WEST AFRICAN INSTITUTE FOR FINANCIAL AND ECONOMIC MANAGEMENT (WAIFEM)

WEST AFRICAN FINANCIAL AND ECONOMIC REVIEW (WAFER)

Volume 22 ■ December 2022 ■ Number 2

ISSN 0263-0699

West African Institute for Financial and Economic Management

West African Financial and Economic Review (WAFER)

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The Institute is grateful to the African Capacity Building Foundation (ACBF) for the financial support toward the publication of this journal.

Editor's Comment

In this December 2022 edition of the WAFER Journal, we included five peer-reviewed articles, which emanated from two capacity-building training programmes of WAIFEM namely Advanced Modelling and Forecasting for Policy Analysis for Senior Economists and Directors of Research (Bayesian DSGE Model) and Econometric Methods for Policy Analysis. In all, participants from three WAIFEM member countries (namely The Gambia, Ghana, and Sierra Leone) successfully produced papers using the Bayesian DSGE Approach in Macroeconomic Modelling, whilst participants from Nigeria produced papers using Volatility Models. The titles of the research papers are:

- Estimating a Small Open Economy DSGE Model for Sierra Leone
- Estimating a Small Open Economy Bayesian DSGE Model for Ghana
- Modelling Oil Price Volatility with Structural Break: A Re-Examination
- Oil Price Volatility and Stock Returns Nexus in the COVID-19 Pandemic Era
- Should Monetary Policy Respond to Productivity and Demand Shocks in The Gambia? A Bayesian DSGE Investigation.

The findings from the paper entitled "**Estimating a Small Open Economy DSGE Model for Sierra Leone**" demonstrates evidence of interest rate smoothing and the need for exchange rate consideration in monetary policy suggests that the country's central bank should adopt a more flexible exchange rate regime. Additionally, the estimated degree of openness parameter confirms Sierra Leone's increasing integration into the global economy, highlighting the need for policymakers to focus on trade and investment liberalization policies. The evidence of a significant inflation-output trade-off also underscores the importance of policymakers maintaining a balance between inflation and economic growth objectives. Moreover, the significant impacts of global inflation shocks and their pass-through effects on domestic economic conditions have important implications for inflation management and the country's macroeconomic stability.

The study entitled "**Estimating a Small Open Economy Bayesian DSGE Model for Ghana**" has as its key findings that the transmission of shocks suggests that adjustments in the Bank of Ghana's key policy rate significantly affect exchange rate dynamics, inflation, and the output gap in the short-run but the impact is not permanent. Moreover, the study finds that a technology shock permanently and positively impacts the output gap, inflation, and exchange rate developments. The study further suggests that a positive trade shock significantly affects the output gap, and inflation, which precipitates a rise in the monetary policy rate to moderate the effects of the opening up of the output gap and increased inflation. The study recommends that monetary policy tools should be deployed effectively to ward off any threat to price stability triggered by various types of shocks by coordinating with fiscal authorities to avoid policy conflicts.

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The findings from the study on "**Modelling Oil Price Volatility with Structural Break: A Re-Examination**" suggest that the EGARCH (1,1) model seems to offer a better fit, relative to all the other models estimated, suggesting that asymmetric models are superior to symmetric models when modeling oil price volatility. The findings also show that the inclusion of additional structural breaks does not significantly vary the results from the initial estimates obtained from the COVID-19 break date alone. Thus, the study recommends the inclusion of the COVID-19 structural break when modelling oil price volatility due to its superimposing effect on other break dates. Furthermore, the study recommends that portfolio managers and policymakers in oil-exporting and oil-importing economies need to consider pandemic risk as a critical risk factor in their analyses given its significant impact on crude oil prices and the resultant effect on their economies and financial markets.

The study "**Oil Price Volatility and Stock Returns Nexus in the COVID-19 Pandemic Era"** indicates that by using the EGARCH model, oil price volatility only has significant effects on stock returns in the net oil exporting countries but is insignificant for net oil importing countries. The same findings were obtained for both the full data sample and the COVID-19 pandemic period. The study recommends that the stability of oil prices is required for stocks listed in net oil exporting countries to perform well.

Finally, the finding from the study **"Should Monetary Policy Respond to Productivity and Demand Shocks in The Gambia? A Bayesian DSGE Investigation"** indicates that Monetary Policy Rate's response to both demand and productivity shocks is transient. Thus, the study suggests that the monetary authority of The Gambia need not respond to demand and productivity shocks since their effects are short-lived.

The painstaking efforts of our facilitators, authors, and reviewers in bringing out these papers are highly commendable.

Baba Yusuf Musa, Ph. D.
Editor-in-Chief

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Volume 22 **December 2022** **Number 2**

Published in Lagos, Nigeria by
West African Institute for Financial and Economic Management (WAIFEM),
Central Bank of Nigeria Learning Center, Navy Town Road, Satellite Town,
PMB 2001, Lagos, Nigeria.

ISSN 0263-0699

Printed by
Kas Arts Service Ltd.
08056124959

OIL PRICE VOLATILITY, EXCHANGE RATE INSTABILITY AND ECONOMIC GROWTH IN NIGERIA: A VAR STUDY

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Abstract

This paper analyses the interrelationship among oil price volatility, exchange rate instability and economic growth in Nigeria from 2000Q1 to 2021Q4. It adopts the VAR methodology. The findings show that a long run relationship exists among the variables in Nigeria. Economic growth responds positively to shocks to oil price and exchange rate throughout the forecast period. The predominant causes of variations in economic growth are associated with own shocks followed by oil price volatility and exchange rate instability. Thus, the government should take an advantage of positive oil price shocks in the international market to boost its economy. This can be achieved in the short term by reducing oil bunkering, theft and other illegal oil activities in the oil sector through transparency and accountability in crude oil deals as well as effective surveillance and monitoring management system of oil facilities across the nation. In the long term, it should improve its productive capacity by encouraging private sector participation, fixing the moribund oil refineries, and building of new modular refineries to cater for domestic consumption and exports. This will help mitigate the destabilizing effects that oil price volatility and exchange rate instability could have on the Nigerian economy.

Key words: Oil price volatility, exchange rate instability, economic growth, Nigeria

1.0 INTRODUCTION

Crude oil plays a significant role in the economic development of countries all over the world. Nigeria is an oil-producing country whose economic activities are largely driven by oil revenues. Since, the Nigerian economy depends largely on crude oil

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proceeds, shocks to oil prices can have extensive implications on its economic fundamentals. This is because oil accounts for over 90% of Nigeria's export revenues and over 90% of its foreign exchange earnings. In addition, over 80% of government revenue comes from oil (CBN, 2022).

Since Nigeria predominantly depends on oil export revenues, positive shocks to oil prices should directly translate into faster economic growth. However, this has not always been the case and there has been an increasing concern that oil price shocks can affect exchange rate stability which in turn results in internal and external instability. For instance, it was observed that a positive oil price shock has sometimes led to a decline in output in Nigeria (Iyke, 2019). Also, Keji (2018) noted that, in recent years, oil price fall has critically disrupted economic growth in Nigeria. In contrast, Ifeonyemetalu, Ogu, and Ojimadu (2020) showed that oil price has often had a positive and significant effect on the economic growth in Nigeria. Thus, the appropriate effect of oil price shocks on the Nigerian economy would seem to be indeterminate perhaps because Nigeria depends heavily on imported refined oil, capital and consumer goods. The implication is that positive oil price shocks could lead to imported inflation, exchange rate depreciation and depletion of external reserves which could in turn retard economic growth.

Although some researches have been carried out on the relationship among oil price volatility, exchange rate fluctuations and economic growth in Nigeria, most of the studies were conducted on the relations between oil price volatility and economic growth (Akalpler & Nuhu, 2018; Gummi, Buhari & Muhammad, 2017; Iyke, 2019; Keji, 2018) while others focused on the relationship between oil price uncertainties and exchange rate instability (Czech & Niftiyev, 2021; Sanusi, 2020; Igbinovia & Ogiemudia, 2021). Though a few of the studies focused on investigating the relationship among oil price, exchange rate and economic growth (Abdulkareem & Abdulhakeem, 2016; Musa, Maijama'a, Shaibu, & Muhammad (2019), they did not simultaneously analyze the interrelationship among these variables in Nigeria. This paper, therefore, contributes to knowledge by examining simultaneously the interrelationship among oil price, exchange rate and economic growth in Nigeria using the VAR approach.

Thus, the remaining part of this paper is organized thus: following this introductory section is section 2 which focuses on a review of the related literature with particular attention on theoretical and related empirical literature. Section 3 presents the model specification, methodology, and data sources. The results and discussion of the empirical study are presented in section 4. Section 5 provides some concluding remarks.

2.0 LITERATURE REVIEW

There are various channels in the literature through which oil price changes affect the economy. Changes in oil prices are caused majorly by two factors: the demand pull and cost push factors. For instance, a change in oil price occasioned by an increase in demand results in wealth transfer effect in oil exporting countries and inflation effect in oil importing economies. Whereas, a change in oil price because of a favourable change in supply of the crude oil translates to a supply-side shock effect. According to Tang, Wu, and Zhang (2010), the transmission channels of oil price changes to other key macroeconomic variables can be categorized into six effects: output effect; wealth transfer effect; inflation effect; real balance effect; sector adjustment effect and unexpected effect. However, this paper focuses mainly on the output effect and income/wealth transfer effect channels.

The output effect assumes that a rising oil price signals an increased scarcity of energy which is a basic input to production. Thus, a rising oil price is indicative of a classic supply-side shock that reduces potential output. According to Tang et al., (2010), crude oil is one of the most fundamental raw materials for industrial production. Hence, an oil price shock can increase the marginal cost of production by cutting down firms' capacity utilization. This leads to a reduction of output and unemployment. In other words, the growth of output and productivity are slowed due to oil price volatility.

On the other hand, the income transfer effect assumes that the oil prices affect exchange rates through a reallocation of wealth between oil-exporting and oil-importing countries (Golub, 1983; Krugman, 1983). For example, an increase in oil price leads to a transfer of income from net oil-importing economies to oil-exporting countries. It may trigger the depreciation of the currencies of the oil importing countries and appreciation in the currencies of the oil exporting countries when the oil import demand is inelastic (Golub, 1983). This results in a reduction in consumption expenditure in the oil-importing countries since the purchasing power of consumers has been eroded by the oil price increase. This income redistribution leads to lower aggregate demand. However, according to Krugman (1983), the relationship between oil prices and exchange rates may be either positive or negative. The sign depends on the countries' trade balance, trade elasticities, capital flows, and the scale of speculative transactions in the financial market.

The empirical literature on the relationships among oil price volatility, exchange rate instability and economic growth has highlighted several effects of each variable on the other. A number of authors have considered the effects of the international oil price on economic activities in various countries. In this light, Rodríguez-Benavides, Andrés-Rosales, del Río-Rama, and Irfan (2022) showed that the uncertainty of the international price of oil had a differentiated effect on the different sectors of economic activity in Mexico. It did not influence the primary sector. It had a negatively impact on the secondary sector, and there was mixed evidence in the tertiary sector. Furthermore, it was observed that both positive and negative shocks to the international oil price had asymmetric effects at the sectoral level in Mexico. Similarly, Keji (2018) showed that there was a negative link between oil price collapse and the economic growth in Angola, Nigeria and Sudan. It was also discovered that oil price fall greatly disrupted economic growth of the selected economies. Another study by Chien, Chau, Jalees, Zhang, Nguyen, and Baloch (2021) revealed that oil price had a negative impact on the economic development of Pakistan. The findings showed that a 30% shortage of oil supply was responsible for the highest fluctuated structure of oil pricing, which suddenly increased the projected welfare loss through a 40% reduction in gross domestic product in Pakistan.

In Nigeria, Iyke (2019) revealed that positive oil price uncertainty led to a decline in output, whereas negative oil price uncertainty led to a rise in output. The response of output to these uncertainties was asymmetric. In contrast, it was established by Akalpler & Nuhu (2018) and Maijama'a, Shaibu, & Muhammad, (2019) that oil price was positively related to economic growth in Nigeria. Though Ifeonyemetalu, Ogu, and Ojimadu (2020) showed that fluctuations in oil prices had a positive effect on economic growth, it was insignificant.

A few other studies have shown the effects of oil price and exchange rate on the economic growth. In this vein, Abdulkareem and Abdulhakeem (2016) who considered, real gross domestic product, interest rate, exchange rate and oil price, found that oil price was the major source of macroeconomic volatility in Nigeria. The implications of the findings were that the Nigerian economy is vulnerable to both internal and external shocks. The findings of Musa, Maijama'a, Shaibu, and Muhammad (2019) in Nigeria suggest that crude oil price and exchange rate instability could adversely affect economic growth in both the long-run and the short-run.

Some studies have also attempted to investigate the relationship between oil prices and exchange rate volatility. Hence, Sanusi's (2020) empirical evidence suggested the presence of asymmetric relationship in both short and long run. It was found that oil price increase did not significantly affect exchange rate movement or volatility in the selected countries while oil price reduction had a significant effect on exchange rate volatility in both short and long run. Similarly, the findings of Igbinovia and Ogiemudia (2021) showed that oil price had a long run positive insignificant influence on exchange rate volatility and a short run negative insignificant effect on exchange rate volatility in Nigeria. However, Czech and Niftiyev (2021) revealed that a rise of crude oil prices was associated with the exchange rates decrease thereby leading to appreciations in the currencies of Azerbaijani and Kazakhstani against the U.S. dollar. From the foregoing, although some researches have been carried out on the relationship among oil price volatility, exchange rate fluctuations and economic growth in Nigeria, most of the studies were conducted on the relations between oil price volatility and economic growth (Akalpler & Nuhu, 2018; Gummi, Buhari & Muhammad, 2017; Iyke, 2019; Keji, 2018) while others focused on the relationship between oil price uncertainties and exchange rate instability (Czech & Niftiyev, 2021; Sanusi, 2020; Igbinovia & Ogiemudia, 2021). Though a few of the studies focused on investigating the relationship among oil price, exchange rate and economic growth (Abdulkareem & Abdulhakeem, 2016; Musa, Maijama'a, Shaibu, & Muhammad

(2019), they did not simultaneously analyze the interrelationship among these variables in Nigeria. Thus, this study seeks to fill this research gap by analyzing the interrelationship among oil price volatility, exchange rate instability and economic growth in Nigeria using the VAR technique.

3.0 METHODOLOGY

The VAR model is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables. The VAR approach sidesteps the need for structural modelling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system. The mathematical representation of the VAR model for this study is:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_p Y_{t-p} + \varepsilon_t \qquad (1)$$

Where, Y_t is a vector of endogenous variables, X_t is a vector of exogenous variables, $A_1, \dots, A_p$ are matrices of coefficients to be estimated, and ε_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables.

However, where the endogenous variables are found to be non-stationary but co-integrated, the VAR becomes unsuitable and this justifies the use of the Vector Error Correction (VEC) model. A VEC model is a restricted VAR designed for use with nonstationary series that are known to be co-integrated. The VEC has co-integration relations built into the specification so that it restricts the long-run behaviour of the endogenous variables to converge to their co-integrating relationships while allowing for short-run adjustment dynamics. The co-integration term is known as the *error correction* term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

Thus, the study adopted the VEC modelling approach because the variables of interest are difference stationary and co-integrated. The Augmented Dickey-Fuller unit root and the Johansen co-integration techniques were used to test for the non-stationarity and co-integration properties of the variables. For the sake of complete analysis, other econometric analyses such as the Forecast Error Variance Decomposition (FEVD) and the Impulse Response Function (IRF) were also conducted. The IRF traces the reaction of all the variables in the VAR system to innovations in one of the variables and therefore can be used to analyze the effects of structural innovations. On the other hand, the FEVD represents the decomposition of forecast error variances and therefore gives estimates of the contributions of distinct innovations to the variances. Thus, FEVDs can be interpreted as showing the portion of variance in the prediction for each variable in the system that is attributable to its own innovations and to shocks to other variables in the system.

In light of the foregoing, the VEC model of this study, in compact form, is specified as follows:

$$\Delta Y_t = \alpha_j + \beta_{ij} \sum_{i=1}^{n} \Delta Y_{t-i} + \rho_j ECM_{t-1} + \varepsilon_j \quad (2)$$

Where,

Y_t = Vector of the endogenous variables

Y_{t-i} = Vector of the lagged endogenous variables

$RGDP$ = Growth rate of real gross domestic product

$OILP$ = Oil price

EXR = Exchange rate

$GEXP$ = Government expenditure

ECM_{t-1} = Error correction term

Δ = Difference operator

α_j= Vector of j intercept terms

β_{ij} = Matrix of $i \times j$ coefficients

ε_j = Vector of j stochastic terms

Therefore, the specification of the over-parameterized VAR/VEC model for this study is given in matrix notation as follows:

$$\begin{bmatrix} \Delta RGDP_t \\ \Delta OILP_t \\ \Delta EXR_t \\ \Delta GEXP_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} + \sum_{i=1}^{n} \begin{bmatrix} \beta_{11} & \cdots & \beta_{1j} \\ \vdots & \ddots & \vdots \\ \beta_{41} & \cdots & \beta_{4j} \end{bmatrix} \begin{bmatrix} \Delta RGDP_t \\ \Delta OILP_t \\ \Delta EXR_t \\ \Delta GEXP_t \end{bmatrix} + \begin{bmatrix} \rho_1 \\ \rho_2 \\ \rho_3 \\ \rho_4 \end{bmatrix} ECM_{t-1} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \end{bmatrix}$$

Quarterly data were collected on all the variables from various issues of the Central Bank of Nigeria annual reports and statistical bulletins and Nigeria Annual Abstract of Statistics published by the Nigerian National Bureau of Statistics. The data were collected for the period 2000Q1 to 2021Q4.

4.0 RESULTS

The descriptive statistics for variables of the study are reported in Table 1 in the appendix. As shown in Table 1, the mean of real gross domestic product (RGDP) is ₦53.41 trillion; oil price (OILP), US$65.42 per barrel, exchange rate (EXR), ₦188.81/US$1 and that of government expenditure (GEXP) is ₦4.5 trillion within the period of review. The wide margins between the minimum and maximum values of the variables indicate some variations in them. Similarly, their coefficients of variations reveal that real gross domestic product is the most volatile variable followed by oil price and exchange rate. The least volatile is government expenditure. The distributions of all the variables are positively skewed except real gross domestic product. While real gross domestic product and oil price were leptokurtic, exchange rate and government expenditure were platykurtic. The Jarque-Bera statistics reveal that all the variables are normally distributed.

As regards the unit root tests, the results of Augmented Dickey Fuller (ADF) tests of the variables at levels and first differences are presented in Table 2 in the appendix. The ADF regressions included an intercept and a trend. As depicted in Table 2, all the endogenous variables are integrated of order one, symbolically denoted as I(1). In other words, they are difference stationary. Since, they are integrated of the same order, the Johansen co-integration test was conducted for a long run relationship among them. Hence, the results of the co-integration tests using the multivariate Johansen cointegration approach are presented in Tables 4a and 4b in the appendix. The co-integration test based on the trace test in Table 3a indicates that there were two co-integrating equations at the 5% level. Also, as shown in Table 3b, the maximum Eigen value test indicates two co-integrating equations at the 5% level. Hence, there was a long run relationship among the variables. This implies that if real GDP, oil price and exchange rate diverge due to a sudden oil price and/or exchange rate shock, they will tend to converge in the long run. This is because a common force pulls them towards a common equilibrium path.

The results of the VAR lag order selection criteria tests are presented in Table 4 in the appendix. From Table 4, the lag order selection criteria indicate that the optimum lag order for the endogenous variables in the VEC model is two. Thus, in estimating the VEC model, the highest lag order introduced in the first differences of the endogenous variables was two.

In order to test for autocorrelation problem in the VEC system, we estimated the VEC residual portmanteau and LM tests for autocorrelations. Also, the VEC residual normality test was conducted. The results are reported in Table 6 in the appendix. From the table, the VEC residual portmanteau and LM tests for autocorrelations indicate that there is no residual autocorrelations in the VEC model up to lag order of three (3). This is because the Q-statistic and the adjusted Q-statistic were not significant at the 5% level. Therefore, we could not reject the null hypothesis of no residual autocorrelation in the VEC model. This depicts that the VEC system is free form the problem of contemporaneous serial correlation problem. The normality test indicates that the residuals are multivariate normal.

The results of the roots of the characteristic autoregressive (AR) polynomial are reported in Table 7 as well as the inverse roots of the characteristic AR polynomial in Figure 1 in the appendix. Form the results in Table 7, all the roots had moduli less than one and they all lie within the unit circle as shown in Figure 1. This shows that the VEC specification satisfies the stability condition. Thus, the VEC model is stable and as such the impulse response functions and forecast error decomposition functions are valid.

4.1 Discussion of Findings

In order to conduct the dynamic analysis among the variables, the Impulse Response Functions (IRFs) were examined first. The IRFs results are in the form of the dynamic impulse responses of the variables in the VEC model to an increase in each relevant variable equivalent to the sample standard deviation. The results in graphical form are presented in the Figure 2 in the appendix.

The impulse response functions reveal that real gross domestic product showed a negative response to shocks to government expenditure throughout the forecast period but transitory. Hence, government expenditure had a transitory effect on real gross domestic product. However, real gross domestic product responded positively to impulses in crude oil price and exchange rate throughout the quarters of forecast. These results are in agreement with those obtained by Gummi, Buhari and Muhammad (2017); Akalpler and Nuhu (2018); Ifeonyemetalu, Ogu, and Ojimadu (2020). Also, a standard shock to oil price has a positive transitory effect on real gross domestic output and government expenditure though the effect on government expenditure is less compared to that on aggregate economic output. These results further support the idea of Musa, Maijama'a, Shaibu, and Muhammad (2019) who found that crude oil price and exchange rate had significant positive impacts on economic growth. In contrast, an impulse to oil price has a negative transitory effect on exchange rate. This result is in agreement with Czech and Niftiyev's (2021) findings which showed that a rise of crude oil price was associated with exchange rate decrease. Again, one standard shock to exchange rate has a negative explosive effect on real gross domestic output and oil price throughout the period of forecast. However, it has a positive non-transitory effect on government expenditure. The impulse response of government expenditure to an innovation to oil price showed a positive effect on government expenditure throughout the forecast period but transitory. However, government expenditure responded negatively to impulses in exchange rate but petered out towards the end of the forecast period.

The forecast error variance decomposition functions reflect the proportion of forecast error variance in each variable that is attributed to its own fundamental innovations and innovations in the other variables. The graphs of the forecast error variance decomposition functions are shown in Figure 3 in the appendix. From the graphs, it can be observed that fundamental shocks to real gross domestic product from itself accounted for 100% innovations in the first quarter of forecast. The innovations, however, declined in the other quarters through to 87.9% in the fourth quarter of forecast. Innovations in crude oil prices and exchange rate accounted for virtually no variations in real gross domestic product in the first quarter of the forecast but increased to about 4.4% and 7.4% respectively in the fourth quarter of the forecast.

Although impulses in government expenditure accounted for no variations in real gross domestic product in the first quarter of the forecast but increased slightly to about 0.19% in the last quarter of the forecast year. The forecast error decomposition functions show that among the variables studied, the predominant causes of variations in real gross domestic product are associated with own shocks followed by crude oil price and exchange rate while government expenditure accounted for the least variations in real gross domestic product. These results seem to be consistent with other research findings (Abdulkareem & Abdulhakeem, 2016; Musa, Maijama'a, Shaibu & Muhammad, 2019; Ifeonyemetalu, Ogu & Ojimadu. 2020) which found crude oil price and exchange rate are major sources of macroeconomic volatility in Nigeria.

5.0 CONCLUSION AND POLICY IMPLICATIONS

This study sets out to examine the interrelationship among oil price volatility, exchange rate instability and economic growth in Nigeria. The study adopts the VAR modeling technique. The data used are quarterly series covering the period 2000Q1 to 2021Q4. The findings show that crude oil price, exchange rate, government expenditure and real gross domestic product are co-integrated indicating that a long run relationship exists among them. The results also reveal that real gross domestic product responded to shocks in crude oil prices and exchange rate in the long run. The implication is that crude oil price volatility and exchange rate instability cause fluctuations in economic growth in Nigeria. Overall, the results show that predominant causes of variations in economic growth were associated with own shocks but followed by crude oil price volatility and exchange rate instability while government expenditure accounted for the least variations in economic growth. The evidence from this study suggests that a fall in international crude oil price reduces the economy's foreign exchange earnings and international reserves. The reduced foreign earnings will mount pressure on the exchange rate and the cost of importation will increase. This in turn will increase the cost of production in economy because of the increased cost of importing raw materials from abroad. As a result, economic growth will be affected adversely. Thus, the Nigerian government should take an advantage of positive oil price shocks in the international market to boost its economy. This can be achieved in the short term by reducing oil bunkering, theft and other illegal oil activities in the oil sector through transparency and accountability in oil dealings as well as effective surveillance and monitoring management system of oil facilities across the nation. In the long term, it should improve its productive capacity by encouraging private sector participation, fixing the moribund oil refineries, and building of new modular refineries to cater for domestic consumption and exports. This will help mitigate the destabilizing effects that oil price volatility and exchange rate instability could have on the Nigerian economy.

A limitation of this study is that the quarterly data does not provide further detailed information on the nature of the interrelationship among oil price, exchange rate and economic growth as higher frequency data such as monthly, weekly or daily will provide. Since the study was limited to using quarterly data, it was not possible to forecast the dynamic effects of oil price volatility and exchange rate instability on economic output on monthly or weekly basis in Nigeria. However, other studies may focus on using higher frequency data such as monthly or weekly to analyse the interrelationship among these variables in Nigeria. Regression techniques suitable for high frequency data such as the various classes of Generalized Autoregressive Conditional Heteroskedasticity (GARCH) modeling techniques should be employed.

References

Abdulkareem, A. & Abdulhakeem, K. A. (2016). Analysing oil price-macroeconomic volatility in Nigeria. *CBN Journal of Applied Statistics*, *7*(1a), 1-22.

Akalpler, E. & Nuhu, A. B. (2018). The impact of oil price instability on economic growth: Evidence from Nigeria. *Business, Economics and Management Research Journal*, 1(1), 39-53.

Chien, F. Chau, K. Y., Jalees, T. Zhang, Y., Nguyen, V. C., & Baloch, Z. A. (2021). Crude oil price volatility and economic growth: Mediating role of macroeconomic indicators. *The Singapore Economic Review*, *1*(1), 1-10. https://doi.org/10.1142/S021759082150051X

Czech, K., & Niftiyev, I. (2021). The impact of oil price shocks on oil-dependent countries' currencies: The case of Azerbaijan and Kazakhstan. *Journal of Risk and Financial Management*, *14*(431), 1-13. https://doi.org/10.3390/jrfm14090431

Golub, S. S. (1983). Oil prices and exchange rates. *The Economic Journal 93(*576), 1-12.

Greene, W. H. (2003). *Econometric Analysis.* Fifth Edition. Upper Saddle River, N. J. USA: Prentice-Hall.

Gummi, U. M., Buhari, A. S, & Muhammad, A. (2017). Oil price fluctuations and economic growth in Nigeria: Evidence from Granger causality test. *Australasian Journal of Social Science, 3,* 1-16. Doi: 10.3923/aujss.2017.1.16

Ifeonyemetalu, J. O., Ogu, C. & Ojimadu, P. K. (2020). Impact of oil price fluctuation on economic growth in Nigeria. *Journal of Economics and Finance*, *11*(6), 43-54.

Igbinovia, L. E., & Ogiemudia, A. O., (2021). Oil Price and exchange rate volatility in
Nigeria. *Oradea Journal of Business and Economics, 6*(1), 74-86. http://doi.org/10.47535/1991ojbe123

Iyke, B. N. (2019). Real output and oil price uncertainty in an oil-producing country. *Bulletin of Monetary Economics and Banking,22* (2), 163 – 176.

Keji, S. A. (2018). An empirical nexus between oil price collapse and economic growth in Sub-Saharan African oil based economies. *Jurnal Perspektif Pembiayaan dan Pembangunan Daerah*, *5*(4), 300-313.

Musa, K., Maijama'a, R., Shaibu, H., & Muhammad, A. (2019). Crude oil price and exchange rate on economic growth: ARDL approach. *Open Access Library Journal*, *6*, 1-5. doi: 10.4236/oalib.1105930.

Rodríguez-Benavides, D., Andrés-Rosales, R., del Río-Rama, M. & Irfan, M. (2022). Modeling oil price uncertainty effects on economic growth in Mexico: A sector-level analysis. *Environmental Science and Pollution Research,* 29, 73987–74002. https://doi.org/10.1007/s11356-022-20711-2

Sanusi, K. A. (2020). Oil prices asymmetric and exchange rate volatility: Case of oil-exporting emerging countries. *Journal of International Studies*, *4*, 101-109.

Tang, W., Wu, L., & Zhang, Z. (2010). Oil price shocks and their short- and long-term effects on the Chinese economy. *Energy Economics*, *32*, 3–14.

APPENDIX

Table 1

Descriptive Statistics

	RGDP	OILP	EXR	GEXP
Mean	53,409.49	65.42	188.81	4503.77
Maximum	73,382.77	113.77	399.96	12,164.10
Minimum	25,430.42	25.04	102.11	701.10
Std. Dev.	16,444.34	28.88	89.07	3,194.31
Coeff.of variation	3.25	2.27	2.12	1.41
Skewness	-0.32	0.34	1.13	0.87
Kurtosis	1.63	2.05	2.87	2.97
Jarque-Bera	2.11	1.26	4.71	2.75
Probability	0.35	0.53	0.09	0.25

*Source**:** Results Extract from EViews 8*

Table 2

Results of ADF Unit Root Tests

Variable	**Lag**	**ADF Test Statistic**	**5% Critical Value**	**Order of Integration**	**Remarks**
RGDP	0	-2.19	-3.01	I(1)	Non-stationary
OILP	0	-3.75	-3.64	I(1)	Non-stationary
EXR	2	-0.11	-3.67	I(1)	Non-Stationary
GEXP	3	-1.85	-3.69	I(1)	Non-stationary
Δ*RGDP*	0	-3.75	-3.66	I(0)	Stationary
Δ*OILP*	0	-4.20	-3.66	I(0)	Stationary
Δ*EXR*	1	-4.12	-3.67	I(0)	Stationary
Δ*GEXP*	4	-3.69	-3.73	I(0)	Stationary

Source: Author's results using E-views

Note: "Δ" denotes first difference.

Table 3a

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.96	98.96	47.86	< 0.01
At most 1 *	0.71	34.73	29.80	0.01
At most 2	0.24	10.07	15.49	0.28
At most 3 *	0.20	4.46	3.84	0.03

Table 3b

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.96	64.23	27.58	< 0.01
At most 1 *	0.71	24.66	21.13	0.02
At most 2	0.24	5.61	14.26	0.66
At most 3 *	0.20	4.46	3.84	0.03

Source: Results Extract from EViews 8

Note: * denotes rejection of the hypothesis at the 0.05 level; **MacKinnon-Haug-Michelis (1999) p-values

Table 4

VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
1	-17.43	NA	7.69e+12	41.02	41.48	41.21
2	-17.56	132.02*	2.02e+12*	39.68*	40.60*	40.05*
3	-16.96	14.77	2.42e+12	39.86	41.24	40.41

Source: Results Extract from EViews 8.0

Note: * 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, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

Table 5

Estimated VEC Model

Co-integrating Equation				
RGDP(-1)	1.00			
OILP(-1)	-573.23			
	(97.99			
	[-5.85]			
EXR(-1)	-368.81			
	(87.14)			
	[-4.23			
GEXP(-1)	7.67			
	(2.61)			
	[2.94]			
C	19315.86			
Error Correction:	**D(RGDP)**	**D(OILP)**	**D(EXR)**	**D(GEXP)**
CointEq1	-0.018	0.00017	0.00022	-0.0042
	(0.0053)	(0.00018)	(6.3E-05)	(0.0025)
	[-3.49]	[0.937]	[3.54]	[-1.646]
D(RGDP(-1))	0.609	0.0021	0.0002	0.0079
	(0.13)	(0.0044)	(0.0016)	(0.062)
	[4.68]	[0.49]	[0.129]	[0.128]
D(RGDP(-2))	0.208	-0.0027	-0.0011	0.0177
	(0.132)	(0.0044)	(0.0016)	(0.063)
	[1.57]	[-0.602]	[-0.706]	[0.28]
D(OILP(-1))	-6.03	0.310	-0.0501	0.0389
	(3.74)	(0.125)	(0.045)	(1.787)
	[-1.61]	[2.48]	[-1.123]	[0.022]
D(OILP(-2))	-1.08	-0.269	0.0768	-0.785
	(3.82)	(0.128)	(0.046)	(1.827)
	[-0.28]	[-2.104]	[1.68]	[-0.430
D(EXR(-1))	11.02	-0.853	0.497	6.60
	(11.59)	(0.388)	(0.138)	(5.54)
	[0.95]	[-2.20]	[3.589]	[1.19]
D(EXR(-2))	10.22	0.544	0.038	4.672
	(11.62)	(0.389)	(0.139)	(5.56)

	[0.88]	[1.399]	[0.278]	[0.84]
D(GEXP(-1))	0.084	0.0088	0.00024	0.656
	(0.265)	(0.0089)	(0.0032)	(0.127)
	[0.32]	[0.99]	[0.076]	[5.176]
D(GEXP(-2))	0.0056	-0.0044	0.00168	0.152
	(0.28)	(0.0095)	(0.0034)	(0.135)
	[0.0197]	[-0.461]	[0.498]	[1.12]
C	35.995	1.21	1.9613	-18.67
	(96.52)	(3.23)	(1.153)	(46.18)
	[0.37]	[0.376]	[1.701]	[-0.404]
R-squared	0.61	0.30	0.69	0.83
Adj. R-squared	0.56	0.17	0.66	0.48
F-statistic	12.91	2.92	18.76	9.46

VEC Granger Causality/Block Exogeneity Wald Tests Results

Dependent variable: D(RGDP)

Excluded	**Chi-Square**	**Df.**	**Prob.**
D(OILP)	67.57	2	< 0.01
D(EXR)	3.51	2	0.17
D(GEXP)	12.85	2	< 0.01
All	131.13	6	< 0.01

Source: Results Extract from Eviews 8.0

Notes: () represents standard error; [] denotes t-statistics

Table 6

VEC Residual Tests for Autocorrelations and Normality

VEC Residual Tests for Autocorrelations							Normality Test	
	Portmanteau Tests				LM Test			
Lags	**Q-Stat.**	**Prob.**	**Adj. Q-Stat.**	**Prob.**	**LM-Stat**	**Prob.**	**Jarque-Bera Stat.**	**Prob.**
1	1.79	NA*	1.81	NA*	19.50	0.24		
2	15.49	NA*	15.84	NA*	12.45	0.71	9.79	0.28
3	32.44	0.26	33.42	0.22	10.20	0.86		

Source: Results Extract from EViews 8.0

Note. *The test is valid only for lags larger than the VAR lag order for the VEC residual Portmanteau tests for autocorrelations

Table 7

Roots of Characteristic Polynomial

Root	Modulus
1.00	1.00
1.00	1.00
1.00	1.00
0.94	0.94
0.77 - 0.21i	0.79
0.77 + 0.21i	0.79
0.72	0.72
0.21 - 0.52i	0.56
0.21 + 0.52i	0.56
-0.28 - 0.10i	0.30
-0.28 + 0.10i	0.30

Source: Results Extract from EViews 8.0

Note. VEC specification imposes 3 unit root(s).

