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**Research Paper**

# Granger Causality Analysis of Some Macroeconomic Variables in Ghana

[1]Gabriel Asare Okyere*, [2]Gabriel Obed Fosu, [2]Robert Owusu Boakye
*[1,2]Department of Mathematics, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.*

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***ABSTRACT:-*** *The study investigates the relationship between stock prices and macroeconomic indicators in Ghana using monthly data from November 1990 to December 2011 using multivariate Vector Autoregressive(VAR) model. The Granger causality analysis was used to examine the direction of causality between stock prices and the various macroeconomic factors. It was realized that, the various macroeconomic variables fail Granger cause stock price. However, exchange rate and money supply Granger cause interest rate, inflation rate Granger cause money supply and a bi-directional causality between exchange rate to money supply.*

***Keyword**:-* *Granger Causality Test, Macroeconomic variable, Stock Prices, Vector Autoregressive*

## I. INTRODUCTION

Capital market plays a significant role in the financial sector of every economy through stabilization of the financial sector. It provides important investment channels for domestic and foreign capital and an efficient market that promote economic growth [1]. According to Fama [2], a market is efficient if prices rationally, fully and instantaneously reflect all relevant available information and no profit opportunities are left unexplained. In an efficient market, past information is of no use in predicting future prices, the market reacts to new information only.

Developed countries have fully explored the mobilization of resources through the capital market, but developing countries are yet to fully enjoy the benefits of raising capital via the capital market. In Ghana, the increasing integration of the financial markets and the implementation of various market reforms has incidentally placed substantial significance on the activities of the stock market.

The informational efficiency of national stock markets have been examined extensively through the study of the causal relationship between stock price indices and macroeconomic aggregates [3,4,5]. It can be argued that, if real economic activity affect stock prices, then an efficient stock market instantaneously reacts and incorporates available information about economic variables. The rational behaviour of market participants ensures that past and current information is fully reflected in current stock prices. As such, investors are not able to develop trading rules and thus, may not consistently earn higher than normal returns. In an informationally efficient market, past(current) level of economic activities are not useful in predicting current(future) stock prices.

The analysis on stock markets has become incisive in most policy circles since such market are increasingly becoming sensitive in the financial sector and subsequently on the whole economy. In the quest to perform well, several factors come to play in determining the stock prices of the Ghana Stock Exchange(GSE). Imperatively, this study investigates the causal relationship between stock market and real macroeconomic variables in Ghana, with the inclusion of money supply, real gross domestic product as a measure of economic activity and oil price to capture the effect of possible external shocks. We determine the long run and short-run relationship in the modern stock and macroeconomic variables using a calibrated vector autoregressive(VAR) model and Granger causality test.

It is evident that macroeconomic variables such as interest rate, exchange rate, money supply, inflation (Consumer Price Index), real economic production have some impact on the share price of stock exchange markets in both developed and developing countries where studies have been conducted [6,7]. Schwert [8] reports that stock market volatility is higher during recessions. He explained that, there is a weak evidence that

*Corresponding Author: Gabriel Asare Okyere

*Department of Mathematics, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.*

macroeconomic volatility can help predict stock volatility and a strong evidence that financial asset volatility helps predict future macroeconomic volatility. According to Moore [9], the general level of stock prices has been much higher at the top of an economic boom than the bottom of an economic recession in the USA, given reason for the turn in stock prices prior to the turn in business activity. Stock prices are stated to lead the swing in the business cycle. The relationship between interest rate and market returns are anticipated to be a negative one either through the inflationary or discount factor effect [3]. Mireku et al. [4] examined the dynamic relationships between the stock market index and the macroeconomic factors using cointegration test and vector error correction models (VECM). They established a cointegration between macroeconomic variables and stock prices in Ghana, indicating that interest rate and exchange rate have a negative effect on stock prices with a positive relationship between inflation and stock price.

## II. METHOD

This study specifies the following augmented functional model of the stock market performance for Ghana which is based on the theoretical and empirical literature on asset valuation:

$$\ln GSE_t = \delta_0+\delta_1 \ln INFL_t+\delta_2 \ln INTR_t+\delta_3 \ln EXR_t+\delta_4 \ln M2_t+\delta_5 \ln OILP_t+\delta_6 \ln RGDP_t+\varepsilon_t \qquad (1)$$

where *GSE* is the Ghana Stock Exchange All-Share index which serves as a proxy for stock market performance; *INFL* is the rate of inflation; *EXR* is the exchange rate; *INTR* is the interest rate; *M*2 is a measure of money supply; *OILP* is oil prices to proxy external supply shocks which is also treated as an exogenous variable since Ghana is a small oil importing country and hence cannot influence the world market price of oil; *RGDP* is a measure of economic activity; *t* is time and ε is the usual white noise error term.

