The impact of Crude oilprice volatility on selected Asian emerging economies

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Abstract

This paper empirically investigates the impact of oil price volatility on six major emerging economies of Asia, namely China, India, Indonesia, Malaysia,Philippines and Thailand. Following Andersen et al. (2004) quarterly oil price volatility is measured by using the realized volatility (RV).For China, according to the VAR analysis along with the Granger causality test, generalized impulse response functions and generalized variance decompositions, it can be inferred that oil price volatility impacts output growth in the short run. For India oil price volatility impacts both GDP growth and inflation. In Philippines oil price volatility impacts inflation. For the Indonesian economy oil price volatility impacts both GDP growth and inflation before and after the Asian financial crisis. In Malaysia oil price volatility impacts GDP growth, while there is a very little feedback from the opposite side. For Thailand, oil price volatility impacts output growth for the whole studied period. However, after the Asian financial crisis the impact seems to disappear.It seems that oil subsidization of the Thai Government by introduction of the oil fund plays a significant role in improving economic performance by lessening the adverse effect of oil price volatility on macroeconomic indicators.

Keywords: Oil price volatility, Emerging economies, Asian financial crisis, Generalized impulse response functions, Generalized variance decompositions.

JEL Classification: C32, Q43, O13

1. Introduction

An impressive body of literature demonstrate that,oil price shocks exert adverse impacts on economies from both supply and demand side (Hamilton(1983);Loungani(1986);Mory(1993);Brown and Yucel(2002);Jimenez-Rodriguez(2008);Jbir and Zouari-Ghorbel (2009) and so forth).Alternatively, large oil price variability, either increases or decreases, *i.e.* oil price volatility, may adversely affect the economy in the short run because they delay business investment by raising uncertainty (Bernanke 1983) or by inducing costly sectoral resource reallocation(Hamilton 1988). Hence, previous research concerning oil price and economic activities mainly investigates two different aspects of the relationship between oil price and economic activities: the impact of oil price shocks and the impact of oil price volatility. These two approaches differ in the way they incorporate oil price in their models. While the first approach takes oil prices at their levels, the second approach employs different volatility measures to capture the oil price uncertainty.

In contrast to the large number of studies that analyse the impact of oil price shocks, papers investigating the impact of oil price volatility on the economic activities are very limited and have their origin in the increase of oil price volatility from the mid-1980s. Furthermore, studies identifying the impact of oil price volatility in the context of developing nations are almost nonexistent in the literature. One exception is Rafiq, Salim, and Bloch(2009), where the authors analyses the impact of oil price volatility on Thai economy.Nevertheless, in the light of increasing demand for oil from developing nations, comprehensive studies on identifying the impact of oil price volatility on major developing economies are warranted. This paper attempts to fill this research gap in the oil price-output related literature. While Rafiq, Salim, and Bloch(2009) studies only Thai economy, this study analyses the impact of oil price volatility in six emerging Asian economies namely, China, India, Indonesia, Malaysia, Philippines, and Thailand.

The remainder of the paper is organized as follows. Section 2 elaborates two different channels through which oil price volatility may impact the macroeconomy. Section 3 presents a critical review of earlier literature followed by an analytical framework in section 4. Empirical results from the estimation are presented in section 5. Conclusion and policy implications are offered in the final section.

2. The Macroeconomic Implications of Oil Price Volatility

It is now well established in both empirical and theoretical literature that oil price shocks exert adverse impacts on different macroeconomic indicators through raising production and operational costs. Alternatively, large oil price changes- either increases or decreases, i. e. volatility- may affect the economy adversely because they delay business investment by raising uncertainty or by inducing costly sectoral resource reallocation.

Bernanke (1983) offers theoretical explanation of the uncertainty channel by demonstrating that, when the firms experience increased uncertainty about the future price of oil then it is optimal for them to postpone irreversible investment expenditures. When a firm is confronted with a choice of whether to add energy-efficient or energy-inefficient capital, increased uncertainty born by oil price volatility raises the option value associated with waiting to invest. As the firm waits for more updated information, it forgoes returns obtained by making an early commitment, but the chances of making the right investment decision increase. Thus, as the level of oil price volatility increases, the option value rises and the incentive to investment declines (Ferderer 1996). The downward trend in investment incentives ultimately transmits to different sectors of the economy.

Hamilton (1988) discusses the sectoral resource allocation channel. In this study by constructing a multi-sector model, the author demonstrates that relative price shocks can lead to a reduction in aggregate employment by inducing workers of the adversely affected sectors to remain unemployed while waiting for the conditions to improve in their own sector rather than moving to other positively affected sectors. Lilien(1982) demonstrates further by showing that aggregate unemployment rises when relative price shocks become more variable.

3. Oil Price Volatility and the Economy

Previous research in oil price-economy relationship mainly investigates two different aspects of the linkage between oil price and economic activities: the impact of oil price shock and the impact of oil price volatility. These two approaches differ in the way they incorporate oil price in their model. While the first approach takes oil prices at their levels, the second approach employs different volatility measures to capture the oil price uncertainty.

In response to two consecutive oil shocks in the early and late 1970s, a considerable number of studies have examined the impact of shocks to oil price levels on economic activities. This huge list of studies is pioneered by Hamilton(1983) and is extendedby, Burbridge and

Harrison (1984), Gisser and Goodwin(1986), Mork(1989), Mork and Olsen(1994), Cunado and Gracia(2005), Huang, Hwang, and Peng (2005), Lardic and Mignon (2006), Chen and Chen (2007), Huntington (2007), Cologni and Manera(2008),Hamilton(2008), Chen (2009), Jimenez-Rodriguez(2009), Jbir and Zouari-Ghorbe(2009), and several others to be named. Among the impressive body of literature on oil price and economy relationship, studies like, Mork (1989), Jimenez-Rodriguez and Sanchez(2005) and Farzanegan and Markwardt(2009) indicate that for some economies this impact of oil price on economic activities is asymmetric, *i.e.*the negative impact of oil price increases is larger than the positive impact of oil price decreases.

In contrast to the above studies that analyse the impact of oil price shocks, papers investigating the impact of oil price volatility on the economies are very limited and have their origin in the increase of oil price volatility from the mid-1980s. Lee, *et al*. (1995) find that oil price changes have a substantial impact on economic activities of the US (notably GNP and unemployment) only when prices are relatively stable, rather than highly volatile or erratic. Ferderer (1996) analyses the US data spanning from 1970:01 to 1990:12 to see whether the relation between oil price volatility and macroeconomic performance is significant. In this study, the oil price volatility is measured by the simple standard deviation and it concludes that sectoral shocks and uncertainty channels offer a partial solution to the asymmetry puzzle between oil price and output.

Using the measure of realized volatility constructed from daily crude oil future prices traded on the NYMEX (New York Mercantile Exchange), Guo and Kliesen (2005) find that over the period 1984-2004 oil price volatility has a significant effect on various key US macroeconomic indicators, such as fixed investment, consumption, employment, and the unemployment rate. The findings suggest that changes in oil prices are less significant than the uncertainty about future prices. It is to be noted here that, all the above mentioned studies on identifying the impact of oil price volatility are undertaken with respect to the US economy. One recent paper that investigates the impact of oil price volatility in the context of developing economies is Rafiq, Salim & Bloch (2009).

