The Dynamics of Economic Growth, Oil Prices, Stock Market Depth, and Other Macroeconomic Variables: Evidence from the G-20 Countries

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Abstract
This paper examines the linkages between economic growth, oil prices, depth in the stock market, and three other key macroeconomic indicators: real effective exchange rate, inflation rate, and real rate of interest. We employ a panel vector autoregressive model to test Granger causality for the G-20 countries over the period 1961-2012. A novel approach to this study is that we clearly demarcate the long-run and short-run relations between the economic variables. The results show a robust long-run economic relationship between economic growth, oil prices, stock market depth, real effective exchange rate, inflation rate, and real rate of interest. In the long run, real economic growth is found to respond to any deviation in the long-run equilibrium relationship that is found to exist between the different measures of stock market depth, oil prices, and the other macroeconomic variables. In the short run we find a complex network of causal relationships between the variables. While the empirical evidence of short-run causality is mixed, there is clear evidence that real economic growth responds to various measures of stock market depth, allowing for real oil price movements and changes in the real effective exchange rate, inflation rate, and real rate of interest.

Keywords: Oil prices; Stock market depth, Economic growth, Other macroeconomic variables, Panel VAR, Granger causality, G-20 countries

JEL: C33 G10 O49 Q43

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1. Introduction

Oil is a non-renewable and strategic commodity, vital to the growth of all economies. Most G-20 countries, which have high oil consumption, are net oil importers. Therefore, as such, they pay close attention to oil prices, their own macroeconomic indicators (including economic growth), as well as their exchange rates against the US dollar – the international currency of oil. The purpose of this paper is to examine the linkages between real economic growth and real oil prices in the presence of three other key macroeconomic indicators of a modern economy which operate adjacently: the real effective exchange rate, the inflation rate, and the real rate of interest. We also investigate the significance of stock market depth as an additional variable which may affect and be affected by economic growth and the other macroeconomic variables that we consider in this study. Since the concept of stock market depth is fairly broad,[1] we use three different indicators to characterize depth in the stock market: market capitalization (MAC), stock market turnover ratio (TUR), and stocks traded in the stock market (TRA). The covariates we consider have not been simultaneously used in previous research on the nexus between oil prices and economic growth, nor has there been a study on this topic for the G-20 countries.

Endogenous growth theory as articulated by Levine and Zervos (1996) and others, stress that stock market depth is key in nurturing long-run economic growth since it facilitates efficient inter-temporal allocation of resources, capital accumulation, and technological innovation. Levine (1991) in particular underscores the beneficial effects on investment and growth from the existence of depth in the stock market. However, as Barro and Sala-i-Martin (1995) assert, the development of this market is endogenous since it is a regular part of the process of economic

[1] Depth in the stock market may generally be defined in terms of a higher quantity, an improved quality, or an enhanced efficiency of the services offered by the market. These are of course defined in relation to the national income of a country to allow for different levels of country need and state of development.

growth. Thus, while stock market depth may lead to economic growth, the latter itself may lead to stock market depth. The same logic applies to the relationship between economic growth and the other macroeconomic variables that we probe in this study. That is, these macroeconomic variables may impact economic growth and also be affected by economic growth.

In this paper we make an important contribution to the literature. We examine the nature of the causal link among a full range of relevant variables: these being economic growth, oil prices, real effective exchange rate, inflation rate, real rate of interest, and three different indicators to characterize depth in the stock market (MAC, TUR and TRA) simultaneously for the G-20 countries. Although the relationship between oil prices and economic activity has been extensively studied since the seminal work of Hamilton (1983), prior research has considered only a sub-set of the variables that we have chosen in this study. Typically, studies examine the causal relationship between oil prices and economic growth in the presence of one or two other economic variables. To wit, stock market considerations have often been ignored in considering the nexus between oil prices and economic growth. In all, despite the fact that the causal relationship between oil prices, economic growth and such variables as effective exchange rate, inflation rate, and real rate of interest have been scrutinized separately before, previous investigations have considered only a sub-set of these variables together. In other words, they have not all been considered in the same empirical model. If there are causal relationships between these variables, then the results of previous studies may lack validity due to the omission of other relevant variables. Thus, a novel feature of our study is that we examine the possible causal linkages between oil prices and economic growth conjointly with several other variables. We also consider the G-20[2] – a group of countries that has not heretofore received much attention in this literature. In addition, this group of countries is studied over a lengthy and contemporary span of time, namely over 1961-2012. We use panel cointegration and panel Granger causality tests in order to uncover relevant causal links among the variables. In contrast, previous studies offer less robust results since their shorter data span reduces the power of unit root and cointegration tests. Finally, a remarkable feature of this study is that we clearly demarcate the long-run and short-run relations between the economic variables.

The rest of this paper is organized as follows. Section 2 surveys the relevant literature. Section 3 describes the data and our variables. Section 4 delineates our empirical estimation strategy. Section 5 summarizes and discusses our results. The final section concludes with some policy implications.

2. Review of the Literature

This section reviews three strands of the literature, each relating to the Granger-causal relationship between: economic growth and stock market depth; economic growth and oil prices; and economic growth and other macroeconomic variables.

2.1 Causality between stock market depth and economic growth

The notion that stock market depth is one of the basic determinants of economic growth is forwarded in Beck and Levine (2004), Calderon and Liu (2003), Levine (1997), and Graff (2003). Subsequent research concentrates in identifying the exact nature of the relationship

[2] The consideration of this group, in comparison to earlier studies, has three advantages: 1) it increases the sample size and power of the test; 2) it allows heterogeneity among the countries; and 3) it permits us to check the robustness of the empirical results through a vector error-correction model (VECM).

between the two variables (see, for instance, Cheng, 2012; Kar et al., 2011; Hou and Cheng, 2010; Nowbusting and Odit, 2009; Arestis et al., 2001; Enisan and Olufisayo, 2009; Nieuwerburgh et al., 2006; Singh, 1997; Atje and Jovanovic, 1993; Bosworth, 1975). This interest stems primarily from the inherent policy implication; however, empirical studies on the relationship between stock market depth and economic growth do not provide any clear-cut answer and currently there is no consensus among economists about the nature of this relationship. Three possible relationships have been emphasized in the empirical literature on the causal link between stock market depth and economic growth.

The first relationship is described by a supply-leading hypothesis, which suggests the presence of unidirectional causality from stock market depth to economic growth. Several studies support this hypothesis. For instance, Kolapo and Adaramola (2012) employed multivariate Granger causality approach (over the period 1990-2010) and found evidence in favour of a unidirectional causality from stock market depth to economic growth for Nigeria. Similarly, support for this hypothesis is found in Enisan and Olufisayo (2009) for the Sub-Saharan African countries (1980-2004), Nieuwerburgh et al. (2006) for Belgium (1830-2000), and Tsouma (2009) for mature and emerging markets (1991-2006).

The second relationship is described by a demand-following hypothesis which implies the presence of unidirectional causality from economic growth to stock market depth. The studies that support this hypothesis are Kar et al. (2011) for MENA countries (1980-2007), Panopoulou (2009) for five[3] countries (1995-2007), Liu and Sinclair (2008) for China (1973-2003), Odhiambo (2008) for Kenya (1969-2005), Ang and McKibbin (2007) for Malaysia (1960-2001), and Liang and Teng (2006) for China (1952-2001).

[3] Austria, Belgium, France, Germany and the Netherlands.

The third possible relationship is characterized by a feedback hypothesis which intimates the existence of bidirectional causality between economic growth and stock market depth. The studies that lend support to this hypothesis are Cheng (2012) for Taiwan (1973-2007), Hou and Cheng (2010) for Taiwan (1971-2007), Darrat et al. (2006) for emerging markets (1970-2003), Caporale et al. (2004) for Argentina, Chile, Greece, Korea, Malaysia, the Philippines and Portugal (1977-1998), Wongbangpo and Sharma (2002) for ASEAN countries (1985-1996), and Huang et al. (2000) for the United States, Japan and China (1992-1997).

2.2 Causality between oil prices and economic growth

The second strand of the literature examines the direction causality between economic growth and oil prices. Like the previous case, three possible relationships have been emphasized in the empirical literature on the causal link between oil price and economic growth.

