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ABSTRACT

This study examines the response of stock markets to oil price volatilities in Japan, Singapore, Korea and Malaysia by applying the generalized impulse response and variance decomposition analyses to the monthly data spanning 1986:01 – 2011:02. The results suggest that the reaction of stock markets to oil price shocks varies significantly across markets. Specifically, the stock market responds positively in Japan while negatively in Malaysia; the signal in Singapore and South Korea is unclear. We find that the stock market inefficiency, among others, appeared to have slowed the responses of the stock market to aggregate shocks such as oil price surges.

Key words: oil price fluctuation, stock return, exchange rate, emerging market, VAR model.

JEL: Q43, F3, G14, G15.

1. INTRODUCTION

Oil prices had been fairly stable until 1973. Since then, the impact of oil price shocks on the world economy has been larger (Hamilton, 2003). A considerable economic literature has been conducted on studying the oil price-macroeconomy relationship. Recent studies are either using time series data on one country (e.g. Guoand Kliesen, 2005; Breitenfellner and Cuaresmo, 2008) or conducting cross-sectional data analysis across countries (e.g. Cunado and Gracia, 2003, 2005; Jimenez and Marcelo, 2005; Cologni and Manera, 2008).

The critical role of oil in an economy would make one expect changes in oil price to be correlated with changes in stock prices (Huang et al., 1996). In fact, investigating the relationship between oil and stock markets has been a recent trend in the energy sector (crude oil market). However, in sharp contrast to the large volume of studies conducted on the oil-and-macroeconomic-variable relationships, the number of analyses on oil-stock interaction has been relatively few. This fairly limited number of studies is explained due to the short history of oil price volatility (only started fluctuating since 1973) which might lead to difficulties in linking oil price changes with the changes of stock prices (Kilian, 2007; Driesprong et al., 2004). Consequently, inference is not so statistically meaningful and experience is too little for understanding the exact mechanisms through which changes in crude oil price affect stock markets.

Jones and Kaul (1996) were among the first economists studying oil-stock relationships. They employed the standard cash-flow/dividend valuation model by (Campbell, 1991)[4] to investigate the linkage between oil and stock markets of four advanced economies: United States (US), Canada, Japan and United Kingdom (UK). They contend that the stock markets

[4]The conventional valuation model in Campbell's (1991) framework suggests that stock prices reflect an infinite series of discounted expected cash flows. Therefore, unexpected stock returns of a typical firm are driven by changes in expectations of cash flows and discount rates for all future periods.

of US and Canadian rationally reflected the impact of oil price shocks on current and expected future cash flows. The results are, however, not significant for Japan and UK. Sadorsky (1999) modeled the oil price volatility using generalized autoregressive conditional heteroskedasticity (GARCH) approach. The empirical evidence suggests a unidirectional relationship running from oil price volatility to economic activity. That is, oil prices changes have an impact on the economic activity while changes in economic activity have negligible impact on oil prices. It also reports a significant negative effect of oil price hikes on US real stock returns with increasing magnitude since the mid-1980s.

Due to its critical role in the economy, movements in oil prices receive a special attention in daily media. Nevertheless, studies on oil price-and-stock price relationship are not only few in number, but most of which has been concentrating on developed economies. Thus, it is worth our efforts to carry out studies on emerging economies which have become increasingly attractive destinations for huge amounts of capital movement from major economies. These studies would enhance our understandings of the interaction between oil price volatilities and emerging stock market performances. Further, they would enable foreign investors to understand the conditional relationship between risk and returns across countries.

Our study is among the very few dealing with a panel data set of developed and emerging markets within a unified framework. We employed the unrestricted vector autoregression (VAR) model to estimate the generalized impulse response functions (IRFs) and variance decompositions (VDCs) in favor of the traditional orthogonalized approach. Further, we provide discussion on our findings that oil prices and stock returns in oil importing countries might not be statistically significant and negatively related, despite their theoretical relationships. For instance, an oil price shock of one standard deviation (around 10%) immediately increases stock returns in Japan by 0.6%, in Singapore by 0.1% and negligible in

South Korea. As all the countries in our study are net oil importers, the positive effect of oil price shock on stock market returns in Japan and Singapore are not the same as expected in theory. Moreover, we find that it appears to take time before information about oil price changes become fully reflected in stock market prices. The rest of this paper is organized as follows. In section 2 we provide reviews on the oil price and stock price relationship. In section 3 we discuss the data, our regression model and methodology. Section 4 presents our empirical study. Finally, section 5 concludes with a brief review of the principal findings and a discussion of directions for further study.

2. RELATIONS BETWEEN OIL PRICE AND STOCK PRICES

Overall, the response of aggregate real stock returns is positive or negative, greatly depending on whether the increase in crude oil price is driven by demand or supply shocks in the crude oil market (Kilian and Park, 2009). Furthermore, rises in oil prices may have adverse effects on emerging market economies that uses oil, but has no oil production facilities while having positive effects on emerging market economies that produce oil.

2.1. A negative relationship

This hypothesis basically assumes unidirectional casualty running from oil price to stock price but not vice versa. Put it another way, when oil price rises, the stock market returns seem to decline; however, changes in stock market returns has no impact on the crude oil price. We find a body of research supporting for this argument (e.g. Anoruo and Mustafa, 2007). There are several theoretical mechanisms describing the impact of changes in oil price on stock prices. In a microeconomic view, rising oil prices adversely affect earnings of those companies for which oil is a direct or indirect cost of production (Sadorsky, 1999; Maghyereh, 2004). If the firms cannot fully pass this cost increase to their consumers, the firms' profits and dividends which are key drivers of stock prices will decline (Al-Fayoumi, 2009). The effect is immediate or lagged depending on the efficiency of the stock market.

In the macroeconomic view, an oil price hike acts like an inflation tax on both consumers and producers with two consequences (Basher and Sadorsky, 2006). First, consumers have less disposable income to spend on other goods and services and have to find alternative energies. Second, non-oil-producing countries have to bear the rising costs and face with increasing risk and uncertainty caused by oil price volatility which negatively affects stock prices and reduces wealth and investment. Further, oil price hikes are often thought to bring inflationary pressures, which urge central banks to control inflation by raising interest rate. As shown in the equity pricing model in Huang (1996), the equity price equals to the expected present value of future cash flows. Therefore, the rising interest rate has a direct impact on the discount rate in this equity pricing formula, which leads to a decline in stock prices.

It seems logical to assume an opposite relationship between oil price and stock market performance in net oil-importing countries. Particularly, an increase in oil price puts a downward pressure on foreign exchange rates and upward pressure on domestic inflation rates in these countries. Since a higher expected inflation rate raises the discount rate, a rise in oil price has a negative impact on stock market returns (Huang et al., 1996). The negative effect of rising oil prices on stock markets in net oil importing countries has been supported by a number of researches (Cheung and Ng, 1998; Sadorsky, 1999; Park and Ratti, 2008).

However, several empirical studies are not in line with this hypothesis. For instance, Al-Fayoumi (2009) investigated the relationship between oil price and stock returns on three oil importing countries: Turkey, Tunisia and Jordan. These countries are presumed to have more energy intensive than many advanced economies and thus expected to be more exposed to higher oil prices. Results, however, reveal an insignificant effect of oil price changes on stock market returns. Also, Narayan and Narayan (2010) examined the relationship between oil price and stock market in Vietnam and found that, in the long-run, both oil price and exchange rate have significantly positive effects on the stock price.