Rafiq, Salim & Bloch (2009) investigates the impact of oil price volatility on key macroeconomic variables in Thailand by using vector auto-regression systems. The variables used for this purpose are oil price volatility, GDP growth, investment, unemployment, inflation, interest rate, trade balance and budget deficit of Thailand for the period of 1993:1 to 2006:4. The oil price volatility data is constructed using the realized volatility measure. Since the structural break test indicates breaks during the Asian financial crisis, this study employs two different VAR systems, one for the whole period and the other for the period after the crisis. For the whole time period, the causality test along with impulse response functions and variance decomposition tests indicate that oil price volatility has significant impact on unemployment and investment. However, the empirical analysis for the post-crisis period shows that the impact of oil price volatility is transmitted to the budget deficit. This study, nevertheless, suffers from several theoretical and empirical flows. First, given the small data set this study includes too many variables which may cause model misspecification issue. Second, considering variables like, output, employment, and investment within the same model with few data points may raise multicolenearity. Third, performing structural break test for stationary series does not add any value to the overall empirical performance of the study. Fourth, this study employs orthogonalized forms of impulse response functions and variance decompositions, the results from which are sensitive to the ordering of variables. Hence, this studyin handincludes only two macroeconomic variables in the model which may indicate the overall macoeconomic performance of the economies namely, GDP growth and inflation. Furthermore, it employs generalized version of the impulse response functions and variance decompositions tests which provide more robust results in small samples and are not sensitive to the ordering of the variables.

Some observations can be made from the above discussion on the relationship between oil prices and/or volatility and the economy. Firstly, there is some evidence that oil price shocks have important impact on aggregate macroeconomic indicators, such as GDP, interest rates, investment, inflation, unemployment and exchange rates. Secondly, the evidence generally suggests that impact of oil price changes on the economy is asymmetric; that is, the negative impact of oil price increases is larger than the positive impact of oil price decreases. Finally, there have been a few academic endeavours made to analyse the impact of oil price volatility per se on economic activities and, more importantly, such studies are conducted almost exclusively in the context of developed countries, especially the US. This study in hand fills that gap in oil price–economy nexus in literature.

4. Data sources and analytical framework

(a) Data: This study uses quarterly data on three different variables, namely oil price volatility, GDP growth and inflation. The data periods covered for China, India, Indonesia, Malaysia, Philippines and Thailand are 1999:2 to 2009:1, 1996:4 to 2009:1, 1993:2 to 2009:1, 1991:2 to 2009:1, 1986:1 to 2009:1, and 1993:2 to 2009:1, respectively. GDP growth rate and inflation data are quarter to quarter change based on real GDP and CPI data. For China, real GDP is constructed from nominal GDP.Nominal GDP, GDP deflator, and CPI data are collected from IFS CD September 2009. The base year for real GDP is 2000. For India, the nominal GDP data are collected from Main Economic Indicators (MEI), a publication of Organization for Economic Co-operation and Development (OECD). Data on GDP deflator are collected from IFS CD September 2009. Both nominal GDP and GDP deflator are in Million Indian Rupee. Real GDP with a base year of 2000 is calculated from adjusting nominal GDP with the deflator. CPI data are also extracted from IFS CD of September 2009 based on Million Indian Rupee.

For Indonesia, real GDP with the base year of 2000 is collected from Main Economic Indicators (MEI) by OECD. The unit for real GDP is Billion Indonesian Rupiah. CPI for Indonesia is collected from IFS CD of September 2009. With respect to Malaysia, all the relevant data of nominal GDP, GDP deflator and CPI are collected from IFS CD of September 2009. The base year for GDP deflator and CPI is 2000. The scale for all the series is Million Malaysian Ringgit.

Nominal GDP, GDP deflator and CPI data for Philippines are also found from IFS CD, September 20008. Base year for GDP deflator and CPI is 2000. Scale for all the series is Million Philippine Peso. Similar to Malaysia and Philippines, all the three series for Thailand are collected from IFS CD of September 2009. The base year for GDP Deflator and CPI is 2000. Real GDP of all the concerned countries are not seasonality adjusted.

Realized Oil Price Variance: Based on the nature of data under consideration, various volatility measures, both parametric and non-parametric (such as historical volatility (HS), stochastic volatility (SV), implied volatility (IV), realized volatility (RV) and conditional volatility (CV)) have been suggested in the literature. The parametric models can reveal well documented time varying and clustering features of conditional and implied volatility. However, the validity of the estimate relies a great deal on the model specifications along with the particular distributional assumptions and, in the instances of implied volatility, another assumption regarding the market price of volatility risk has to be met (Andersen et al. 2001 a, ABDE hereafter). This stylized fact is also unveiled in a seminal article by Andersen *et al.* (2001 b, ABDL hereafter), where they argue that the existence of multiple competing parametric models points out the problem of misspecification. Moreover, the conditional volatility (CV) and stochastic volatility (SV) models are hard to adopt in a multivariate framework for most of the practical applications.

An alternative measure of volatility, termed as *realized volatility,* is introduced by ABDE (2001 a) and ABDL (2001 b, 2003). Furthermore, the theory of quadratic variation suggests that, under appropriate conditions, realized volatility is an unbiased and highly efficient estimator of volatility of returns, as shown in ABDL (2001 and 2003), and Barndorff-Nielsen & Shephard (2002, 2001). In addition to that, by treating volatility as observed rather than latent, the approach facilitates modelling and forecasting using simple methods based on observable data (ABDL, 2003).

According to Andersen *et al*. (2004), *realized volatility* or *realized variance* is the summation of intra-period squared returns

$$RV_t(h) \equiv \sum_{i=1}^{t/h} r_{t-1+ih}^{(h)2}$$

where the *h*-period return (in this study this is daily oil price return) is given by $r_t^{(h)} = \log(S_t) - \log(S_{t-h})$, *t* is the total number of working days in a quarter and *h* is 1 as this study uses daily price data. Hence, $1/h$ is a positive integer. In accordance with the theory of quadratic variation, the realized volatility $RV_t(h)$ converges uniformly in probability to IV_t as $h \rightarrow 0$, as such allowing for ever more accurate nonparametric measurements of integrated volatility. Furthermore, papers of Zhang *et al*. (2005) and Aït-Sahalia *et al*. (2005) state that the realized variance is a consistent and asymptotically normal estimator once suitable scaling is performed.

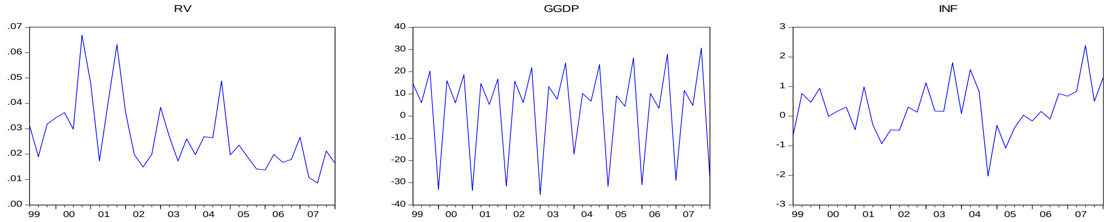
In calculating the quarterly volatility measure, the daily crude oil prices of “Arab Gulf Dubai FOB $US/BBL” are considered and transformed into local prices by adjusting the world oil prices with the respective foreign exchange rates. Dubai oil prices are collected from Datastream and the source is ICIS Pricing, and exchange rates for different currencies are also found from Datastream and the source is GTIS-FTID.

Graphical representations of data are given below in Figure 1. These figures reveal two important facts; (i) crude oil price has been highly volatile in recent years, particularly in the second half of 1990s, and (ii) since none of the GDP data are seasonally adjusted, there are signs of seasonality in the GDP growth data series for all the countries. Hence, this study performs seasonal adjustment for GDP growth data of all the countries.