The first relationship is a supply-leading hypothesis, which hints at the presence of unidirectional causality from oil price to economic growth[4]. The studies that lend support to this hypothesis are Benhmad (2013) for the United States (1947-2007), Lee and Chiu (2011) for industrialized countries (1965-2008), Filis (2010) for Greece (1996-2008), and Rafiq et al. (2009) for Thailand (1993-2006). The second relationship is a demand-following hypothesis, which suggests the presence of unidirectional causality from economic growth to oil price. The studies by Akhmat and Zaman (2013) for South Asia (1975-2010), Herrerias et al. (2013) for China (1995-2009), Chu and Chang (2012) for a group of six countries, namely Canada, France, Germany, Japan, the United Kingdom and the United States (1971-2010), Hanabusa (2009) for

[4] Higher oil prices resulted higher costs of production and subsequently, to lower production or lower expected earnings (Filis, 2010; Jones et al., 2004). This leads to oil conservation policies (Behmiri and Manso, 2012a).

Japan (2000-2008), Lee and Chang (2005) for Taiwan (1954-2003), and Aqeel and Butt (2001) for Pakistan (1955-1996) provide support for this hypothesis.

The third relationship offers a feedback hypothesis, which states that there is bidirectional causality between economic growth and oil price. Studies that lend support to this hypothesis are Bildirici and Bakirtas (2014) for BRICS countries (1980-2011), Behmiri and Manso (2013) for Sub-Saharan African countries (1985-2011), Behmiri and Manso (2012a) for OECD countries (1976-2209), Behmiri and Manso (2012b) for Portugal (1980-2009), Zhu et al. (2011) for both OECD and Non-OECD countries (1995-2009), Zamani (2007) for Iran (1967-2003), and Yoo (2006) for South Korea (1968-2002).

2.3 Causality between other macroeconomic variables and economic growth

The third strand of the literature investigates the direction of causality between economic growth and macroeconomic variables such as the real effective exchange rate, the inflation rate, and the real rate of interest. As with the other two cases, the empirical literature posits three possible causal links between macroeconomic variables (real effective exchange rate/ inflation rate/ real rate of interest) and economic growth.

The first relationship is a supply-leading hypothesis, that is, unidirectional causality from a macroeconomic variable to economic growth. Studies that lend support to this hypothesis are Pradhan et al. (2013) for sixteen Asian countries (1988- 2012), Darrat (1999) for Taiwan (1973-2007), and Masih and Masih (1996b) for Thailand and Malaysia (1955-1991).

The second relationship is a demand-following hypothesis, which is unidirectional causality from economic growth to a particular macroeconomic variable. The studies by Kim et al. (2013)

for MENA countries (1980-2007), Filis (2010) for Greece (1996-2008), and Masih and Masih (1996a) for developing countries (1955-1991) lend support to this approach.

The third relationship is a feedback hypothesis, i.e., bidirectional causality between economic growth and any one of the macroeconomic variables described above. The studies that lend support this hypothesis are Andres and Hernando (1997) for mature and emerging markets (1991-2006), Andres et al. (2004) for 21 OECD countries (1961-1993), and Baillie et al. (1996) for Argentina, Brazil, Israel and the United Kingdom (1995-2007).

An interesting feature of our study is that we entertain the possibility of causal links between several variables simultaneously. In doing so, we meld these three strands of the literature. These links are examined in the context of a group of countries that have heretofore not received much attention.

3. Description of Data

Data used in this analysis are annual time series on the following variables: stock market depth (STM)[5], which is represented by three indicators: market capitalization (MAC), stock market turnover ratio (TUR), and stocks traded in the stock market (TRA); real per capita economic growth rate (GDP); real oil prices (OIL); and three other macroeconomic variables: real effective exchange rate (REE), inflation rate (INF), and real interest rate (RIR). The data set is an unbalanced panel of the G-20 countries over the period 1961-2012. The G-20 countries include 19 member countries plus the European Union (EU), which is represented by the President of the European Council and by the European Central Bank. Thus, although we look at

[5] Stock market depth plays a central role in economic performance (Ngare et al., 2014). Since it cannot be captured by a single measure, this study follows Gries et al. (2009), Levine and Zervos (1998), and Gregorio and Guidotti (1995) in employing three measures of stock market depth. (Different studies use one or more of these measures and market capitalization is the most common among them in the literature.)

the G-20, within this group of important industrialized and developing economies, we observe only 19 member nations, which are used for our analysis. To include the EU, the twentieth member, would have meant double-counting some countries.

The countries and time periods are selected for the empirical investigation on the basis of data availability. The data are obtained from *World Development Indicators*, published by the World Bank, as well as from OECD, IMF, and the Bank for International Settlements. All variables and data sources are summarized in Table 1. The variables used in this study are transformed to their natural logarithm forms.

<< Insert Table 1 here>>

4. Estimation Strategy

We utilize a panel vector autoregressive (VAR) model in order to identify the possible causal nexus between the variables. The advantage of this approach is that it exploits individual time series and cross-sectional variations in data. Thus, it avoids biases associated with cross-sectional regressions by taking into account the country-specific fixed effect (Levine, 2005).

The estimation follows three steps: first, a panel unit root test is performed to identify the nature of stationarity (order of integration) of the time series variables; second, a panel cointegration test is conducted in order to determine whether there is a long-run relationship between the time series variables; and third, a VAR model is constructed to ascertain the direction of causality between the variables. These three tests are discussed in more detail below.

4.1 Panel unit root test

We use the Levine-Lin-Chu (LLC) test (Levine et al., 2002) and the Im-Pesaran-Shin (IPS) test (Im et al., 2003) to check the order of integration of the data. Both LLC and IPS tests are based on the principles of the conventional Augmented Dickey Fuller (ADF) test. The LLC test explores the heterogeneity of intercepts across members of the panel, while the IPS test explores the heterogeneity in the intercepts, as well as in the slope coefficients. Both tests are applied by averaging individual ADF *t*-statistics across cross-section units. The tests use the equation:

$$\Delta Y_t = \mu_i + \gamma_i Y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta Y_{it-j} + \lambda_i t + \varepsilon_{it} \qquad \textbf{(1)}$$

where,

i = 1, 2…., N (denotes the cross sectional dimension); t = 1, 2…., T (denotes the time period);

Y_{it} is the series for country i in the panel over time period t; p_i is the number of lags selected for the ADF regression;

ε_{it} represents independently and normally distributed random errors for all i and t with zero means and finite heterogeneous variances (σ_i^2).

The LLC test considers the coefficients of the autoregressive term as homogenous across all individuals, in other words, $\gamma_i = \gamma \ \forall i$. It tests the null hypothesis that each individual in the panel has an integrated time series, in other words, H_0: $\gamma_i = \gamma = 0 \ \forall i$ against an alternative H_A: $\gamma_i = \gamma < 0 \ \forall i$. It considers pooling the cross-section time series data and is based on the following *t*-statistics:

$$t_y^* = \frac{\hat{\gamma}}{s.e.(\hat{\gamma})} \qquad \textbf{(2)}$$

Here, in the LLC test, γ is restricted by being kept identical across regions under both the null and alternative hypotheses.

It is clear that the null hypothesis of the LLC test is very restrictive, but the IPS test relaxes this assumption by allowing γ to vary across i under the alternative hypothesis. Hence, the null hypothesis of the IPS test is H_0: $\gamma_i = 0 \ \forall i$, while the alternative hypothesis is that at least one of the individual series in the panel is stationary, in other words, the alternative H_A is $\gamma_i < 0 \ \forall i$. The alternative hypothesis simply implies that γ_i differs across countries.

Due to the heterogeneity examined, each equation was estimated separately by means of the ordinary least squares technique, and the test statistics were obtained as (studentized) averages of the test statistics for each equation.

The IPS *t*-bar statistic is simply defined as the average of the individual Dickey-Fuller τ statistics, as follows:

$$\bar{t} = \frac{1}{N}\sum_{i=1}^{N}\tau_i \quad \text{and} \quad \tau_i = \frac{\hat{\gamma}_i}{s.e.(\hat{\gamma}_i)} \tag{3}$$

Assuming that the cross-sections are independent, the IPS test uses the mean-group approach and obtains τ_i, and then proposes the use of the standardized *t*-bar statistic as follows:

$$\bar{Z} = \sqrt{N}\left(\bar{t} - E(\bar{t})\right) / \sqrt{\operatorname{var}(\bar{t})} \tag{4}$$

where, $E(\bar{t})$ represents the mean and $\operatorname{var}(\bar{t})$ represents the variance of each τ statistic. They are generated by simulations, and are tabulated in IPS (Im et al., 1997). The statistic $\bar{Z}$ converges to a standard normal distribution as N and T become infinitely large; thereby we can compute its significance level (Im et al., 2003; Greasley and Oxley, 2010). Based on Monte Carlo simulation results, the IPS test displayed more favorable finite sample properties than the LLC test.

4.2 Panel cointegration test

The cointegration test, introduced by Granger (1988), is relevant to the problem of the purpose of long-run relationships between variables. If a linear combination between two or more non-stationary time series is stationary, then the two or more series are cointegrated. If two or more series are cointegrated, it is possible to interpret the variables in these series as being in a long-run equilibrium relationship (Engle and Granger, 1987).