Figure 1

Inverse roots of AR characteristic polynomial

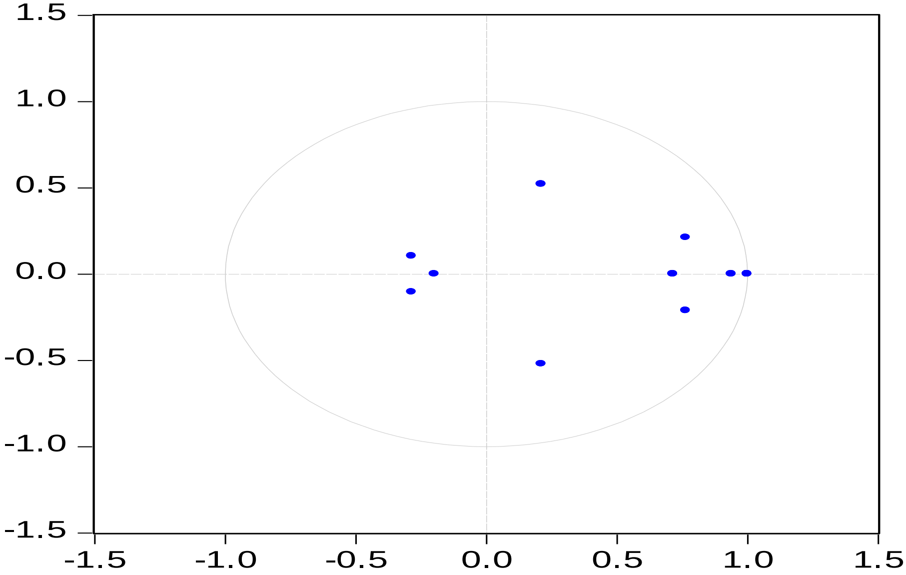


Figure 2

Impulse Response Functions

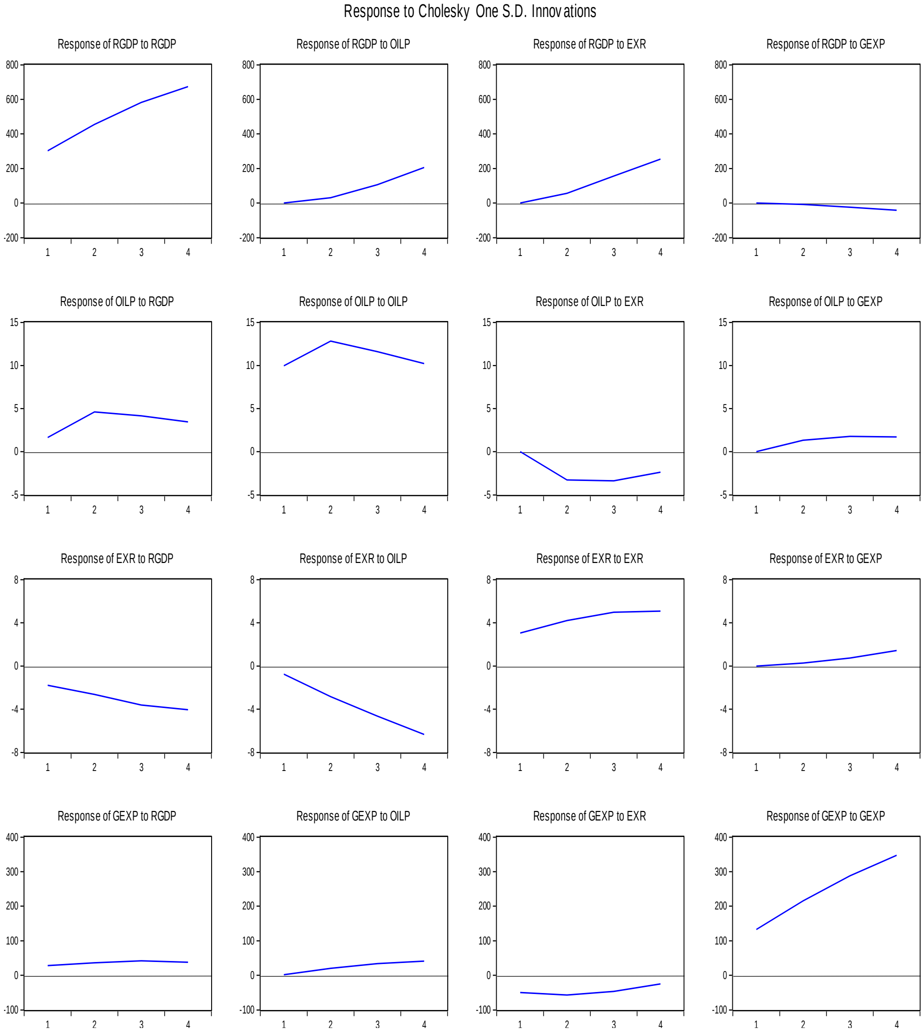
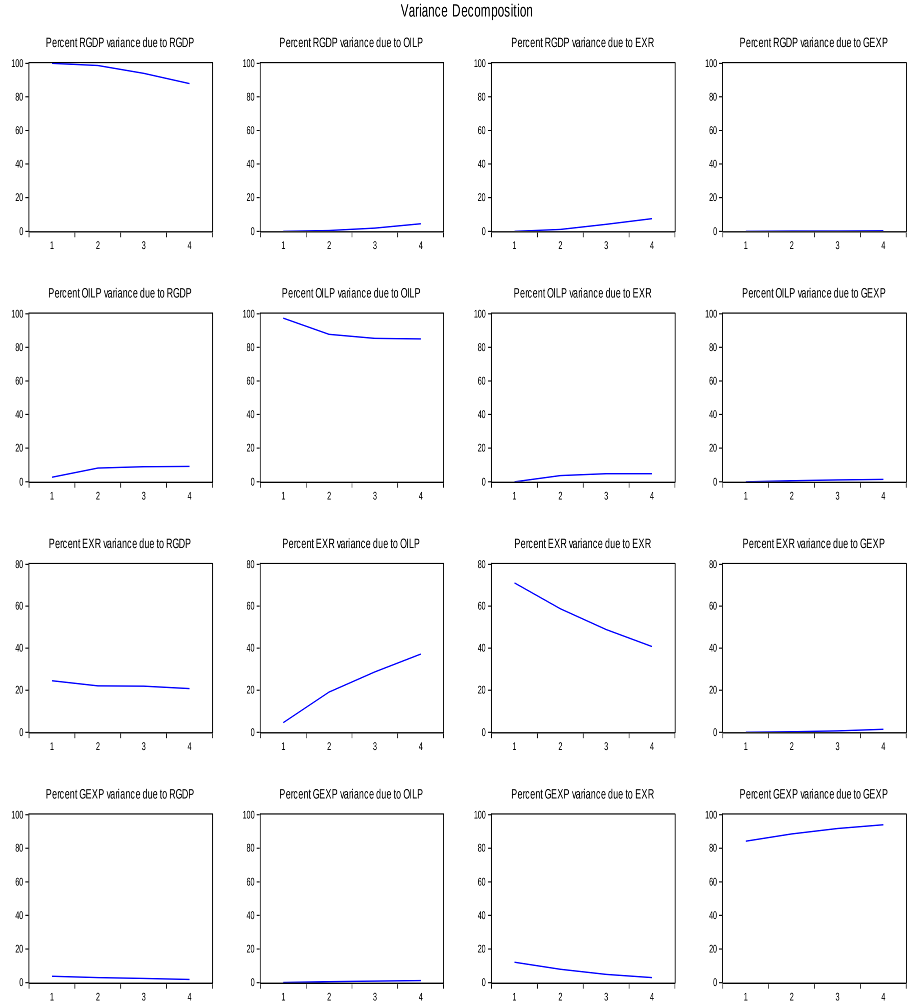


Figure 3

Forecast Error Decomposition Functions



ESTIMATING A SMALL OPEN ECONOMY DSGE MODEL FOR SIERRA LEONE

Kabineh Kpukumu[1] and Mohamed Sillah[2]

Abstract

This study focuses on the Sierra Leone economy to explore the interconnection between macroeconomic variables (prices, interest rate, and output), domestic and external (exogenous) shocks (monetary policy shock, terms of trade shock, technology shock, and global shocks), and implications for monetary policy in the economy. The study treats Sierra Leone as a small open economy as it deserves and therefore adopts an open economy model to examine the interactions between Sierra Leone, on the one hand, and the rest of the world (proxied by the United States), on the other hand. The study adapts a Bayesian DSGE model estimated with the Markov Chain Monte Carlo method within the Bayesian framework, with quarterly data between 2011Q1 and 2021Q4. Among other things, the study established that the exogenous shocks have varying impacts on the macroeconomic variables and from these offered several policy suggestions to guide monetary policy actions in Sierra Leone.

Keywords: Bayesian DSGE, Small Open Economy, Sierra Leone, Monetary Policy, Trade

JEL Classification: C11, F41, O55, E52, F10

1.0 INTRODUCTION

In an era of increasing globalization and interconnectedness, understanding the intricate dynamics of small open economies has become a crucial endeavor for

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policymakers, researchers, and economists alike. Such economies, often found among least developed countries (LDCs), are characterized by their vulnerability to external shocks and limited policy tools to mitigate the resulting economic fluctuations. As a result, accurately estimating and analyzing the macroeconomic variables that drive these economies, along with the identification and measurement of different types of shocks, has gained paramount importance. Cashin, Cespedes, and Sahay (2004), oil price shocks can have profound macroeconomic implications, triggering changes in inflation, interest rates, output, and exchange rates. Such shocks can significantly disrupt the delicate equilibrium of SOEs, rendering them highly susceptible to economic fluctuations and posing significant challenges for policymakers. Baumeister and Kilian (2016), can have profound implications for trade-dependent SOEs, impacting their competitiveness, export performance, and overall macroeconomic stability.

Sierra Leone confronts a range of macroeconomic challenges that are intricately linked to external shocks. One of these challenges arises from terms of trade shocks, which can impact the country's export competitiveness and foreign exchange earnings. Given Sierra Leone's reliance on primary commodities such as diamonds, iron ore, and agricultural products, fluctuations in global commodity prices can significantly affect its terms of trade, trade balances, and overall economic performance. Furthermore, Sierra Leone's economy is susceptible to global output shocks. Variations in global economic growth rates can transmit through trade channels, influencing Sierra Leone's export volumes, investment levels, and employment opportunities. Fluctuations in global demand and economic activity can pose challenges for sustaining robust economic growth and reducing unemployment in the country. Lastly, global price shocks, such as fluctuations in commodity prices, can directly impact Sierra Leone's economy. Given the country's heavy reliance on imported inputs and commodities, changes in global prices can influence input costs, production decisions, and profitability across various sectors. This, in turn, affects the country's competitiveness, industry performance, and overall economic stability.

Furthermore, traditional economic models often fall short in accounting for these shocks as they relate to domestic macroeconomic challenges. This study is therefore motivated by the need to develop a tailored framework that can aptly capture the aforementioned challenges and shocks. To achieve it, we utilize the Dynamic Stochastic General Equilibrium (DSGE) model. By this estimation, we aim to enhance our understanding of the macroeconomic challenges associated with these external shocks. Such insights will contribute to the formulation of effective monetary policy to mitigate the adverse effects of external shocks on inflation, interest rates, output gaps, exchange rates, and overall economic growth.

Our study is distinct from the extant literature on Sierra Leone in various ways. Previous studies such as Tamuke and Barrie (2021) employed the Maximum Likelihood Estimation variant of the DSGE model to assess the impacts of productivity and monetary policy shocks on key macroeconomic variables within the context of a closed economy. Sillah et al. (2022) utilized the Bayesian DSGE model to ascertain the impacts of demand, monetary policy, and productivity shocks on the economy. And Barrie and Jackson (2022) used the Bayesian DSGE model to assess the impacts of technological shock on key macroeconomic variables in the country. However, from the above existing studies and to our knowledge, no previous study has used DSGE modeling (an advanced technique) to examine the impacts of terms of trade shocks, global output shocks, and global price shocks on the macroeconomy of Sierra Leone. The study further incorporated technology shock and monetary policy shocks and found additional insights into the existing findings.

The remaining sections of the paper are organized as follows: Section 2 presents the literature review, while Section 3 outlines the basic structure of a small open economy DSGE model with its underlying assumptions, description of variables used and data sources, and choice of priors. Section 4 presents model estimation and results. Section 5 presents the conclusion, policy implication, and suggestions for future research. The final section outlines the references used in the study.

2.0 LITERATURE REVIEW

2.1 Theoretical Literature Review

The theoretical literature on small open economy DSGE models has laid the groundwork for understanding the theoretical underpinnings and economic mechanisms driving these models. Researchers have developed and refined various theoretical frameworks to capture the dynamics of small open economies. The following studies represent some influential contributions in this area. Obstfeld and Rogoff (1995) present a theoretical framework for analyzing exchange rate dynamics in small open economies. The study highlights the role of nominal rigidities, price stickiness, and monetary policy in driving exchange rate movements. The authors provide insights into the interactions between real and monetary factors in determining exchange rates, which are crucial for understanding small open economy DSGE models. Gali and Monacelli (2005) develop a theoretical framework that explores the interactions between monetary policy, exchange rate volatility, and macroeconomic fluctuations in small open economies. The study emphasizes the role of interest rate rules, exchange rate regimes, and the interplay between nominal and real rigidities. The authors provide insights into the transmission mechanisms of monetary policy and its impact on exchange rates. Benigno and Benigno (2006) analyze the design of target rules for international monetary policy cooperation in small open economies. The study addresses issues related to optimal policy rules, exchange rate stabilization, and coordination among central banks. The authors provide theoretical insights into international monetary policy coordination's challenges and potential benefits in small open economy DSGE models.

2.2 Empirical Literature Review

In recent times, economists have greatly utilized the Dynamic Stochastic General Equilibrium (DSGE) model to analyze macroeconomic issues and evaluate monetary policy. In the Asia and Euro regions, Zheng and Guo (2013) examined a small open economy DSGE model for China that incorporates indeterminacy in the form of self-fulfilling expectations. The authors find that the model with indeterminacy can better explain the volatility of output and inflation in China. They also find that the endogenous risk premium channel, which captures the impact of self-fulfilling expectations on macroeconomic outcomes, is particularly important in explaining the behavior of inflation in China. Smets and Wouters (2003) constructed an estimated dynamic stochastic general equilibrium (DSGE) model for the Euro area. Their study shows that monetary policy is crucial in stabilizing inflation, output, and other macroeconomic variables in the region. They also conclude that structural shocks, including productivity and preference shocks, have significant impacts on the economy, emphasizing the necessity of incorporating such shocks in DSGE models. Adolfson et al. (2007) focus on estimating an open economy DSGE model with incomplete exchange rate pass-through. The authors employ a Bayesian approach and estimate the model using Swedish data. They found that incomplete pass-through plays a crucial role in explaining the dynamics of macroeconomic variables, highlighting the importance of incorporating this feature in small open economy DSGE models.

Similarly, studies utilizing DSGE modeling have been carried out in African countries. For instance, Le and Naraidoo (2019) developed a small open economy DSGE model for South Africa that incorporates commodity price fluctuations and financial market imperfections. The authors find that commodity price fluctuations significantly impact the economy and that monetary policy can help stabilize the economy by responding to these fluctuations. The study also finds that financial market imperfections can amplify the effects of monetary policy on the real economy and that a more accommodative monetary policy can help reduce the negative effects of these imperfections. Hollander et al. (2019) investigate the impacts of oil shocks in a small open economy using the New Keynesian DSGE model for an oil-importing country, South Africa. They found out that foreign real oil price shocks have a strong and persistent effect on domestic production and consumption activities and hence, are a fundamental driver of output, inflation, and interest rate in both the short- and long run. Oil price shocks also generate a trade-off between output and inflation stabilization. Barrie and Jackson (2022) investigated the impact of technological shocks on the Sierra Leone economy using a DSGE approach. They found out that investment-specific technological shock partly explains business cycle fluctuations in Sierra Leone. Moreover, the analysis indicates that technology shock on output, capital, and consumption is more persistent than that of interest rate. Tamuke and Barrie (2021) used the Maximum Likelihood Estimation (MLE) DSGE variant to examine the impact of monetary policy and productivity shocks on major macroeconomic variables, including output, inflation, and monetary policy rate, in Sierra Leone. Their findings revealed that both monetary and productivity shocks have long-lasting impacts on output, inflation, and interest rate in Sierra Leone, although the effects of productivity shocks do not appear to be statistically significant. Sillah et. al. (2022) utilized the DSGE model to analyze the impacts of monetary policy, productivity, and demand shocks on key macroeconomics in Sierra Leone. They found that monetary policy and demand shocks have a transitory effect on inflation, interest rates, and output. However, productivity shocks have a permanent effect on inflation, interest rate, and output in Sierra Leone.

Notwithstanding the limited existing literature on the macroeconomic dynamics of Sierra Leone using dynamic stochastic general equilibrium (DSGE) estimation, none has yet employed the Bayesian DSGE methodology to model Sierra Leone as a small open economy, specifically focusing on the effects of external shocks such as world output, world inflation, and terms of trade on the country's macroeconomic dynamics. These shocks hold significant implications in an economy hugely dependent on imports like Sierra Leone. Consequently, this study aims to address this research gap and provide essential insights for policymakers by incorporating the mentioned shocks and technological and monetary policy shocks.

3.0 SMALL OPEN ECONOMY DSGE MODEL

In this study, we adopt the approach of Lubik and Schorfheide (2007) and Del Negro and Schorfheide (2009) by outlining the basic structure of a small open economy model. Specifically, the model includes two economies – Sierra Leone (home) and the rest of the world (United States of America). To capture the interaction between these two economies, we specify the consumption Euler equation as an open economy IS curve,

$$outp_t = E_t(y_{t+1}) - (\gamma + \varkappa)\,(R_t - E_t \mathrm{inf}_{t+1}) + \delta_z \mathrm{z}_t - \alpha(\gamma + \varkappa) E_t(\Delta \mathrm{q}_{t+1}) + \frac{\varkappa}{\gamma} E_t(\Delta y^*_{t+1}), \tag{1}$$

The domestic output gap ($outp_t$), as noted by Richard and Olofin (2013), can be determined by several factors, including the logarithmic deviation of domestic output level (y_t), ex-ante real interest rate ($R_t - E_t \mathrm{inf}_{t+1}$), productivity shock ($\mathrm{z}_t$), terms of trade ($q_t$), and foreign output level (y^*_t). From the above equation, α,γ, and δ_z represent the degree of openness, intertemporal substitution elasticity, and persistence of technology shock respectively. When $\alpha=0$, the above equation will be reduced to its closed economy variant.

The Phillips curve is derived from the optimal price-setting strategy of domestic firms, and is expressed as follows:

$$\mathrm{inf}_t = \beta E_t \mathrm{inf}_{t+1} + \alpha\beta E_t \Delta q_{t+1} - \alpha\Delta q_t + \frac{\chi}{\gamma+\varkappa}(y_t - \bar{y}_t) \quad (2)$$

This is the open economy version of the New Keynesian Phillips curve, which has become a widely used tool for analyzing inflation dynamics in modern economic analysis. The variables $y_t - \bar{y}_t$ signifies an output gap, and χ signals price adjustment in the economy (Del Negro and Schorfheide (2009)).

The next important equation in this model is the monetary reaction function, which links the interest rate to the deviations in inflation, output gap, and exchange rate. Given that Sierra Leone is import-dependent, the exchange rate serves as one of the channels through which external shocks affect the economy, and by extension, an unstable exchange rate poses a challenge to monetary policy implementation in the country. Also, theoretically, stabilizing the currency involves not only ensuring price stability but also ensuring a stable exchange rate. Against this backdrop, we assume that the Bank of Sierra Leone responds to changes in CPI inflation and real output by adjusting the interest rate, and most importantly incorporating exchange rate policy in its monetary policy framework. The equation is given thus,

$$R_t = \delta_R R_{t-1} + (1-\delta_R)[\Omega_1 inf_t + \Omega_2 outp_t + \Omega_3 \Delta e_t] + \varepsilon_{Rt}, \quad (3)$$

where the parameters Ω_1, Ω_2, Ω_3, and ε_{Rt} reflect changes in inflation, output gap, exchange rate, and the unanticipated monetary policy shock respectively. The parameter δ_R symbolizes interest rate smoothing.

Assuming the validity of purchasing power parity (PPP), this paper presents an expression for the changes in the nominal exchange rate as follows,

$$\Delta e_t = inf_t - inf_t^* - (1-\alpha)\Delta q_t , \quad (4)$$

Where the parameter inf_t^* refers to the global inflation rate. This equation links changes in nominal exchange rate to home and global inflation, and changes in the terms of trade.

Next, the terms of trade variable is considered exogenous and is represented thus,

$$\Delta q_t = \delta_q \, \Delta q_{t-1} + \varepsilon_{qt} \, , \tag{5}$$

Where the parameter ε_{qt} signifies terms of trade shocks.

Also, an AR(1) process is assumed to govern the technology shock,

$$z_t = \delta_z z_{t-1} + \varepsilon_{zt} \, , \tag{6}$$

Moreover, we assume that the world output and inflation, denoted by GDP_t^* and inf_t^* respectively, are governed by exogenous AR(1) processes,

$$GDP_t^* = \delta_{GDP*} GDP_{t-1}^* + \varepsilon_{GDP*t} \, , \; inf_t^* = \delta_{inf*} inf_{t-1}^* + \varepsilon_{inf*t} \tag{7}$$

Lastly, to ensure that the DSGE model is fully structured, rational expectations are incorporated as thus,

$$\eta_t^{inf} = inf_t - E_{t-1} inf_t, \qquad \eta_t^y = y_t - E_{t-1} y_t \, . \tag{8}$$

3.1 Data Description

The study utilizes quarterly data from multiple sources covering the period 2011:Q1 – 2021:Q4 with 44 observations in total. Seven (7) variables were used in this study, namely: domestic CPI (a proxy for inflation), monetary policy rate (a proxy for interest rate), official nominal exchange rate, domestic real GDP, US output (a proxy for world output), US CPI (a proxy for world inflation), and terms of trade. The data on the monetary policy rate and nominal exchange rate were obtained from the Bank of Sierra Leone data warehouse, data on real GDP and domestic CPI were obtained from the databases of World Bank (World Development Indicators) and Statistics Sierra Leone respectively, data on US output and CPI were both obtained from the Federal Reserve Economic Data (Federal Reserve Bank of St. Louis), and the data on the terms of trade were obtained from the Penn World Table 10.01 (University of Groningen). The specifics regarding the processing and description of the data are illuminated as follows.

The domestic CPI was used to compute inflation. We collected and transformed the month-on-month CPI to quarterly CPI using the average observation for every quarter. Next, we calculated the annualized inflation rate as

$P = 400 * \ln\left(\frac{CPI_t}{CPI_{t-1}}\right)$. The same was done for the foreign CPI (CPI^*), $P^* = 400 * \ln\left(\frac{CPI_t^*}{CPI_{t-1}^*}\right)$, where CPI^* indicates a foreign CPI.

To obtain the domestic and foreign output gaps, we calculated the real output and potential output. In this study, real output is calculated as the gross domestic product (RGDP), and its HP trend is considered as potential output (PGDP). In applying the Hodrich-Prescott filter, the smoothing constant was assumed to be 1600. Next, we computed the annualized domestic output gap as the percentage log deviation of real output in terms of potential output, $outp_t = 100 * \ln\left(\frac{GDP}{PGDP}\right)$. The same was done to obtain the foreign output gap ($outp_t^*$), $outp_t^* = 100 * \ln\left(\frac{GDP^*}{PGDP^*}\right)$, where $RGDP^*$ is the world (US) GDP^* and $PGDP^*$ is its potential output. The monetary policy rate, obtained from the Bank of Sierra Leone's (BSL) data warehouse, was used as a proxy for interest rate. It is in quarterly frequency. The nominal exchange rate, obtained from BSL's data warehouse, was used for the exchange rate variable. Its monthly data was transformed to quarterly frequency. Thereafter, a log difference was taken to calculate the percentage changes in the exchange rate $e_t = 400 * \ln\left(\frac{e_t}{e_{t-1}}\right)$.
The terms of trade, denoted as q, is captured as the relative price of exports (X_t) relative to imports(M_t), $q_t = \frac{X_t}{M_t}$. Also, we calculate the percentage changes in the terms of trade by taking log differences, $\Delta q_t = 100 * \ln\left(\frac{q_t}{q_{t-1}}\right)$.

3.2 Selection of Priors

To achieve precise and dependable estimation outcomes, we utilize the Markov Chain Monte Carlo (MCMC) approach to estimate the model by incorporating information from both the provided samples and prior distributions. The parameters in a DSGE model usually carry economic meanings, which we utilize to define informative priors. To achieve this, however, priors need to be carefully selected based on sound judgment and economic understanding. Table 1 below presents the calibrated priors. The parameters Ω_1, Ω_2, and Ω_3 represent the inflation deviation, output gap, and depreciation rate coefficients in the monetary reaction function, i.e. they capture the

Central Bank's responses to changes in inflation, output, and exchange rate when setting the interest rate. The δ_R parameter represents the interest rate smoothing parameter in the monetary reaction function. In Sierra Leone, two of the Central Bank's main objectives are to achieve price stability and support economic growth. Thus based on our knowledge of our economy, we assume a beta distribution with shape parameters (95, 05) for both Ω_1 and Ω_2, thereby placing the prior mean at 0.95. This signals a strong response by the bank to changes in these parameters. We assume a beta distribution with shape parameters (10, 75) for Ω_3, thereby placing the prior mean at 0.1. This means that the bank places lesser emphasis on changes in the exchange rate when setting the interest rate. We assume a beta distribution with shape parameters (50, 50), placing the prior mean at 0.5.

The parameter α represents the degree of openness. Specifically, it captures the sensitivity of inflation to changes in the output gap in an open economy, where output gaps are affected not only by domestic factors but also by external demand and supply conditions. Due to the less open nature of our economy, we assume a beta distribution with shape parameters (25, 75) for α, placing the prior mean at 0.25. The parameter χ represents the inflation–output trade-off, indicating the degree to which the central bank is prepared to allow short-term deviations of inflation from its target to stabilize the output gap. Based on the assumption that the central bank tries to achieve price stability that will support economic growth, we assume a beta distribution (50, 25), placing the prior mean at 0.5. Economically, this suggests that policymakers balance inflation and output gap stabilization. The parameter β represents the sensitivity of price to changes in expected future price and expected terms of trade. In the theoretical monetary policy rule, β is assumed to have a mean of 0.5. Thus, we assume a beta distribution (50, 50) for β, which is consistent with monetary theory. The parameter γ represents intertemporal substitution elasticity, i.e. the responsiveness of consumers to changes in the real interest rate. Due to the large informal sector in the country, a considerable amount of financial transactions take place outside the banking system. Lavally and Nyambe (2019) conducted a study the on Monetary Policy Transmission Mechanism in Sierra Leone and concluded that the transmission mechanisms are weak. Based on these issues, we assume that consumers are moderately sensitive to changes in the real interest rate, thus a beta distribution (50, 50) was given for γ, placing the prior mean at 0.5.

The δ_q parameter indicates the degree of persistence in terms of trade shock. We assume the parameter's beta distribution (50, 20), placing the prior mean at 0.5. Economically, it means that shocks to the terms of trade would have impacts on the economy, but last for a moderate not long-lasting duration. The same assumption holds for the δ_z, δ_{RGDP*}, and δ_{P*} representing technology shock, world output shock, and world inflation shock respectively. The inverse gamma distributions for the standard deviation of the shocks remain the same as in theoretical literature, e.g. Lubik and Schorfheide (2007).

Table 1: Priors for Distributions

Parameters	Interpretation	Range	Density Function	Para (1)	Para (2)
Ω_1	Inflation deviation coefficient	0, + ∞	Beta	95	05
Ω_2	Output gap coefficient	0, + ∞	Beta	95	05
Ω_3	Depreciation rate coefficient	0, + ∞	Beta	10	75
δ_R	Interest rate smoothing parameter	(0,1)	Beta	50	50
α	Degree of openness	(0,1)	Beta	25	75
χ	Inflation–output trade-off	(0, + ∞)	Beta	50	25
γ	Intertemporal substitution elasticity	(0,1)	Beta	50	50
δ_q	AR (1) for terms of trade shock	(0,1)	Beta	50	20
δ_z	AR (1) for technology shock	(0,1)	Beta	50	20
δ_{y*}	AR (1) for world output shock	(0,1)	Beta	50	20

δ_{P*}	AR (1) for world inflation shock	(0,1)	Beta	50	20
σ_R	Std. dev of monetary policy shock	$(0, +\infty)$	Inverse gamma	0.10	2.00
σ_q	Std. dev of terms of trade shock	$(0, +\infty)$	Inverse gamma	1.50	2.00
σ_z	Std. dev of technology shock	$(0, +\infty)$	Inverse gamma	0.10	2.00
σ_{y*}	Std. dev of world output shock	$(0, +\infty)$	Inverse gamma	1.50	2.00
σ_{P*}	Std. dev of world inflation shock	$(0, +\infty)$	Inverse gamma	0.5	2.00

3.3 Convergence Diagnostics

We initiated our Bayesian DSGE estimation process without the block option. The outcomes from this Bayesian DSGE estimation reveal that there exists significant autocorrelation in the MCMC iterations, as demonstrated in Appendix 1. This is also supported by the fact that the effective sample size summary statistics demonstrate an exceedingly low average efficiency of approximately 0.001 percent, as presented in Appendix 2. Hence, this suggests the presence of a convergence issue in the MCMC iteration. Given this, we proceeded to investigate if implementing the block option could improve the efficiency of the MCMC sampling. Therefore, based on their density functions, we used the parameters alpha, beta, chi, omega1, omega2, omega3, kappa, deltar, deltaz, deltaystar, deltapstar, gamma, deltaq, and the respective standard deviations of the delta-variables to estimate Bayesian DSGE with a block option. Finally, upon analyzing the results from the different diagnostics, we noticed a substantial improvement in the efficiency of the MCMC sampling when utilizing the block option.

4.0 EMPIRICAL ANALYSIS

We apply the MCMC method in this section to estimate the small open economy model for Sierra Leone during the period 2011:Q1 – 2021:Q4. The control variables, known as structural parameters, used are alpha, beta, chi, kappa, omega1, omega2, omega3, and gamma. The state variables used are r (deltar), q (deltaq), z (deltaz), pstar (deltapstar), and ystar (deltaystar) which represent monetary policy shock, terms of trade shock, technology shock, world inflation shock, and world output shock respectively. The shocks to the state variables are denoted by e.u, e.v, e.z, e.pstar, and e.ystar and their respective standard deviations are 2.99, 2.25, 13.45, 6.76, and 51.67. The model estimation results based on the block option scenario are presented in detail. We noticed that utilizing the block option, along with a higher number of burn-in iterations, resulted in a more efficient outcome. Therefore, the ensuing discussion of the results in Table 2 is based on this approach. The efficiency of the parameters increased in comparison to the Bayesian DSGE model that did not implement the block option (refer to Appendix 3). Additionally, Table 3 shows that the effective sample sizes for all the parameters improved significantly when compared to the non-block approach (refer to Appendix 4). The estimates presented in Table 2 indicate that there is no significant evidence of high autocorrelation in the MCMC iterations. Furthermore, the results demonstrate an enhanced MCMC acceptance rate of approximately 44%, along with a maximum efficiency rate of approximately 22 percent. Our prior assumptions were nearly identical to the estimated values of the structural parameters.

4.1.1 Monetary policy reaction function

Table 2 shows that the posterior mean values of the inflation deviation coefficient, Ω_1, output gap coefficient, Ω_2, and depreciation rate coefficient, Ω_3 are 0.94, 0.93, and 0.12, respectively. If the observed inflation is 1% above the target inflation rate, the nominal interest rate would rise by 94 basis points. However, this increase in the nominal interest rate would result in a decrease in the real interest rate. This highlights the central bank's commitment to price stability. While combating inflation is crucial for maintaining economic stability, excessively high-interest rates may lead to reduced borrowing and investment, potentially slowing down economic growth. On the other hand, lower real interest rates, while stimulating borrowing and investment, can also encourage excessive risk-taking and asset price inflation. A delicate balance between controlling inflation and promoting sustainable economic expansion is essential, taking into account the potential trade-offs between price stability and growth objectives. If the real output increases by 1% compared to its potential value, both the nominal and real interest rates would rise by 93 basis points simultaneously. This reflects the central bank's aim to stabilize output fluctuations. While the central bank's intention to stabilize output is commendable, excessively large interest rate adjustments may exacerbate the business cycle's ups and downs. There needs to be a careful assessment of the optimal magnitude and timing of interest rate movements to prevent excessive volatility, as abrupt adjustments could potentially amplify economic fluctuations and dampen overall economic performance. Likewise, in the case of a 1% depreciation of the nominal exchange rate of BSL, the central bank would raise the interest rate by 12 basis points. This reflects the central bank's commitment to maintaining exchange rate stability. While stabilizing the exchange rate is crucial for maintaining competitiveness in international trade, higher interest rates resulting from exchange rate depreciation can increase borrowing costs and potentially dampen domestic economic activity. A good balance between exchange rate stability and supporting economic growth could be pursued, considering the potential impact on exports, imports, and overall competitiveness. Furthermore, the parameter for interest rate smoothing, δ_R, is around 0.77, indicating partial adjustment and suggesting a strong inclination of the BSL to smooth out interest rate fluctuations. While interest rate smoothing can help mitigate abrupt shocks and provide stability, it raises questions regarding the central bank's ability to respond effectively to changing economic conditions. Delays or slow adjustments in interest rates may lead to a less timely and impactful policy response, potentially affecting the central bank's ability to achieve its objectives.

4.1.2 Structural Parameters

From Table 2, the estimated degree of openness parameter α is around 0.25, which is in line with the trend of Sierra Leone's growing openness in recent times. The Phillips curve's slope coefficient χ is approximately 0.59, indicating evidence of a significant inflation-output trade-off. Therefore, the expectation-augmented Phillips curve is considered appropriate for explaining the inflation movements in Sierra Leone. The intertemporal substitution elasticity, denoted as γ, is estimated to be around 0.51, suggesting that consumers in Sierra Leone are moderately sensitive to changes in interest rates or other economic factors. It is noteworthy that the AR (1) coefficients for shocks are positive and significant. The state variables r (deltar), q (deltaq), z (deltaz), pstar (deltapstar), and ystar (deltaystar) exhibit autocorrelation values of 0.77, 0.68, 0.89, 0.68, and 0.46, respectively. The estimations indicate that the technology shock (deltaz, 0.89 percent) displays the highest degree of persistence compared to the other shocks. This result is consistent with Sillah et.al (2022) and Houssa et al. (2010). However, unlike Sillah et al. (2022) which treats household consumption in a closed economy context, this study is based on the New Keynesian DSGE approach which treats household consumption as an IS curve in an open economy context. Theoretically, the technology shock is often viewed as a permanent shock that possesses greater rigidities, thus rendering it more persistent than other shocks. Also, world output shock (deltaystar, 0.46 percent) indicates the lowest degree of persistence compared to the other shocks, suggesting that economic agents tend to react more promptly to it relative to the other shocks. Moreover, the persistence of world inflation (0.68) is considerably higher than that of world output (0.46). The economic intuition for this occurrence is that Sierra Leone is both a price-taker in the global economy and an import-dependent nation. Thus, the impact of shocks due to global inflation would persist for a longer time in the country. Another possible explanation is that Sierra Leone's exchange rate regime is linked to a currency (US$) that is prone to high inflation, leading to higher pass-through effects of world inflation on domestic inflation. Also, it is worth mentioning that all the estimated variances of the fundamental shocks are statistically significant. Furthermore, consistent with Lubik and Schorfheide's findings in 2007, the standard deviations of world output (6.75) and world inflation (51.67) are substantially greater than that of the monetary shock (2.99).

Table 2: Model Estimation Results (with block option)

Variables	**Mean**	**Std. dev.**	**MCSE**	**Median**	**Equal-tailed [95% cred. interval]**	
gamma	0.514064	0.048091	0.001339	0.514698	0.418407	0.606398
kappa	0.743825	0.049477	0.000961	0.746205	0.641635	0.83317
alpha	0.247917	0.04314	0.00144	0.245644	0.169579	0.340912
deltaz	0.887501	0.023139	0.001181	0.889261	0.8386	0.927907
beta	0.864814	0.029385	0.000742	0.866673	0.801448	0.916468
chi	0.593304	0.054466	0.000955	0.594382	0.485932	0.698544
deltar	0.770256	0.048437	0.002769	0.774507	0.668049	0.852123
omega1	0.941563	0.025246	0.000445	0.944813	0.883397	0.980845
omega2	0.93165	0.029076	0.000481	0.935608	0.865306	0.976733
omega3	0.121186	0.036382	0.000645	0.118345	0.06033	0.202171
deltaq	0.676152	0.053178	0.000809	0.67719	0.571088	0.776343
deltaystar	0.463419	0.041819	0.00123	0.463463	0.383296	0.545248
deltapstar	0.678694	0.057456	0.001843	0.679127	0.561428	0.787259
sd(e.u)	2.989125	0.704405	0.043528	2.89664	1.870334	4.558908
sd(e.v)	2.248089	0.248372	0.004116	2.224899	1.821111	2.794291
sd(e.z)	13.45375	3.601113	0.172332	12.95923	7.854535	21.63399
sd(e.ystar)	51.67128	11.1674	0.475422	50.56067	33.31078	77.05489
sd(e.pstar)	6.755875	0.765976	0.022715	6.659855	5.489144	8.390763
Acceptance Rate			0 .4383			
Log marginal Likelihood			-775.01791			

Note: A total of 20,000 iterations and 5,000 burn-ins were conducted. The acceptance rate is based on the random-walk Metropolis-Hastings sampling.

Table 3: Summary Statistics for Effective Sample Size

Variables	ESS	Corr. time	Efficiency
gamma	1290.6	15.5	0.0645
kappa	2652.33	7.54	0.1326
alpha	897.48	22.28	0.0449
deltaz	383.65	52.13	0.0192
beta	1569.49	12.74	0.0785
chi	3253.39	6.15	0.1627
deltar	305.96	65.37	0.0153
omega1	3222.49	6.21	0.1611
omega2	3647	5.48	0.1824
omega3	3177.96	6.29	0.1589
deltaq	4316.48	4.63	0.2158
deltaystar	1155.8	17.3	0.0578
deltapstar	971.39	20.59	0.0486
sd(e.u)	261.89	76.37	0.0131
sd(e.v)	3641.79	5.49	0.1821
sd(e.z)	436.66	45.8	0.0218
sd(e.ystar)	551.75	36.25	0.0276
sd(e.pstar)	1137.1	17.59	0.0569

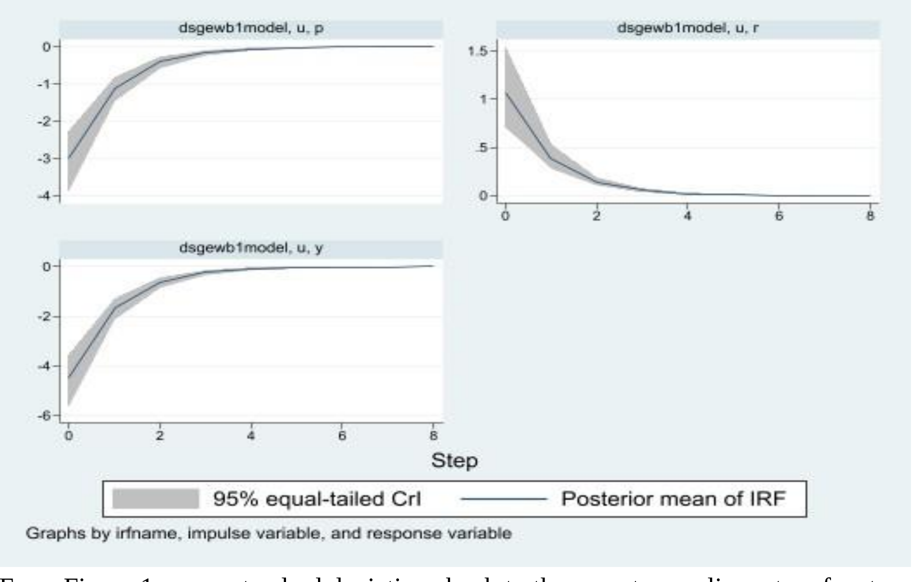
Note: ESS means effective sample size and corr. time refers to correlation time.

Upon examining the convergence diagnostics, it is evident that the trace plots exhibit reasonably good mixing. The autocorrelations decay at a moderate pace, although deltar and deltaz display slightly higher autocorrelations compared to the other parameters (refer to Appendix 4). The trace appears to be free from any time trend and maintains a constant mean and variance. Additionally, the density for both the first and second half, as well as the overall densities, show minimal variation in comparison to the density of the complete MCMC sample. Therefore, these observations suggest that our model does not have any convergence issues. Moreover, we assess the informativeness of certain parameters by comparing their prior and posterior distributions. To achieve this, we plot the prior and posterior distributions of kappa, beta, and chi. Based on the densities obtained, it can be concluded that the data is informative (refer to Appendix 5).

4.2 Analysis of Impulse Responses

This sub-section presents the impacts of the exogenous shocks on the economy as indicated by the impulse response functions. Figure 1 illustrates the responses of the real output gap, domestic inflation rate, and interest rate to a one-unit structural shock to the monetary policy rate, along with their corresponding pointwise 95% probability intervals based on posterior mean estimates.