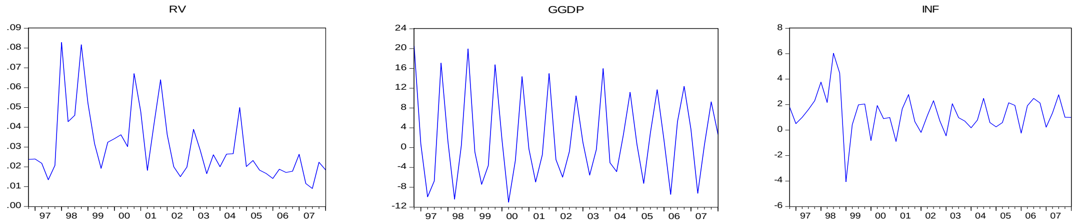
The seasonal adjustment is performed through implementing the U.S. Census Bureau's X12 seasonal adjustment program. The X11 additive method along with default X12 seasonal filter has been adopted in this regard. All the seasonally adjusted GDP growth series are presented in Appendix Figure 1.

Figure 1: Variables Used in This Paper

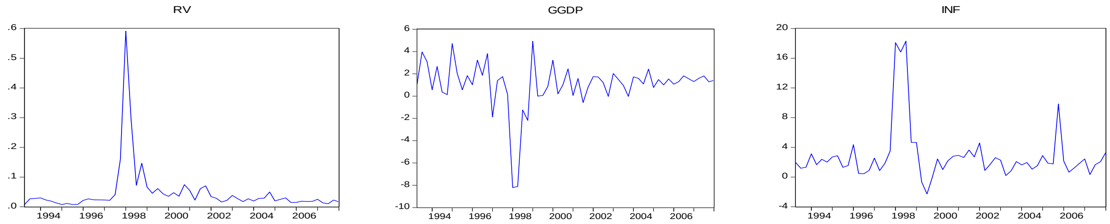
a. China



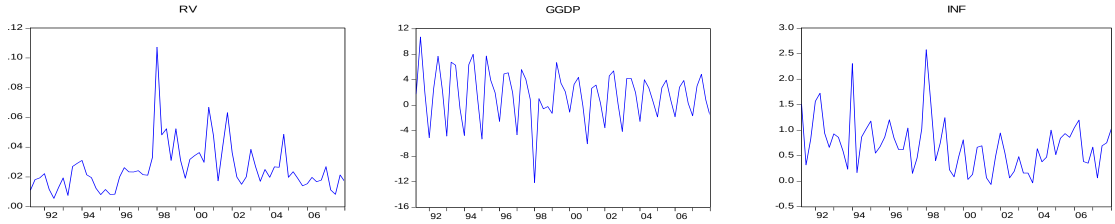
b. India



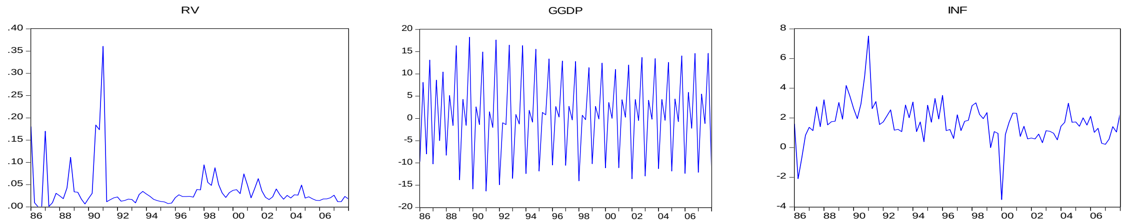
c. Indonesia



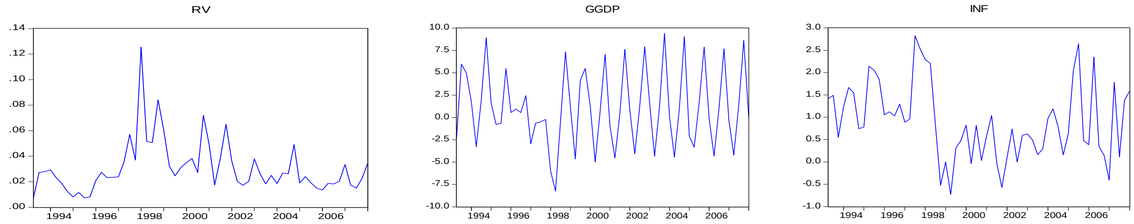
d. Malaysia



e. Philippines



f. Thailand



Note: RV, GGDP and INF stand for realized volatility for oil prices, GDP growth and inflation, respectively.

From visual scrutiny of the seasonally adjusted series along with realized volatility and inflation data, it can be inferred that with respect to most of the series for Indonesia, Malaysia and Thailand there are spikes around the period of Asian financial crisis, *i.e.* from early 1997-mid 1998. This is not unusual given the fact that these three economies were among the most severely affected ones during the crisis period. In addition to that, all the variables seem to be stationary at levels.

Summary statistics of all the variables are offered in Appendix Table 1. The simple correlation analysis indicates that GDP growth rate, oil price volatility and inflation are significantly correlated for most of the countries. Another significant finding is that, for most of the countries, GDP growth is negatively and inflation is positively correlated with the oil price volatility. Prior to identifying causality among the variables, an investigation of time-series properties of the data is warranted and the following section discusses these properties.

(b) Methodology: This article employs the Granger-causality test to examine the causal relationship between oil price volatility, output growth, and inflation of six major emerging economies of Asia.

Vector Auto-regression (VAR) of the following form is considered for this purpose:

$$Y_t = \alpha_0 + \sum_{i=1}^{n} \beta_i Y_{t-i} + \sum_{i=1}^{n} \lambda_i X_{t-i} + \mu_t \qquad (1)$$

$$X_t = \phi_0 + \sum_{i=1}^{n} \varphi_i Y_{t-i} + \sum_{i=1}^{n} \eta_i X_{t-i} + \nu_t \qquad (2)$$

where n is the number of the optimum lag length. In this study, optimum lag lengths are determined empirically by the Schwarz Information Criterion (*SIC*). For each equation in the above VAR, Wald χ^2statistics are used to test the joint significance of each of the other lagged endogenous variables in equation. In addition, the Wald χ^2 statistics tell us whether an endogenous variable can be treated as exogenous. Moreover, roots of the characteristics polynomial test is undertaken to confirm whether the VAR system satisfies the stability condition.

The conventional Granger-causality test based on standard VAR is conditional on the assumption of stationarity of the variables constituting the VAR. This study employs Augmented Dickey-Fuller (*ADF*), Philips-Perron (*PP*), and Kwiatkowaski-Philips-Schmidt-Shin (*KPSS*) unit root tests for this purpose. The combinined use of these tests makes it possible to test for both the null hypothesis of non-stationarity and stationarity, respectively. This process of joint use of unit root (*ADF*and*PP*) and stationarity (*KPSS*) tests is known as confirmatory data analysis (Brooks 2002).

Granger causality test suggests which variables in the models have significant impacts on the future values of each of the variables in the system. However, the result will not, by construction, be able to indicate how long these impacts will remain effective in the future. Variance decomposition and impulse response functions give this information. Hence, this paper conducts generalized variance decompositions and generalized impulse response functions analysis proposed by Koop *et al*(1996) and Pesaran and Shin (1998). The unique features of these approaches are that the results from these analyses are invariant to the ordering of the variables entering the VAR system and they provide more robust results for small samples.Impulse response functions trace the responsiveness of the dependent variable in the VAR system to a unit shock in error terms. Variance decomposition gives the proportions of the movement in the dependent variables that are due to their "own" shocks, versus shocks to the other variables.

5. Analyses and Findings:

(a) Time-Series Properties of Data: This study performs three different unit root tests, namely Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests[1]. According to the results of the unit root tests, it can be inferred that all three series for all the countries are stationary at their levels[2]. The graphical representations of the variables reveal some spikes in the concerned variables for Indonesia, Malaysia and Thailand during the Asian financial crisis. Thus, this study performs two

[1] Results not reported due to space limitation. However, results will be provided upon request.
[2]This result is expected since both GDP growth and inflation have already been differenced and RV is the sum of the squares of price returns.

different VAR analyses for these three countries; where one VAR analysis is performed for the whole time period, while another VAR analysis is performed for the period after the crisis, *i.e.* from the fourth quarter of 1998 after which the impact of the crisis seems to diminish. Findings from the VAR analyses for each of the countries are in order.