2.2. A positive relationship

In this hypothesis, rising crude oil price is associated with a booming economy reflected in stronger business performance, which results in an increase in oil demand. Such cases often happen when the economy recovers from recession. As the global demand picks up, it leads to the rise of basic material prices. To meet the rising demand, factories should pick up steam and need more resources – like labor and fuel for energy. An increase in labor demand means higher wages and more spending, which definitely makes the overall economy look brighter.

Further, an increase in oil price is expected to have a positive impact on stock markets in oil exporting countries, through income and wealth effects. This is due to a rise in government revenues and public expenditure on infrastructure and other omega projects (Al-Fayoumi, 2009). Moreover, higher oil price represents an immediate transfer of wealth from net oil importers to net oil exporters. The length of the effect depends on where the government of oil exporters put the resulting additional income. If the income is used to purchase goods and services domestically, the resulting effect is generating a higher level of economic activity and improving stock market returns in these countries (Bjørnland, 2009).

On modeling the impact of oil prices on stock market returns in Norway, Bjørnland (2009) examined the transmission channels of oil prices for macroeconomic behavior of this country, which includes stock returns as an important channel of wealth. This paper employed the structural VAR model to capture the interaction among different variables and results suggested a positive and significant influence of oil price hikes on stock returns, which is consistent with this hypothesis.

3. DATA AND METHODS

The monthly sample for Japan, Singapore, South Korea, and Malaysia spans from January-1986 to February-2011, inclusive of a total of 302 observations for each country. The West Texas Intermediate (WTI) crude oil spot price, quoted in US dollar (USD) and acquired from the US's Energy Information Administration[5], is chosen as a representative of the world oil price. Although there are prices of three types of oil: Brent, WTI and Dubai – serving as a benchmark for other types of crude oil, the choice of crude oil prices would not significantly affect the study since crude oil prices have been observed to fluctuate in the same direction empirically (Chang, 2003). Stock price index, consumer price index (CPI) and nominal exchange rate (local currency/USD) data are obtained from CEIC's data sources. All the data (except for share price indices and exchange rates) are seasonally adjusted to eliminate the influence of seasonal fluctuations.

Considering the inflation factor, oil price and stock price are transformed into real terms at the 2005 price level. In order to get rid of exchange rate differences, oil prices are converted from USD into the currency of each country. National real oil prices are obtained as products of WTI crude oil prices and exchange rates (local currency per USD) deflated using the inflation indicator (CPI) of each of the country. It is important to note that the choice of oil price variable between world oil price and national oil price are difficult and relevant. In reality, national oil prices are influenced by many factors such as price-controls, high and varying taxes on petroleum products, exchange rate fluctuations and national price index variations. Taking into account such considerations, the use of world oil price in USD and converted into each country's currency by means of the market exchange rate for the analysis across countries is justified. All the data series are transformed to logarithmic form to stabilize the variability in the data.

[5]http://www.eia.doe.gov/dnav/pet/pet_pri_spt_s1_m.htm

Table 1 and 2 tabulate the descriptive statistics of all raw and logged data, respectively. The coefficient of standard deviation (indicator of variance) indicates that in Japan, South Korea and Malaysia, the oil price series has the highest volatility compared to the other two series. In log, oil price series has the highest volatility in Japan, Singapore and Malaysia. In South Korea, logged stock price series has the highest volatility.

[Please place Table 1 and 2 here]

The correlations between the variables are reported in Table 3. Oil and stock prices have the highest correlation in South Korea, followed by Singapore, Malaysia and Japan. The correlation between oil price and stock price is negative in Japan while positive in the other countries. Stock price and exchange rate have the highest correlation in Singapore, followed by Japan, Malaysia and South Korea. This correlation is negative in Singapore while positive in the other threes. The correlation between oil and exchange rate achieves the highest in Malaysia, South Korea, Japan and Singapore. The sign is positive in the former two countries while negative in the latter two.

[Please place Table 3 here]

Methodologically, we used the unrestricted VAR models to estimate the generalized-forecast error VDCs and the generalized IRFs. We incorporated the selected variables of each country into an unrestricted VAR system which is known for its ability to account for problems with intervention and transfer function analysis (Sims, 1980). This methodology provides a multivariate framework where it treats all its variables as jointly endogenous and imposes no a priori restrictions on structural relationships, if any, between the variables being analyzed. In the context of a VAR framework, if the series are I(0), variables are entered as levels into the system. If not, we need to difference the variables to get a stationary process. Such cases usually happen when dealing with financial data such as stock index, exchange rate.

The suitability of an unrestricted VAR is often questioned when variables in the system are cointegrated. Commonly, the use of a vector error correction model (VECM) or cointegrating VAR is supported when variables are integrated of order one, I(1). Since cointegrating vectors bind the long run behavior of variables, results produced by VECM in IRF and VDC analyses expect to reflect more accurately relationships among the variables than those produced by unrestricted VARs. In the short run, however, unrestricted VARs are believed to perform better than a VECM in terms of forecast variance (e.g. Engle and Yoo, 1987; Clements and Hendry, 1995). Due to the short-term nature of the IRF and VDC analysis, unrestricted VARs are thus employed in this study, even if cointegrating relationships are found in Johansen cointegration analysis.

This study specifically employed the generalized IRF and the generalized forecast error VDC of Koop et al. (1996) and Pesaran and Shin (1998) to understand the impacts and responses of the shocks, in favour of the more traditional orthogonalized approach. It is because results of the orthogonalized approach are sensitive to the ordering of the variables in the VAR system while the generalized approach does not have this shortcoming. In our study, the VDC analysis assesses the relative importance of shocks in oil price and exchange rate to the movement of stock prices. The IRF traces over time the effects on a variable of an exogenous shock to another variable and thus allows us to examine the dynamic effects of oil price shocks and exchange rate volatilities on stock prices.

We estimated the following model for each country in our empirical analysis:

$$lnSP_t = \alpha_0 + \beta_1 lnOP_t + \beta_2 lnER_t + \varepsilon_t \quad (1)$$

This model is proposed by Narayan and Narayan (2010), under the assumption that all variables are characterized by a unit root process. In the regression equation (1), $lnSP$ is the natural log of stock prices, $lnOP$ is the natural log of crude oil prices, and $lnER$ is the natural log of nominal exchange rates (local currency/USD). The subscript t denotes the month of observation. The mechanisms through which oil prices impact stock prices have been discussed thoroughly in the previous section. The next paragraphs will thus provide arguments on the stock price-exchange rate relationships.

First, this relationship could be negative or positive, depending on whether the economy is export-or import-dominant, respectively. For an export dominant country, an increase in exchange rate would result in a decline in the country's export competitiveness, thus has a negative impact on the domestic stock prices. For an import dominant country, on the other hand, an appreciation of exchange rate would reduce input costs, thus generates a positive effect on the domestic stock prices (Narayan and Narayan, 2010). Second, variations in exchange rates affect the competitiveness of firms who borrow in foreign currencies to finance their operations. This is because changes in exchange rates affect the earnings as well as its cost of funds and hence its stock prices (Dornbusch and Fischer, 1980). Third, an appreciation of the local currency makes exports less attractive and thus leads to a decrease in foreign demand and hence revenues for the firm. This would also lead to a fall in the exporting firm's value and its stock prices (Gavin, 1989). Fourth, we can use the portfolio balance approach which concentrate on the role of capital account transactions. Particularly, a vibrant stock market attracts capital inflows from foreign investors, which leads to an increase in the demand for its domestic currency. The opposite situation happens when stock prices fall. In such cases, investors would sell their stocks to avoid further losses and convert their money into foreign currency. Consequently, the local currency will depreciate. Fifth, investors' wealth and liquidity demand could be a function of the stock market performance. In this respect, movements in stock price may also affect exchange rates and money demand as foreign investment in domestic equities could increase over time due to the benefits of international diversification accruing to foreign investors (Mishra, 2004).