Figure 1: Response of domestic inflation, output gap, and interest rate to monetary policy shock

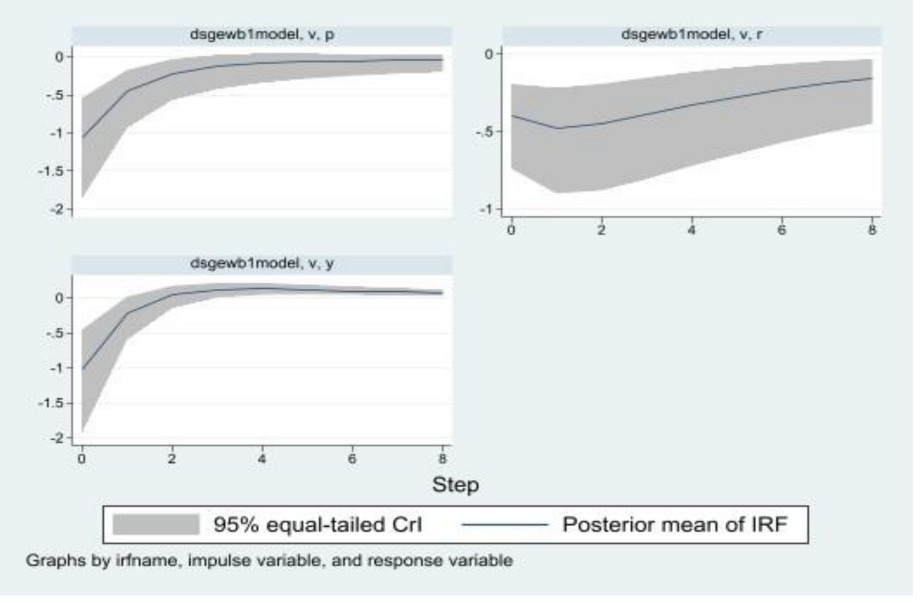


From Figure 1, a one standard deviation shock to the monetary policy rate refers to a sudden increase or decrease in the interest rate set by the Bank of Sierra Leone, which is responsible for regulating the country's monetary policy. The graph on the top-left shows that when the Bank of Sierra Leone makes a sudden change to the monetary policy rate, inflation in the economy responds in the expected direction, with a decline in inflation following a rate hike, and an increase in inflation following a rate cut. However, within the first quarter, inflation starts rising again and reaches its steady state in the third quarter. This suggests that monetary policy can have an impact on the economy, at least in the short term. This is consistent with the study done by Alpanda et al. (2010). There are several reasons why the effect of monetary policy on inflation may be transitory. For example, businesses and households may adjust their spending and investment decisions in response to changes in interest rates. These adjustments can take time to take effect, and the effect of the policy shock may wear off as these adjustments are made. Also, due to high levels of informality in the country, monetary policy may be less effective in controlling inflation. This is because informal businesses may not be affected by changes in interest rates and may continue to operate at the same level, even when the cost of borrowing increases. As noted by Lavally and Nyambe (2019) in their study, the transmission channels of monetary policy are not effective in Sierra Leone. Thus, the ineffective mechanism would undermine the full effects of monetary policy shocks on inflation.

The graph on the bottom-left signifies the response of the domestic output gap to a one-standard-deviation shock in the monetary policy rate. Like the response of the inflation rate to the monetary policy shock, the output gap immediately declines with a sudden positive change to the monetary policy rate. This is consistent with the findings of Alpanda et al. (2010) for the South African economy. However, within the first quarter, the output gap starts rising again and until the shock fizzles out in the third quarter. The initial decline in the output gap in response to the monetary policy shock suggests that the shock has a contractionary effect on the economy. In other words, the central bank's decision to raise interest rates may lead to a reduction in economic activity, which would cause the output gap to decrease. This reduction may occur because higher interest rates increase the cost of borrowing, making it more expensive for businesses and households to invest and consume. However, the subsequent rise in the output gap after a short period, reaching its steady state around quarter 3, indicates that the effect of the monetary policy shock is transitory. This means that the initial contractionary effect is not sustained, and the output gap eventually returns to its previous level. The transitory nature of the impact may be due to various factors, including adjustments made by businesses and households to changes in interest rates, the effectiveness of the transmission mechanism, and the presence of structural factors that limit the impact of monetary policy on the economy.

Finally, the graph on the top right corner signifies the response of interest rate to a one standard deviation shock in the monetary policy rate. The interest rate immediately rises with a sudden positive change to the monetary policy rate. However, within the first quarter, the interest starts falling again and reaches its steady state in the fourth quarter. This is because the monetary policy rate is the rate at which the central bank lends to commercial banks, and a higher monetary policy rate increases the cost of borrowing for commercial banks. This increase in the cost of borrowing is then passed on to households and businesses, causing interest rates to rise. The steady state of interest rates around the fourth quarter suggests that the transitory impact of monetary policy shock on interest rates is eventually absorbed, and the interest rate returns to its long-term equilibrium level. The long-term equilibrium level of interest rates is determined by various factors such as inflation expectations, economic growth prospects, and the supply and demand for credit. The fall in interest rates after the initial rise may occur due to various reasons. For instance, when interest rates rise, households and businesses may reduce their borrowing, which can lead to a decrease in demand for credit. A decrease in demand for credit can, in turn, lead to a fall in interest rates. Similarly, businesses may postpone investments and other long-term expenditures, which can lead to a fall in demand for credit.

Figure 2: Response of domestic inflation, output gap, and interest rate to terms of trade shock

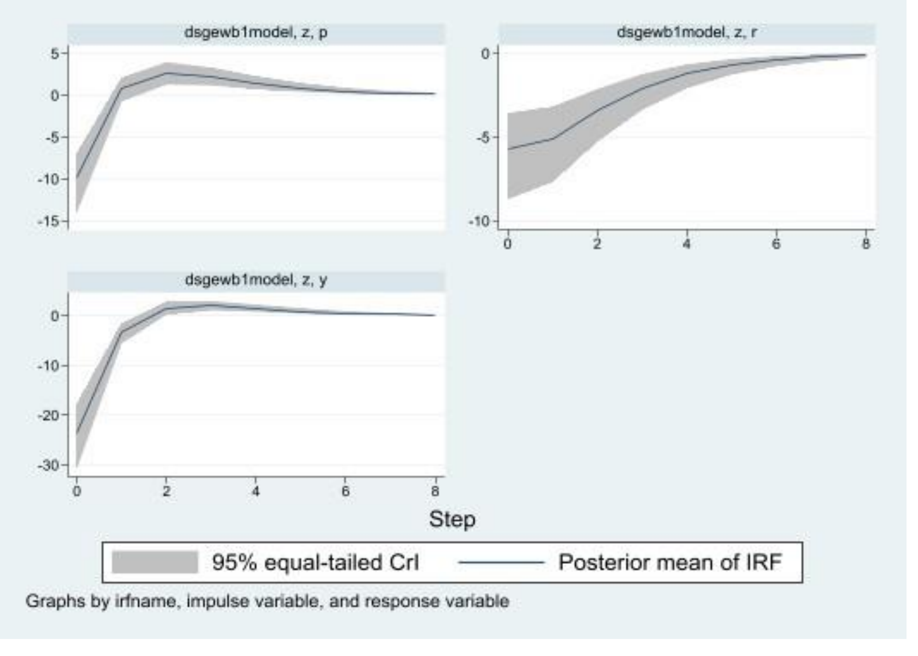


From Figure 2, the graph on the top-left indicates the response of domestic inflation to a one-standard-deviation shock in terms of trade shocks. It is observed that a positive shock in terms of trade leads to an initial decline in the domestic inflation rate, suggesting a disinflationary effect on the economy. In other words, the shock leads to a reduction in the cost of imported goods, which lowers the overall price level in the economy. This reduction may occur because a favorable change in the terms of trade leads to a decrease in the cost of imported raw materials and intermediate goods, which reduces the cost of production for firms and leads to lower prices for consumers. This is consistent with the findings of Bukhari and Khan (2008). However, the subsequent rise in the inflation rate after a short period, reaching a steady state around the third quarter, indicates that the effect of the terms of trade shock is transitory. The rise in the inflation rate after the initial decline may occur due to various reasons. For instance, when the cost of imported goods decreases, it may lead to an increase in demand for these goods, which can result in a rebound in prices, thus a rise in the inflation rate.

The graph on the bottom-left signifies the response of the domestic output gap to a one-standard-deviation shock in terms of trade. Just like the response of the inflation rate to the shock, the output gap immediately declines with a sudden positive change to the terms of trade. However, within the first quarter, the output gap starts rising again and dies out in the 3rd quarter. The subsequent rise in the output gap after a short period, fizzling out around the third quarter, indicates that the effect of the terms of trade shock on the output gap is transitory. The initial decline in the output gap in response to the shock to the terms of trade indicates that the shock has a positive impact on the economy. The positive impact may occur because an improvement in the terms of trade leads to an increase in the demand for a country's exports, which stimulates economic activity and increases output. This is consistent with Zheng and Guo (2013). Alternatively, a favorable change in the terms of trade may lead to a reduction in the cost of imported inputs, which lowers the cost of production for firms and stimulates output. Furthermore, the rise in the output gap after the initial decline could be attributed to various reasons. For example, when the demand for exports increases, it may lead to an increase in domestic production, which can result in an expansion in output. However, the expansion in output may be temporary if businesses are unable to sustain the increased production levels due to capacity constraints or if the shock to the terms of trade was temporary. Additionally, the positive impact of the terms of trade shock on the output gap may be offset by other factors that lead to a decrease in output, such as a rise in production costs or a decrease in domestic demand.

Finally, the graph on the top-right corner signifies the response of interest rate to a one standard deviation shock in the terms of trade. The interest rate immediately rises with a sudden positive change to the terms of trade. This is consistent with Bukhari and Khan (2008) and Zheng and Guo (2013). However, it starts falling shortly until the first quarter, thereafter, it starts rising again within the first quarter unto the eighth quarter. The initial rise in the interest rate in response to the terms of the trade shock indicates that the shock has a positive impact on the economy. This is because an improvement in the terms of trade can increase the country's income, which in turn, raises the demand for credit by households and firms, leading to a rise in the interest rate. Furthermore, the shock may also increase the investment demand, which raises the demand for credit and drives up the interest rate. However, the subsequent fall in the interest rate after the initial rise is noteworthy. This suggests that the impact of the terms of trade shock on the interest rate is not sustained and has a transitory effect. The transitory nature of the impact can be due to several factors, such as adjustments made by financial markets to changes in the terms of trade or the effectiveness of the transmission mechanism. The rise in the interest rate from the first to the eighth quarter could be due to various reasons, such as an increase in demand for credit by households and firms or an increase in investment opportunities. The subsequent rise in the interest rate suggests that the shock has a more long-term impact on the interest rate.

Figure 3: Response of domestic inflation, output gap, and interest rate to technology shock

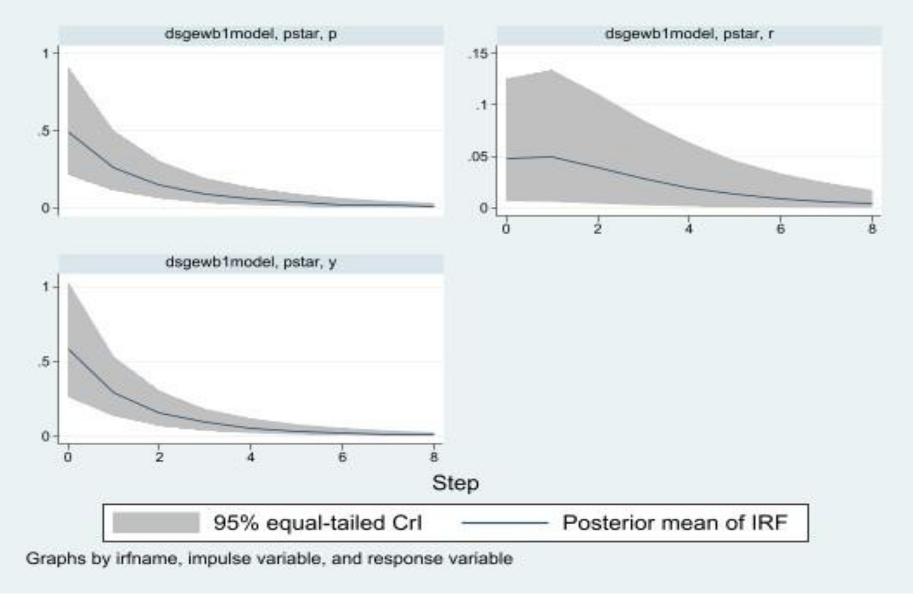


From Figure 3, the graph on the top-left indicates the response of domestic inflation to a one-standard-deviation shock in technology. It is observed that a positive shock in technology leads to an initial decline in the domestic inflation rate, suggesting a disinflationary effect on the economy. The initial decline in the inflation rate in response to a technology shock can be due to several factors. For instance, an improvement in technology can lead to a reduction in production costs, which, in turn, can lead to a reduction in the prices of goods and services. Additionally, an increase in productivity due to technological improvements can lead to an increase in the supply of goods and services, which can also lead to a decline in prices. However, the inflation rate starts rising after a short period and dies out around the third quarter. This suggests that the effect of technology shocks on inflation is not permanent and has a transitory effect on the economy. The transitory nature of the impact could be attributed to several factors, such as the time it takes for firms to fully adjust to the new technology or the time it takes for the economy to fully realize the benefits of the new technology. The rise in inflation after the initial decline can occur due to several reasons. For example, if the new technology leads to an increase in demand for goods and services, this can lead to an increase in prices. This is in line with Zheng and Guo (2013). Additionally, if the new technology increases productivity, it can lead to an increase in wages, which can also lead to an increase in prices. Therefore, the rise in inflation after the initial decline can occur due to a combination of demand and supply-side factors. Moreover, the inflation rate dying out around the third quarter implies that the transitory impact of technology shocks on inflation lasts for a relatively short period. Once the economy fully adjusts to the new technology and realizes its benefits, the impact on inflation diminishes, and the inflation rate returns to its long-run equilibrium level.

The graph on the bottom-left signifies the response of the domestic output gap to a one-standard-deviation shock in technology. Just like the response of the inflation rate to the shock, the output gap immediately declines with a sudden positive change in technology. This is in line with Barrie and Jackson (2022). However, within the first quarter, the output gap starts rising again and fizzles out in the third quarter. The subsequent rise in the output gap after a short period, reaching a steady state around the third quarter, suggests that the impact of technology shocks on the output gap is transitory. The transitory nature of the impact can be due to several factors, such as the time it takes for firms to fully adjust to the new technology or the time it takes for the economy to fully realize the benefits of the new technology. The initial decline in the output gap in response to a technology shock could be explained by several factors. For example, if the new technology leads to an increase in productivity, this can increase output and potentially reduce the output gap. Additionally, if the new technology leads to an increase in investment, this can also increase output and potentially reduce the output gap. The rise in the output gap after the initial decline could be due to several reasons. For example, if the new technology leads to an increase in demand for goods and services, this can increase output and potentially increase the output gap. Moreover, if the new technology leads to an increase in investment, this can also increase output and potentially increase the output gap. Therefore, the rise in the output gap after the initial decline can occur due to a combination of demand and supply-side factors.

Finally, the graph on the top right signifies the response of the interest rate to a one-standard-deviation shock in technology. Just like the responses of the two aforementioned variables to the shock, the interest rate immediately declines with a sudden positive change in technology. The fall in interest rates can also occur because the positive technology shock leads to an increase in the supply of loanable funds. This can occur because the increased productivity of firms can lead to higher profits, which can lead to increased savings by households and firms, increasing the supply of loanable funds. However, within the first quarter, the interest rate starts rising and reaches its steady state in the sixth quarter. This can occur because the initial fall in interest rates may have led to increased demand for credit, which could lead to an increase in inflationary pressures. In response to these pressures, the central bank may increase the interest rate to reduce the demand for credit and control inflation. The interest rate may continue to rise until it reaches a steady state where the inflationary pressures are under control, and the economy is operating at its potential level. This is consistent with the results of Barrie and Jackson (2022).

Figure 4: Response of domestic inflation, output gap, and interest rate to world inflation shock

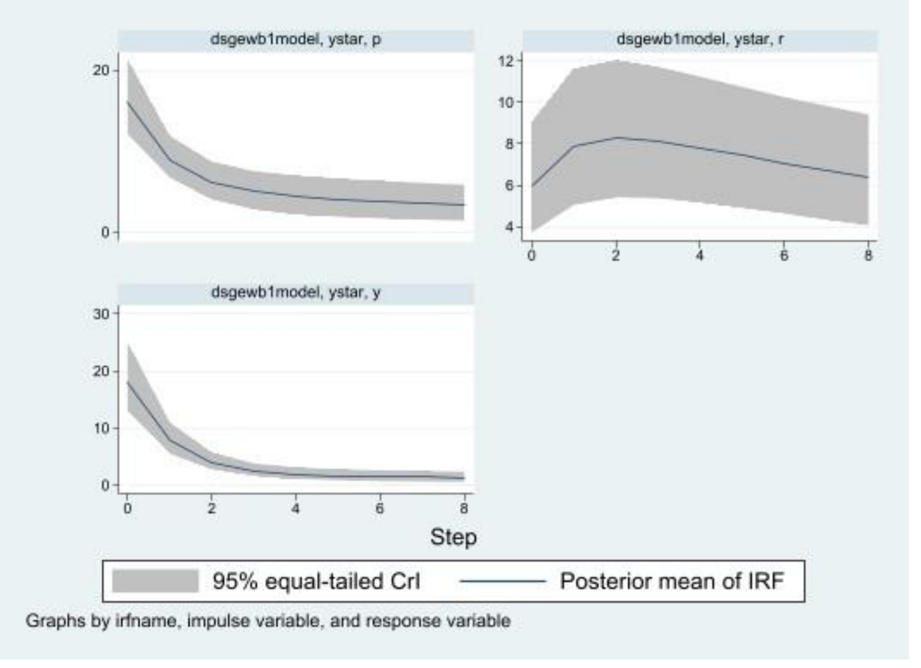


From Figure 4, the graph on the top-left indicates the response of domestic inflation to a one-standard-deviation shock in world inflation. The shock leads to an initial increase in domestic inflation, which is consistent with the idea that inflation can be imported from other countries through trade and capital flows. This is in line with the findings of Bukhari and Khan (2008). However, this increase in inflation is short-lived and the inflation rate starts to fall shortly after the shock, indicating a transitory effect on inflation. Several factors can explain the transitory nature of the shock of inflation. One possible explanation is that the initial increase in inflation may lead to a tightening of monetary policy, which in turn reduces demand and dampens inflationary pressures. Additionally, the shock may lead to an appreciation of the domestic currency, which can reduce the cost of imported goods and services, thus dampening inflation.

The graph on the bottom-left indicates the response of the domestic output gap to a one-standard-deviation shock in world inflation. It is observed that a one standard deviation shock to world inflation initially leads to an increase in the output gap. This can occur because an increase in world inflation can lead to an increase in demand for goods and services in the domestic economy, which could necessitate production, thereby increasing output and potentially reducing the output gap. However, the output gap starts falling shortly after the initial increase and reaches a steady state around the fourth quarter. This can occur because the increase in demand due to the initial rise in world inflation may not be sustainable in the long term. As a result, the output gap may start falling as the initial boost to demand fades away. Moreover, if the central bank responds to the initial increase in inflation by tightening monetary policy, this can lead to a decrease in demand and output, which can also contribute to the subsequent fall in the output gap. Additionally, if the initial increase in demand leads to an increase in prices, this can reduce the competitiveness of domestic producers, leading to a decline in output and a subsequent fall in the output gap. Therefore, the increase in the output gap after the shock to world inflation can be seen as a short-term effect, which eventually fades away and may even reverse in the long term due to various demand and supply-side factors.

Finally, the graph on the top-right indicates the response of interest rates to a one-standard-deviation shock in world inflation. The shock leads to an initial increase in interest rate until the first quarter, which is consistent with the central bank's reaction to the increase in inflation. This is consistent with Bukhari and Khan (2008). However, the interest rate starts falling continuously from the first quarter until the eighth quarter when it fizzles out. This decline in the interest rate is likely because the shock to world inflation is temporary and does not require sustained monetary policy tightening to counteract its effects.

Figure 5: Response of domestic inflation, output gap, and interest rate to a world output shock



From Figure 5, the graph on the top-left indicates the response of domestic inflation to a one-standard-deviation shock in world output. We observe that this shock initially leads to a rise in the domestic inflation rate, indicating an increase in the price level. This initial rise in inflation may be due to the increased demand for domestic goods and services resulting from the shock to world output. This is consistent with the results of Bukhari and Khan (2008). However, shortly after this initial rise, the inflation rate starts falling until around the fourth quarter when it reaches a steady state. This indicates that the effect of the shock on inflation is transitory, and the inflation rate returns to its initial level after a period. The fall in inflation after the initial rise may be due to several factors such as a decrease in demand for domestic goods and services or an increase in the supply of goods and services in response to the shock.

The graph on the bottom-left indicates the response of the domestic output gap to a one-standard-deviation shock in world output. It is observed that a one standard deviation shock to world output leads to an initial increase in the domestic output gap. This means that the difference between actual output and potential output increases, indicating an increase in economic activity. The initial increase in the output gap may occur because an increase in world output can lead to an increase in demand for goods and services produced domestically, which can increase economic activity and output. However, the output gap starts to fall shortly after the initial increase and reaches a steady state around the fourth quarter. This can occur due to several factors. For example, if the increase in world output is transitory and not sustained, the initial rise in the output gap may be temporary and short-lived, and the output gap may return to its previous level. Additionally, if the increase in world output leads to an increase in the price of inputs, such as raw materials, this can increase production costs and potentially reduce domestic output and the output gap.

Finally, the graph on the top-right indicates the response of interest rate to a one standard deviation shock in world output. It can be seen that the shock initially leads to a fall in domestic interest rates. When world output increases, the demand for domestic goods and services also increases. This increase in demand leads to an increase in domestic output, which in turn reduces the demand for domestic savings. Since interest rates represent the price of borrowing, the reduction in the demand for domestic savings puts downward pressure on domestic interest rates. However, within the first quarter, we see that domestic interest rates start to rise again. This can be attributed to the increase in the investment demand that comes with the increase in domestic output. As domestic output increases, firms may need to invest in new equipment or expand their production capacity to meet the increase in demand for their goods and services. This increase in demand for investment puts upward pressure on domestic interest rates. From the third quarter to the eighth quarter, we see that domestic interest rates start to fall again, but remain above the initial fall. This can be attributed to the fact that as domestic output reaches its steady state, the demand for investment starts to decline. As the demand for investment falls, the upward pressure on domestic interest rates also falls. This is consistent with Bukhari and Khan (2008) However, interest rates remain above the initial fall due to the initial increase in demand for investment in response to the shock.

5.0 CONCLUSION AND RECOMMENDATION

This study centers around the economy of Sierra Leone, with a specific focus on exploring the interconnectedness between macroeconomic variables (such as prices, interest rates, and output), domestic, and external (exogenous) shocks, and their implications for monetary policy in the Sierra Leone economy. These shocks include monetary policy shocks, terms of trade shocks, technology shocks, and global shocks. Sierra Leone, being a predominantly import-dependent and undiversified small open economy, serves as the underlying motivation for this study.

We conduct a comparative analysis of two scenarios to determine the most efficient approach for estimating our small open economy DSGE model for Sierra Leone. The first scenario involved the application of Bayesian DSGE without the block option, while the second scenario incorporated the Bayesian DSGE with the block option. A block option is a technique that helps to group and analyze different parts of an economic model separately, allowing for a more accurate estimation and understanding of how the economy functions. Our results reveal that the second scenario, which utilized Bayesian DSGE with a block option, combined with a larger MCMC size (20,000) and burn-in iterations of 5000, generated a more efficient estimation. A larger MCMC size and more iterations allow for a more extensive exploration of different possibilities and configurations within the model. This helps to reduce the influence of random variations and provides a more precise estimation of the relationships and dynamics between the economic variables. This finding offers valuable insights into the optimal method for modeling small open economies such as Sierra Leone, highlighting the importance of incorporating the block option in conjunction with Bayesian methods to achieve a more accurate and effective estimation. Based on the quarterly data from 2011Q1 to 2021Q4, we have drawn some significant conclusions below.

Firstly, model estimates reveal compelling evidence of interest rate smoothing, indicating that changes in the exchange rate of Leone, inflation deviations, and output gaps influence the interest rate. Particularly, there is a positive relationship between changes in the aforementioned variables and nominal interest rates. This finding underscores the importance of incorporating exchange rates into monetary policy decision-making in developing economies, as scholars such as Taylor (2000) and Xie and Zhang (2002) advocate. Secondly, the estimated model suggests that the economy is moderately open, with evidence of a significant inflation-output trade-off. Consumers are moderately sensitive to changes in interest rates or other economic factors.

The impacts of the monetary policy shock on the short-term dynamics of the economy are significant. Specifically, the shock leads to an initial decline in both the domestic inflation rate and the output gap, but shortly after, they start rising until the third quarter when it fizzles out. On the other hand, the shock leads to an initial increase in the domestic interest rate and gradually increases until the third quarter when it dies out. This suggests that the transmission mechanism is weak. To strengthen the weak transmission mechanism, the monetary authorities could regulate lending and borrowing activities in the economy. By regulating lending and borrowing activities, policymakers can affect the supply and demand for credit, which can impact economic growth and inflation.

The impacts of the terms of trade shock on the short-term dynamics of the economy are relevant. Particularly, the shock leads to an initial decline in both the domestic inflation rate and the output gap, but shortly after, they start rising until the third quarter when they finally attain a steady state. On the other hand, the shock leads to an initial increase in the domestic interest rate and starts increasing in the first quarter until the eighth quarter when it attains a steady state. Thus, policymakers may need to consider policies that promote export diversification and reduce dependence on a few primary commodities to mitigate the impacts of terms of trade shocks.

The technology shock has significant impacts on the short-term dynamics of the economy. In particular, the shock leads to an initial decline in the domestic inflation rate, output gap, and domestic interest rate. Shortly after the initial decline, they start rising until the third quarter (for the domestic inflation and output gap) and the fifth quarter (for interest rate) before it dies out. Thus, policymakers may consider policies that encourage investment in technological advancements to boost economic growth.

The impacts of the world inflation shock on the short-term dynamics of the economy are considerable. Particularly, the shock leads to an initial increase in the domestic inflation rate, output gap, and domestic interest rate. However, shortly after the initial rise, the impacts start falling until the fourth quarter (for domestic inflation and output gap) and the sixth quarter (for domestic interest rate) when they finally attain a steady state.

The impacts of the world output shock on the short-term dynamics of the economy are considerable. Particularly, the shock leads to an initial increase in the domestic inflation rate and the output gap. However, shortly after the initial rise, the impacts start falling until the fourth quarter when they finally attain a steady state. On the other hand, the shock leads to an initial decline in the domestic interest rate. After a short period, the interest rate starts increasing until the third quarter and declines thereafter until the eighth quarter.

Furthermore, the estimated results of Sierra Leone's DSGE model have important economic implications for the country. The evidence of interest rate smoothing and the need for exchange rate consideration in monetary policy suggests that the country's central bank should adopt a more flexible exchange rate regime. Additionally, the estimated degree of openness parameter confirms Sierra Leone's increasing integration into the global economy, highlighting the need for policymakers to focus on trade and investment liberalization policies. The evidence of a significant inflation-output trade-off also underscores the importance of policymakers maintaining a balance between inflation and economic growth objectives. Moreover, the significant impacts of global inflation shocks and their pass-through effects on domestic economic conditions have important implications for inflation management and the country's macroeconomic stability.

One of the limitations of the study is that the model estimation is based on a relatively short sample (2011Q1 to 2021Q4), which may not capture the full range of economic fluctuations and shocks that Sierra Leone has experienced in the past. Also, the study does not explicitly consider the impacts of political factors on the economy, such as corruption, governance quality, and political instability, which can significantly affect economic outcomes in developing countries. Thus, future research could incorporate these factors into the model to better understand their impact on economic performance. The study does not suggest the appropriate mix of monetary and fiscal policies to achieve macroeconomic stability. Therefore, future research could explore these issues in more depth to inform policy decisions in Sierra Leone.

Finally, going forward, policymakers and researchers alike must continue to build on this work, leveraging the insights gained from this analysis to inform evidence-based policy decisions that promote sustainable economic growth and development in Sierra Leone.

REFERENCES:

Adolfson, M., Laséen, S., Lindé, J., & Villani, M. (2007). Bayesian estimation of an open economy

DSGE model with incomplete pass-through. Journal of International Economics, 72(2), 481-511.

Alpanda, S., Kotzé, K., & Woglom, G. (2010). The Role of the exchange rate in a New Keynesian

DSGE model for the South African economy. *South African Journal of Economics*, *78*(2), 170-191.

Barrie, M. S., & Jackson, E. A. (2022). Impact of Technological Shock on Sierra Leone Economy: A Dynamic Stochastic General Equilibrium (DSGE) Approach.

Benigno, G., & Benigno, P. (2006). Designing target rules for international monetary policy co-operation.

Baumeister, C., & Kilian, L. (2016). Forty years of oil price fluctuations: Why the price of oil may still surprise us. Journal of Economic Perspectives, 30(1), 139-160.

Bukhari, A. H., & Khan, S. U. (2008). A small open economy DSGE model for Pakistan. The Pakistan Development Review, 963-1008.

Cashin, P., Cespedes, L. F., & Sahay, R. (2004). Commodity currencies and the real exchange rate. Journal of Development Economics, 75(1), 239-268.

Del Negro, M., & Schorfheide, F., 2009. Inflation dynamics in a small open-economy model under inflation targeting: some evidence from Chile. In: Schmidt-Hebbel, K., Walsh,

C.E. (Eds.), Monetary policy under uncertainty and learning. Central Bank of Chile, Santiago.

Gali, J., & Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies*, *72*(3), 707-734.

Hollander, H., Gupta, R., & Wohar, M.E. (2019). The Impact of Oil Shocks in a Small Open Economy New-Keynesian Dynamic Stochastic General Equilibrium Model for an Oil-Importing Country: The Case of South Africa. Emerging Markets Finance and Trade, 55(7), 1593-1618.

Houssa, R., Otrok, C., & Puslenghea, R. (2010). A model for monetary policy analysis for Sub-Saharan Africa. *Open Economies Review*, *21*, 127-145.

Lavally, M., & Nyambe, J. M. (2019). Monetary Policy Transmission Mechanism in Sierra Leone.

Journal of Economics, Management, and Trade 23(2), 1-13.

Le, V. P. M., & Naraidoo, R. (2019). Monetary Policy in a Model with Commodity and Financial Markets (No. 201928).

Lubik, T.A., & Schorfheide, F., 2004. Testing for indeterminacy: an application to US monetary policy. American Economic Review, 94 (1), 190–217.

Lubik, T.A., & Schorfheide, F., 2007. Do central banks respond to exchange rate movements?

A structural investigation. Journal of Monetary Economics 54, 1069–1087.

Obstfeld, M., & Rogoff, K. (1995). Exchange rate dynamics redux. Journal of Political Economy, 103(3), 624-660.

Richard, O. O., & Olofin, O. P. (2013). A small open economy model for Nigeria: A DSGE framework. Journal of Economic and Financial Modelling, 1(1), 1-13.

Sillah, A., Barrie, M.S., Kamara, A., Lahai, J., & George, P. (2022). Analysis of Monetary Policy, Productivity and Demand Shocks on Output, Inflation, and Interest Rate in Sierra Leone: A Bayesian DSGE Approach. West African Financial and Economic Review (WAFER), 22(1), 87-114.

Smets, F., & Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the Euro area. Journal of the European Economic Association 1 (5), 1123–1175.

Tamuke, E. C.E. & Barrie, A.S. I (2021). Analysing Monetary Policy and Productivity Shocks on Output, Inflation and Monetary Policy Rate in Sierra Leone: A DSGE Approach. West African Financial and Economic Review (WAFER), 21(2), 141-148.

Taylor, J.B., 2000. Using monetary policy rules in emerging market economies. Working Paper. Stanford University.

Xie, P., & Zhang, X., 2002. Three conflicts between monetary policy and exchange rate policy. International Economic Review 5–6, 30–35 (in Chinese).

Zheng, T., & Guo, H. (2013). Estimating a small open economy DSGE model with indeterminacy: Evidence from China. *Economic Modelling*, *31*, 642-652.

APPENDICES

APPENDIX 1: Bayesian Estimation Result without Block Option

```
Bayesian linear DSGE model                    MCMC iterations  =     12,500
Random-walk Metropolis–Hastings sampling      Burn-in          =      2,500
                                              MCMC sample size =     10,000
Sample: 1 thru 44                             Number of obs    =         44
                                              Acceptance rate  =     .05759
                                              Efficiency:  min =    .001084
                                                           avg =    .001227
Log marginal-likelihood = -8959.1139                       max =    .001249
```

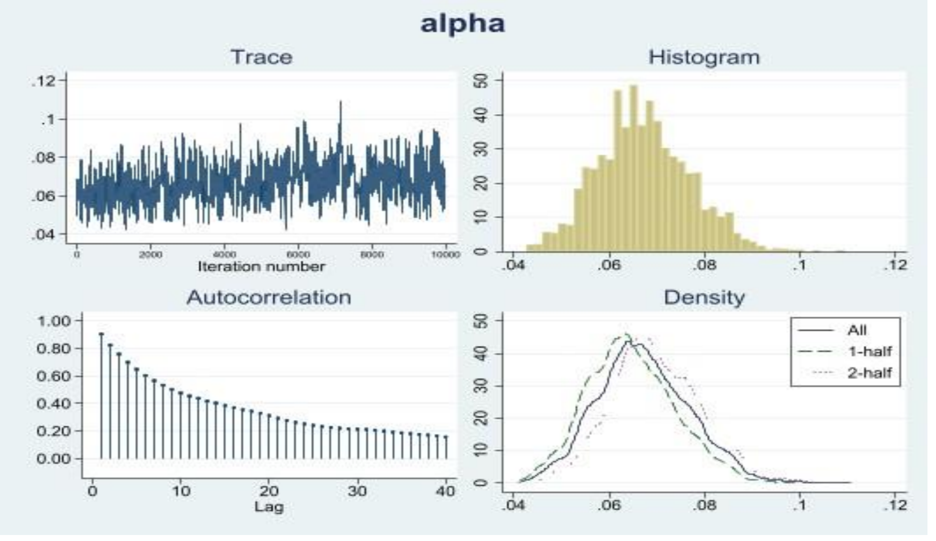
	Mean	Std. dev.	MCSE	Median	Equal-tailed [95% cred.	interval]
gamma	.010318	5.31e-12	1.5e-12	.010318	.010318	.010318
kappa	.2441263	4.59e-12	1.3e-12	.2441263	.2441263	.2441263
alpha	.5616273	6.07e-12	1.7e-12	.5616273	.5616273	.5616273
deltaz	.8112838	6.48e-12	1.8e-12	.8112838	.8112838	.8112838
beta	.9878644	6.35e-13	1.8e-13	.9878644	.9878644	.9878644
chi	.1255009	5.68e-12	1.6e-12	.1255009	.1255009	.1255009
deltar	.369598	6.41e-12	1.8e-12	.369598	.369598	.369598
omega1	.4150632	6.04e-13	1.7e-13	.4150632	.4150632	.4150632
omega2	.1883106	5.30e-12	1.5e-12	.1883106	.1883106	.1883106
omega3	.8707357	4.19e-12	1.2e-12	.8707357	.8707357	.8707357
deltaq	.2724316	5.21e-12	1.5e-12	.2724316	.2724316	.2724316
deltaystar	.9997049	3.86e-14	1.2e-14	.9997049	.9997049	.9997049
deltapstar	.3336598	5.86e-13	1.7e-13	.3336598	.3336598	.3336598
sd(e.u)	.5623638	8.88e-12	2.5e-12	.5623638	.5623638	.5623638
sd(e.v)	.4282303	3.61e-12	1.0e-12	.4282303	.4282303	.4282303
sd(e.z)	.8926728	4.79e-12	1.4e-12	.8926728	.8926728	.8926728
sd(e.ystar)	1.102539	4.71e-12	1.3e-12	1.102539	1.102539	1.102539
sd(e.pstar)	.4437069	4.29e-12	1.2e-12	.4437069	.4437069	.4437069

APPENDIX 2: Effective Sample Size Summary Statistics without Block Option

```
Efficiency summaries    MCMC sample size =    10,000
                        Efficiency:  min =   .001084
                                     avg =   .001227
                                     max =   .001249
```

	ESS	Corr. time	Efficiency
gamma	12.39	807.42	0.0012
kappa	12.36	808.83	0.0012
alpha	12.37	808.25	0.0012
deltaz	12.35	809.40	0.0012
beta	12.08	828.05	0.0012
chi	12.38	808.05	0.0012
deltar	12.34	810.48	0.0012
omega1	12.49	800.68	0.0012
omega2	12.40	806.67	0.0012
omega3	12.40	806.15	0.0012
deltaq	12.36	808.80	0.0012
deltaystar	10.84	922.93	0.0011
deltapstar	12.22	818.60	0.0012
sd(e.u)	12.36	808.86	0.0012
sd(e.v)	12.35	809.76	0.0012
sd(e.z)	12.38	807.49	0.0012
sd(e.ystar)	12.36	808.84	0.0012
sd(e.pstar)	12.44	803.82	0.0012