(b) The Impact of Oil Price Volatility on Economic Activities: This sub-section discusses the impacts of oil price volatility in each economy separately. For Indonesia, Malaysia and Thailand, seemingly the most affected countries by the financial crisis, two different VAR systems are employed to investigate and compare the impact of oil price volatility on economic activities for the whole time period and for the period after the crisis. And for China, India and Philippines, seemingly the least affected economies, one VAR analysis is performed for the whole time period.

In selecting the appropriate lag length, theSchwarz Information Criterion (*SIC*) VAR lag order selection criteria have been consulted. Since we are using quarterly data for this study, the maximum lag length provided in lag selection test is 6. According to the results of these tests, the appropriate lag length suggested for China, India, Indonesia for the whole sample period, Indonesia after 1998:4, Malaysia for the whole period, Malaysia after 1998:4, Philippines, Thailand for the whole period and Thailand after 1998:4 are 3, 2, 4, 4, 2, 2, 1, 1 and 2, respectively[3]. The test for stability of the VAR systems is checked and the *inverse* characteristic roots of the auto-regressive (AR) polynomial indicate that all the VARs with suggested lags are appropriate for investigating the relationship between volatility of oil prices and other concerned macroeconomic indicators.

5.b.1 Impact analysis for China

According to the VAR result of China, the coefficients and t-statistics for most of the lags in GDP growth equation reveal that oil price volatility seems to have negative impact in GDP growth[4]. Granger causality tests are consulted to find out the direction of causality among the variables. The results of the Granger causality tests for China are reported in Appendix Table 2. The causality tests reveal that, in China, there exists a bi-directional causality between oil price volatility and GDP growth. In addition to that, there is also a bi-directional causality between GDP growth and inflation.

[3] Same as footnote 1.
[4] Same as Footnote 1.

The results of impulse response functions are presented in Appendix Figure 2. According to the figures, in response to a one S.E. shock to realized volatility of oil prices, GDP growth instantly becomes negative and after one quarter time horizon the response seems to diminish. Furthermore, in response to a one S.E. shock in GDP growth, inflation responds positively before it diminishes after three quarters.

In response to a one S.E. shock in inflation GDP growth rises during the first quarter and from the second quarter time horizon the response seems to die down and persist horizontally into the future. Thus, the impulse response functions of China confirm most of the findings from the causality test except for the causality from GDP growth to oil price volatility. Thus, according to the impulse response functions oil price volatility has a short-term negative impact on GDP growth in China.

The results of variance decompositions are presented in Appendix Table 3. According to the results, 17.10% of the variations in GDP growth can be explained by realized volatility at the end of five quarters, while this figure goes up to 20.90% after twenty quarters. Inflation also explains a fair portion of the variations in output growth. On the other hand, 25.50% variation in realized volatility can be explained by GDP growth after five quarters as it goes down to 16.80% at the end of twenty quarters. GDP growth explains inflation with an amount of 28.90% after five quarters which increases up to 29.70% at the end of twenty quarters. Hence, the results of variance decomposition analysis also conform to the causality directions identified.

Therefore, according to the VAR analysis along with the causality test, impulse responses functions and variance decompositions, it can be inferred that in China oil price volatility impacts GDP growth in the short run and both GDP growth and inflation are strongly tied together. It is to be mentioned here that, due to limitation of space, from now on this study would provide major findings with respect to different countries for different time periods.

5.b.2 Impact analysis for India

According to the VAR output for India, it can be inferred that oil price volatility has significant negative impact on GDP growth and positive impact in inflation as indicated by the coefficients and t-statistics of RV in GDP growth and inflation equations within the VAR system, respectively[5]. The results from Granger causality test are presented in Appendix Table 4. The causality test reveals that there is a bi-directional causality between realized

[5] Same as Footnote 1.

volatility and GGDP growth. A bi-directional causality is also found between realized volatility and inflation. The causality between GDP growth and inflation is also bi-directional.

The impulse response functions are presented in Appendix Figure 3. The results of variance decomposition are reported in Appendix Table 5. Results of both of these tests are consistent with the Granger causality test results even when the time horizon is expanded to 20 quarters. Hence, according to the VAR analysis for India, it can be inferred that oil price volatility impacts both GDP growth and inflation in the Indian economy. Furthermore, both GDP growth and inflation are closely related.

5.b.3 Impact analysis for Indonesia

This study analyses the Indonesian economy on the basis of two different VAR systems for two different time periods. The first one is for the whole data set *i.e.* from 1993:2 to 2009:1; the second VAR is for the period after the crisis *i.e.* from 1998:4 to 2009:1. These two VARs are implemented to capture any significant change in the impact analysis due to the Asian financial crisis.

As per the VAR results,the coefficients and t-statistics for RV in GGDP growth and inflation equations indicate a negative link between oil price volatility and GGDP growth and a positive relationship between inflation and oil price volatility[6]. The results of Granger causality test are reported in Appendix Table 6.

According to the results, oil price volatility Granger causes both GDP growth and inflation, while only inflation causes volatility in oil prices. Moreover, there is a bi-directional causality between GDP growth and inflation. The impulse response functions (IRF) are presented in Appendix Figure 4.The results from variance decomposition (VD) analysis are reported in Appendix Table 7. In summary, according to VAR results along with the findings from IRF and VD, for the whole data period from 1993:2 to 2009:1, different tests within the VAR(4) framework for Indonesia reveal that oil price volatility impacts both GDP growth and inflation, and like China and India GDP growth and inflation are closely related. Furthermore, the fact that inflation causes realized volatility, keeps oil price volatility endogeneous to the VAR model.

Now, this study presents the VAR outcome for the period after the Asian financial crisis for Indonesia to see whether there is any dissimilarity in the dynamics of the impact

[6] Same as Footnote1.

channels.From the coefficients and t-statistics of realized volatility in GDP growth and inflation equations of the VAR (4) estimation for the period after the crisis, it can be inferred that oil price volatility exerts negative impact on GDP growth and positive impact on inflation even after the financial crisis is over[7]. The results of the Granger causality test are reported in Appendix Table 8. The Granger causality test further indicates that after the crisis oil price volatility causes both GDP growth rate and inflation of Indonesia. In addition to that, the bi-directional causality between GDP growth and inflation also holds true for the time period after the crisis. However, a significant dissimilarity between two models is that after the crisis oil price volatility seems to become exogeneous in the model since none of the variable seems to cause realized volatility after the Asian financial crisis.

This study further performs impulse response functions and variance decompositions analysis to check the robustness of the causality test. Results from impulse response functionsare presented in Appendix Figure 5and the results from variance decomposition analysis are presented in Appendix Table 9. Findings of Impulse Responses and Variance Decompositions are consistent with the causality test results in most of the cases.

Based on two different VAR analyses for Indonesia, it can be inferred that for the Indonesian economy that oil price volatility impacts on both GDP growth and inflation for both of the time periods, for the whole sample period and for the period after the Asian financial crisis. Furthermore, the link between GDP growth and inflation is bi-directional for both of the VAR systems.

5.b.4 Impact analysis for Malaysia

The data plots for Malaysia portrays a spike during early 1997 to mid 1998 and the Malaysian economy was one of the most adversely affected economies during the Asian financial crisis. Thus, Malaysian data are also investigated on the basis of two different VAR systems, one for the whole period from 1991:2 to 2009:1 and the other is for the period after the crisis *i.e.* from 1998:4 to 2009:1. The VAR (2) results for the whole periods indicate that realized volatility impacts output growth negatively in Malaysia[8]. The Granger causality test results are presented in Appendix Table 10. According to the causality results there are a bi-directional causality between oil price volatility and GDP growth, a uni-directional causality running from inflation to realized volatility and a bi-directional causality between GDP growth and inflation in Malaysia for the whole period from 1991:2 to 2009:1.