Pedroni's panel cointegration method (Pedroni, 2000) can be used to determine the existence of cointegration among the different series considered in this study. The technique starts with the following regression equation:

$$OIL_{it} = \beta_{0OILi} + \beta_{1OILi}t + \beta_{2iOIL}STM_{it} + \beta_{3OILi}GDP_{it} + \beta_{4OILi}REE_{it} + \beta_{5OILi}INF_{it} + \beta_{6OILi}RIR_{it} + \varepsilon_{it} \quad \textbf{(5)}$$

where $\varepsilon_{it} = \gamma_i \varepsilon_{it-1} + \xi_{it}$ **(6)**

and,

i = 1, 2, ….., N (denotes the cross sectional dimension); and t = 1, 2…., T (denotes the time period).

OIL is real oil prices, *STM* is stock market depth, *GDP* is real per capita economic growth rate, *REE* is real effective exchange rate, *INF* is inflation rate, and *RIR* is real interest rate. These variables are defined in Table 1. β_{0OILi} is a country-specific intercept or fixed-effects parameter which is allowed to vary across individual cross-sectional units. $\beta_{1OILi}t$ is a deterministic time trend specific to the individual countries in the panel. The slope coefficients (β_{kOILi}; for k =1, …, 6) can vary from one individual to another, allowing the cointegrating vectors to be heterogeneous across countries.

Pedroni (2000) proposed seven different statistics for the cointegration test in the panel data setting. Of the seven proposed statistics, the first four are known as panel cointegration statistics and are within-dimension statistics, while the last three are known as group mean panel cointegration statistics and are between-dimension statistics. Their levels are based on the way the autoregressive coefficients are manipulated to arrive at the final statistic. There are basically five steps to obtain these cointegration statistics, as set out below.

Step 1: Compute the residuals ($\hat{\varepsilon}_{it}$) from the panel regression (Equation 5). The estimation involves the inclusion of all appropriate fixed effects, time trends or common time dummies.

Step 2: Compute the residuals ($\hat{\zeta}_{it}$) from the following regression:

$$\Delta Y_{it} = \beta_{1i}\Delta X_{1it} + \beta_{2i}\Delta X_{2it} + ... + \beta_{mi}\Delta X_{mit} + \varepsilon_{it} \quad \textbf{(7)}$$

for t = 1, 2, . . . , T; i = 1, 2, . . . , N; m = 1, 2, . . . , M

where, Y_i is the dependent variable and X_{mi} are regression variables. In this equation, T refers to the number of observations over time, N refers to the number of individual members in the panel, and M refers to the number of regression variables. $\beta_{1i}, \beta_{2i},..., \beta_{mi}$ are the slope coefficients and ε_{it} shows the deviations from the modeled long-run relationship. If the series involved in the equation are cointegrated, ε_{it} should be stationary.

Step 3: Compute ($\hat{L}^2_{11i}$), the long-run variance of $\hat{\zeta}_{it}$:

$$\hat{L}^2_{11i} = \frac{1}{T}\sum_{t=1}^{T}\hat{u}^2_{it} + \frac{2}{T}\sum_{S=1}^{K_i}\left(1 - \frac{S}{K_i + 1}\right)\sum_{t=s+1}^{T}\hat{u}_{it}\hat{u}_{it-s} \quad \textbf{(8)}$$

where u_{it} is residual, and is obtained from the error of the cointegration equation (5), S and K are lag lengths, (see Newey and West, 1987; Pedroni, 1999 for details).

Step 4: Construct the residuals ($\hat{u}_{it}$) of the ADF test for $\hat{\varepsilon}_{it}$ and compute the following variances of these residuals:

$$\hat{S}_i^2 = \frac{1}{T}\sum_{t=1}^{T}\hat{u}_{it}^2 \qquad \text{and} \qquad \tilde{S}_{NT}^2 = \frac{1}{T}\sum_{t=1}^{T}\hat{S}_i^2 \tag{9}$$

where, $\hat{S}_i^2$ is the individual contemporaneous variance and $\hat{u}^2{}_{it}$ is the long-run variance of the residual $\hat{u}_{it}$; and $\tilde{S}_{NT}^2$ is the contemporaneous panel variance estimator.

Step 5: Compute the panel-*t* and group-*t* statistics (Pedroni, 2000). These statistics are asymptotically normally distributed.

Based on the cointegration residuals, Pedroni (2004) developed seven panel cointegration statistics (four panel-*t* and three group-*t* statistics). The mathematical exposition and the asymptotic distributions of these panel cointegration statistics are explained in Pedroni (1999). Under an appropriate standardization, based on the moments of the vector of the Brownian motion functionality, these statistics have a standard normal distribution. Accordingly, the null hypothesis of no cointegration is then tested, based on the above description of a standard normal distribution. The null hypothesis of no cointegration of the pooled (within-dimension) estimation follows H_0: $\gamma_i = 1 \ \forall i$ against an alternative hypothesis H_A: $\gamma_i = \gamma < 1 \ \forall i$, in the residuals from the panel cointegration. The within-dimensional estimation assumes a common value for $\gamma_i = \gamma$.

By contrast, the group means panel cointegration statistics (pooled between-dimension) tests the null hypothesis of no cointegration, that is, H_0: $\gamma_i = 1 \ \forall i$ against an alternative hypothesis of cointegration, that is, H_A: $\gamma_i < 1 \ \forall i$. Hence, under the alternative hypothesis, the between-dimensional estimation does not assume a common value for $\gamma_i = \gamma$. Therefore, this allows an additional source of possible heterogeneity across the individual country members of the panel.

These statistics diverge to negative infinity under the alternative hypothesis. The left tail of the normal distribution is usually employed here to reject the null hypothesis.

If we find cointegration between the variables, we proceed to test for the direction of causality between them.

4. 3 VECM estimation and Granger causality test

The panel Granger causality test, as proposed by Holtz-Eakin et al. (1988) and used by Liddle and Lung (2013), is deployed to ascertain the direction of causality between the variables. The following econometric models are used.[6]

$$\Delta OIL_{it} = \eta_{OILj} + \sum_{k=1}^{p_1} \alpha_{OILik} \Delta OIL_{it-k} + \sum_{k=1}^{p_2} \beta_{OILik} \Delta STM_{it-k} + \sum_{k=1}^{p_3} \delta_{OILik} \Delta GDP_{it-k} + \sum_{k=1}^{p_4} \mu_{OILik} \Delta REE_{it-k} + \sum_{k=1}^{p_5} \lambda_{OILik} \Delta INF_{it-k} + \sum_{k=1}^{P_6} \theta_{OILik} \Delta RIR_{it-k} + \omega_{OILi} ECT_{OILit-1} + \varepsilon_{OILit} \qquad \textbf{(10)}$$

H_0: $\beta_{OILik = 0}$; $\delta_{OILik} = 0$; $\mu_{OILik} = 0$; $\lambda_{OILik} = 0$; $\theta_{OILik} = 0$; $\omega_{OILik} = 0$ for k = 1,..., P_1- P_6

H_A: $\beta_{OILik \neq 0}$; $\delta_{OILik} \neq 0$; $\mu_{OILik} \neq 0$; $\lambda_{OILik} \neq 0$; $\theta_{OILik} \neq 0$; $\omega_{OILik} \neq 0$ for at least one k

$$\Delta STM_{it} = \eta_{STMj} + \sum_{k=1}^{p_1} \alpha_{STMik} \Delta STM_{it-k} + \sum_{k=1}^{p_2} \beta_{STMik} \Delta OIL_{it-k} + \sum_{k=1}^{p_3} \delta_{STMik} \Delta GDP_{it-k} + \sum_{k=1}^{p_4} \mu_{STMik} \Delta REE_{it-k} + \sum_{k=1}^{p_5} \lambda_{STMik} \Delta INF_{it-k} + \sum_{k=1}^{P_6} \theta_{STMik} \Delta RIR_{it-k} + \omega_{STMi} ECT_{STMit-1} + \varepsilon_{STMit} \qquad \textbf{(11)}$$

H_0: $\beta_{STMik = 0}$; $\delta_{STMik} = 0$; $\mu_{STMik} = 0$; $\lambda_{STMik} = 0$; $\theta_{STMik} = 0$; $\omega_{STMik} = 0$ for k = 1,..., P_1- P_6

H_A: $\beta_{STMik \neq 0}$; $\delta_{STMik} \neq 0$; $\mu_{STMik} \neq 0$; $\lambda_{STMik} \neq 0$; $\theta_{STMik} \neq 0$; $\omega_{STMik} \neq 0$ for at least one k