APPENDIX 3: Bayesian DSGE without Block Option (The Graphical Approach)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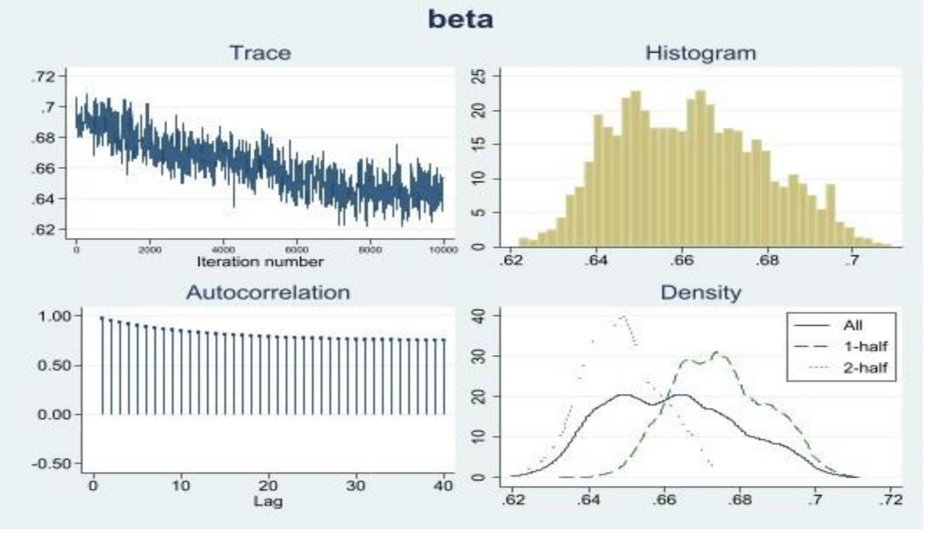
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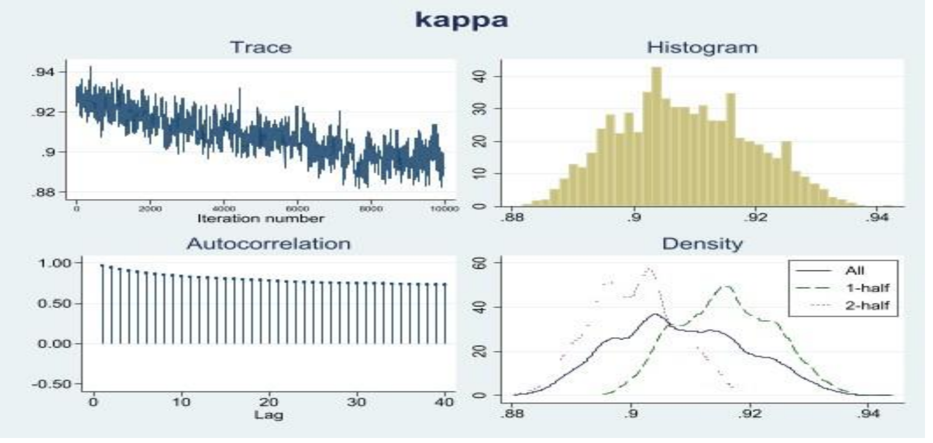
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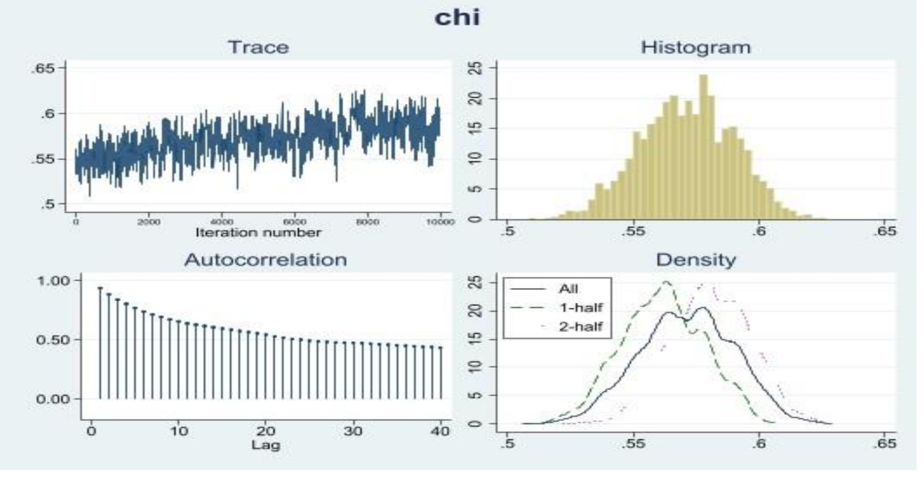
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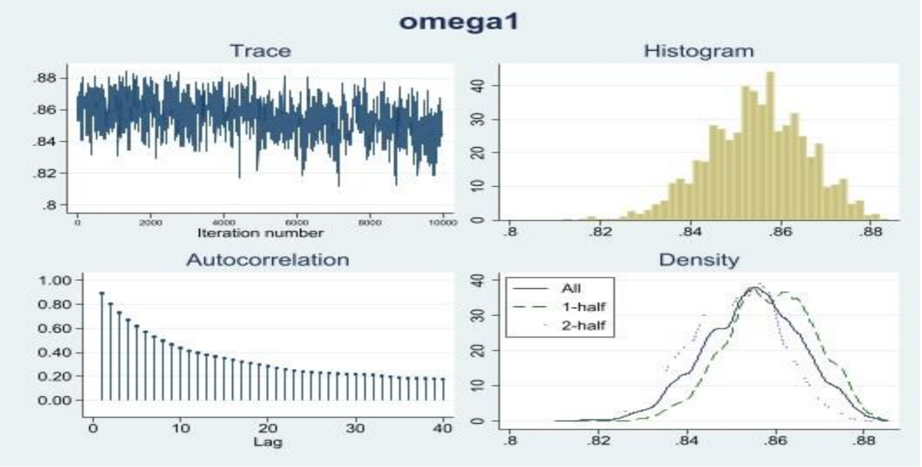
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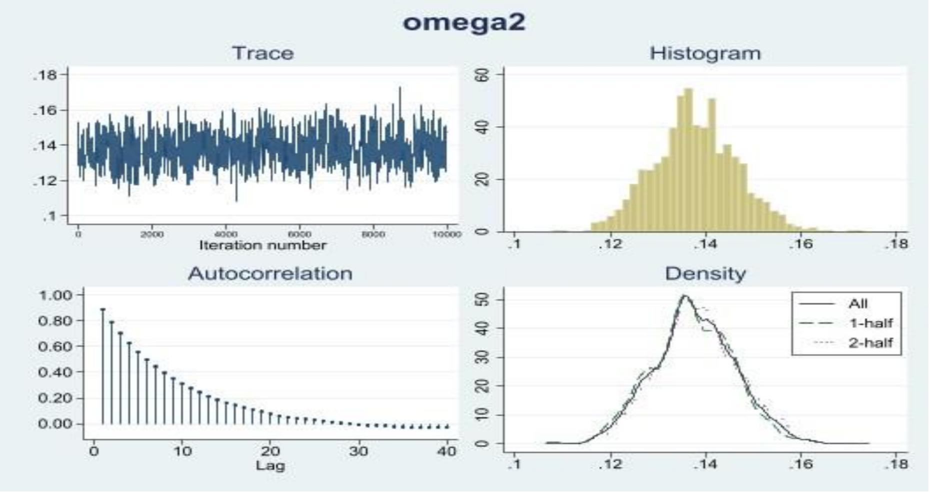
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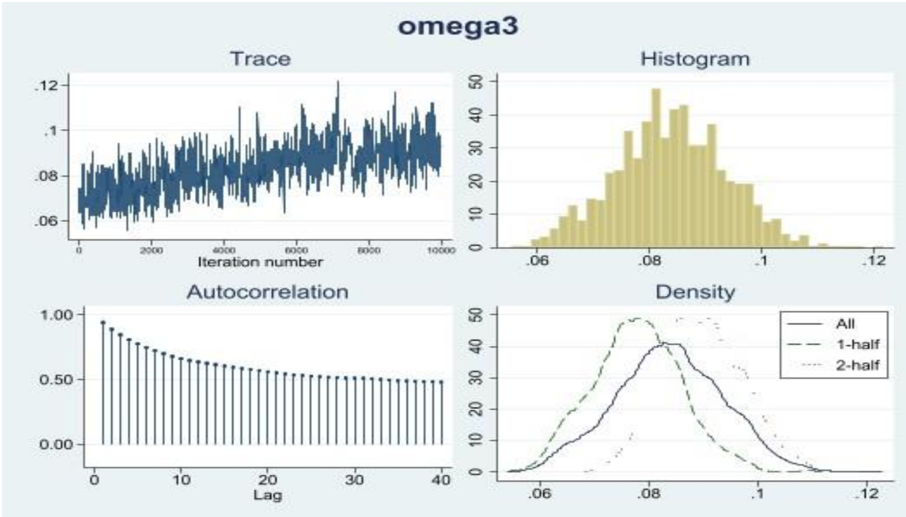
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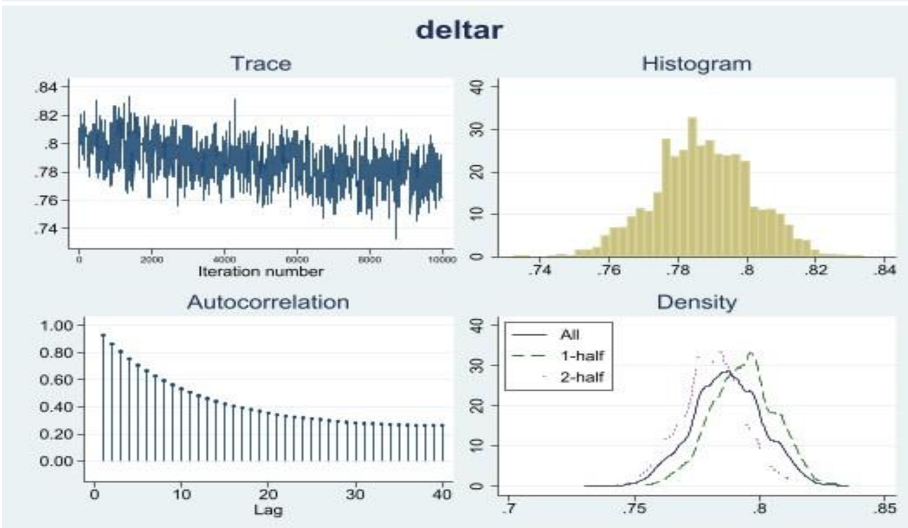
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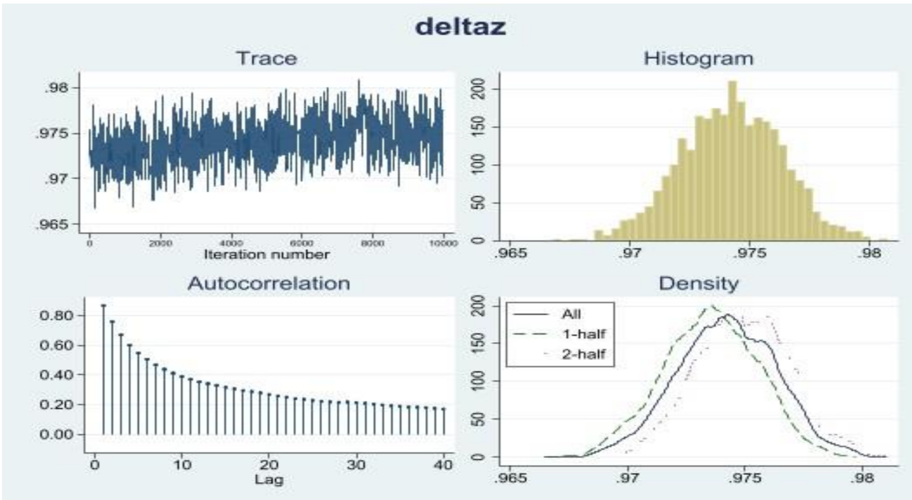
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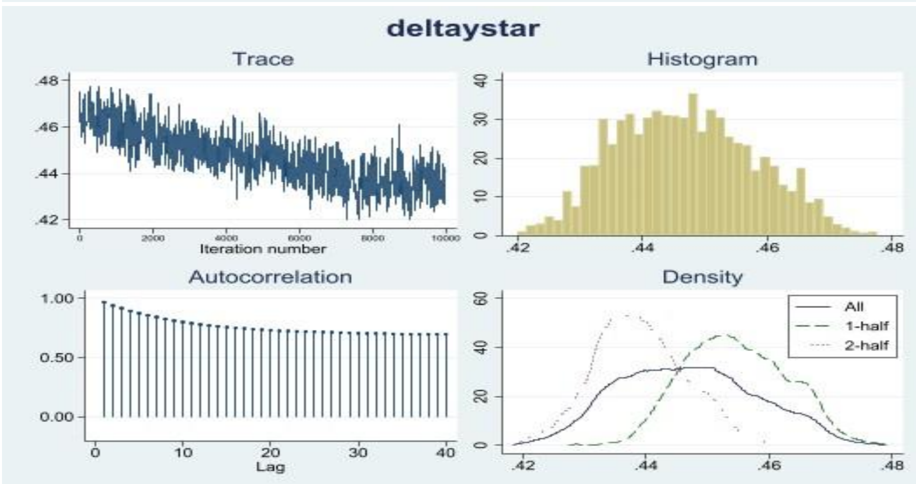
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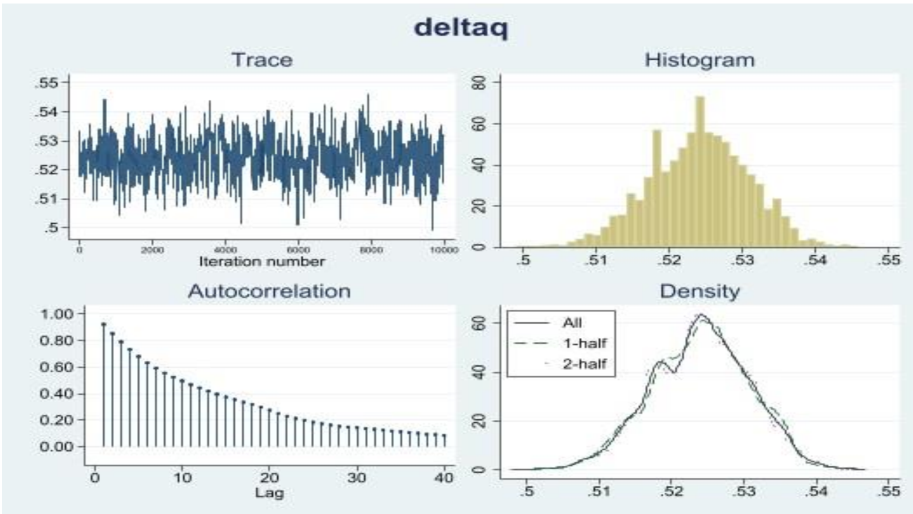
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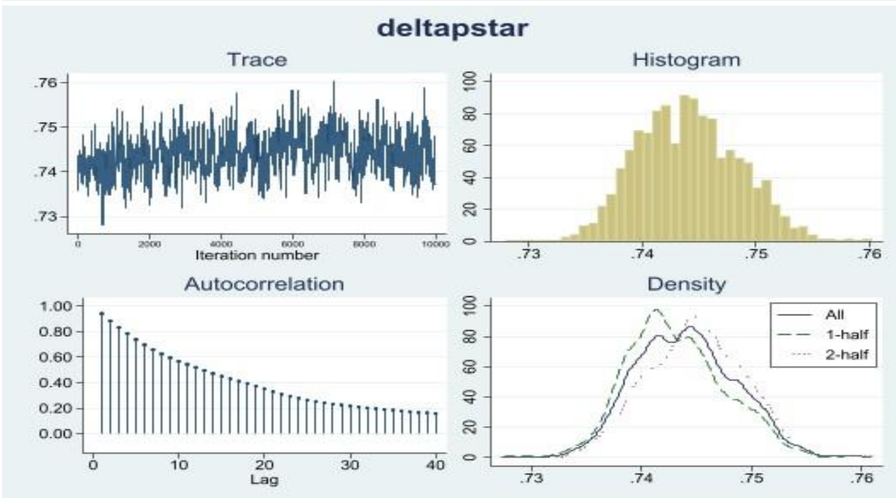
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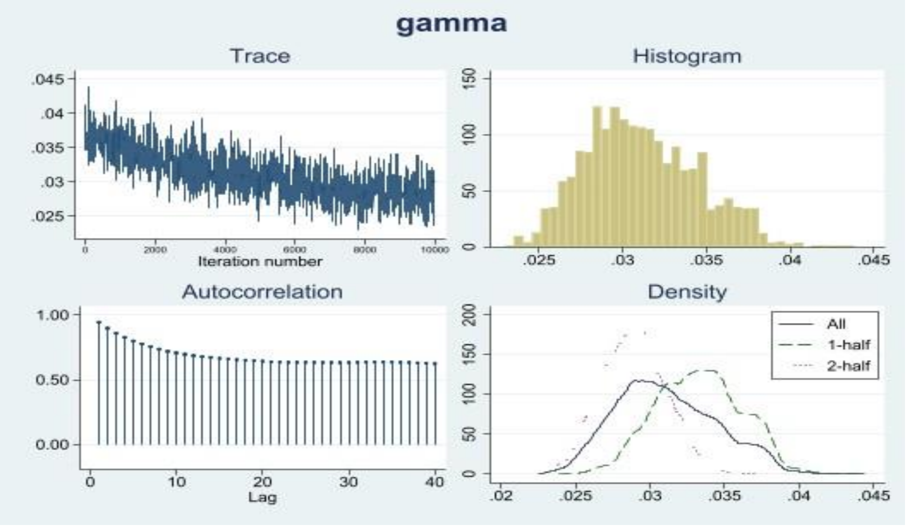
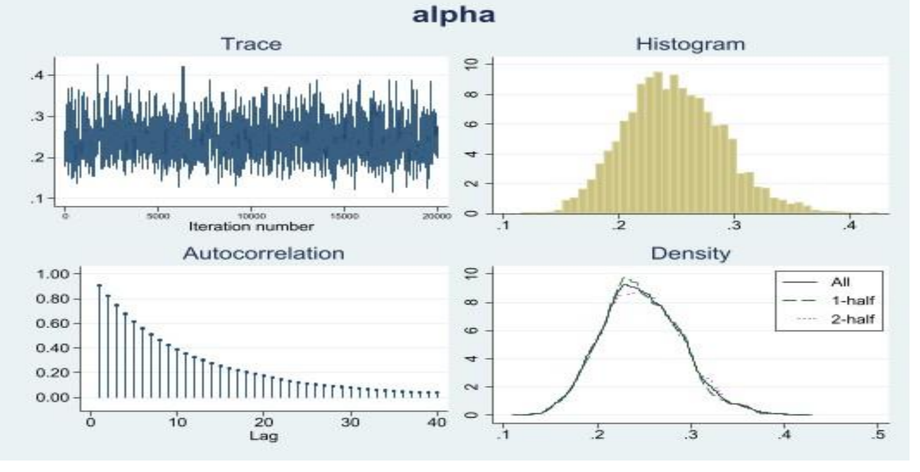
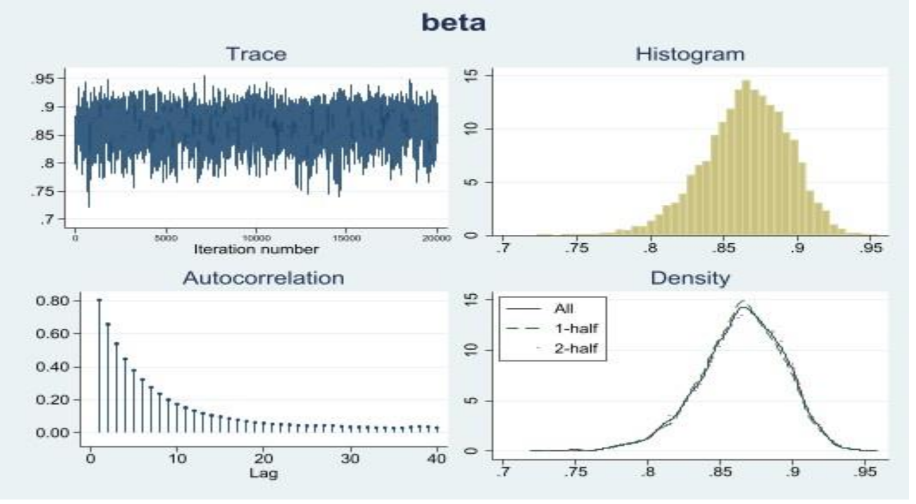


APPENDIX 4: Bayesian DSGE without Block Option (The Graphical Approach)

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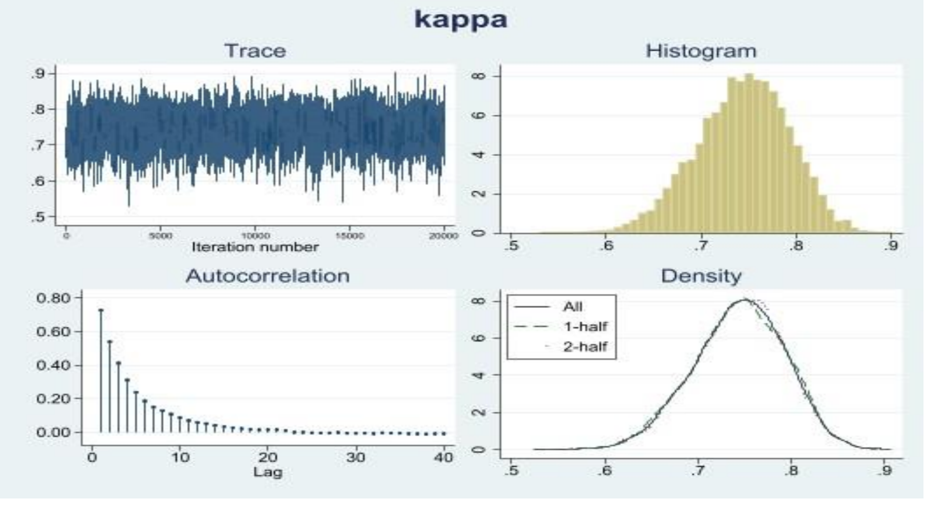
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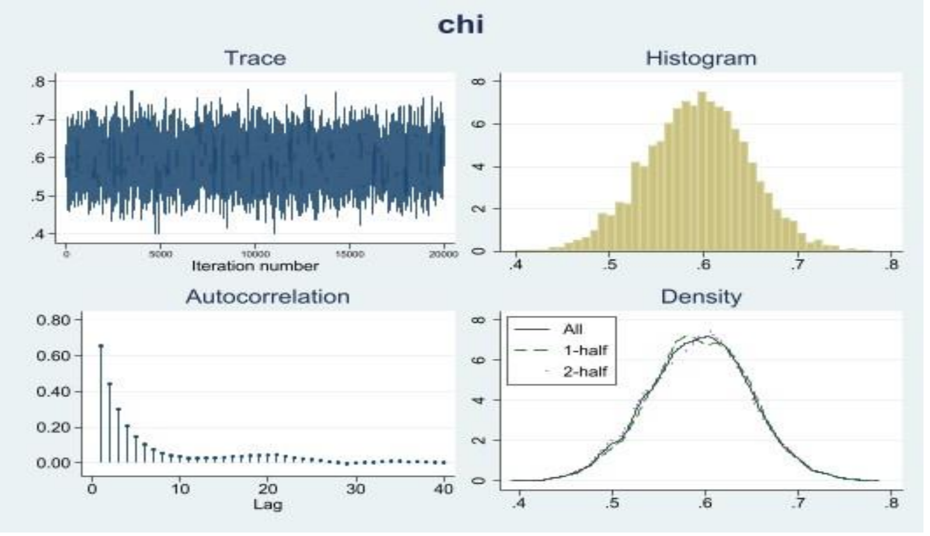
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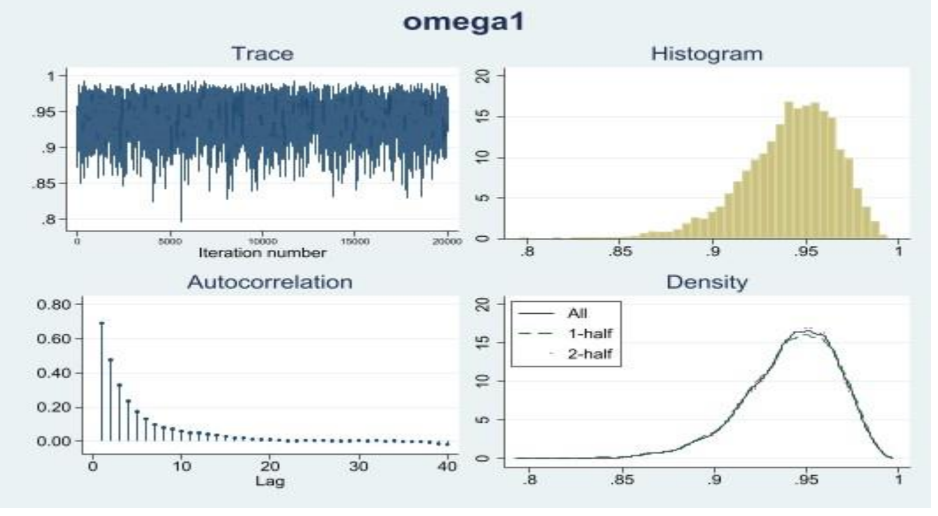
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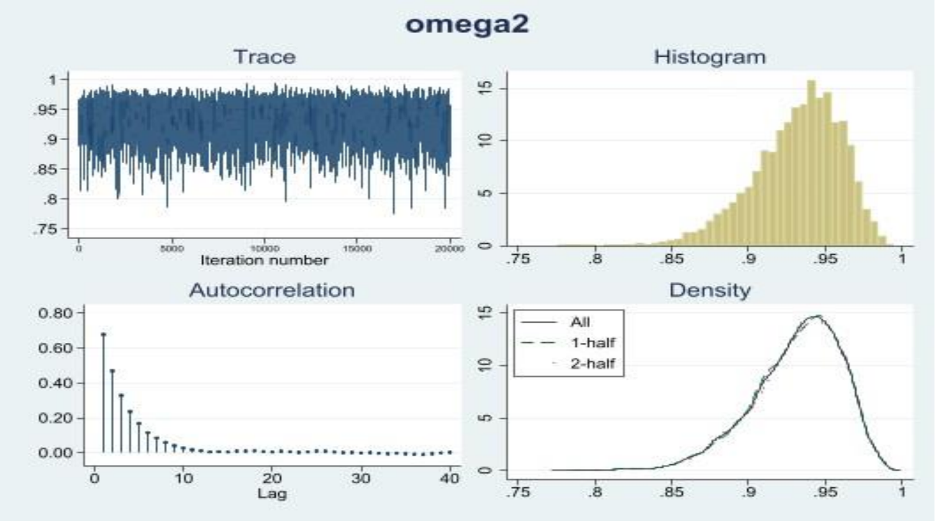
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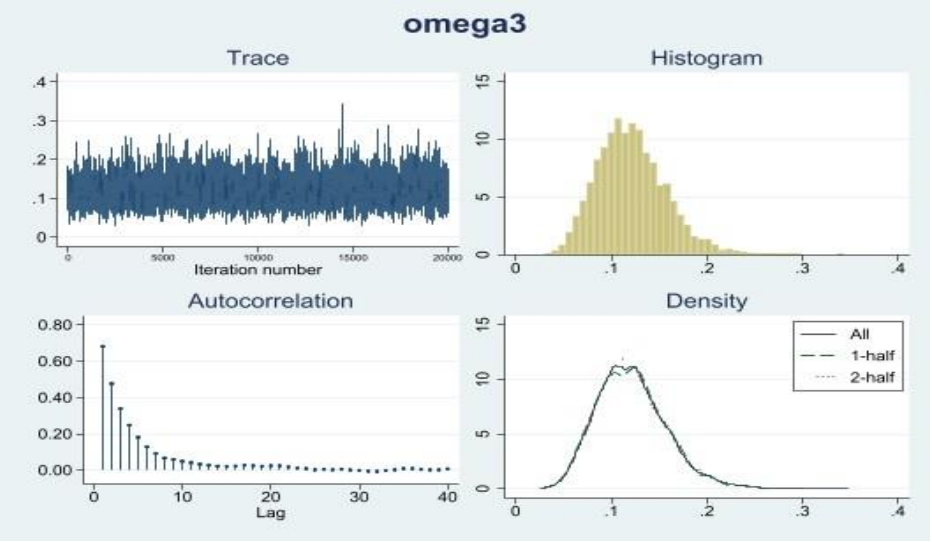
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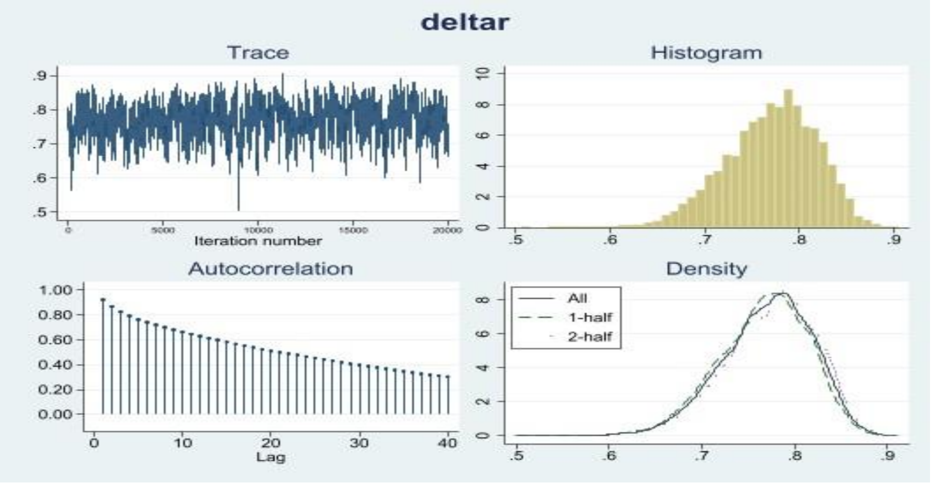
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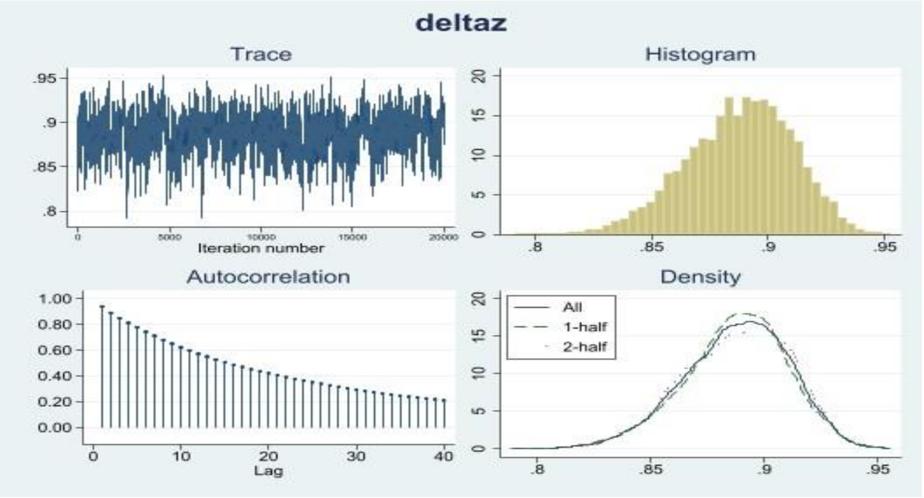
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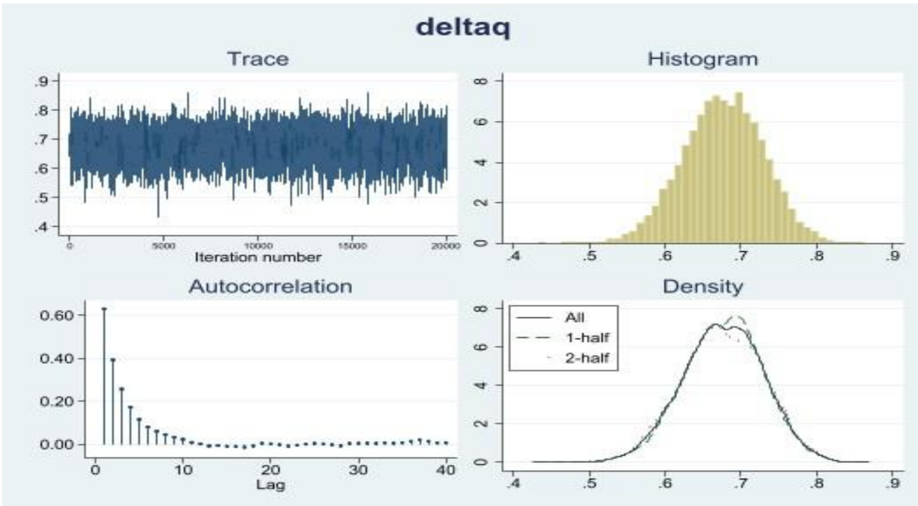
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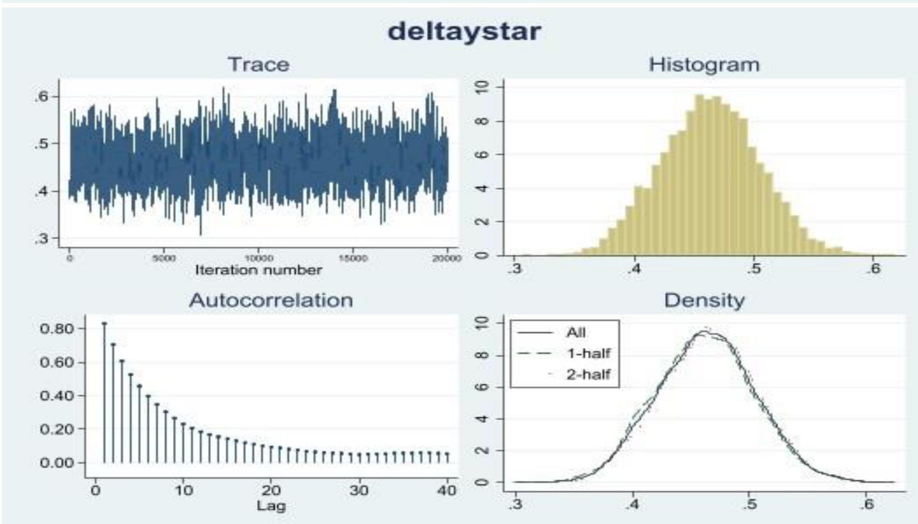
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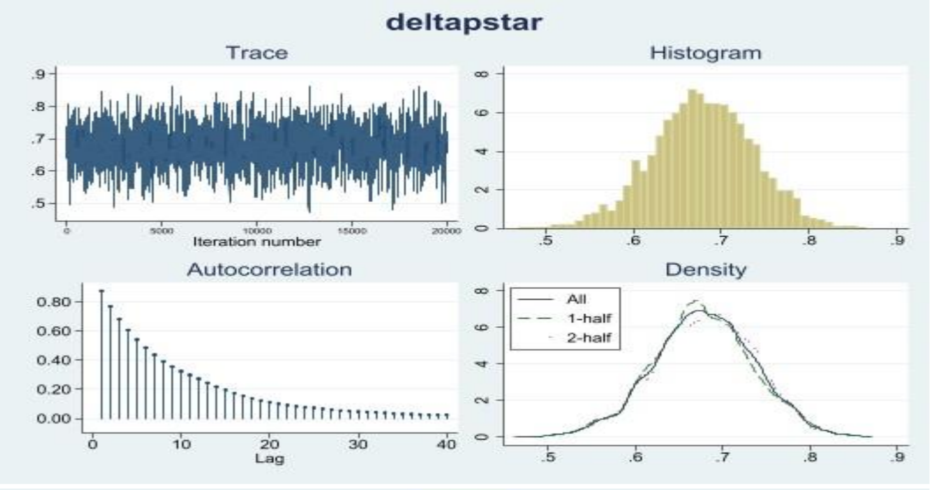
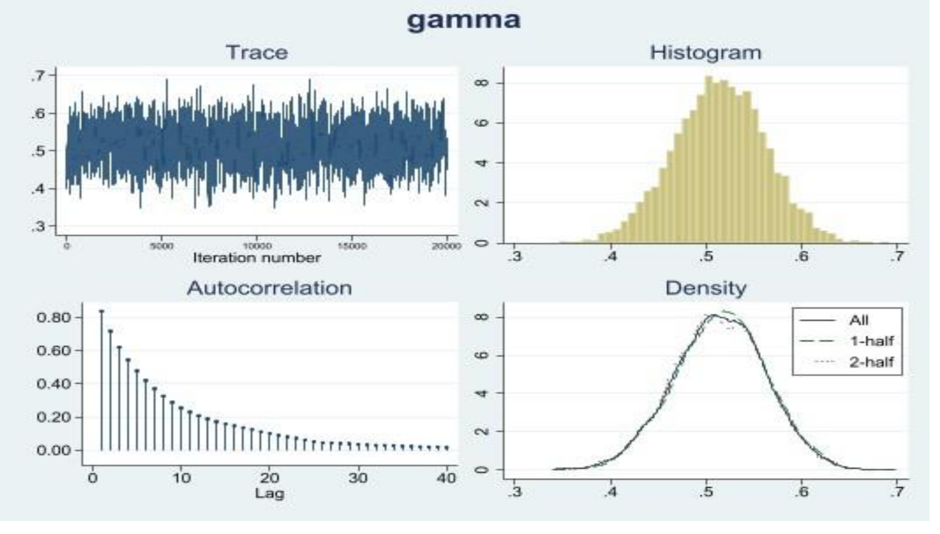
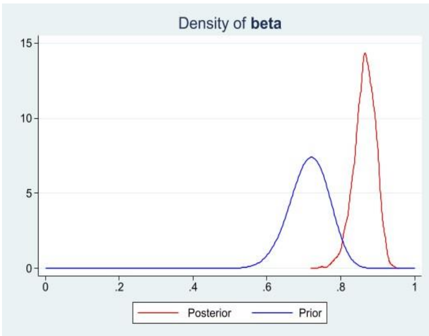




APPENDIX 5: Posterior Distributions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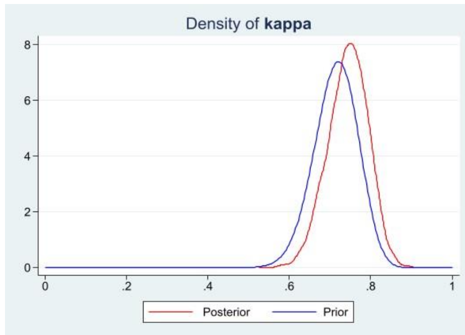
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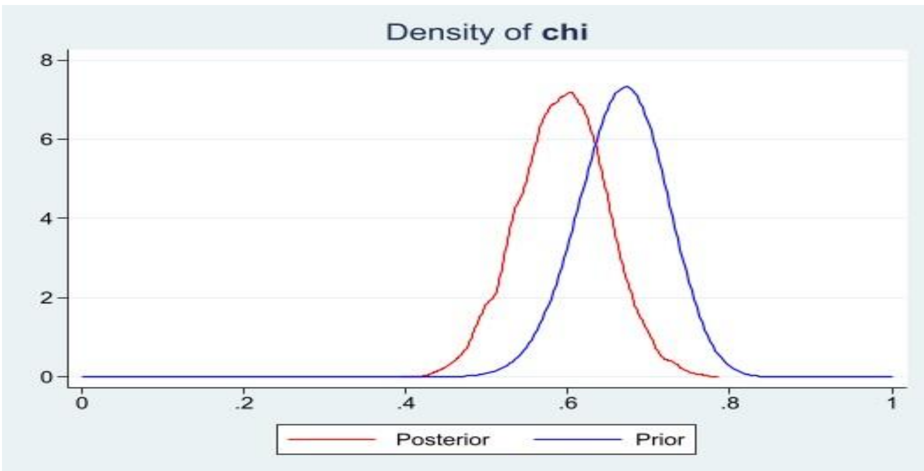
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ESTIMATING A SMALL OPEN ECONOMY BAYESIAN DSGE MODEL FOR GHANA

Victor Osei[1], James Korley Attuquaye[2] and Daniel Delali Ngoh[3]

Abstract

This paper investigates a Bayesian specification of a Dynamic Stochastic General Equilibrium (DSGE) model to analyse the dynamic interactions of macroeconomic variables for a small open economy using Ghana as a case study. The model reflects the main characteristics of the Ghanaian economy, including inflation targeting the central bank with the monetary policy rate as its key policy tool, the effects of exchange rate developments on price dynamics, and trade openness. We deployed the Bayesian DSGE framework to examine Ghana's monetary policy practice and how macroeconomic shocks propagate through the economy during the period from 2006 to 2022. The transmission of shocks suggests that adjustments in the Bank of Ghana's key policy rate significantly affect exchange rate dynamics, inflation, and the output gap in the short-run but the impact dies out after about four quarters. Moreover, the study finds that a technology shock permanently and positively impacts the output gap, inflation, and exchange rate developments. The study further suggests that a positive trade shock significantly affects the output gap, and inflation, while the monetary policy rate rises to moderate the effects of the rising output gap and inflation. It is therefore recommended that monetary policy tools should be deployed effectively in a measured fashion by monetary authorities to ward off any threat to price stability triggered by various types of shocks in coordination with existing fiscal policies to avoid policy conflicts in Ghana.