[7] Same as Footnote 1.
[8] Same as Footnote 1.

Impulse response function findings are presented in Appendix Figure 6. The results of variance decompositions are reported in Appendix Table 11. According to the VAR results along with impulse response functions and variance decompositions for the whole period it can be inferred that, oil price volatility impacts GDP growth in Malaysia, GDP growth and inflation impact each other, and both GDP growth and inflation have small impact realized volatility.

The analysis for the Malaysian economy after the financial crisis starts with the VAR (2) estimation[9].The coefficients of realized volatility in GDP growth equation indicate that oil price volatility has negative impact on the Malaysian output growth. Findings of causality tests are reported in Appendix Table 12. The causality test results for the period after the crisis are almost similar to that of the causality test results for the whole period. There exist a bi-directional causality between GDP growth and realized volatility, a bi-directional causality between inflation and GDP growth, and a uni-directional causality running from inflation to oil price volatility.The results from impulse response functions and variance decompositions are presented in Appendix Figure 7 and Appendix Table 13, respectively. All the tests reveal that there is not much change in the two VAR analyses performed for the Malaysian economy. In both of the VAR systems, oil price volatility impacts GDP growth, while there is a very little feedback from the opposite side. Furthermore, like all the other economies analysed so far, GDP growth and inflation seem to be strongly tied together in the Malaysian economy.

5.b.5 Impact analysis for Philippines

Results from VAR (1) estimation for Philippines reveals that in Philippines oil price volatility positively affects inflation[10]. Results from the Granger causality test are given in Appendix Table 14. The Granger causality test indicates a bi-directional causality between oil price volatility and inflation, and also a bi-directional causality between GDP growth and inflation. For the purpose of checking the robustness of the Granger causality test impulse responses and variance decompositions are implemented.

Impulse response functions and variance decompositions are presented in Appendix Figure 8 and Appendix Table 15. According to the results from VAR, Granger causality, impulse response and variance decompositions tests it can be inferred that, in Philippines oil price volatility impacts inflation; and GDP growth and inflation are closely related in the short run.

[9] Same as Footnote 1.
[10] Same as Footnote 1.

5.b.6 Impact analysis for Thailand

Since the Thai economy has also been severely affected by the Asian financial crisis and as the data suggests a spike during the crisis period, like Indonesia and Malaysia, this study implements two different VARs for Thailand in a similar fashion. VAR (1) output for the whole period of Thailand indicates that in the Thai economy GDP growth is significantly impacted negatively by oil price volatility[11].

The causality test findings for the whole data set are reported in Appendix Table 16. The causality test results indicate that in Thailand, oil price volatility Granger causes GDP growth and inflation Granger cause both oil price volatility and GDP growth. The impulse response functions for the whole time period for Thailand are presented in Appendix Figure 9.The results from variance decomposition analysis are reported in Appendix Table 17. For the whole period, in the Thai economy, all the tests within the VAR framework suggest that oil price volatility impacts GDP growth. Now, this study performs a separate VAR analysis for the period after the Asian financial crisis.

From the VAR (2) estimation results for the period from 1998:4 to 2009:1 it seems that the impact of RV in GDP growth becomes insignificant after the financial crisis[12]. The Granger causality test within this time frame is reported in Appendix Table 18. Most of the causal relationship found for the whole period are absent in these causality test results for the period after the financial crisis, except the causality tests find that there is a bi-directional causality running from inflation to output growth. Furthermore, realized volatility seems to be exogenous to this system.

The impulse response functions for this period after the financial crisis are presented in Appendix Figure 10. The results from the variance decomposition analysis are reported in Appendix Table 6.19. From the VAR analyses for Thailand it can be inferred that oil price volatility impacts output growth for the whole period, however after the Asian financial crisis the impact seems to disappear. This finding is consistent with Rafiq, Salim & Bloch (2008) where the authors find that impact of oil price volatility no longer exists in the Thai economy after the financial crisis.

[11] Same as Footnote 1.
[12] Same as Footnote 1.

6.Conclusion and Policy Implications

This study investigates the short-term impact of oil price volatility in six emerging economies of Asia. One of the unique features of this paper is that, here the oil price volatility for each country is calculated using a non-parametric approach namely realized oil price variance. Furthermore, to the author's knowledge this is one of the pioneering studies that analyses the impact of oil price volatility on developing economies. Since Indonesia, Malaysia and Thailand were severely affected by the Asian financial crisis and as the data in hand portrays spikes during this period, this study implements two different VAR systems for these countries trying to compare between the impact channels for the whole period and for the period after the crisis.

For China, according to the VAR analysis along with the Granger causality test, impulse response functions and variance decompositions, it can be inferred that oil price volatility impacts output growth in the short run. For India oil price volatility impacts both GDP growth and inflation. In Philippines oil price volatility impacts inflation. Furthermore, for all these economies GDP growth and inflation are closely related in the short run. Another important feature of the results from these three countries is that for all the VAR models, oil price volatility seems to be slightly endogeneous. This may be caused by the use of exchange rates in constructing the realized volatility measure.

Based on two different VAR analyses for Indonesia, it can be inferred that for the Indonesian economy oil price volatility impacts both GDP growth and inflation for both of the time periods, for the whole sample period and for the period after the Asian financial crisis. Furthermore, the link between GDP growth and inflation is bi-directional for both of the VAR systems. However, one significant difference in results from the two VARs is that, oil price volatility seems to become exogeneous to the economy after the financial crisis.

There is not much difference between the two VAR analyses performed for the Malaysian economy. In both of the VAR systems, oil price volatility impacts GDP growth, while there is a very little feedback from the opposite side. Furthermore, like all the other economies analysed so far, GDP growth and inflation seems to be strongly tied in the Malaysian economy.

From the VAR analyses for Thailand, it can be inferred that oil price volatility impacts output growth for the whole period. However, after the Asian financial crisis the impact seems to disappear. This finding is consistent with Rafiq, Salim & Bloch (2008) where the authors find that impact of oil price volatility no longer exists in the Thai economy after the financial crisis. Thus, the results after the financial crisis show that adverse effect of oil price volatility has been mitigated to some extent. It seems that oil subsidization of the Thai Government by introduction of the oil fund plays a significant role in improving economic performance by lessening the adverse effect of oil price volatility on macroeconomic indicators. The policy implication of this result is that the government should keep pursuing its policy to stabilize domestic oil price through subsidization and thus help stabilize economic growth.

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Appendix Figure 1: GGDP after Seasonal Adjustment

Note: GGDP_SA represents seasonally adjusted GDP growth.