The major shortcoming of existing literature on the stock price-exchange rate relationship is that it is based on a two-variable framework. Such a system 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 rates on stock prices.

4. ANALYSIS AND INTERPRETATION

4.1. Tests for stationarity

Unit root tests are performed on the log levels and first differences of our variables: crude oil price, stock price, nominal exchange rate for each country – in order to examine the integrational properties of the data series. For this purpose, three tests are employed: Augmented Dickey-Fuller (Dickey and Fuller, 1981), Phillips Perron (Phillips and Perron, 1988) and Kwiatkowski, Phillips, Schmidt, Shin (Kwiatkowskietal, 1992) – with a constant and trend, and without trend. The null of both ADF and PP tests is a unit root existing in each variable, I(1) while the null of KPSS test is testing for I(0).

Table 4 reports the results. The common suggestion of ADF and PP tests is that all the variables are I(1). The results from KPSS test also indicate that, at 1% level, all the variables are I(1), except for the log of stock price in Japan case (test with a constant and a trend). Overall, the results indicate that all the variables are integrated of order one, I(1), that is, stationary in the first difference. Since all the series are nonstationary at the levels and integrated of the same order one, this suggests a possibility of the presence of cointegrating relationship between oil prices, stock prices and exchange rates in the countries under examination. The next section will explore such a possibility.

[Please place Table 4 here]

4.2. Johansen multivariate cointegration analysis

Johansen cointegration tests (Johansen, 1988 and Johansen and Juselius, 1990) are performed to test the existence of cointegrating relationships among the three variables: real stock prices, nominal exchange rates and real oil prices. As a pre-test, variables are entered as levels into VAR models with different lag lengths and F-tests are employed to select the optimal number of lag lengths needed in the cointegration analysis. Three criterions, the Akaike information criterion (AIC) (Akaike, 1969), Schwarz criterion (SC) and the likelihood ration (LR) test are applied to determine the optimal lag length needed.

4.2.1. Optimal lag length selection

An arbitrary choice of a maximum of 8 lag intervals (or 8 months) is chosen. Table 5 reports the AIC and SC statistics from lag 1 to lag 8 in the VAR. For Japan and Malaysia, AIC and SC suggest the same choice of optimal lag length, which are lag 2 periods (2 months) for both countries. For Singapore and South Korea, optimal lag lengths based on AIC and SC are different. In order to determine the optimal lag lengths for these two countries, the LR test is applied. For Singapore, the LR test is employed to test the hypothesis of lag 2 against lag 3. The resulting LR test statistics of 19.41 would suggest that we would reject the null hypothesis of 2 lags at 5% significance level. For South Korea, the LR test is used to test the hypothesis of lag 2 against lag 4. The resulting LR test statistics of 24.094 would also suggest that we can reject the null hypothesis of 2 lags at 5% level. Therefore for Japan and Malaysia, we choose 2 lags (i.e. 2 months) as the optimal number of lag lengths while for Singapore and South Korea, the lag periods chosen are 3 and 4, respectively.

[Please place Table 5 here]

4.2.2. Establishing the number of cointegrating vectors

The Johansen's multivariate cointegration technique is applied to the system of three integrated variables of order one for each country. The lag structure is selected based on the procedure in the previous section. We use the two test assumptions in Johansen test, which allows for a linear deterministic trend in the data series, and an intercept with and without trend in the cointegrating equation. Table 6 presents the results of this test. Given the first assumption, both the eigenvalue and the trace test statistics indicate no long-run relationships existing among the three variables in any country. In the absence of cointegration, oil and stock markets can be considered segmented rather integrated markets, despite their relatively strong correlations in the short run. This implies that, from the perspective of investments, diversification can be achieved by holding assets in both the oil and stock markets.

Given the second assumption, the results are slightly different. Both the eigenvalue and the trace test statistics still confirm no long-run equilibrium relationship among the three variables in Japan, Singapore and South Korea. For Malaysia, the maximum eigenvalue test statistic, however, gives rise to one long-run equilibrium relationship shared among these variables. Since scholars generally prefer the performance of the maximum eigenvalue test than that of the trace test[6], we assume that the variables are cointegrated in Malaysia case. This finding suggests that stock prices, oil prices and exchange rates share one long-run relationship in Malaysia. That is, these variables do move simultaneously and are bound together by a single force in this country. In such a case, although these markets may wander apart for some time, they will eventually revert back to their mean distance.

[Please place Table 6 here]

[6]See pp. 393 of Enders, Walter, 1995, Applied Econometric Time Series. John Wiley and Sons Inc.: New York.

4.3. Granger causality analysis

Usually the VAR approach is used when we have an econometric hypothesis of interest that x_t Granger causes y_t but y_t does not Granger cause x_t. The Granger approach assesses whether past information on one variable would help in predicting the outcome of some other variable, given past information on the latter (Granger, 1969). It is important to note that, despite its name, Granger causality is not sufficient to imply true causality. Sims (1972) is a very famous paper showing that money Granger causes output, but output does not Granger cause money. Later Sims concluded that this does not hold if interest rates are included in the system. This illustrates a major drawback of the Granger causality test, namely the dependence on the right choice of the conditioning set, which, that we cannot assure, has been chosen large enough in practice. The Granger causality tests are most useful when the data are reasonably described by a 2-dimensional system. The tests may, however, produce misleading results when the true relationship involves three or more variables. Another potentially serious problem is the choice of sampling period: a long sampling period may hide the causality whereas for example VAR-systems of monthly data may give rise to serious measurement errors (e.g. due to seasonal adjustment procedures). Therefore, although Granger causality is a useful tool, it must be used and interpreted with care.

The Granger causality/Block exogeneity (BXO) test examines whether the lags of excluded variables affect the endogenous variables. The nature of causality among stock price, oil price and exchange rate in pairs for Japan, Singapore, South Korea and Malaysia are probes and the findings are reported in Table 7. There is no evidence for strong dependence of stock prices on oil prices and on exchange rates, except for South Korea (with dependence of stock prices on exchange rate). Exchange rate is the driving factor of stock and oil markets in South Korea. There are causal relationships running from stock price to oil price in Japan and Singapore. Further, there are bidirectional relationships between oil price and exchange rate in Singapore and between stock price and exchange rate in South Korea. In Malaysia, no significant causality is found among the variables.

[Please place Table 7 here]

Pairwise Granger causality tests are performed with the corresponding lag lengths determined from previous sections. Results in Table 8 suggest that, at 10% level, stock return does Granger cause oil price return in Japan and in Singapore. In Singapore, oil price and exchange rate are Granger causality of each other. Further, there is a unidirectional causality running from exchange rate to oil price in South Korea. Bidirectional relationships are found between stock price and exchange rate in South Korea. No stable long-run relationship is found between any two of the three variables in Malaysia case. These findings confirm the results from the VAR Granger Causality/Block Exogeneity Wald tests in the previous section.