Keywords: Open economy, trade shock, monetary policy, technology shock, inflation targeting, Bayesian DSGE

JEL Classification: F10, F19, E52, 033, E39, E11

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Acknowledgment: The authors acknowledge the immense contributions of the staff of the Research and Macroeconomic Management Departments of the West African Institute of Financial and Economic Management (WAIFEM), and the course facilitators, Prof. Afees A. Salisu, Dr. Yaya OlaOluwa, and Dr. Abubakar Jamaladeen. We are also grateful to fellow participants from Gambia, Liberia, Nigeria, and Sierra Leone.

Disclaimer: This research paper represents the views of the authors and does not represent the views of the Bank of Ghana. The views articulated herein should be attributed to the authors and not the Bank of Ghana or its Monetary Policy Committee.

1.0 INTRODUCTION

Macroeconomic policies are targeted at achieving robust and sustainable economic growth, general price stability, and sound financial systems. Thus, the general welfare of citizens is enhanced through declining unemployment and stable purchasing power. A sound, robust, and stable financial system underpin intermediations and risk management, which in turn enhances consumption and investment. These in tandem anchor effective monetary policy transmission. Additionally, a stable foreign exchange market is hinged on a strong and resilient balance of payment position to external shock. The emergence of external and domestic shocks largely weakens the effectiveness of these policy objectives (Joon-ho et al, 2022; Xin and Xiaoguang, 2021).

The evolution of monetary policy in Ghana started with direct controls and monetary targeting before the Bank of Ghana adopted inflation targeting (IT) as its monetary policy framework in 2007. Inflation targeting encompasses the announcement of an inflation target by the central bank. The Bank of Ghana (BoG) has set its target to 8±2 percent and uses interest rate as the main toolkit to keep inflation within the targeted range (Michael et al, 2020; Kyereboah-Coleman, 2012).

The complex nature of monetary policy transmission, together with multiple channels, intrinsic shock-dependence of macroeconomic developments, and transmission lags which interact within a dynamic endogenous system, a well-organized and informative analytical infrastructure to support forward-looking policy decisions is underscored. The Bank of Ghana currently uses a Quarterly Projection Model which sits within a Forecasting and Policy Analysis System (FPAS) as the key analytical infrastructure to inform policymakers. The model is a semi-structural new Keynesian macroeconomic model which composes of four main blocks. These are the aggregate demand block, a Phillips curve, an exchange rate block, and a monetary policy rule (Abradu-Otoo, et al, 2022).

Domestic and external shocks are volatile and persistent, in developing economies, causing volatility in the macroeconomic variables. The frequency of significant shocks has necessitated other models to supplement the existing monetary policy frameworks to ensure stability in developing economies and improve the welfare of the citizenry.

Some studies have examined the consequences of shocks on monetary policy in small open economies (Hove and Tchana, 2015; Medina and Soto, 2005; Laxton and Pesenti, 2003; Gali and Monacelli, 2005; Devereux et al., 2006). These studies mainly focus on commodity terms of trade shocks, demand shocks, interest rate shocks, and productivity shocks. Though these shocks are important and relevant in developing economies, other germane surprises on the macroeconomic variables have to do with technology shocks and how monetary policy has to react.

The interactions of consumer and government spending, business investment, and export (aggregate demand) with the capacity of the economy to produce goods and services (aggregate supply) to determine price levels evolve. Central banks, especially inflation-targeting economies use all available tools to ensure inflation is well-anchored, stabilised, and remains within the medium-term target band. During periods of deviation of inflation from its target, the bank deploys its available monetary policy toolkits to return inflation to its steady state target.

The DSGE model has strong micro-theory foundations to complement the Bank of Ghana's inflation forecasting model. Most Central banks are currently and progressively adopting Dynamic Stochastic General Equilibrium (DSGE) models for macroeconomic analysis, monetary policy evaluation, and forecasting. The European

Central Bank adopted the DSGE model developed by Smets and Wouters (2003) to analyse the economy of the Eurozone to inform its monetary policy deliberations and decisions.

This study thus explores the channels of transmission of three macroeconomic shocks, namely, monetary policy shock, terms of trade shock, and technology shock, and their impacts on macroeconomic variables (Inflation dynamics, output gap, and exchange rate) with relevant implications for monetary policy decisions based on Dynamic Stochastic General Equilibrium (DSGE) models in the context of an inflation targeting country where price stability is the core mandate. Additionally, this paper accesses the impact of the aforementioned shocks in a developing economy in Sub-Sahara Africa, which has adopted inflation targeting framework and flexible exchange rate regime as a follow-up study with different research objectives to the seminary work by Owusu-Afriyie and Farouke (2022).

The main objectives for this study are as follows, (i) to investigate the effects of monetary policy shock on both inflation dynamics and output variability in Ghana; (ii) to analyse the dynamic impact of technology shock on inflation, monetary policy rate, and output gap; and finally, (iii) to examine the effect of trade shock on both inflation and output gap, to access the impact of the global shock on the Ghanaian economy.
This study will contribute to knowledge in terms of correcting misalignment in macroeconomic variables underpinned by country-specific fluctuations and shape monetary policy decision-making in an inflation-targeting country. It also provides a rigorous theoretical understanding of the effects of the wide-ranging equilibrium effects of monetary policy shock, terms of trade shock, and technology shock, and their impacts on macroeconomic variables (Inflation dynamics, output gap, and exchange rate) using the DSGE model in a developing country.

The study is organised as follows; section 1 highlights the introduction and motivation for the study whereas section 2 provides a brief survey of the empirical literature on the use of the DSGE model in evaluating monetary policy decisions. Section 3 outlines the methodology adopted for the study. The empirical results will be discussed in section 4 while, section 5 will summarize the findings and conclude the paper with some suggested policy recommendations based on the findings of the study.

2.0 LITERATURE REVIEW

2.1 Theoretical literature surveyed

Modeling techniques for macroeconomic analysis have improved significantly and more useful tools are still emerging through constant research and innovations. The emergence of criticisms of macroeconomic models in the 1970s resulted in alternative methodologies free from the critique by Lucas (Lucas, 1979). The revolutionary theory of rational expectations hypothesis caused a complete shift in macroeconomic theory and practice. Kydland and Prescott (1982) suggested an innovative solution of a new form of macroeconomic model which emphasizes the optimizing behaviour of economic agents that incorporate rational expectations within a Dynamic Stochastic General Equilibrium (DSGE) approach. This new approach to studying macroeconomic theory occasioned the development of different macroeconomic models such as the Real Business Cycle (RBC) that incorporated both market imperfections and rigidities. These models have strong micro-foundations. The DSGE structure thus is inherited from these new macroeconomic models including RBC modelling with nominal and real rigidities, and market distortions (Goodfriend and King, 1997; Gali, 2009).

An economy characterized by high inflation results in serious and long-term costs to the economy and people. Thus, attempts by central banks to tame inflation help protect the vulnerable in every economy. The key objective of Monetary authorities is to formulate an optimal policy rule which guarantees the maximization of welfare and ensures price stability, to promote resilient output growth. To obtain this policy objective, several inflation-targeting central banks including the Bank of Ghana, are guided by the Taylor Rule. In the Taylor rule, monetary policy reacts to the target variables such as inflation variability, output gap, and other real variables including exchange rate dynamics. The conduct of monetary policy under the new Keynesian school of thought is therefore characterized by ensuring price stability while making output as close as possible to its potential level (Clarida et al., 1998, 1999, 2000, 2001; Svensson, 2000, 2002, 2003).

The emergence of New Keynesian DSGE models with obvious theoretical foundations provides the framework for counter-factual policy analysis and trials (Christiano et al., 2000; Smets and Wouters, 2003, 2007) and could be used to explain in detail the transmission mechanism process of several shocks in various sectors of the economy. According to Gali and Gertler (2007), the tell-tale sign that these frameworks possess underpins the widespread use of the DSGE framework at central banks in the process of monetary policy implementation. As indicated by Schmitt-Grohe and Uribe (2007), earlier studies on the use of DSGEs, focused mainly on stylized theoretical policy settings.

2.2 Empirical Literature Surveyed

Mehdi (2008) investigated a new Keynesian small open economy DSGE model in the Islamic economic framework for Iran. The prohibition of interest rates in the Islamic economic framework has posed several problematic challenges in macro model building and execution of monetary policy mechanisms that have not been fully analyzed in the literature that is focused on developed countries. This paper attempted to develop and estimate a New Keynesian small open economy DSGE Model for Iran using a Bayesian methodology. The exchange rate was used as an alternative monetary policy instrument for the Iranian economy. Similarly, Duval and Vogel (2008) also studied monetary policy in a small open economy New Keynesian DSGE model including oil as a production input and a component of final demand. It investigates the performance of alternative price level definitions, notably headline, and core CPI, in standard interest rate rules concerning output and inflation stabilization. The analysis puts special emphasis on the impact of price and real wage rigidity and their interaction on the policy trade-off induced by the oil price shock. Also, Unalmis et al. (2008) modelled the price of oil endogenously within a DSGE framework. Specifically, using a new Keynesian small open economy model, they analyzed the aspects of an increase in the price of oil caused by an oil supply shock and an oil demand shock. In addition, they investigated the sensitivity of the general equilibrium outcomes to the degrees of oil dependence and openness, as well as the strength of the response of monetary policy authority to inflation.

Also, Adnan, H. B and Safdar (2009) estimated a small open economy DSGE model for Pakistan based on a new Keynesian framework characterized by nominal rigidity in prices using the Bayesian approach. The study suggested that (i) high inflation in Pakistan does not hit domestic consumption significantly; (ii) the Central Bank of Pakistan responds to high inflation by increasing the policy rate by 100 to 200 bps; (iii) exchange rate appreciates in both the cases of high domestic and. imported inflation; (iv) tight monetary policy stance helps to curb domestic inflation as well as imported inflation but appreciates exchange rate significantly (v) pass-through of exchange rate to domestic inflation is very low; finally parameter value of domestic price stickiness shows that around 24 percent domestic firms do not re-optimize their prices which implies averaged price contract is about two quarters. In addition, Mohammed (2014) employed a simple New Keynesian Small Open Economy DSGE model featuring multiple sectors with monopolistic competition, nominal rigidities in prices, a fixed exchange regime, and the introduction of a simple medium-sized informal sector. He estimated the DSGE model with Bayesian methodology using quarterly data from Morocco. Estimation results suggest a relatively weaker role of price rigidities in the non-tradable sector. It also suggests a much more aggressive reaction of the central bank to inflationary pressures with a relatively higher weight given to fluctuations in inflation compared with fluctuations in output and the real exchange rate. The study of the Bayesian impulse-response functions confirms the shock-absorbing role of the informal sector for productivity shocks and pleads towards excluding imported inflation from the inflation target.

Again, Berg et al (2015), the authors used a stylized framework for modeling African economies using the dynamic stochastic general equilibrium (DSGE) approach. The authors introduce several features relevant to low-income countries, including a large population without access to financial markets, restricted international capital mobility, low governance quality, and explicit central bank balance-sheet effects. The calibrated model was very useful in addressing important macroeconomic policy issues in many African economies. The study focused on (i) reserve accumulation policy responses to aid surges, (ii) government spending, financing schemes, and fiscal multipliers, (iii) management of natural resource revenues, and (iv) public investment surges and debt sustainability. Moreso, Iskender (2016) analyzed the effects of fiscal and monetary policy shocks on economic performance in the Kyrgyz Republic using a dynamic stochastic general equilibrium model within a Bayesian estimation framework. The study concluded that a fiscal stimulus boosts output with an increase in hours of work and a decline in consumption and investment while a contractionary monetary shock leads to a decrease in all of those variables.

Finally, DSGE has been used by a few authors to evaluate monetary policy reaction to the shock effects of aggregate demand and productivity in Ghana. Using a DSGE framework, Owusu-Afriyie et al (2022) concluded that exogenous shocks of demand and productivity turn to influence the direction of monetary policy in Ghana while the response of monetary policy to productivity shock turns to be non-monotonic but somewhat permanent. In terms of filling the existing literature gap on Ghana regarding the lack of DSGE research-based work on Ghana. In line with this missing literature, this study seeks to fill this literature gap by estimating a small open economy Bayesian DSGE model for Ghana and assessing the impact of terms of trade, technology, and monetary policy shocks on macroeconomic variables. These were not explored in the earlier work published.

3.0 FRAMEWORK AND METHODOLOGY

3.1 Small Open Economy DSGE Model

The paper considers a small open economy model for Ghana and the rest of the world using the US as a proxy. The study follows the work by Zheng and Guo (2013) who also followed Lubik and Schorfheide (2007) and Del Negro and Schorfgheide (2009). The DSGE model is detailed as follows.

3.1.1 The Household

The household optimisation problem results in a consumption Euler equation that relates current income to expected future income, expected future inflation, monetary policy rate (interest rate), and changes in future terms of trade as well as the expected changes in future income. This is represented by an open economy IS curve as follows.

$$out_t = E_t(out_{t+1}) - (\tau + \lambda)(mpr_t - E_t inf_{t+1}) + \rho_u u_t - \alpha(\tau + \lambda)E_t(g_{t+1}) + \frac{\lambda}{\tau} E_t(\Delta out^*_{t+1}) \quad (1)$$

where $0 < \alpha < 1$ is the import share, and the equation reduces to its closed economy variant when $\alpha = 0$. τ is the intertemporal substitution elasticity and $\lambda = \alpha(2 - \alpha)(1 - \tau)$. mpr_t, inf_t, and out_t, denote the interest rate, CPI inflation rate, and aggregate output gap, respectively. u_t, is the growth rate of an underlying non-stationary technology process A_t, g_t, is the terms of trade, defined as the current account balance to GDP ratio, and, out_t^* is the United States output gap, which is a proxy for world output. To obtain stationarity of the model, all real variables are expressed in terms of deviations from the steady state.

3.1.2 The firms

The optimal price-setting strategy of domestic firms leads to the following Phillips curve, which states that current inflation depends on expected future inflation, expected changes in future terms of trade, and output gap respectively. It is stated as follows:

$$inf_t = \beta E_t inf_{t+1} + \alpha\beta E_t \Delta g_{t+1} - \alpha_t \Delta g_t + \frac{\mathrm{K}}{\tau+\lambda}\, out_t \quad (2)$$

The slope coefficient $\mathrm{K} = (1 - \theta\beta)(1 - \theta)/\theta$ is a structural parameter and captures the degree of price stickiness in the economy, where β is the discount rate for the representative of household and θ is the fraction of the firms that update their price by the steady-state inflation rate, while $1 - \theta$ can set prices optimally each period (Del Negro and Schorfgheide, 2009). The nominal rigidities disappear and the price is flexible as long as $K \rightarrow \infty$.

3.1.3 The monetary policy decision rule

About Taylor (2000), central banks should react to adjustments in exchange rates to sharpen the effect of monetary policy. Also, according to Xie and Zhang (2002), monetary policy frameworks in emerging market economies should address exchange rate policy. Following these approaches, this study assumes that the monetary policy authority in Ghana changes the interest rate in reaction to deviations in headline inflation from the target and real output from its potential. Also, it considers movement in the nominal exchange rate (depreciation). It is also assumed that the Bank of Ghana somewhat adjusts the interest rate according to an interest rate smoothing parameter, ρ_{mpr}. The monetary policy reaction function is expressed as follows:

$$mpr_t = \rho_{mpr} mpr_{t-1} + (1 - \rho_{mpr})[\phi_1 inf_t + \phi_2 out_t + \phi_3 \Delta e_t] + \varepsilon_{mprt} \quad (3)$$

where the interest rate smoothing parameter is $0 \leq \rho_{mpr} < 1$, the monetary policy reaction coefficients $\phi_1, \phi_2, \phi_3 \geq 0$, and the error term ε_{mprt} can be interpreted as an unanticipated monetary policy shock. To evaluate the hypothesis of whether Ghana incorporates changes in the exchange rate in the monetary policy reaction function, we will estimate the model independently with the restrictions $\delta_3 \geq 0$ and $\delta_3 = 0$, and compute a posterior odds ratio for the two separate specifications accordingly.

3.1.4 Purchasing parity assumption

The paper assumes that purchasing power parity (PPP) holds, thus the changes in the nominal exchange rate equation is stated as follows:

$$\Delta e_t = inf_t + inf_t^* - (1 - \alpha)\Delta g_t, \quad (4)$$

where inf_t^* is the US inflation rate (a proxy for the word inflation rate)

3.1.5 Evolution of Terms of trade shock

It must be noted that the terms of trade is assumed as an exogenous variable, and the law of motion for its growth rate is also expressed as follows,

$$\Delta g_t = \rho_g \Delta g_{t-1} + \varepsilon_{gt}, \quad (5)$$

3.1.6 Evolution of technological shock

The law of motion for technology shock is assumed to follow an AR (1) process express below,

$$u_t = \rho_u u_{t-1} + \varepsilon_{ut} \quad (6)$$

3.1.7 The Law of Motion for world output gap and world inflation

In addition, we also assume the US output and inflation, out_t^* and inf_t^*, follow exogenous AR (1) processes,

$$out_t^* = \rho_{out^*} out_{t-1}^* + \varepsilon_{out^*t}, \;\; inf_t^* = \rho_{inf^*} out_{t-1}^* + \varepsilon_{inf^*t}, \quad (7)$$

3.2 Selected model variables and Their Measurements

3.2.1 Output gap

To obtain the output gap, we compute the real output and potential output. In this study, the real output is measured as the gross domestic product (GDP), and its Hodrick-Prescott (HP) trend is taken as the potential output. The annualized output gap is then calculated as a percentage log deviation of real output concerning potential output. $Gap_t = 400 \times \log(\frac{real\ output_t}{potential\ output_t})$.

3.2.2 Inflation rate

The inflation rate used in this study is the year-on-year change in the consumer price index (CPI) as published by the Ghana Statistical Service.

3.2.3 Nominal interest rate

The nominal interest rate used is the Monetary Policy Rate announced by the Monetary Policy Committee of the Bank of Ghana.

3.2.4 Exchange rate

The year-on-year change in the exchange rate was computed from the Ghana cedi to the US Dollar exchange rate as published by the Bank of Ghana. Here, we define the level of the exchange rate as the amount of Ghana cedis that is needed to purchase one US dollar.

3.2.5 Terms of Trade

The current account balance expressed as a percentage of GDP is used in the study to proxy terms of trade.

3.3 Data Sources and Description

This study uses quarterly data spanning from 2006:Q1 to 2022:Q4 with 68 observations. Data on Ghana’s GDP, inflation rate, nominal interest rate, exchange rate, and terms of trade were extracted from the Bank of Ghana’s Quarterly Statistical Bulletin as published on the official website. (https://www.bog.gov.gh/publications/statistical-bulletin/). Additionally, the US output gap and inflation rate were extracted from the Congressional Budget Office's February 2023 10-year projections (https://www.cbo.gov/data/budget-economic-data) and Federal Reserve Bank of St Louis (https://fred.stlouisfed.org/) respectively.

4.0 ESTIMATION STRATEGY, DATA DESCRIPTION AND CHOICE OF PRIORS

4.1 Model estimation

The study applies the Bayesian approach in estimating the Dynamic Stochastic General Equilibrium (DSGE) model. This method uses the Markov Chain Monte Carlo (MCMC) statistical process with the number of iterations set at 20,000 and the burn-in period set at 5,000. The technique applies the Metropolis-Hastings sampling algorithm. The trace, histogram, autocorrelation, and density plots are applied in the convergence diagnostic analysis. Finally, the block option in the Bayesian DSGE STATA command is adopted to avoid the problem of high autocorrelation and non-stationarity in the individual distribution parameters.

4.2 Choice of Prior for the DSGE Model

The estimation technique used in Bayesian DSGE requires some information on the sample and the prior distribution of the parameters. The choice of prior is determined largely by theory, empirical findings, stylized facts, and some degree of judgement. The priors in the studies by Zheng and Guo (2013), and Owusu-Afriyie and Farouke (2022) were largely adopted. Table 1 shows the choice of priors:

Table 1: Prior to distributions

Parameter	Interpretation	Range	Density Function	Para (1)	Para (2)
$\boldsymbol{\phi_1}$	Inflation Deviation Coefficient	(0,+∞)	Gamma	1.10	0.50
$\boldsymbol{\phi_2}$	Output gap coefficient	(0,+∞)	Gamma	1.00	0.50
$\boldsymbol{\phi_3}$	Depreciation rate coefficient	(0,+∞)	Gamma	0.10	0.05
$\boldsymbol{\rho_{mpr}}$	Interest rate smoothing parameter	(0,1)	Beta	0.50	0.20
$\boldsymbol{\alpha}$	Degree of openness	(0,1)	Beta	0.25	0.05
K	Inflation-output trade-off	(0,+∞)	Gamma	0.50	0.25
$\boldsymbol{\beta}$	Discount factor	(0,1)	Beta	0.70	0.30
$\boldsymbol{\tau}$	Intertemporal substitution elasticity	(0,1)	Beta	0.50	0.20
$\boldsymbol{\rho_g}$	AR (1) for terms of trade shock	(0,1)	Beta	0.50	0.20
$\boldsymbol{\rho_u}$	AR (1) for technology shock	(0,1)	Beta	0.50	0.20
$\boldsymbol{\rho_{out^*}}$	AR (1) for world output shock	(0,1)	Beta	0.50	0.20
$\boldsymbol{\rho_{inf^*}}$	AR (1) for world inflation shock	(0,1)	Beta	0.50	0.20
$\boldsymbol{\sigma_{\varepsilon_{mprt}}}$	Std. dev of monetary policy shock	(0,+∞)	Inverse gamma	0.10	2.00
$\boldsymbol{\sigma_g}$	Std. dev of terms of trade shock	(0,+∞)	Inverse gamma	1.50	2.00
$\boldsymbol{\sigma_u}$	Std. dev of technology shock	(0,+∞)	Inverse gamma	0.10	2.00
$\boldsymbol{\sigma_{out^*}}$	Std. dev of world output shock	(0,+∞)	Inverse gamma	1.50	2.00
$\boldsymbol{\sigma_{inf^*}}$	Std. dev of world inflation shock	(0,+∞)	Inverse gamma	0.50	2.00

5.0 EMPIRICAL ANALYSIS OF THE ESTIMATED DSGE MODEL

In this section, we adopt the MCMC simulation to estimate a small open economy model spanning the period 2006-2022 in Ghana and discuss the model estimation results extensively: what follows are the impulse responses, which explore the response of the Ghanaian economy to shocks. In this paper, we explore monetary policy shock, terms of trade shock, and technology shock.

5.1 Estimation results

We estimate a log-linearized micro-founded DSGE model derived from optimization problems of firms and other economic agents. The model captures two main monetary policy transmission channels – the interest rate channel and the exchange rate channel. The interest rate channel works through financial intermediaries, mainly banks. The central bank conducts operations in the short-term money market in such a way that interest rates adjust to the new level of the prime rate. Market players start repricing their financial products accordingly which then affects the cost of loans, consequently affecting demand and then domestic prices. The exchange rate channel works through terms of trade, which is a component of domestic output and thus affects prices. In addition, changes in terms of trade impact exchange rate developments, and hence the monetary policy rate has to adjust to make financial instruments within the domestic economy competitive.

5.1.1 Monetary policy reaction function

As shown in Table 2, the posterior mean of the inflation deviation coefficient ϕ_1, output gap coefficient ϕ_2 and depreciation rate coefficient ϕ_3 are 0.92, 0.95, and 0.08, respectively. By interpretations, if headline inflation increases by 1 percentage point above its target, the monetary policy rate is raised by 92 basis points but the real interest rate declines; if the real output is 1 percent higher than its potential value, the interest rate increases by 95 basis points; similarly, if the Ghana cedi depreciates by 1 percent against the US dollar, the monetary policy committee reacts with an 8 basis points hike in the policy rate. Additionally, ρ_{mpr}, which indicates the degree of interest rate smoothing (or policy inertia) is approximately 0.76, which reflects evidence of gradual policy adjustment and implies a relatively strong willingness of the monetary policy committee to smoothen the movement of the interest rate.

The estimated degree of openness, $\boldsymbol{\alpha}$ is about 0.26, which is representative of a small open economy like Ghana. Next, the slope coefficient in the Phillips curve, K, which reflects the impact of a deviation in output from its long-term trend on inflation is about 0.72; hence a 1 percent increase in output deviation adds 0.72 percentage points to inflation. The intertemporal substitution elasticity, $\boldsymbol{\tau}$, is approximately 0.41, which reflects how strongly Ghanaian households substitute their current consumption against future consumption in response to a change in the real interest rate. Also, the AR (1) coefficients for shocks are significant, and the persistence in world output and world inflation (proxied by the US economy) are 0.63 and 0.64 respectively.

Table 2: Model estimation results

Parameter	Mean	95% Interval
$\boldsymbol{\phi_1}$	0.9226	[0.8555,0.9722]
$\boldsymbol{\phi_2}$	0.9516	[0.9024,0.9839]
$\boldsymbol{\phi_3}$	0.0794	[0.0393,0.1327]
$\boldsymbol{\rho_{mpr}}$	0.7593	[0.7122,0.7981]
$\boldsymbol{\alpha}$	0.2567	[0.1785,0.3444]
K	0.7294	[0.6370,0.8132]
$\boldsymbol{\beta}$	0.9200	[0.8798,0.9509]
$\boldsymbol{\tau}$	0.4125	[0.3174,0.5115]
$\boldsymbol{\rho_g}$	0.6629	[0.5629,0.7574]
$\boldsymbol{\rho_u}$	0.9553	[0.9361,0.9713]
$\boldsymbol{\rho_{out^*}}$	0.6265	[0.5479,0.6971]
$\boldsymbol{\rho_{inf^*}}$	0.6391	[0.5315,0.7432]
$\boldsymbol{\sigma_{\varepsilon_{mprt}}}$	0.9552	[0.7627,1.2347]
$\boldsymbol{\sigma_g}$	3.1043	[2.6738,3.7544]
$\boldsymbol{\sigma_u}$	1.2748	[0.7704,1.9858]
$\boldsymbol{\sigma_{out^*}}$	6.8127	[4.2924,10.6819]
$\boldsymbol{\sigma_{inf^*}}$	5.3587	[4.5107,6.4220]

5.2 Impulse response analysis

5.2.1 Monetary policy shock

In this section, we analyse the impulse response functions obtained from the DSGE model examined in this paper and provide insights for policymakers regarding the propagation of three main shocks: monetary policy, terms of trade, and technology shocks in the open economy model.

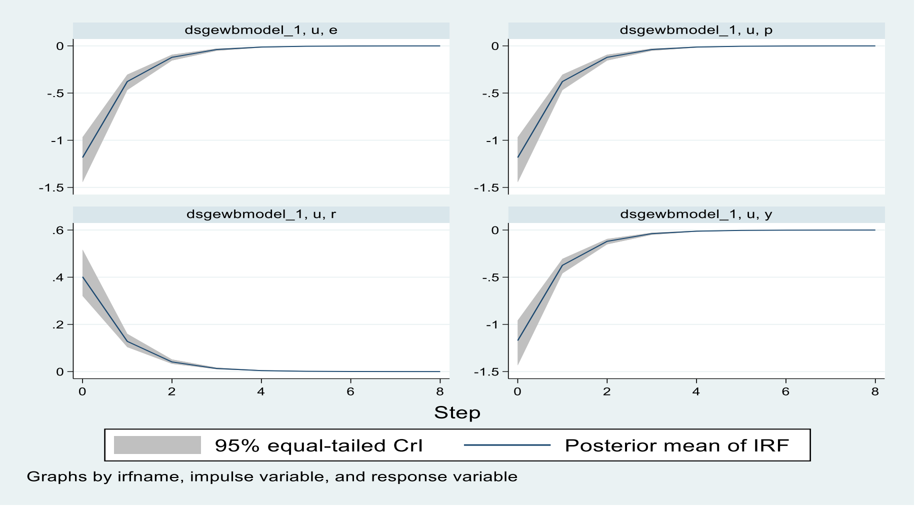
Figure 1 displays the posterior mean responses and a 95 percent confidence interval for the exchange rate, real output, inflation rate, and interest rate to a one-time monetary policy shock. We observe that the transmission of a one-unit positive shock to the interest rate aligns with economic theory. When the monetary policy rate is increased, money market rates adjust upwards, impacting the cost of loans.

Abradu-Otoo, Amoah, and Bawumia (2003) also investigated the transmission mechanisms of monetary policy in Ghana and found that a positive shock to interest rate led to a depreciation in the exchange rate, which they attributed to the undeveloped nature of the financial structures in the country, preventing free mobility of capital. However, given the advancements in Ghana's financial sector, which have facilitated more fluid movements of capital since the time of Abradu-Otoo, Amoah, and Bawumia's (2003) study, our results are more consistent with economic theory. In particular, the appreciation of the domestic currency following a positive shock to the monetary policy rate is in line with the expectations of a small open economy with free capital mobility, where higher interest rates attract capital inflows, thereby strengthening the domestic currency. The stronger currency, together with the rate hike, results in a contraction of output by about 1.2 percent, and inflation falls below the steady state by about 1.2 percent.

It is crucial to note that this decline in output may have detrimental effects on employment and household incomes, particularly, the vulnerable. Fiscal and monetary authorities may need to consider establishing targeted stimulus measures, such as coordinated fiscal policies and/or financial support programs, to assist impacted people and businesses and lessen these consequences.

After about four quarters, the interest rate returns to a steady state, and real output and inflation also return to a steady state.

Figure 1: Response of exchange rate, inflation, interest rate, and output gap to a policy rate shock



Note: The impulse response graphs represent percentage deviations in depreciation (top-left quadrant), inflation (top-right quadrant), policy rate (bottom-left), and output gap (bottom-right quadrant) due to a one standard deviation shock to the policy rate.

5.2.2 Technology shock

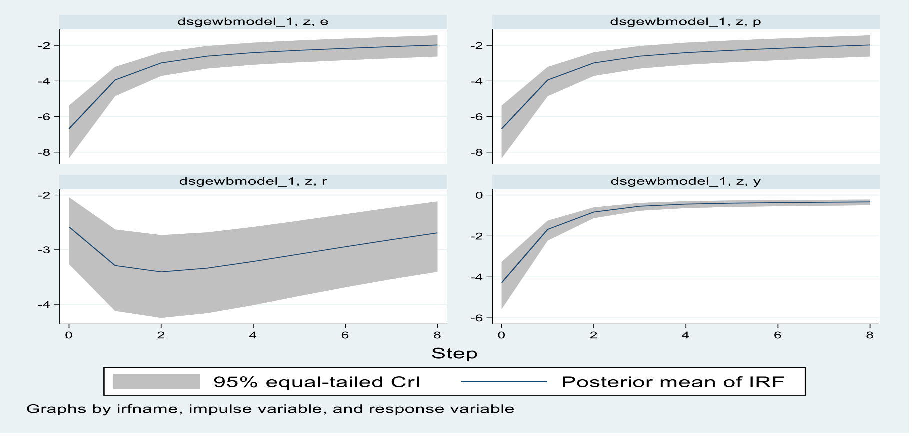
In this section, we analyze the response of output gap, inflation, and exchange rate to a one standard deviation positive technology shock. Our results (Figure 2) are consistent with the findings of Gali (1999), Gali and Rabanal (2004), and Basu, Fernald, and Kimball (1998).

We observe that in response to a positive technology shock, the output gap widens as labour productivity rises more than output, aligning with the existing literature. The improvement in efficiency due to the shock lowers the marginal cost for producers, leading to a decline in inflation, and the exchange rate appreciates in the near term. Consequently, the monetary authority can afford to lower interest rates to accommodate the spare capacity created by the shock.

Interestingly, our study finds that the shock appears to cause a permanent shift in the economy, as a complete return to a steady state is not observed. Additionally, our results suggest that the policy rate falls further down for two more quarters before gradually adjusting up over the forecast horizon. This is in line with existing studies that have also found a prolonged effect of technology shocks on the economy (Fofana, Antwi, and Mensah, 2019).

It is worth noting that most of the studies in Ghana adopt less extensive structural models. Therefore, our study's use of a more detailed DSGE model may yield more precise estimates and a better understanding of the transmission mechanism of shocks in the economy. Nonetheless, our results are consistent with other studies that have found that technology shocks lead to an increase in labour productivity and a decline in inflation in Ghana.

Figure 2: Response of exchange rate, inflation, policy rate, and output gap to a technology shock

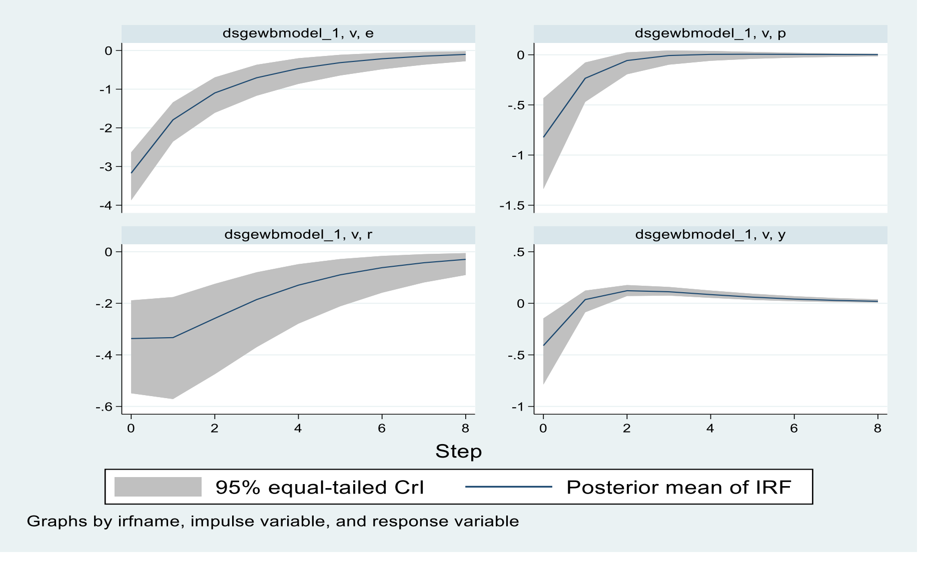


Note: The impulse response graphs represent percentage deviations in depreciation (top-left quadrant), inflation (top-right quadrant), policy rate (bottom-left quadrant), and output gap (bottom-right quadrant) due to a one standard deviation shock to technology.

5.2.3 Terms of trade shock

The findings also reveal that a positive term of trade shock improves Ghana's net foreign assets and appreciates the domestic currency upon impact (see Figure 3). The study also indicates a decline in domestic headline inflation by about 0.8 percent in response to the shock. The central bank responds to these changes by reducing the interest rate, allowing for an accommodative monetary policy stance. On output, we observe an initial widening of the output gap via the trade channel, as the domestic currency strengthens and imports become cheaper. However, the initial widening of the output gap is short-lived due to the quick closure of the gap, driven by an increase in imports that boost production. This broadly aligns with the nature of the Ghanaian economy, where intermediate and capital goods form a significant proportion of non-oil imports, leading to an increase in production. Based on the results, the central bank may use the findings to employ a basket of monetary policy tools aimed at supporting growth and employment in the short run while maintaining price stability in the long run.

Figure 3: Response of exchange rate, inflation, policy rate, and output gap to terms of trade shock

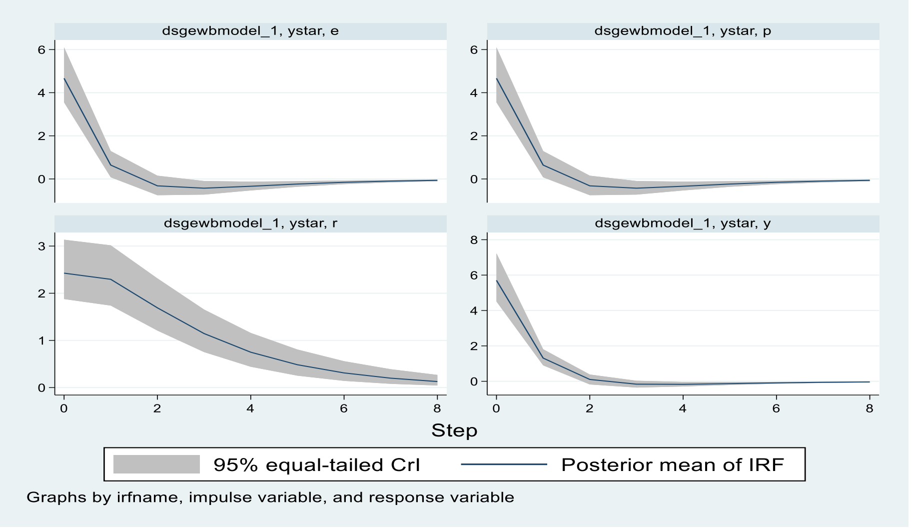


Note: The impulse response graphs represent percentage deviations in depreciation (top-left quadrant), inflation (top-right quadrant), policy rate (bottom-left quadrant), and output gap (bottom-right quadrant) due to a one standard deviation shock to terms of trade.

