting Japan in March 11th 2011. A downgrade of the U.S. sovereign debt rating amid a deteriorating outlook for the world's largest economy, as well as a spreading European debt crisis, have triggered a rush to gold that has boosted its prices. The Japanese investors are swinging away from US dollars and other currencies into hard assets in the face of global political and financial uncertainty. In an uncertain international economic crisis, the only certain thing is that countries are increasing their gold reserves and Japan is obviously not an exceptional case (Refer to Figure 2.3). Japan's gold reserves which are worth about US\$43.17 billion on the open market constitutes, however, only 3.3% of the country's total foreign reserves.

Japanese investors are using gold as a safe haven in the aftermath of the Japanese earthquake and tsunami. In addition to loss of life, the disasters caused the destruction to much of Japan's infrastructure which requires huge reconstruction efforts. Japan's enormous demand for raw materials will drive up commodity prices and increase inflationary pressure. This, together with so much excess liquidity being pumped into stock markets, will enhance the appeal of gold as a hedge against inflation and a wealth protector since the investors see a need to diversify their assets after seeing volatile movements in currencies, stocks and others.

**Figure 2.3: Japan's Gold Reserves (1950-2011)**



Source: IMF International Financial Statistics

For the case of Japan, one could not assert about the sign of the relationship between oil and gold prices, owing to the special characteristics of the country and its economy. First, Japan is a country that has a long history of suffering from many severe natural disasters, especially recent typhoons and localized rainstorms. For instance, as a consequence of a severe earthquake, followed by a tsunami, hitting northern Japan on the 11th of March 2011, all commodity prices including that of gold and oil were marked sharply down. This is because equity investors covered losses and the market contemplated serious disruption to Japanese industrial output resulted from such disasters. Second, oil and gold prices denominated in Japanese yen would also be firmed when there is a weakening of the US dollar, which brings some stability back to the commodity market. Third, the underlying factors associated with a rise in crude oil prices in the Japanese perspective also play a critical role in altering the connection between oil and gold prices. On the one hand, if rising crude oil prices are caused by Japan's extra oil demand for power generation and the uncertainty over the restart of nuclear reactors due to the damaging effects of the natural disasters on its economy, the



appeal of gold as a hedge against risk and uncertainty is expected to increase and so does the price of gold. As compared to stocks, gold appeared to hold its value very well during the few days when markets were falling almost in panic. On the other hand, if rising oil prices are associated with expectations for an improvement in the economy, which is often viewed to be less risky, one may expect the appeal of gold to decrease and thus the price of gold to fall. As a result, there has been no consensus on the sign and direction of the oil price-gold price relationship for the Japanese case.

Since Japan is a major oil-consuming-and-importing as well as gold-holding-and-exporting country, the fluctuations of oil and gold prices are also expected to have significant economic implications for movements of key macroeconomic variables in the economy. Despite this fact, no studies have been conducted on this particular subject. This study aims to fill this gap by studying the dynamics between the two strategic commodities: oil and gold, and the financial variables in Japan. Interest rate, exchange rate and stock price index are selected as the three representative financial variables in the empirical investigation of Japan. The reason is that the interest rate is a variable that captures the monetary policy instrument, the exchange rate is an important transmission channel in an open economy, and the stock market is an indicator of the health of an economy. Further, exchange rate has strong bearing on commodities such as oil and gold which are all priced in US dollars. Investment in stock markets provides an alternative to commodities. Hence, stock market index may provide a relational lead to commodity prices in slow growth environment as is the recent situation. For the Japanese case, the nominal interest rate on yen assets has been forced toward zero during recent decades. In fact, the economy has been in a liquidity trap in more than a decade because of the presence of deflation in a weak economy. The goal of this near-zero interest rate policy is part of the quantitative easing policy in order to deal with deflation and prolonged recession. In addition to the economic significance as described above, the

findings of this study would help the Japanese monetary authority in conducting monetary policy and investors of Japanese yen in building their optimal portfolios.

## **2.4. DATA AND METHODS**

### **2.4.1. Data**

This study uses monthly data spanning from January-1986 to December-2011, which consisted of 312 observations for each series. The choice of monthly frequency is made due to the unavailability of daily data on inflation factor included in this study. The Dubai Fateh monthly crude oil price (quoted in US dollar) acquired from International Monetary Fund (IMF) is chosen as a representative of the world oil price to study the subject for the Japan case. This is because Fattouh (2011) ascertains that the Dubai crude is the main benchmark used for pricing crude oil exports to East Asia. He opines that it is a major impetus when key OPEC countries abandoned the administered pricing system in 1988 and started pricing their crude export to Asia on the basis of the Dubai crude. Horsnell and Mabro (1993) also assert that the Dubai market became known as the “Brent of the East”.

The monthly average of the London afternoon (pm) fix (quoted in US dollar) obtained from the World Gold Council is selected as a representative of the world gold price. The data of Japanese macroeconomic variables including the consumer price index (CPI), the interest rate, the exchange rate (JPY/USD) and the stock price index (2005=100) are obtained from International Financial Statistics (IMF). The original share price index series is already obtained in real terms with 2005 as a base year. The exchange rate is obtained in units of the domestic currency (Japanese yen) per one unit of the US dollar. An increase in the exchange rate thus implies a depreciation of the Japanese yen against the US dollar. The overnight call rate (interbank short-term interest rate) is chosen as a representative for the short term interest

rate of Japan as it has often been used as the short-term interest rate in empirical studies of the Japanese economy (e.g., Campbell and Hamao, 1993). In the case of Japan, the overnight interbank call rate is also an explicit policy instrument for the Bank of Japan (Iwata and Wu, 2006).

Considering the inflation factor, oil price and gold price are entered into the model in real terms (adjusted to the base year 2005). In order to get rid of the effect of any exchange rate differences, the prices of oil and gold are converted from the US dollar into the domestic currency of Japan, which is the Japanese yen. For instance, national real oil prices are obtained as products of Dubai crude oil prices and exchange rates (Japanese yen per US dollar) deflated using the inflation indicator (monthly CPI with the base year of 2005) of Japan. The choice of oil price and gold price variables between the world price and the national price is difficult and relevant. In reality, national prices of gold and oil are influenced by many factors such as price controls, high and varying taxes on petroleum products, exchange rate fluctuations and national price index variations. Such considerations justify the choice of using the world price in US dollars and converted into the Japanese yen by means of the market exchange rate in this study.

All of the variables are transformed into natural logarithms to stabilize the variability in the data. Log transformation can also reduce the problem of heteroskedasticity because it compresses the scale in which the variables are measured, thereby reducing a tenfold difference between two values to a twofold difference (Gujarati, 1995). Since all of the variables are converted to natural logarithms, their first differences are interpreted as percentage changes in the variables.

Table 2.1 tabulates the descriptive statistics of the series in level, log and first difference of log level. The coefficient of standard deviation indicates that in level, the real gold price has

the highest volatility, followed by real oil price, real stock price, exchange rate and interest rate. After taking log transformation, however, the interest rate has the highest volatility, and the oil price is more volatile than the gold price. The interest rate is the only variable that has negative mean in log levels and first differences of log levels; due to the fact that the Japanese nominal interest rate in recent periods (about 16 years) has been a way too low, less than 1%. For oil, gold and stock price series, the mean of the first differences of the logged variables implies annualized average return. Overall stock is the only asset that yields negative annualized average real return whereas for gold and oil, the returns are positive. However, oil offers higher average real return but with higher level of volatility (higher risk) as compared to that of gold. The skewness, kurtosis and Jarque-Bera statistics indicate that both oil price and gold price are significantly non-normally distributed, especially compared to the stock price.

Table 2.2 presents the contemporaneous correlation matrix between all the logged variables. The contemporaneous correlation coefficients, at a first glance, indicate that the Japanese financial variables are all significantly and positively related to each other. Hence, a shock to one of the variables is likely to affect the others. Oil and gold prices have the highest and positive correlation (about 0.73), which is the same as expected in theory. The gold price is negatively and significantly correlated with the stock price and the JPY/USD exchange rate. This suggests that an increase in gold price seems associated with an appreciation of the Japanese yen against the US dollar and vice versa, which seems contradictory with the common thought that gold is a hedge against exchange rate fluctuations. Meanwhile, the oil price is negatively and significantly correlated with the stock price and the exchange rate of Japan. While the negative impact of rising oil price on stock market in a net oil importing country like Japan could be expected, its positive effect on the value of the Japanese yen against the US dollar seems unexpected as described in previous section. Further, the oil price

and the gold price are significantly correlated with the interest rate but the sign is positive for gold whereas negative for oil. These results seem, once again, unreasonable and contradictory to the previous arguments. In general, however, the results produced by simple correlation analysis are not reliable enough for meaningful implications as the relationships between two variables may involve their interactions with other variables and/or may be lead and lag and more importantly, they do not imply causality. More advanced techniques are needed in order to achieve more reliable results as well as to assess the existence and direction of causality.

**Table 2.1: Descriptive statistics of series**

	Gold price	Oil price	Stock price	Exchange rate (JPY/USD)	Interest rate
Level					
Mean	56867.19	3687.43	113.67	117.50	1.73
Std. dev.	24835.65	2506.74	35.15	19.94	2.35
Skewness	1.18	1.45	0.75	0.56	1.26
Kurtosis	3.75	4.45	3.37	4.013	3.37
Jarque-Bera	80.20	136.67	30.82	29.39	83.76
Probability	0.00	0.00	0.00	0.00	0.00
Observations	312	312	312	312	312
Log					
Mean	10.87	8.03	4.69	4.75	-1.67
Std. dev.	0.40	0.59	0.31	0.17	3.06
Skewness	0.53	0.63	0.02	-0.05	-0.58
Kurtosis	2.31	2.32	2.49	3.27	2.02
Jarque-Bera	20.86	26.79	3.41	1.08	29.79
Probability	0.00	0.00	0.18	0.58	0.00
Observations	312	312	312	312	312
First difference of log					
Mean	0.0016	0.0017	-0.0011	-0.0030	-0.0158
Std. dev.	0.04	0.10	0.05	0.03	0.32
Skewness	-0.02	-0.42	-0.45	-0.41	1.48
Kurtosis	3.75	7.44	4.61	3.59	36.73
Jarque-Bera	7.40	264.11	44.51	12.99	14846.67
Probability	0.02	0.00	0.00	0.00	0.00
Observations	311	311	311	311	311

Note: The period spans from Jan-1986 to December-2011

**Table 2.2: Correlation matrix (in log level)**

	Gold price	Oil price	Stock price	Exchange rate (JPY/USD)	Interest rate
Gold price	1.00	---	---	---	---
Oil price	0.73**	1.00	---	---	---
Stock price	-0.15**	-0.36**	1.00	---	---
Exchange rate	-0.20**	-0.36**	0.54**	1.00	---
Interest rate	0.16**	-0.34**	0.59**	0.35**	1.00

Note: \* and \*\* denote significance at 5% and 1%, respectively.

#### 2.4.2. Methodology

For the testing purposes in this study, a relatively new and advanced method of the bounds testing to cointegration (or autoregressive distributed lag (ARDL)) procedure, developed by Pesaran et al. (2001) is employed to empirically analyzed the long-run and short-term relationships and dynamic interactions among the variables of interest. The ARDL approach is selected for several reasons. First, the bounds testing (ARDL) approach to cointegration is more appropriate for estimation in finite or small sample studies. Second, unlike other well-known cointegration methods, the cointegrating relationship can be estimated by Ordinary Least Squares (OLS) in the bounds test procedure once the lag order of the model is identified. Third, the bounds test does not require the pre-test for existence of unit root of the series as in the Johansen-Juselius and Engle-Granger cointegration approaches. The ARDL approach is applicable irrespective of whether the variables are purely  $I(0)$ , purely  $I(1)$  or mutually cointegrated. Fourth, it enables to identify specific forcing relationships for regressors in the ARDL system. One issue, however, to note with the use of bounds testing is

that although the integration order of the series is only needed to identify critical values for inferences, the system crashes in the presence of I(2) series. Last but not least, it is contented that the endogeneity problems are avoided with appropriate modification of the orders of the ARDL model (Pesaran and Shin, 1999).

The empirical testing procedure is follows. First, it tests for cointegrating relationship using the bounds testing procedure (Pesaran and Pesaran, 1997; Pesaran et al., 2001) which helps to identify the long-run relationship by posting a dependent variable followed subsequent by its forcing variables. Since there has been no consensus about the directions of the long-run relationships due to the scarcity of related literature, unrestricted error correction model (UECM) regressions are estimated as follows:

$$\begin{aligned}
\Delta LOP_t = & \alpha_0 + \alpha_1.LOP_{t-1} + \alpha_2.LGOLDP_{t-1} + \alpha_3.LIR_{t-1} + \alpha_4.LSP_{t-1} + \alpha_5.LER_{t-1} \\
& + \sum_{i=1}^k \alpha_{6i}.\Delta LOP_{t-i} + \sum_{i=0}^m \alpha_{7i}.\Delta LGOLDP_{t-i} + \sum_{i=0}^n \alpha_{8i}.\Delta LIR_{t-i} \\
& + \sum_{i=0}^p \alpha_{9i}.\Delta LSP_{t-i} + \sum_{i=0}^q \alpha_{10i}.\Delta LER_{t-i} \\
& + \varepsilon_{1t}
\end{aligned}
\tag{Eq. 2.1}$$

$$\begin{aligned}
\Delta LGOLDP_t = & \beta_0 + \beta_1.LOP_{t-1} + \beta_2.LGOLDP_{t-1} + \beta_3.LIR_{t-1} + \beta_4.LSP_{t-1} + \beta_5.LER_{t-1} \\
& + \sum_{i=0}^k \beta_{6i}.\Delta LOP_{t-i} + \sum_{i=1}^m \beta_{7i}.\Delta LGOLDP_{t-i} + \sum_{i=0}^n \beta_{8i}.\Delta LIR_{t-i} \\
& + \sum_{i=0}^p \beta_{9i}.\Delta LSP_{t-i} + \sum_{i=0}^q \beta_{10i}.\Delta LER_{t-i} \\
& + \varepsilon_{2t}
\end{aligned}
\tag{Eq. 2.2}$$



$$\begin{aligned}
\Delta LIR_t &= \gamma_0 + \gamma_1 \cdot LOP_{t-1} + \gamma_2 \cdot LGOLDP_{t-1} + \gamma_3 \cdot LIR_{t-1} + \gamma_4 \cdot LSP_{t-1} + \gamma_5 \cdot LER_{t-1} \\
&+ \sum_{i=0}^k \gamma_{6i} \cdot \Delta LOP_{t-i} + \sum_{i=0}^m \gamma_{7i} \cdot \Delta LGOLDP_{t-i} + \sum_{i=1}^n \gamma_{8i} \cdot \Delta LIR_{t-i} \\
&+ \sum_{i=0}^p \gamma_{9i} \cdot \Delta LSP_{t-i} + \sum_{i=0}^q \gamma_{10i} \cdot \Delta LER_{t-i} \\
&+ \varepsilon_{3t}
\end{aligned} \tag{Eq. 2.3}$$

$$\begin{aligned}
\Delta LSP_t &= \delta_0 + \delta_1 \cdot LOP_{t-1} + \delta_2 \cdot LGOLDP_{t-1} + \delta_3 \cdot LIR_{t-1} + \delta_4 \cdot LSP_{t-1} + \delta_5 \cdot LER_{t-1} \\
&+ \sum_{i=0}^k \delta_{6i} \cdot \Delta LOP_{t-i} + \sum_{i=0}^m \delta_{7i} \cdot \Delta LGOLDP_{t-i} + \sum_{i=0}^n \delta_{8i} \cdot \Delta LIR_{t-i} \\
&+ \sum_{i=1}^p \delta_{9i} \cdot \Delta LSP_{t-i} + \sum_{i=0}^q \delta_{10i} \cdot \Delta LER_{t-i} \\
&+ \varepsilon_{4t}
\end{aligned} \tag{Eq. 2.4}$$

$$\begin{aligned}
\Delta LER_t &= \mu_0 + \mu_1 \cdot LOP_{t-1} + \mu_2 \cdot LGOLDP_{t-1} + \mu_3 \cdot LIR_{t-1} + \mu_4 \cdot LSP_{t-1} + \mu_5 \cdot LER_{t-1} \\
&+ \sum_{i=0}^k \mu_{6i} \cdot \Delta LOP_{t-i} + \sum_{i=0}^m \mu_{7i} \cdot \Delta LGOLDP_{t-i} + \sum_{i=0}^n \mu_{8i} \cdot \Delta LIR_{t-i} \\
&+ \sum_{i=0}^p \mu_{9i} \cdot \Delta LSP_{t-i} + \sum_{i=1}^q \mu_{10i} \cdot \Delta LER_{t-i} \\
&+ \varepsilon_{5t}
\end{aligned} \tag{Eq. 2.5}$$

Where LOP, LGOLDP, LIR, LSP and LER are natural log transformation of oil price, gold price, interest rate, stock price and exchange rate respectively;  $\Delta$  is the first difference operator; k, m, n, p and q are lag lengths;  $\alpha_0, \beta_0, \gamma_0, \delta_0$  and  $\mu_0$  are the drift;  $\alpha_i, \beta_i, \gamma_i, \delta_i$  and  $\mu_i$  (i=1 to 5) are the long-run multipliers;  $\alpha_i, \beta_i, \gamma_i, \delta_i$  and  $\mu_i$  (i=6 to 10) are the short-run multipliers and  $\varepsilon_{it}$  (i=1 to 5) are white noise errors. The lag lengths are determined by the Akaike Information Criteria (AIC).

The null hypothesis of “no cointegration” in the long run in each equation from (3.1) to (3.5), respectively, is following:

$$F(LOP_t|LGOLDP_t, LIR_t, LSP_t, LER_t): \quad \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$$

$$F(LGOLDP_t|LOP_t, LIR_t, LSP_t, LER_t): \quad \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$$

$$F(LIR_t|LOP_t, LGOLDP_t, LSP_t, LER_t): \quad \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$$

$$F(LSP_t|LOP_t, LGOLDP_t, LIR_t, LER_t): \quad \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$$

$$F(LER_t|LOP_t, LGOLDP_t, LSP_t, LIR_t): \quad \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = 0$$

The general F-statistics are used to test the hypotheses by computing the variables in levels. The statistics are compared with critical values obtained from Pesaran et al. (2001). There are two types of critical values, depending on the properties of the series. One type is for the purely stationary I(0) series (i.e. the lower level critical value), and the other type is for the purely I(1) series (i.e. the upper level critical value). If there is a mixed of I(0) and I(1) series, then the calculated F-statistics are compared with the upper and lower level critical values. The null hypothesis of no cointegration is accepted if the test statistic was smaller than the lower critical value. On the other hand, there is not enough evidence to accept the null hypothesis if the computed test statistic was bigger than the upper critical value. The test result is inconclusive when the computed F-statistics lied between the lower and upper bounds of critical values.

Next step is the estimation of the long-run and short-run parameters within a vector error representation model, which consisted of a two-step procedure. First, the order of the lags is selected and the ARDL model is then estimated. An augmented ARDL( $p, q_1, q_2, \dots, q_k$ ) model could be expressed as:

$$\Phi(L, p)y_t = \alpha_0 + \sum_{i=1}^k \theta_i(L, q_i)x_{it} + \delta'w_t + u_t \quad [\text{Eq. 2.6}]$$

Where  $p$  is the order of the dependent variable,  $p = 1, 2, \dots, m$  and  $q_i$  is the lag of the  $i$ th independent variable,  $q_i = 1, 2, \dots, m$ ;  $\Phi(L, p)$  and  $\theta_i(L, q_i)$  are polynomial lag operators of the maximum order equal to  $p$  and  $q_i$ , for the dependent and independent variables, respectively, and have following representations:

$$\Phi(L, p) = 1 - \sum_{j=1}^p \phi_j L^j \quad [\text{Eq. 2.7}]$$

$$\theta_i(L, q_i) = \sum_{j=0}^{q_i} \theta_{ij} L^j \quad [\text{Eq. 2.8}]$$

$L$  is a lag operator;  $y_t$  represents any of the variables in this group as a dependent variable;  $\alpha_0$  is a constant;  $x_{it}$  is the  $i$ th independent variable,  $i = 1, 2, \dots, k$ ;  $w_t$  is a  $s \times 1$  vector of deterministic variables (i.e., intercept, time trend, dummies).

The ARDL procedure estimates  $(m + 1)^{k+1}$  number of regressions in order to obtain the optimal lag length for each variable, where  $m$  is the maximum lag length and  $k$  is the number of variables. The appropriate model could be selected based on any known selection criteria such as AIC, Schwarz Bayesian Criterion (SBC), etc. The long-run coefficients for the response of a dependent variable to a change in an independent variable can be computed based on the selected appropriate model, as follow:

$$\hat{\theta}_i = \frac{\hat{\theta}_i(1, \hat{q}_i)}{\hat{\Phi}(1, \hat{p})} = \frac{\sum_{j=0}^{\hat{q}_i} \hat{\theta}_{ij}}{1 - \sum_{j=1}^{\hat{p}} \hat{\phi}_j} \quad [\text{Eq. 2.9}]$$

Where  $\hat{p}$  and  $\hat{q}_i$  are the estimated values of  $p$  and  $q_i$

The error correction model associated with the selected ARDL ( $\hat{p}, \hat{q}_1, \hat{q}_2, \dots, \hat{q}_k$ ) could be represented as follow:

$$\Delta y_t = -\Phi(1, \hat{p})EC_{t-1} + \sum_{i=1}^k \theta_{i0} \Delta x_{it} + \delta' \Delta w_t - \sum_{j=1}^{\hat{p}-1} \varphi_j \Delta y_{t-j} - \sum_{i=1}^k \sum_{j=1}^{\hat{q}_i-1} \theta_{ij} \Delta x_{i,t-j} + u_t \quad [\text{Eq. 2.10}]$$

Where  $\Phi(1, \hat{p}) = 1 - \sum_{j=1}^{\hat{p}} \hat{\phi}_j$  and  $EC_t$  is the error correction term, which is defined by:

$$EC_t = y_t - \sum_{i=1}^k \hat{\theta}_i x_{it} - \hat{\Gamma}' w_t$$

Where  $\hat{\Gamma}$  is the long-run coefficient associated with the deterministic variables with fixed lags. The parameters  $\varphi_j$  and  $\theta_{ij}$  are the short-run dynamic coefficients.

In other words, from the estimation of the UECMs, the long run elasticities are the coefficient of the one lagged explanatory variable (multiplied by a negative sign) divided by the coefficient of the one lagged dependent variable (Bardsen, 1989). The short-run effects are captured by the coefficients of the first-differenced variables in the UECMs.

## **2.5. RESULTS AND INTERPRETATION**

### **2.5.1. Stationarity test**

This section examines the integrated order of all the variables by applying several unit root tests. Note here that the bounds test is based on the assumption that all variables could be  $I(0)$  or  $I(1)$  or some  $I(0)$  and  $I(1)$ . When the variables are integrated of order 2 (i.e.  $I(2)$  series) or beyond, the computed F-statistics by Pesaran et al (2001) are no longer valid. Therefore, the stationarity tests were used to ensure that the regressors in the system are not  $I(2)$  stationary so as to avoid spurious results. For this purpose, four unit root tests are employed. Out of which, three tests, namely Dickey and Fuller (1979) (ADF), Phillips and Perron (1988) (PP), and Kwiatkowski et al. (1992) (KPSS) do not account for a structural break. The null of the ADF and PP tests is that the series has a unit root, i.e. non-stationary while the null of the KPSS test is that the series is stationary, thus they provide a good cross check. The fourth test, namely Zivot and Andrews (1992), accounts for one endogenous structural break to test the null of unit root against the break- stationary alternative.

The results of unit root tests are presented in Table 2.3 and 2.4. The four unit root tests have a mixed conclusion on the stationarity of the five logged series at levels but have a common suggestion that all the five logged variables are stationary in their first differences. Hence, the results after performing a range of unit roots test with and without structural breaks show a mixed conclusion between  $I(0)$  and  $I(1)$  series. It may be concluded, however, that there is no risk of existence of  $I(2)$  variables. The findings justify the use of bounds testing to cointegration methodology in this study.

**Table 2.3: Results of unit root tests without accounting for a structural break:**

		ADF	PP	KPSS
Log levels				
Intercept				
Japan	Gold price	0.33 (0)	0.22	0.66*
	Oil price	-1.63 (1)	-1.23	1.50**
	Stock price	-1.52 (1)	-1.48	1.21**
	Exchange rate	-2.11 (1)	-2.42	1.18**
	Interest rate	-1.65 (1)	-1.57	1.23**
Intercept and trend				
Japan	Gold price	-0.78 (0)	-0.78	0.49**
	Oil price	-3.25 (1)	-3.48*	0.43**
	Stock price	-3.44* (1)	-3.37	0.07
	Exchange rate	-2.88 (1)	-2.99	0.17*
	Interest rate	-1.89 (1)	-1.70	0.28**
First differences				
Intercept				
Japan	Gold price	-15.86** (0)	-15.86**	1.04**
	Oil price	-12.64** (0)	-12.36**	0.25
	Stock price	-12.84** (0)	-12.90**	0.20
	Exchange rate	-13.33** (0)	-13.03**	0.15
	Interest rate	-11.08** (0)	-11.03**	0.10
Intercept and trend				
Japan	Gold price	-16.26** (0)	-16.23**	0.04
	Oil price	-12.64** (0)	-12.45**	0.05
	Stock price	-12.91** (0)	-12.96**	0.08
	Exchange rate	-13.31** (0)	-13.01**	0.13
	Interest rate	-11.07** (0)	-10.95**	0.07

Note: \* and \*\* denote significance at 5% and 1%, respectively. Lag lengths are in parentheses. Without trend, critical values for ADF, PP and KPSS tests are respectively: at 1% = -3.45, -3.45 and 0.74; at 5% = -2.87, -2.87 and 0.46; at 10% = -2.57, -2.5 and 0.35. With trend, critical values for ADF, PP and KPSS tests are respectively: at 1% = -3.99, -3.99 and 0.22; at 5% = -3.42, -3.43 and 0.15; at 10% = -3.14, -3.14 and 0.12.