Appendix Table 1: Summary Statistics

a. China

Descriptive Statistics

Variables	Mean	Std. Deviation	Observation
RV	0.0269	0.0135	36
GGDP	2.9387	20.5930	36
INF	0.2549	0.8505	36

Correlations

Variables	RV	GGDP	INF
RV	1.000		
	(0.000)		
GGDP	-0.037	1.000	
	(0.831)	(0.000)	
INF	0.336	0.050	1.000
	(0.049)	(0.776)	(0.00)

Note: Significance levels are in bracket. This is based on two tailed tests. Time is taken as a controlled variable. Degrees of freedom is 33.

a. India

Descriptive Statistics

Variables	Mean	Std. Deviation	Observation
RV	0.0302	0.0174	46
GGDP	1.6468	1.7895	46
INF	1.3075	1.5394	46

Correlations

Variables	RV	GGDP	INF
RV	1.000		
	(0.000)		
GGDP	-0.226	1.000	
	(0.136)	(0.000)	
INF	0.060	0.241	1.000
	(0.696)	(0.111)	(0.00)

Note: Significance levels are in bracket. This is based on two tailed tests. Time is taken as a controlled variable. Degrees of freedom is 43.

b. Indonesia

Descriptive Statistics

Variables	Mean	Std. Deviation	Observation
RV	0.04720	0.0174	60
GGDP	1.0101	1.7895	60
INF	2.8391	1.5394	60

Correlations

Variables	RV	GGDP	INF
RV	1.000		
	(0.000)		
GGDP	-0.749	1.000	
	(0.001)	(0.000)	
INF	0.701	0.637	1.000
	(0.001)	(0.000)	(0.00)

Note: Significance levels are in bracket. This is based on two tailed tests. Time is taken as a controlled variable. Degrees of freedom is 57.

c. Malaysia

Descriptive Statistics

Variables	Mean	Std. Deviation	Observation
RV	0.0259	0.0164	68
GGDP	1.4940	1.7512	68
INF	0.7092	0.5121	68

Correlations

Variables	RV	GGDP	INF
RV	1.000		
	(0.000)		
GGDP	-0.573	1.000	
	(0.000)	(0.000)	
INF	0.289	0.372	1.000
	(0.018)	(0.002)	(0.00)

Note: Significance levels are in bracket. This is based on two tailed tests. Time is taken as a controlled variable. Degrees of freedom is 65.

d. Philippines

Descriptive Statistics

Variables	Mean	Std. Deviation	Observation
RV	0.0376	0.0503	89
GGDP	1.0189	1.2435	89
INF	1.6911	1.3334	89

Correlations

Variables	RV	GGDP	INF
RV	1.000		
	(0.000)		
GGDP	-0.120	1.000	
	(0.265)	(0.000)	
INF	0.432	0.128	1.000
	(0.000)	(0.234)	(0.00)

Note: Significance levels are in bracket. This is based on two tailed tests. Time is taken as a controlled variable. Degrees of freedom is 86.

e. Thailand

Descriptive Statistics

Variables	Mean	Std. Deviation	Observation
RV	0.0305	0.0202	60
GGDP	1.0289	1.9181	60
INF	0.9059	0.8413	60

Correlations

Variables	RV	GGDP	INF
RV	1.000		
	(0.000)		
GGDP	-0.348	1.000	
	(0.007)	(0.000)	
INF	0.115	0.293	1.000
	(0.387)	(0.024)	(0.00)

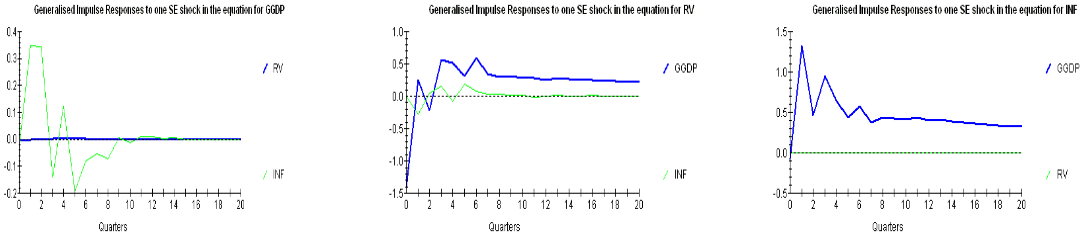
Note: Significance levels are in bracket. This is based on two tailed tests. Time is taken as a controlled variable. Degrees of freedom is 57.

Appendix Table 2: Granger Causality Test for China

Null Hypotheses	χ^2	D.F.	Probability
RV does not Granger causes GGDP	8. 342	3	0.065
INF does not Granger causes GGDP	6.638	3	0.084
GGDP does not Granger causes RV	8.838	3	0.052
INF does not Granger causes RV	3.894	3	0.273
GGDP does not Granger causes INF	31.697	3	0.000
RV does not Granger causes INF	0.618	3	0.892

Note: Here RV is dependent variable.

Appendix Figure 2: Findings from Generalized Impulse Response Function for China



Appendix Table 3: Findings from Generalized Forecast Error Variance Decomposition for China

Quarters	Variance Decomposition of GGDP			Variance Decomposition of RV			Variance Decomposition of INF		
	GGDP	RV	INF	GGDP	RV	INF	GGDP	RV	INF
1	0.829	0.178	0.154	0.270	0.875	0.012	0.224	0.154	0.733
5	0.693	0.171	0.225	0.255	0.852	0.077	0.289	0.141	0.613
10	0.624	0.201	0.259	0.202	0.677	0.149	0.298	0.148	0.603
15	0.579	0.205	0.284	0.179	0.633	0.106	0.297	0.148	0.603
20	0.551	0.209	0.299	0.168	0.609	0.135	0.297	0.148	0.603

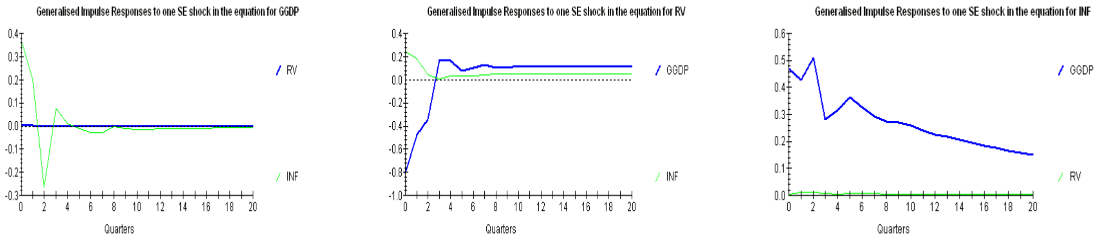
Note: All the figures are estimates rounded to three decimal places.

Appendix Table 4: Granger Causality Test for India

Null Hypotheses	χ^2	D.F.	Probability
RV does not Granger causes GGDP	4.3341	2	0.098
INF does not Granger causes GGDP	5.107	2	0.093
GGDP does not Granger causes RV	4.095	2	0.088
INF does not Granger causes RV	2.851	2	0.091
GGDP does not Granger causes INF	6.976	2	0.031
RV does not Granger causes INF	11.091	2	0.004

Note: Here RV is dependent variable.

Appendix Figure 3: Findings from Generalized Impulse Response Function for India



Appendix Table 5: Findings from Generalized Forecast Error Variance Decomposition for India

Quarters	Variance Decomposition of GGDP			Variance Decomposition of RV			Variance Decomposition of INF		
	GGDP	RV	INF	GGDP	RV	INF	GGDP	RV	INF
1	0.913	0.054	0.109	0.046	0.971	0.139	0.169	0.079	0.825
5	0.716	0.182	0.205	0.123	0.832	0.169	0.169	0.226	0.652
10	0.617	0.235	0.251	0.117	0.810	0.191	0.161	0.274	0.618
15	0.571	0.261	0.272	0.114	0.806	0.196	0.157	0.295	0.604
20	0.546	0.274	0.283	0.113	0.804	0.199	0.155	0.306	0.597

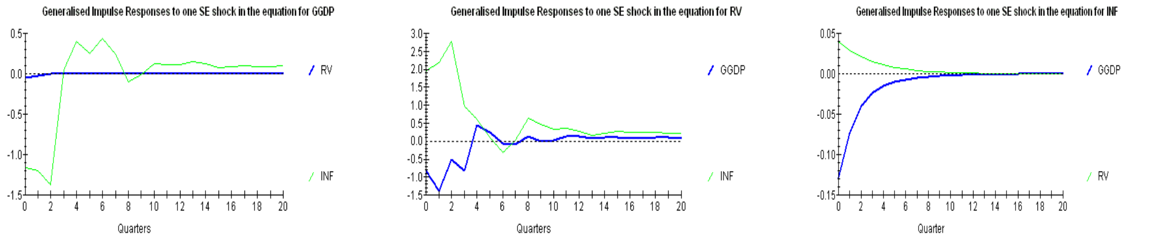
Note: All the figures are estimates rounded to three decimal places.