The log-linear specification of the equation (1) is shown in equation (2). This has the potential of reducing hetroscedasticity [10]. The stochastic relationship between the variables in its estimable form is specified as follows:

$$\ln GSE_t = \delta_0+\delta_1 \ln INFL_t+\delta_2 \ln INTR_t+\delta_3 \ln EXR_t+\delta_4 \ln M2_t+\delta_5 \ln OILP_t+\delta_6 \ln RGDP_t+\varepsilon_t \qquad (2)$$

The VAR has proven very useful for describing the dynamic behaviour of economic and financial time series and for forecasting. VAR is actually a set of reduced form equations from a system of simultaneous equations. Assuming we have two macroeconomic variables, that is, real interest rate $y_t$ and rate of inflation $\pi_t$. Because these have some degree of hysteresis, they can partly be explained by their past values, which is given as:

$$\begin{aligned} y_t &= \beta_{10} + \beta_{11}\pi_t + \beta_{12}y_{t-1} + u_t;\ u_t \sim iid(0,\sigma_u^2) \\ \pi_t &= \beta_{20} + \beta_{21}y_t + \beta_{22}\pi_{t-1} + v_t;\ v_t \sim iid(0,\sigma_v^2) \end{aligned} \qquad (3)$$

The reduced form equations are as follows:

$$\begin{aligned} y_t &= \delta_1 + \theta_{11}y_{t-1} + \theta_{12}\pi_{t-1} + \eta_{1t} \\ \pi_t &= \delta_2 + \theta_{21}y_{t-1} + \theta_{22}\pi_{t-1} + \eta_{2t} \end{aligned} \qquad (4)$$

Equation (4) is typically *VAR*(1) system with

$$\eta_{1t} = \frac{u_t + \beta_{11}v_t}{1-\beta_{11}\beta_{21}};\ \eta_{2t} = \frac{v_t + \beta_{21}u_t}{1-\beta_{21}\beta_{11}};\ \delta_1 = \frac{\beta_{10}+\beta_{11}\beta_{20}}{1-\beta_{11}\beta_{21}};$$

$$\theta_{11} = \frac{\beta_{12}}{1-\beta_{11}\beta_{21}};\ \theta_{21} = \frac{\beta_{21}\beta_{12}}{1-\beta_{11}\beta_{21}};\ \theta_{22} = \frac{\beta_{22}}{1-\beta_{11}\beta_{21}}$$

$$\delta_2 = \frac{\beta_{20}+\beta_{21}\beta_{10}}{1-\beta_{11}\beta_{21}};\ \theta_{12} = \frac{\beta_{11}\beta_{22}}{1-\beta_{11}\beta_{21}}$$

We draw conclusion on the relationship among the endogenous variables based on Impulse Response Functions (IRFs). The IRFs for *y* are simply $\frac{\partial y_t}{\partial \eta_{1t-i}}, \frac{\partial y_t}{\partial \eta_{2t-i}}$ and for $\pi : \frac{\partial \pi_t}{\partial \eta_{1t-i}}, \frac{\partial \pi_t}{\partial \eta_{2t-i}}$ for $i = 0, \cdots, T$

We let $Y_t = (y_{1t}, y_{2t}, \cdots, y_{nt})$ denote an *n*×1 vector time series variables, which are GSE-All share index, money supply, inflation, exchange rate, interest rate, composite index for real economic activities and oil prices. The basic *p−lag* vector autoregressive (VAR(p)) model has the form:

$$Y_t = c + \Pi_1 Y_{t-1} + +\Pi_2 Y_{t-2} + \cdots + \Pi_p Y_{t-p} + \varepsilon_t, t = 1, \cdots, T \qquad (5)$$

where $\Pi_i$ are $n\times n$ coefficient matrices and $\varepsilon_t$ in an $n\times 1$ unobservable white noise vector process with zero mean and serially uncorrelated with time invariant covariance matrix Σ.

Since the basic *VAR*(*p*) model my be too restrictive to represent sufficiently the main characteristic of the data, we include other deterministic terms (linear trend or seasonal dummy variables) and exogenous variables to represent the data reasonably well. Equation (5) is then modified as:

$$Y_t = \Pi_1 Y_{t-1} + +\Pi_2 Y_{t-2} + \cdots + \Pi_p Y_{t-p} + \Phi D_t + \Gamma X_t + \varepsilon_t \qquad (6)$$

where $D_t$ represents an $n\times n$ matrix of deterministic components, $X_t$ represents an $m\times 1$ matrix of exogenous variables, and Φ and Γ are parameter matrices.

Assuming that equation (5) is covariance stationary, and there are no restrictions on the parameters of the model. In Seemingly Unrelated Regression (SUR) notation, each equation in the VAR(p) may be written as:

$$y_i = Z\pi_i + e_i, \quad i = 1, \cdots, n \qquad (7)$$

where $y_i$ is a $T\times 1$ vector of observations on the $i^{th}$ equation, $Z$ is a $T\times K$ matrix with $t^{th}$ row given by $Z_t' = (1, Y_{t-1}', \cdots, Y_{t-p}')$, $K = np + 1$, $\pi_i$ is a $K\times 1$ vector of parameters and $e_i$ is a $T\times 1$ error with covariance matrix $\sigma_i^2 I_T$. Since the VAR(p) is in the form of a SUR model where each equation has the same explanatory variables, each equation may be estimated separately by the ordinary least squares without losing efficiency relative to generalized least squares.