**Table 2.4: Results of Zivot-Andrews test with accounting for one structural break**

		[k]	t-statistics	Break point
Log levels				
Intercept				
Japan	Gold price	0	-4.64	2005M10
	Oil price	2	-5.92**	2008M09
	Stock price	1	-3.08	2004M12
	Exchange rate	1	-3.25	2008M09
	Interest rate	1	-6.11**	2006M05
Intercept and trend				
Japan	Gold price	0	-4.55	2005M10
	Oil price	2	-5.70**	2008M10
	Stock price	1	-3.48	2005M06
	Exchange rate	1	-3.68	2006M06
	Interest rate	1	-5.76**	2006M05
First differences				
Intercept				
Japan	Gold price	1	-10.61**	2008M03
	Oil price	0	-9.34**	2009M01
	Stock price	0	-9.84**	2003M05
	Exchange rate	4	-7.62**	2007M07
	Interest rate	0	-8.05**	2007M04
Intercept and trend				
Japan	Gold price	1	-10.71**	2008M03
	Oil price	0	-9.52**	2008M08
	Stock price	0	-9.98**	2001M10
	Exchange rate	4	-8.01**	2001M08
	Interest rate	0	-8.25**	2000M12

Note: \* and \*\* denote significance at 5% and 1%, respectively. The critical values for Zivot and Andrews test are: Without trend (only intercept): -5.34, -4.80 and -4.58 at 1%, 5% and 10% significance levels, respectively; With intercept and trend: -5.57, -5.08 and -4.82 at 1%, 5% and 10% significance levels, respectively.

Among all the breaks identified, there are some noteworthy breaks in the series, which correspond to potential structural breaks experienced by the Japanese economy from 1986 to 2011. These include the 2001 dot-com bubble, the end of the zero interest rate policy by the Bank of Japan in 2006, and the 2008 subprime crisis.

### **2.5.2. Bounds test results and interpretation**

The bound testing procedure first tests for the presence of long-run relationships among variables, described in the equation system in Section 2.4.2. A general-to-specific modeling approach guided by the short run data span and AIC is used respectively to select a maximum lag of 5 for the conditional ARDL-VECM. Following the procedure in Pesaran and Pesaran (1997, pp.305), first OLS regressions for the first difference part of the system is estimated and then the joint significance of the parameters of the lagged level variables when added to the first regression is tested. Pesaran and Pesaran (1997) stated that “this OLS regression in first differences are of no direct interest” to the bounds cointegration test. The F-test examines the null hypothesis that the coefficients of the lagged level variables are zero (i.e. no long-run relationship exists).

The calculated F-statistics for the cointegrating relationships among the five variables in the system are presented in Table 2.5. Several diagnostic and stability tests were employed to ascertain the goodness of fit of the ARDL models. Specifically, this study applies the three diagnostic tests to all of the ARDL models, including the Lagrange multiplier test of residual serial correlation, the functional form test by Ramsey’s RESET test using the square of the fitted values, and heteroskedasticity based on the regression of squared residuals on squared fitted values. The results suggest an absence of major diagnostic problems at 10% significance levels and indicate that the estimated models are well specified. As a final test for structural stability, the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) tests proposed by Brown et al. (1975) are applied. Since the plots of CUSUM and CUSUMSQ statistics do not cross the critical value lines, this indicates that the coefficients are stable over the sample period.



Critical values are taken from Table C1.iii in Appendix C, Case III: unrestricted intercept and no trend for  $k=5$  by Pesaran et al. (2001). The results suggest that, at 10% level, the data do not provide enough evidence to accept the null hypothesis of no cointegration when the regressions are normalized on LGOLDP, LOP, LER and LIR variables. There are thus four cointegrating vectors among the group of five variables. The more cointegrating vectors there are among the group, the more stable the relationship is, since there are fewer ways (or directions) in which the prices or values can move apart. The first cointegrating vector indicates that the prices of oil, Japanese stock, the JPY/USD exchange rate and the Japanese interest rate are the forcing variables of the real gold price denominated in Japanese yen. This implies that when a common stochastic shock hits the system, all the variables move together but the four variables: oil price, Japanese stock price, JPY/USD exchange rate and Japanese interest rate move first and then the gold price in real Japanese yen follows. The second cointegrating vector reveals that gold price, Japanese stock price, JPY/USD exchange rate and Japanese interest rate are the forcing variables of the oil price in real Japanese yen. The third cointegrating vector suggests that the prices of gold, oil and Japanese stock, and interest rate are the forcing variables of the JPY/USD exchange rate. Finally, the fourth cointegrating vector shows that the prices of gold, oil and Japanese stock, and the JPY/USD exchange rate are the forcing variables of the Japanese interest rate. The findings, however, change, if considered at 5% significance level since there are now only two cointegrating vectors: the LGOLDP and LIR equations.

Though some of the research used 10% as the criterion to reject the null, using 10% as significance level may not be appropriate. This is because unit root and cointegration tests differ from traditional test that uses  $I(0)$  variables. As a result, using 10% as significance level is inappropriate in terms of a greater likelihood with which the null is rejected. Table 2.6 thus reports the coefficient estimates of the long-run relationships but only the two

cointegrating equations detected from the previous procedure at 5% significance level are considered, which are the LGOLDP and LIR equations.

**Table 2.5: Bounds test cointegration procedure results**

Cointegration hypothesis	Lag structure	F-statistics	Outcome at 5% level	Outcome at 10% level
$F(LGOLDP_t LOP_t, LSP_t, LER_t, LIR_t)$	2-3-3-0-1	4.82***	Cointegration	Cointegration
$F(LOP_t LGOLDP_t, LSP_t, LER_t, LIR_t)$	1-0-0-0-2	3.41*	No cointegration	Cointegration
$F(LSP_t LGOLDP_t, LOP_t, LER_t, LIR_t)$	1-0-1-0-2	2.27	Inconclusive	Inconclusive
$F(LER_t LGOLDP_t, LOP_t, LSP_t, LIR_t)$	1-2-0-3-0	3.69*	No cointegration	Cointegration
$F(LIR_t LGOLDP_t, LOP_t, LSP_t, LER_t)$	2-2-3-0-0	3.82**	Cointegration	Cointegration

Note: Asymptotic critical value bounds are obtained from Table C1.iii in Appendix C, Case III: unrestricted intercept and no trend for  $k=5$  (Pesaran et al., 2001, page [T2]). Lower bound  $I(0)=2.26, 2.62, 3.41$  and upper bound  $I(1) = 3.35, 3.79, 4.68$  at 10%, 5% and 1% significance level, respectively. \*, \*\* and \*\*\* denote statistical significance at 10%, 5% and 1% level, respectively.

First, the results reveal that there is long-run bidirectional and positive interactions between the real oil price and the real gold price, both denominated in Japanese yen. This result strengthens the common findings from existing literature on the co-movement of oil and gold prices (e.g., Melvin and Sultan, 1990; Pindyck and Rotemberg, 1990; Narayan et al., 2012; Le and Chang, 2012) and the common thought that oil price and gold price move in sympathy. Rising oil prices seem to have deteriorated the Japanese economy, leading to falling income and economic activity, lower exports, declining stock markets and other asset markets. Indeed, the negative correlation between oil prices and real economic activity was found in a considerable number of empirical studies (e.g., Rasche and Tatom, 1977, 1981; Hamilton, 1983, 2011; Burbidge and Harrison, 1984; Gisser and Goodwin, 1986; Rotemberg and Woodford, 1996; Carruth et al., 1998). Since a declining economy is often viewed to be

more risky, the appeal of gold as a hedge against risk and uncertainty may rise and so does the price of gold.

The results also indicate that gold price and stock price have significantly negative effects on the Japanese nominal interest rate. Notice that the real stock price is more pronounced than the real gold price in determining the Japanese interest rate. A 1% increase in the gold price leads the Japanese interest rate to decrease by only 6.19% while a 1% increase in the Japanese stock price lowers the interest rate by 9.34%. The results indicate that there is a stable causality from the gold price to the interest rate and from the stock price to the interest rate in Japan. This finding strengthens results from prior studies (e.g., Koutsoyiannis, 1983; Fortune, 1987; Cai et al., 2001) and the common thought that low nominal interest rates are related to an increase in the demand for gold and hence the gold price.

The negative relation between Japanese stock price and nominal interest rate is consistent with Fama's (1981) theory. Fama (1981) argues that expected inflation is negatively correlated with anticipated real activity, which in turn is positively related to returns on the stock market. Therefore, stock market returns should be negatively correlated with expected inflation, which is often proxied by the short-term nominal interest rate.

In contrast to that of gold, the price of oil does not have significant long-run effects on any of the Japanese financial variables. It could be explained due to the fact that, despite its urgent fuel needs in the short term, Japan's annual consumption of oil has been falling in recent periods (Refer to Figure 2.1). This arises from structural factors, such as fuel substitution (i.e. the shift to natural gas in the industrial sector), an aging population and government-mandated energy efficiency targets. Further, given Japan's current-account surplus that mirrors the country's domestic savings balance rather than its trade balance, as well as the currency's traditional standing as a safe bet in times of crisis, a rise in oil price will unlikely

to place sustained downward pressure on the yen. In the event of a major oil shock that hits the global economy, the yen could yet come back into favor.

**Table 2.6: Estimated long-run coefficients using the ARDL approach**

	LGOLDP equation	LIR equation
LGOLDP	---	-6.19**
LOP	2.04**	2.26
LSP	0.41	-9.34***
LER	0.37	2.60
LIR	0.06	---
CONST	1.50	82.63***

Note: \*, \*\* and \*\*\* denote statistical significance at 10%, 5% and 1% level, respectively.

The results of testing short-run dynamics are provided in Table 2.7, which provide some additional findings from testing long-run dynamics. It shows that most of the impact on the real gold price return denominated in the Japanese yen in the short run comes from its own past growth rate (lag two months), current oil growth rate, past three-month stock returns as well as percentage changes in the current exchange rate. The effect is negative for its past growth rate while positive for the rest. The positive short-run impact of oil price changes on real gold price return is similar to what is found in the long run. Meanwhile, the positive impact of stock return on gold price return could be explained that in the short run, investors with higher real income (i.e. higher real purchasing power) resulting from their stock investment might increase their demand for gold jewelry as this is a normal, or even a luxury, good. Thus, they buy more gold, which leads to an increase in the demand for gold and hence its price in the short run. The positive influence of JPY/USD exchange rate on the real gold

price denominated in Japanese yen is straightforward. Since the world gold price is denominated in US dollar, a stronger Japanese yen against the US dollar would unambiguously imply a lower gold price in Japanese yen.

For the Japanese interest rate, most of the influences on its percentage changes arise from its past one-month growth rate, and past three month oil return. Both the influences are positive. The positive influence of oil prices on nominal interest rate is consistent with empirical findings from prior studies (e.g., Tang et al., 2010; Cologni and Manera, 2008). This is reasonable due to the fact that, since oil is an essential input in most economic activity, an increase in oil prices are expected to generate inflation in the economy. In the short run, interest rate soars accordingly to mitigate the inflation rate boosted up by the rising oil price. Alternatively, this can be explained using the real balance effect (Cologni and Manera, 2008). Under this theory, after an increase in oil prices, as people desire to rebalance their portfolios toward liquidity, there will be an increase in the money demand. Hence, if monetary authorities fail to meet the growing money demand, the price level will rise without a corresponding increase in the money supply. This will likely lead to a decrease in the real balances and in turn will push up interest rates. The stock and gold returns, by contrast, influence the Japanese interest rate in the long run but not in the short run.

The error correction term ( $ECM(-1)$ ) in both the equations given in Table 7 has the right sign, which is negative, and statistically significant, indicating that a given variable returns to equilibrium after deviation from it. Besides the statistical significance, the absolute values of estimated  $ECM(-1)$  are relatively big, indicating the relatively quick speed of adjustment to equilibrium following short-run shocks. For instance, about 66% of the disequilibrium caused by previous period shocks converges back to the long run equilibrium in the LIR equation. It takes only about 1.5 months ( $1/0.66=1.515$  months) to correct the disequilibrium in the LIR equation. The equilibrium correction is thus fairly quick.

**Table 2.7: Error correction representation for the selected ARDL models**

	LGOLDP equation	LIR equation
$\Delta LGOLDP_t$	---	0.094
$\Delta LGOLDP_{t-1}$	-0.013	-0.700
$\Delta LGOLDP_{t-2}$	-0.155***	0.794*
$\Delta LOP_t$	0.092***	-0.173
$\Delta LOP_{t-1}$	-0.022	0.130
$\Delta LOP_{t-2}$	-0.033	-0.264
$\Delta LOP_{t-3}$	-0.036	0.518***
$\Delta LSP_t$	-0.019	-0.341
$\Delta LSP_{t-1}$	0.095**	---
$\Delta LSP_{t-2}$	-0.005	---
$\Delta LSP_{t-3}$	0.104**	---
$\Delta LER_t$	0.572***	0.164
$\Delta LER_{t-1}$	---	---
$\Delta LER_{t-2}$	---	---
$\Delta LER_{t-3}$	---	---
$\Delta LIR_t$	0.6282E-3	---
$\Delta LIR_{t-1}$	-0.009	0.431***
$\Delta LIR_{t-2}$	---	-0.088
$\Delta CONST$	-0.01	-2.76***
ECM(-1)	-1.17*	-0.66*

Note: \*, \*\* and \*\*\* denote statistical significance at 10%, 5% and 1% level, respectively.

As a final step, robustness checks are conducted using the simple average of three crude oil price measures – Petroleum West Texas Intermediate (WTI), Petroleum UK Brent and Petroleum Dubai – in US dollars per barrel with similar transformations. The objective is to find if there is any significant difference in the results. Since the results are not affected much by the choice of market crude, the use of Dubai crude oil price in US dollars is retained in this study.

### **2.5.3. Policy implications**

The major findings of this study present several policy implications. First, the results suggest that in the long run, the gold price and the Japanese stock price have significantly negative impacts on the Japanese interest rate. This suggests that changes in gold and stock prices can send the Japanese monetary authority signals on the future direction of short-term interest rates as defined by the overnight call rate (interbank short-term interest rate). An increase in the gold price and/or stock prices is a recipe for loosening monetary policy, conducive to a fall in the short-term interest rate. Under such circumstances, equity traders should short (sell) Japanese interest-sensitive stocks, and banks should swap the Japanese yen for major currencies. Further, this study finds that in the long run, oil prices are positively related to gold prices. This finding suggests that, in terms of portfolio diversifications, portfolio managers should include either oil or gold as assets in their commodity portfolios.

Last but not least, it finds that the oil price shock does not have a significant and stable impact on any of Japanese financial variables in the long run and thus the oil prices seem to have limited information for the economic policy makers. Although for a major and net oil importer like Japan, this finding is strange at the first place, it reflects the recent situation in the country. This result may be attributable to the continuous decrease in Japan's annual oil

consumption during recent periods and/or special characteristics of the Japanese financial and monetary system.

The results from error correction approach indicate that in the short run, the oil and gold prices seem to have more useful information for the economic policy makers and thus policy makers should definitely give oil and gold a critical weight in their policy decisions. For investors, traders and portfolio managers, they may observe movements in gold and oil prices to predict fluctuations in the Japanese interest rate.

This study finds that in the short run, gold returns are negatively related to the value of the Japanese yen against the US dollar. This suggests that in the short run, investors should sell the Japanese yen when they observe an increase in the price of gold. Further, this finding strengthens the common sense view that gold can be used to hedge against fluctuations in the exchange rate for the Japanese case. Since oil and gold prices move in sympathy, this also implies that, like gold, oil returns seem related with the depreciation of the Japanese yen. When the Japanese yen depreciates, it will adversely affect the asset portfolio return of those investors who hold yen-denominated assets in their portfolios. In order to reduce the wealth loss denominated in the yen and to maintain their real purchasing power, the investors may find those assets whose values fluctuate against the Japanese yen's value. In such cases, the results suggest that the optimal choice for investors in a short term would be to include either oil or gold in their portfolios. Further, the finding has implications for monetary authority on how to conduct monetary policy that can use the derived information to adjust future interest rates to stabilize gold prices.

Last but not least, since the relationship between the exchange rate of the domestic currency (the yen) against the dollar and the gold price is found to be negative in the short run, this implies that a weakening yen is linked to higher future oil prices. Policy makers in Japan, a



net oil importer, that do not link their currencies to the dollar should consider the consequences of a strong dollar on domestic oil prices and the impact on their balance of payments. They should perhaps follow demand management techniques and use indigenous alternative energy sources to reduce the consumption of imported oil in the future.

## **2.6. CONCLUSION**

Oil and gold are the two most strategic commodities in the world and may have significant implications for the movements of macroeconomic variables, including those of financial variables, of any economy. Despite this fact, very little research has been conducted on dynamics between strategic commodities and performance of financial variables. This study aims to fill in this gap.

The focus of this paper is to investigate the dynamic relationships between the prices of oil and gold and the financial variables in Japan, namely, stock price, exchange rate and interest rate. The choice of financial variables are made based on theoretical macroeconomic basis that the interest rate is a variable that captures the monetary policy instrument, the exchange rate is an important transmission channel in an open economy, and the stock market is an indicator of the health of an economy. Japan is chosen for the empirical investigation in this study as it is a major oil-consuming-and-importing and gold-holding-and-exporting country. The results should provide relevant information to policy makers responsible for the impact of commodities' price fluctuations on interest rate and exchange rates. Further, since the Japanese yen is a major currency, the findings of this study would benefit not only the Japanese monetary authority but also those investors who hold the Japanese yen in their portfolios. The information will also be informative for traders and investors who are interested in hedging. It will also be useful for market participants who are interested to

switch between commodities and stocks, and for portfolio managers who are interested in whether to use commodities to diversity away stock market risk in their portfolios. The bounds test to cointegration, which is a relatively new cointegration technique, is employed as the methodology in this study.

This study finds that the real prices of oil and gold in Japanese yen are positively related to each other in both the long run and the short run. Besides, in the long run, rising stock and gold prices are found to have a negative influence on the short-run interest rate proxied by the over-night call rate of Japan. Surprisingly, the oil price shock does not have a significant and stable impact on any of Japanese financial variables in the long run and thus the oil price seems to have limited information for the Japanese economic policy makers. Besides the positive relation between oil and gold price returns, some additional results are obtained in the short run. Specifically, the exchange rate (JPY/USD) is positively related to real gold price denominated in Japanese yen. Interest rate is positively linked to real oil price in yen. Hence, in the short run, the oil and gold prices seem to have more useful information for the economic policy makers and policy makers should definitely give oil and gold a critical weight in their policy decisions. For investors, traders and portfolio managers, they may observe movements in gold and oil prices to predict fluctuations in the Japanese macro-financial variables.

### **3. ESSAY THREE: OIL PRICE SHOCKS AND TRADE IMBALANCES**

#### **3.1. Introduction**

The link between oil price shocks and trade balances is a relatively new concern in the literature. A very first study on this subject is carried out by a suitably adapted dynamic equilibrium model of international business cycles based on properties of business cycles in eight developed countries between 1955 and 1990 (Backus and Crucini, 2000). The study found that oil accounts for much of the variation in the terms of trade over the period 1972-1987. Their results seem likely to hold regardless of the financial market structure. However, it is argued that the nature of financial market risk sharing may have major implications for the responses of external balances to the permanent oil price shock (Bodenstein et al., 2011). A two country DSGE model (the US – as a home country – versus “rest of the world”) was employed in the study to investigate how a rise in oil prices affects the trade balance and the non-oil terms of trade for the US case. The study generalized the Backus and Crucini (2000)’s model by allowing for the convex costs of adjusting the share of oil used in the production and consumption. Instead of using the “complete markets” framework as in Backus and Crucini (2000), the study introduced incomplete financial markets across national borders in its benchmark specification. It was found that, under complete markets, the non-oil terms of trade remain unchanged, and so as for the non-oil trade balance whereas under incomplete markets, the former suffers from a depreciation that induces the latter to improve enough to correct the deficit.

A dynamic equilibrium model of international business cycles or a generalized dynamic equilibrium model may present insightful findings but both of which suffer from a drawback. It is related to the fact that the parameter values were calibrated based on the US data and simulated in the models. Such results and conclusions may not be generalized for other

economies that have some distinctive characteristics in terms of oil, e.g., not only an oil exporting economy but also an oil-deficient or oil importing economy. There are also several other deficiencies in the current literature on the oil price-trade balance relationship. First, the number of studies in this area is few (see Backus and Crucini, 2000; Rebucci and Spatafora, 2006; Bollino, 2007; Setser, 2007; Kilian et al., 2009; Bodenstein et al., 2011) and most of them studied the subject for the US case thus there has been no consensus on the matter. Second, a panel data set of countries, including oil-exporting and oil-importing economies, were examined in one study (Kilian et al., 2009) but there have been no studies for the cases of oil-refinery economies such as Singapore. Third, most of the studies have only investigated the short-run dynamics between oil price shocks on external balances (including trade) while having ignored the possible long-run causality. Fourth, most of the existing studies run an entire sample and elicit interpretation from the results, which may mislead due to the ignorance of possible structural breaks as there could be various and significant variations of the relationships within a long period of time. Last but not least, the decomposition of overall trade balances into oil and non-oil balances seems being ignored. This issue is actually rare in economic studies as few oil-producing countries publish or include an analysis of the non-oil balance in the budget. It is shown that an excessive focus on the overall trade balance often leads to fiscal policy moving in tandem with oil revenue, resulting in a volatile non-oil fiscal deficit with concomitant adverse macroeconomic and fiscal consequences (Barnett and Ossowski, 2002). This highlights that decomposing the overall balance into oil and non-oil balances is critical for policy makers, especially in oil-dependent economies, in order to understand fiscal policy developments, evaluate sustainability, and determine the macroeconomic impacts of fiscal policy.

This study aims to be a valuable addition to the scarce literature on the subject and to make up the abovementioned deficiencies in the current literature. It investigates whether a large

part of the variability of trade imbalances is associated with extreme movements in global oil prices. The possible relationships are being somewhat generalized by examining three oil-distinctive economies. The country sample of this study consists of an oil exporter (Malaysia), an oil-refinery economy (Singapore) and a net oil importer (Japan). All the three economies chosen are highly dependent on trade for growth. For instance, in the case of Malaysia, the dependency to the external trade demand was very strong and become a key factor to induce her economic growth. Almost two-thirds of the growth (value added) was geared by the external demand compared with one third of domestic final demand inducement (Shan et al., 2011). Such an economy could possibly be sensitive with any external shocks and it is thus of crucial importance to see if and how oil price shocks impact its trade imbalances.

The methodological approach takes into account the possible existence of an endogenous structural break in performing unit root tests and cointegration analysis on the entire sample spanning from January 1999 to November 2011. The Toda and Yamamoto (1995) causality (TY hereafter) procedure was then performed on the entire sample for each country case. With the entire sample results, this study examines if Malaysia' improvements in trade balances are associated with rising oil prices. For an oil refinery economy like Singapore, it tests whether the results indicate long-run impacts of oil prices on the overall trade balance and its components. For Japan, it examines whether and how oil price shocks have led to significant movements in oil and non-oil components but not for the economy's overall trade balance.

This study confirms the results based on the entire sample by the stability analysis. It breaks the entire sample further into three sub-samples corresponding to major economic events to capture the possible different natures of oil price shocks. The results of this study could have implications for both policy makers and economic modeling of the impact of oil price shocks.

It follows the Gregory and Hansen (1996) approach to cointegration with structural change and the TY procedure to test for the long-run non-causality between the variables of interest. To investigate the short-run dynamics between the variables of interest, the generalized impulse response function (IRF) by Koop et al. (1996) and Pesaran and Shin (1998) was employed to examine how each type of trade balance in each country case responds to a generalized one standard deviation shock of the world oil price.

The rest of the paper is organized as follows. Section 2 discusses the mechanisms by which oil price shocks are expected to drive external (including trade) balances. Section 3 describes the data and preliminary observations. Section 4 presents the econometric framework of this study. Section 5 reports the empirical results. The stability, robustness and policy implications of the results are also presented. Section 6 concludes the main findings of this study.

### **3.2. Theoretical background**

The impact of oil price shocks on the external accounts of an economy work through two main channels, the trade channel and the financial channel. The trade channel works through changes in quantities and prices of tradable goods whereas the financial channel works through changes in external portfolio positions and asset prices (Kilian et al., 2009). This study focuses on the trade channel and discusses the mechanisms by which oil prices are expected to drive trade balances and review the related literature.

Oil price shocks have direct and indirect economic impacts for both oil-importing and oil-exporting economies. The indirect impact is the transmission of the shock through the international trade. First, a rise in world oil prices is often thought to bring inflationary

pressure and raise prices in trading-partner countries. This in turn raises the domestic import prices in both oil-importing and oil-exporting economies. Monetary authorities of trading-partner economies may also raise interest rates in an effort to curb inflation, leading to declines in consumption, investment and thus economic growth in the trading-partner economies. This in turn decreases the demand for many export commodities from the domestic economy of both oil importers and oil exporters.

For a net oil-exporting economy, the direct effect of rising world oil prices is expected to be positive, as it gets more export revenues. The indirect effects are, however, expected to be negative. First, as mentioned in the previous paragraph, rising global oil prices raise the domestic import prices of both oil importers and exporters. Second, an increase in the world oil price due to shocks from the supply side constitutes a negative supply shock to net oil importers, resulting in a slowdown in the domestic economic growth of oil importing economies and in turn reduces their oil exports and other exports from oil exporters. The gain for an oil-exporting economy is thus not as large as one could assume at first glance. The net impact of oil price shocks on the trade balance of an oil-exporting economy depends on the magnitude of higher oil export revenues relative to the rising price of the home country's imports. This argument strengthens a common concern that large fluctuations in the world oil price not only bring adverse effects to the economies of oil importers but also poses challenges for policy makers in oil-exporting economies. To oil exporters, the oil revenue poses fiscal challenges that stem from the fact that it is exhaustible, volatile and largely originates from abroad. Oil price hikes may further cause increased uncertainty, especially for those economies perceived to be risky like emerging markets. The capital account may also be adversely affected due to a decline in foreign portfolios and direct investments into the country, or even a capital flight. Thus, even though soaring global oil prices should be considered positive to net oil exporters and negative to net oil importers, the real situation is

not that simple. Despite this fact, net oil exporters may still benefit from higher oil prices by likely improvements in their terms of trade and the resulting increases in oil export revenues can be used for more of both consumption and investment (Korhonen and Ledyeva, 2008).