[Please place Table 8 here]

4.4. Generalized impulse response analysis

We used the first differences of the logged variables in the unrestricted VARs to estimate the generalized IRFs and the generalized forecast error VDCs. IRF illustrates the impact of a unit shock to the error of each equation of the VAR. The results suggest that the stock prices are immediately responsive to innovations in oil prices in Japan, Singapore and Malaysia. The responses of stock prices to one standard deviation (around 10%) of oil price shock after one month are 0.6%, 0.1%, 0.0% and -0.3% in Japan, Singapore, South Korea and Malaysia, respectively. Three months after the oil price shocks, the responses of stock prices are -0.0%, 0.5%, 0.2% and 0.3%, respectively. Thus the effect of oil price shock on stock price dies out quickly in Japan while the stock market in South Korea starts to response to the shock. In brief, the empirical results indicate that stock prices are influenced by oil prices in all the four countries with the varying degree.

Overall the effect of oil price on stock price is inconclusive. For instance, in each country, the sign is sometimes negative and sometimes positive. Over the five months afterwards, the response of stock price to oil price shocks is largest in Singapore and South Korea, since these two economies are commonly known as seriously exposed to world oil price fluctuations. In Japan, the influence of oil price on stock returns dies out quickly after the first month of the shock. On the other hand, in Singapore and South Korea, the impact increases afterwards. The oil price shock has asymmetric effects on stock market in Malaysia.

Further, we can see that exchange rates affect stock prices but the effect also varies across the countries. Specifically, the impact of exchange rates on stock price is continually positive in Japan whilst continually negative in Malaysia. On the other hand, in Singapore and South Korea, the influence is sometimes negative, sometimes positive. Based on the statistics on exports and imports covering the period 1986-2011 from International Financial Statistics (IFS), all the four countries are net export economies. The findings are thus not clearly consistent with the abovementioned theories on stock prices and exchange rates. The responses of stock prices to innovations of exchange rates are also dying out promptly in Japan while maintained in the other countries after several months of the shocks.

The results from IRF analysis have following implications. First, changes in oil price will cause an immediate decline in stock prices if the stock market is efficient. This is because an informationally efficient stock market reflects all the current, available information, including oil price shocks (Cong et al, 2008). Second, the shocks from oil prices and exchange rates have longer lasting effects in less developed stock markets. That is, the impacts of oil prices and exchange rates take longer time to work through the system. The implication of this finding is that the longer it takes for innovation to pass through the system, the greater the probability and opportunity for arbitrage between the stock and crude oil commodity markets and the benefit of portfolio diversification. However, this does not work for Japan case. It is worth to notice that the stock market in Japan is more developed than in Singapore, South Korea and Malaysia. The empirical evidence thus partly reflects the varying degree of efficiency across aggregate stock markets.

[Please place Table 9 and Figure 1 here]

4.5. Variance decomposition analysis

Due to its dynamic nature, VDC accounts for the share of variations in the endogenous variables resulting from the endogenous variables and the transmission to all other variables in the system (Brooks, 2008). In our study, the VDC analysis specifically provides a tool for determining the relative importance of changes in oil price and nominal exchange rate in explaining the volatility in real stock price. The results in Table 10 clearly show that most of the variations in each of the three series are due to its own innovation. Immediately after the shock, oil prices contribute 1.7%, 0.0%, 0.0% and 0.3% to the variation in stock returns in Singapore, South Korea and Malaysia. However, the effect is decreasing overtime in Japan while increasing in the other three countries. After 5 months of the shock, the contribution of oil prices to variation in stock returns are 1.6%, 1.0%, 2% and 0.6%, respectively. Thus, in Singapore, South Korea and Malaysia, oil price shock does not have an immediate impact on the stock markets. Rather, it takes some time after the shock for the oil price to have effect on stock markets. This finding once again confirms what we have concluded from the previous section. Further, the results indicate that exchange rates explain stock returns better than oil prices do in Singapore, South Korea and Malaysia. Particularly, five months after the shock, exchange rates contribute 0.2%, 9.9%, 16.3% and 12.3% to the variation in the stock returns in Japan, Singapore, South Korea and Malaysia, respectively.

[Please place Table 10 here]

4.6. Stability test

As a final step, the VAR for generalized impulse responses and variance decompositions are checked for stability. The results indicate that the VAR system for each country is stable in that all inverse roots of AR characteristic polynomial are within the unit circle.

5. CONCLUSION

Our paper provides a comprehensive study on the relationship of oil price and stock market. We discuss theoretical hypotheses on this captioned relationship and compares with empirical evidence from prior research. The empirical investigation includes monthly data for the following countries: Japan, Singapore, South Korea, and Malaysia. We estimated the regression equation from Narayan and Narayan (2010) with newer methods by incorporating the first differences of logged variables into unrestricted VARs to estimate the generalized forecast error VDCs and generalized IRFs. The results show that the impact of oil price fluctuations on stock markets is not so statistically significant. Although the presumptions of oil price-stock price relationship seem reasonable, in practice when we look at a very broad data set, the results may show mixed. Because the aggregate stock price index usually comprises of many market segments; some of which confirm one of the arguments while the others favor the other argument. For example, in the period of rising oil prices, we may see a decline in the stock price index of transportation market sector as transportation costs are negatively affected. In contrast, the impact on the energy sector is favorable, i.e. gas and oil companies, wind and solar enterprises will show increased profits since now they can charge higher prices. Furthermore, we found that different stock markets respond differently to oil price shocks. In Japan, the reaction takes effect immediately after the shock. In Singapore, South Korea and Malaysia, it takes time for the impact to happen and work through the whole system. This finding leads us to conclude that in the presence of stock market inefficiency, the responses of stock market to shocks of the economy might be slow. Finally, the results indicate that oil price shocks have non-linear impacts on stock market returns and strengthens findings from prior researches (e.g. Arouri and Fouquau, 2009; Jawadi et al, 2010).

Further research efforts could either eliminate some of the limitations or expand the scope of investigation in this study. First, further study could, for example, empirically either test for potential structural breaks; or expand the set of variables in the model, such as employment and/or other energy process. Second, since the long-run relationship between oil price and stock prices expected to vary from one industry to another, a sectoral analysis of the matter would be informative. It would also create opportunities for future research efforts to investigate the impact of oil shocks on real stock returns across industries, say, manufacturing industry, either within a country or for a panel of countries. In addition, studies can be conducted to investigate asymmetric reactions of sectoral indices to oil price changes. The empirical findings would be extremely useful for investors who need to have insights of how international oil price changes influence certain stocks across industries to make right investment decisions. Third, future work could investigate the mechanisms via which changes in oil price affects firm behaviors and stock prices in order to create an economic model relating oil prices to firms' dividends and performance. Fourth, since oil price has a presumably significant impact on stock prices and oil price changes are readily public information, it is interesting from a practical point of view to consider the ability of oil price changes in predicting movement in stock returns. Last but not least, due to the crucial role of understanding causes of oil price shocks, we could undertake further studies on to what extent the effects depend on different causes behind oil price changes. In other words, mechanism and theories of the various responses to oil price shocks remain to be researched.