Let $\hat{\Pi} = [\hat{\pi}_1, \cdots, \hat{\pi}_n]$ denote the the $K\times n$ matrix of least squares coefficients for the $n$ equations and *vec*(Π) denote the operator that stacks the columns of the $n\times K$ matrix Π into a long $nK\times 1$ vector. That is:

$$vec(\hat{\Pi}) = \begin{bmatrix} \hat{\pi}_1 \\ \vdots \\ \hat{\pi}_n \end{bmatrix}$$

Under the standard assumptions regarding the behaviour of stationary and ergodic models [11] *vec*(Π) is consistent and asymptotically normally distributed with asymptotic covariance matrix:

$$var = \hat{\Sigma} \otimes (Z'Z)^{-1} \qquad (8)$$

where $\hat{\Sigma} = \frac{1}{T-k} \sum_{t=1}^{T} \hat{\varepsilon}_t \hat{\varepsilon}_t'$ and $\hat{\varepsilon}_t = Y_t - \hat{\Pi}' Z_t$ is the multivariate least squares residual from equation (5) at time t. Hence, asymptotically valid *t−tests* on individual coefficients may be constructed in the usual way. More general linear hypotheses of the form *R.vec*(Π)=*r* involving coefficients across different equations of the VAR may be tested using using the Wald statistic:

$$Wald = \left(R.vec(\hat{\Pi}) - r\right)' \left\{R\left[var(vec(\hat{\Pi}))\right]R'\right\}^{-1} \left(R.vec(\hat{\Pi}) - r\right) \qquad (9)$$

Under the null, equation (9) has a limiting $\chi^2(q)$ distribution where *q*=*rank*(*R*) gives the number of linear restrictions.

The lag length for the VAR(p) was determined by the three most common information criteria which are the Akaike(AIC), Schwarz-Bayesian(BIC) and Hannan-Quinn (HQ) given respectively as:

$$AIC(p) = \ln\left|\bar{\Sigma(p)}\right| + \frac{2}{T} pn^2$$
$$BIC(p) = \ln\left|\bar{\Sigma(p)}\right| + \frac{\ln T}{T} pn^2$$
$$HQ(p) = \ln\left|\bar{\Sigma(p)}\right| + \frac{2 \ln\ln T}{T} pn^2$$

The AIC criteria asymptotically overestimates the order with positive probability, whereas the BIC and HQ criteria estimate the order consistently under fairly general conditions if the true order of *p* is less than or equal to $p_{max}$.

To ascertain the direction of causality between stock prices and its determinants in the model, a Granger causality test was conducted to find the direction of causality and possible feedback between stock prices and the regressors in the model. The Granger causality test is performed by estimating equations of the following form [12]:

$$Dx_t = a + \grave{a}_{i=1}^{n} b_i Dx_{t-i} + \grave{a}_{j=1}^{m} l_j Dy_{t-j} + m_t$$

$$Dy_t = a + \grave{a}_{i=1}^{n} b_i Dy_{t-i} + \grave{a}_{j=1}^{m} l_j Dx_{t-j} + n_t$$

The *F−test* is applied to test the null hypothesis of Granger-non-causality against the alternative of Granger-causality.

## III. RESULTS AND DISCUSSIONS

The data set covers a twenty one year period from November 1990 to December 2011 on monthly basis, thus making use of 254 data points enough for effective regression analysis. All data are secondary and were obtained from the Ghana Stock Exchange, Bank of Ghana and International Financial Statistics(IFS). The analysis was done using STATA.

In Ghana, between November 1990 and December 2011, the GSE All-share index and interest rate (91 Day Treasury Bill rate) averaged 3227.534 and 27.04715% respectively. Within the same period inflation averaged 21.80% with a minimum inflation being 8.39000%, whiles the expected value for crude oil price was $39.61827 with $132.5500 per barrel as the highest price within the period. This is presented in Table 1.

**Table 1: Summary Statistics**

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| GSE | 3227.534 | 3978.927 | 57.6995 | 19823.77 |
| EXR | .6282398 | .4872959 | .034400 | 1.584050 |
| INTR | 27.04715 | 12.10836 | 9.14000 | 47.92833 |
| INFL | 21.80106 | 12.69155 | 8.39000 | 66.43559 |
| M2 | 2881.322 | 4153.905 | 28.3924 | 18366.99 |
| RGDP | 142.1612 | 45.58836 | 84.5500 | 271.2100 |
| OILP | 39.61827 | 28.90600 | 10.4100 | 132.5500 |

GSE Index and exchange rate shows upward trends, albeit with fluctuations. Money supply generally trends upwards with mild fluctuations whiles inflation oscillates quite swiftly within the period. Crude oil prices also trended upwards for the period under investigation with unexpected spikes around 2008. This was the period when the world market price of crude oil increased extremely, the stock index dropped significantly during that short period and increased a year after the world economy began to recover from the recession. Figures 1 and 2 illustrates the trends analysis of the GSE-All Share Index and the macroeconomic variables respectively. All the figures are plotted after taking the logarithm of the model.