For a net oil-importing economy, an exogenous increase in the price of imported crude oil is often regarded as a negative term-of-trade shock through their effects on production decisions (see, e.g., Kim and Loungani, 1992; Backus and Crucini, 2000). The imported oil is considered an intermediate input in the domestic production and thus an increase in oil prices leads to a direct increase in the input cost and results in a decline in real gross domestic product (GDP). Firms and households will have to curtail their expenditure and investment plans. Real output falls at least temporarily in oil importing economies. The domestic economy of net oil importers would produce less and hence export less, but may not correspondingly consume less imported produce. The impact of an exogenous rise in oil prices on the overall trade balance of net oil importers is expected to be negative.

This interpretation is, however, questionable in two regards. First, under standard assumptions, imported oil enters the production function of domestic gross output, which is separable in value added and imported energy, but not that of domestic value added. Holding capital and labor fixed, oil price shocks do not alter value added and thus, by definition, cannot be productivity shocks for real GDP. Instead, they affect the economy by changing domestic capital and labor inputs. Second, if oil price shocks are viewed as cost shocks to a net oil importer, the impact on the domestic output should be bounded by the cost share of oil in the domestic production, which is known to be very small. Thus, oil price shocks are not capable of explaining large fluctuations in real GDP and hence those in the real trade of the domestic economy (Kilian, 2010).



It cannot be denied, however, that the direct impact of oil price shocks on the balance of payments, which is through the current account, for a net oil importer is negative. Rising oil prices imply a higher oil import bill that may be compounded by lower export revenues for oil-intensive goods and services. The current account will immediately be negatively affected. Over time, the initial trade deficit will decline, and the non-oil trade balance will increase. In the meantime, policy responses may further cushion or amplify these effects (Kilian et al., 2009). Net oil importers can still benefit from higher oil prices if they are able to export more to net oil exporters.

The impact of a permanent rise in oil prices on overall and non-oil trade balances of a country, as occurs in the real world with incomplete financial markets, depends on the divergence in wealth effects between oil-importing and oil-exporting country blocks (Bodenstein et al., 2011). If a net oil importer experiences a highly persistent deterioration in its oil trade balance, the only way to satisfy its intertemporal trade balance condition is to improve its non-oil trade balance by a sufficient amount. This may require some initial worsening of its non-oil terms of trade (or real exchange rate, as the latter adjusts proportionately). If under complete markets, the situation would be dramatically different. In response to an oil price hike, a net oil importer could receive an insurance transfer so as to enable it to satisfy its intertemporal current account balance constraint without having to run an eventual non-oil trade surplus. In such a case, oil price shocks would have a negligible impact on the non-oil trade balance of a country.

There has been no consensus on the impact of oil price fluctuations on trade balances. It is thus worth investigating the net effect of rising global oil prices on trade balances and their oil and non-oil components, especially to conduct a comparative analysis in this area. This study examines the relationships between the variables of interest for three East Asian economies, including Malaysia (a major oil exporter of the region), Singapore (an oil refinery

and small open economy) and Japan (a major economy and net oil importer of the world). It employs the vector autoregressive (VAR) technique to capture the complexities of the dynamics between these variables and other variables, including industrial production (as a proxy for real income as the data on GDP is only available at quarterly frequency) and real exchange rate, that may influence the relationship between oil price shocks and trade balances.

The role of income and exchange rate in affecting trade flows is well recognized in literature. A large number of studies have been conducted to analyze the effects of these two factors on exports, imports and the balance of trade (payments) (e.g., Beckerman, 1951; Singh, 2002; Chinn, 2004). The existence of a theoretical relationship between exchange rate and the trade balance is confirmed by an elasticity model of the balance of trade (Krueger, 1983). Nominal depreciation (appreciation) of exchange rate is assumed to change the real exchange rate and thus has a direct effect on the trade balance. A country may devalue her currency to gain international competitiveness and to improve its trade balance (Bahmani-Oskooee, 2001). Devaluation or depreciation increases exports by making exports relatively cheaper, and discourage imports by making imports relatively more expensive, thus helping to improve the trade balance. It is argued, however, that there is a short run phenomenon dubbed the “J-curve” effect in the movement of trade balance, i.e., there will be an initial deterioration before a country’s trade balance could eventually improve (Bahmani-Oskooee, 1985; Bahmani-Oskooee and Malixi, 1992; Marwah and Klein, 1996).

The theoretical linkages between the oil market and the currency market are also well established. It has been argued that there is a potential impact of exchange rates on oil price movements, which is based on the law of one price for tradable goods (Bloomberg and Harris, 1995). Since oil is a homogeneous and internationally traded commodity priced in US dollars (USD), depreciation in the US dollar reduces the price of oil to foreigners relative to

the price of their commodities in foreign currencies, thereby increasing their purchasing power and oil demand and, in turn, pushing up the crude oil price in US dollars. Since the US dollar is the major invoicing and settlement currency in international oil markets, the primary channel through which an oil price shock is transmitted to the real economy is the domestic currency's exchange rate with the US dollar and the effects are different on oil exporting and importing countries (Reboredo, 2012). A stronger domestic currency compared to the US dollar increases the purchasing power of oil-importing countries (except the US) while negatively affecting oil exporting countries. Conversely, a cheaper local currency against the US dollar may adversely affect oil-importing countries and lead to a demand shock in the long term that ultimately affects oil-exporting countries. Oil prices are considered to have the role in explaining for exchange rate movements (Golub, 1983; Krugman, 1983). An oil-exporting (oil-importing) country may experience exchange rate appreciation (depreciation) when oil prices rise and depreciation (appreciation) when oil prices fall. It is shown that the US dollar, over the past ten years, has often appreciated when oil prices were low and depreciated when oil prices were high and opined that greater exchange rate flexibility would help oil exporting economies manage the volatility in export and government revenues associated with global oil price fluctuations (Setser, 2007).

A vast quantity of literature suggests that there is a significant relationship between oil price movements and economic activity, especially with respect to output. The effects in net oil importers and net oil exporters are also expected to be different. An oil price increase should be considered good news to oil exporting countries and bad news to oil importing countries whereas the reverse should be expected when the oil price decreases (Jimenez-Rodriguez and Sanchez, 2005). An oil price change driven by a global aggregate demand shock, however, may have a very different effect than an oil price change driven by an increase in precautionary demand driven by fears about future oil supplies (Kilian, 2009). It is shown

that the effects of exogenous shocks to global oil production on inflation and real output in G-7 countries appear to be a temporary reduction in real GDP growth, including that of the US (Kilian, 2008b). Rising real oil prices caused by oil-specific demand increases are, however, associated with a temporary increase in the US's real economic activity (Kilian, 2009).

In brief, in a multivariate framework, high oil prices tend to reduce asset prices, including equities and exchange rates, in net oil importers and to raise them in net oil exporters. A rise in the world oil price further worsens the trade balance of net oil importers, leading to a higher current account deficit and a deteriorating net foreign asset position. At the same time, it is argued that higher oil prices tend to decrease private disposable income and corporate profitability, reducing domestic income and hence domestic demand in oil-importing countries; and this, along with a depreciation of the exchange rate, acts to bring the current account back into equilibrium overtime (Rebucci and Spatafora, 2006). The process works broadly in reverse in net oil exporters: trade surpluses are offset by stronger economic growth and, over time, real exchange rate appreciation. It is observed that in the past, as higher oil prices led to rising interest rates, slowing economic growth and domestic demand, and altering exchange rates and asset prices, current accounts (including trade balances, of course) have tended to adjust relatively quickly to oil price shocks in net oil importers (Rebucci and Spatafora, 2006).

### **3.3. Data**

#### **3.3.1. Data descriptions**

This study focuses on the impact of oil price shocks on overall trade balances and their oil and non-oil components over the period spanning from January 1999 to November 2011. The

country sample, as stated above, consists of three East Asian economies, namely, Malaysia, Singapore and Japan that represent three distinct characteristics in terms of oil. The choice of investigation period was due to the availability of comprehensive data sets.

The Dubai crude oil spot price quoted in US dollars was chosen as a representative of the world oil price. The Dubai crude is the main benchmark used for pricing crude oil exports to East Asia and it is a major impetus when key OPEC countries abandoned the administered pricing system in 1988 and started pricing their crude exports to Asia on the basis of the Dubai crude (Fattouh, 2011). Separately the Dubai market became known as the “Brent of the East” (Horsnell and Mabro, 1993). The oil price is defined in real terms by deflating the Dubai oil price (USD per barrel) by the US producer price index (PPI). It is because the data on GDP deflator is not available at monthly frequency. In the context of the methodology followed here, the definition of real oil prices represents a common shock to all countries.

Data on overall trade balance, oil trade balance, non-oil trade balance, bilateral exchange rate with the US dollar, industrial production index (IPI) and consumer price index (CPI) of the three selected economies are acquired from IMF’s International Financial Statistics or the country’s department of statistics and mostly denominated in nominal terms. If the trade (including oil and non-oil) balance data are denominated in domestic currency, then it is converted to current US dollars using nominal exchange rates (USD/local currency) and the newly achieved data are deflated using US PPIs. The acquired IPI data for each country is in real terms, measured in the 2005 prices. The exchange rate data are in nominal terms, thus the series are transformed into real terms using the CPI data with 2005 as the base year.

### 3.3.2. Observations

Descriptive statistics for the variables in levels are provided in Table 3.1. It is interesting to note that, on average, all of the three economies run overall trade surpluses over the examined period with the highest level belonging to Japan. The volatility of the overall trade balance is also highest in Japan. Malaysia is the only economy that runs an oil trade surplus, reflecting the fact that it is a major net oil exporter of the region for decades, and the surplus is quite stable on average. In contrast, the other two economies run oil trade deficits but the oil trade deficit of Singapore is still about 20 times lower than that of Japan. The bilateral exchange rate with the US dollar is most volatile in Japan whereas least volatile in Singapore. In contrast, industrial production index – a measure of real production output – is most stable in Japan while least stable in Singapore.

The contemporaneous correlation coefficients reported in Table 3.2, at first glance, indicate that the overall trade balance and their non-oil components are linearly associated in most of the economies. A shock to one of the variables is thus likely to affect the others. The oil trade balances of Japan and Singapore are highly and negatively related with the oil price, with a higher degree of significance belonging to Japan. The trade balance of Japan is also highly and negatively correlated to the oil price. This is reasonable due to the fact that it is a net oil importer. The trade balance and its oil and non-oil components in Malaysia are significantly and positively associated with the oil price. This is expected as Malaysia is a major oil producer and net exporter and thus likely to be favorably influenced by the positive oil price shock. The simple correlation coefficients, however, do not imply causality. Using more advanced techniques is thus essential in order to assess the existence and direction of causality.

**Table 3.1: Descriptive statistics for the variables at levels:****January 1999 to November 2011**

Variable	Mean	Max	Min	Standard deviation
Dubai oil price (US\$/barrel)	47.920	100.506	12.934	20.976
Malaysia				
Trade balance (US\$ mn)	2139.829	3923.139	644.164	590.995
Oil trade balance (US\$ mn)	263.302	807.218	-380.930	152.531
Non-oil trade balance (US\$ mn)	1876.527	3437.085	447.082	551.239
Industrial production index	93.392	115.990	55.450	14.812
Exchange rate (MYR/USD)	3.538	3.828	2.932	0.246
Singapore				
Trade balance (US\$ mn)	1776.662	4555.208	-560.279	1138.852
Oil trade balance (US\$ mn)	-314.976	518.253	-2415.798	438.965
Non-oil trade balance (US\$ mn)	2091.639	5193.704	-246.193	1159.276
Industrial production index	101.298	185.110	56.695	26.707
Exchange rate (SGD/USD)	1.541	1.730	1.159	0.144
Japan				
Trade balance (US\$ mn)	6081.507	15716.53	-9834.513	4892.130
Oil trade balance (US\$ mn)	-6145.522	-1904.025	-13541.28	2493.713
Non-oil trade balance (US\$ mn)	12227.03	20705.85	-5157.692	4281.582
Industrial production index	96.324	117.300	67.000	9.196
Exchange rate (JPY/USD)	106.578	130.588	86.356	10.535

Note: All variables are in real terms using 2005 base year.

**Table 3.2: Correlations among the variables of interest:**

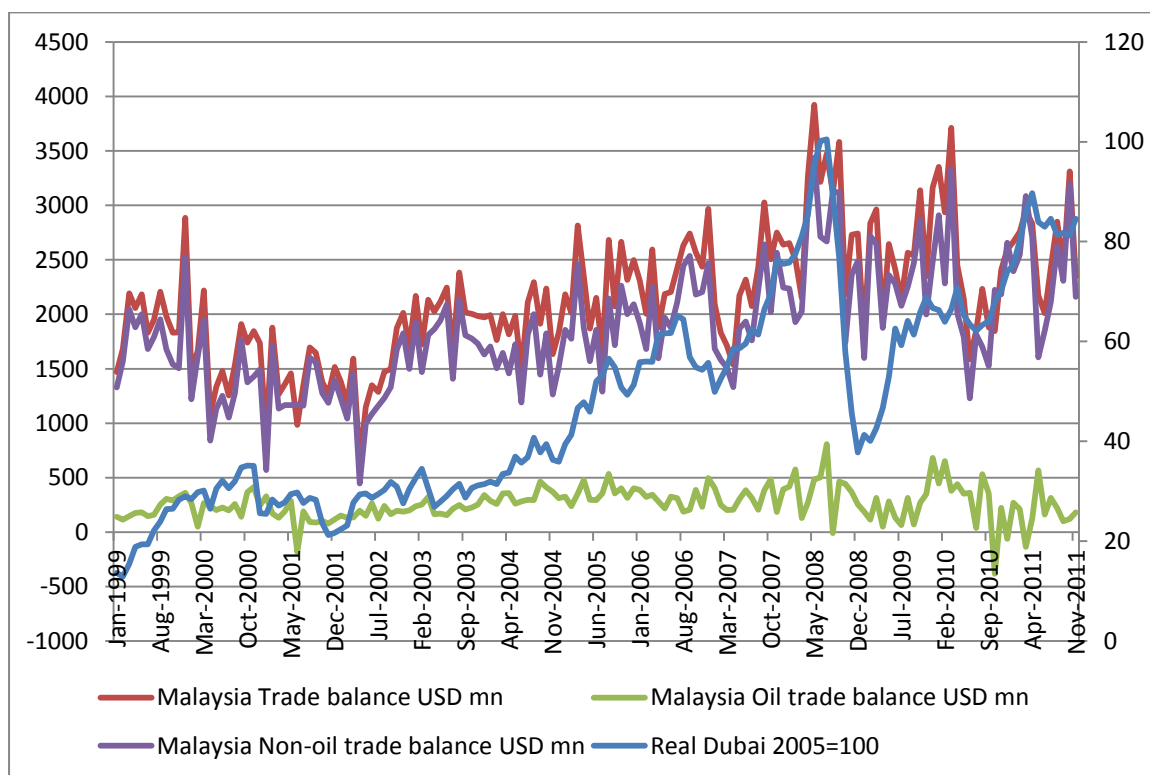
**January 1999 to November 2011**

	Oil price	Trade balance	Oil trade balance	Non-oil trade balance
<b>Japan</b>				
Oil price	1	---	---	---
Trade balance	-0.516**	1	---	---
Oil trade balance	-0.929**	0.484**	1	---
Non-oil trade balance	-0.048	0.860**	-0.029	1
<b>Singapore</b>				
Oil price	1	---	---	---
Trade balance	0.512**	1	---	---
Oil trade balance	-0.376**	0.146	1	---
Non-oil trade balance	0.646**	0.927**	-0.235**	1
<b>Malaysia</b>				
Oil price	1	---	---	---
Trade balance	0.693**	1	---	---
Oil trade balance	0.261**	0.381**	1	---
Non-oil trade balance	0.671**	0.967**	0.132	1

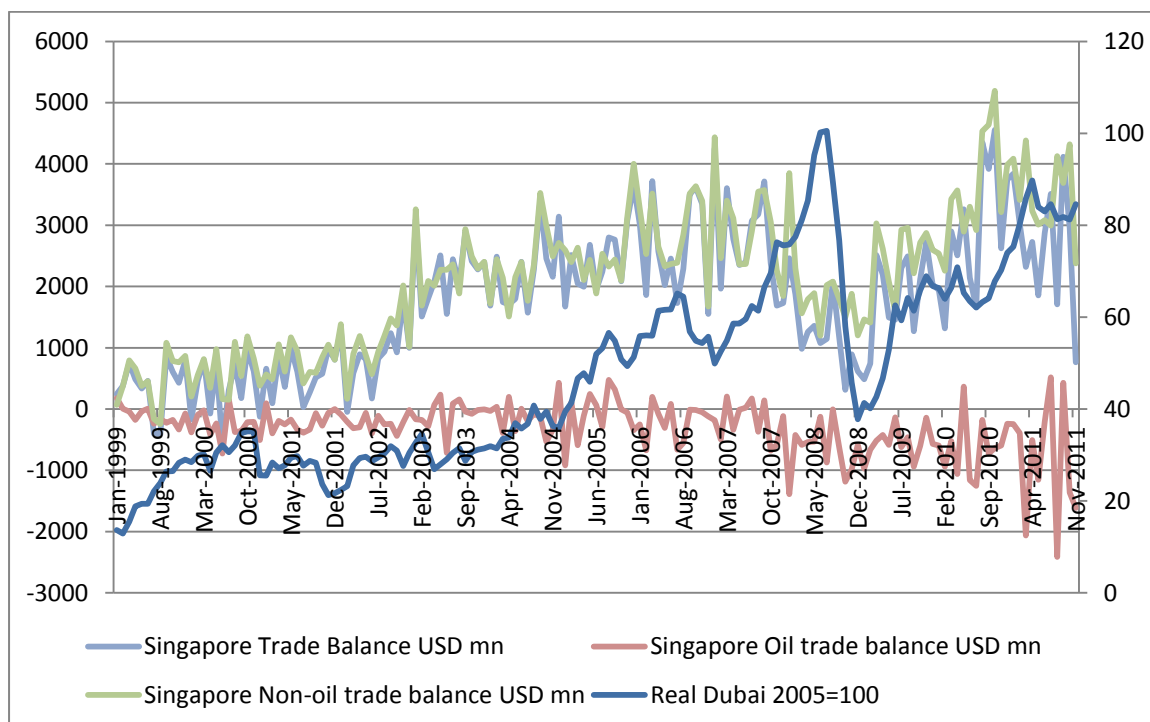
Note: \* and \*\* denote significance at 5% and 1% levels, respectively.



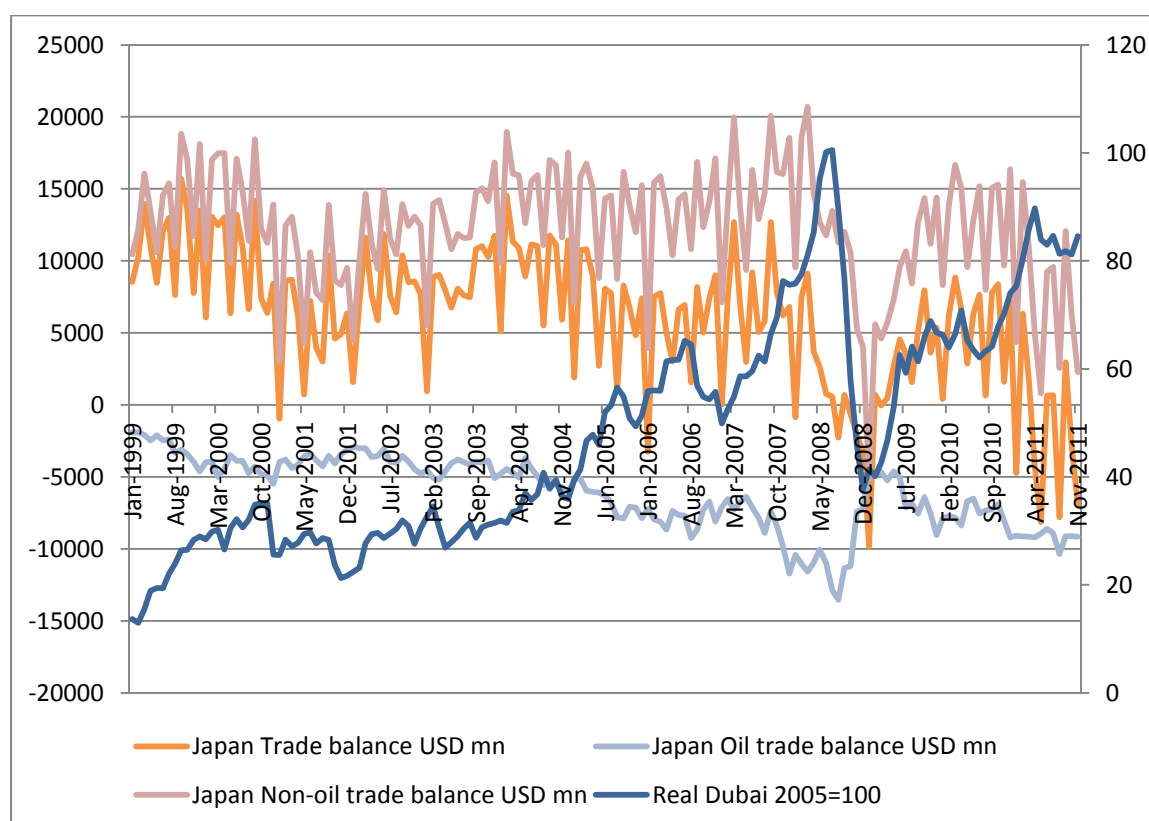
**Figure 3.1: World oil prices and Malaysia's external balances**



**Figure 3.2: World oil prices and Singapore's external balances**



**Figure 3.3: World oil prices and Japan's external balances**



Plots of Dubai oil prices against overall trade balances and their oil and non-oil components (all are in nominal US dollars) are presented in Figure 3.1, 3.2 and 3.3 for Malaysia, Singapore and Japan, respectively. Some observations can be made directly from the plots. First, most of the series, except for oil trade balances, are remarkably volatile. Second, overall trade balances and their non-oil components are strongly move in tandem for all of the selected economies. Third, the most dramatic shifts in overall trade balances and their non-oil components are synchronous with movements of crude oil prices for most of the countries. Fourth, there is a negative co-movement between Dubai crude oil prices and oil trade balances for the Japanese case. Last but not least, the plots seem to suggest that there are structural breaks in the data series. Observed structural breaks correspond to events that have economic and geopolitical aspects, e.g., December 2002 (energy crises), July 2008 (oil and subprime crisis).

### 3.4. Econometric framework

This section highlights the econometric framework used to study the cointegrating relationships between the variables of interest as well as to examine the long-run causality from oil price shocks to trade balances and their oil and non-oil components and the short-run impacts of the former on the latter.

#### 3.4.1. Unit root tests

Since the TY procedure requires determining the maximum order of integration of the series, this study first examined the time series properties of the variables in the models by using both the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test. The null of KPSS, namely stationarity, differs from the null of ADF, which is non-stationarity and so it provides a good cross-check at conventional levels of significance.

A break in the deterministic trend affects the outcome of unit root tests. Several studies have found that the conventional unit root tests fail to reject the unit root hypothesis for series that are actually trend stationary with a structural break. The work by Zivot and Andrews (ZA hereafter) (1992) provides methods that treat the occurrence of the break date as unknown. Hence, the ZA test (with allowing for a single break in both intercept and trend) is employed to account for an endogenous structural break in the data series.

To test for a unit root against the alternative of trend stationary process with a structural break, the following regression is used:

$$y_t = \mu + \theta DU_t(\tau_b) + \beta t + \gamma DT_t(\tau_b) + \alpha y_{t-1} + \sum_{i=1}^k \varphi_i \Delta y_{t-i} + \varepsilon_t \quad [\text{Eq. 3.11}]$$

where  $DU_t(\tau_b) = 1$  if  $t > \tau_b$  and 0 otherwise, and  $DT_t(\tau_b) = t - \tau_b$  for  $t > \tau_b$  and 0 otherwise.  $\Delta$  is the first difference operator and  $\varepsilon_t$  is a white noise disturbance term with variance  $\sigma^2$ .  $DU_t$  is a sustained dummy variable that captures a shift in the intercept, and  $DT_t$  represents a shift in the trend occurring at time  $\tau_b$ . The model accommodates the possibility of a change in the intercept as well as a broken trend. The breakpoint is estimated by the ordinary least squares (OLS) for  $t = 2, 3 \dots T-1$ , and the breakpoint  $\tau_b$  is selected by the minimum t-stat ( $t_{\hat{\alpha}}$ ) on the coefficient of the autoregressive variable.  $t_{\hat{\alpha}}$  is the one-sided t-stat for testing  $\alpha = 1$  in the model. The lag length  $k$  is determined using the general to specific approach adopted by Perron (1989). The null of a unit root is rejected if  $t_{\hat{\alpha}} < k_{inf,\alpha}$  where  $k_{inf,\alpha}$  denotes the size  $\alpha$  left-tail critical value.

### 3.4.2. The Gregory-Hansen (1996) cointegration analysis

Different methodological alternatives have been proposed in econometric literature to empirically analyze the long-run relationships and dynamics interactions between time-series variables. The two-step procedure of Engle and Granger (1987) and the full information maximum likelihood-based approach of Johansen (1988) and Johansen and Juselius (1990) are the most widely used methods. The cointegration frameworks in these studies, however, have limitations when dealing with data as major economic events may affect the data generating process. In the presence of structural breaks, tests for the null hypothesis of cointegration are severely oversized in which they tend to reject the null hypothesis despite one with stable cointegrating parameters. The presence of structural breaks in turn leads to inefficient estimation and lower testing power (Gregory et al., 1996). The sensitivity of the outcome of the tests to structural breaks has been documented in several studies (e.g., Wu, 1998; Lau and Baharumshah, 2003). This study thus employs the Gregory and Hansen (GH

hereafter) (1996) tests for cointegration to account for the possible presence of a structural break as suggested from the preliminary observations.