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Table 1: Descriptive statistics (Level)

	Exchange rate	Oil price	Stock price
Japan			
Mean	118.7690	3938.171	115.3462
Std. dev.	18.98073	2397.475	34.46711
Skewness	0.739332	1.551602	0.780172
Kurtosis	4.261368	4.878465	3.443337
Jarque-Bera	47.53349	165.5778	33.10954
Probability	0.000000	0.000000	0.000000
Observations	302	302	302
Singapore			
Mean	1.676346	57.12708	79.47094
Std. dev.	0.218140	29.29168	31.96938
Skewness	0.558713	1.203347	0.582600
Kurtosis	2.789582	3.695516	2.889332
Jarque-Bera	16.26921	78.97202	17.23839
Probability	0.000293	0.000000	0.000181
Observations	302	302	302
South Korea			
Mean	982.4686	40742.93	82.86493
Std. dev.	219.7869	20911.81	38.64834
Skewness	0.466213	1.383191	0.946957
Kurtosis	2.265360	4.357082	3.384548
Jarque-Bera	17.73137	119.4730	46.99611
Probability	0.000141	0.000000	0.000000
Observations	302	302	302
Malaysia			
Mean	3.165458	122.6313	87.69261
Std. dev.	0.557891	71.95675	35.25223
Skewness	0.070055	1.226143	0.172136
Kurtosis	1.290961	3.541859	2.335277
Jarque-Bera	37.00061	79.36714	7.051454
Probability	0.000000	0.000000	0.029430
Observations	302	302	302

Table 2: Descriptive statistics (Log)

	Exchange rate	Oil price	Stock price
Japan			
Mean	4.764884	8.131502	4.705064
Std. dev.	0.156310	0.519025	0.292862
Skewness	0.177786	0.645148	0.063841
Kurtosis	3.290633	2.584738	2.550319
Jarque-Bera	2.653821	23.11944	2.749650
Probability	0.265296	0.000010	0.252884
Observations	302	302	302
Singapore			
Mean	0.508406	3.931223	4.290246
Std. dev.	0.127637	0.466545	0.425992
Skewness	0.281639	0.433898	-0.408134
Kurtosis	2.514170	2.314127	2.902195
Jarque-Bera	6.962522	15.39559	8.504579
Probability	0.030769	0.000454	0.014232
Observations	302	302	302
South Korea			
Mean	6.865664	10.50574	4.308472
Std. dev.	0.220400	0.451452	0.481617
Skewness	0.175593	0.597344	-0.445161
Kurtosis	1.840234	2.439298	3.746223
Jarque-Bera	18.47724	21.91597	16.98148
Probability	0.000097	0.000017	0.000205
Observations	302	302	302
Malaysia			
Mean	1.136638	4.663861	4.377542
Std. dev.	0.177673	0.520297	0.468316
Skewness	-0.000315	0.602467	-0.814529
Kurtosis	1.253789	2.110315	3.301460
Jarque-Bera	38.36975	28.22954	34.53755
Probability	0.000000	0.000001	0.000000
Observations	302	302	302

Table 3: Correlation matrix (Logged variables)

	Exchange rate	Oil price	Stock price
Japan			
Exchange rate	1.000000		
Oil price	-0.230925	1.000000	
Stock price	0.474116	-0.239731	1.000000
Singapore			
Exchange rate	1.000000		
Oil price	-0.199987	1.000000	
Stock price	-0.788995	0.512119	1.000000
South Korea			
Exchange rate	1.000000		
Oil price	0.437879	1.000000	
Stock price	0.070482	0.561131	1.000000
Malaysia			
Exchange rate	1.000000		
Oil price	0.561604	1.000000	
Stock price	0.267097	0.511215	1.000000

Table 4: Results of unit root tests without accounting for a structural break: 1986:01 – 2011:02

		ADF	PP	KPSS
Log levels				
Intercept				
Japan	Exchange rate	-2.3890 (1)	-2.7334	1.0719
	Oil price	-1.3338 (1)	-1.3113	1.2947
	Stock price	-1.9497 (1)	-1.9112	1.0962
Singapore	Exchange rate	-1.1320 (1)	-0.8598	0.8988
	Oil price	-1.3614 (1)	-1.3221	1.2142
	Stock price	-2.5134 (0)	-2.5455	1.6413
South Korea	Exchange rate	-1.4138 (2)	-1.5331	1.2799
	Oil price	-1.2913 (1)	-1.1963	1.4818
	Stock price	-2.8186 (1)	-2.8584	1.1396
Malaysia	Exchange rate	-1.6053 (1)	-1.6682	1.3946
	Oil price	-1.3329 (1)	-1.0827	1.6051
	Stock price	-2.6064 (1)	-2.2167	1.2857

Intercept and trend				
Japan	Exchange rate	-3.0550 (1)	-3.1970	0.1666
	Oil price	-2.5320 (1)	-2.9407	0.4031
	Stock price	-3.5233 (1)	-3.4635	***0.0729***
Singapore	Exchange rate	-1.5169 (1)	-1.2738	0.2622
	Oil price	-2.3094 (1)	-2.5312	0.4166
	Stock price	-3.6956 (1)	-3.7008	0.1509
South Korea	Exchange rate	-2.2429 (2)	-2.3560	0.1976
	Oil price	-2.9101 (1)	-3.3418	0.4422
	Stock price	-3.3010 (1)	-3.2556	0.1827
Malaysia	Exchange rate	-1.3038 (1)	-1.3657	0.2328
	Oil price	-2.7643 (1)	-2.9874	0.3743
	Stock price	-3.2609 (1)	-2.7252	0.2351
First differences				
Intercept				
Japan	Exchange rate	-13.0844 (0)	-12.7827	0.1551
	Oil price	-14.1236 (0)	-13.9954	0.1893
	Stock price	-12.4855 (0)	-12.5550	0.1488
Singapore	Exchange rate	-12.6167 (1)	-12.3729	0.2176
	Oil price	-14.7021 (0)	-14.5992	0.1517
	Stock price	-15.5465 (0)	-15.5825	0.0798
South Korea	Exchange rate	-12.3838 (1)	-9.7824	0.0704
	Oil price	-14.5338 (0)	-14.4442	0.2122
	Stock price	-12.1508 (0)	-12.2017	0.1508
Malaysia	Exchange rate	-13.2072 (0)	-13.2873	0.1705
	Oil price	-14.3560 (0)	-14.2111	0.1036
	Stock price	-11.4963 (0)	-11.0907	0.0926
Intercept and trend				
Japan	Exchange rate	-13.0618 (0)	-12.7564	0.1272
	Oil price	-14.1206 (0)	-13.9852	0.0349
	Stock price	-12.5169 (0)	-12.5802	0.0800
Singapore	Exchange rate	-12.5957 (0)	-12.3508	0.2197
	Oil price	-14.6931 (0)	-14.5853	0.0314
	Stock price	-15.5439 (0)	-15.5774	0.0406
South Korea	Exchange rate	-12.3661 (1)	-9.7641	0.0703
	Oil price	-14.5451 (0)	-14.4936	0.0257
	Stock price	-12.1548 (0)	-12.2075	0.1270
Malaysia	Exchange rate	-13.2425 (0)	-13.3167	0.0852
	Oil price	-14.3330 (0)	-14.1813	0.0275
	Stock price	-11.4985 (0)	-11.0732	0.0613