Appendix Table 6: Granger Causality Test for Indonesia from 1993:2 to 2009:1

Null Hypotheses	χ^2	D.F.	Probability
RV does not Granger causes GGDP	33.306	4	0.000
INF does not Granger causes GGDP	6.736	4	0.097
GGDP does not Granger causes RV	5.076	4	0.279
INF does not Granger causes RV	7.383	4	0.066
GGDP does not Granger causes INF	9.141	4	0.015
RV does not Granger causes INF	13.105	4	0.011

Note: Here RV is dependent variable.

Appendix Figure 4: Findings from Generalized Impulse Response Function for Indonesia from 1993:2 to 2009:1



Appendix Table 7: Findings from Generalized Forecast Error Variance Decomposition for Indonesia from 1993:2 to 2009:1

Quarters	Variance Decomposition of GGDP			Variance Decomposition of RV			Variance Decomposition of INF		
	GGDP	RV	INF	GGDP	RV	INF	GGDP	RV	INF
1	0.641	0.618	0.319	0.149	0.987	0.254	0.244	0.761	0.847
5	0.529	0.679	0.350	0.124	0.956	0.227	0.223	0.804	0.686
10	0.532	0.664	0.344	0.123	0.943	0.216	0.221	0.791	0.671
15	0.519	0.658	0.345	0.119	0.934	0.213	0.215	0.776	0.658
20	0.511	0.653	0.345	0.117	0.926	0.211	0.211	0.766	0.649

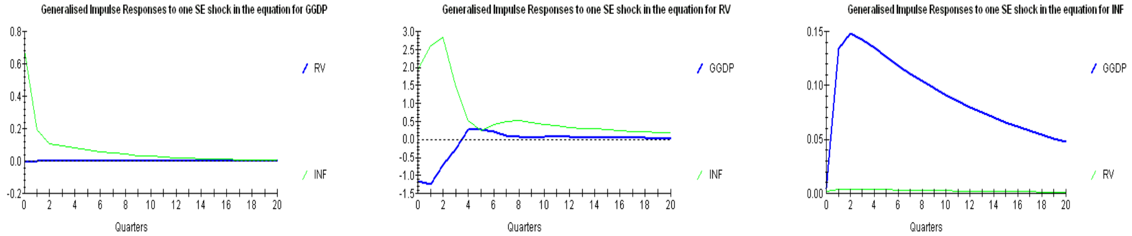
Note: All the figures are estimates rounded to three decimal places.

Appendix Table 8: Granger Causality Test for Indonesia from 1998:4 to 2009:1

Null Hypotheses	χ^2	D.F.	Probability
RV does not Granger causes GGDP	54.799	4	0.000
INF does not Granger causes GGDP	4.265	4	0.087
GGDP does not Granger causes RV	1.237	4	0.872
INF does not Granger causes RV	1.031	4	0.905
GGDP does not Granger causes INF	7.237	4	0.047
RV does not Granger causes INF	3.031	4	0.091

Note: Here RV is dependent variable.

Appendix Figure 5: Findings from Generalized Impulse Response Function for Indonesia from 1998:4 to 2009:1



Appendix Table 9: Findings from Generalized Forecast Error Variance Decomposition for Indonesia from 1998:4 to 2009:1

Quarters	Variance Decomposition of GGDP			Variance Decomposition of RV			Variance Decomposition of INF		
	GGDP	RV	INF	GGDP	RV	INF	GGDP	RV	INF
1	0.879	0.114	0.055	0.053	0.939	0.020	0.154	0.149	0.846
5	0.784	0.124	0.177	0.095	0.893	0.029	0.227	0.192	0.735
10	0.754	0.154	0.180	0.172	0.802	0.064	0.264	0.225	0.671
15	0.737	0.172	0.181	0.106	0.862	0.082	0.285	0.244	0.634
20	0.728	0.182	0.181	0.122	0.841	0.091	0.296	0.255	0.613

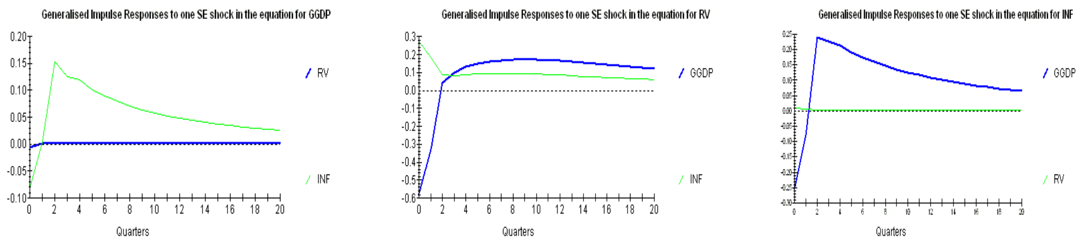
Note: All the figures are estimates rounded to three decimal places.

Appendix Table 10: Granger Causality Test for Malaysia from 1991:2 to 2009:1

Null Hypotheses	χ^2	D.F.	Probability
RV does not Granger causes GGDP	4.957	2	0.084
INF does not Granger causes GGDP	4.077	2	0.096
GGDP does not Granger causes RV	4.625	2	0.099
INF does not Granger causes RV	7.765	2	0.021
GGDP does not Granger causes INF	7.721	2	0.006
RV does not Granger causes INF	3.013	2	0.222

Note: Here RV is dependent variable.

Appendix Figure 6: Findings from Generalized Impulse Response Function for Malaysia from 1991:2 to 2009:1



Appendix Table 11: Findings from Generalized Forecast Error Variance Decomposition for Malaysia from 1991:2 to 2009:1

Quarters	Variance Decomposition of GGDP			Variance Decomposition of RV			Variance Decomposition of INF		
	GGDP	RV	INF	GGDP	RV	INF	GGDP	RV	INF
1	0.896	0.135	0.122	0.094	0.945	0.247	0.320	0.019	0.966
5	0.810	0.222	0.165	0.169	0.845	0.189	0.275	0.142	0.747
10	0.749	0.242	0.184	0.169	0.802	0.176	0.297	0.161	0.652
15	0.712	0.261	0.190	0.171	0.783	0.172	0.319	0.160	0.608
20	0.690	0.273	0.193	0.172	0.773	0.171	0.332	0.158	0.584

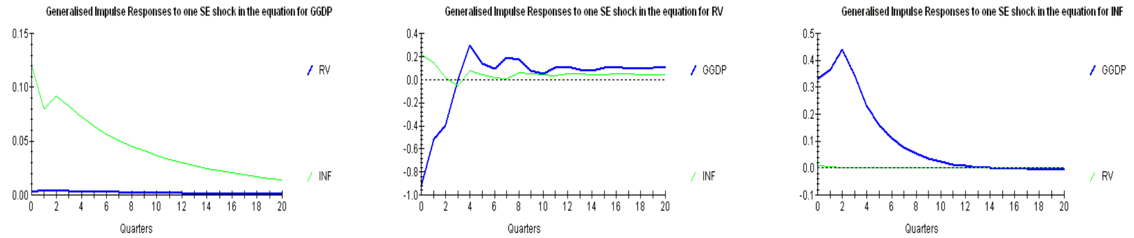
Note: All the figures are estimates rounded to three decimal places.

Appendix Table 12: Granger Causality Test for Malaysia from 1998:4 to 2009:1

Null Hypotheses	χ^2	D.F.	Probability
RV does not Granger causes GGDP	4.490	2	0.088
INF does not Granger causes GGDP	7.806	2	0.066
GGDP does not Granger causes RV	5.957	2	0.071
INF does not Granger causes RV	4.343	2	0.091
GGDP does not Granger causes INF	13.586	2	0.016
RV does not Granger causes INF	3.099	2	0.212

Note: Here RV is dependent variable.