The GH (1996) tests for threshold cointegration explicitly incorporate a break in the cointegrating relationship. The GH statistics can be seen as a multivariate extension of the endogenous break univariate approach and enable to test for cointegration by taking into account for a breaking cointegrated relationship under the alternative. This approach is implemented to take into account breaks occurred in the three selected Asian economies. The cointegration procedure consists of two steps. First, as suggested by Gregory and Hansen (1996), the Hansen (1992)'s linearity (instability) tests are performed to determine whether the cointegrating relationship has been subject to a structural change. The  $L_C$  test is employed to verify whether the long-run relationship between oil price shocks and trade balances (and their oil and non-oil components) in each economy is subject to a break. The  $L_C$  statistic is recommended when the likelihood of parameter variation is relatively constant throughout the sample. As to the second step, cointegration tests are conducted by allowing a break in the long-run equation, following the approach suggested by Gregory and Hansen (1996). The advantage of this test is the ability to treat the issue of a break (which can be determined endogenously) and cointegration altogether.

The GH test allows to assess if the cointegration amongst the variables of interest holds over a first period of time and then, in a priori unknown period  $T_b$  (the timing of the change point), it shifts to another long run relationship. Three different models are employed in this study corresponding to the three different assumptions concerning the nature of the shift in the cointegrating vector: the level shift model (C), the level shift with trend model (C/T) and the regime shift model (C/S). To model the structural change, the step dummy variable  $D_t(T_b)$  is defined as:  $D_t(T_b) = 1$  if  $t > T_b$  where  $1(\cdot)$  denotes the indicator function, and

$D_t(T_b) = 0$  otherwise. The three models: C, C/T and C/S representing the general long-run relationship are respectively defined as following:

$$y_t = \mu + \theta D_t(T_b) + \alpha' x_t + u_t \quad [\text{Eq. 3.12}]$$

$$y_t = \mu + \theta D_t(T_b) + \alpha' x_t + \beta t + u_t \quad [\text{Eq. 3.13}]$$

$$y_t = \mu + \theta D_t(T_b) + \alpha' x_t + \delta' x_t D_t(T_b) + u_t \quad [\text{Eq. 3.14}]$$

where  $y_t$  is a scalar variable,  $x_t$  is a m-dimensional vector of explanatory variables (both  $x_t$  and  $y_t$  are supposed to be  $I(1)$ ),  $u_t$  is the disturbance term, parameters  $\mu$  and  $\theta$  measure respectively the intercept before the break in  $T_b$  and the shift occurred after the break, while  $\alpha$  are the parameters of the cointegrating vector,  $\beta$  is the trend slope before the shift, and  $\delta$  is the change in the cointegrating vector after the shift.

The standard methods to test for the null hypothesis of no cointegration are residual-based. OLS were employed to estimate equations (3.12), (3.13) and (3.14), and then a unit root test was applied to the regression errors (Gregory and Hansen, 1996). The time break is treated as unknown and is estimated with a data dependent method, i.e. it is computed for each break point in the interval  $[0.15T, 0.85T]$  where  $T$  denotes the sample size (Zivot and Andrews, 1992). The date of the structural break will correspond to the minimum of the unit root test statistics computed on a trimmed sample.

### 3.4.3. The Toda-Yamamoto (1995) approach

Following GH test, this study employed the TY methodology to do causality test. The most common way to test for causal relationships between two variables is the Granger causality proposed by Granger (1969) but it has probable shortcomings of specification bias and

spurious regression (Gujarati, 1995). In order to avoid the shortcomings, the TY procedure is adopted to improve the power of the Granger-causality test. The procedure is a methodology of statistical inference, which makes parameter estimation valid even when the VAR system is not co-integrated. One advantage of the TY procedure is that it makes Granger-causality test much easier as researchers do not have to test for cointegration or transform VAR into ECM. This interesting yet simple procedure requires the estimation of an augmented VAR that guarantees the asymptotic distribution of the Wald statistic, since the testing procedure is robust to the integration and cointegration properties of the process. In other words, this technique is applicable irrespective of the integration and cointegration properties of the system, and fitting a standard VAR in the levels of the variables rather than first differences like the case with the Granger causality test. Thereby, the risks associated with possibly wrongly identifying the orders of integration of the series, or the presence of cointegration are minimized and so are the distortion of the tests' sizes as a result of pre-testing (Giles, 1997; Mavrotas and Kelly, 2001).

The method involves using a Modified Wald statistic for testing the significance of the parameters of a VAR(p) model where p is the optimal lag length in the system. The estimation of a VAR(p+d<sub>max</sub>) guarantees the asymptotic  $\chi^2$  distribution of the Wald statistic, where d<sub>max</sub> is the maximum order of integration in the model. In this study, the lag lengths in the causal models were selected based on the Schwarz Bayesian Information Criteria (SIC) and the VAR was made sure to be well-specified by, for instance, ensuring that there is no serial correlation in the residuals. If need be, the lag length was increased until any autocorrelation issues are resolved. Needless to say, the system must satisfy the stability conditions and the common assumptions to yield valid inferences. The null of “no Granger causality” is rejected if the test statistic is statistically significant. Rejection of the null

implies a rejection of Granger non-causality. That is, a rejection supports the presence of Granger causality.

#### **3.4.4. Generalized impulse response analysis**

The TY procedure provides a powerful means for long-run Granger causality tests but it does not tell how the series respond when there is a shock in one of the variables within the system. A number of prior studies in literature use the sum of the coefficients to indicate the sign of the causality but it may produce misleading results as there are all of the dynamic effects between the equations that have to be taken into account. If the response function is positive for all periods, fading away to zero, it can be interpreted that the sign of the causality is positive. If it is positive, then negative, and then dampens down, it may not be interpreted that there is a clear-cut sign of causality. Instead, it could be said that the sign depends on the time horizon. That is precisely what an IRF does.

To identify the sign of causality, this study employed a generalized impulse response analysis developed by Koop et al. (1996) and Pesaran and Shin (1998). The generalized approach is superior to the traditional approach as it is not subject to the orthogonality critique. In the traditional impulse response analysis, the results are sensitive to the order of the variables in the system. The generalized approach, however, does not have this shortcoming.



### 3.5. Empirical results

#### 3.5.1. Entire sample: January 1999 to November 2011

The results of unit root tests without and with accounting for a structural break are respectively reported in Table 3.3 and 3.4. The finding is mixed in a few cases but the common suggestion of the unit root tests is that in level, most of the series are nonstationary while in first difference, most of the variables are stationary. This finding leads to conclude that the maximum order of integration for all groups of variables in the three economies is 1.

**Table 3.3: Results of unit root tests without accounting for a structural break:  
January 1999 to November 2011**

		ADF	KPSS
Variables in level			
	Dubai	-1.714 (1)	1.349***
Japan	Trade balance	-1.431 (12)	1.028***
	Oil trade balance	-2.260 (0)	1.190***
	Non-oil trade balance	-2.849 (12)*	0.247
	Industrial production	-3.297 (12)**	0.161
	Exchange rate	-1.781 (1)	0.268
Singapore	Trade balance	-2.353 (2)	0.889***
	Oil trade balance	-3.336 (2)**	1.176***
	Non-oil trade balance	-1.677 (3)	1.145***
	Industrial production	-1.133 (2)	1.372***
	Exchange rate	0.405 (0)	0.935***

Malaysia	Trade balance	-2.558 (2)	1.197***
	Oil trade balance	-4.359 (2)***	0.387*
	Non-oil trade balance	-2.679 (2)*	1.237***
	Industrial production	-1.493 (12)	1.361***
	Exchange rate	-0.356 (1)	0.993***
Variables in first difference			
	Dubai	-7.956 (0)***	0.025
Japan	Trade balance	-4.169 (11)***	0.268
	Oil trade balance	-13.554 (0)***	0.034
	Non-oil trade balance	-3.940 (11)***	0.316
	Industrial production	-2.746 (11)*	0.056
	Exchange rate	-9.819 (0)***	0.236
Singapore	Trade balance	-11.300 (2)***	0.171
	Oil trade balance	-9.713 (4)***	0.168
	Non-oil trade balance	-11.258 (2)***	0.430*
	Industrial production	-14.090 (1)***	0.180
	Exchange rate	-10.678 (0)***	0.697**
Malaysia	Trade balance	-13.966 (1)***	0.194
	Oil trade balance	-10.034 (3)***	0.271
	Non-oil trade balance	-14.343 (1)***	0.500*
	Industrial production	-3.230 (11)**	0.389*
	Exchange rate	-9.481 (0)***	0.329

Note: Lag lengths are in parentheses. The critical values (without trend) for ADF and KPSS tests are respectively: at 1% = -3.47 and 0.74; at 5% = -2.88 and 0.46; at 10% = -2.58 and 0.35. \*, \*\* and \*\*\* denotes significance at 10%, 5% and 1% levels.

**Table 3.4: Results of Zivot-Andrews unit root tests with accounting for an endogenous structural break: January 1999 to November 2011**

		Lag	t-stat	Break point
Variables in level				
	Dubai	2	-5.296**	2008M09
Japan	Trade balance	2	-4.219	2002M02
	Oil trade balance	4	-5.660***	2008M11
	Non-oil trade balance	2	-4.202	2008M05
	Industrial production	2	-5.255**	2008M12
	Exchange rate	1	-3.728	2006M06
Singapore	Trade balance	3	-4.944*	2007M10
	Oil trade balance	4	-6.836***	2007M10
	Non-oil trade balance	4	-4.549	2008M02
	Industrial production	2	-4.725	2008M04
	Exchange rate	1	-3.283	2005M04
Malaysia	Trade balance	3	-5.530**	2002M10
	Oil trade balance	2	-5.303**	2003M12
	Non-oil trade balance	3	-5.634**	2002M09
	Industrial production	2	-4.268	2008M09
	Exchange rate	2	-3.052	2004M02
Variables in first difference				
	Dubai	0	-8.645***	2008M07
Japan	Trade balance	3	-11.049***	2009M03

	Oil trade balance	3	-6.033***	2008M09
	Non-oil trade balance	3	-10.143***	2009M04
	Industrial production	1	-19.977***	2009M05
	Exchange rate	4	-7.638***	2001M08
	Trade balance	3	-9.776***	2009M03
Singapore	Oil trade balance	4	-9.842***	2009M03
	Non-oil trade balance	3	-10.255***	2009M03
	Industrial production	4	-8.580***	2009M06
	Exchange rate	0	-11.257***	2008M05
	Trade balance	3	-8.274***	2008M10
Malaysia	Oil trade balance	3	-10.182***	2001M07
	Non-oil trade balance	1	-14.449***	2008M10
	Industrial production	1	-14.544***	2001M07
	Exchange rate	4	-4.290	2009M08

Note: The critical values for Zivot and Andrews test (with intercept and trend) are -5.57, -5.08 and -4.82 at 1%, 5% and 10% levels of significance respectively. \*, \*\* and \*\*\* denote significance at 10%, 5% and 1% levels, respectively.

Following the modeling approach described earlier, this study next tested for the instability of the long run relationship between oil prices and trade balances and their oil and non-oil components with the inclusion of two control variables: real exchange rate and industrial production. The test statistics  $L_C$  are reported in Table 3.5.

**Table 3.5: Hansen (1992)'s instability test results: January 1999 to November 2011**

Dependent variable:		Japan	Singapore	Malaysia
Trade balance	$L_C$	0.666	0.615	1.040*
		(0.147)	(0.183)	(0.028)
Oil trade balance	$L_C$	0.587	1.983**	1.481**
		(> 0.2)	(< 0.01)	(< 0.01)
Non-oil trade balance	$L_C$	1.043*	0.845	0.889
		(0.028)	(0.064)	(0.053)

Note: \* and \*\* denote significance, i.e. rejection of the null hypothesis of stability at 5% and 1% levels, respectively.  $L_C$  tests are performed by Eviews 7. Numbers in (.) are p-values. C and @TREND are used as deterministic regressors, and no lags are specified.

The results show that, at 10% level, there is not enough evidence to accept the null of stability in most of the long-run equations, since most of the test statistics are significant at the 10% level. The only two exceptions are the trade balance equations of Japan and Singapore. The findings, however, dramatically change if the test results are considered at 1% significance level. Most of the long-run relationships are stable at 1% level. The only two exceptional cases are the oil trade balance equations of Singapore and Malaysia.

The next step, as presented earlier, was conducting the threshold cointegration tests by Gregory and Hansen (1996). They provide an alternative approach with tests that are based on the notion of regime change and are a generalization of the usual residual-based cointegration test. These tests allow for an endogenous structural break in the cointegration. This study then investigated the presence of a cointegrating relationship under a structural shift between oil prices and trade balances (and their oil and non-oil components), controlling

for real output and real exchange rate, and compute modified versions of the cointegration ADF tests of Engle and Granger (1987), as well as modified  $Z_t$  and  $Z_\alpha$  tests of Phillips and Ouliaris (1990), i.e.

$$ADF^* = \inf_{T_b} ADF(T_b) \quad [\text{Eq.3.15}]$$

$$Z_t^* = \inf_{T_b} Z_t(T_b) \quad [\text{Eq. 3.16}]$$

$$Z_\alpha^* = \inf_{T_b} Z_\alpha(T_b) \quad [\text{Eq. 3.17}]$$

All the three statistics obtained from the C, C/T and C/S models are reported for comparison, where the lag  $k$  was set as in Perron (1997), following a general to specific procedure. The results of the GH threshold cointegration tests are presented in Table 3.6. It indicates that there is not enough evidence to accept the null of no cointegration for most of the equations in the three selected economies. The results seem invariant to the model specifications (C, C/T or C/S). The existence of a cointegration relationship among national trade (oil and non-oil) balance, industrial production and exchange rate, and world oil price, indicates that allowing for structural change in the cointegration relation, the series “move together” in the long run, and they share a common stochastic trend although in the short run the series may diverge from each other. In the presence of structural breaks, however, such cointegration relationships can be used in making forecasts. For example, more accurate forecasts of national trade balances can be made based on available information of world oil price, national industrial production and exchange rate using the cointegration relationship among these variables. The use of error correction models in forecasting has minimal requirement on data because past information on the three explanatory variables can be easily obtained. Such forecast information can be used to guide government decision making on trade policy matters such as trade balance and volatility management, thus increasing economic efficiency.

**Table 3.6: Gregory and Hansen (1996) Cointegration Test Results:**

**January 1999 to November 2011**

Dependent variable:		Trade balance	Oil trade balance	Non-oil trade balance
Japan				
Level shift C	ADF*	-4.192 (4)	-6.254 (5)**	-3.356 (2)
		[2008M12]	[2008M12]	[2001M10]
	$Z_{\alpha}^*$	-136.120**	-99.600**	-154.010**
		[2009M02]	[2009M03]	[2009M02]
	$Z_t^*$	-10.904**	-8.525**	-11.996**
		[2009M02]	[2009M03]	[2009M02]
	ADF*	-3.817 (3)	-6.722 (5)**	-3.333 (2)
		[2009M05]	[2009M05]	[2001M10]
	$Z_{\alpha}^*$	-144.037**	-107.272**	-157.506**
		[2009M02]	[2009M01]	[2009M02]
Regime shift C/S	$Z_t^*$	-11.368**	-9.006**	-12.266**
		[2009M02]	[2009M01]	[2009M02]
	ADF*	-4.909 (3)	-7.410 (5)**	-4.456 (2)
		[2009M04]	[2008M11]	[2008M11]
	$Z_{\alpha}^*$	-152.573**	-103.801**	-176.814**
		[2008M11]	[2007M12]	[2008M11]
	$Z_t^*$	-12.059**	-8.805**	-13.774**
		[2008M11]	[2007M12]	[2008M11]
Singapore				
Level shift C	ADF*	-6.704 (1)**	-7.529 (3)**	-10.249 (0)**
		[2002M09]	[2007M10]	[2002M09]
	$Z_{\alpha}^*$	-133.843**	-205.859**	-126.247**

		[2002M11]	[2007M09]	[2002M09]
	$Z_t^*$	-10.768**	-17.529**	-10.305**
		[2002M11]	[2007M10]	[2002M11]
	ADF*	-10.491 (0)**	-7.612 (3)**	-10.070 (0)**
Level shift		[2007M11]	[2007M10]	[2007M12]
with trend	$Z_\alpha^*$	-135.895**	-205.749**	-124.935**
C/T		[2007M10]	[2007M11]	[2007M12]
	$Z_t^*$	-10.768**	-17.552**	-10.141**
		[2002M11]	[2007M10]	[2002M09]
	ADF*	6.822 (1)**	-7.361 (3)**	-10.353 (0)**
		[2002M10]	[2002M08]	[2002M09]
Regime shift	$Z_\alpha^*$	-136.608**	-207.459**	-128.867**
C/S		[2002M11]	[2007M11]	[2002M11]
	$Z_t^*$	-10.944**	-17.777**	-10.479**
		[2002M11]	[2007M10]	[2002M11]
Malaysia				
	ADF*	-5.492 (3)*	-5.447 (6)*	-5.665 (3)*
		[2002M12]	[2000M11]	[2002M12]
Level shift	$Z_\alpha^*$	-118.306**	-151.461**	-128.277**
C		[2003M02]	[2001M02]	[2003M02]
	$Z_t^*$	-9.846**	-12.112**	-10.440**
		[2003M01]	[2001M02]	[2003M02]
	ADF*	-5.583 (3)*	-5.441 (6)	-5.664 (3)*
Level shift		[2007M11]	[2000M11]	[2002M12]
with trend	$Z_\alpha^*$	-117.094**	-152.138**	-128.081**
C/T		[2003M01]	[2007M12]	[2003M02]
	$Z_t^*$	-9.777**	-12.181**	-10.428**



		[2003M01]	[2007M12]	[2003M02]
	ADF*	-5.869 (3)	-5.718 (6)	-5.846 (3)
		[2002M12]	[2009M04]	[2002M10]
Regime shift	$Z_{\alpha}^*$	-125.615**	-156.226**	-131.794**
C/S		[2002M09]	[2009M10]	[2002M09]
	$Z_t^*$	-10.331**	-12.498**	-10.704**
		[2002M09]	[2009M10]	[2002M09]

Note: \* and \*\* denote significance, i.e. rejection of the null hypothesis of no cointegration at 5% and 1% levels, respectively. Numbers in (.) are lag orders to include in equations. Time breaks are in [.]. 5% critical values for level shift, level shift with linear trend, regime shift models based on Gregory and Hansen (1996, Table 1, m=3) are respectively -5.28, -5.57, and -6.00 for ADF\* and  $Z_t^*$ , and are -53.58, -59.76 and -68.94 for  $Z_{\alpha}^*$ . 1% critical values for level shift, level shift with linear trend, regime shift models based on Gregory and Hansen (1996, Table 1, m=3) are respectively -5.77, -6.05, and -6.51 for ADF\* and  $Z_t^*$ , and are -63.64, -70.27 and -80.15 for  $Z_{\alpha}^*$ .

The Hansen (1992) instability tests do not support for the presence of structural change at 1% level for most of the equations and the GH cointegration test suggests that there is a long-run (equilibrium) relationship between oil prices and trade balances (and their oil and non-oil components) in most of the economies in this study. This finding suggests that there would be possible causality between these variables and such a possibility is explored by conducting the TY procedure. As mentioned in the previous section, to set the stage for the TY test, the order of integration of the variables was initially determined using the results from the unit root tests. The appropriate lag structures are determined to include in the VAR models using the SIC. The lag length, if needed, was increased until there is no serial correlation in the residuals. All estimated VAR systems are stable. The TY test is employed to specifically investigate if there is causality running from oil price to trade balance including its oil and non-oil components. Table 3.7 presents the results.

The oil price appears to Granger-cause the trade balance and the oil trade balance of Malaysia. This is expected as crude oil has, over the years, contributed to the country's development in its own ways and superseded other resources in becoming the major fuel of Malaysia's economic growth. The oil and gas sector accounts for 30% of the economy's manufacturing income and about 8% of the annual GDP. As a major oil producer and exporter of the region, no doubt that Malaysia benefits from the rising oil price. The higher oil prices would raise the national income and the government's revenue. According the national oil company (Petronas), it has paid the government a total of RM403.3 billion between 1974 and 2008.

**Table 3.7: Toda-Yamamoto Non-Causality Test Results:**

**January 1999 to November 2011**

Null hypothesis		Japan	Singapore	Malaysia
Oil price → Trade balance	Lag	3	3	3
	Wald statistic	1.995	3.353	9.036*
	p-value	0.573	0.340	0.029
Oil price → Oil trade balance	Lag	1	3	3
	Wald statistic	65.297**	8.082*	8.033*
	p-value	0.000	0.044	0.045
Oil price → Non-oil trade balance	Lag	3	2	3
	Wald statistic	8.262*	0.301	5.971
	p-value	0.041	0.860	0.113

Note: Lag lengths were determined based on Schwarz Information Criterion (SIC). \* and \*\* denote significance, i.e. rejection of the null hypothesis of no causality at 5% and 1% levels, respectively.

For Japan, the results show that the oil price Granger-causes the oil and non-oil components of its trade balances. This is not surprising since Japan is a major industrialized economy which is highly dependent on oil so as to meet 45% of its energy needs. Japan is always among the top oil consumers of the world for decades and the country has virtually no domestic oil or gas reserves; as a result, its oil consumption purely relies on imports from other countries. More interestingly, despite the causality found from oil price to Japan's oil and non-oil components, it is shown that there is no causality running from oil price to the country's overall trade balance. This suggests that the causality from oil price to Japan's oil trade balance and its non-oil trade balance may have opposite signs and may have canceled out each other. Since Japan has always been a major net oil importer (the 3<sup>rd</sup> largest oil consuming economy following the U.S. and China), oil price shocks are expected to negatively cause its oil trade balance. This, in turn, suggests that the impact of oil shocks on its non-oil trade balance is positive, which implies that the oil price shock to Japan arises from the demand side and this is similar to the argument by Kilian et al. (2009).

For Singapore, in contrast to the case of Japan, at 1 % level, there is not enough evidence on the existence of causal relationships among the oil price and all the three types of trade balances. Singapore is an interesting case. The economy has no domestic oil reserves but has operated as the oil trading center of Asia since the mid-1980s (Horsnell, 1997). Despite being a net oil importer, Singapore is one of the world's top three export refining center. The oil industry mainly imports crude oil from oil-producing countries and refines it before exporting. This process adds value to the raw material and hence makes it more valuable. Thus, in the case of Singapore, rising oil prices would come with both positive and negative impacts on the economy. The negative impact is a higher oil import bill whereas the positive one is the rising revenues from exporting oil refinery products. In the long run, the two

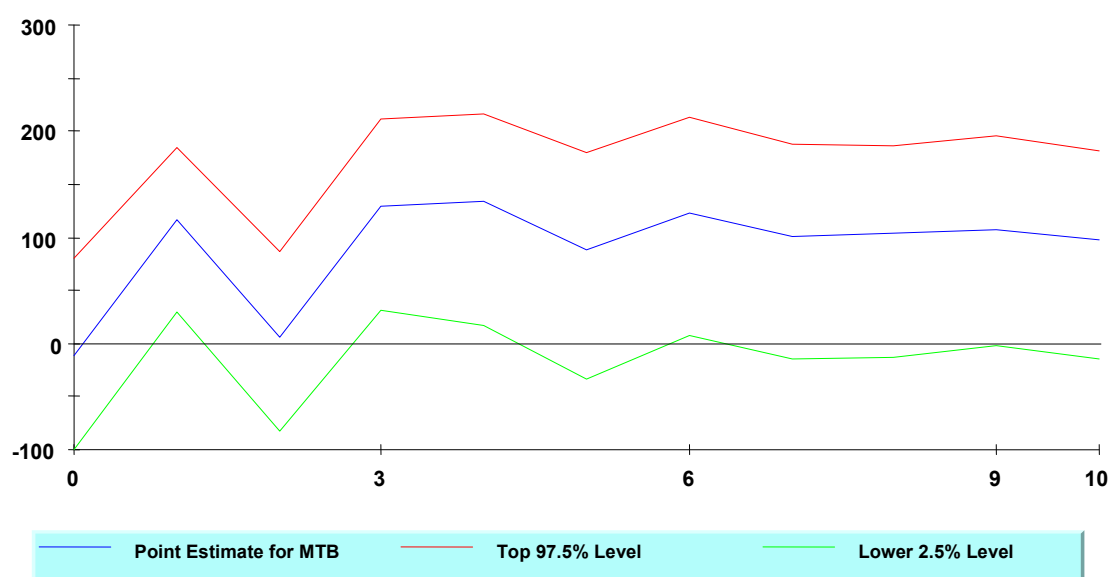
effects may cancel out each other, which lead to an insignificant long-run causality between the variables of interest.

The long-run causality analysis fails to establish causal linkages from oil prices to trade balances and their oil and non-oil components in a number of cases (e.g., none is found for Singapore) but there may still be short-run temporary effects. As this study focuses on the impact of the oil price shock on the trade balance as well as its oil and non-oil components, it only estimated the generalized IRFs of overall, oil and non-oil trade balances based on a one-standard deviation shock to the oil price for the three selected economies. Figure 3.4 illustrates the plots of the estimated IRFs. Before interpreting the IRFs, it is important to note here that the variables are found to be cointegrated from the previous section so that this study estimated the generalized IRFs based on VECM models of the variables. The roots of the characteristic polynomial of all models satisfy the stability condition in that they are all in the unit circle.