Note: 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 5: AIC and SC statistics from VAR (1) to VAR (8)

Lag intervals	Japan		Singapore		South Korea		Malaysia	
	AIC	SC	AIC	SC	AIC	SC	AIC	SC
1	-9.850384	-9.700034	-10.67316	-10.52281	-8.960122	-8.809771	-10.06278	-9.912428
2	**-10.06108**	**-9.797968**	-10.81374	**-10.55063**	-9.511568	**-9.248455**	**-10.31837**	**-10.05525**
3	-10.02388	-9.648002	**-10.81854**	-10.44266	-9.581098	-9.205222	-10.31486	-9.938989
4	-9.986082	-9.497444	-10.79334	-10.30470	**-9.582411**	-9.093773	-10.29208	-9.803441
5	-9.975286	-9.373885	-10.76861	-10.16720	-9.540602	-8.939201	-10.29044	-9.689044
6	-9.954610	-9.240446	-10.75713	-10.04296	-9.566026	-8.851863	-10.25401	-9.539845
7	-9.928193	-9.101267	-10.72604	-9.899114	-9.578429	-8.751503	-10.23017	-9.403248
8	-9.896930	-8.957241	-10.71420	-9.774510	-9.548352	-8.608663	-10.30000	-9.360311

Note: Figures in bold denote optimal lag lengths selected by the respective criterion.

Table 6: Johansen-Juselius multivariate cointegration test results

r	**n-r**	λ_{max}	**95%**	**Tr**	**95%**
Assumption 1: the level data have linear deterministic trends but the cointegrating equations have only intercepts					
Japan (lags = 2)					
$\boldsymbol{r = 0}$	$r = 1$	13.92478	21.13162	20.62286	29.79707
$\boldsymbol{r \leq 1}$	$r = 2$	6.683508	14.26460	6.698078	15.49471
$\boldsymbol{r \leq 2}$	$r = 3$	0.014571	3.841466	0.014571	3.841466
Singapore (lags = 3)					
$\boldsymbol{r = 0}$	$r = 1$	20.11724	21.13162	26.84784	29.79707
$\boldsymbol{r \leq 1}$	$r = 2$	4.065149	14.26460	6.730607	15.49471
$\boldsymbol{r \leq 2}$	$r = 3$	2.665458	3.841466	2.665458	3.841466
South Korea (lags = 4)					
$\boldsymbol{r = 0}$	$r = 1$	17.20593	21.13162	22.84914	29.79707
$\boldsymbol{r \leq 1}$	$r = 2$	5.118030	14.26460	5.643205	15.49471
$\boldsymbol{r \leq 2}$	$r = 3$	0.525175	3.841466	0.525175	3.841466
Malaysia (lags = 2)					
$\boldsymbol{r = 0}$	$r = 1$	9.859682	21.13162	19.75807	29.79707
$\boldsymbol{r \leq 1}$	$r = 2$	6.809314	14.26460	9.898388	15.49471
$\boldsymbol{r \leq 2}$	$r = 3$	3.089074	3.841466	3.089074	3.841466
Assumption 2: The level data and the cointegrating equations have linear trends					
Japan (lags = 2)					
$\boldsymbol{r = 0}$	$r = 1$	19.39539	25.82321	33.94797	42.91525
$\boldsymbol{r \leq 1}$	$r = 2$	8.669254	19.38704	14.55257	25.87211
$\boldsymbol{r \leq 2}$	$r = 3$	5.883321	12.51798	5.883321	12.51798
Singapore (lags = 3)					
$\boldsymbol{r = 0^*}$	$r = 1$	23.26548	25.82321	40.32356	42.91525
$\boldsymbol{r \leq 1}$	$r = 2$	14.06011	19.38704	17.05808	25.87211

$\boldsymbol{r \leq 2}$	$r = 3$	2.997973	12.51798	2.997973	12.51798
South Korea (lags = 4)					
$\boldsymbol{r = 0}$	$r = 1$	22.19637	25.82321	39.65089	42.91525
$\boldsymbol{r \leq 1}$	$r = 2$	12.40190	19.38704	17.45452	25.87211
$\boldsymbol{r \leq 2}$	$r = 3$	5.052622	12.51798	5.052622	12.51798
Malaysia (lags = 2)					
$\boldsymbol{r = 0}$	$r = 1$	27.23742*	25.82321	37.73048	42.91525
$\boldsymbol{r \leq 1}$	$r = 2$	7.356998	19.38704	10.49307	25.87211
$\boldsymbol{r \leq 2}$	$r = 3$	3.136071	12.51798	3.136071	12.51798

Note: r = number of cointegrating vectors, n-r = number of common trends, λ_{max} = maximum eigenvalue statistic, Tr = trace statistic. * denote rejection of the hypothesis at the 0.05

Table 7: Granger Causality Test

Excluded variables	**Dependent variables**			
	Exchange rate	Oil price	Stock price	BXO*
Japan				
Exchange rate		0.197	0.311	2.585
		(0.906)	(0.856)	(0.630)
Oil price	0.903		1.434	11.469
	(0.637)		(0.488)	(0.022)
Stock price	1.651	11.326		1.500
	(0.438)	(0.004)		(0.022)
Singapore				
Exchange rate		9.849	1.574	7.382
		(0.020)	(0.665)	(0.287)
Oil price	7.019		3.054	27.052
	(0.071)		(0.383)	(0.000)
Stock price	0.586	17.829		4.494
	(0.900)	(0.001)		(0.610)
South Korea				
Exchange rate		7.839	15.845	15.944
		(0.098)	(0.003)	(0.043)
Oil price	3.378		7.025	11.944
	(0.497)		(0.135)	(0.154)
Stock price	11.877	0.756		23.917
	(0.018)	(0.944)		(0.002)
Malaysia				
Exchange rate		0.514	0.522	5.107
		(0.774)	(0.770)	(0.277)
Oil price	0.518		1.244	2.336
	(0.772)		(0.537)	(0.674)
Stock price	4.361	1.063		1.682
	(0.113)	(0.588)		(0.794)

*Note: Granger Causality test and Block Exogeneity (BXO) Wald tests are performed on the first differences of logged variables. Both the chi-sq and (probability in parenthesis) are reported.

Table 8: Pairwise Granger Causality Tests – Sample: 1986:01-2011:02

Null Hypothesis	Observations	F-Statistic	Probability	Decision*
Japan (lags = 2)				
Oil price does not Granger Cause Exchange rate	299	0.46742	0.62708	Accepted
Exchange rate does not Granger Cause Oil price	299	0.06928	0.93308	Accepted
Stock price does not Granger Cause Exchange rate	299	0.84417	0.43095	Accepted
Exchange rate does not Granger Cause Stock price	299	0.03310	0.96744	Accepted
Stock price does not Granger Cause Oil price	299	5.67083	0.00383	Rejected
Oil price does not Granger Cause Stock price	299	0.59761	0.55079	Accepted
Singapore (lags = 3)				
Oil price does not Granger Cause Exchange rate	298	2.28412	0.07909	Rejected
Exchange rate does not Granger Cause Oil price	298	2.92513	0.03416	Rejected
Stock price does not Granger Cause Exchange rate	298	0.11922	0.94876	Accepted
Exchange rate does not Granger Cause Stock price	298	0.48000	0.69644	Accepted
Stock price does not Granger Cause Oil price	298	5.60253	0.00095	Rejected
Oil price does not Granger Cause Stock price	298	0.97800	0.40344	Accepted
South Korea (lags = 4)				
Oil price does not Granger Cause Exchange rate	297	0.98952	0.41354	Accepted
Exchange rate does not Granger Cause Oil price	297	2.82879	0.02507	Rejected
Stock price does not Granger Cause Exchange rate	297	3.14810	0.01482	Rejected
Exchange rate does not Granger Cause Stock price	297	4.17898	0.00264	Rejected
Stock price does not Granger Cause Oil price	297	1.01292	0.40097	Accepted
Oil price does not Granger Cause Stock price	297	1.93822	0.10416	Accepted