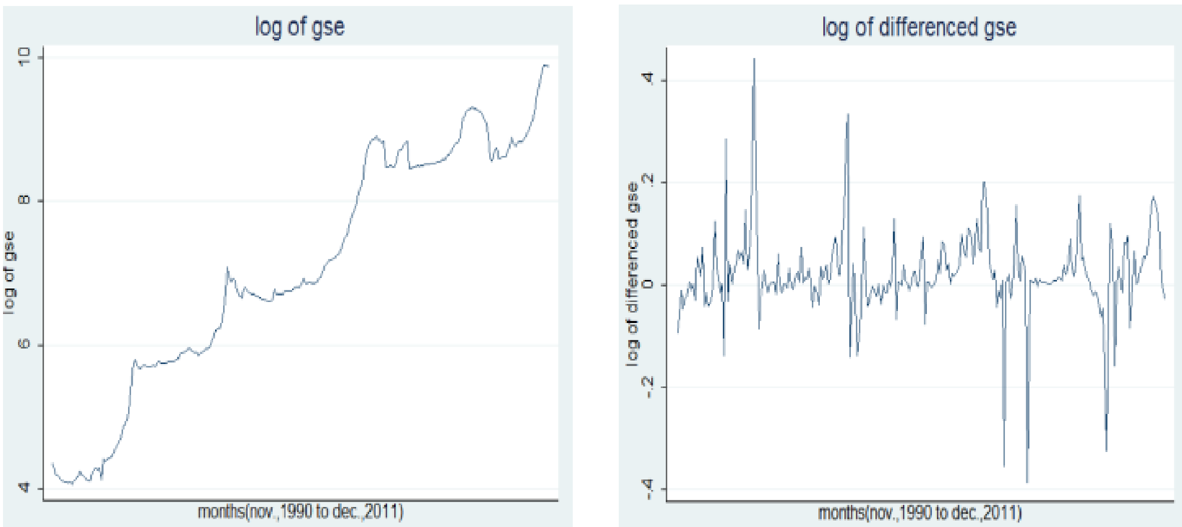


**Figure 1: Logarithm level and logarithm first differences of GSE share price index**

To ascertain the long run relationship among the variables, the order of integration of each of the series is checked using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and DF-GLS tests. An inspection of the variables in their levels are shown in Table 2, depicting non-stationarity of these series. However, first differencing them achieved stationarity since they are mean-reversible. We apply the unit roots of ADF, PP and DF-GLS. The results in Table 3 indicate that each of the series is integrated of order one, thus contain unit root, which is a necessary precondition for estimating our VAR model.

**Table 2: Unit Root Tests of Model Variables at Level**

| Variable | ADF | | PP | | DF-GLS | |
|---|---|---|---|---|---|---|
| | Test Statistic | 5% Critical Value | Test Statistic | 5% Critical Value | Test Statistic | 5% Critical Value |
| ln−*GSE* | 1.653 | 3.430 | 2.289 | 3.430 | 1.648 | 2.916 |
| ln−*EXR* | 0.036 | 3.430 | 0.585 | 3.430 | 0.645 | 2.916 |
| ln−*INTR* | 1.805 | 3.430 | 2.292 | 3.430 | 1.248 | 2.916 |
| ln−*INFL* | 1.332 | 3.430 | 2.030 | 3.430 | 1.340 | 2.916 |
| ln−*M*2 | 2.157 | 3.430 | 2.242 | 3.430 | 1.997 | 2.916 |
| ln−*RGDP* | 0.877 | 3.430 | 0.718 | 3.430 | 1.051 | 2.916 |
| ln−*OILP* | 3.329 | 3.430 | 3.598 | 3.430 | 2.916 | 2.916 |

**Table 3: Unit Root Tests of Model Variables after first differencing**

| Variable | ADF | | PP | | DF-GLS | |
|---|---|---|---|---|---|---|
| | Test Statistic | 5% Critical Value | Test Statistic | 5% Critical Value | Test Statistic | 5% Critical Value |
| ln−*GSE* | 10.840 | 3.430 | 10.840 | 3.430 | 8.756 | 2.916 |
| ln−*EXR* | 8.0280 | 3.430 | 8.0280 | 3.430 | 7.163 | 2.916 |
| ln−*INTR* | 12.106 | 3.430 | 12.106 | 3.430 | 9.036 | 2.916 |
| ln−*INFL* | 13.119 | 3.430 | 13.119 | 3.430 | 13.099 | 2.916 |
| ln−*M*2 | 14.866 | 3.430 | 14.866 | 3.430 | 14.600 | 2.916 |
| ln−*RGDP* | 18.809 | 3.430 | 18.809 | 3.430 | 17.840 | 2.916 |
| ln−*OILP* | 12.239 | 3.430 | 12.239 | 3.430 | 8.322 | 2.916 |

The results of the lag selection order criteria are presented in Table 4. The results indicate that, AIC, FPE and HQ criterion are all selecting lag order of one while the BIC criterion select a lag order of zero. Thus, we use one lag in the VAR estimations.

**Table 4: Lag selection-order criteria**

| Lag | LL | LR | df | p | FPE | AIC | HQ | BIC |
|---|---|---|---|---|---|---|---|---|
| 0 | 2679.14 | | | | 9.5e-19 | -21.6368 | -21.5967 | -21.5373* |
| 1 | 2796.39 | 234.5 | 49 | 0.000 | 5.4e-19* | -22.1894* | -21.8691* | -21.3937 |
| 2 | 2844.77 | 96.756 | 49 | 0.000 | 5.5e-19 | -22.1843 | -21.5837 | -20.6925 |
| 3 | 2889.05 | 88.569 | 49 | 0.000 | 5.7e-19 | -22.1462 | -21.2652 | -19.9581 |
| 4 | 2939.64 | 101.17* | 49 | 0.000 | 5.7e-19 | -22.159 | -20.9978 | -19.2748 |
| 5 | 2970.13 | 60.977 | 49 | 0.117 | 6.6e-19 | -22.0091 | -20.5676 | -18.4287 |
| 6 | 2990.95 | 41.646 | 49 | 0.763 | 8.4e-19 | -21.781 | -20.0592 | -17.5043 |

* indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, BIC: Schwarz information criterion, HQ: Hannan-Quinn information criterion, df: degree of freedom

**Table 5: Eigenvalue stability condition**

| | GSE | EXR | INTR | INFL | M2 | RGDP | OILP |
|---|---|---|---|---|---|---|---|
| Eigenvalue | .7869126 | .4439254 | .3351195 | .2474902 | -.1630326 | .09949 + .08523i | .09949 - .08523i |
| Modulus | .786913 | .443925 | .33512 | .24749 | .163033 | .131004 | .131004 |

A diagnostics test was performed on the VAR model in Table 8 and it was found that, the estimated model is stationary. This is shown by the eigenvalues in Table 5. All the eigenvalues are found in the unit circle which is suggestive of stability of the VAR model estimated. Thus, the estimated VAR model is appropriate.

*[$H_0$ : The variable has unit root (non-stationary) $H_A$ : The variable does not have unit root (stationary). When the value of the test statistic is more than 5% critical value, we reject the null hypothesis and accept the alternative hypothesis.)]*

The bivariate Granger causality test was conducted to find out the direction of causality and possible feedback among the variables. The result is shown in Table 6 and 7. It indicates a unidirectional causality running from exchange rate to interest rate, money supply to interest rate and inflation to money supply. Past values of exchange rate and money can be used to predict the current values of interest rate but the reverse. Also, money supply Granger cause exchange rate and exchange rate Granger cause money supply, showing a bi-directional causality between exchange rate and money supply. There were no causality between stock prices and the macroeconomic variable

**Table 6: Granger causality Wald tests**

| Equation | Excluded | chi2 | df | Prob > chi2 |
|---|---|---|---|---|
| $\Delta\ln GSE$ | $\Delta\ln EXR$ | .40694 | 1 | 0.524 |
| $\Delta\ln GSE$ | $\Delta\ln INTR$ | .06082 | 1 | 0.805 |
| $\Delta\ln GSE$ | $\Delta\ln INFR$ | .01164 | 1 | 0.914 |
| $\Delta\ln GSE$ | $\Delta\ln M2$ | 1.3688 | 1 | 0.242 |
| $\Delta\ln GSE$ | $\Delta\ln RDGP$ | .33559 | 1 | 0.562 |
| $\Delta\ln GSE$ | $\Delta\ln OILP$ | .56141 | 1 | 0.454 |
| $\Delta\ln GSE$ | ALL | 3.9085 | 6 | 0.689 |

The results from the impulse response analysis showed that, when one standard deviation positive impulse is given to each one of these macroeconomic variables, stock market prices will fluctuate around a constant mean price for 2 to 3 months but will eventually die out and become stationary and positive after 5 months into the future.

## IV. CONCLUSION

We examined the causal relation between some macroeconomic variables and stock prices in Ghana from November, 1990 to December, 2011 using multivariate vector autoregressive(VAR) approach and Granger causality test. The empirical results indicate that, all the time series variables exhibit trends (non stationary). The differenced series achieved stationarity which were used in the estimation of the VAR model. A VAR(1) model was used in the estimation of the relationship between stock prices and macroeconomic factors. Empirical results indicate that, exchange rate and money supply were feedback causal, exchange rate Granger cause interest rate, money supply Granger cause interest rate, and inflation rate Granger cause money supply. However all these macroeconomic variables fail Granger cause stock price for the period under consideration. This indicate that, GSE as a leading indicator of stock market performance cannot be totally explained by macroeconomic factors