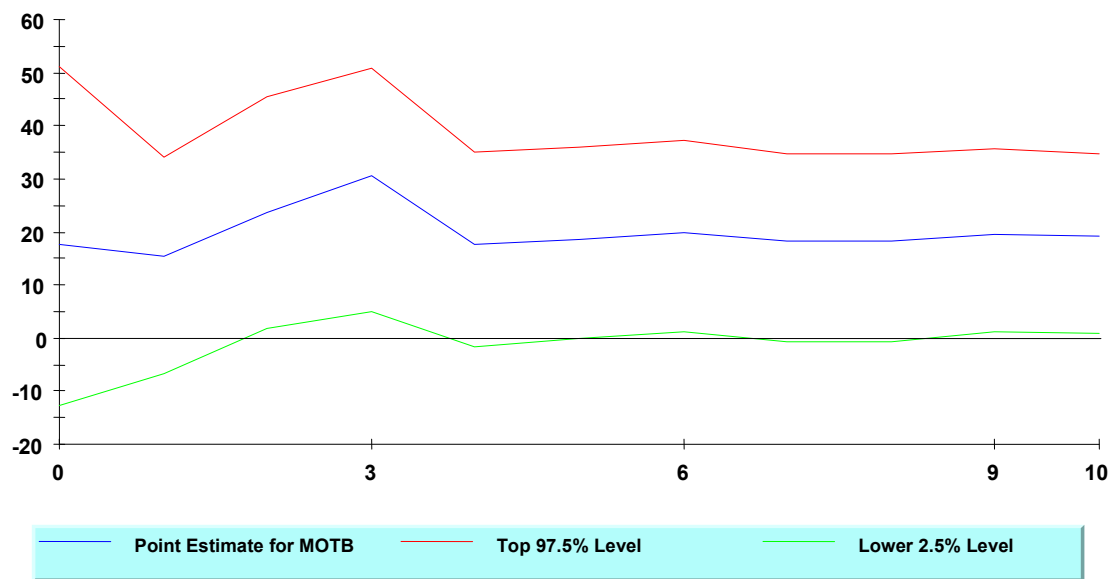
**Figure 3.4: Generalized IRFs based on VECMs: Jan – 1999 to Nov – 2011**

Malaysia

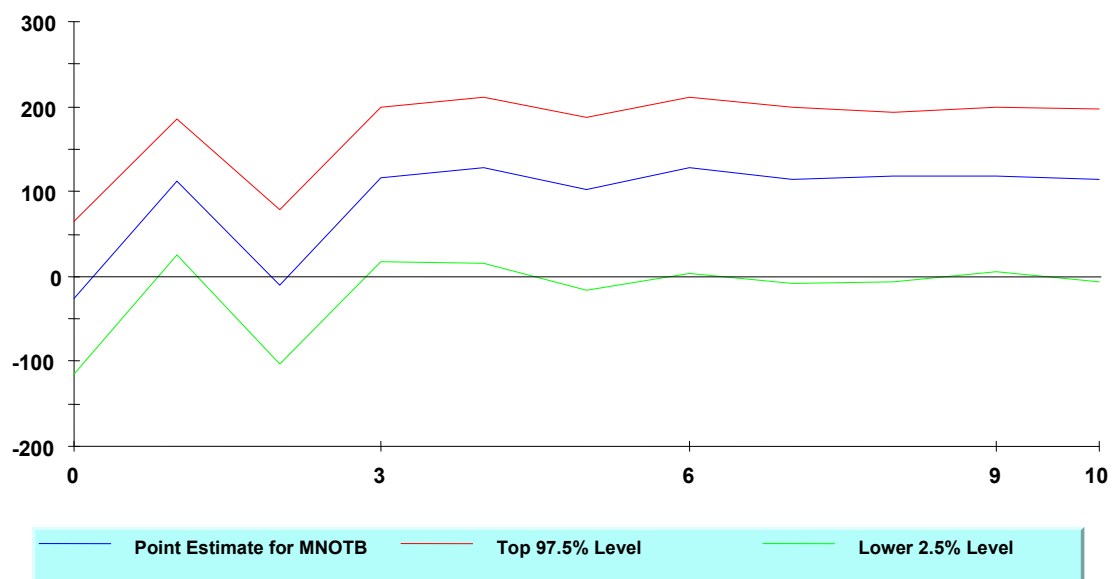
**Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price**



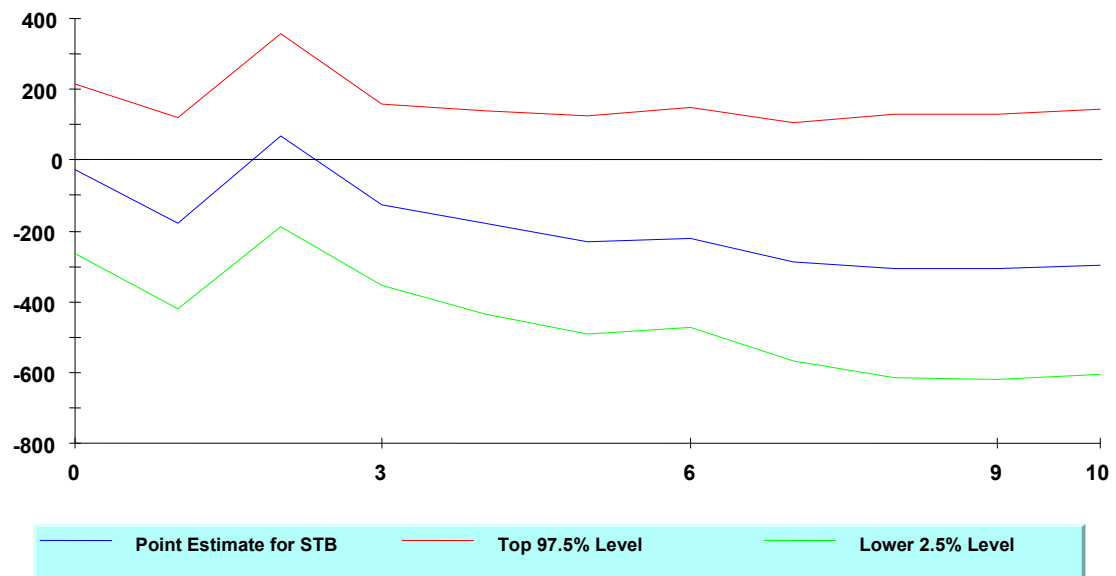
### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price



### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price



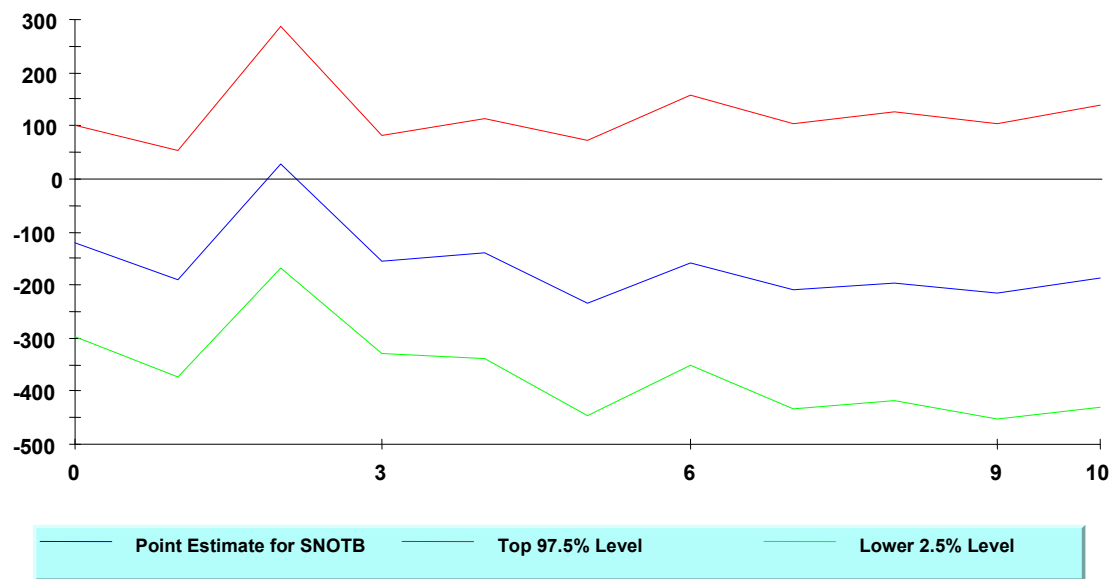
### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price



### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price

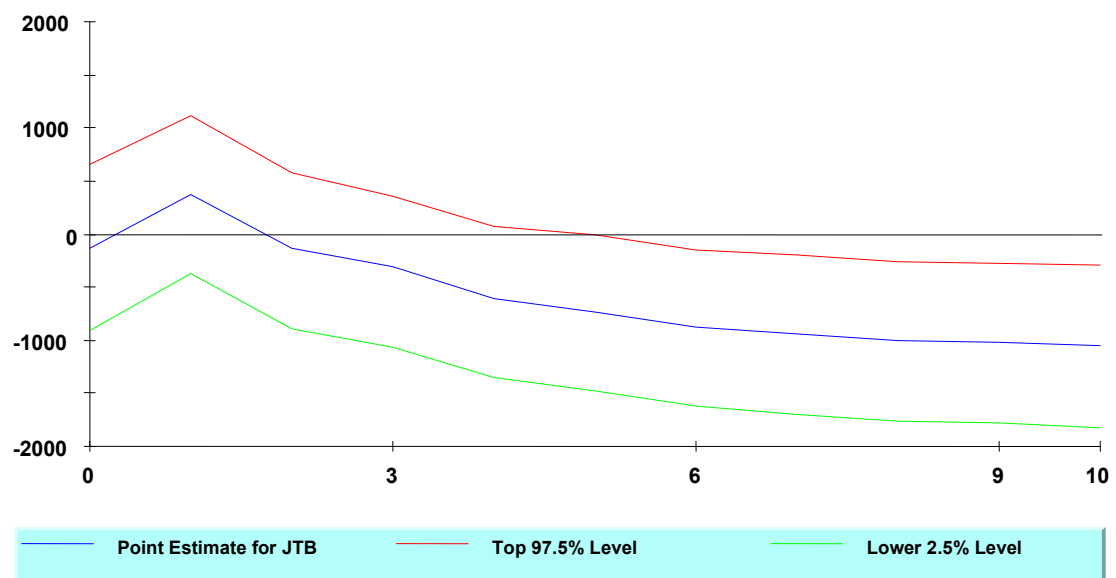


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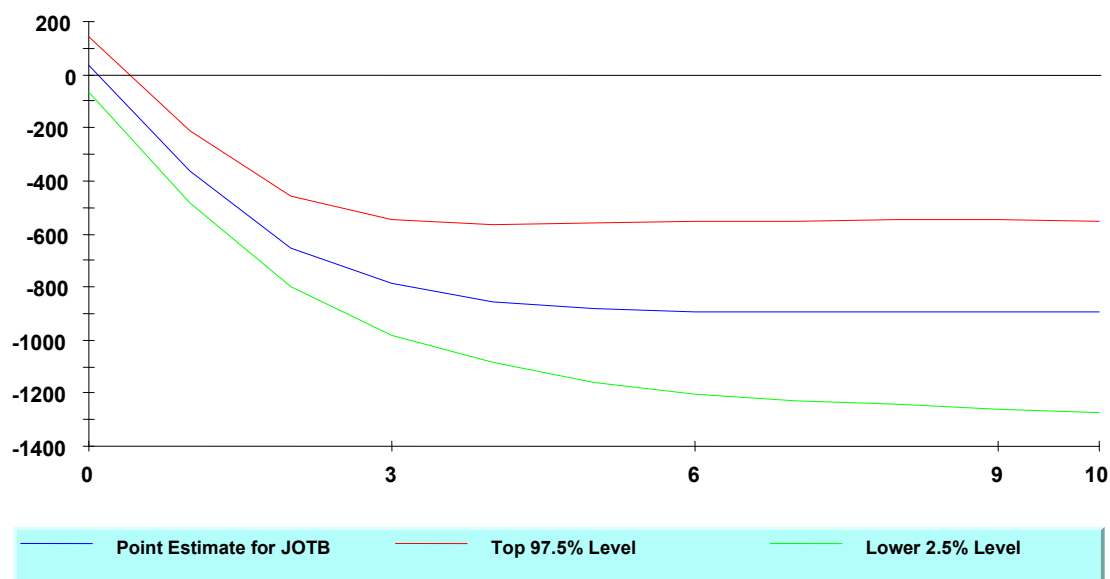


Japan

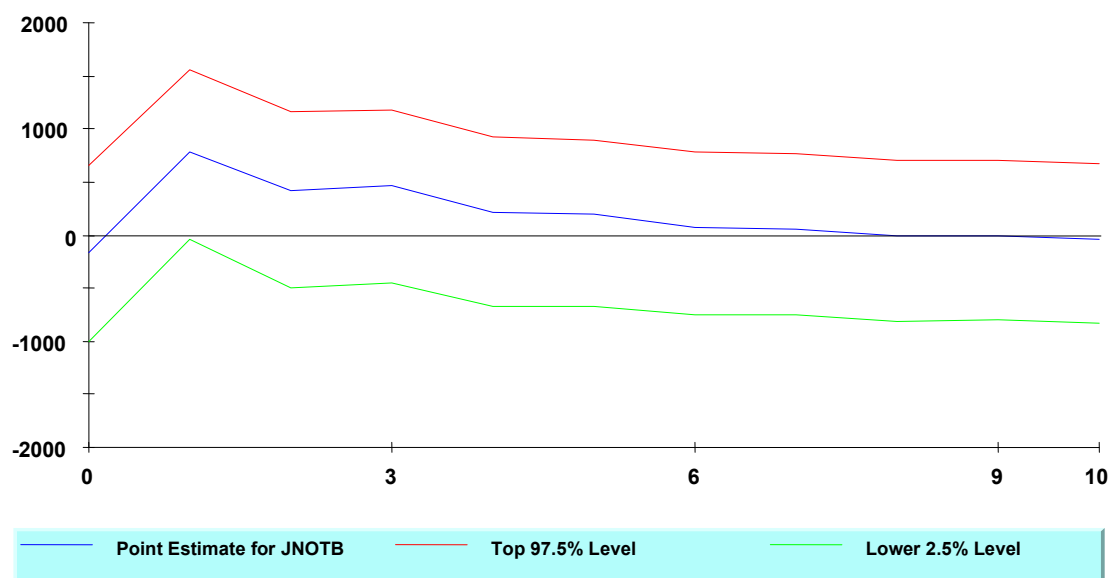
### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price



### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price



### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price



Note: OP denotes for the oil price; MTB, MOTB and MNOTB respectively denotes for Malaysia's overall, oil and non-oil trade balances; STB, SOTB and SNOTB respectively denotes for Singapore's overall, oil and non-oil trade balances; JTB, JOTB and JNOTB respectively denotes for Japan's overall, oil and non-oil trade balances.



As regards to the plots presented in Figure 3.4, for Malaysia, in general, all the responses of overall, oil and non-oil trade balances to the oil price shock over the 10-month horizon after the shock are positive though quite volatile. Overall, the results show that the feedback between oil price shocks and Malaysia's trade balances including their oil and non-oil balances is statistically significant and positive. This finding suggests that Malaysia's improvements in trade balances including their oil and non-oil components are associated with rising oil prices. In other words, for the Malaysia case, the direct positive effects of oil price hikes seem to outweigh the indirect negative effects. This finding shows a contradiction to findings from a structural VARX model by Abeysinghe (2001) in which it is found that, due to the indirect effect that is transmitted through a trade matrix, net oil exporters (Indonesia, Malaysia) cannot escape the negative influence of higher oil prices. The finding also explains that Malaysia has experienced unstable trade balances that are mainly due to the extreme volatility of world oil prices in the recent decade. This implies that, while high oil prices may benefit the economy with resulting trade surpluses, policy makers in Malaysia would need to control the oil price volatility so as to maintain the country's sustainable trade surpluses over time.

For Singapore, the short run responses of its overall trade balance and non-oil trade balance are relatively similar, which are persistently negative during the first 10 months after the shock. In contrast, the response of its oil trade balance seems fluctuating during the same periods, sometime increases and sometime decreases. The sign of the response is positive for 2 months (from the 3<sup>rd</sup> to the 4<sup>th</sup> month after the oil price shock) and negative for the rest of the 10 month-horizon. The results imply that, despite being the world's third largest oil refining industry, a rise in global oil prices seems to hurt Singapore's overall trade balance and their oil and non-oil components, at least in the short run. The results reflect the special characteristics of the oil industry of Singapore. Singapore is the largest oil refining and

trading center in the region but the country does not have oil reserves of its own and has to depend on the international market for all of its trading activities. The import dependence and export-oriented nature of the oil industry makes Singapore refineries more vulnerable to market changes than other refineries in the region. In recent years, the refiner's margin is declining due to price volatility and higher competition in the product market. Unlike almost every other country in the Asia-Pacific region, oil markets in the island are self-regulated with minimum government intervention. Given the fact that the economy has lived by international trade as well as its industrial life is heavily based on petroleum products, it is time for the authorities of Singapore to monitor oil price fluctuations so as to implement timely policies to sustain its overall trade balances. The government should work closely with the oil industry to improve energy efficiency and to accelerate the development of new, sustainable feedstock and technologies for the industry. These efforts will lower the industry's energy intensity.

For Japan, the overall trade balance responds positively from time to time during the first 5 months of the oil shock but persistently negative afterwards. For the non-oil trade balance, the response steadily increases and reaches its peak in the 4<sup>th</sup> month and decreases afterwards and dies out in the 9<sup>th</sup> month after the shock. The positive response of Japan's non-oil trade balance to oil price shocks seems to be consistent with what was concluded from the TY causality analysis. That is, for the Japan case, oil price shocks seem to be a shock from the demand side. This could explain for the fact that despite the economy's heavy dependence on oil imports and rising oil import prices, the non-oil trade balance still responds positively during the first 6-7 months after the shock. In contrast, the country's oil trade balance seems heavily dampened by the oil price shock. This could be explained due to the fact that the Japanese economy is highly dependent on oil but has no ability to produce and thus its oil demand would be very inelastic. When the price of oil increases sharply, the volume of its oil

imports, or the amount of oil imported, decreases only slightly. The substantial oil trade deficit seems to outweigh the positive non-oil trade balance after four months of the shock and thus results in the economy's overall trade deficit. In brief, this study concludes that an increase in the global oil price would heavily dampen the oil trade deficit of the economy, at least in the short run. This finding is attributable to the fact that Japan has virtually no domestic oil and gas reserves but it is always among top oil consumers of the world for decades. The economy has to purely depend on oil imports and could not avoid importing large quantities of oil and oil-based products from abroad to meet the domestic consumption and demand, especially from industrial sectors. A positive shock of the world oil price would worsen the oil trade deficit of Japan because now it would have to pay a higher price for the same quantity of oil that the economy demands, *ceteris paribus*. The findings show that Japan's overall trade deficit seems to be driven by its oil trade deficit, i.e. the surge in its oil imports, in the short run. This would suggest some policy implications for the Japanese authorities in order to reduce the trade balance variability. First, the oil industry in Japan is facing competition under the market mechanism. Japan's government should take responsibility for securing stable supplies of oil products in case of emergencies such as the 11<sup>th</sup> March earthquake, since stable energy supply is a pillar of the nation's security. Second, prompt actions should be taken to revise the energy policy so as to reduce the share of oil consumed in the primary energy mix as well as the share of oil used in the transportation sector and to expand the use of oil substitutes such as nuclear power and natural gas. For instance, high levels of investment in research and development of energy technology so as to increase energy efficiency should be encouraged.

### 3.5.2. Stability analysis

Since the results from Hansen instability tests seem to indicate that parameters in most of the equations are stable at 1% level but fail to do so at 10% level of significance, the abovementioned main findings of this study are investigated by the stability analysis. In order to confirm parameter stability using recursive residuals, CUSUM (cumulative sum) and CUSUM-sq (CUSUM squared) tests proposed by Brown et al. (1975) were performed. These tests depend on cumulative sum of recursive residuals that provides analysis of parameter variations. CUSUM cumulative sum of recursive residuals needs to remain within the boundaries of 5 % critical lines in order to ensure stability. The same is valid in CUSUM-sq. The results show that the stability of the parameters is confirmed through CUSUM for most of the models as the plots stayed within the critical bounds. Yet, the data do not provide enough evidence to accept the null of parameter stability through CUSUM-sq for all of the models as the CUSUM-sq statistic strays out the 95% confidence band.<sup>3</sup>

It is well known that the spot prices of crude oil have been profoundly influenced by events that have economic and geopolitical aspects (Kilian, 2010; Hamilton, 2009 and 2010). Since the oil industry has been established in 1870, it had undergone a long period of calm and stability in prices. The oil price has always fluctuated with varying conditions of global supply and demand. After the first oil crisis in 1973, the fluctuations became so much more volatile, and often times seemingly far larger than what could be explained by basic supply/demand constraints. The instability test results reflect the fact that there are several oil price shocks within the investigation period of this study (i.e., from January 1999 to November 2011) and not all oil price shocks are alike (Kilian, 2009). In early 1999, some oil price rises took place and reached their maximum in 2000, coinciding with a time when the growth rate of the economy and the level of world trade were particularly high. The oil

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<sup>3</sup> To conserve space, the results are not presented here but they are available upon request.

shocks in 2002-2003 were influenced mainly by the civil unrest in Venezuela, whilst oil price movements in 2003 were mostly affected by the Iraq war, the Nigerian civil war and hurricane disasters in the Gulf of Mexico. In 2005, the sharp rise of crude oil prices was the consequence of the surging demand from the most dynamic economies (such as China, India and the U.S.) and the low level of excess capacity. Despite this, the world economy was characterized by high rates of growth and low inflation rates. In 2007, there was weak economic growth, inflationary tensions and financial instabilities; crude oil prices continued to rise due to the strong demand from emerging economies and some speculation. In 2008, oil prices began to fall. During the whole of this period, movements in oil prices were greater in nominal terms and more persistent than in the first period.

Identifying sources of higher oil prices appears to be crucial in assessing the effects of higher oil prices on macroeconomic aggregates, suggesting that policies aimed at dealing with higher oil prices must take careful account of the origins of higher oil prices (Kilian, 2009). The interest of this study is to examine the impact of oil price shocks on trade balances and their oil and non-oil components and if the nature of oil price shocks could matter. The instability of the economic system may be reflected in the parameters of the estimated models that can induce misleading results when such parameters are used for inference or forecasting. This leads to declare estimating the models for different time periods more appropriate and insightful. In other words, besides the entire sample (January 1999 to November 2011), this study looks at the stability of the causal relationships established by splitting the sample into three to cover major events throughout the investigated period: for a first sub-sample (January 1999 to December 2002), for a second sub-sample (January 2003 to July 2008) and for a third sub-sample (August 2008 to November 2011).

The first breakpoint of December 2002 was chosen as there is clear evidence of persistent aggregate demand pressures on the price of crude oil (see Kilian, 2008a and b). Large and

sustained increases in the surge of oil prices since 2002 have been associated with increasing global demand for crude oil, along with other industrial commodities, especially when the ability to increase crude oil production in the near future is limited. This observation is important because it suggests that oil demand shocks may have played a central role in explaining earlier episodes of oil price shocks as well (Kilian, 2008a). There were the 2002/03 twin shocks that were associated with civil unrest in Venezuela and the Iraq War (Kilian, 2008b). The second breakpoint of July 2008 was chosen as oil price steadily rose between 2003 and July 2008 and achieved its peak in July 2008 and started to decline afterwards. High oil prices and economic weakness contributed to a demand contraction in late 2008. The choice of July 2008 as a breakpoint is also supported by Kilian (2010) that large sustained oil price increases occurred in mid-2008 were due to speculative demand shocks defined as any demand shock that reflects forward looking behavior by traders played an important role during the global financial crisis.

The Chow breakpoint test provides evidence for the existence of a structural break in these two points at conventional significance levels for all cases.<sup>4</sup> The results obtained by performing unit root tests and GH cointegration tests on the three sub-samples are similar to what were attained based on the entire sample and are thus not presented here to conserve space as they are not the main concern in this section<sup>5</sup> as the focus of this study is to carry out the TY procedure and estimate IRFs based on VECMs for the three specified sub-samples and present the results. The sub-sample analysis allows to perform a comparative analysis and conclude on the stability of the oil price-trade balance relationship and to see if the nature of the relationships has indeed changed.

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<sup>4</sup> To conserve space, the results are not presented here but they are available upon request.

<sup>5</sup> When performed on any sub-sample, the results from unit root tests still suggest all the variables are I(1) series and those from GH cointegration tests also indicate cointegration among the variables.

The TY procedure is performed on the three sub-samples first, and the results are reported in Table 3.8. The results show that, at 10% level, causality structures significantly vary among the sub-samples and compared to the entire sample. For Japan, causality is running from oil price to trade balance and to non-oil trade balance for the first sub-sample, i.e. from January 1999 to December 2002. This is contradictory to the finding based on the entire sample for Japan's overall trade balance but similar to what was found for its non-oil trade balance based on the entire sample. Meanwhile, the causality running from oil price to oil trade balance is found significant for all the sub-samples, which is the same as the finding based on the entire sample. Oil prices have increased remarkably since January 1999 to November 2011. For an oil-importing country like the Japan, this has substantially increased the cost of oil imports. The results of the stability of long-run causality from oil price to Japan's oil trade balance suggest that increases in oil prices have been the main cause of the deterioration of the Japanese oil trade deficit. One factor can explain for this stability: The real volume of Japan's oil imports has remained essentially constant during the entire period spanning from January 1999 to November 2011. One explanation for why the demand for oil imports has not declined in response to higher prices possibly comes from the fact that Japanese firms are fairly limited in their ability to adjust their use of energy sources, such as oil. The underlying mechanism may imply that it could take some time for the Japan's oil trade deficit to adjust in response to persistently higher oil prices, as businesses need time to install new, less energy-intensive equipment.

For Singapore, the results indicate causality from oil price to the country's oil trade balance for the first sub-sample. No causality from oil price to overall trade balance and its non-oil component is detected for any sub-sample, which is consistent with the findings based on the entire sample. As to Malaysia, in contrast to the causality found from oil price to overall and oil trade balances based on the entire sample, none of such causality is found based on the

three sub-samples. Yet, the causality from oil price to non-oil trade balance was found for the third sub-sample, i.e. from August 2008 to November 2011.

Following the TY procedure, generalized IRFs based on VECMs are estimated for the three specified sub-samples to see if the short-run dynamics between the variables of interest vary considerably among different sub-samples and compared to the entire sample. Figure 3.5 presents the results. The results observed from sub-sample outcomes seem different among each other and compared to the entire sample, in terms of sign and/or statistical significance of the impact of oil price shocks on trade balances.