Malaysia (lags = 2)				
Oil price does not Granger Cause Exchange rate	299	0.37009	0.69099	Accepted
Exchange rate does not Granger Cause Oil price	299	0.63821	0.52897	Accepted
Stock price does not Granger Cause Exchange rate	299	2.30606	0.10145	Accepted
Exchange rate does not Granger Cause Stock price	299	0.21940	0.80313	Accepted
Stock price does not Granger Cause Oil price	299	0.91558	0.40142	Accepted
Oil price does not Granger Cause Stock price	299	0.58261	0.55908	Accepted

Note: Pairwise Granger Causality tests are performed on the first differences of logged variables.
*Decisions are made at 10% significance level.

Table 9: Generalized Impulse Responses

Months after shock	**Japan**			**Singapore**			**South Korea**			**Malaysia**		
	DLEX	DLOP	DLSP	DLEX	DLOP	DLSP	DLEX	DLOP	DLSP	DLEX	DLOP	DLSP
Response of stock prices to innovations in												
1	0.002	0.006	0.048	-0.024	0.001	0.076	-0.026	0.000	0.066	-0.021	-0.003	0.060
2	0.001	-0.001	0.015	0.002	0.004	0.008	-0.000	-0.000	0.023	-0.008	0.001	0.025
3	0.001	-0.000	0.004	-0.001	0.005	0.009	0.009	-0.002	0.004	-0.003	0.003	0.005
4	0.000	-5.59E-05	0.001	0.004	-0.004	-0.007	0.001	0.004	0.001	-0.002	0.002	0.000
5	0.000	1.60E-05	0.000	0.001	-0.002	0.000	-0.009	-0.007	0.003	-0.001	0.001	0.000
Response of crude oil prices to innovations in												
1	0.022	0.079	0.010	0.001	0.074	0.001	0.019	0.078	0.000	0.012	0.078	-0.004
2	0.006	0.015	0.012	-0.013	0.010	0.002	0.005	0.013	-0.001	0.002	0.015	0.001
3	0.001	0.006	0.014	-0.005	0.002	0.012	-0.009	0.000	0.004	-0.004	0.002	0.006
4	0.000	0.001	0.006	-0.003	1.56E-05	0.014	-0.011	-0.001	0.004	-0.002	0.000	0.003
5	0.000	0.000	0.002	-0.000	0.003	0.005	-0.004	-0.002	0.006	-0.001	0.000	0.001
Response of exchange rates to innovations in												
1	0.026	0.007	0.001	0.012	0.000	-0.004	0.026	0.006	-0.010	0.019	0.003	-0.007
2	0.008	0.001	0.000	0.004	-0.001	-0.001	0.017	0.004	-0.009	0.005	0.000	-0.002
3	0.002	0.001	0.002	-4.49E-05	-0.001	0.000	0.000	0.000	-0.004	0.000	-0.000	-0.002
4	0.000	0.000	0.001	-0.000	-0.001	0.000	-0.004	-0.003	-0.004	2.41E-05	-0.000	-0.001
5	7.49E-05	0.000	0.001	0.000	-0.000	-0.000	-0.001	-0.000	-0.003	0.000	-0.000	-0.000

Note: D and L are first difference and natural log operators, respectively. EX stands for exchange rate, OP stands for oil price, and SP stands for stock price.

Table 10: Generalized forecast error variance decomposition of real stock returns

Months ahead	Exchange rate	Oil price	Stock price
Japan			
0	.0013906	.017055	1.00000
1	.0017513	.015924	.99554
2	.0020358	.015793	.99503
3	.0021027	.015785	.99494
4	.0021119	.015785	.99493
5	.0021128	.015785	.99493
Singapore			
0	.099670	.3853E-3	1.0000
1	.098654	.0031678	.99372
2	.097105	.0066600	.98989
3	.098578	.0094146	.98667
4	.098705	.0099431	.98581
5	.098742	.010340	.98540
South Korea			
0	.15171	.1955E-4	1.0000
1	.13291	.2158E-4	.98070
2	.14476	.9739E-3	.94939
3	.14458	.0047529	.94569
4	.15625	.014952	.92780
5	.16337	.019738	.91794
Malaysia			
0	.12485	.0027454	1.0000
1	.12123	.0028632	.99812
2	.12269	.0051060	.99437
3	.12306	.0056906	.99308
4	.12312	.0057480	.99293
5	.12312	.0057511	.99292

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

Figure 1: Generalized impulse response of DLEX, DLOP and DLSP to 1 standard deviation innovations

Note: D and L are first difference and natural log operators, respectively. EX stands for exchange rate, OP stands for oil price, and SP stands for stock price.