Appendix Figure 7: Findings from Generalized Impulse Response Function for Malaysia from 1998:4 to 2009:1



Appendix Table 13: Findings from Generalized Forecast Error Variance Decomposition for Malaysia from 1998:4 to 2009:1

Quarters	Variance Decomposition of GGDP			Variance Decomposition of RV			Variance Decomposition of INF		
	GGDP	RV	INF	GGDP	RV	INF	GGDP	RV	INF
1	0.870	0.140	0.045	0.096	0.954	0.235	0.189	0.137	0.883
5	0.818	0.205	0.153	0.134	0.859	0.137	0.237	0.271	0.847
10	0.724	0.287	0.217	0.134	0.814	0.105	0.243	0.319	0.826
15	0.687	0.308	0.201	0.133	0.797	0.095	0.243	0.330	0.776
20	0.672	0.315	0.194	0.132	0.790	0.092	0.242	0.333	0.757

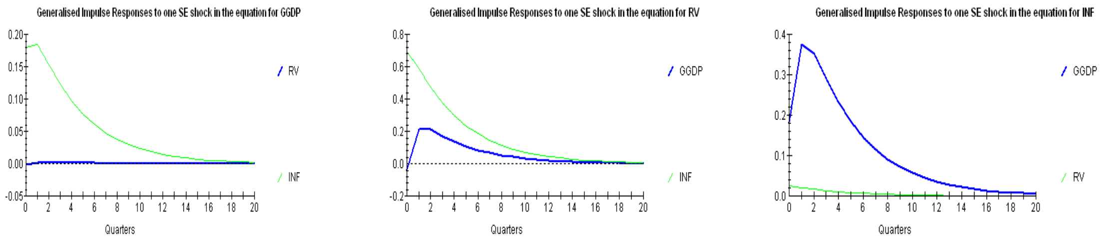
Note: All the figures are estimates rounded to three decimal places.

Appendix Table 14: Granger Causality Test for Philippines

Null Hypotheses	χ^2	D.F.	Probability
RV does not Granger causes GGDP	0.042	1	0.837
INF does not Granger causes GGDP	7.681	1	0.019
GGDP does not Granger causes RV	0.661	1	0.416
INF does not Granger causes RV	3.652	1	0.091
GGDP does not Granger causes INF	6.107	1	0.014
RV does not Granger causes INF	4.013	1	0.072

Note: Here RV is dependent variable.

Appendix Figure 8: Findings from Generalized Impulse Response Function for Philippines



Appendix Table 15: Findings from Generalized Forecast Error Variance Decomposition for Philippines

Quarters	Variance Decomposition of GGDP			Variance Decomposition of RV			Variance Decomposition of INF		
	GGDP	RV	INF	GGDP	RV	INF	GGDP	RV	INF
1	0.949	0.022	0.080	0.001	0.944	0.366	0.279	0.122	0.898
5	0.841	0.061	0.189	0.006	0.841	0.481	0.296	0.227	0.795
10	0.824	0.067	0.206	0.007	0.826	0.496	0.298	0.227	0.795
15	0.823	0.067	0.208	0.007	0.825	0.497	0.298	0.227	0.795
20	0.823	0.068	0.208	0.007	0.825	0.497	0.298	0.227	0.795

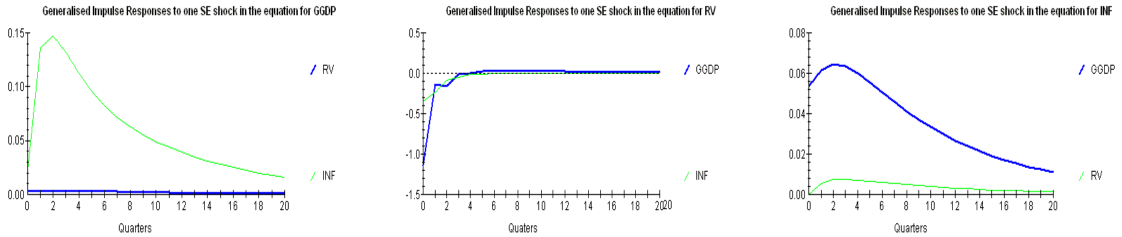
Note: All the figures are estimates rounded to three decimal places.

Appendix Table 16: Granger Causality Test for Thailand from 1993:2 to 2009:1

Null Hypotheses	χ^2	D.F.	Probability
RV does not Granger causes GGDP	17.945	1	0.000
INF does not Granger causes GGDP	11.701	1	0.001
GGDP does not Granger causes RV	0.009	1	0.924
INF does not Granger causes RV	6.694	1	0.009
GGDP does not Granger causes INF	0.318	1	0.573
RV does not Granger causes INF	0.152	1	0.696

Note: Here RV is dependent variable.

Appendix Figure 9: Findings from Generalized Impulse Response Function for Thailand from 1993:2 to 2009:1

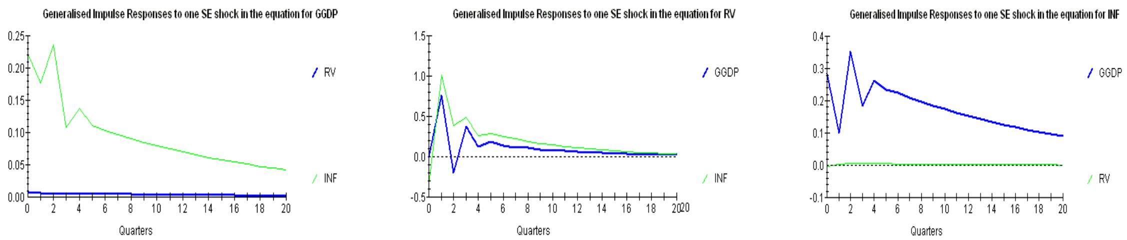


Appendix Table 17: Findings from Generalized Forecast Error Variance Decomposition for Thailand from 1993:2 to 2009:1

Quarters	Variance Decomposition of GGDP			Variance Decomposition of RV			Variance Decomposition of INF		
	GGDP	RV	INF	GGDP	RV	INF	GGDP	RV	INF
1	0.969	0.045	0.051	0.037	0.947	0.053	0.021	0.030	0.961
5	0.894	0.152	0.104	0.046	0.786	0.213	0.058	0.044	0.834
10	0.891	0.154	0.106	0.055	0.735	0.261	0.065	0.088	0.789
15	0.889	0.154	0.106	0.057	0.721	0.273	0.066	0.101	0.776
20	0.889	0.155	0.107	0.058	0.717	0.276	0.067	0.105	0.772

Note: All the figures are estimates rounded to three decimal places.

Appendix Figure 10: Findings from Generalized Impulse Response Function for Thailand from 1998:4 to 2009:1



Appendix Table 19: Findings from Generalized Forecast Error Variance Decomposition for Thailand from 1998:4 to 2009:1

Quarters	Variance Decomposition of GGDP			Variance Decomposition of RV			Variance Decomposition of INF		
	GGDP	RV	INF	GGDP	RV	INF	GGDP	RV	INF
1	0.986	0.058	0.182	0.037	0.985	0.032	0.109	0.016	0.979
5	0.867	0.069	0.301	0.118	0.945	0.114	0.203	0.060	0.885
10	0.891	0.077	0.345	0.129	0.933	0.163	0.224	0.105	0.835
15	0.863	0.078	0.361	0.103	0.944	0.180	0.233	0.124	0.813
20	0.850	0.075	0.369	0.108	0.934	0.188	0.237	0.134	0.802

Note: All the figures are estimates rounded to three decimal places.