**Table 3.8: Toda-Yamamoto Non-Causality Test Results: Sub-samples**

Null hypothesis	Sub-sample		Japan (m=1)	Singapore (m=1)	Malaysia (m=1)
Oil price → Trade balance	1 <sup>st</sup> sub-sample	Lag	1	1	1
		Wald statistic	6.481*	0.446	1.403
		p-value	0.011	0.504	0.236
	2 <sup>nd</sup> sub-sample	Lag	1	1	2
		Wald statistic	0.556	2.240	4.013
		p-value	0.456	0.135	0.135
	3 <sup>rd</sup> sub-sample	Lag	1	1	1
		Wald statistic	0.384	0.240	1.887
		p-value	0.535	0.624	0.170
Oil price → Oil trade balance	1 <sup>st</sup> sub-sample	Lag	1	1	1
		Wald statistic	11.048**	13.369**	0.807
		p-value	0.001	0.000	0.369
	2 <sup>nd</sup> sub-sample	Lag	1	1	1
		Wald statistic	13.195*	0.040	1.918
		p-value	0.0003	0.842	0.166
	3 <sup>rd</sup> sub-sample	Lag	1	1	1
		Wald statistic	11.271**	0.841	0.440
		p-value	0.001	0.359	0.507
Oil price → Non-oil trade balance	1 <sup>st</sup> sub-sample	Lag	1	1	1
		Wald statistic	8.173**	0.041	1.513
		p-value	0.004	0.839	0.219
	2 <sup>nd</sup> sub-sample	Lag	1	1	2
		Wald statistic	0.013	1.781	2.223
		p-value	0.911	0.182	0.329
	3 <sup>rd</sup> sub-sample	Lag	1	1	1
		Wald statistic	0.014	0.187	2.958*
		p-value	0.906	0.666	0.085

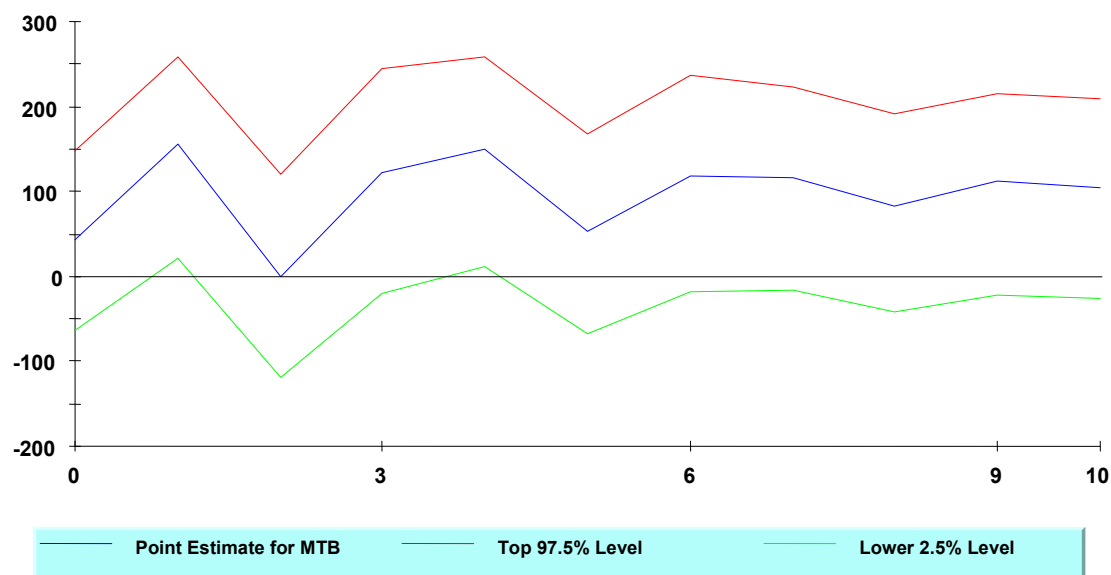
Note: Lag lengths were determined based on Schwarz Information Criterion (SIC). \* and \*\* denote significance, i.e. rejection of the null hypothesis of no causality at 5% and 1% levels, respectively.

**Figure 3.5: Generalized IRFs based on VECMs: Subsamples**

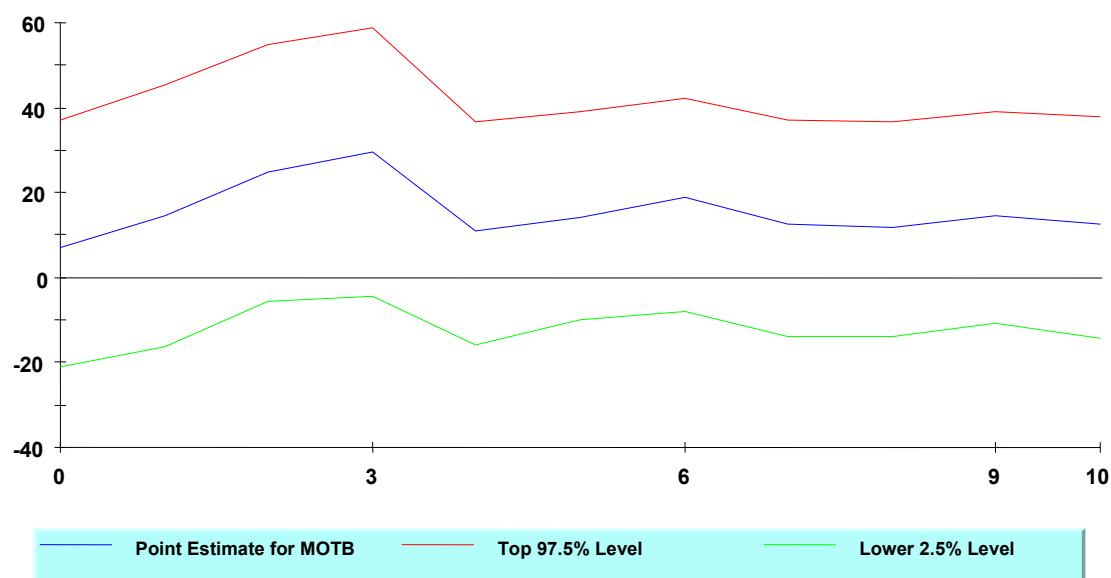
Subsample 1: Jan 1999 to Dec 2002

Malaysia

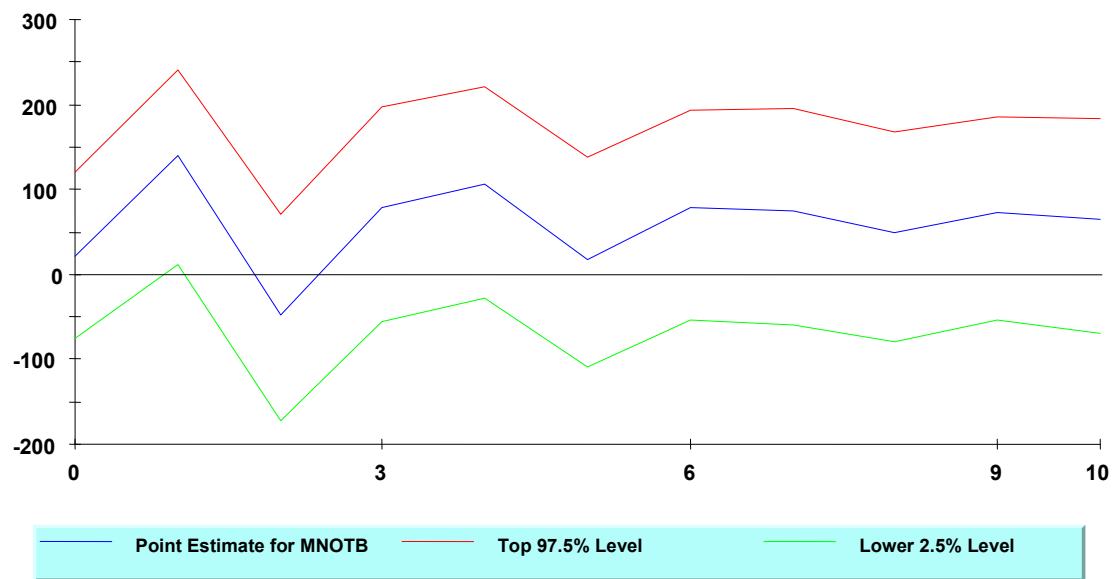
**Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price**



**Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price**

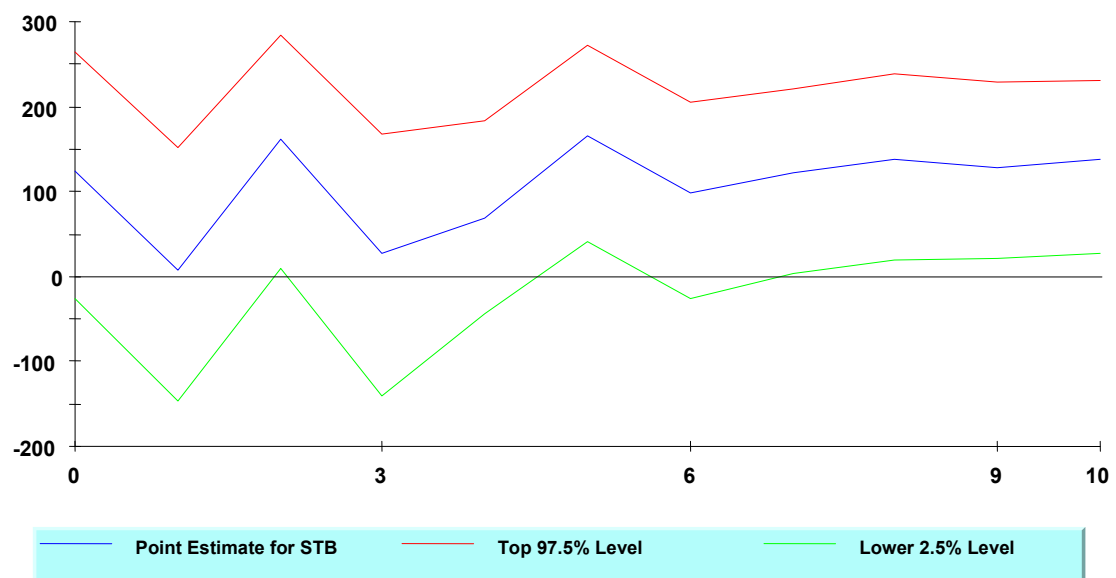


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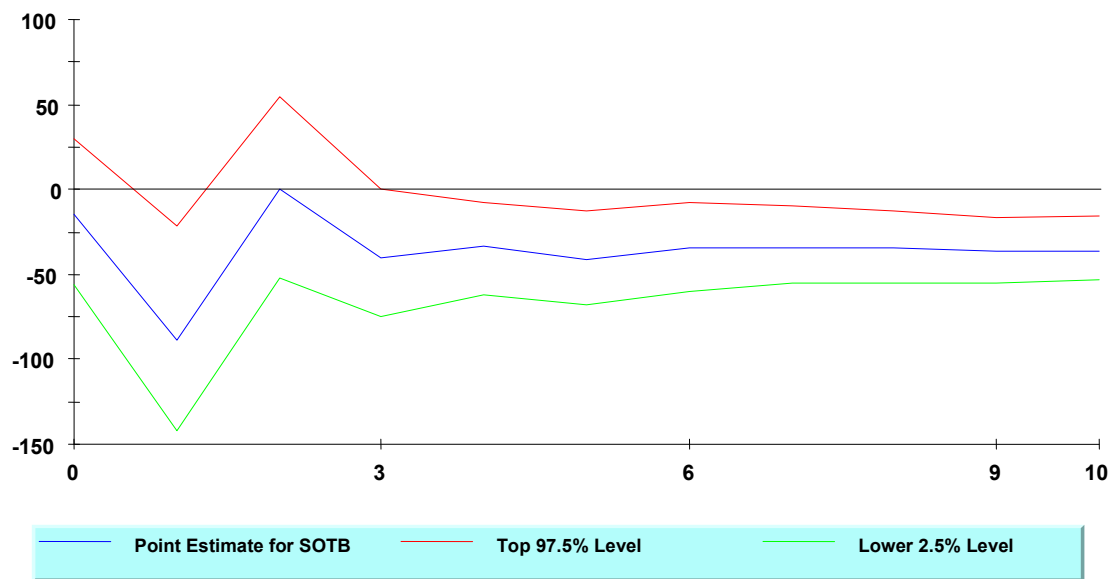


Singapore

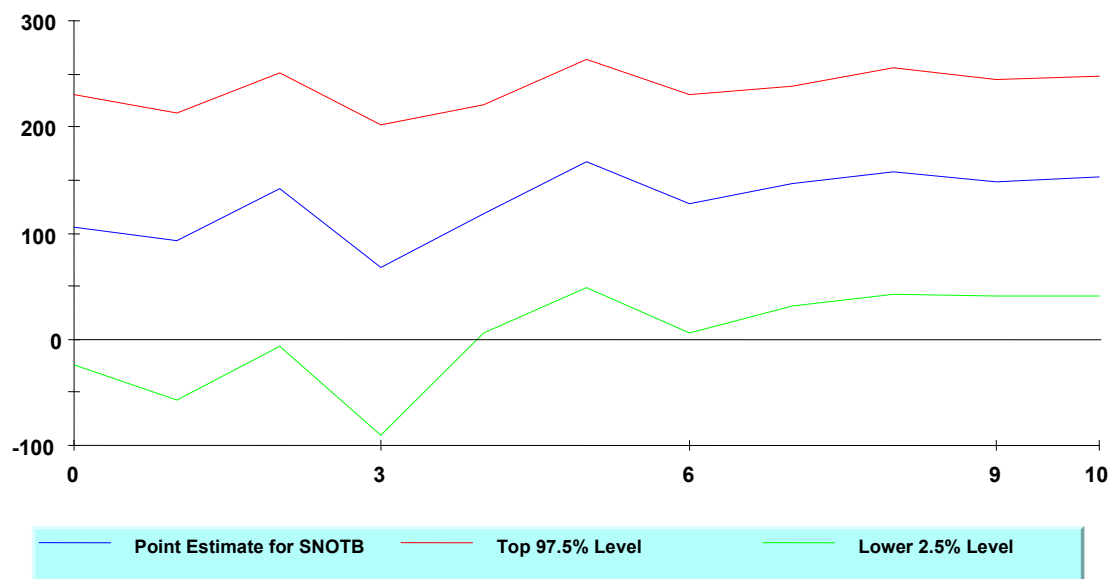
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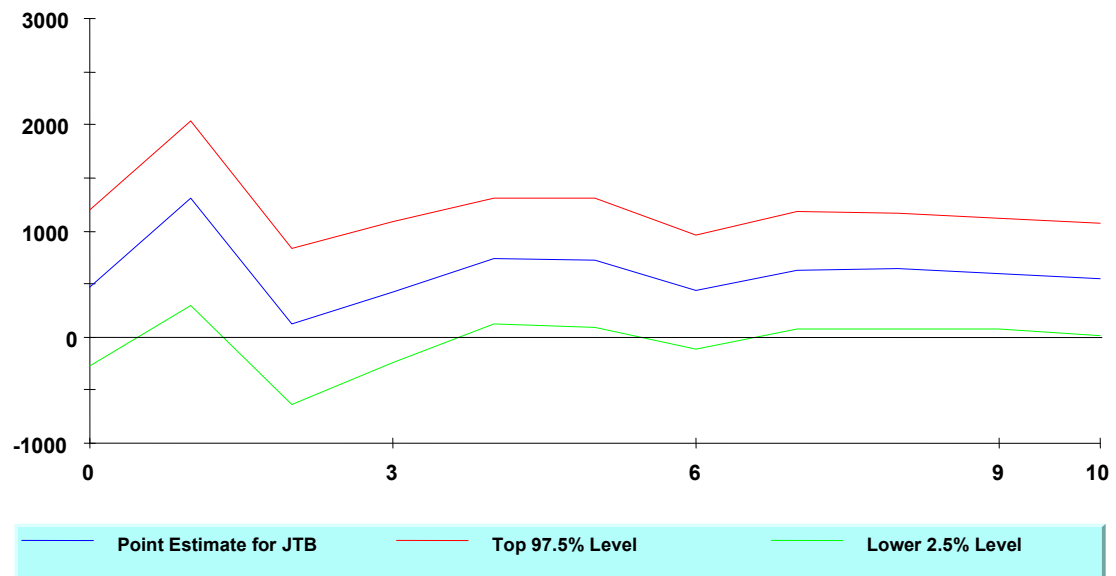


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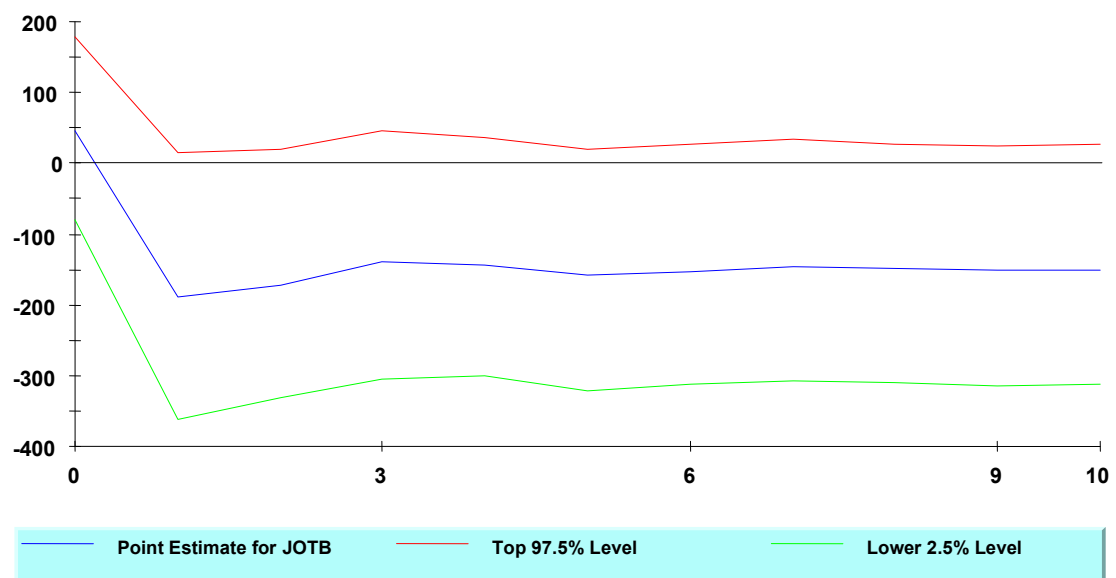


Japan

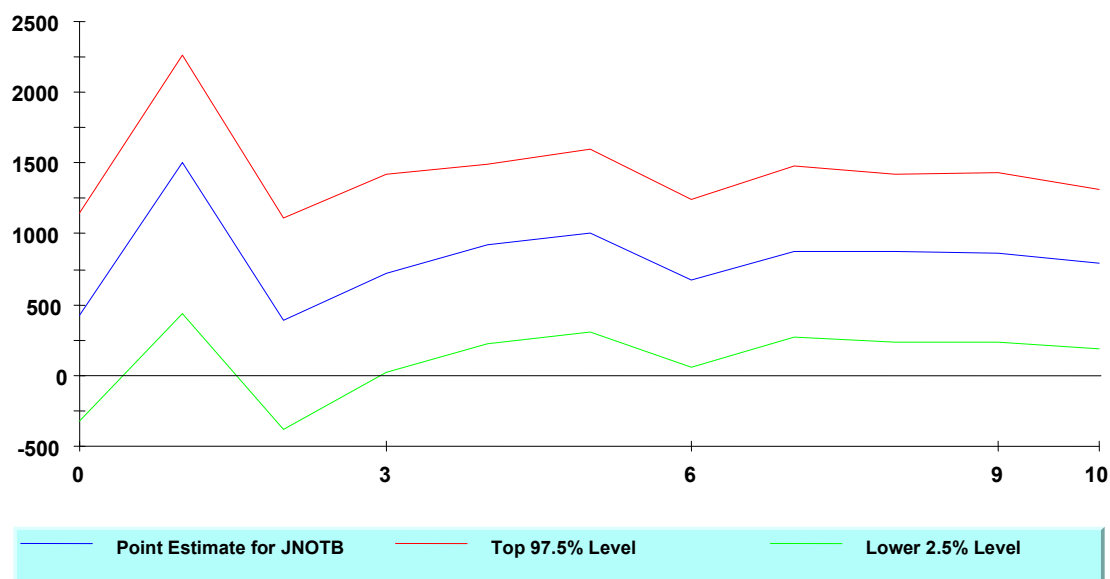
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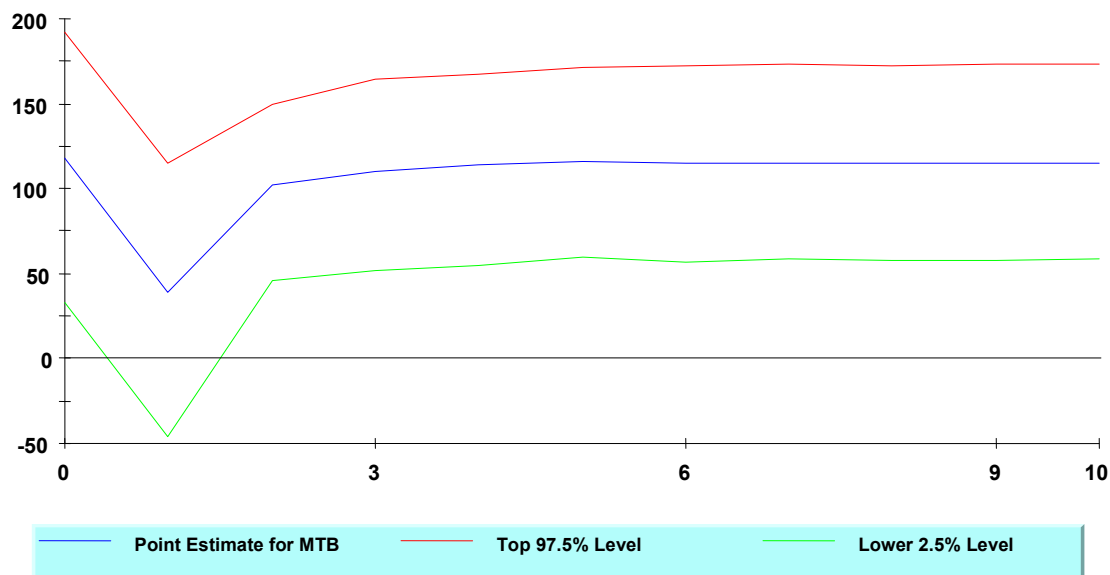
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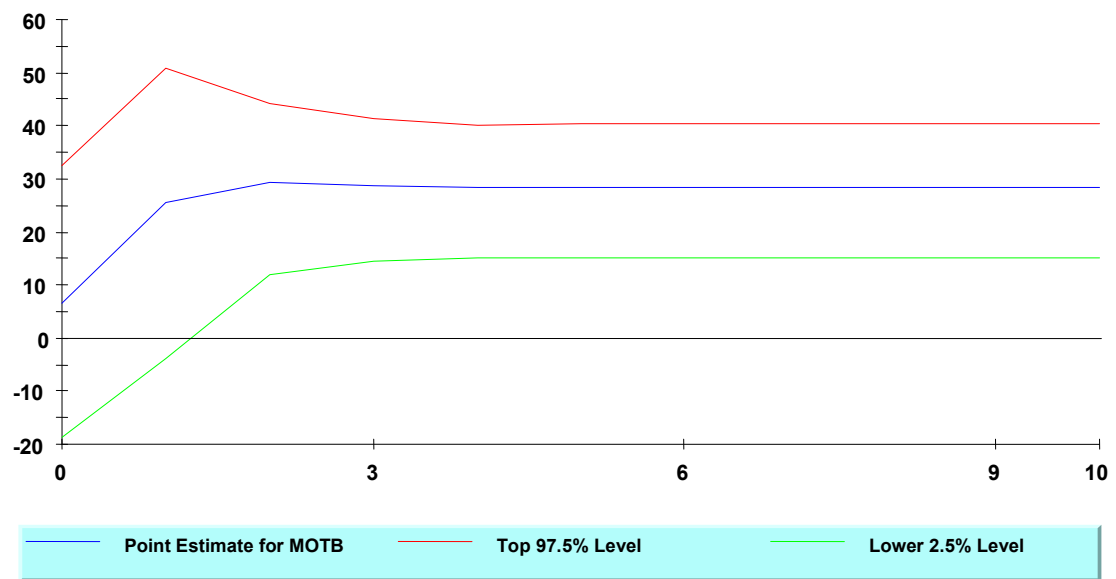
Subsample 2: Jan 2003 to Jul 2008

Malaysia

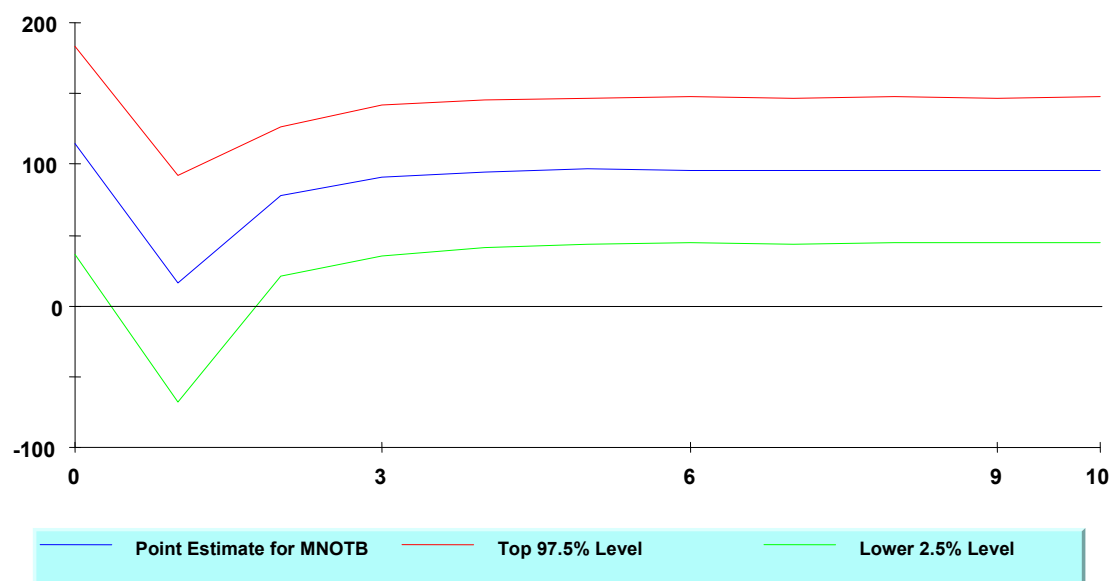
### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price