Figure 1a: Japan case

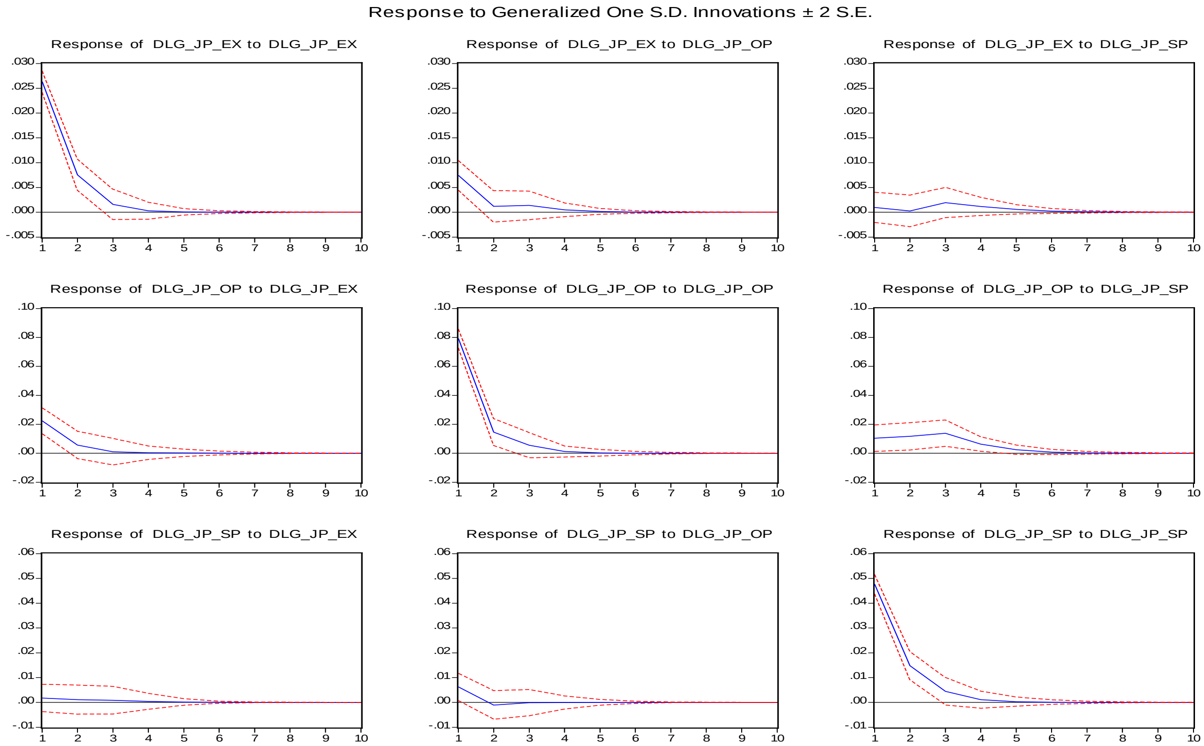

Figure 1b: Singapore case

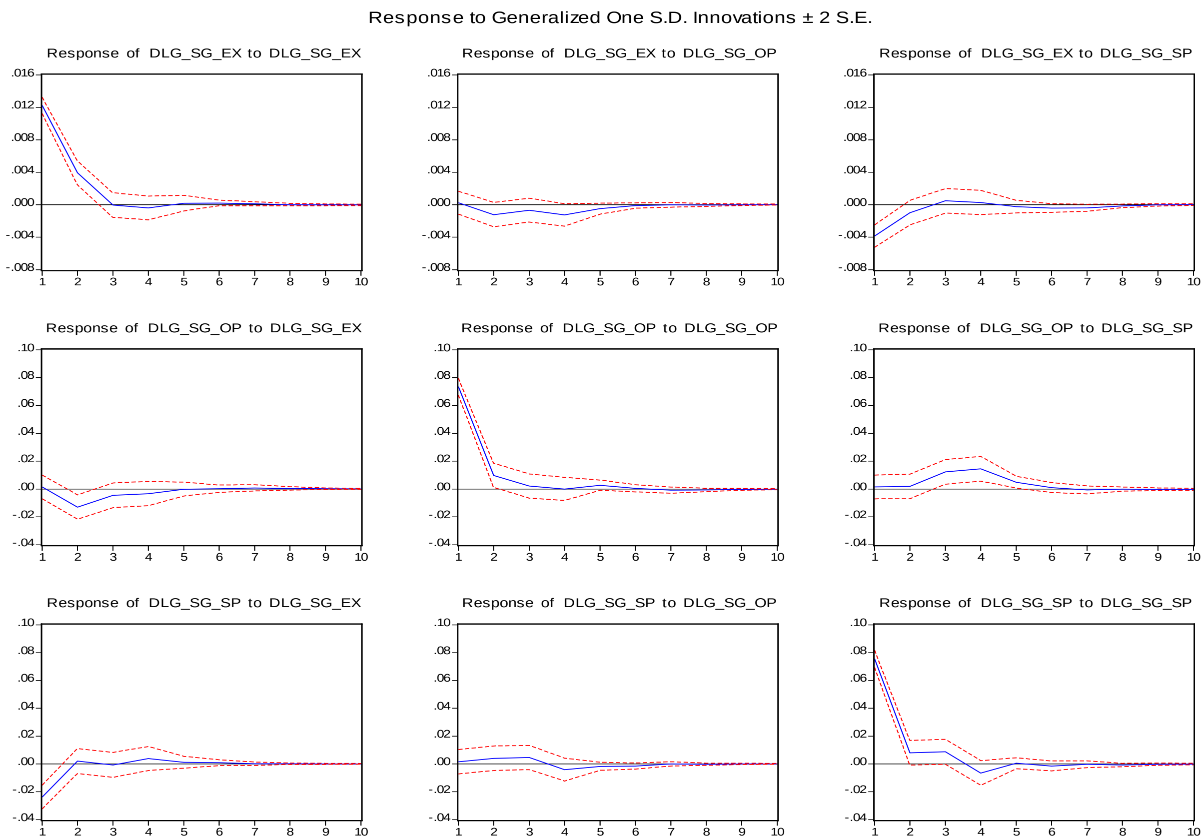

Figure 1c: South Korea case

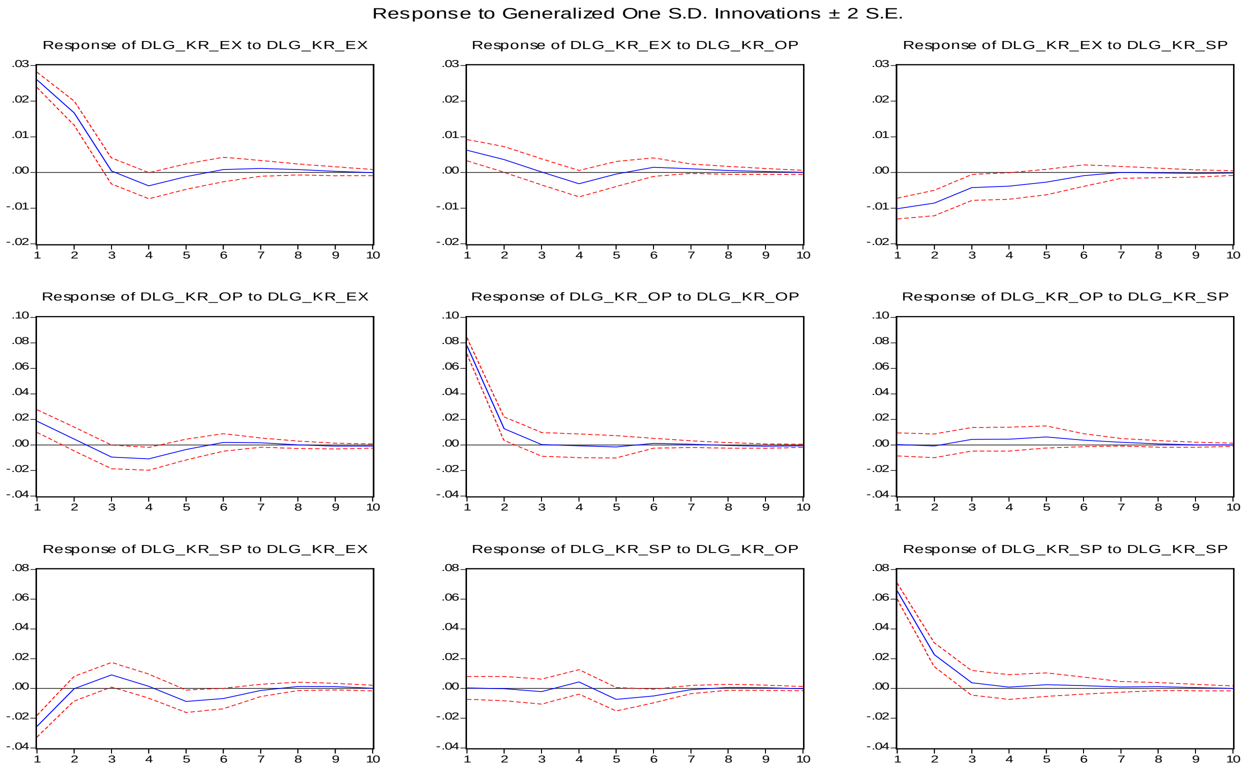

Figure 1d: Malaysia case