[6] As is evident from the estimating equations below, we do not concentrate on the possible inter-causal relationships between our three macroeconomic variables *REE*, *INF*, and *RIR*. Some results, however, are reported in the next section.

$$\Delta GDP_{it} = \eta_{GDPj} + \sum_{k=1}^{p_1} \alpha_{GDPik} \Delta GDP_{it-k} + \sum_{k=1}^{p_2} \beta_{GDPik} \Delta STM_{it-k} + \sum_{k=1}^{p_3} \delta_{GDPik} \Delta OIL_{it-k} + \sum_{k=1}^{p_4} \mu_{GDPik} \Delta REE_{it-k} + \sum_{k=1}^{p_5} \lambda_{GDPik} \Delta INF_{it-k} + \sum_{k=1}^{P_6} \theta_{GDPik} \Delta RIR_{it-k} + \omega_{GDPi} ECT_{GDPit-1} + \varepsilon_{GDPit} \quad \textbf{(12)}$$

H_0: $\beta_{GDPik = 0}$; $\delta_{GDPik} = 0$; $\mu_{GDPik} = 0$; $\lambda_{GDPik} = 0$; $\theta_{GDPik} = 0$; $\omega_{GDPik} = 0$ for k = 1,..., P_1- P_6

H_A: $\beta_{GDPik \neq 0}$; $\delta_{GDPk} \neq 0$; $\mu_{GDPik} \neq 0$; $\lambda_{GDPik} \neq 0$; $\theta_{GDPik} \neq 0$; $\omega_{GDPk} \neq 0$ for at least one k

$$\Delta REE_{it} = \eta_{REEj} + \sum_{k=1}^{p_1} \alpha_{REEik} \Delta REE_{it-k} + \sum_{k=1}^{p_2} \beta_{REEik} \Delta GDP_{it-k} + \sum_{k=1}^{p_3} \delta_{REEik} \Delta STM_{it-k} + \sum_{k=1}^{p_4} \mu_{REEik} \Delta OIL_{it-k} + \sum_{k=1}^{p_5} \lambda_{REEik} \Delta INF_{it-k} + \sum_{k=1}^{P_6} \theta_{REEik} \Delta RIR_{it-k} + \omega_{REEi} ECT_{REEit-1} + \varepsilon_{REEit} \quad \textbf{(13)}$$

H_0: $\beta_{REEik = 0}$; $\delta_{REEik} = 0$; $\mu_{REEik} = 0$; $\lambda_{REEik} = 0$; $\theta_{REEik} = 0$; $\omega_{REEik} = 0$ for k = 1,..., P_1- P_6

H_A: $\beta_{REEik \neq 0}$; $\delta_{REEik} \neq 0$; $\mu_{REEik} \neq 0$; $\lambda_{REEik} \neq 0$; $\theta_{REEik} \neq 0$; $\omega_{REEik} \neq 0$ for at least one k

$$\Delta INF_{it} = \eta_{INFj} + \sum_{k=1}^{p_1} \alpha_{INFik} \Delta INF_{it-k} + \sum_{k=1}^{p_2} \beta_{INFik} \Delta REE_{it-k} + \sum_{k=1}^{p_3} \delta_{INFik} \Delta GDP_{it-k} + \sum_{k=1}^{p_4} \mu_{INFik} \Delta STM_{it-k} + \sum_{k=1}^{p_5} \lambda_{INFik} \Delta OIL_{it-k} + \sum_{k=1}^{P_6} \theta_{INFik} \Delta RIR_{it-k} + \omega_{INFi} ECT_{INFit-1} + \varepsilon_{INFit} \quad \textbf{(14)}$$

H_0: $\beta_{INFik = 0}$; $\delta_{INFik} = 0$; $\mu_{INFik} = 0$; $\lambda_{INFik} = 0$; $\theta_{INFik} = 0$; $\omega_{INFik} = 0$ for k = 1,..., P_1- P_6

H_A: $\beta_{INFik \neq 0}$; $\delta_{INFik} \neq 0$; $\mu_{INFik} \neq 0$; $\lambda_{INFik} \neq 0$; $\theta_{INFik} \neq 0$; $\omega_{INFik} \neq 0$ for at least one k

$$\Delta RIR_{it} = \eta_{RIRj} + \sum_{k=1}^{p_1} \alpha_{RIRik} \Delta RIR_{it-k} + \sum_{k=1}^{p_2} \beta_{RIRik} \Delta INF_{it-k} + \sum_{k=1}^{p_3} \delta_{RIRik} \Delta REE_{it-k} + \sum_{k=1}^{p_4} \mu_{RIRik} \Delta GDP_{it-k} + \sum_{k=1}^{p_5} \lambda_{RIRik} \Delta STM_{it-k} + \sum_{k=1}^{P_6} \theta_{RIRik} \Delta OIL_{it-k} + \omega_{RIRi} ECT_{RIRit-1} + \varepsilon_{RIRit} \quad \textbf{(15)}$$

$$H_0\text{: } \beta_{RIRik} = 0; \delta_{RIRik} = 0; \mu_{RIRik} = 0; \lambda_{RIRik} = 0; \theta_{RIRik} = 0; \omega_{RIRik} = 0 \text{ for } k = 1,..., P_1 - P_6$$

$$H_A\text{: } \beta_{RIRik} \neq 0; \delta_{RIRik} \neq 0; \mu_{RIRk} \neq 0; \lambda_{RIRik} \neq 0; \theta_{RIRik} \neq 0; \omega_{RIRk} \neq 0 \quad \text{for at least one } k$$

where,

p_1, p_2, p_3, p_4, p_5, and p_6 are lag lengths;

i represents country i in the panel (i = 1, 2…., N);

t denotes the year in the panel (t = 1, 2, …., T) ;

ε_{it} is a normally-distributed random error term for all i and t with a zero mean and a finite heterogeneous variance.

The *ECT*s are error-correction terms, derived from the cointegrating equations. The *ECTs* represent the long-run dynamics, while differenced variables represent the short-run dynamics between the variables. The above model is meaningful if the time series variables are integrated of order one (hereafter I(1)) and are cointegrated. If the time series variables are I(1) and are not cointegrated, then *ECT* component will be removed in the estimation process. We examine both short-run and long-run causal relationships. The short-run causal relationship is measured through *F*-statistics and the significance of the lagged changes in independent variables, whereas the long-run causal relationship is measured through the significance of the *t*-test of the lagged *ECTs.* Based on equations 10-15, Figure 1 presents various possible hypotheses concerning the causal relationships among the variables.

<< Insert Figure 1 here>>

It should be noted that prior to estimation, one has to specify the number of lag lengths in the estimation process. Unfortunately, there is no standard rule for deciding the optimum lag length, although there are reliable formal model specification criteria available (Hendry, 1995). Preferably, the lag structure is allowed to vary across countries, variables, and equation systems. However, for a relatively large panel such as ours, this would increase the computational burden substantially. For this reason, under each system, we allow different maximum lag lengths for the variables, but do not allow them to vary across countries. We estimate each equation accordingly and choose the combination of lags which minimizes the Akaike Information Criterion (AIC) and Schwartz-Bayesian Information Criterion (SBC).

5. Empirical Results and Discussion

We report three sets of results, corresponding to our three models. Each of our models uses a different indicator of the stock market. Thus, we set up Model 1 to test the causal relationship between GDP, MAC, OIL, REE, INF, and RIR; Model 2 to test the causal relationship between GDP, TUR, OIL, REE, INF, and RIR; and Model 3 to test the causal relationship between GDP, TRA, OIL, REE, INF, and RIR.

Our first set of results indicates that all the variables are I(1) as well as being cointegrated in each of the three models (see Table 2). This result suggests the existence of a long-run relationship between all the variables in each of the three models.

<<Insert Table 2 here>>

Consequently, we perform the Granger causality test, using a vector error-correction model (VECM) and utilizing equations (10)-(15), the results of which are shown in Table 3. The panel Granger causality test results are for both the long-run, as represented by the significance of lagged error-correction term, and for the short-run, as represented by the significance of the *F*-statistic.

<<Insert Table 3 here>>

5.1 Long-Run Causality

From Table 3, in Models 1-3, when ΔGDP is the dependent variable, the lagged error-correction term (ECT_{-1}) is statistically significant in all three Models at conventional significance levels. This implies that GDP tends to converge to its long-run equilibrium path in response to changes in its regressors (MAC, TUR, TRA, OIL, REE, INF and RIR). The significance of the ECT_{-1} coefficient in the ΔGDP equation in each of the three models confirms the existence of long-run equilibrium between real economic growth rate and its determinants which are one of the different measures of stock market depth (MAC/TUR/TRA), real oil prices, and the other macroeconomic variables, being real exchange rate, inflation rate, and real rate of interest.