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## APPENDIX

**Table 7: Granger causality Wald tests**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $\Delta\ln EXR$ | $\Delta\ln GSE$ | 8.0e-05 | 1 | 0.993 | $\Delta\ln M2$ | $\Delta\ln GSE$ | 1.9499 | 1 | 0.163 |
| $\Delta\ln EXR$ | $\Delta\ln INTR$ | .84919 | 1 | 0.357 | $\Delta\ln M2$ | $\Delta\ln EXR$ | 27.315 | 1 | 0.000 |
| $\Delta\ln EXR$ | $\Delta\ln INFR$ | .07166 | 1 | 0.789 | $\Delta\ln M2$ | $\Delta\ln INTR$ | .49676 | 1 | 0.481 |
| $\Delta\ln EXR$ | $\Delta\ln M2$ | 15.246 | 1 | 0.000 | $\Delta\ln M2$ | $\Delta\ln INFR$ | 4.3865 | 1 | 0.036 |
| $\Delta\ln EXR$ | $\Delta\ln RDGP$ | .03183 | 1 | 0.858 | $\Delta\ln M2$ | $\Delta\ln RDGP$ | 3.4022 | 1 | 0.065 |
| $\Delta\ln EXR$ | $\Delta\ln OILP$ | .06795 | 1 | 0.794 | $\Delta\ln M2$ | $\Delta\ln OILP$ | 1.5e-05 | 1 | 0.997 |
| $\Delta\ln EXR$ | ALL | 15.688 | 6 | 0.016 | $\Delta\ln M2$ | ALL | 39.709 | 6 | 0.000 |
| $\Delta\ln INTR$ | $\Delta\ln GSE$ | .00085 | 1 | 0.977 | $\Delta\ln RDGP$ | $\Delta\ln GSE$ | 1.6826 | 1 | 0.195 |
| $\Delta\ln INTR$ | $\Delta\ln EXR$ | 8.3365 | 1 | 0.004 | $\Delta\ln RDGP$ | $\Delta\ln EXR$ | .85863 | 1 | 0.354 |
| $\Delta\ln INTR$ | $\Delta\ln INFR$ | .64105 | 1 | 0.423 | $\Delta\ln RDGP$ | $\Delta\ln INTR$ | .01574 | 1 | 0.900 |
| $\Delta\ln INTR$ | $\Delta\ln M2$ | 8.1084 | 1 | 0.004 | $\Delta\ln RDGP$ | $\Delta\ln INFR$ | .59226 | 1 | 0.442 |
| $\Delta\ln INTR$ | $\Delta\ln RDGP$ | .08803 | 1 | 0.767 | $\Delta\ln RDGP$ | $\Delta\ln M2$ | .05195 | 1 | 0.820 |
| $\Delta\ln INTR$ | $\Delta\ln OILP$ | .01154 | 1 | 0.914 | $\Delta\ln RDGP$ | $\Delta\ln OILP$ | .11407 | 1 | 0.736 |
| $\Delta\ln INTR$ | ALL | 12.879 | 6 | 0.045 | $\Delta\ln RDGP$ | ALL | 4.0512 | 6 | 0.670 |
| $\ln INFR$ | $\Delta\ln GSE$ | .58045 | 1 | 0.446 | $\Delta\ln OILP$ | $\Delta\ln GSE$ | 3.4961 | 1 | 0.062 |
| $\Delta\ln INFR$ | $\Delta\ln EXR$ | 2.3157 | 1 | 0.128 | $\Delta\ln OILP$ | $\Delta\ln EXR$ | .33514 | 1 | 0.563 |
| $\Delta\ln INFR$ | $\Delta\ln INTR$ | 3.1834 | 1 | 0.074 | $\Delta\ln OILP$ | $\Delta\ln INTR$ | .09814 | 1 | 0.754 |
| $\Delta\ln INFR$ | $\Delta\ln M2$ | .43174 | 1 | 0.511 | $\Delta\ln OILP$ | $\Delta\ln INFR$ | .17679 | 1 | 0.674 |
| $\Delta\ln INFR$ | $\Delta\ln RDGP$ | .16386 | 1 | 0.686 | $\Delta\ln OILP$ | $\Delta\ln M2$ | .32186 | 1 | 0.570 |
| $\Delta\ln INFR$ | $\Delta\ln OILP$ | .00121 | 1 | 0.972 | $\Delta\ln OILP$ | $\Delta\ln RDGP$ | .20835 | 1 | 0.648 |
| $\Delta\ln INFR$ | ALL | 7.9281 | 6 | 0.243 | $\Delta\ln OILP$ | ALL | 4.6069 | 6 | 0.595 |