5.2.4 World demand shock

Given that Ghana is a small-open economy relative to the rest of the world, there is no feedback from the domestic economy to the US economy. However, we observe feedback on the Ghanaian economy concerning shocks from the rest of the world as expected. For instance, Cerra and Saxena (2008) show that global demand shocks have a significant effect on output and prices in low-income countries, while Rodrik (1998) posits that trade openness can make developing countries more vulnerable to external shocks. A positive world output shock increases domestic demand via increased demand for Ghana's export (figure 4). This increases real output above potential (positive output gap), which introduces inflationary pressures within the domestic economy. This is in line with findings from a study by Amoateng and Acquah (2018) on the effect of global oil price shocks on Ghana's economy which suggested that a positive shock leads to an increase in real GDP and inflation in the short run but with the effect tapering off in the medium term. To balance the positive demand shock, rising inflation, and depreciation, the central bank increases the interest rate to reverse a self-reinforcing positive spiral. The shock is short-lived and domestic output declines along with a fall in the inflation rate. Our results contribute to the literature on the response of small open economies to global demand shocks, highlighting the importance of monetary policy in stabilizing the economy in response to such shocks confirming further the findings of Owusu-Afriyie and Farouke (2022).

Figure 4: Response of exchange rate, inflation, policy rate, and output gap to a world demand shock

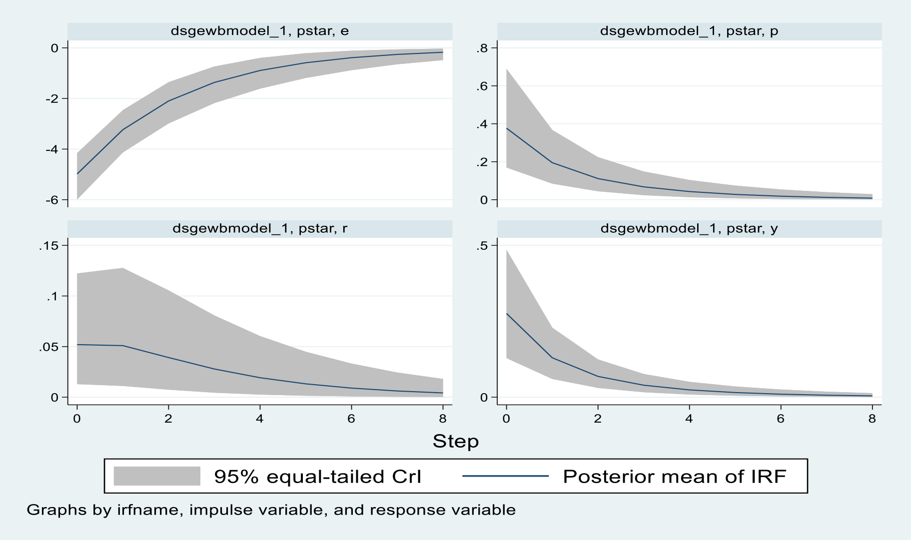


Note: The impulse response graphs represent percentage deviations in depreciation (top-left quadrant), inflation (top-right quadrant), policy rate (bottom-left quadrant), and output gap (bottom-right quadrant) due to a one standard deviation shock to the world output gap.

5.2.5 World inflation shock

We also observed that domestic inflation reacts in the same direction as the world inflation shock. As reflected in Figure 5, the shock causes an appreciation of the domestic currency on impact, since a rise in the interest rate is anticipated. The interest rate hike is in response to imported inflation and overheating in the domestic economy. This shock is temporary and dies out after about eight quarters.

Figure 5: Response of exchange rate, inflation, policy rate, and output gap to a world inflation shock



Note: The impulse response graphs represent percentage deviations in depreciation (top-left quadrant), inflation (top-right quadrant), policy rate (bottom-left quadrant), and output gap (bottom-right quadrant) due to a one standard deviation shock to world inflation.

6.0 SUMMARY, CONCLUSION, AND POLICY RECOMMENDATIONS

6.1 Summary

Ghana has steadily increased its level of economic openness and integration into the global economy in recent years. Consequently, the current account balance has consistently recorded a deficit, thus, contributing to exchange rate pressures. The monetary policy committee of the Bank of Ghana incorporates exchange rate dynamics when setting its key interest rate. Furthermore, key international considerations like trade openness should be taken into consideration in both monetary policy theory and practice. Therefore, this paper examined a small open economy Bayesian DSGE framework to analyse the transmission mechanism, including the multiple channels through which shocks affect macroeconomic variables within the Ghanaian economy.

Utilizing quarterly data on Ghana from 2006 to 2022, we arrive at the following key findings. We confirmed that shocks originating from the domestic economy and the world economy exert a significant impact on macroeconomic variables. The study suggested that the output gap and inflation respond to monetary policy shocks significantly. This indicates that the Bank of Ghana could effectively use its key monetary policy rate to support forward-looking policy decisions which can impact growth and affect firms' pricing decisions. There is also strong evidence of interest rate smoothing. Additionally, the findings are in favour of the idea that central banks in developing economies like Ghana should consider exchange rate dynamics when formulating monetary policy (Taylor, 2000; Xie and Zhang, 2002). Moreover, the study finds that a positive technology shock leads to a widening output gap because labour productivity increases more than real output. The increase in productivity brought about by the positive technology shock lowers the marginal cost of production, which has the immediate effect of reducing inflation and increasing the value of the currency. As a result, the central bank can afford to reduce interest rates to make room for the spare capacity introduced by the shock. It was also observed that an improvement in the terms of trade temporarily widens the output gap through the trade channel as a result of a stronger currency and cheaper imports. This was however found to be temporary and the production disparity quickly closes based on the uniqueness of the Ghanaian economy, given that almost one-third of non-oil imports are intermediate and capital goods. Finally, the study further found evidence that both domestic output and inflation respond positively and significantly to a world demand shock with the appropriate monetary policy reaction to moderate its effect on price stability in the domestic economy.

6.2 Conclusion

In conclusion, the study investigated how shocks, both domestic and external impact the overall Ghanaian economy and also, how effective monetary policy responds to these overwhelming shocks. The paper employed the Bayesian DSGE methodology to analyse the policy interactions among the selected macroeconomic variables (output gap, inflation, monetary policy rate, terms of trade, and exchange rate) using Ghana's data. The study strongly concludes that shocks irrespective of the sources turn out to have a significant impact on macroeconomic variables in Ghana and the deployment of appropriate monetary policy tools could moderate the shock effect on the national economy accordingly.

6.3 Policy Recommendations

I. Increased funding for research and development remains key to the achievement of economic efficiency and structural transformation. Based on the findings of this study, technology shock had a permanent effect on productivity and also growth-enhancing. These findings suggest that if Government could invest more in research and development, it could potentially lead to increased innovation and discovery of new production technologies, which will impact growth positively in the long run. Therefore, it is recommended that current efforts must be geared towards making more economic resources available for funding research and development initiatives that could ultimately lead to greater economic efficiency and structural transformation as new technologies emerge out of this concerted Government effort.

II. Increasing trade openness could be more beneficial to Ghana's growth agenda. Following the findings of this study suggest that positive terms of trade shock had a greater impact on both productivity and currency appreciation. The results of the findings further suggest that policies that promote international trade are welfare-enhancing as well. It is recommended that trade policies that are inimical to trade development should be expunged from our trade policy documents as the country stands to gain more from increased openness while trade policies aiming at expanded exports should be strengthened accordingly.

III. Finally, monetary policy strategies can be employed to reverse an inflation threat to the national economy with an appropriate monetary policy tool. Based on this study, a positive trade shock significantly affected the output gap, and inflation, while monetary policy responded to moderate the effects of the rising output gap and inflation. In line with the above finding, this study, therefore, recommends that monetary policy tools should be deployed effectively in a measured fashion by monetary authorities to ward off any threat to price stability triggered by various types of shocks in the domestic economy in coordination with existing fiscal policies to avoid policy conflicts.

REFERENCES

Abradu-Otoo, P., Acquaye, I., Addy, A., Akosah, N. K., Attuquaye, J., Harvey, S., & Nalban, V. (2022). Quarterly Projection Model for the Bank of Ghana.

Abradu-Otoo, P., Amoah, B., & Bawumia, M. (2003). An investigation of the transmission mechanisms of monetary policy in Ghana: A structural vector error correction analysis. *Bank of Ghana, Working Paper*, *2*.

Amoateng, A. Y., & Acquah, H. D. (2018). Monetary policy transmission mechanism in Ghana: An empirical investigation. *Journal of African Business*, *19*(4), 450-472.

Basu, S., Fernald, J., & Kimball, M. (1998). Are technology Improvements Contractionary? s. *Discussion Papers*, *625*.

Berg, A., Yang, S. C. S., & Zanna, L. F. (2015). Modeling African economies: A DSGE approach. in Célestin Monga, and Justin Yifu Lin (eds), *The Oxford Handbook of Africa and Economics: Volume 1*.

Cerra, V., & Saxena, S. C. (2008). Growth dynamics: the myth of economic recovery. *American Economic Review*, *98*(1), 439-457.

Christiano, L. J., Eichenbaum, M., & Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, *113*(1), 1-45.

Clarida, R., Gali, J., & Gertler, M. (1999). The science of monetary policy: a new Keynesian perspective. *Journal of economic literature*, *37*(4), 1661-1707.

Clarida, R., Gali, J., & Gertler, M. (2000). Monetary policy rules and macroeconomic stability: evidence and some theory. *The Quarterly Journal of Economics*, *115*(1), 147-180.

Clarida, R., Gali, J., & Gertler, M. (2001). Optimal monetary policy in open versus closed economies: an integrated approach. *American Economic Review*, *91*(2), 248-252.

Devereux, M. B., Lane, P. R., & Xu, J. (2006). Exchange rates and monetary policy in emerging market economies. *The Economic Journal*, *116*(511), 478-506.

Duval, Romain and Vogel, Lukas (2008). Oil Price Shocks, Rigidities and the Conduct of Monetary Policy: Some Lessons from a New Keynesian Perspective. *OECD Economics Department Working Papers 603*.

Fofana, F., Antwi, S. K., & Mensah, J. K. (2019). The effects of technology shocks on output and inflation: Evidence from Ghana. Journal of African Business, 20(4), 466-484.

Gali, J. (2009). Monetary Policy, inflation, and the Business Cycle: An Introduction to the New Keynesian Framework. Princeton University Press

Gali, J. and Gertler, M. (2007). Macroeconomic modeling for monetary policy evaluation. Technical report, National Bureau of Economic Research.

Gali, J., & Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies*, *72*(3), 707-734.

Gali, J. (1999). Technology, employment, and the business cycle: do technology shocks explain aggregate fluctuations? *American economic review*, *89*(1), 249-271.

Galí, J., & Rabanal, P. (2004). Technology shocks and aggregate fluctuations: How well does the real business cycle model fit postwar US data? *NBER macroeconomics annual*, *19*, 225-288.

Hove, S., Mama, A. T., & Tchana, F. T. (2015). Monetary policy and commodity terms of trade shocks in emerging market economies. *Economic Modelling*, *49*, 53-71.

Goodfriend, M., & King, R. G. (1997). The new neoclassical synthesis and the role of monetary policy. *NBER macroeconomics annual*, *12*, 231-283.

Iskender, S. (2016). An estimated dsge model for the Kyrgyz Republic: policy implications. Thesis pp 1-30.

Joon-Ho, H., Dong, J.L, & Cyn-Young, P (2022). Domestic and External Monetary Policy Shocks and Economic Inequality in the Republic of Korea. ADB Economics *Working Paper Series*, (654).

Kyereboah-Coleman, A. (2012), "Inflation targeting and inflation management in Ghana", *Journal of Financial Economic Policy*, Vol. 4 No. 1, pp. 25-40.

Kydland, F. E., & Prescott, E. C. (1982). Time to build and aggregate fluctuations. *Econometrica: Journal of the Econometric Society*, 1345-1370.

Laxton, D., & Pesenti, P. (2003). Monetary rules for small, open, emerging economies. *Journal of Monetary Economics*, *50*(5), 1109-1146.

Lucas Jr, R. E. (1976, January). Econometric policy evaluation: A critique. In *Carnegie-Rochester conference series on public policy* (Vol. 1, pp. 19-46). North-Holland.

Michael, B. & Atsuyoshi, M. & Zakari, M. (2020). Inflation Targeting and Monetary Policy in Ghana, *Journal of African Economies*, Volume 29, Issue 2, March 2020, Pages 121–145.

Mehdi, F. (2008). A New Keynesian Small Open Economy DSGE Model in Islamic Economic Framework: The Case of Iran. Journal of Economic Literature

Mohammed, A. L. (2014). DSGE models for developing economies: an application to Morocco. MPRA Paper No. 63404. Online at https://mpra.ub.uni-muenchen.de/63404/

Owusu-Afriyie, E, Owusu-Afriyie, J & Farouk, A.A (2022). Analysis of monetary policy response to productivity and demand shocks in Ghana: a Bayesian DSGE approach. *Journal of West African Financial and Economic Review*, *22*(1), 201-242.

Rodrik, D. (1998). Why do more open economies have bigger governments? *Journal of political economy, 106*(5), 997-1032.

Schmitt-Grohé, S., & Uribe, M. (2007). Optimal simple and implementable monetary and fiscal rules. *Journal of Monetary Economics*, *54*(6), 1702-1725.

Smets, F., & Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the euro area. *Journal of the European economic association*, *1*(5), 1123-1175.

Smets, F., & Wouters, R. (2007). Shocks and frictions in US business cycles: A Bayesian DSGE approach. *American economic review*, *97*(3), 586-606.

Soto, C., & Medina, J. P. (2005). Oil shocks and monetary policy in an estimated DSGE model for a small open economy. *Documentos de Trabajo (Banco Central de Chile)*, (353), 1.

Svensson, L. E. (2000). The zero bound in an open economy: A foolproof way of escaping from a liquidity trap.

Svensson, L. E. (2002). Inflation targeting: should it be modeled as an instrument rule or a targeting rule? *European Economic Review*, *46*(4-5), 771-780.

Svensson Lars, E. O. (2003). Escaping from a Liquidity Trap and Deflation: The Foolproof Way and Others. *NBER Working Paper*, (10195), 1-22.

Taylor, J. B. (2000, November). Using monetary policy rules in emerging market economies. In *75th Anniversary Conference," Stabilization and Monetary Policy: The International Experience", Bank of Mexico*.

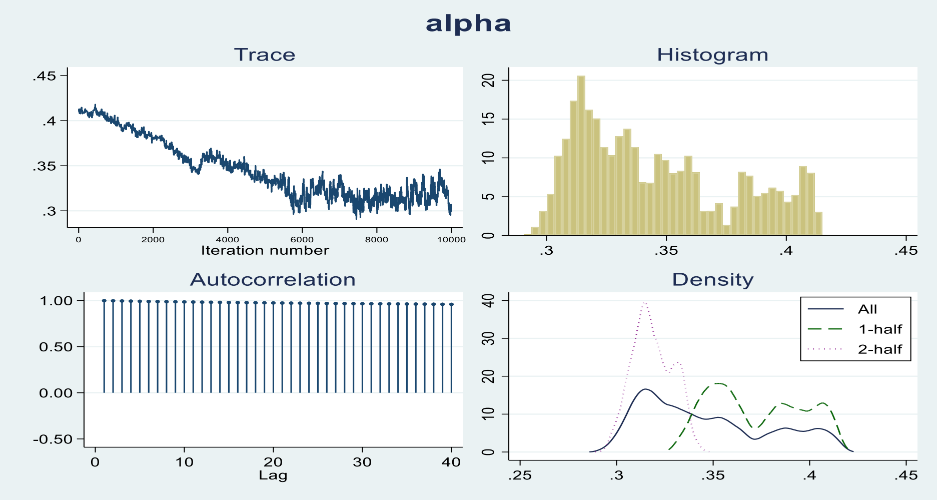
Ünalmış, D., Unalmis, I., & Unsal, F. (2008). *Oil Price Shocks, Macroeconomics Stability and Welfare in a Small Open Economy*. Department of Economics, University of York.

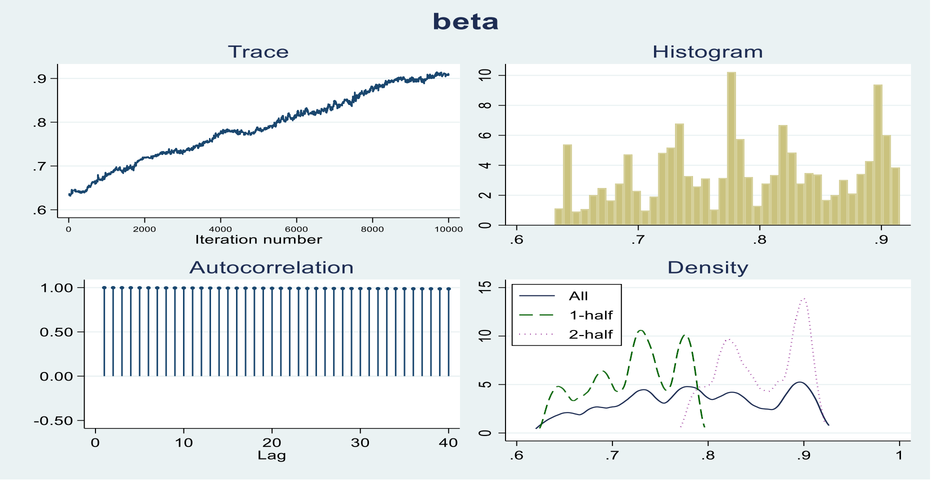
Xie, P., & Zhang, X. (2002). Three conflicts between monetary policy and exchange rate policy. *International Economic Review*, *5*, 30-35.

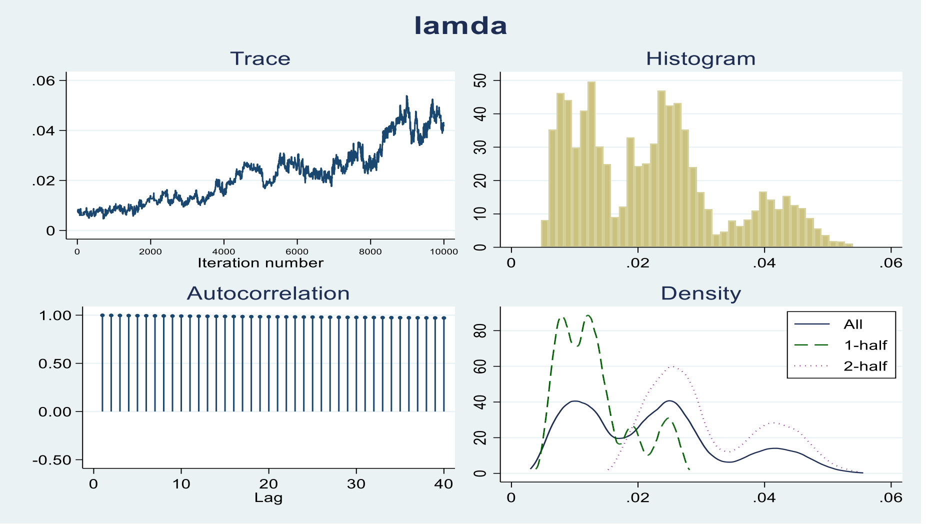
Xin, X & Xiaoguang, X (2021). External shocks in a small open economy: an evaluation of monetary policy rules. *Economic Research Review, 35*(1), 4988–5013.

APPENDIX A
(CONVERGENCE DIAGNOSTICS)

A. Convergence Diagnostics for parameters without Block option



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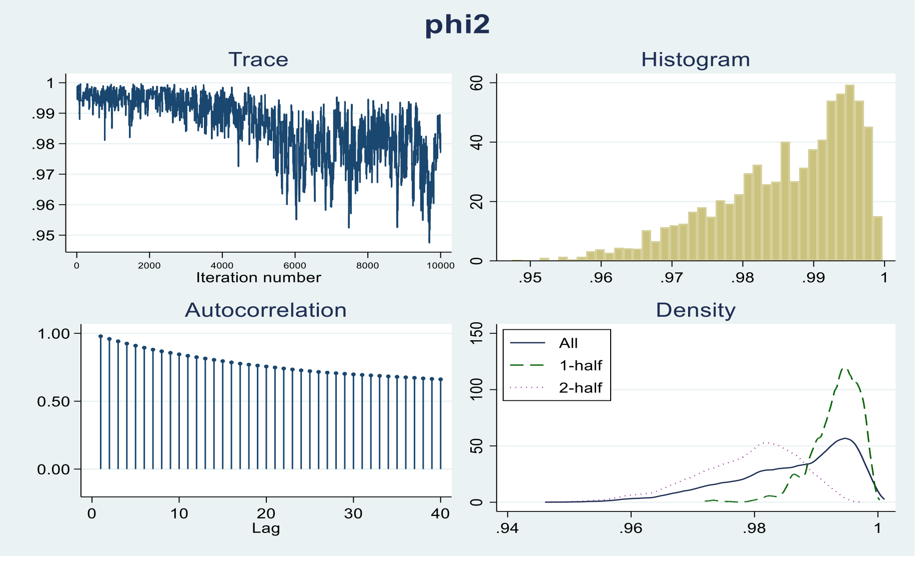
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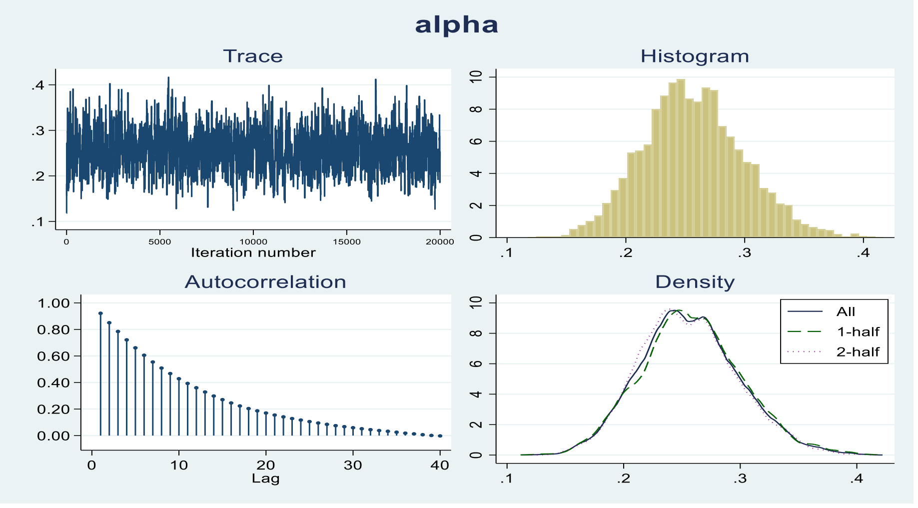

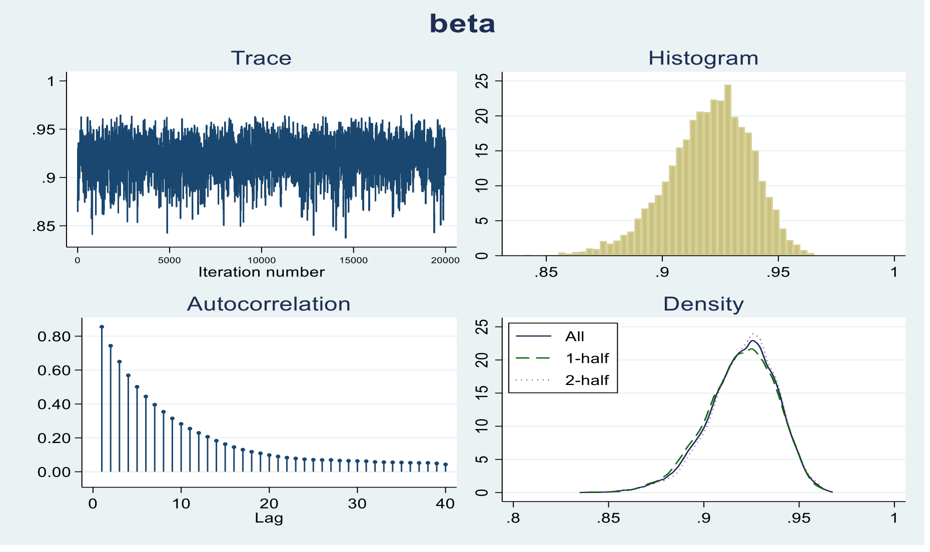

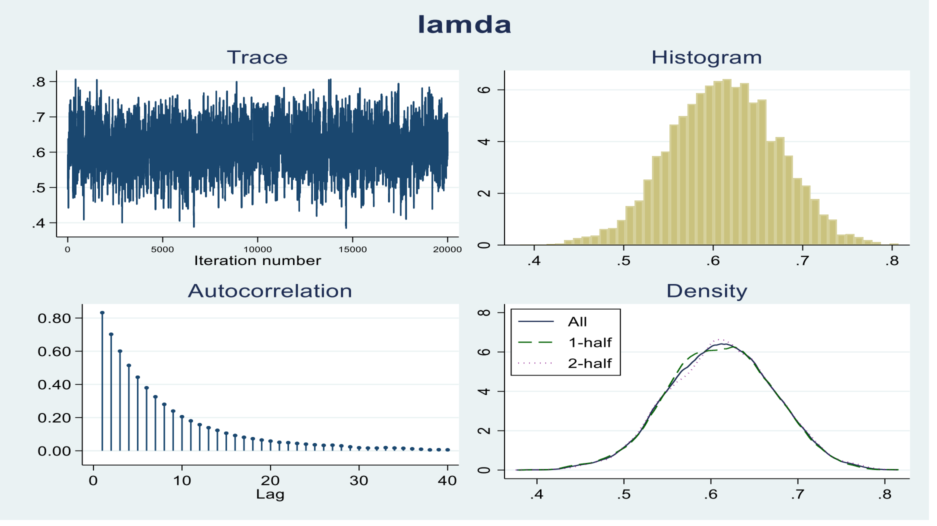
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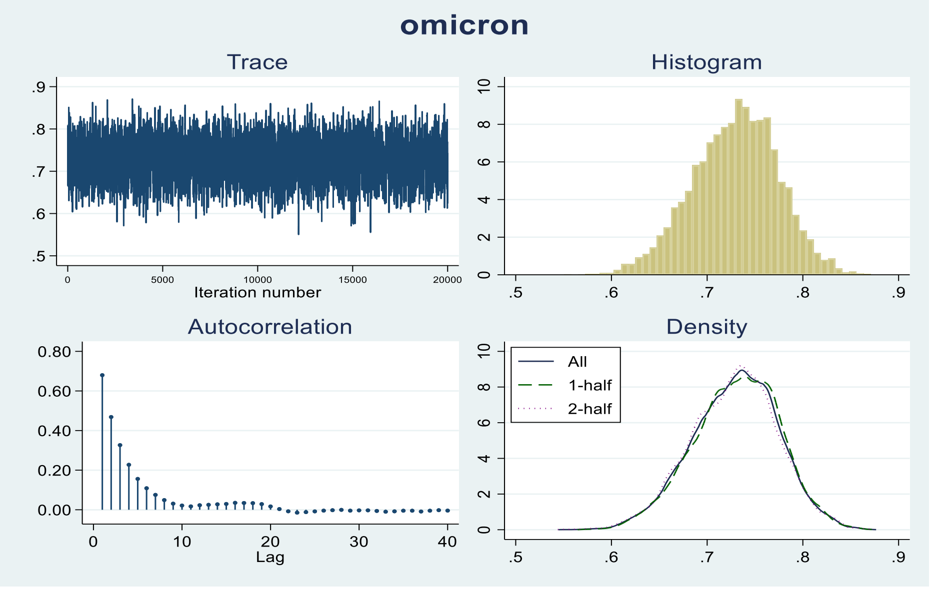
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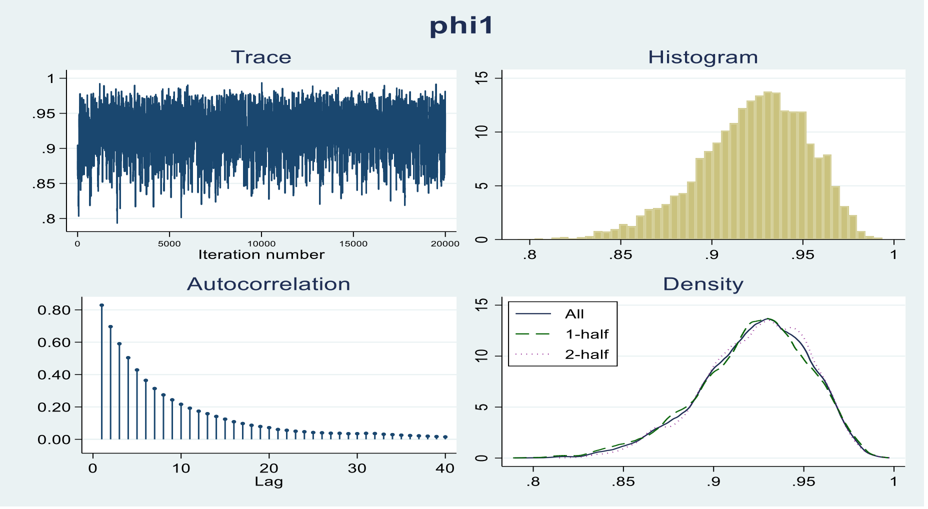
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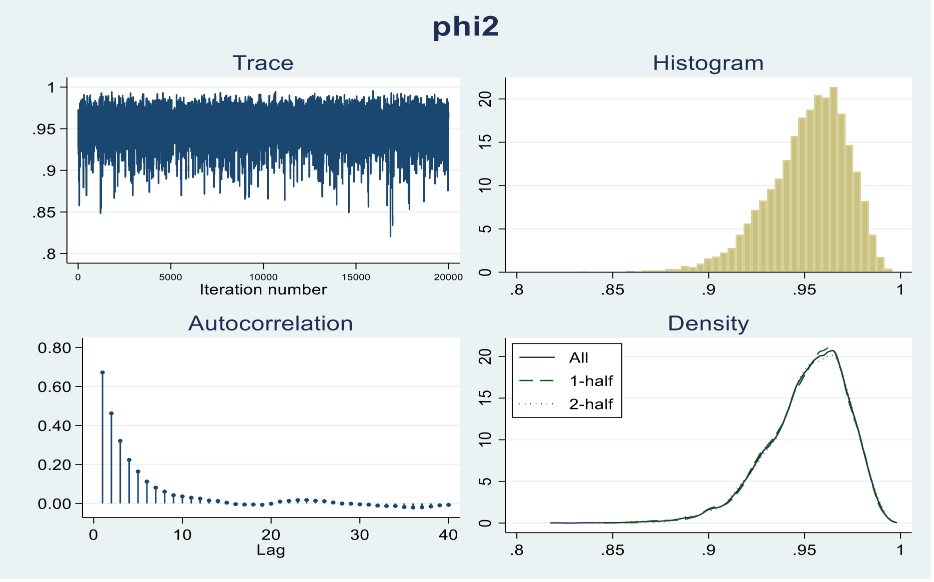
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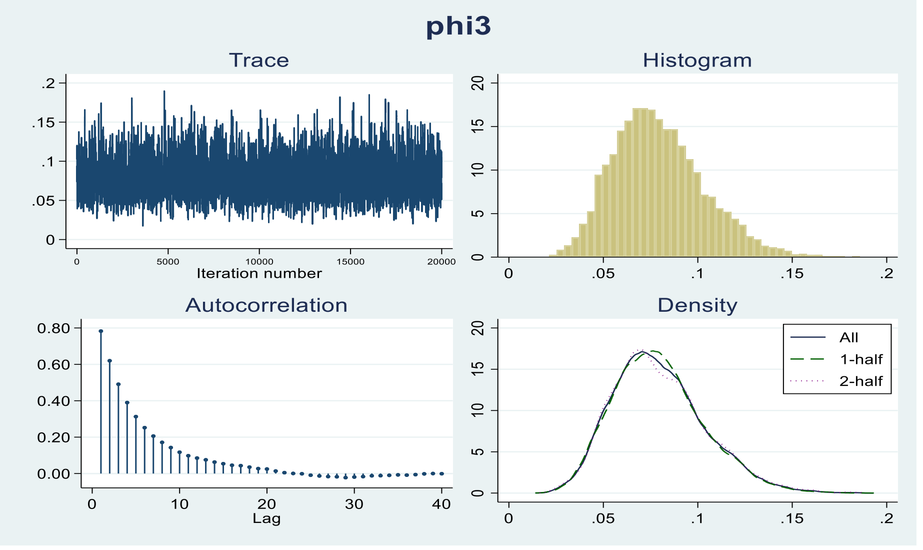
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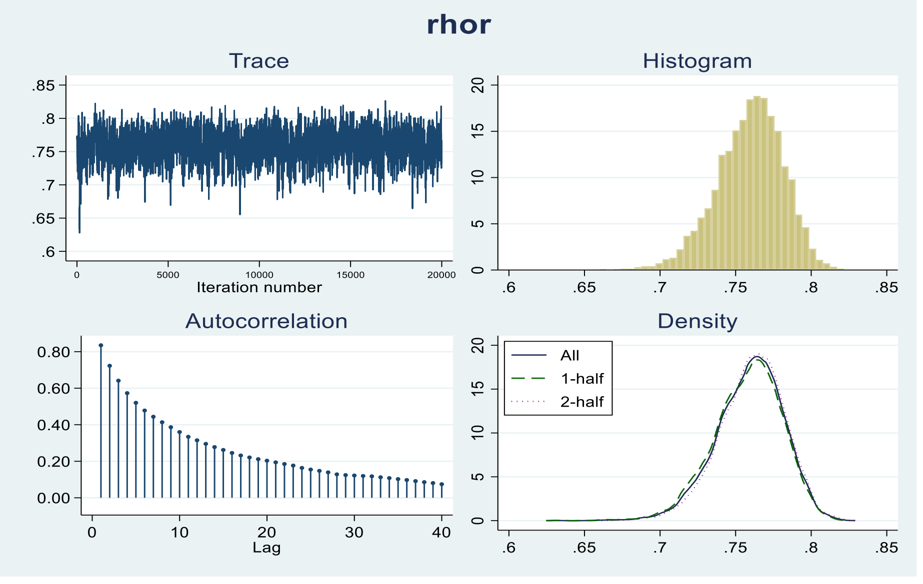
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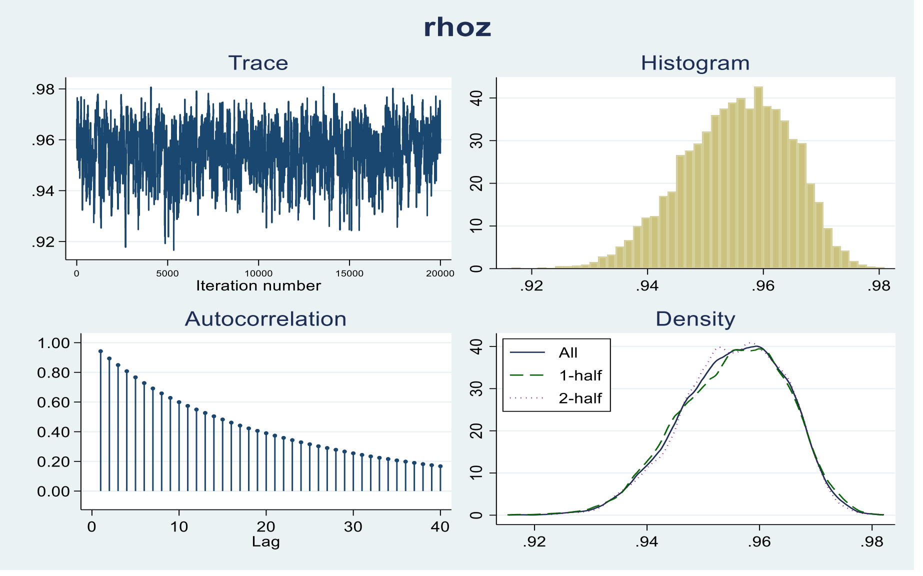
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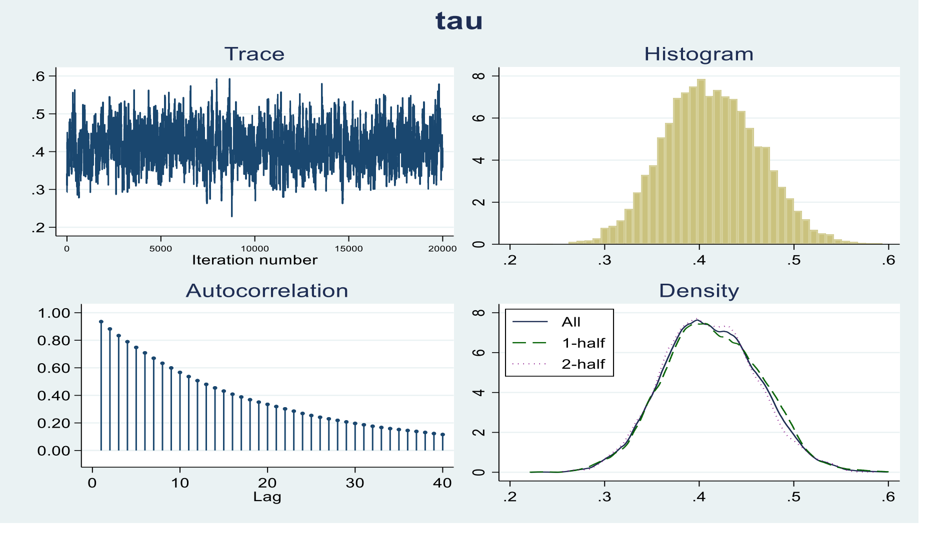
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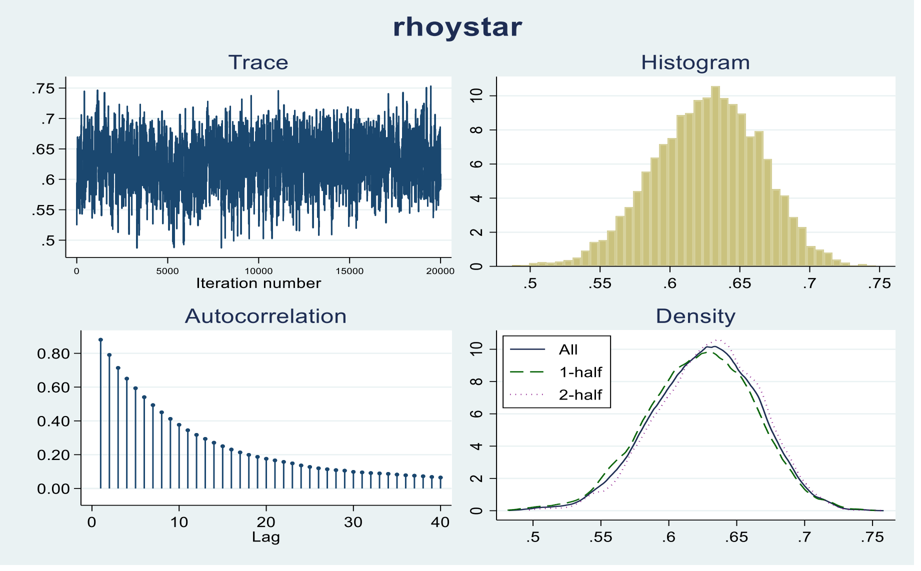
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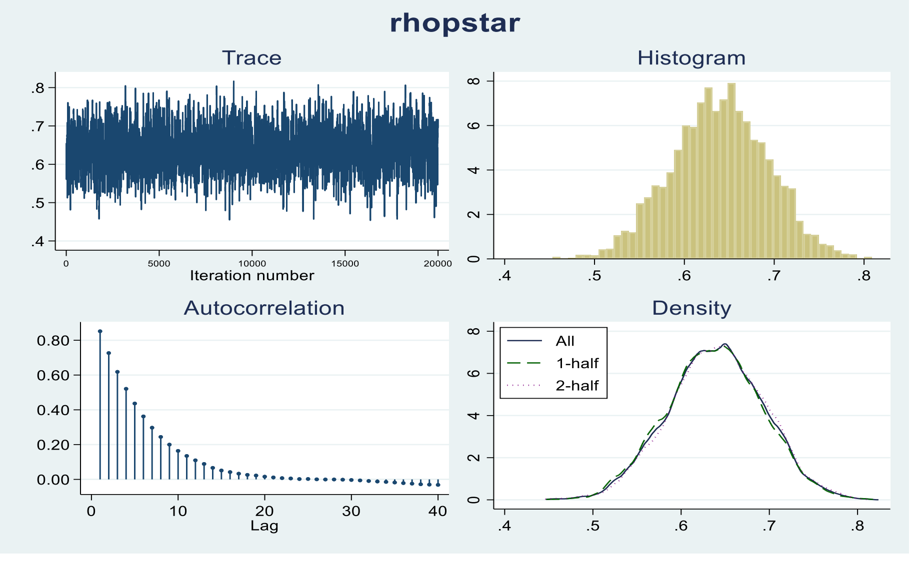
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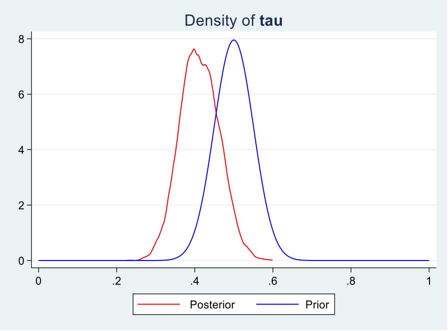
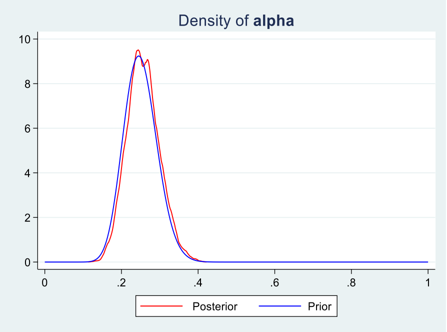
APPENDIX B: EFFICIENCY SUMMARIES