The empirical results allow us to infer that if there is any deviation from the long-run equilibrium relationship between the chosen economic variables, then real economic growth responds to correct this deviation. The estimated error-correction coefficient is found to be significant for all the three measures of stock market depth. The highest rate of correction is recorded for TUR. The estimated error-correction coefficient shows that for any deviation in the long-run equilibrium relationship, 41% of the deviations are corrected in the following year. The correction to any disequilibrium in the long-run relationship holds for the other measures of stock market depth, although the rate of adjustment is lower: 31% for MAC and 21% for TRA.

The lagged error-correction terms in the ΔMAC, ΔTUR, or ΔTRA equations in Table 3 are not statistically significant in any of the three models. Hence, stock market depth variables show no evidence of correcting any deviations from the long-run equilibrium. This is true for the other macroeconomic variables including oil prices in the panel VECM model. The upshot is that if there is any deviation in the long-run equilibrium relationship, we find real economic growth to respond to this deviation while stock market depth, oil prices, and other macroeconomic variables tend to evolve independently. Furthermore, the role of the stock market depth variables are clearly embedded in the dynamics of real economic growth, allowing for oil price movements and changes in the other macroeconomic variables that are chosen in this study.

5.2 Short-Run Causality

In contrast to the long-run Granger causality results, our study reveals a wide spectrum of short-run causality results between the six variables. These results are summarized in Table 4 and presented below.

<<Insert Table 4 here>>

In Model 1, we find the existence of bidirectional causality between real effective exchange rate and economic growth [GDP <=> REE], inflation and economic growth [GDP <=> INF], market capitalization and oil prices [OIL <=> MAC], market capitalization and real effective exchange rate [REE <=> MAC], market capitalization and real interest rate [RIR <=>MAC], real effective exchange rate and oil prices [OIL <=> REE], real effective exchange rate and inflation [REE <=> INF], real effective exchange rate and real interest rate [REE <=> RIR], and real interest rate and inflation [RIR <=> INF]. Moreover, there is unidirectional causality from real interest rate to economic growth [RIR => GDP], inflation to market capitalization [INF => MAC], and oil prices to real interest rate [OIL => RIR].

In Model 2, we note the existence of bidirectional causality between economic growth and real effective exchange rate [REE <=> GDP] and economic growth, inflation [INF <=> GDP], and inflation and real effective exchange rate [REE <=> INF]. Additionally, we find unidirectional causality from economic growth to turnover ratio [GDP => TUR], oil prices to turn over ratio [OIL => TUR], turnover ratio to real interest rate [TUR => RIR], real effective exchange rate to oil prices [REE => OIL], real interest rate to real effective exchange rate [RIR => REE], and inflation to real interest rate [INF => RIR].

In Model 3, we reveal the existence of bidirectional causality between traded stocks and economic growth [TRA <=> GDP], real effective exchange rate and economic growth [REE <=> GDP], real interest rate and economic growth [RIR <=> GDP], traded stocks and real effective exchange rate [TRA <=> REE], inflation and real effective exchange rate [INF <=> REE], and real interest rate and real effective exchange rate [RIR <=> REE]. Moreover, we find the unidirectional causality from oil prices to traded stocks [OIL => TRA], inflation to both traded stocks and real interest rate [INF => TRA; INF => RIR], economic growth to inflation [GDP => INF], and real effective exchange rate to oil price [REE => OIL].

5.3 Perturbation Results

Finally, we employ innovation accounting to assess the nature of responses to perturbations of the different variables in the system of equations. To this end, we deploy generalized impulse response functions (GIRFs). The use of GIRFs is to trace the effect of a one-off shock to one of the innovations on the current and future values of the endogenous variables. The key consequence of the GIRFs are that the responses are invariant to any re-ordering of the variables in the vector error-correction model (VECM) and, as orthogonality is not imposed, it allows for meaningful interpretation of the initial impact response of each variable to shocks to any other variables. Figures 2, 3 and 4 display the GIRFS of the three panel VAR models. Our discussion of the impulse response functions centers on the responses of economic growth, oil prices, stock market depth (MAC/TUR/TRA), and other macroeconomic variables (REE, INF, and RIR) to their own and other shocks. In particular, the GIRFs indicate how long and to what extent both stock market development and other three macroeconomic determinants react to changes in the oil price-growth nexus in the panel of the G-20 countries.

<<Insert Figures 2, 3 and 4 here>>

Figure 2 shows the responses of all the variables to a one standard deviation shock in other variables. In each case the stock market activity variable is found to display an initial cyclical response to an exogenous shock (albeit in varying degrees). However, the responses of all the variables to exogenous shocks stabilize in around 5 years. In Figures 3 and 4 the responses of all variables to an exogenous shock is found to be very similar thereby suggesting that for the three different measures of stock market depth, the responses of variables are broadly similar.

6. Conclusion

The purpose of this paper was to examine the linkages between real economic growth and real oil prices in the presence of three other key macroeconomic indicators of a modern economy which operate adjacently: the real effective exchange rate, the inflation rate, and the real rate of interest. We also considered the significance of the stock market depth as an additional variable which may affect and be affected by economic growth and the other macroeconomic variables chosen in this study. Since the concept of stock market depth is fairly broad, we used three different indicators to characterize depth, these being MAC, TUR, and TRA. A novel feature of our study is that we entertained the possibility of causal links between several variables simultaneously. In doing so, we blended in the different strands of research that have undertaken causality tests with a subset of the variables chosen in this study.

Our study used panel cointegration and causality tests. We found that there was a general long-run equilibrium relationship among economic growth, oil prices, stock market depth, and three other macroeconomic variables. An interesting feature that emerges by considering the broad set of macroeconomic variables used in this study is that any deviation that occurs in the long-run relationship is found to be corrected by economic growth. In other words, economic growth adjusts to correct any deviation from the long-run relationship between the variables. In the short run, however, we find a complex network of causal relations which seem to give no clear picture as to which of the three stock market indicators Granger-causes oil prices, economic growth, or the other macroeconomic variables. We find evidence of univariate causality as well as feedback relationships for the three different models. Our results support the supply-leading hypothesis in that financial institutions, as efficient providers of capital and risk diversifiers, are found to support economic growth in the G-20 countries. It has been argued in the literature that the reverse holds, that is, the financial sector grows in response to the demand in the real economy. In this case, financial development is a result of economic growth and may not be a requirement for it (as argued in Cavenaile et al., 2014). Our results show that may be true in the short run, given the unidirectional causality and feedback that is found to exist between the stock market depth variables, economic growth, oil prices, and other macroeconomic variables. In addition, the measure of the stock market depth and the response of economic growth do not seem to evoke any significant difference with respect to adjustment to short-term deviations. From the analysis of our data set of the G-20 countries, it seems that promoting the development of the stock market depth may support long-run economic growth.

In terms of policy implication, our results suggest that the G-20 countries could promote their long-run economic growth by supporting the development of their stock market and stabilizing their macroeconomic environment. More specifically, the development of the stock market should entail not only making the market more assessable to users that currently do not have access to the financial sector, but to put regulations in place that would ensure the financial stability of the stock market and the guarding of investors' money within the market. As expected, the stability of oil prices is key to economic growth and policymakers in the G-20 countries would need to monitor these oil prices and at the same time promote low inflation and stable exchange rates in order to stimulate further economic growth. This result supports the view that more developed equity markets may provide liquidity that lowers the cost of foreign capital especially when countries cannot generate sufficient domestic savings due to low interest rates. These equity markets provide incentives for managers to make investment decisions that affect firm values over a longer time period than the managers' employment horizons through equity-based compensation schemes (Dow and Gorton, 1997). Besides, more developed equity markets allow portfolio diversification, enabling individual firms to engage in specialized production, with resulting efficiency gains (Acemoglu and Zilibotti, 1997).

Acknowledgment: The authors thank an anonymous referee and the editor for helpful comments on a previous version of this paper.

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Table 1. Definition of Variables

VARIABLE	DEFINITION
GDP	**Growth rate of real per capita income** (in percentage): Income is defined as gross domestic product. This is our measure of economic growth (Source: WDI).
MAC	**Market capitalization**: Percentage change in the market capitalization of the listed companies (Source: WDI).
TUR	**Turnover ratio**: Percentage change in the turnover ratio in the stock market (Source: WDI).
TRA	**Traded stocks**: Percentage change in the total value of traded stocks (Source: WDI).
OIL	**Crude Oil prices**: The crude oil price is expressed in real terms, i.e. deflated by US consumer price index (CPI 2005 = 100). It consists of a simple average of three spot prices: Dated Brent, West Texas Intermediate, and the Dubai Fateh, in US dollars per Barrel (Source: OECD; IMF; Benhmad, 2012).
REE	**Real effective exchange rate**: The real US dollar effective exchange rate (on average) against the local currency (Source: Benhmad, 2012; BIS, 2005).
INF	**Inflation rate (in percentage)**: Percentage change in consumer price index (Source: WDI).
RIR	**Real interest rate (in percentage):** Real interest rate is the lending interest rate adjusted for inflation (using the gross domestic product deflator) (Source: WDI).