**Table 8: VAR(1) Estimation Results**

| | | Coef. | Std. Error | z | $P>z$ | 95% C. Interval | |
|---|---|---|---|---|---|---|---|
| $\Delta\ln GSE_t$ | $\Delta\ln GSE_{t-1}$ | .3930872 | .0581496 | 6.76 | 0.000 | .279116 | .5070584 |
| $\Delta\ln GSE_t$ | $\Delta\ln EXR_{t-1}$ | .1267267 | .1986563 | 0.64 | 0.524 | -.2626326 | .5160859 |
| $\Delta\ln GSE_t$ | $\Delta\ln INTR_{t-1}$ | -.0167455 | .0678986 | -0.25 | 0.805 | -.1498243 | .1163334 |
| $\Delta\ln GSE_t$ | $\Delta\ln INFL_{t-1}$ | .0071477 | .0662536 | 0.11 | 0.914 | -.122707 | .1370024 |
| $\Delta\ln GSE_t$ | $\Delta\ln M2_{t-1}$ | .1631536 | .1394505 | 1.17 | 0.242 | -.1101643 | .4364715 |
| $\Delta\ln GSE_t$ | $\Delta\ln RGDP_{t-1}$ | .0629945 | .1087415 | 0.58 | 0.562 | -.150135 | .276124 |
| $\Delta\ln GSE_t$ | $\Delta\ln OILP_{t-1}$ | .0445691 | .0594831 | 0.75 | 0.454 | -.0720156 | .1611538 |
| $\Delta\ln EXR_t$ | $\Delta\ln GSE_{t-1}$ | -.0001241 | .013864 | -0.01 | 0.993 | -.027297 | .0270488 |
| $\Delta\ln EXR_t$ | $\Delta\ln EXR_{t-1}$ | .6522205 | .0473634 | 13.77 | 0.000 | .55939 | .7450511 |
| $\Delta\ln EXR_t$ | $\Delta\ln INTR_{t-1}$ | .0149178 | .0161883 | 0.92 | 0.357 | -.0168107 | .0466463 |
| $\Delta\ln EXR_t$ | $\Delta\ln INFL_{t-1}$ | .0042286 | .0157961 | 0.27 | 0.789 | -.0267312 | .0351884 |
| $\Delta\ln EXR_t$ | $\Delta\ln M2_{t-1}$ | .1298192 | .0332476 | 3.90 | 0.000 | .0646551 | .1949833 |
| $\Delta\ln EXR_t$ | $\Delta\ln RGDP_{t-1}$ | -.0046253 | .025926 | -0.18 | 0.858 | -.0554394 | .0461887 |
| $\Delta\ln EXR_t$ | $\Delta\ln OILP_{t-1}$ | .0036968 | .0141819 | 0.26 | 0.794 | -.0240991 | .0314928 |
| $\Delta\ln INTR_t$ | $\Delta\ln GSE_{t-1}$ | .0015475 | .0530043 | 0.03 | 0.977 | -.1023389 | .105434 |
| $\Delta\ln INTR_t$ | $\Delta\ln EXR_{t-1}$ | .5228268 | .1810782 | 2.89 | 0.004 | .16792 | .8777336 |
| $\Delta\ln INTR_t$ | $\Delta\ln INTR_{t-1}$ | .2136174 | .0618906 | 3.45 | 0.001 | .092314 | .3349208 |
| $\Delta\ln INTR_t$ | $\Delta\ln INFL_{t-1}$ | .0483526 | .0603912 | 0.80 | 0.423 | -.0700119 | .1667172 |
| $\Delta\ln INTR_t$ | $\Delta\ln M2_{t-1}$ | -.3619525 | .1271112 | -2.85 | 0.004 | -.6110859 | -.1128192 |
| $\Delta\ln INTR_t$ | $\Delta\ln RGDP_{t-1}$ | -.0294085 | .0991195 | -0.30 | 0.767 | -.2236792 | .1648622 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $\Delta\ln INTR_t$ | $\Delta\ln OILP_{t-1}$ | -.0058249 | .0542197 | -0.11 | 0.914 | -.1120936 | .1004438 |
| $\Delta\ln INFL_t$ | $\Delta\ln GSE_{t-1}$ | -.042194 | .0553818 | -0.76 | 0.446 | -.1507404 | .0663524 |
| $\Delta\ln INFL_t$ | $\Delta\ln EXR_{t-1}$ | .2879134 | .1892008 | 1.52 | 0.128 | -.0829133 | .6587401 |
| $\Delta\ln INFL_t$ | $\Delta\ln INTR_{t-1}$ | .1153786 | .0646668 | 1.78 | 0.074 | -.011366 | .2421233 |
| $\Delta\ln INFL_t$ | $\Delta\ln INFL_{t-1}$ | .1525003 | .0631001 | 2.42 | 0.016 | .0288263 | .2761742 |
| $\Delta\ln INFL_t$ | $\Delta\ln M2_{t-1}$ | -.087267 | .1328129 | -0.66 | 0.511 | -.3475756 | .1730416 |
| $\Delta\ln INFL_t$ | $\Delta\ln RGDP_{t-1}$ | .0419235 | .1035657 | 0.40 | 0.686 | -.1610616 | .2449085 |
| $\Delta\ln INFL_t$ | $\Delta\ln OILP_{t-1}$ | .0019687 | .0566518 | 0.03 | 0.972 | -.1090668 | .1130042 |
| $\Delta\ln M2_t$ | $\Delta\ln GSE_{t-1}$ | .0339371 | .0243034 | 1.40 | 0.163 | -.0136968 | .0815709 |
| $\Delta\ln M2_t$ | $\Delta\ln EXR_{t-1}$ | .4339345 | .0830277 | 5.23 | 0.000 | .2712032 | .5966657 |
| $\Delta\ln M2_t$ | $\Delta\ln INTR_{t-1}$ | .0200012 | .028378 | 0.70 | 0.481 | -.0356187 | .075621 |
| $\Delta\ln M2_t$ | $\Delta\ln INFL_{t-1}$ | -.0579945 | .0276905 | -2.09 | 0.036 | -.1122668 | -.0037222 |
| $\Delta\ln M2_t$ | $\Delta\ln M2_{t-1}$ | .3241882 | .0582828 | 5.56 | 0.000 | .209956 | .4384204 |
| $\Delta\ln M2_t$ | $\Delta\ln RGDP_{t-1}$ | .0838288 | .0454481 | 1.84 | 0.065 | -.0052479 | .1729055 |
| $\Delta\ln M2_t$ | $\Delta\ln OILP_{t-1}$ | .0000948 | .0248607 | 0.00 | 0.997 | -.0486313 | .048821 |
| $\Delta\ln RGDP_t$ | $\Delta\ln GSE_{t-1}$ | .0430157 | .0331612 | 1.30 | 0.195 | -.0219792 | .1080105 |
| $\Delta\ln RGDP_t$ | $\Delta\ln EXR_{t-1}$ | .1049756 | .1132886 | 0.93 | 0.354 | -.1170659 | .3270172 |
| $\Delta\ln RGDP_t$ | $\Delta\ln INTR_{t-1}$ | -.0048572 | .0387208 | -0.13 | 0.900 | -.0807486 | .0710343 |
| $\Delta\ln RGDP_t$ | $\Delta\ln INFL_{t-1}$ | .029077 | .0377827 | 0.77 | 0.442 | -.0449758 | .1031298 |
| $\Delta\ln RGDP_t$ | $\Delta\ln M2_{t-1}$ | -.0181265 | .079525 | -0.23 | 0.820 | -.1739927 | .1377396 |
| $\Delta\ln RGDP_t$ | $\Delta\ln RGDP_{t-1}$ | -.1634301 | .0620125 | -2.64 | 0.008 | -.2849723 | -.0418878 |
| $\Delta\ln RGDP_t$ | $\Delta\ln OILP_{t-1}$ | -.0114568 | .0339217 | -0.34 | 0.736 | -.0779421 | .0550284 |
| $\Delta\ln OILP_t$ | $\Delta\ln GSE_{t-1}$ | .1106542 | .0591798 | 1.87 | 0.062 | -.005336 | .2266445 |
| $\Delta\ln OILP_t$ | $\Delta\ln EXR_{t-1}$ | .1170419 | .2021757 | 0.58 | 0.563 | -.2792152 | .513299 |
| $\Delta\ln OILP_t$ | $\Delta\ln INTR_{t-1}$ | -.0216477 | .0691015 | -0.31 | 0.754 | -.1570842 | .1137888 |
| $\Delta\ln OILP_t$ | $\Delta\ln INFL_{t-1}$ | .0283504 | .0674274 | 0.42 | 0.674 | -.1038048 | .1605056 |
| $\Delta\ln OILP_t$ | $\Delta\ln M2_{t-1}$ | -.080516 | .1419209 | -0.57 | 0.570 | -.3586759 | .1976439 |
| $\Delta\ln OILP_t$ | $\Delta\ln RGDP_{t-1}$ | -.0505145 | .110668 | -0.46 | 0.648 | -.2674197 | .1663908 |
| $\Delta\ln OILP_t$ | $\Delta\ln OILP_{t-1}$ | .277204 | .0605369 | 4.58 | 0.000 | .1585539 | .3958541 |