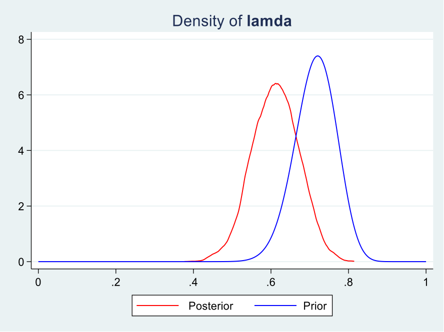
	WITHOUT BLOCK		WITH BLOCK	
Parameters	**ESS**	**Efficiency**	**ESS**	**Efficiency**
$\boldsymbol{\delta_1}$	12.33	0.0012	1366.39	0.0683
$\boldsymbol{\delta_2}$	17.05	0.0017	3626.84	0.1813
$\boldsymbol{\delta_3}$	11.22	0.0011	2196.96	0.1098
$\boldsymbol{\rho_{mpr}}$	10.80	0.0011	754.27	0.0377
$\boldsymbol{\alpha}$	11.22	0.0011	914.17	0.0457
K	10.92	0.0011	3432.39	0.1716
$\boldsymbol{\beta}$	10.88	0.0011	1154.01	0.0577
$\boldsymbol{\tau}$	11.18	0.0011	521.69	0.0261
$\boldsymbol{\rho_g}$	11.06	0.0011	4064.35	0.2032
$\boldsymbol{\rho_u}$	11.73	0.0012	436.11	0.0218
$\boldsymbol{\rho_{x^*}}$	12.90	0.0013	738.17	0.0369
$\boldsymbol{\rho_{\pi^*}}$	12.55	0.0013	1810.65	0.0905
$\boldsymbol{\sigma_{\varepsilon_{mprt}}}$	10.86	0.0011	605.00	0.0302
$\boldsymbol{\sigma_g}$	10.76	0.0011	3643.45	0.1822
$\boldsymbol{\sigma_u}$	11.01	0.0011	397.41	0.0171
$\boldsymbol{\sigma_{x^*}}$	10.93	0.0011	341.99	0.0171
$\boldsymbol{\sigma_{\pi^*}}$	10.94	0.0011	1027.66	0.0514

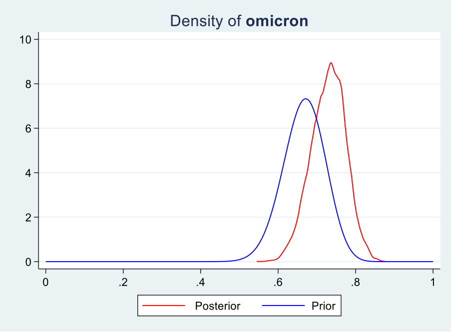
Note: MCMC size is 10,000 with a burn-in length of 2,500 for the model without block while MCMC size is 20,000 with a burn-in of 5,000 for the model with block. The average efficiency for the model without a block is 0.001166 but 0.07932 for the model with a block.

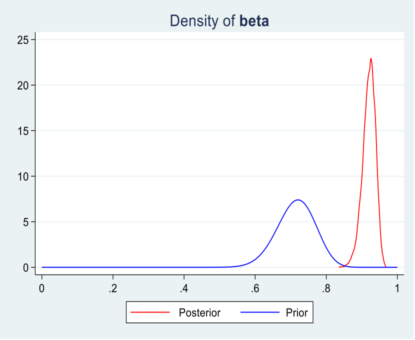
APPENDIX C: PRIOR AND POSTERIOR DENSITY GRAPHS OF THE PARAMETERS

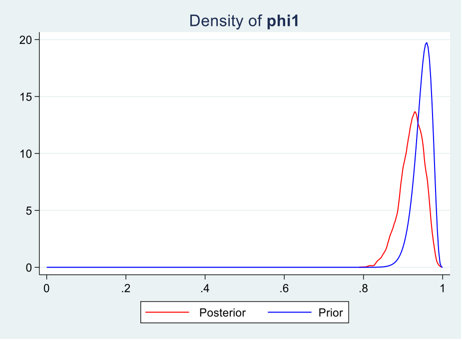


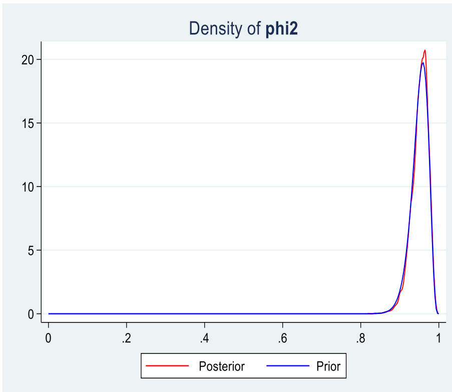








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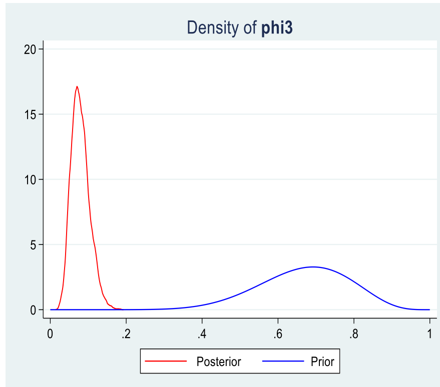
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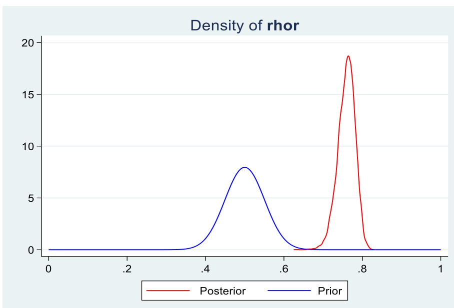
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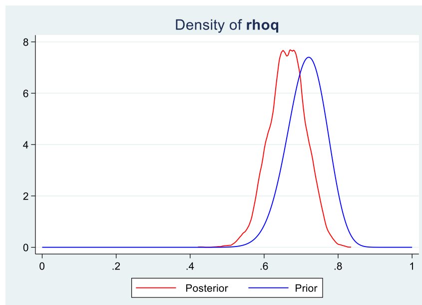
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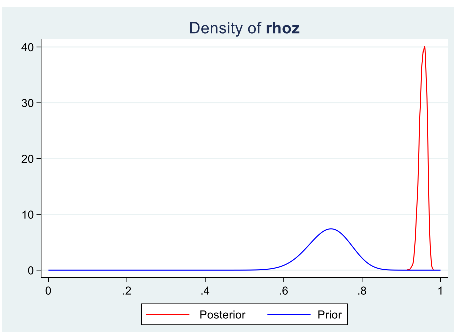
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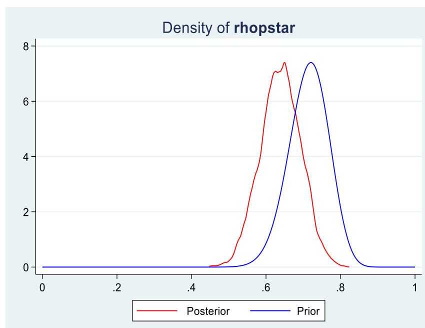
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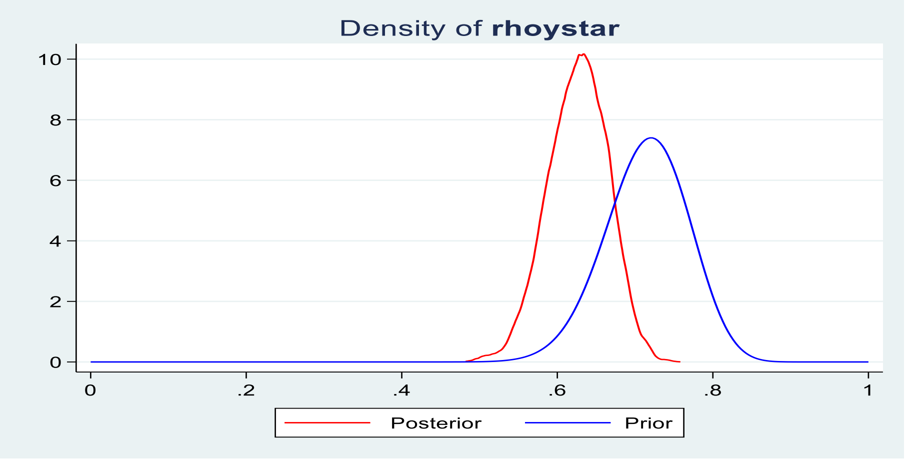
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DETERMINANTS OF THE CHOICE OF EXCHANGE RATE REGIMES IN THE ECOWAS

Hassan O. Ozekhome*[1]

Abstract

The monetary and economic unification agenda in the ECOWAS region cannot be realized without an exchange rate regime that will ensure that the region is economically competitive, diversified, robust and resilient to the needed macroeconomic performance and external and internal stability (balance). Against this background, this paper investigates the determinants of the choice of exchange rate regime in the ECOWAS using a discrete binary model. To uncover the relationship across countries and across time, a binary logit estimation is implemented. The findings show that the determinants of the choice of exchange rate regimes in the ECOWAS sub-region are economic size, trade openness, degree of capital mobility, inflation rate, inflation volatility, foreign reserves and socio-political stability. Specifically, a greater degree of domestic openness, economic size, capital mobility, inflation, inflation variability and socio-political stability are more likely to be associated with floating rate regimes, while the high level of fiscal deficit and high reserves to import ratios are less likely to be associated with floating rates. The paper recommends a greater degree of exchange rate flexibility to enhance regional trade and external competitiveness, allow investment and financial linkages, provide the flexibility to accommodate domestic and external shocks, and mitigate sustained disequilibria associated with the fixed rate regime, as this can facilitate the monetary unification agenda for West Africa.

Keywords: *Exchange rate regimes, Optimum currency areas, Binary logit regression.*
JEL Classification*: E42, F33, F36, F42*

1.0 INTRODUCTION

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The author is are grateful to the anonymous reviewers for their helpful comments on earlier versions of the paper

The debate over the choice of the exchange-rate regime, and in particular, which regime is appropriate at any given point in time or across time, has dominated empirical investigation and policy discourse over the last decade (see Ozekhome, 2017; Nathaniel, et al., 2019; Das, 2019; IMF, 2022). The exchange rate regime is a crucial component of the macroeconomic policy of any country. The fundamental aim of the regime choice is to adopt an exchange rate that is consistent with the attainment of external objectives, particularly in an increasingly integrated world of international trade and financial linkages, with high capital mobility. The exchange rate regime choice has vast implications for international trade flows and competitiveness, resource allocation, investment external balance, fiscal viability, external debt management, employment, productivity and output (Ozekhome, 202). For instance, maintaining a sustainable current account balance and the promotion of international trade and competitiveness, as well as long-run economic growth requires the combination of fiscal, monetary and trade policies, which includes appropriate exchange rate policy, as well as debt management in response to changing conditions. In this direction, policymakers may consider the choice of maintaining a flexible or fixed regime in adjusting to a shock or external disequilibria in the balance of payments.

While economic outcomes are sensitive to the nature of the prevailing exchange rate arrangements, they are also influenced by structural characteristics of the national and international environment, such as the degree of international capital mobility (Fausten, 2010). Most member countries of the ECOWAS switched from the fixed/pegged exchange rate regime to the flexible exchange rate regime in the 1980s to allow greater flexibility and adjustment to external disequilibria and adjustment to shocks arising from increased international trade and financial linkages. For instance, a flexible exchange regime allows monetary policy independence, with inbuilt flexibility to accommodate and respond to domestic and external shocks and thus, the use of exchange rate as an instrument for adjusting to shocks, but imparts a lower degree of credibility. Nevertheless, it increases transaction costs and uncertainty, given its perceived high volatility and sustained misalignment that discourages trade and investment, and hence, economic growth. There are also costs and benefits associated with a fixed exchange rate regime, with the extreme being a monetary union. The most obvious benefit is that it reduces transaction costs, as well as exchange rate uncertainty. In addition, it increases price transparency and could potentially enhance policy discipline and credibility. The main cost is the inability to pursue an independent monetary policy and to rely on the exchange rate as an instrument of macroeconomic adjustment (IMF, 2022).

Floating rates are generally considered particularly suitable for countries with idiosyncratic economic structures. The literature suggests that at least four elements are critical to the viability of currency unions in the presence of asymmetric structures and shocks. They are labour mobility, where the free movement of labour smoothens regional disparities in unemployment rates; capital mobility, which allows savings and investment to seek out the most profitable opportunities while barriers to capital movement hinder this; openness and regional interdependence, enabling the use of the same currency where goods move freely between the regions, and where a significant regional trade is carried out; and wage and price flexibility, such that resources can only be allocated to their best uses given that wages and prices are sufficiently flexible (Hochreiter & Siklos, 2002). Experience of exchange rate crisis has shown that inappropriately selected exchange rate regimes, not hinged on a country's economic and structural perspective could induce widespread economic and financial crises, with external and internal disequilibria. The devastation brought about by the economic and financial crises in Latin America and Asian countries in the 1990s, and the inglorious role played by the lack of an optimal exchange rate regime in fuelling the crisis, no doubt informed policymakers on the need for an appropriate exchange rate management. An inappropriate exchange rate regime not based on careful identification of the fundamental prevailing economic situation and subsisting challenge, as well as the goal of the external sector could obviate the attainment of external and domestic long-run policy (Ozekhome, 2017). To this end, the determination of an optimal exchange rate regime is critical for attaining external equilibrium (balance) and macroeconomic stabilization.

In investigating the choice of exchange rate regimes, various explanations have been provided using the optimum currency (OCA) theory and its long-run fundamental economic determinants such as economic size and openness. Financial market considerations, such as international financial integration and/or capital account openness, foreign exchange and capital markets configuration and macroeconomic variables, like the level of a country's deficit, international reserves and inflation rate have also provided explanations for the choice of exchange rate regime (Frankel, 1995, Edwards, 1996; Hausmann et al, 2000). The social welfare-function maximization framework has also been used to provide meaningful explanations and relationships in the choice of exchange rate regimes (Berger, Sturm & de Haan, 2000). Several other studies (Berger, Sturm & de Hann, 2000; Papaioannou, 2003) emphasized the role of political and institutional variables such as the independence of the central bank, and political stability as additional long-run determinants of exchange rate regime choice. The determinants of the choice of exchange rate regimes have also been analysed from the perspective of the economic consequences and policy requirements associated with maintaining a given exchange rate regime. In line with this, countries switch from a given exchange rate regime to others (e.g. fixed to floating rate regime) in the expectation of potential economic benefits associated with such a switch. For example, countries with substantial foreign real shocks would find it optimal to adopt the flexible rate system (IMF, 2005).

The high inflationary environment in many countries during the past decades presented a novel approach and dynamics to the issue of exchange rate choice that centred on inflation transmission between countries. Following this position, several studies (see Gali, & Gertler, 2007; IMF, 2022) stressed that potential credibility gains might also influence the choice of exchange rate regimes. For instance, a fixed exchange rate regime might aid the importation of low-inflation credibility policies from a foreign central bank to a domestic economy. In this regard, the choice of exchange rate regime should as a matter of policy importance, considers the existence of asymmetries among countries. For instance, where there are substantial variations in economic structure and shocks, the floating rates are optimal, except satisfactory wage and price flexibility, as well as resource mobility, are available to accommodate adjustments. Thus, the trade-off between credibility and flexibility has been found to influence exchange rate regime choice (see Giavazzi & Pagano, 1988; Rodrick & Devarajan, 1990; Papaioannou, 2003). Here, the monetary authority seeks to maximize a utility function or minimize a loss function in terms of the choice between fixed and flexible exchange rate regimes. The regime choice must, therefore, compare the expected losses under each scenario. Others (see Milesi-Ferretti, 1995; Frankel, 1996, Edward, 1996; Berger et al 2001; Papaioannou, 2003) emphasized the trade-off between credibility and flexibility. Following this contention, Giavazzi and Pagano (1988) and Mendoza (2001), maintained that a flexible exchange rate allows a country to have an independent monetary policy, enabling the flexibility to accommodate domestic and foreign shocks, while a fixed exchange rate regime lowers the degree of flexibility to accommodate shocks, but offers a higher level of credibility. Some other studies (Collins, 1996; Edward & Savastano, 1999; Klein & Marion, 1997, Blomberg & Hess, 1997) maintain that a flexible exchange rate regime has political-economy advantages in that it reduces the political costs associated with exchange rate fluctuations. Hochreiter et al (2003), in this regard, arguing that an exchange rate regime can be conceived as a mechanism to allocate inter-temporally, the burden of the inflation tax.

While many studies have investigated the determinants of the choice of exchange rate regime or exchange rate regime switching in many developed and emerging economies (see Papaioannou, 2003; Fiess & Shankar, 2009; Aliyev, 2014; Ozekhome, 2017; Das, 2019), there is however, paucity of empirical studies on determinants of the choice of exchange regimes at cross-country and regional levels, like the ECOWAS. This is important given the current state of affairs regarding the proposed single currency drive, wherein sound exchange rate management is relevant. Few other studies have considered the connections between exchange rate regimes and macroeconomic fundamentals (see for instance, Gnimassoun & Coulibaly, 2014; Gnimassoun 2015; Nathaniel et al., 2019, MF, 2022). Nevertheless, there is no specific study devoted to the choice of exchange rate regimes at the ECOWAS level. Without a doubt, exchange rate regime choices have vast implications for monetary and economic integration in the ECOWAS. Accordingly, this study has empirical and policy relevance as it could broaden policy makers' understanding of the drivers of exchange rate regime choices in the ECOWAS, for the attainment of domestic and external outcomes. In addition, the findings from this study will inform policies to enhance regional economic and monetary integration because of the ongoing move towards introducing a common currency within the region. Furthermore, the implementation of appropriate exchange rate arrangements will help ensure that the component economies of the ECOWAS remain competitive, with strong economic and financial linkages. The study utilizes a binary choice model within a panel framework using data on ECOWAS countries to examine the probability of the factors being associated with the floating and fixed exchange rate regimes as reference categories, and no study to the best of the author's knowledge has been devoted to this

Following, this introduction, the paper is structured as follows. Section 2 presents a review of the literature that focuses on the theoretical, empirical and policy issues connected with the choice of exchange rate regimes. Section 3 contains the methodology and data. The empirical results and analyses are presented in section 4, while the conclusion and evidence-based policy perspectives are presented in section 5.

2.0 Literature Review

The OCAs credited to Mundell (1961) and Mckinnon (1963) draw heavily on contemporary debates about fixed versus flexible exchange rates. It explains the choice of exchange rate regime to some long-run economic determinants that are relatively stable over time (e.g growth rate of GDP, openness, inflation and fiscal deficits), as well as structural characteristics and nature and degree of shocks generated by trade flows, including terms of trade deterioration. In its traditional form, the theory maintains that a low degree of openness and large economic size should support a floating exchange rate regime. Nevertheless, countries with a high degree of openness to international capital flows are likely to find exchange rate flexibility optimal. Successive versions of the theory (see Fischer, 1977; Marston, 1981) emphasize the nature and size of economic shocks, as well as the structure of the economy as potential determinants of the optimal choice of exchange rate regimes. For external and domestic real shocks, e.g. a change in demand for domestic goods, as well as external nominal shocks, a higher level of exchange rate flexibility is desirable. If however, the country is faced with domestic nominal shocks, it will not be necessary to have an exchange rate flexibility. The Mundell-Fleming model suggests that the choice of exchange rate regime is mainly determined by the nature of shocks affecting the economy (Lahiri, Singh & Vegh, 2006). Accordingly, in the case of real shocks flexible exchange rate is optimal. If however, monetary shocks exist, a fixed exchange rate regime is preferred. Extending Friedman's analysis, Mundell (1963) introduced a world of capital mobility, where the choice between fixed and floating rates depends on the shock's origin, either real or nominal and the degree of capital mobility. For an open economy, with high capital flows, a floating exchange rate offers insulation against real shocks, e.g. a shift in export demand or terms of trade. A fixed exchange rate, on the other hand, is preferable where there are nominal shocks, e.g. a change in the demand for money.

A bulk of the theoretical literature focuses on how exchange rate regime choice is likely to determine macroeconomic stability. Although variations exist concerning the theoretical arguments, the broad-spectrum of an idea is that the appropriate exchange rate system will vary by the nature and degree of disturbance in the economy, particularly idiosyncratic shocks. Where the individual variance of real and monetary shocks is computed, if the ratio of the variances between monetary and real shocks tends towards infinity (due either to the fact that the former tends towards infinity or because the latter approaches zero), the freely floating exchange rate system becomes optimal. Similarly, where the ratio tends towards zero (because the variance of the effective monetary shock approaches zero or because the variance of the real shock tends towards infinity), the fixed exchange rate regime becomes the optimal exchange rate (Ziky et al., 2013). A higher degree of real shock variance increases the attractiveness of exchange rate fixity. Nevertheless, the probability of adopting flexible exchange rate increases where large variances of shocks are associated with money demand, money supply, foreign prices and purchasing power parities (Azienman & Frankel, 1981). For small-sized developing economies, with highly concentrated (undiversified) production patterns, high real shock variances unlike the diversified economies are conspicuous. Such economies, therefore find it optimal to adopt a higher fixed exchange rate regime. ECOWAS countries, for instance, are characterized by dependence on primary commodities for exports that have low-value capacity, structural weakness in terms of trade deterioration, heavy dependence on essential imports, especially capital machinery, intermediate goods and raw materials substantial capital flows; and relatively low coefficients of price elasticity of domestic and foreign demand for imports and exports, respectively. The considerations tend to subject the economies to internationally generated and transmitted trade shocks, as well as volatility in commodity prices, which eventually precipitate macroeconomic fluctuations and external disequilibria (Ozekhome, 2017).

In the capital account openness hypothesis, capital market factors are potential determinants of exchange rate regime choice. Increased capital mobility (i.e. .open capital account) prompts countries to move towards hard pegs or pure floats (see Fischer, 2001). Measures of capital account openness that have been identified in the literature as explaining the exchange rate regime choice are defector capital openness, measured by the ratio of gross international inflows and outflows of capital to gross domestic product (Ozekhome, 2017). This measure of financial openness captures de facto financial integration in terms of realized /actual capital flows. Other measures that have been used are ratios of foreign assets of the banking system to money supply and capital controls drawn or constructed by the IMF (Poirson, 2001; Papaioannou, 2003). Finally, the institutional and historical characteristics hypothesis relates some of the long-run determinants of exchange rate regime choice to institutional and political variables. Several empirical studies in the institutional and historical characteristics tradition consider variables connected to political economy or institutional capacity such as political stability/instability, government characteristics and central bank independence to influence the choice of change rate regimes. For example, a lack of institutional strength or political stability may make it difficult to sustain a fixed exchange rate regime, but may also increase the attractiveness of the fixed rate regime, particularly a currency union. Following this postulation, strong fiscal institution, as well as political stability favours the durability of the fixed or floating rate regime (Berger, et al., 2001).

On the empirical determinants of the choice of exchange rate regimes, studies are diverse and inconclusive. While some studies (see Corden, 2002; IMF, 2005) maintain that openness could motivate fixed exchange rate regimes, others assert that foreign shocks should predominate in countries with higher levels of openness, raising the incentive for floating rates as shocks absorbers (Eichengreen & Masson, 1998; Mussa et al., 2000; Papaioannou, 2003). Specifically, a greater degree of terms of trade volatility is likely to favour floating rate regimes, since they help to mitigate the effects of short-term real external shocks. Several others (see Mussa et al., 2000; Berger et al., 2000; Fischer, 2001; Das, 2019) argue that a greater degree of openness offers higher scope for a substantial foreign exchange market, thus providing an incentive for the floating regime. Besides, openness, by its very nature, might be endogenous to the exchange rate regime, creating reservations as to whether a correlation between openness and fixed exchange rate regimes could be accorded a clear-cut spontaneous interpretation (Jaun & Mauro, 2002). Many empirical studies, in a bid to investigate the impact of explanatory variables on the choice of exchange rate regimes, used several optimum currency area variables. These variables include openness, economic size (measured as GDP in common currency), level of economic development (captured by GDP per capita), and share of trade (Edwards, 1999; Berger, et al., 2000; Poirson, 2001; Papaioannou, 2003; Ozekhome, 2017; Das, 2019, Nathaniel et al., 2019).

To evaluate the significance of these long-run determinants, most studies use cross-country regressions. Various studies have produced significantly different results for each such determinant, depending on the sample of countries, period analyzed, estimation method, exchange rate classification, and additional factors included in the estimation. Most of the empirical findings show an ambiguous role of these determinants in explaining the choice of exchange rate regimes in countries. Specifically, openness, the most frequently examined variable is found to be associated with floating regimes in studies such as Berger et al. (2000), Papaioannou (2003), and Ozekhome (2017); significantly correlated with fixed rates regime in Honkanpohja and Pikkarainen (1994); and not significantly connected to any specific regime by Poirson (2001). For example, in Rodriguez (2016), the greater the size of tradable sectors, the lower the propensity that a country's government will adopt a pegged currency, and the desirability of fixed exchange rate regimes are higher with small and open economies about trade and financial flows. Per capita GDP is significantly associated with floating regimes in Papaioannou (2003), IMF (2005) Gnimassiun (2015), and Das (2019; significantly related with fixed rate regimes in Honkanpohja and Pikkarainen (1994), and Edward (1999); and not robustly associated with any regime in Rizzo (1998) and Poirson (2001). Nevertheless, a few variables appear to generate relatively significant results as regard exchange rate regime choice.

For instance, the size of an economy appears to be positively and significantly associated with floating rates in Papaioannou (2003), Fiess and Shankar (2009), Ozekhome (2017), Das, (2019), Nathaniel et al., (2019), IMF (2022). In addition, IMF (2005) finds evidence that small–sized economies with a low degree of product diversification in international trade tend to select pegged exchange rate regimes in a bid to circumvent the extreme volatility of the real exchange rate. Besides, inflation, measured as the growth rate of the consumer price index (CPI) is found mostly positive and significant for floating exchange rate regimes in Poirson, (2001), Papaioannou (2003) Ozekhome (2017), Furthermore, high level of inflation significantly affects the probability of choosing any regime in the opposite direction than low/moderate inflation (Papaioannou, 2003; Das, 2019; Nathaniel et al., 2019). Similarly, the simple inflation differential tends to be positively and significantly associated with floating rate regimes in Holden et al (1997).

Several volatility variables have also been found to be associated with floating rate regimes. For instance, Poirson, (2001) and Papaioannou (2003) find terms of trade volatility to be positively and significantly associated with floating regimes, while Honkanpohja and Pikkarainen, (1994) find a positive but not significant relationship. Furthermore, the variability of export growth is positively and significantly associated with floating regimes in IMF (2005) and positive but not significant for floating rate regimes in Papaioannou (2003). Similarly, to Edwards (1999), external variability when interacting with openness is negative and significant for floating regimes. A floating rate regime performs the role of a shock absorber. The volatility of the real exchange rate is positive and significant for floating rate regimes in Edwards (1999); Papaioannou (2003) and IMF (2005). Some other studies (see for example, Fischer, 2001; Poirson, 2001; Papaioannou, 2003; Ziky et al., 2013; Ozekhome, 2017) find capital account openness/ economic and financial integration) a robust determinant of exchange rate regime choice, with increased capital flows being highly associated with the floating exchange rate regime (i.e. high probability).

Political and institutional variables have also been found as potential long-run factors that influence exchange rate regime choice (see Papaioannou, 2003; Aliyev, 2014, Rodriguez, 2016). For example, the absence of strong institutional settings (institutional strength) and/or political instability may reduce the probability of adopting a flexible exchange rate regime (Berger, et al., 2000; Berger et al., 2001; Rodriguez, 2016). Variables like fiscal institutions, independence of the central bank (see Ziky, et al., 2013; Aliyev; 2014), and government characteristics are critical to a lower inflationary bias. In addition, credibility gain influences the choice of an optimal exchange rate regime when institutional strength or political stability (i.e. political and institutional dynamics) in a country can sustain a peg. Finally, macroeconomic variables, such as inflation rate, foreign exchange reserves, exports, fiscal deficits and output volatility are found to influence exchange rate regime choice in Berger et al (2000), Poirson (2001), Papaioannou, 2003), Stancik (2006), and Ozekhome (2017). Some studies consider the reverse link between exchange rate regime and macroeconomic fundamentals, in terms of the extent to which the choice of exchange rate regimes influence external outcome variables, and find exchange rate regime to be significant to external balance, particularly, in ensuring current account sustainability (see Gnimassoun & Coulibaly, 2014; Gnimassoun, 2015; IMF, 2022).

Gap(s) in the Literature

From the review of the pertinent literature, there is an appreciable scarcity of empirical studies on the determinants of the choice of exchange rate regimes at cross-country or regional levels, including ECOWAS. Besides, the existing few studies (e.g. Aliyev, 2014; Ozekhome, 2017) did not account for factors such as the degree of capital mobility/financial integration, fiscal management and institutional characteristics, such as political stability in the choice of exchange rate regime. These factors are crucial, especially for an evolving region, where economic, structural and institutional constraints, as well as government characteristics, affect exchange rate policy. Besides, given the current state of affairs regarding the proposed single currency drive in the region, the determination of an appropriate exchange rate policy, against the backdrop of the prevailing economic situation and subsisting challenge faced by the region is sacrosanct. The study is therefore relevant for adducing empirically-oriented policy perspectives for economic and monetary integration in the ECOWAS region.

3.0 METHODOLOGY

3.1. Theoretical Framework

Based on the theoretical underpinnings of the OCAs, the growth rate of GDP (output), trade openness, capital mobility (international capital flows), foreign reserves, interest rate, government consumption (a proxy for fiscal policy), inflation and inflation variability are associated with the choice of exchange rate regimes. For instance, countries with undiversified production and exports tend to have greater vulnerabilities to shocks and need exchange rate flexibility to facilitate adjustment to shocks. The submission is based on the fact that the exchange rate could be extremely misaligned in a peg regime. Nevertheless, where the economy is diversified (i.e. with increased production capacities), a greater possibility to float arises, given the fact the exchange rate will probably be more stable where it floats in such circumstances (IMF, 2005). The greater the degree of economic openness to trade and the higher the integration of the economy with its trade partners, the more robust the desirability of a fixed exchange rate becomes since the variability of the exchange rate could depress trade and investment. A fixed exchange rate regime is considered a viable means to stimulate trade through a lower degree of exchange rate variability and attendant transaction costs (IMF, 2005).

In theory, a greater degree of capital mobility (higher capital openness)- measured as a ratio of gross international inflows and outflows of capital to gross domestic product tends to justify exchange rate flexibility because the flexibility of the exchange rate has an inbuilt mechanism that responds to externally-generated and transmitted shocks from volatile, unguarded and destabilizing capital flows. Alternatively, during periods when countries adopt open capital account policies, they are more likely to float than peg. In this case, the benefits of fixed exchange rate diminish as integration to global financial markets and capital flows increases, given that the regime has a weak capacity to accommodate (absorb) shocks and serve as an insulator in crises. High capital mobility is, therefore, incompatible with a fixed rate regime. In line with Frenkel and Azienman (1982), for external shocks and real domestic shocks, e,g a change in demand for domestic goods, as well as foreign nominal shocks, the probability/desirability of a floating rate regime, is higher. If however, the country is faced with domestic nominal shocks, an exchange rate adjustment will not be necessary, making the fixed rate regime ideal. For countries with more significant monetary shocks than real shocks, a fixed exchange rate system is likely to be potent in stabilizing output. In such circumstances, a greater level of capital mobility would necessitate the adoption of a fixed exchange rate regime. In the case of countries characterized by significant real shocks, the fixed exchange rate offers greater output insulation, where the mobility of capital remains low. Nevertheless, in a fixity rate regime, considerable capital flows tend to amplify the destabilising consequences associated with a real shock. Therefore, countries with considerable levels of real shocks and capital flexible exchange rates will prefer flexible exchange rates (IMF, 2005). Growth and economic resilience in advanced economies have greatly been promoted a great deal by flexible exchange rate regimes in environments characterized by central bank credibility in the maintenance of low and stable inflation and the robust and well-functioning financial sector infrastructure. On the contrary, developing countries with weak institutional structures and unable to maintain low inflation find pegged exchange rates optimal. Accordingly, countries that have high inflation, as well as underdeveloped financial sectors may benefit by pegging their exchange rates (IMF, 2005). Finally, the more vulnerable an economy is to external shocks, in the absence of any external adjustment mechanism, particularly, exchange rate shock, the stronger the case for the accumulation of high reserves to serve as a precautionary buffer. In this case, fixed exchange rate regimes tend to find greater appeal with accumulations of reserves since no other means of insulation or adjustment exist. A low level of reserves, on the other hand, is compatible with the floating rate as insulation from external shocks may radiate through the market adjustment mechanisms.

3.2 Model Specification

To identify the determinants of exchange rate regimes in ECOWAS countries, this paper specifies and estimates a panel data binary choice logistic regression model. A logit model is essentially a binary choice model that assumes an entity, in this context; a country is faced with two alternatives- fixed exchange rate and flexible exchange rate regimes in this context, which are dependent on some country-specific economic and structural characteristics, nature and degree of shocks (i.e. idiosyncratic disturbance) and the goal of the external sector. A discrete choice model that employs

a dichotomous (binary) regression technique is adopted, in which the adoption of the floating rate of the two extreme divides of exchange rate regimes choices takes the value of one (1) and zero (0), otherwise. The dependent variable being qualitative, therefore, requires a qualitative dependent variable estimation technique for which the panel logit model is used to capture the probability of adopting a given exchange rate regime. In the model, the probability of a country choosing any of two of the extreme divide of exchange rate regimes (i.e. fixed and floating) is presumed to be dependent on/or influenced by some economic and structural characteristics, as well as political/institutional variables.
The model is specified in the form:

$$Pr_{i,t\,(}Y = 1) = f(X, I, Z) \quad (1)$$

Where P(Y=1) is the probability of choosing a flexible exchange rate regime; X represents domestic and external economic factors, including the growth rate of gross domestic product (GGDP); openness of the domestic economy to trade flows (OPN); degree of capital mobility {i.e. volume of gross international capital flows (CAPFL)}; inflation rate (INF); inflation volatility (INFV)- level of international reserves (FRES); and fiscal deficits (FD)- to capture the effect of fiscal policy actions in terms of fiscal discipline/irresponsibility in choice of exchange rate regimes; I and Z represents political and institutional factors that may influence exchange rate regime choice. In estimation the of mode 1, it should be noted that the response of Y, $y_{i,}$ can assume the values of one (1) and zero (0), with probabilities π_1 and 1- π_1, respectively. For individual countries, $n_{i,}$= 1 for all i, This indicates the stochastic nature of the model. Assume further that the logit of the underlying probability is linearly dependent on the predictors

$$logit\ (\pi_i) = x_i\,\beta \quad (2)$$

Where x_i is a vector of covariates, and β is a vector of regression coefficients; β_i thus, measures the change in the probability associated with a unit change in the explanatory variables, holding all other variables constant. Here, a logistic cumulative distribution frequency (CDF), which is superior to the probit model that uses the cumulative normal distribution for the critical transformation is utilized. Following Rodriguez

(2007), the exponential of (2), gives the odds ratio, where I represent the probability that the ith country adopts a flexible exchange rate regime and is given by :

$$\left(\frac{\pi i}{1-\pi i}\right) = \exp\{x_i\,\beta\} \tag{3}$$

Solving for the probability in the logit model in equation (4) gives:

$$Pr_{i,t}\left(Y = \frac{1}{x}, I, Z\right) = \pi_1 = \frac{1}{1+\exp\{xi,\beta + Y\ (I\ ,\delta_i Z)\}} \tag{4}$$

The left-hand side of equation (6) is the probability scale, while the right-hand side represents the non-linear function of the predictors, where z_{it} is a vector of exogenous control variables. In the model, it is difficult to express the effect of the probability of increasing a predictor by one unit, while holding other variables constant (Rodriguez, 2007). This implies that the coefficients cannot be interpreted as the effect on y for a one–unit change in x, ceteris paribus. To address this inherent problem, the marginal effects, which show the probability of choosing a given exchange rate regime due to a change in any of the predictors are computed. The marginal effects provide partial estimates of the previous point estimates. They measure the change in the probability of the predicted or dependent variable when the predictor or independent variable increases/decreases by one unit. Based on this, the analysis of the logistic regressions is centred on the marginal effects and conditional probabilities. Marginal effects are obtained by taking the derivatives (rate of change) concerning the given explanatory variable in the form:

$$\left(\frac{d\pi_i}{d\pi_i j}\right) = \beta_j\,\pi_i(1-\pi_i) \tag{5}$$

Thus, the marginal effects of the j-the explanatory variable on the probability $\pi i, depends\ on$ the coefficient β_j and the value of the probability. Marginal effects, in addition, are used to demonstrate the effect of each of the explanatory variables on the probability (choice) of a given exchange rate regime.