***Note 1**:* All monetary measures are in real US dollars.

Note 2: WDI: World Development Indicators; IMF: International Monetary Fund; OECD: Organization of Economic Cooperation and Development; and BIS: Bank for International Settlements.

Table 2. Results of Panel Unit Root and Panel Cointegration Tests

	GDP	MAC	TUR	TRA	OIL	REE	INF	RIR	Cointegration Status
Model 1: GDP, MAC, OIL, REE, INF, RIR									
Unit Root Inferences	**I [1]**	**I [1]**	**NA**	**NA**	**I [1]**	**I [1]**	**I [1]**	**I [1]**	**Cointegrated**
Model 2: GDP, TUR, OIL, REE, INF, RIR									
Unit Root Inferences	**I [1]**	**NA**	**I [1]**	**NA**	**I [1]**	**I [1]**	**I [1]**	**I [1]**	**Cointegrated**
Model 3: GDP, TRA, OIL, REE, INF, RIR									
Unit Root Inferences	**I [1]**	**NA**	**NA**	**I [1]**	**I [1]**	**I [1]**	**I [1]**	**I [1]**	**Cointegrated**

Note 1: GDP: Growth rate of real per capita income; MAC: Market capitalization; TUR: Turnover ratio; TRA: Traded stocks; OIL: Real oil prices; REE: Real effective exchange rate; INF: Inflation rate; and RIR: Real interest rate.

Note 2: Variables shown above are defined in Table 1.

Note 3: Inferences of unit root test is through LLC (Levine-Lin-Chu) statistics and IPS (Im-Pesaran-Shin) statistics; and inferences of cointegration test are through Pedroni's panel cointegration test.

Note 4: I[1] means variable is integrated of order one; and cointegrated implies the existence of cointegration, i.e. the occurrence of a long-run relationship between the variables.

Note 5: NA: Not applicable since only one indicator of stock market depth is used at a time.

Table 3. Results of Granger Causality Test

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Independent Variables — **Possible Dependent Variables**

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Model 1: VECM with GDP, MAC, OIL, REE, INF, RIR

	ΔGDP	**ΔMAC**	**ΔOIL**	**ΔREE**	**ΔINF**	**ΔRIR**
ΔGDP	------	2.59	0.73	5.95**	3.97***	0.05
	[----]	[0.05]	[0.69]	[0.05]	[0.10]	[0.98]
ΔMAC	50.7*	------	5.43***	36.5*	1.89	37.3*
	[0.00]	[----]	[0.07]	[0.00]	[0.39]	[0.00]
ΔOIL	3.08	3.37**	------	2.64	0.78	3.77***
	[0.21]	[0.10]	[----]	[0.27]	[0.68]	[0.10]
ΔREE	8.63*	5.57**	4.62***	------	15.5*	1.17
	[0.01]	[0.05]	[0.09]	[----]	[0.00]	[0.56]
ΔINF	4.14***	4.35***	0.20	22.7*	------	8.73*
	[0.10]	[0.10]	[0.91]	[0.00]	[----]	[0.01]
ΔRIR	3.79***	6.19**	0.30	18.5*	7.57*	------
	[0.10]	[0.05]	[0.86]	[0.00]	[0.00]	[----]
ECT_{-1}	-0.31*	0.07	-0.19	0.03	-0.05	0.44
	(-5.42)	(1.58)	(-0.01)	(3.89)	(-0.95)	(7.63)

Model 2: VECM with GDP, TUR, OIL, REE, INF, RIR

	ΔGDP	**ΔTUR**	**ΔOIL**	**ΔREE**	**ΔINF**	**ΔRIR**
ΔGDP	------	5.83**	1.26	6.57**	3.76***	0.40
	[----]	[0.05]	[0.53]	[0.02]	[0.10]	[0.81]
ΔTUR	1.08	------	0.44	1.24	2.50	4.44**
	[0.58]	[----]	[0.80]	[0.54]	[0.29]	[0.10]
ΔOIL	1.59	4.49**	------	1.43	0.51	1.23
	[0.45]	[0.10]	[----]	[0.49]	[0.78]	[0.54]
ΔREE	12.0*	0.59	6.25**	------	16.7*	0.48
	[0.00]	[0.71]	[0.04]	[----]	[0.00]	[0.78]
ΔINF	4.12*	0.29	0.70	8.44*	------	9.55*
	[0.10]	[0.87]	[0.70]	[0.01]	[----]	[0.01]
ΔRIR	2.30	1.04	0.62	9.01*	2.95	------
	[0.35]	[0.60]	[0.73]	[0.01]	[0.23]	[----]
ECT_{-1}	-0.41*	0.05	0.01	0.01	-0.02	0.19
	(-5.42)	(1.58)	(-0.01)	(3.89)	(-0.95)	(7.63)

Model 3: VECM with GDP, TRA, OIL, REE, INF, RIR

	ΔGDP	**ΔTRA**	**ΔOIL**	**ΔREE**	**ΔINF**	**ΔRIR**
ΔGDP	------	6.19**	1.14	11.9*	4.42***	4.86***
	[----]	[0.05]	[0.56]	[0.00]	[0.10]	[0.08]
ΔTRA	7.40*	------	0.45	8.41*	3.84***	22.6*
	[0.00]	[----]	[0.80]	[0.01]	[0.10]	[0.00]
ΔOIL	2.49	4.82**	------	1.25	0.60	1.27
	[0.29]	[0.10]	[----]	[0.53]	[0.74]	[0.53]
ΔREE	12.4	3.40**	6.50**	------	16.3*	0.59
	[0.00]	[0.10]	[0.03]	[----]	[0.00]	[0.79]
ΔINF	2.64*	9.74*	0.44	6.82**	------	9.82*
	[0.27]	[0.01]	[0.80]	[0.03]	[----]	[0.00]
ΔRIR	8.83	5.07**	1.57	7.18**	2.97	------
	[0.01]	[0.05]	[0.46]	[0.03]	[0.23]	[----]
ECT_{-1}	-0.21**	0.17	0.01	0.04	-0.06	0.47
	(-3.72)	(3.92)	(0.02)	(4.84)	(-1.32)	(8.75)

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Note 1: GDP: Growth rate of real per capita income; MAC: Market capitalization; TUR: Turnover ratio; TRA: Traded stocks; OIL: Real oil prices; REE: Real effective exchange rate; INF: Inflation rate; and RIR: Real interest rate.

Note 2: There are three indicators of stock market depth: MAC, TUR, and TRA. A different indicator is used in each model.

Note 3: VECM: vector error-correction model; ECT: error-correction term.

***Note 4*:** *, ** and *** indicate statistical significance at 1%, 5% and 10% levels, respectively.

Note 5: Values in square brackets represent probabilities for *F*-statistics.

Note 6: Values in parentheses represent *t*-statistics.

Note 7: Basis for the determination of long-run causality lies in the significance of the lagged ECT coefficient.