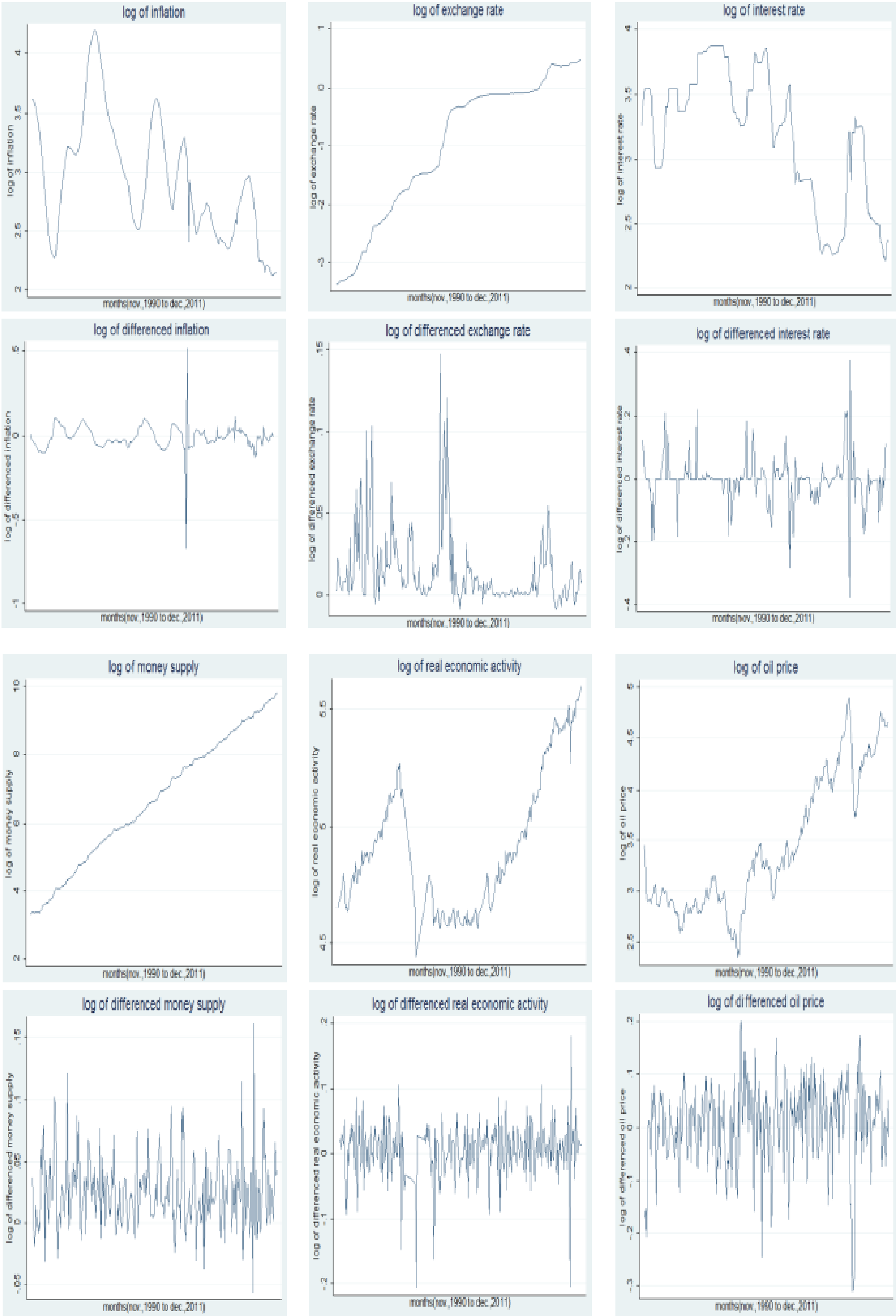


**Figure 2: Macroeconomic variables in their logarithm level and logarithm first differences**