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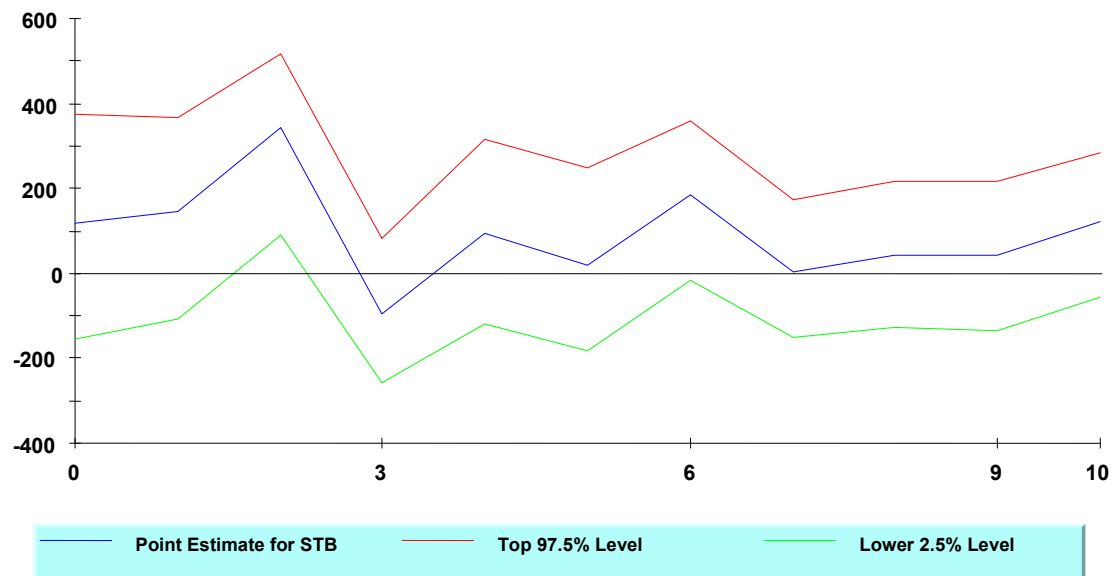


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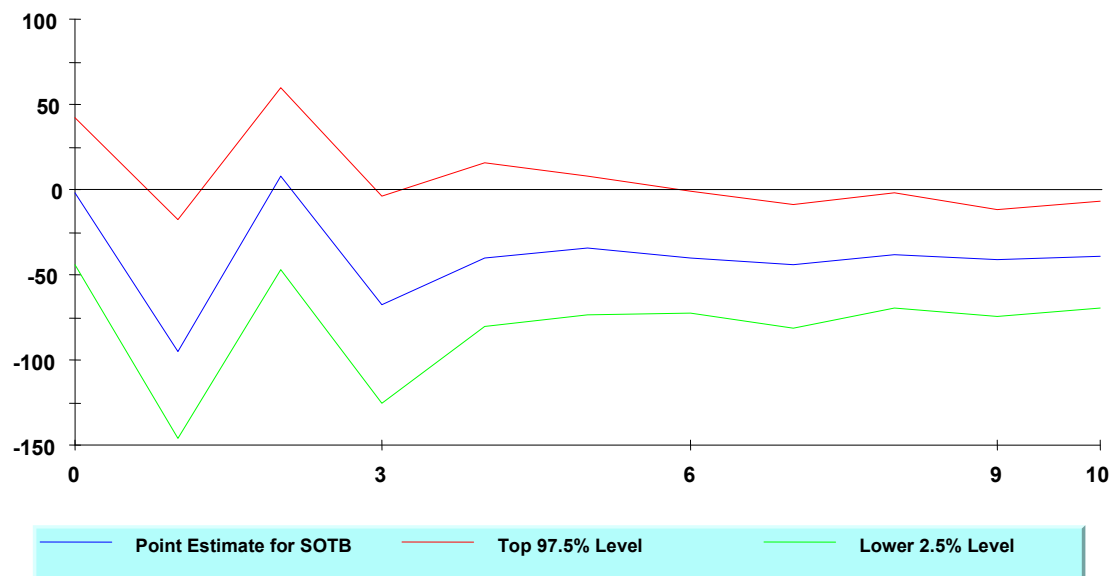


Singapore

### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price

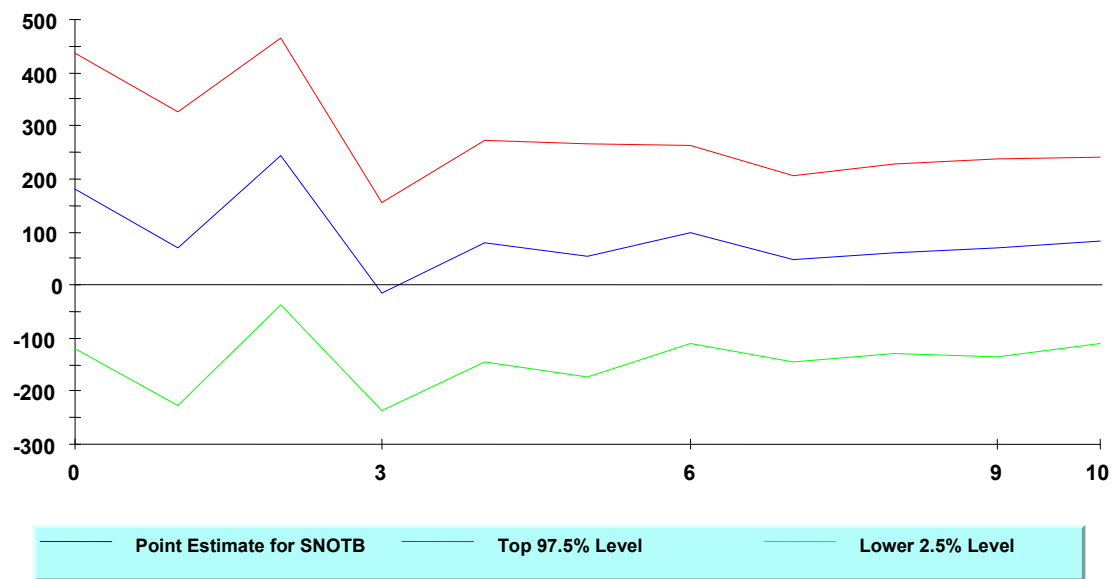


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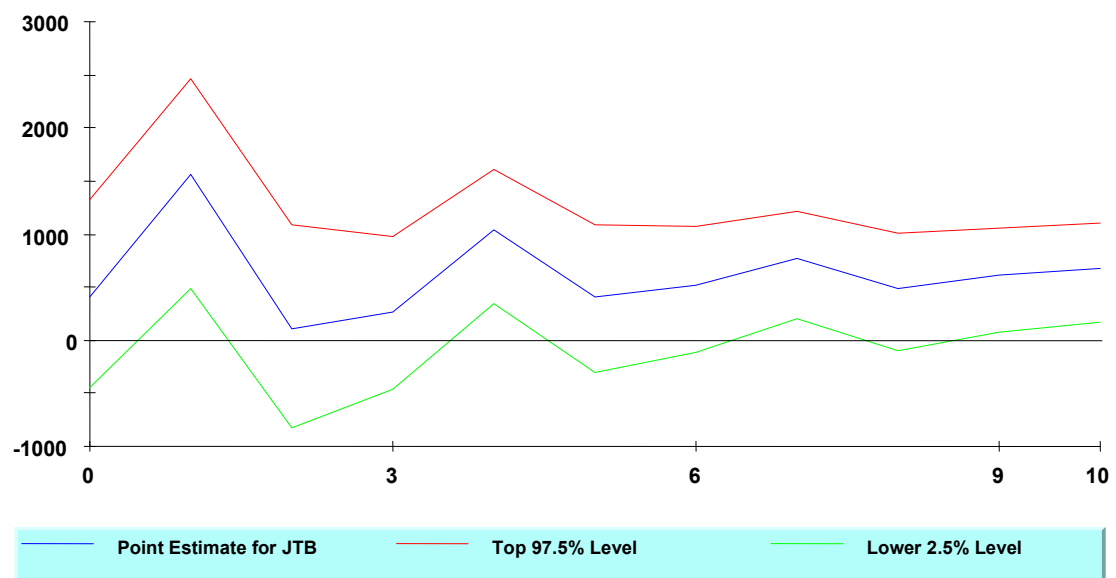


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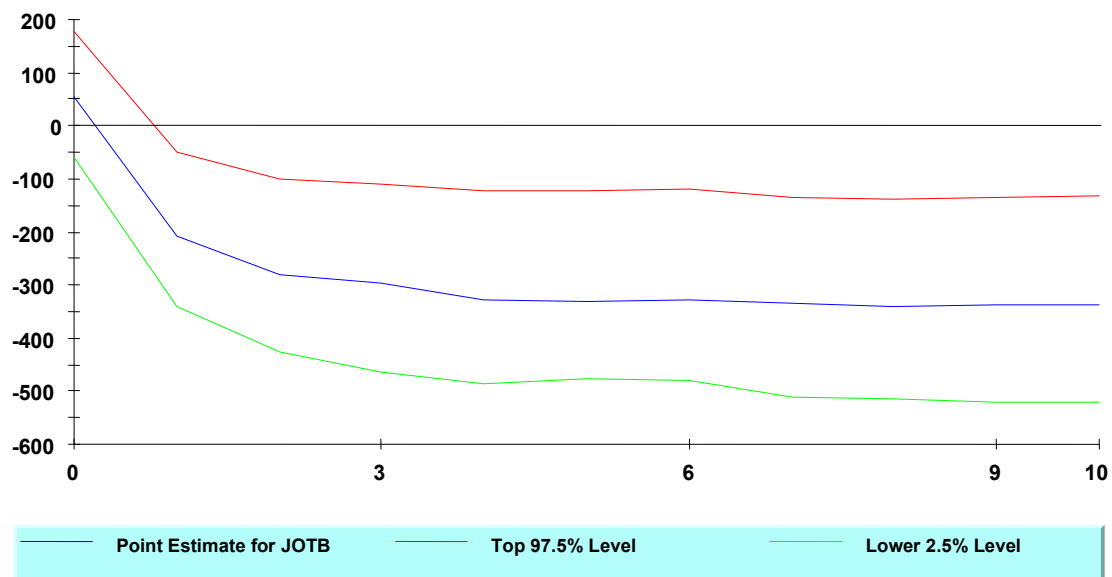


Japan

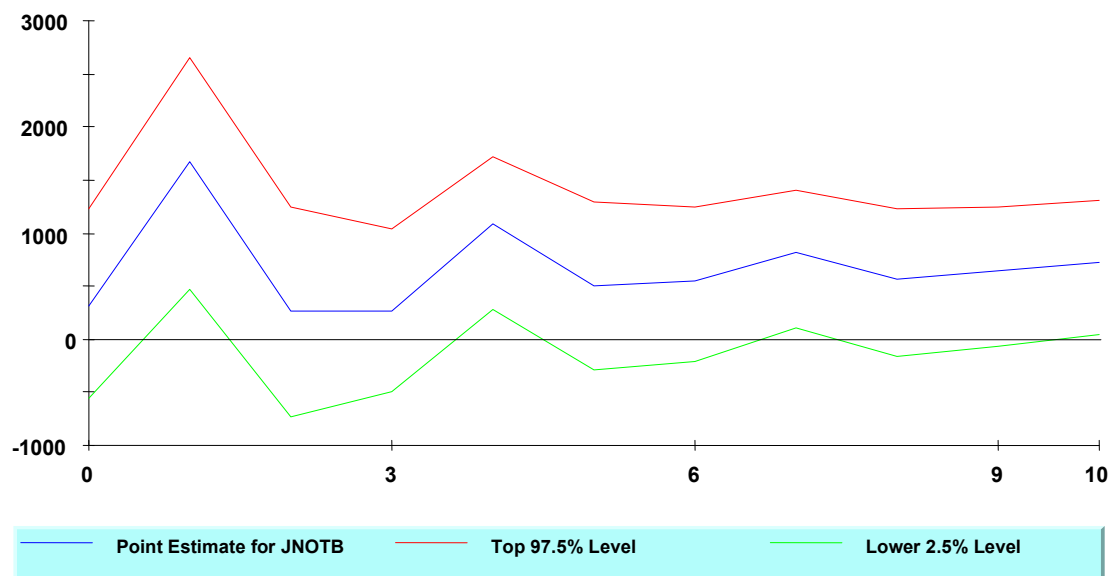
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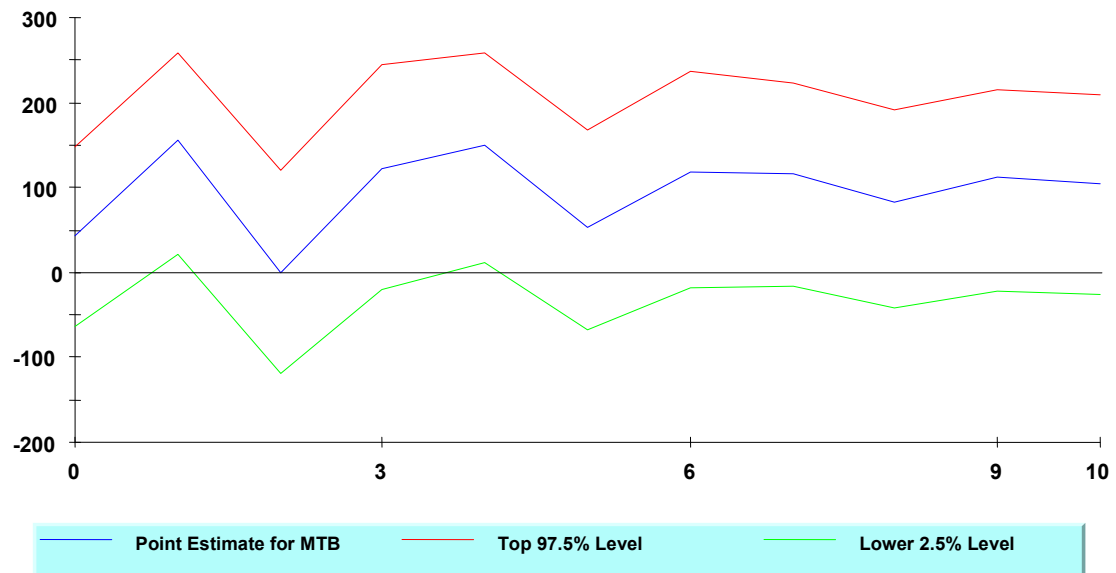
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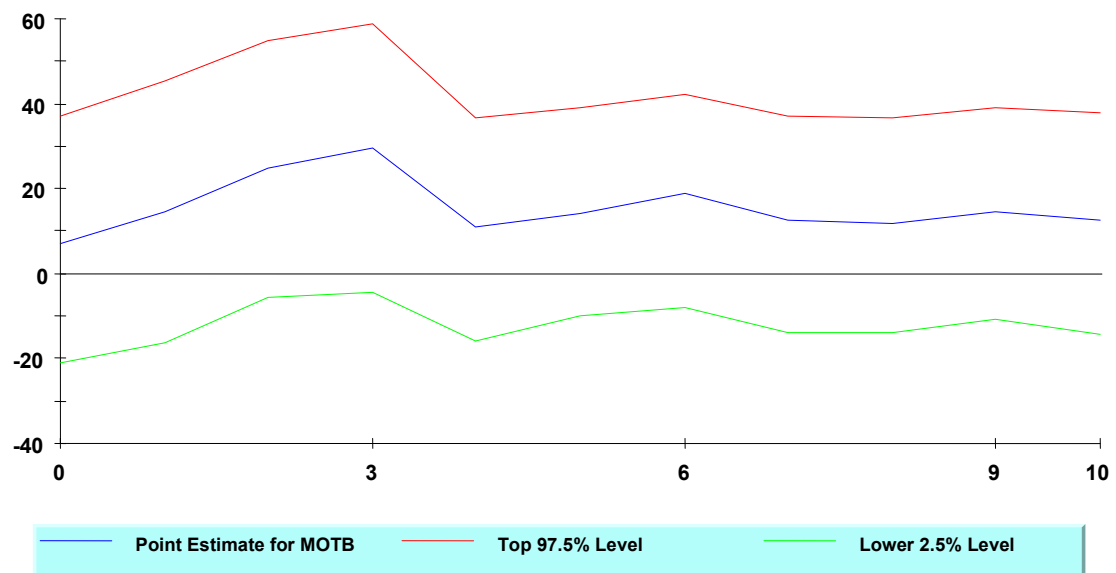
Subsample 3: Aug 2008 to Nov 2011

Malaysia

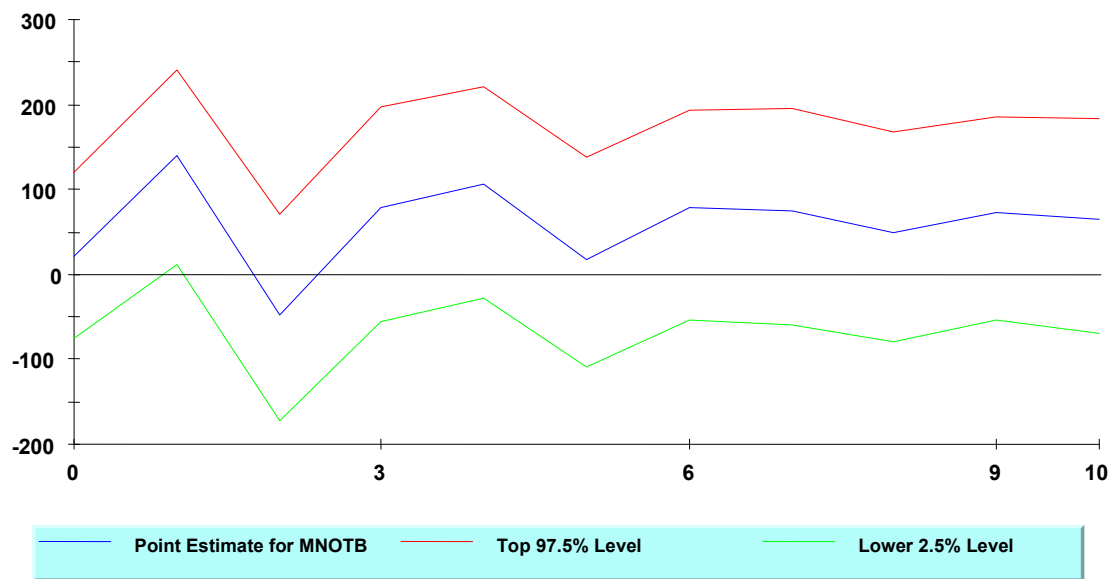
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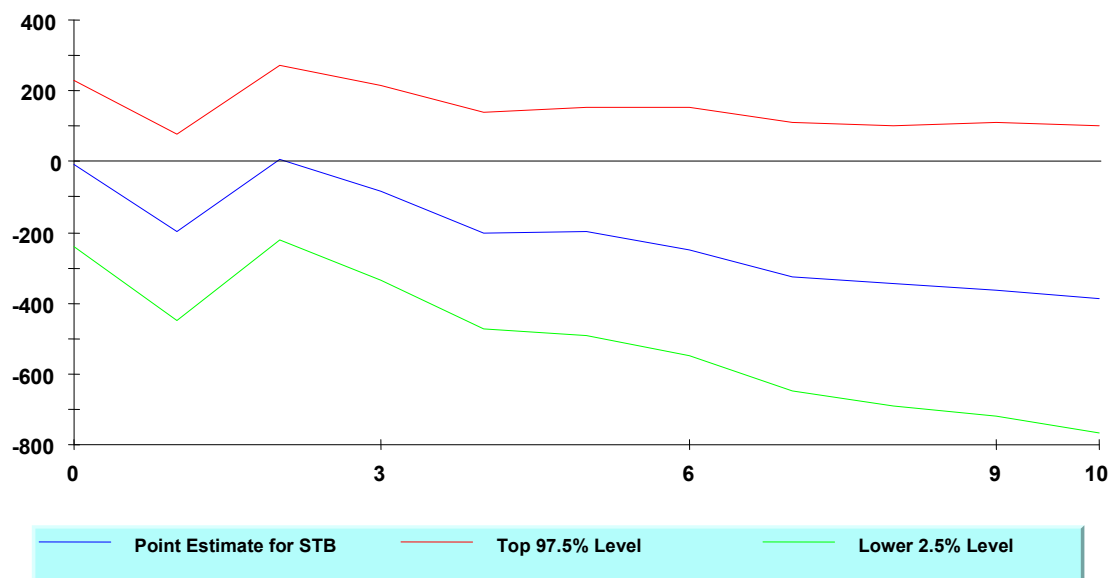


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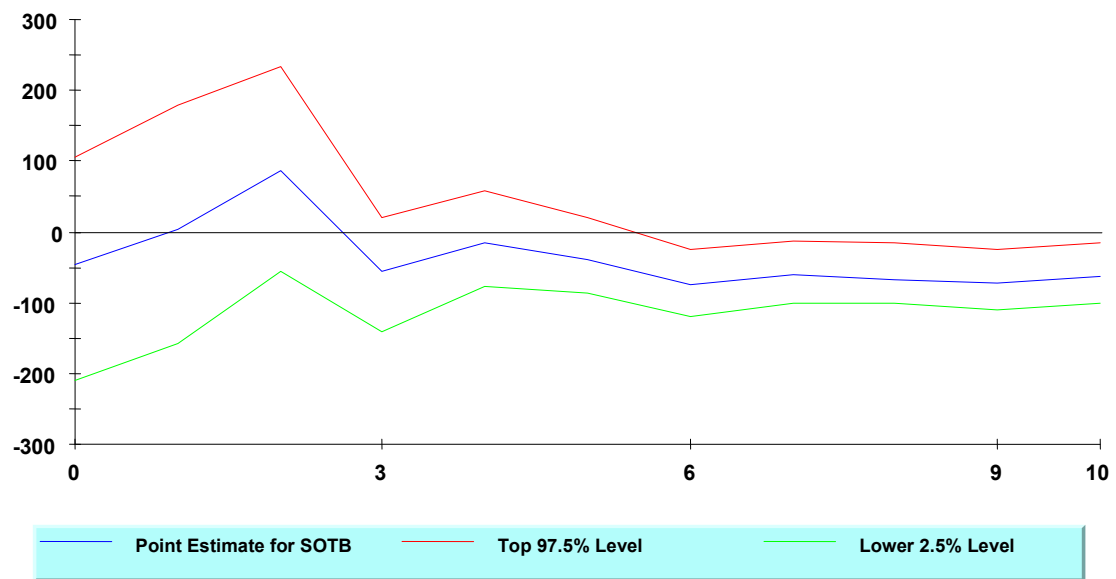


Singapore

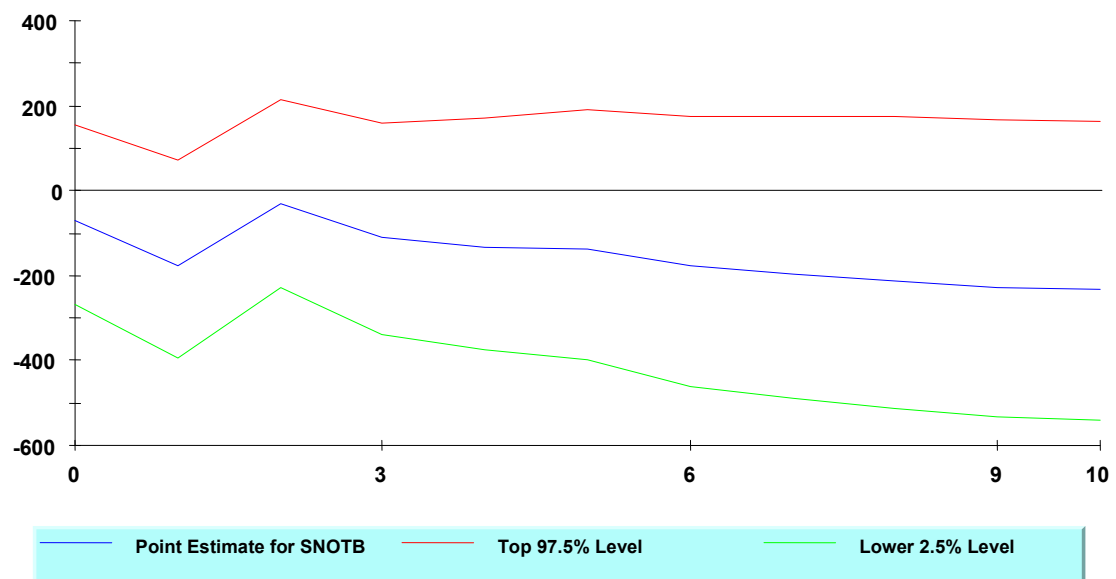
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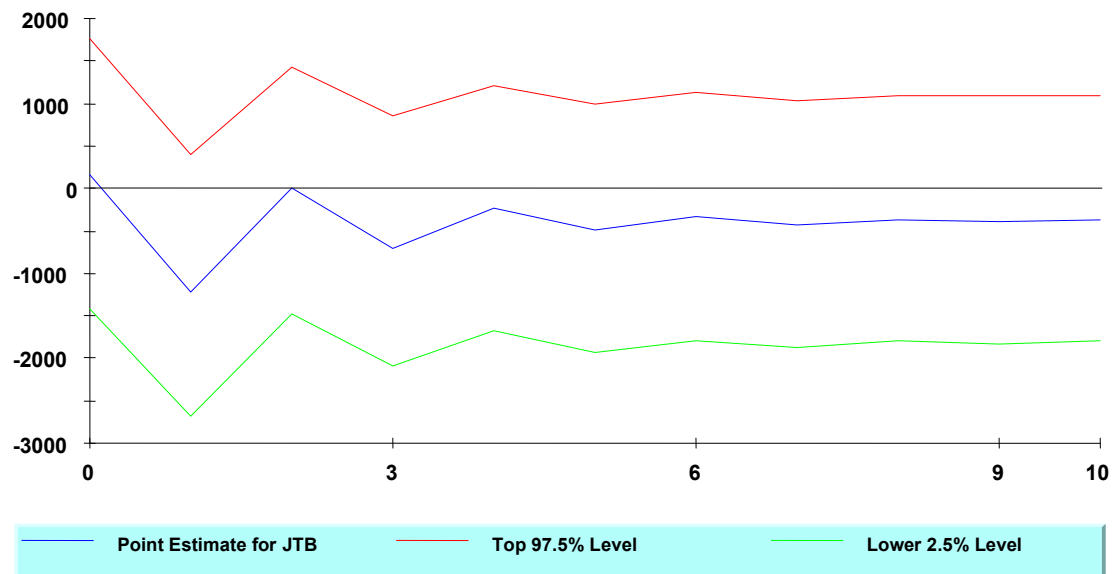


### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price

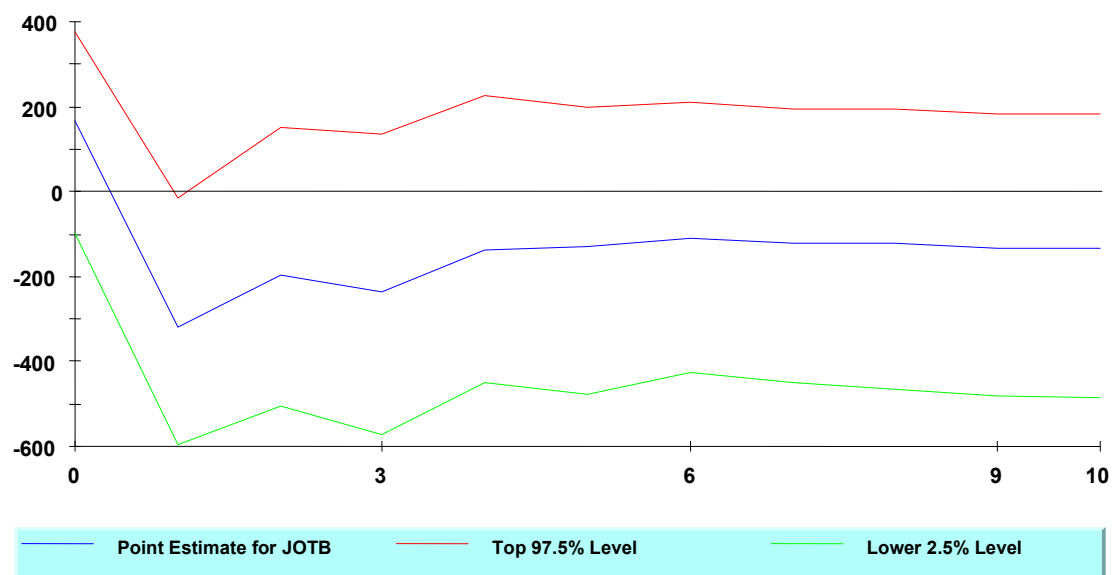


Japan

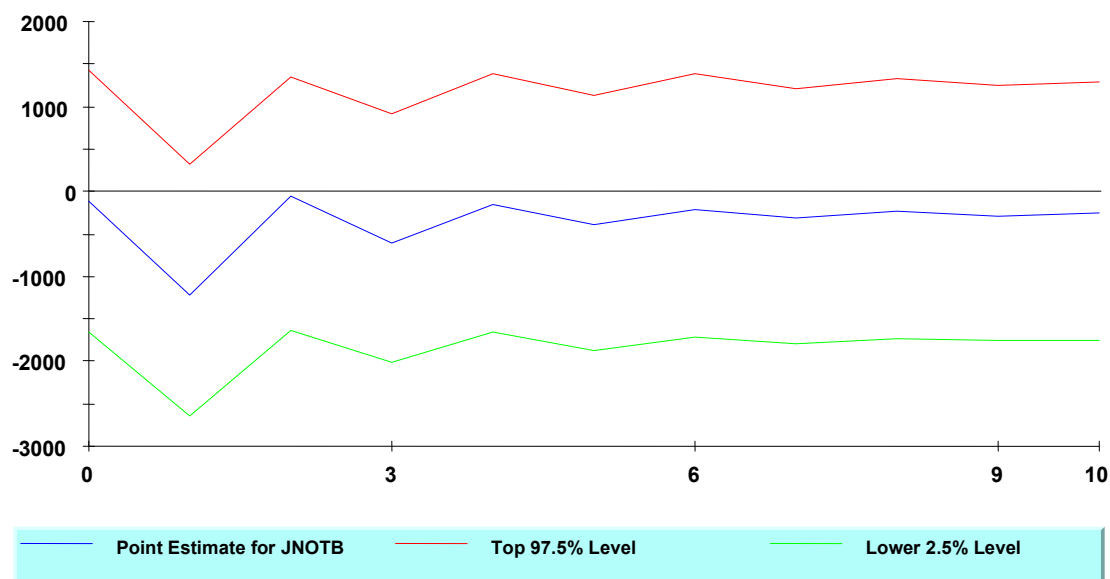
### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price



### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price



### Generalized Impulse Response(s) to one S.E. shock in the equation for Oil price



Note: OP denotes for the oil price; MTB, MOTB and MNOTB respectively denotes for Malaysia's overall, oil and non-oil trade balances; STB, SOTB and SNOTB respectively denotes for Singapore's overall, oil and non-oil trade balances; JTB, JOTB and JNOTB respectively denotes for Japan's overall, oil and non-oil trade balances.

### *IRFs based on the first sub-sample: January 1999 to December 2002*

The East Asian financial crisis started in mid-1997 is probably the worst to Asian economies. The economies of Singapore, Thailand, Indonesia and Malaysia were hit quite seriously by the crisis. During this period, the dollar price of oil fell below US\$12 a barrel by the end of 1998 and that was the lowest price in real terms since 1972, which perhaps will never be seen again. The crisis, however, proved to be short-lived as since 1999 the region started to return to growth and the new industrialization shown to be very real indeed (Hamilton, 2011). The IRFs indicate that during the resumed growth period after the East Asian crisis, the impact of oil price shocks on Malaysia's oil trade balance is flat and positive. In contrast, the influences of oil price shocks on the country's overall and non-oil trade balances seem to be quite

fluctuating, though still positive on average. Malaysia did experience economic and political turmoil as a result of the East Asian financial crisis, though not as badly as some of its neighbors. Yet, the volatile effects of oil price shocks on the country's overall trade balance and its components could be explained due to the decline in oil demand resulting from the slowdown of Asian economic growth as a consequence of the crisis as well as the uncertainties associated with the 9/11 attacks on a U.S. financial – military – government triad in 2001.

For Singapore, oil price shocks appear to negatively impact the country's oil trade balance but favorably affect its overall and non-oil trade balances. Thanks to active management by the government to cushion and guide the economy to cope with the crisis, the Singaporean economy fully recovered in less than one year and continued on its growth trajectory. This is consistent with the finding that oil shocks during this period are positively associated with the country's overall and non-oil trade balances. However, the crisis made international investors reluctant to lend to developing countries, leading to economic slowdowns in developing countries in many parts of the world. The economic slowdowns affected the demand for oil products, including refinery products from Singapore. This might explain for the significantly negative impact of oil price shocks on the country's oil trade balance.

As to Japan, the country's overall trade balance and its non-oil component seem to respond positively to oil price shocks whereas its oil trade balance seems to be adversely affected by the shock in oil prices. The responses of the formers are less significant and more volatile while that of the latter seems to be much more significant. Since Japan is a net oil importer, the negative response of its oil trade balance to rising oil prices seems obvious. Yet, the favorable impact of oil price shocks on the country's non-oil trade balance during the post-crisis period seems to suggest that Japan is not adversely affected by the crisis. This is consistent with the fact that despite the significant depreciation of the Japanese yen due to



mass selling, Japan was the world's largest holder of currency reserves at the time, so it was easily defended, and quickly bounced back.

*IRFs based on the second sub-sample: January 2003 to July 2008*

Reason for rising crude oil price during this period is controversial. There are a number of exogenous geopolitical events that disrupted oil supplies during this period, e.g., a general strike eliminated 2.1mb/day of oil production from Venezuela in December 2002 and January 2003, followed shortly after by the US attack on Iraq, which removed an additional 2.2mb/day over April to July (Kilian, 2008c). However, the disruptions caused by the affected supply were a very small share of the global market and had little apparent effects on global oil supplies (Hamilton, 2011). The impressive global economic growth that leads to strong demand pressures for oil were the key reason for the steady increase in the price of oil over the period between 2003 to mid-2008 (Hamilton, 2009). Much of this increase in the price of oil during this period was fueled by a booming world economy, and, especially in the short run, the expansionary effects of an aggregate demand shock for industrial commodities help to offset the adverse consequences of higher oil prices (Kilian, 2008a). It is also opined that the surge in crude oil prices since 2002 has demonstrated that large and sustained increases in oil prices may be driven primarily by demand for crude oil, especially when the ability to increase crude oil production in the near future is limited (Kilian, 2008a).

Nevertheless, rising crude oil prices, either due to stagnant supply or strong demand, would favor the trade balances of a net oil exporter. The IRFs show that during this period Malaysia's trade balance as well as its oil and non-oil components all seem to be favorably affected by the shock in oil prices. For the overall and non-oil trade balances, the responses

are immediate after the oil price shock, while for the oil trade balance, the effect happens within one month of the shock.

The impact of oil price shocks on Singapore's oil trade balance is remarkably volatile and negative, which is the same sign as in the first sub-sample. The impacts on the country's overall and non-oil trade balances are, however, different from those observed in the first sub-sample, reflected on the more volatility of the reaction functions to the shock, though still positive. For Japan, the effects of oil price shocks on its overall and non-oil trade balances are still positive and the influence on its oil trade balance is still negative.

Based on the results from Singapore and Japan, the findings seem to support for the demand cause of rising crude oil prices during this period, which is consistent with the views expressed in Hamilton (2009, 2011) and Kilian (2008a, d) that the bulk of the increase in oil prices since 2002 has been associated with increasing global demand for crude oil, along with other industrial commodities and much of that increased demand has been associated with rising demand for industrial commodities (including crude oil) from emerging economies in Asia. The finding for the case of Japan is also consistent with the finding in Kilian (2008b) that after the 2002/03 shocks, Japan belongs to one of the countries which were able to maintain average or above average real growth rates. Further, he also showed in the study that following the 2002/03 shocks, there is hardly any evidence of a reduction in real growth being caused by exogenous oil supply shocks.

This evidence also improves the understanding of why the consequences of the increase in crude oil prices since late 2002 have been relatively benign during the 2003-2008 period as concluded in Kilian (2008a). It is because much of this increase in the price of oil was fueled by a booming world economy, and, especially in the short run, the expansionary effects of an

aggregate demand shock for industrial commodities help to offset the adverse consequences of higher oil prices.

*IRFs based on the third sub-sample: August-2008 to November-2011*

As the world economy collapsed in late 2008, so did the real price of oil. More than half of the observed decline in the real price of oil, however, was driven by expectations about a prolonged global recession. The gradual recovery of the real price of oil in 2009 can be attributed equally to a partial reversal of these expectations and to a recovery of the demand for industrial commodities, reflecting the improved state of the global economy (Kilian, 2010). One of the explanations for the rising oil prices during this period is that the overall increase in crude oil demand, in combination with a rapid rise in demand for light sweet crude has led to an extraordinarily tight balance in the crude oil market and a rapid increase in prices (Behr, 2009).

Oil price shocks still positively affect Malaysia's overall and oil trade balances but the effects are much more volatile compared to the other two sub-samples. The influence on the country's non-oil trade balance is also more fluctuating compared to the other two samples and the sign is unclear, sometimes negative sometimes positive. Overall, the results may lead to conclude that the variability of Malaysia's overall trade balance and its oil and non-oil components seem to be indeed associated with world oil price volatilities. Two reasons could be used to explain for this finding. First, throughout this period, world oil markets experienced volatility on an unprecedented scale compared to the other two sub-sample periods. Second, the change in Malaysia's net oil export position is due to the fact that its domestic oil consumption has been rising faster while its domestic oil production has been

falling. As Malaysia increases its oil consumption, its vulnerability to changes in the price of oil will also increase.

As to Singapore, the impacts of the shock of the world oil price on the country's overall trade balance as well as its oil and non-oil components seem to be relatively negligible, but the signs are overall negative for all the three types of trade balances. For Japan, the responses of its overall trade balance and oil and non-oil components are also more volatile compared to the other two sub-periods. The impact of oil price shocks on the country's non-oil trade balance turns to negative, which is different to the results based on the other two sub-samples. The country's oil trade balance seems to be still dampened by the oil price shocks. Thus, these findings seem consistent with Hamilton (2009) that the increases in the world oil price since the mid-2008 have ultimately contributed to the economic slowdown that followed the global financial crisis of 2007–2008.

### **3.5.3. Robustness check**

Finally, this study conducted robustness checks by using a different transformation of the oil price series. In the context of the methodology followed here, the definition of real oil prices represents a common shock to all countries. It is worth noting, however, that the impact of oil price shocks could be different among countries due to changes in bilateral exchange rates with the US dollar. Robustness checks are thus conducted by estimating the models using Dubai crude oil prices converted into domestic currencies and deflated by each country's CPI. The objective of the robustness checks is to find if there is any significant difference in

results. Since the results in all cases are not significantly different, the use of Dubai crude oil price in US dollars is retained in the analysis of this study.<sup>6</sup>

Last but not least, it is well-known that causality results are often quite sensitive to changes in the model specification so that the TY approach is carried out for a new model specification by including an additional potential explanatory variable. The country-specific monthly inflation rate is added as another controlling variable to the baseline model specification. The results obtained by performing the TY-procedure on the entire sample as well as the three sub-samples were basically the same to the original ones. Thus, it may be concluded that those causality results are robust to reasonable changes of the baseline VAR models.

#### **3.5.4. Policy implications**

There are several policy implications based on the findings of this study. For net oil importing economies, the results from the Japanese case imply that even for a major economy, the high oil dependency could lead to unfavorable outcomes associated with oil price shocks for the whole economy, such as the high volatility of the trade balance or trade deficits caused by resulting increases in the oil trade deficit. In order to reduce trade volatilities as well as deficits, there is undoubtedly a need to look for oil substitutes so as to become less oil dependent. The Japanese economy will have to become more energy-efficient, which, in turn, would help contain the cost of its oil imports and increase the economy's flexibility in absorbing future oil price increases. Policy makers in net oil importers should regulate the financial markets so as to provide some insurance against oil price hikes and to diversify risks associated with oil price shocks for those enterprises that are doing business within the economy.

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<sup>6</sup> As space is limited, detailed results on robustness checks will be provided upon request.

For net oil exporting economies, the results from Malaysia suggest an inverse implication. Insurance against falling oil prices should be provided and there are worries about the growing proportion of oil revenues. High dependency on oil revenues to finance fiscal spending is not a viable long-term option because it increases the vulnerability of the government budget and hence the country's economy to oil price fluctuations. There is no quick solution for the world's problem of high dependency on oil. As the global economy continues to expand, it is likely that the demand for oil and natural gas would continue to grow. Oil and gas reserves, which are fast depleting and non-renewable, are continually being extracted to feed the global consumption. The surge in crude oil prices since 2002 has demonstrated that large and sustained increases in oil prices may be driven primarily by demand for crude oil, especially when the ability to increase crude oil production in the near future is limited. The combination of growing demand and depleting reserves may turn many net oil producers and exporters into oil importers. In the case of Malaysia, its annual domestic oil demand continues to grow at 4% whereas the country's oil and gas production remains at 2.7% per year. There is a possibility that the country would become a net oil importer within the next 10 years. The governments of major oil exporters should carry out fiscal adjustments so as to ensure long-term stability of its finances. For instance, the government could seek other sources of revenue through diversification and to focus on increasing its non-oil-based revenues, such as taxes. Among the potential initiatives are tax reforms and reinvestment of oil money in revenue-generating assets. As suggest by Setser (2007), greater exchange rate flexibility would help oil exporting economies become more efficient in managing the volatility in export and government revenues associated with oil price volatility.

Last but not least, the results from the stability analysis imply that the appropriate policy response to oil price shocks depends on the composition of the underlying oil demand and oil supply shocks. For instance, in the specific case of the 2003–2008 oil price shock, the

fundamental problem was oil demand grows faster than oil supply. Since the 2003–2008 oil price shock reflected a shift in the real scarcity of resources, there is nothing a central bank could or should have done in response, beyond making sure that inflation expectations remain anchored in the face of inflationary pressures arising from both oil and industrial commodity prices. A monetary easing would not have been appropriate for such a case of demand-driven since the global demand pressures appeared highly persistent.

### **3.6. Concluding remarks**

This study examines the impact of oil price shocks on overall trade balances as well as their oil and non-oil components. To this end, three advanced procedures are used, that are the Gregory and Hansen (1996) approach to cointegration with structural change, the procedure for non-causality test popularized by Toda and Yamamoto (1995) and the generalized impulse response function (IRF) by Koop et al. (1996) and Pesaran and Shin (1998). The country sample consists of three distinctive characteristics in terms of oil –oil exporting (Malaysia), oil-refinery (Singapore) and oil importing (Japan) economy. By examining the three oil-distinctive economies, it aims to somewhat generalize the possible relationships for other economies.

The Hansen (1992) instability tests do not show the presence of structural change at 1% level for most of the equations in the three selected economies. This study also finds evidence on cointegrating relationships among the variables of interest in the three economies, and the conclusions are robust to model specifications. Using the Toda-Yamamoto (TY) procedure and the generalized IRF analysis, it is found that in the case of Japan, there is only causality running from the oil price to the country's oil and non-oil trade balances, and not the overall trade balance. This finding could be explained by that oil price shocks to Japan arise from the

demand side, thus the positive effect of oil price shock on the country's non-oil trade balance and the negative impact on the oil trade balance may have canceled out each other. This argument is strengthened as the generalized IRF analysis shows that Japan's non-oil trade balance responds positively to oil price shocks. For Malaysia, oil price shocks appear to Granger-cause both overall and oil trade balances and the impacts are positive for both. This finding implies that rising oil revenues due to positive oil price shocks seems to be a major factor contributing to the economy's overall trade surplus in the long run. For Singapore, no evidence on causality among the variables of interest at 1% level of significance is found, which indicates that the positive and negative effects of rising oil prices to this oil refinery economy may cancel out each other in the long run. In the short run, however, positive oil price shocks seem to have an adverse impact on the oil trade balance of this economy. This reflects the fact that despite being the largest major oil trading hub in Asia and the third largest in the world, Singapore is still a net oil importer; it has no domestic oil reserves and has to depend on the international market for all of its trading activities. The impacts on overall and non-oil trade balances of Singapore also depend on the nature of oil price shocks, which is overall similar to what was observed from the Japan case.

Based on the results obtained from analyzing three economies with distinctive oil characteristics, this study concludes the followings. First, oil exporters' improvements in trade balances seem associated with rising oil revenues. Second, for an oil refinery economy like Singapore, oil price shocks seem to have negligible long-run impact on trade balances and their oil and non-oil components. It may, however, have significant impacts in the short run. Third, for net oil importers, the impact of rising global oil prices on oil trade deficit depends on the unique nature of the demand for oil. If the economy is highly dependent on oil but has no ability to produce, its oil demand would be very inelastic. For net oil importing and major oil consuming economies associated with high oil dependency like Japan, rising oil



prices seem to heavily dampen the oil trade deficit which likely to result in the overall trade deficit. However, the short run impact on the non-oil trade balance could be positive, which may eventually translate to a favorable effect on the overall trade balance, if the shock of the oil price rise to the economy stems from the demand side.

The stability analysis indicates that, the impacts of oil price shocks on trade balance and its oil and non-oil components are not always stable. Specifically, when the 13-year sample period is split into three sub-sample periods (1999-2002, 2003-2008 and 2008-2011), the causality and the responses implied by the VECMs differ greatly across the three sub-sample periods and compared to the entire sample.

For the first sub-sample, the impact of oil price shocks on Malaysia's overall trade balance including its oil and non-oil components are all positive on average. But the response of the country's oil trade balance is flat while those of its overall and non-oil trade balances seem to be quite fluctuating. For Singapore, oil price shocks appear to negatively impact the country's oil trade balance but favorably affect its overall and non-oil trade balances. As to Japan, the country's overall trade balance and its non-oil component seem to respond positively to oil price shocks whereas its oil trade balance seems to be adversely affected.

For the second sub-sample, Malaysia's trade balance and its oil and non-oil components all seem to be favorably affected by the shock in oil prices. The impact of oil price shocks on Singapore's oil trade balance is remarkably volatile and negative, which is the same as in the first sub-sample. The impacts on the country's overall and non-oil trade balances are still positive but different from those observed in the first sub-sample. For Japan, the effects of oil price shocks on its overall and non-oil trade balances are also positive but more significant compared to those observed based on the first sub-sample. The influence on its oil trade balance is still negative.

For the third sub-sample, oil price shocks still positively affect Malaysia's overall and oil trade balances but the effects are much more volatile compared to the other two sub-samples. The influence on the country's non-oil trade balance is also more fluctuating and unclear in sign. As to Singapore, the impacts on the country's overall trade balance as well as its oil and non-oil components seem to be relatively negligible. For Japan, the responses of its overall trade balance and oil and non-oil components are more volatile compared to the other two sub-periods. The impact of oil price shocks on the country's non-oil trade balance turns to negative, which is different from the other two sub-samples. The country's oil trade balance seems to be more dampened by the oil price shocks.

## CONCLUSION

This thesis consists of three self-contained essays on oil price fluctuations, financial markets and international trade.

The first essay investigates the impact of oil price shocks on gold price returns using a multivariate structural VAR approach. The findings of this study have several implications. First, the role of gold as a hedge against inflation is strengthened. Second, oil and gold could be close substitutes as safe havens from fluctuations in the value of the US dollar. Third, the oil price does nonlinearly cause the gold price to change and can be used to predict the gold price. This would significantly help monetary authorities and policymakers in monitoring the price of major commodities in markets. Since the number of studies on oil–gold price relationships is very limited, there are many opportunities for further research in the area. For instance, future work could focus on dynamic and time-varying interactions between the oil price and the gold price. Further studies may also evaluate the volatility, risk and spillover effects between the two markets and/or other markets such as those of other precious metals.

The focus of the second essay is to examine the dynamic relationships between the prices of oil and gold and the financial variables in Japan, namely, stock price, exchange rate and interest rate using bounds test to cointegration. Oil and gold are the two most strategic commodities in the world and may have significant implications for the movements of macroeconomic variables, including those of financial variables, of any economy. Despite this fact, very little research has been conducted on dynamics between strategic commodities and performance of financial variables. This study aims to fill in this gap. The choice of financial variables are made based on theoretical macroeconomic basis that the interest rate is a variable that captures the monetary policy instrument, the exchange rate is an important transmission channel in an open economy, and the stock market is an indicator of the health

of an economy. Japan is chosen for the empirical investigation in this study as it is a major oil-consuming-and-importing and gold-holding-and-exporting country.

The results should provide relevant information to policy makers responsible for the impact of commodities' price fluctuations on interest rate and exchange rates. Further, since the Japanese yen is a major currency, the findings of this study would benefit not only the Japanese monetary authority but also those investors who hold the Japanese yen in their portfolios. The information will also be informative for traders and investors who are interested in hedging. It will also be useful for market participants who are interested to switch between commodities and stocks, and for portfolio managers who are interested in whether to use commodities to diversity away stock market risk in their portfolios. The bounds test to cointegration, which is a relatively new cointegration technique, is employed as the methodology in this study.

This study finds that the oil price shock does not have a significant and stable impact on any of Japanese financial variables in the long run and thus the oil price seems to have limited information for the Japanese economic policy makers. In the short run, the oil and gold prices seem to have more useful information for the economic policymakers and policymakers should definitely give oil and gold a critical weight in their policy decisions. For investors, traders and portfolio managers, they may observe movements in gold and oil prices to predict fluctuations in the Japanese macro-financial variables. The scarcity of existing literature on the subject matter would raise many opportunities for further researches. Specifically, further studies could be carried out to extend the scope of this study by investigating the subject with inclusions of more strategic commodities (e.g., precious metals, coal, and natural gas) or with panel data for cross-country analysis.

The third essay examines the impact of oil price shocks on overall trade balances as well as their oil and non-oil components. To this end, three advanced procedures are used, that are the Gregory and Hansen (1996) approach to cointegration with structural change, the procedure for non-causality test popularized by Toda and Yamamoto (1995) and the generalized impulse response function (IRF) by Koop et al. (1996) and Pesaran and Shin (1998). The findings from the stability analysis lead to the following conclusions. First, relationships between oil price shocks and overall trade balances as well as between oil price shocks and trade components (oil and non-oil) are varying considerably from year to year, in terms of sign, magnitude and the signal of causality. The reason is simply because of the different natures of oil price shocks. That is, depending on whether oil price shocks are caused by the demand side or supply side, responses of trade balances and their oil and non-oil components are expected to be different. Thus, conclusions based on all years combined would be misleading. Second, the findings of this study have critical implications for economic modeling of how oil price shocks impact a macroeconomy. The first implication is that trade is an important channel and thus should not be ignored in the model setup. The second one is that in modeling how oil price shocks impact the trade balance including its oil and non-oil components of an economy, it is of crucial importance to distinguish the nature of economy such as an oil-exporting, oil-refinery and oil importing economy, and what is the causes of the shock, i.e. whether it is driven by demand side or supply side. Further research could be conducted by including more countries with different types of oil characteristics in the study sample with the use of different methods such as panel cointegration tests or panel Granger causality tests.

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