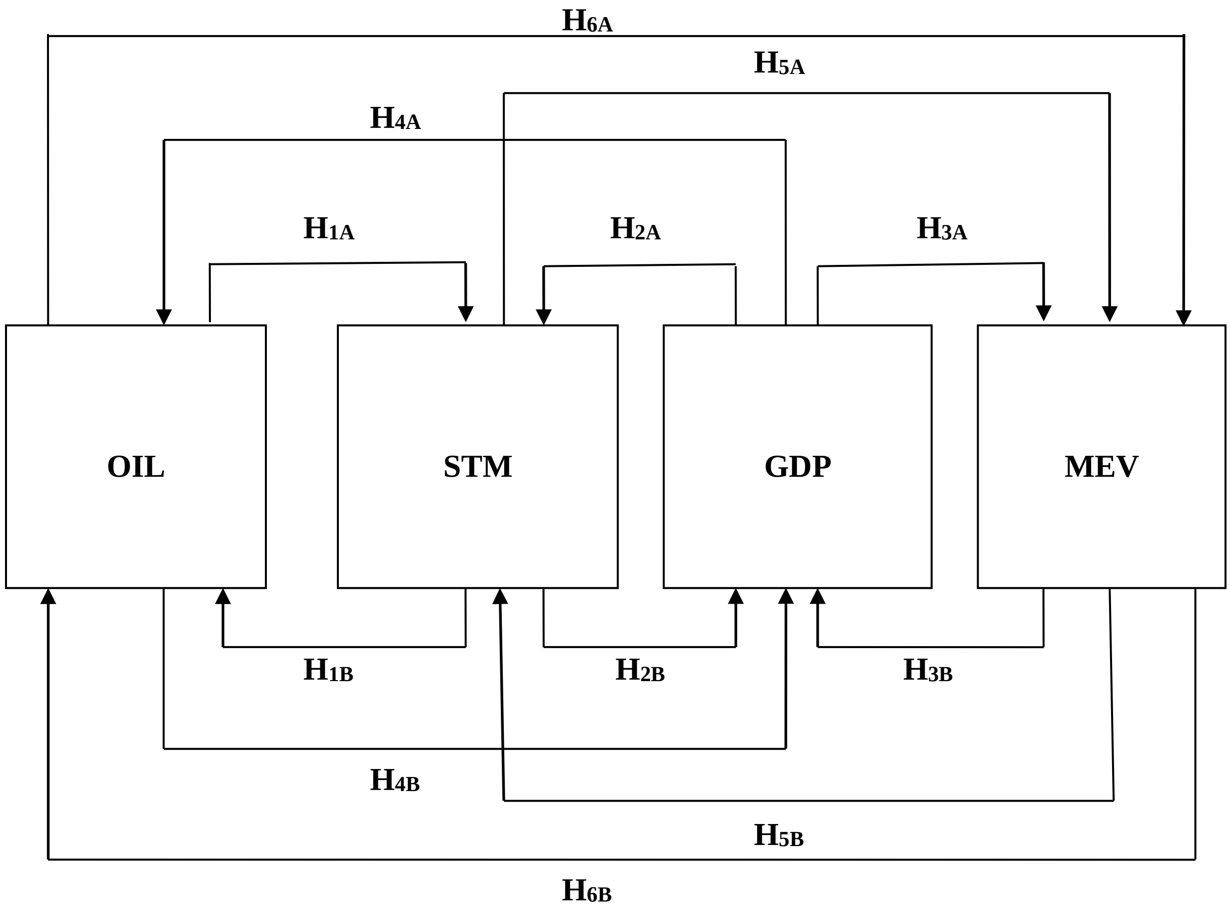
Table 4. Summary of Short-Run Granger Causality between Economic Growth, Stock Market Depth, Oil Prices, and Other Macroeconomic Variables

Causal Relationships Tested in the Models	Direction of Relationships Observed in Model 1	Direction of Relationships Observed in Model 2	Direction of Relationships Observed in Model 3
STM vs. GDP	MAC => GDP	GDP => TUR	TRA <=> GDP
OIL vs. GDP	NA	NA	NA
REE VS. GDP	REE <=> GDP	REE <=> GDP	REE <=> GDP
INF vs. GDP	INF <=> GD	INF <=> GDP	GDP <=> INF
RIR vs. GDP	RIR => GDP	NA	RIR <=> GDP
OIL vs. STM	MAC <=> OIL	TUR <= OIL	TRA <= OIL
REE vs. STM	MAC <=> REE	NA	TRA <=> REE
INF vs. STM	INF => MAC	NA	INF => TRA
RIR vs. STM	RIR <=> MAC	TUR => RIR	RIR <=> TRA
REE vs. OIL	REE <=> OIL	REE => OIL	REE => OIL
INF vs. OIL	NA	NA	NA
RIR vs. OIL	RIR <= OIL	NA	NA
INF vs. REE	INF <=> REE	INF <=> REE	INF <=> REE
RIR vs. REE	RIR <=> REE	RIR => REE	RIR => REE
RIR vs. INF	RIR <=> INF	INF => RIR	INF <=> RIR

Note 1: STM: Stock market depth (which has three indicators: MAC, TUR, and TRA); GDP: Growth rate of real per capita income; MAC: Market capitalization; TUR: Turnover ratio; TRA: Traded stocks; OIL: Real oil prices; REE: Real effective exchange rate; INF: Inflation rate; and RIR: Real interest rate.

Note 2: Variables shown above are defined in Table 1.

***Note 3*:** => / <=: unidirectional causality; and <=>: Bidirectional causality.



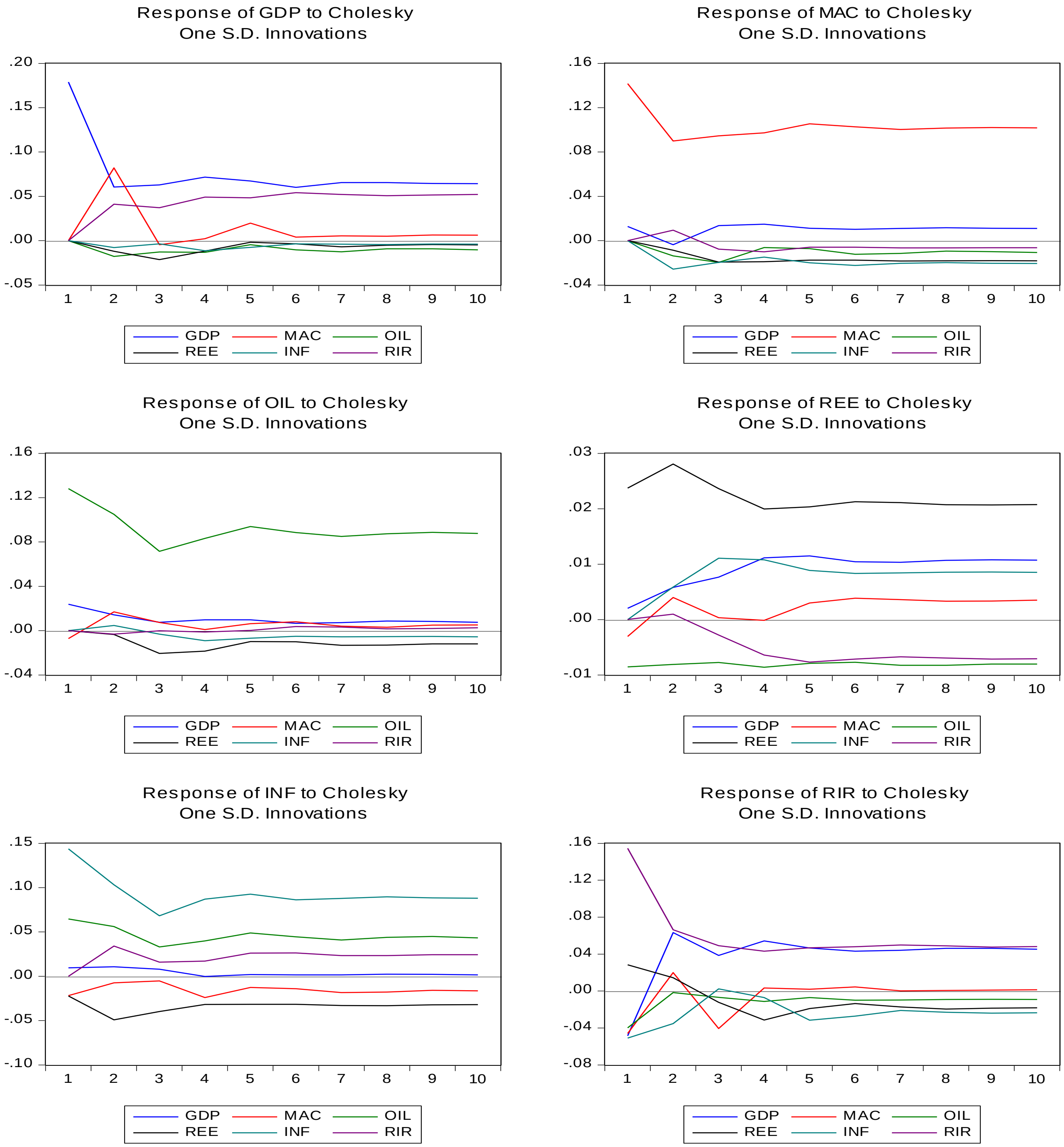
Note 1: OIL: real oil prices; STM: stock market depth; GDP: per capita real economic growth rate; MEV: a vector of three macroeconomic variables: REE, RIR, and INF.

Note 2: REE: real effective exchange rate; RIR: real interest rate; and INF: inflation rate.

Note 3: Arrows represent the direction of possible causal link between the variables – offered as various hypotheses.

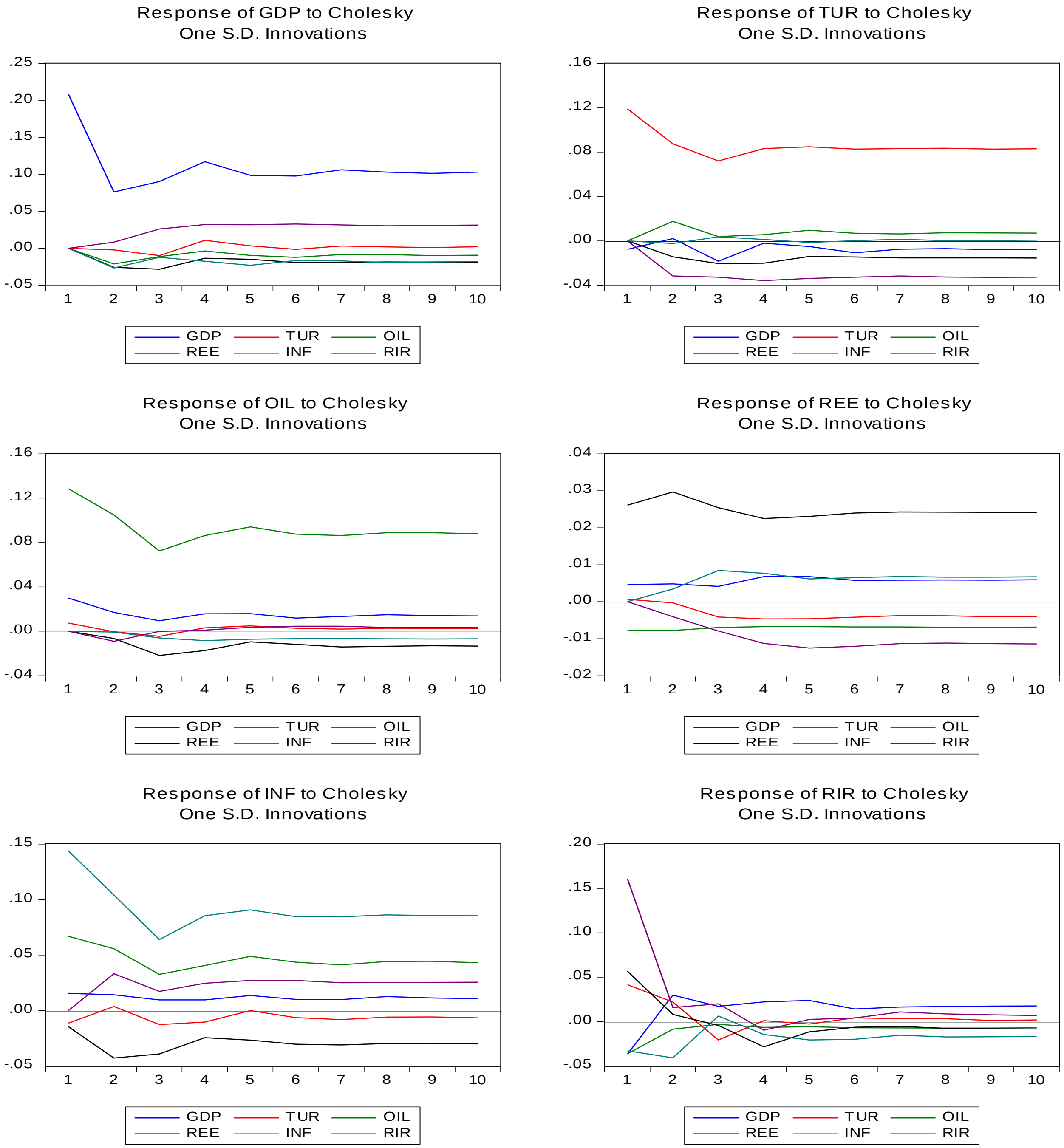
Note 4: Given that MEV is a vector, there are three sub-hypotheses wherever MEV is used. These are not shown in this figure due to space constraints.

Figure 1: Proposed Model and Hypotheses



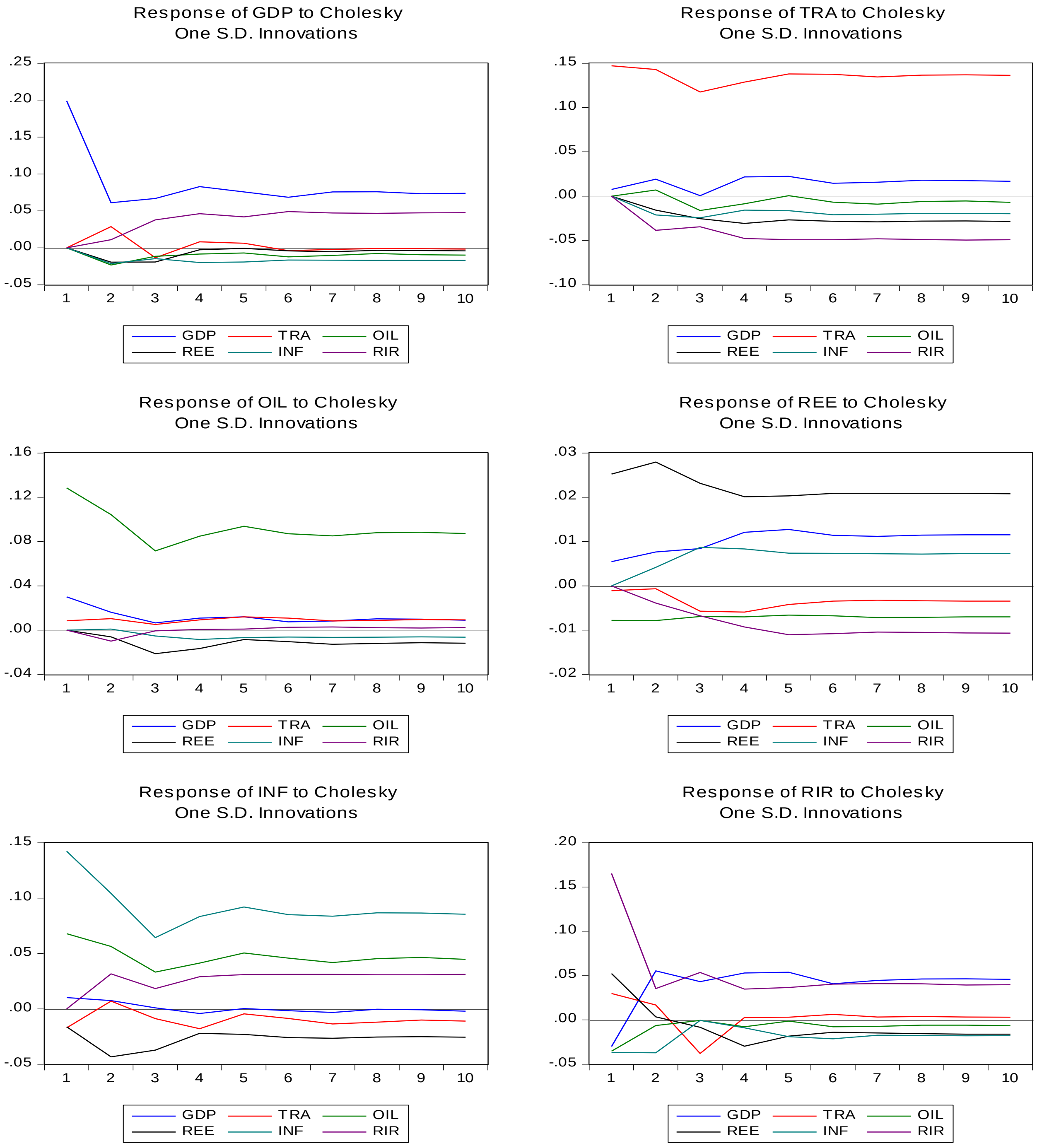
Note: GDP: Growth rate of real per capita income; MAC: Market capitalization; OIL: Real oil prices; REE: Real effective exchange rate; INF: Inflation rate; and RIR: Real interest rate.

Figure 2: Plot of Generalized Impulse Functions for GDP, MAC, OIL, REE, INF, and RIR



Note: GDP: Growth rate of real per capita income; TUR: Turnover ratio; OIL: Real oil prices; REE: Real effective exchange rate; INF: Inflation rate; and RIR: Real interest rate.

Figure 3: Plot of Generalized Impulse Functions for GDP, TUR, OIL, REE, INF, and RIR



Note: GDP: Growth rate of real per capita income; TRA: Traded stocks; OIL: Real oil prices; REE: Real effective exchange rate; INF: Inflation rate; and RIR: Real interest rate.

Figure 4: Plot of Generalized Impulse Functions for GDP, TRA, OIL, REE, INF, and RIR