3.3 Justification for the included variables

Several important variables are important to the choice of exchange rate regimes, in line with the theory. The growth rate of output is a core determinant of the choice of exchange rate regimes in line with the OCAs theory. Economic size for instance, affects the degree of productivity, trade and international competitiveness and the resulting trade transactions requiring appropriate exchange rate regime to facilitate such economic and financial linkages, and in this case, the floating exchange rate regime (Lafrance & St-Amant, 1999; IMF, 2005; Ziky et al., 2013; Das, 2019). Smaller countries, in line with the theoretical underpinning, are more likely to be associated with a fixed rate regime. The inclusion of economic size in the model is thus founded on a strong theoretical position. The openness of the domestic economy, fiscal deficits, foreign reserves, inflation and inflation variability in line with the OCAs theory are important determinants of the choice of exchange rate regime as they could influence the preference relation for exchange rate regimes, depending on their size. Accordingly, economic, and structural characteristics influence exchange rate regime choice. For instance, greater levels of inflation and its variability are likely to be more associated with a floating regime and less likely with a fixed regime (Ozekhome, 2017).

In line with the capital account openness hypothesis, capital flows are an important determinant of the exchange rate regime choice. Following this, countries with greater capital mobility and open capital account are more likely to adopt a flexible exchange rate regime than a fixed rate regime. On the contrary, countries with fewer capital flows are likely to adopt fixed exchange rates, as a lower degree of financial integration may not require the exchange rate to be flexible to accommodate shocks (see Poirson, 2001; Papaioannou, 2003). Finally, institutional and political variables, following the institutional and historical hypothesis (see Edwards, 1996; 1999; Berg et al. 2000; Poirson, 2001) are likely to influence the choice of exchange rate regimes, as institutional quality and political stability, for instance, determines whether a given country/region will adopt a fixed or flexible exchange rate regime. Hence, the inclusion of the political stability variable in the model is theoretically justified.

3.4 Data and data sources

The study employs panel data for the period 1978-2020 for all fifteen (15) ECOWAS member countries. The choice of the period is partly informed by data availability and partly by the fact that a large number of the ECOWAS member countries, particularly, Nigeria and Ghana, had experimented with both the fixed and floating exchange rate regimes (i.e. switch in exchange rate regimes) during the period. The ECOWAS countries seek to attain full economic and monetary integration, through the coordination and harmonization of monetary and fiscal policies, and their convergence. The data are obtained from the World Bank's World Development Indicators (WDI), and ECOWAS Macroeconomic Convergence Report (various issues). The data on political stability is obtained from the Political Risk components, based on International Country Risk Guide (ICRG) rating.

Table 1. Definition of Variables and Measurement

Variable	Definition and Measurement
Regressand: Exchange Rate Regime	A binary choice variable consisting of the two extreme divides of exchange rate regimes (i.e. freely floating) exchange rate. It assumes the value of one (1) for a flexible (floating) exchange rate regime and zero (0) otherwise. A fixed regime is one in which the currency is fixed at a specified rate of exchange to other currencies. The variants are currency union, dollarization and currency board. A floating exchange rate, on the other hand, is largely determined by market forces, without a determinable or predictable path for the rate. It consists of managed floating and independent floating.
Regressors: The growth rate of GDP	Annual growth rate of GDP (a measure of economic output/size).
Inflation rate	The growth rate of the consumer price index.
Inflation volatility	The 3-month standard deviation of the annual inflation rate.

Foreign Reserves	International reserves are the nation's 3 months' import cover as a percentage of total imports. For the fact that international reserves are denominated in US Dollars, it is simply calculated as the percentage share of foreign reserves in nominal imports.
Openness	The sum of total imports and exports to the GDP per cent.
Capital mobility	The absolute value of inward and outward capital flows as a percentage of nominal GDP (i.e. the ratio of gross international capital flows to GDP- i.e. de facto financial integration in terms of actual/ realized capital flows).
Fiscal Management	Fiscal deficit to GDP ratio per cent.
Political Stability	Averages of 12 weighted political risk components (variables) across countries on a comparable basis. Socio-political stability captures stability in the social and political environment, the absence of violence and the likelihood that the government in power will be destabilized or overthrown by unconstitutional means and /or violence, or threatened terrorism/armed conflict.

Source**:** Author

4.0 RESULTS AND DISCUSSION

4.1 Descriptive Characteristics of the Variables

Table 2 shows the descriptive statistics of the data on the variables used for the analysis. This is necessary to have a gloss of the variables in terms of their characterization. The mean growth rate of GDP for the ECOWAS countries in the estimation period is 3.92 per cent, with a median value of 4.10 per cent. Economic performance, in terms of the growth rate of GDP in the region, tended to have assumed a heterogeneous pattern over the estimation period. This implies a divergent growth rate pattern among the individual member countries over the years, due largely to economic disparity, structural imbalance, and economic management and governance. This seemed to have weakened the external competitiveness and the needed drive for regional integration, adumbrated in the unification agenda. The maximum and minimum values of 9.2 per cent and -1.15 per cent respectively, further confirm the disparity of growth rates in the countries during the focus period. The openness of the domestic economy has a mean value of 60.2 per cent and a median value of 59.65 per cent. The maximum and minimum values are 72.50 and 30.92 per cent, respectively. The level of de facto international financial integration- i.e. realized capital flows, measured as total capital flows to GDP per cent is 3.20, with a median value of 3.54 per cent. The corresponding average values of foreign reserves to import ratio, inflation and inflation variability are 9.62, 9.50 and 6.23 respectively. The average fiscal deficit ratio among the countries is -6.5 per cent, a value higher than the fiscal deficit convergence criterion of -3.0%; an indication that most of the countries in the sub-region have continued to run large fiscal imbalances due to the structural inadequacies of their domestic economies. Inflation volatility has the highest standard deviation value of 12.20; an indication of macroeconomic instability in the region during the period. The mean value of social and political stability is 4.20 out of a maximum possible 12, suggesting an indication of some level of socio-political and government stability, since the entrenchment of democratic rule in many ECOWAS countries. Nevertheless, the socio-political instability and weak institutional capacity in the region have contributed to the slow pace of the unification agenda.

Table 2: Descriptive Statistics

	Mean	*Median*	*Max.*	*Min.*	*Std. Dev.*
GRGDP	3.92	4.10	9.20	-1.15	3.20
OPN	60.22	59.65	72.50	30.92	18.28
CAPFL	3.20	3.54	21.50	0.76	6.25
FRES	9.62	9.86	18.60	3.28	9.85
INF	9.50	10.20	20.80	-1.05	5.34
INFV	6.23	7.05	18.42	1.82	12.20
FD	-4.25	-5.05	6.50	-12.3	3.50
POLS	4.20	7.50	12	3.20	1.30

4.3 Unit Root Analysis

Panel unit root test is conducted on the variables using LLC, Fisher-PP and Fisher-ADF unit root tests to examine to investigate the stationarity status of variables. If all the variables are stationary at their level, they would enter the model in their level form. The result of the panel unit root in Table 3 indicates that all variables are overwhelmingly stationary at their level and consequently, enter the model directly. Employing data in a panel framework eliminates non-stationarity. Accordingly, the estimation of a panel model to investigate the determinants of the choice of exchange rate regime in the ECOWAS is justified.

Table 3: Unit Root Test for Variables in Levels

Test	GRGDP	OPN	CAPL	FRES	INF	INFV	FD	POLS
LLC	-4.12***	-2.98***	-3.83**	-3.17***	-2.65**	-2.54**	-3.15***	-2.50**
Fisher-PP	75.23***	46.72**	57.14*	52.25**	46.03**	40.272**	45.38**	51.40**
Fisher-ADF	48.14**	57.24***	52.04**	66.10***	55.26**	50.240**	54.17	60.62**

***, **, * indicate Statistical significance at the 1%, 5% and 10%, respectively;

4.3 Main Results

The main results showing the probability of exchange rate regime choice are presented in Table 4. From the results, all the explanatory variables played satisfactory roles in explaining the choice of exchange rate regime, as they contribute to explaining the systematic variations in the dependent variable, given the impressive goodness of fit that stands at 96 per cent, with a Pseudo R^2 of 92 per cent.

Table 4: Results of Probability of Exchange Rate Regimes (Marginal Effects)

Variables	Marginal Effects
GGDP	0.330*** (2.56)
OPN	0.103** (2.22)
CAPFL	0.013** (2.19)
FRES	-0.030 (-1.073)

INF	0.062** (2.20)
INFV	0.203** (2.31)
FD	-0.024 (-1.25)
POLS	0.030** (1.80)
Diagnostics	
Goodness of Fit	0.96
Pseudo R^2	0.92
Hosmer- Lemeshow Goodness-of-Fit Statistic (Chi-Squared statistic)	8.72 (0.24)
Breusch-Godfrey Serial Correlation LM Test	3.60 (0.52)
Mean VIF	2.03

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

The absolute value of z-statistics in parenthesis GGDP is growth rate of GDP; OPN is openness of the economy to trade; CFL is international capital flows; FRES is foreign reserves, INF is the inflation rate, INFV is inflation variability, and POLS is political stability

From the results, the growth rate of GDP (a measure of economic size) is positive and significant at the 1 per cent level for the probability of choosing any of the exchange rate regimes. From the results, the greater the economic size, the greater the probability of adopting a non-fixed regime, which raised the likelihood/propensity of a floating rate regime. Thus, large economic size is positively and significantly associated with floating rate regimes than the fixed rate system The result is in line with the findings of Von Hagen and Zhou (2002), Mercer-Blackman, Offerdal and Rennhack (2002), Papaioannou (2003), IMF (2005) and Fiess and Shankar (2009). Invariably, countries with higher growth rates of GDP and/ or smaller output variability tend to be associated with floating rate regimes. The size of the economy (output) is a strong determinant of the choice of exchange rate regime in ECOWAS, particularly when the production and exports are undiversified and are likely to be highly vulnerable to shocks, and thus would require exchange rate flexibility, to facilitate adjustment to shocks. This is because an exchange rate may be extremely misaligned under fixed regimes. A diversified economy would therefore, actually be in a better position to float because stability in the exchange rate is more likely, where the exchange rate floats, which, in this case, is necessary to accommodate external vulnerabilities and shocks, as well as facilitate adjustments. A 1 per cent increase in economic size raises the probability of choosing the floating rate regime by 0.33 per cent. Openness is statistically significant at the 5 per cent level. Thus, a higher degree of trade openness of the economy tends to be associated and significantly associated with floating (and thus, not significantly associated with fixed rates). This implies that countries with a higher degree of openness to trade are more likely to favour and find appeal in floating rate regimes, as it help to cushion external shocks and variability. This finding is in line with Berger et al (2000), Papaioannou (2003) and IMF (2005; 2022). The marginal effect on the probability of choosing a floating rate regime due to a 1 per cent increase in the level of domestic openness is 0.10 per cent.

Capital mobility (capital flows) is positively signed, and significant at the 5 per cent level for the choice of exchange rate regimes. From the results, a high degree of international capital flows tends to be significantly associated with floating rate regimes and less likely with fixed rate regimes. This finding supports the findings and position of the IMF (2005) that, increased financial integration and greater exposure to international capital flows and external financial transactions and the associated macroeconomic volatilities require a floating regime to accommodate and mitigate shocks. The result is, nevertheless, at variance with the findings of Juhn and Mauro (2002), and Papaioannou (2003). Following this, greater capital openness and integration into global financial markets and international capital flows lowers the desirability of a fixed exchange rate regime. A 1 per cent increase in the degree of capital mobility (i.e. the volume of gross international capital flows) raises the probability of adopting the flexible exchange rate regime by 0.013 per cent, while a unit per cent increase in the level of financial integration lowers the probability of selecting a fixed rate regime by 0.08 per cent.

The inflation rate and inflation variability are both positive and significant. Thus, high inflation and inflation volatility are significant in the choice of exchange rate regimes. High domestic inflation and inflation variability are significantly associated with the floating rate regime than the fixed exchange rate regime. Thus, countries with higher GDP and lower inflation/inflation variability are more likely to adopt the fixed rate regime. Given that inflation is a proxy for the macroeconomic environment, and its variability- a measure of macroeconomic volatility, the optimal choice of exchange regime for countries with large economic size, as well as structural and idiosyncratic shocks is the floating rate regime due to its shocks adjustment mechanism. The finding corroborates the findings of Von and Hagen (2002), Hochreiter, Korinek and Siklos (2002) and Ozekhome (2017). Frenkel and Azienman (1982) argue that if real disturbances are foreign and domestic or foreign nominal shocks, the desirability of a flexible exchange rate becomes higher, However, where a country is faced with domestic nominal shocks, exchange rate fixity becomes preferable. Similarly, in situations of highly significant monetary disturbance relative to real shocks, a fixed exchange rate regime provides a greater incentive for stabilizing output. In such situations, a higher degree of capital mobility justifies the fixed exchange rate as the most appropriate and effective regime. For countries with a considerable degree of real shocks, exchange rate fixity offers larger insulation of output if capital mobility is low. Nevertheless, in a fixed exchange rate, high capital mobility amplifies the destabilizing effects of a real shock. Therefore, countries with more pronounced real shocks and high capital mobility would find exchange rate flexibility preferable (IMF, 2005). A 1 per cent increase in the rate of inflation and inflation volatility increases the probability of choosing a floating exchange rate regime by 0.06 and 0.20 per cent, respectively.

Foreign reserves (level of international reserves) is negatively signed and statistically significant at the 10 per cent level for floating regimes and positively signed for fixed-rate system, The finding corroborates the findings of Fiess and Shankar (2009). Thus, high levels of foreign reserves (i.e. reserves to import ratio) tend to be more associated with a fixed rate regime, and less likely associated with a floating rate regime. This is because external adjustment mechanisms through the operation of the market forces already exist in the case of any imbalance in the floating rate regime, while such adjustment mechanisms through the exchange rate do not exist in the fixed rate regime. Higher levels of external reserves, therefore, tend to be more likely associated with fixed exchange rates since they are required as precautionary buffers to insulate the economy from potential exogenous negative shocks on the economy, given that there is no insulating or automatic market adjusting mechanisms. By implication, the probability of selecting the fixed rate regime is higher where there is a high level of external reserves, with low-level reserves being more of a policy concern. A unit per cent increase in the level of external reserves raises the probability of adopting a fixed rate regime by 0.03 per cent.

Fiscal deficit– a measure of fiscal management that is positive but not significantly associated with a floating rate regime. Thus, high fiscal deficit to GDP ratios (fiscal impropriety) tends to reduce the probability of choosing the floating rate regimes. The fixed-rate regime has a greater propensity and capacity to tolerate fiscal irresponsibility than with floating rates as the fixed-rate system can easily weather the storm of fiscal imprudence. The result is in line with the findings of Gramlich (2001) that floating currencies avoid fiscal irresponsibility but at variance with the findings of Mercer-Blackman et al. (2002) and Papaioannou (2003). A 1 per cent increase in fiscal impropriety raises the probability of adopting a fixed rate regime by 0.024 per cent, thus lowering the desirability of a floating regime. By implication, better fiscal management raises the probability of adopting a floating rate regime. Finally, socio-political stability is positive and significant at the 10 per cent level, making it a robust predictor of exchange rate regime choice. The finding is in agreement with those of Berger et al. (2002), Aliyev (2014) and Rodriguez (2016). A strong and stable political or institutional framework is often positively and significantly associated with floating rates. By implication, institutional strength and political stability are positively associated with the floating and fixed rate regimes, with that of the floating rate regime being stronger. This could be because strong and stable institutional or political environments are critical to unfettered operations of market mechanisms, reflected in price flexibility, which enables greater flexibility and dynamism in trade and financial transactions. Thus, a lack of institutional strength or political instability makes it difficult to sustain any of the exchange rate regimes. However, the fixed rate regime, tends to find greater appeal under conditions of weak institutions or political instability than the floating rate regime, since monetary policy independence (i.e. independent central bank) exists in the fixed rate regime, thus providing policy credibility for taming high inflationary bias in countries with a history of high inflation.

By adopting a credible fixed rate regime, a country's inflationary bias would theoretically converge to the relatively lower bias of the stable-reserve currency, and thus engender possible credibility gains. Nevertheless, a country's inflationary bias would be lower, and thus credibility gain is reduced if monetary policy is conducted under a conservative and independent central bank/monetary policy. At that point, the attractiveness of a fixed exchange rate regime decreases as the degree of conservatism and independence of the central bank increases (see Papaioannou, 2003; Ziky et al., 2013). The result also supports the findings of Berger et al. (2001), Mendoza (2001) and Aliyev (2014). A 1 per cent improvement in the stability of the political environment raises the probability of choosing the floating rate regime by 0.03 per cent. Based on the findings, the long-run determinants of the choice of exchange rate regime, and in particular, the floating rate system in the ECOWAS are economic size, degree of openness, extent of financial integration, level of foreign reserves, average inflation rate, inflation volatility and political stability /institutional quality. The relative weights (significance) attached to each consideration may however change over time, based on the policy considerations.

To guarantee the appropriateness, reliability, robustness and validity of the result obtained, some key diagnostic post-estimation tests are conducted for non-violation of important logistic regression assumptions such as poor prediction test (based on the Hosmer-Lemeshow test statistic), multicollinearity, cross-sectional dependence and heteroscedasticity. This is because evidence of poor fit (poor prediction), heteroscedasticity, serial cross-sectional dependence and multicollinearity among the variables could violate the working assumptions of the logistic regression, and render the results unrealistic and inconsistent for policy purposes. In the result, the H-L test statistic (Chi-squared value) of 8.72, with a corresponding probability of 0.24, fails the significance test at the 5 per cent level. Thus, the logistic regression has a good fit, as the poor predictions (poor fit) are not significant. The model, therefore, has good predictive power and accuracy. The post-estimation evidence also leads to non-rejection of the null hypothesis of no contemporaneous serial correlations and cross-sectional dependence, using the Breush-Godfrey LM test {with Chi-squared = 3.60 (0.52}. The result of the mean-variance inflation factor shows a clear absence of multicollinearity since the value is less than 10. There is thus, no evidence to invalidate the model results for structural and policy analysis.

5.0 CONCLUSION

This paper examines the determinants of the choice of exchange rate regime in the ECOWAS for the period 1978-2020, a period characterized by fixed and flexible exchange rate regime switch for the countries. The study assesses the key theoretical, empirical and policy issues associated with the choice of exchange regimes, the state of play in the policy debate, as well as the costs and benefits of each regime. The findings from the panel binary logit regression estimation show that the growth rate of real GDP (a measure of real economic size), economic openness, degree of financial integration, foreign reserves, inflation (a measure of the macroeconomic environment), inflation variability (a measure of macroeconomic disturbance) and socio-political stability are the most important variables that influence the choice of exchange rate regime. Specifically, a greater degree of domestic openness, economic size, capital mobility, inflation, inflation variability and socio-political stability are more likely to be associated with floating rate regimes, while high levels of fiscal deficits and high reserves-to-import ratios are more consistent or likely associated with fixed exchange rate regimes. These findings imply that these or any of the long-term economic determinants have consistently influenced the choice of exchange rate regime in the ECOWAS countries to a varying degree during the period.

Based on the empirical findings of this study, it is suggested that greater flexibility of exchange rate be adopted since this will make the proposed single currency of the zone floats against major world currencies. This in turn, will diversify the productive base of the region, make it more competitive globally through unfettered transaction and exchange processes, enhance regional trade, investment and financial linkages, allow adjustment to domestic and external shocks, and mitigate sustained disequilibria that may hinder the monetary unification agenda. Appropriate inflation targeting to minimize the perceived macroeconomic volatility associated with this regime choice is also important, as this can facilitate the long-run economic and monetary unification agenda of the ECOWAS.

REFERENCES

Alesina, A. & Grilli, V. (1992). The European Central Bank: Reshaping monetary politics in Europe. In M. Canzoneri, V. & P. R. Massonj (Eds). Establishing A central bank: Issues in Europe and lessons from the U.S, 49-77, Cambridge: Cambridge University Press.

Aliyev, R. (2014). Determinants of the choice of exchange rate regime in resource-rich countries. Centre for Economic Research and Graduate Education. Academy of the Czech Republic Economics Institute *Working Paper Series*. 1211-3299

Barro, R. J. & Gordon, D. (1983, b). Rules, discretion and reputation in a model of monetary policy. *Journal of Monetary Economics*, 12, 101-121

Bayoumi, T. & Eichengreen, B. (1994). One money or many? Analyzing the prospects for monetary unification in various parts of the world. Princeton, NJ: *Princeton Studies in International Finance*, *76.*

Berger, H., Sturm, I. E. & de Hann, J. (2000). An empirical investigation into exchange rate regime choice and exchange rate volatility. CESIFO Working Paper, No. 263. Munich: Centre for economic studies and institute for economic research.

Berger, H., Jensen, H., Schjelderup, G. (2001). To peg or not to peg: A simple model of exchange rate regime choice in small economies. *Economic Letters*, 73, 161-167.

Blomberg, B. S., & Hess, G. D. (1997). Politics and exchange rate forecasts. *Journal of International Economic*s, 43, 189-205.

Calvo, G.A. & Reinhart, C.M. (2002). Fear of floating. *Quarterly Journal of Economics*, 11 (2), 379-408.

Cohen, B. J. (1992). The New Palgrave Dictionary of money and finance. London: The Macmillan press limited.

Collins, S.M. (1996). On becoming more flexible: Exchange rate regimes in Latin America and the Caribbean. *Journal of Development Economics*, 51, 117-38

Corden, W. (2002). Too sensational: On the choice of exchange rate regimes, Cambridge, Massachusetts, MIT Press.

Courchene, T. and Harris, R.G. (2000). North American monetary union: Analytical principles and operational guidelines. *North American Journal of Economics and Finance*, 1 (August), 3-18.

Crow J, (1999). Canadian exchange rate policy. *Canadian Public Policy*, 25, 3.

Das, S. (2019). China's evolving exchange rate regime. IMF Papers WP/19/50, IMF, Washington DC.

Edwards, S. (1999). 'The choice of exchange rate regimes in developing and middle-income countries' In changes in exchange rates in rapidly developing countries: Theory, practice and policy issues, ed by Takatoshi Ito and Anne O. Krueger, NBER- East-Asia Seminars on economics, vol. 7, Chicago and London: University of Chicago Press.

Edward, S. (1996). The determinants of the choice have been fixed and flexible exchange rate- regimes. *NBER Working Paper* 5756.

Edwards, S., & Savastano, M. A. (1999). Exchange rate in emerging economies: What do we know? What do we need to know? *NBER Working Paper NO.7228.* Cambridge, Massachusetts.

Eichengreen, B. (1994). International monetary arrangements for the 21st century, Washington DC: Brooking Institution.

Eichengreen, B., & Masson, P. (1998). Exit strategies: Policy options for countries seeking greater exchange rate variability. *IMF Occasional Paper* No. 168. Washington: IMF

Fausten, D.K. (2010). Exchange rate regimes. *International Economics, Finance and Trade*, 1(2), 1-7.

Fiess, N. & Shankar, R. (2009). Determinants of exchange rate regime switching. *Journal of International Money and Finance,* 28(1), 68-98.

Fischer, S. (2001). Distinguished lecture on economic development- Exchange rate regimes: Is the bipolar view correct? *Journal of Economic Perspectives*, 15, 3-24.

Fischer, S. (1977). Stability and exchange rate system in monetarist model of the balance of payments, in R.Z. Aliber, the political economy of monetary reform.

Frankel, J.A. (1999). No single currency regime is right for all countries or at all times. *Working Paper* No.7338, Cambridge, MA: *NBER.*

Frankel, J. A. (1995). ‘Monetary regime choice for a semi-open country’ in capital controls, exchange rate and monetary policy in the world economy, ed. by Sebastian Edwards. Cambridge: Cambridge University Press.

Frankel, J. A. & Rose, A.K. (1998).The endogeneity of the optimum currency area criteria. *The Economic Journal*, 108, 1009-1025.

Frenkel, J. & Azienman, J. (1981). Aspects of the optimal management of exchange rates. *Journal of International Economics*, 13, 1-12.

Gali, J. & Gertler, M. (2007). Macroeconomic modelling for monetary policy evaluation. *Journal of Economic Perspectives*, 21(4), 25-45.

Giavazzi, F. & Pagano, M. (1988). The advantage of tying one’s hands: EMS discipline and central bank credibility. *European Economic Revie*w, 32, 323-325

Gnimassiun, B. (2015). The importance of the exchange rate regime in limiting current account imbalances in Sub-Saharan African countries. *Journal of International Money and Finance, 53*, 36-74.

Gnimassiun, B. & Coulibaly, I. (2014). Current account Sustainability in Sub-Saharan Africa: Does the exchange rate regime matter? *Economic Modelling*, *40*, 208-226.

Gujarati, D. N. (2003). Basic econometrics (fourth edition). Boston, McGraw-Hill.

Hausmann, R., Panizza, U. & Stein, E. (2001). Why do countries float the way they float? *Journal of Development Economics*, 66, 387-414.

Holden, M., Holden, P. & Suss, E. (1997). The determinants of exchange rate flexibility: An empirical investigation. *Review of Economics and Statistics*, 61, 327-333.

Honkapohja, S. & Pikkarainen, P. (1994). ‘Country characteristics and the choice of the exchange rate regime: Are mini-skirts followed by maxis? In Exchange rate policies in the Nordic countries, ed. by Johnny Akerholm and Alberto Giovannini. Centre for Economic Policy Research, London.

Hochreiter, E. & Siklos, P. (2002). Alternative exchange rate regimes: The options for Latin America. *North American Journal of Economics and Finance*, 13(2002), 195-211.

Hochreiter, E. Korinek, A. & Siklos, P. (2002). The potential consequences of alternative exchange rate regime: A study of three candidate regions. *International Journal of Economics and Finance*, 16, 201-217.

IMF (2005). World Development Report, Washington D.C., IMF.

IMF (2022). Weather shocks and exchange rate flexibility. IMF Papers WP/22/93, IMF, Washington DC, May 2022

Iyoha, M.A. (2004). *Macroeconomics*, *theory and policy*. Benin City, Mindex Publishing.

Juhn, G. & Mauro, P. (2002). Long-run determinants of exchange rate regimes: A simple sensitivity analysis. *IMF Working Paper* No 02/104. Washington: IMF.

Kletzer, K & Von Hagen, J. (2002). Monetary union and fiscal federalism, ZEI. Mimeo.

Klein, M. W. & Marion, N. (1994). Explaining the duration of exchange rate pegs. *Working Paper No. 4651, National Bureau of Economic Research (NBER*), 1050, Massachusetts Avenue, Cambridge, M.A., 02138, 12-21.

Laidler, D. (1999). Canada's exchange rate options. *Canadian Public Policy*, 25 (September), 324-332.

Marston, R. (1981). Real and monetary disturbances in an exchange rate union. N*BER Working Paper* No. 705, Cambridge, Massachusetts.

Mckinnon, R. I. (1963). Optimum currency areas. *American Economic Review*, 5, 717-725.

Mendoza, E. G. (2001). The benefits of dollarization, when stabilization policy lacks credibility and financial markets, are imperfect. *Journal of Money, Credit and Banking*, 33, 440-474.

Mercer-Blackman, V., Offerdal, E. & Rennhack, R. (2002). How countries in Central America and the Caribbean do choose their exchange rate regime? *Mimeo.* IMF, Washington DC.

Milesi-Ferretti, G. M. (1995). The disadvantage of tying their hands: On the political economy of policy commitments. *The Economic Journal*, 105, 1381-1402.

Mundell, R. (1961). A theory of optimum currency areas. *American Economic Review*, 657-665.

Mussa, M., Masson P., Swoboda, A., Jadresic, E., Mauro, P & Berg, A. (2002). Exchange rate regime in an increasingly integrated world economy. *IMF Occasional Paper* No. 193, Washington DC: IMF.

Nathaniel, O.O., Oladiran, O.I., & Oladiran, A.T. (2019). Impact of exchange rate regime on economic integration in the ECOWAS (1980-2017). *African Journal of Economic Review, 7*(2), 42-59.

Ozekhome, H. (2022). Determinants of real exchange rate in Nigeria: An empirical investigation. *Asian Journal of Economics and Finance (AJEF*), *3*(4), 487-505.

Ozekhome, H. (2017). Exchange rate, trade and macroeconomic stabilization: Evidence from Nigeria. *International Journal of Economic Development, 11*(1), 29-53.

Ozekhome, H. O. (2017). Determinants of the exchange rate regime in the WAMZ: Is there an implication for a monetary union? *West African Economic Review (WAER),* 4(2), 103-28.

Papaioannou, M, G. (2003). Determinants of the choice of exchange rate regimes in six Central American countries: An empirical analysis. *IMF Working Paper* WP/3/59.

Poirson, H. (2001). How countries do choose their exchange rate regime? IMF Working Paper No 01/46. Washington DC: IMF.

Rizzo, J.M. (1998). The economic determinants of the choice of an exchange rate regime: A probit analysis. *Economic Letters*, 59, 283-287.

Rodrick, K & Devarajan, C. (1990). Do the benefits of fixed exchange rates outweigh their costs? The Franc zone in Africa. *Working Paper No. 3727, National Bureau of Economic Research* 1050, Massachusetts, Cambridge, MA, 9-28.

Rodriguez, C. M. (2016). Economic and political determinants of exchange rate regime: The case of Latin *America. International Economics*, 147, 1-26

Rodriguez, G. (2007). Lecture notes on generalized linear models. htttp://data. Princeton. edu/wws509/notes/.

Rogoff, K. (1985). The optimal degree of commitment to an intermediate monetary target. *Quarterly Journal of Economics*, 100, 1169-1190.

Savvides, A. (1990). Real exchange rate variability and the choice of exchange rate regime by developing countries. *Journal of International Money and Finance*, 9, 440-453.

Stancik, J. (2006). Determinants of exchange rate volatility: The case of new EU members. *CERGE-EI Discussion Paper* No. 2006-158, January.

Rose, A.K. & Engel, C. (2000). Currency unions and international integration. *Working Paper* No 7872, 73-96.

Von Hagen, J. & Zhou, J. (2002). The choice of exchange rate regimes: An empirical analysis for transition economies. *Working Paper* No. B 03. 2002. ZEI.

Williamson, J. (2002). An economic policy agenda for Latin America. Washington DC: Institute for International Economics.

Ziky, M., Berentsen, A. & Ouchen, M. (2013). Choosing an optimal exchange rate regime: A critical literature review. *International Journal of Developing and Emerging Economics*, 1(1), 11-35.

MACROPRUDENTIAL POLICY AND FINANCIAL STABILITY IN AFRICA

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Abstract

Macroprudential policy which is a measure that aims to increase the financial system's resilience to shocks by addressing possible systemic risks; is not limited to the advanced economies. Several African countries have also embraced this policy framework, most especially due to their previous experience with financial crises. This study seeks to investigate the impact of macroprudential policy instruments on the financial stability of 15 countries in Africa from 2010 to 2020. System GMM is employed as the estimation technique while the two measures of macroprudential policy are deviation of capital adequacy ratio from the policy target and deviation of non-performing ratio from its target ratio. The results show that while macroprudential policy proves effective in controlling systemic risks in Africa, monetary policy indicators had a moderate impact on financial stability. However, the combination of the monetary policy with macroprudential policy improves the effectiveness of the latter on financial stability. Thus, governments and Central Banks in Africa should intensify efforts on the use of macroprudential policy in lowering systemic risks in their economies.

Keywords: Macroprudential policy; Financial stability; Africa; System GMM
JEL: E00, E44, E50, GO1

1.0 INTRODUCTION

Since the onset of the global financial crisis in 2007, the frameworks for many economies around the world have shifted. While some central banks (South Africa, India, Nigeria, and New Zeeland now pay significant attention to macro-financial links, others have tried to make their financial stability policy more macroprudential (Villar, 2017). Macroprudential policy is a measure that aims to increase the financial

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system's resilience to shocks by addressing possible systemic risks. The macroprudential authorities monitor the financial system by identifying risks and vulnerabilities and taking measures to ensure financial stability. Macroprudential instruments are generally classified into three categories, namely capital-based instruments (countercyclical capital buffers, sectoral capital requirements, capital adequacy ratio, and dynamic provisions); asset-side instruments (loan-to-value (LTV), non-performing loan ratio, and debt-to-income (DTI) ratio limits); and liquidity-based instruments (countercyclical liquidity requirements). Before the current global financial crisis, the depth of macroeconomic risks for a financial system was not fully understood. The aftermath of the crisis which worsened many countries' macroeconomic performance and sent them into protracted recession intensified research on the link between financial stability and macroeconomic performance. A macroprudential framework that targets the risk and cost of financial stability is now considered a better policy option over a micro-prudential approach that combines stable production and inflation (Central Bank of Nigeria, 2016).

Most African nations have adopted this policy framework, especially in light of their prior experience with financial crises. In Nigeria for instance, the CBN has deployed a variety of monetary and macroprudential policies to promote a sound financial system. In 2010, the Bank revised its prudential requirement in response to the consequences of the 2007-2008 global financial crisis and the banking sector's rapid growth following consolidation (Jibrin et al., 2020). Likewise, South Africa has made significant progress in strengthening its macroprudential policy framework and foundations since the 2014 financial sector assessment programme. Institutional arrangements were overhauled by the 2017 Financial Sector Regulations Act which provided South Africa Reserve Bank with a strong financial stability mandate. Thus, the severe financial crisis has given policies to improve financial stability in most African countries more momentum. Africa's central banks increasingly combine monetary policy with micro- and macroprudential regulation. This emphasized the significance of taking measures that minimize the risks to the whole financial system beyond the supervision and control of individual financial institutions (Masson, 2014).

Although a great deal of progress has been made in recent years in determining the efficacy of macroprudential measures, there are still numerous open questions. In particular, reliable quantification of the consequences of various macroprudential interventions has not yet been accomplished in the literature. In the case of Africa, empirical studies on the effectiveness of macroprudential policies are few. While some of the studies carried out focused on conceptual issues, others employed different approaches in a bid to circumvent data challenges in empirically investigating the effectiveness of the policy on financial stability (Okafor and Asuzu, 2018). This study, therefore, fills the gaps in understanding the effectiveness of the macroprudential policy on financial stability by building on the work of Jibrin et al. (2020) which only focused on Nigeria. Specifically, the study aims to examine the impact of some key macroprudential policy instruments on financial stability in some selected countries in Africa and provides policy recommendations based on the findings. Following this introduction, the next section reviews the literature. While the macroprudential policy framework is discussed next, the following section focuses on methodology. The next is the discussion of results and the study is ended with a conclusion.

2.0 LITERATURE REVIEW

2.1 Theoretical Literature

The justification for macroprudential regulation is based on the observation that agents with limited liability, weak enforcement, and asymmetric information are more likely to spread risk for their gain by increasing leverage, expanding their balance sheets, and relying on short-term liquidity. The success of macroprudential policy can be theoretically categorized into three paradigms: the agency paradigm, the externalities paradigm, and the mood swings paradigm. The externalities and mood swings paradigms demonstrate the significance of macroprudential regulation, however. The agency paradigm highlights the importance of principal-agent concerns. In its role as lender-of-last-resort and deposit insurance provider, the government alters the incentives for banks to take risks, hence producing the principal-agent problem (moral hazard). The juxtaposition of deposit insurance with inadequately regulated bank portfolios, on the other hand, encourages financial institutions to take excessive risks. This paradigm, however, assumes that risk originates from individual institutions;

therefore, the macro-prudential approach, which concentrates emphasis on the entire system, is erroneous. (Duniya, 2012).

The fundamental concept of the externalities paradigm is known as a monetary externality. This is referred to as an externality that occurs when the acts of one economic agent have price consequences on the well-being of another agent. According to Greenwald and Stiglitz (1986), where economic distortions (such as incomplete markets or inadequate information) exist, state intervention can make everyone better off from a Pareto standpoint. In reality, several authors have established that pecuniary externalities and other distortions, such as excessive borrowing, excessive risk-taking, and excessive short-term debt, occur when agents face borrowing constraints or other sorts of financial frictions. In its 2010 policy review, the International Monetary Fund argued that risk externalities between financial institutions and the real economy tend to generate market failures that warrant macroprudential intervention (De Nicolo et al., 2012).

In the paradigm of mood swings, rationality, and greed have a substantial influence on the behavior of financial institution management, resulting in excessive optimism during successful times and quick risk aversion during recessions. Thus, pricing signals in financial markets may be inefficient, increasing the likelihood of systemic issues. Consequently, there is a need for a forward-thinking macroprudential regulator capable of reducing uncertainty and emphasizing the risks of financial innovation. However, macroprudential policies are still in development, and there is no one-size-fits-all strategy. In addition to macroprudential policy, a variety of other policies influence financial stability. Thus, the fact that theoretical literature assumes that macroprudential tools effectively achieve their objectives does not exclude the deployment of macroprudential policy in conjunction with other policy frameworks. (Zulkhibri and Naiya, 2016)

2.2 Empirical Literature

Numerous empirical studies have sought to assess the influence of macroprudential policies on a sample of countries from various regions despite the challenge of quantifying policy measures (Alam et al., 2019; CBN, 2016; Grace et al., 2015). Most of these studies demonstrate how certain macroprudential tools, including reserve requirements, dynamic provisioning, loan-to-value (LTV), and debt-to-income (DTI) ratios, have been effective in restraining excessive credit expansion and asset price increases. According to other studies, other macroprudential regulations have little influence on credit expansion in both individual and cross-country assessments (Claessens et al., 2013; Cerutti et al., 2015).

In terms of its goal and tools, macroprudential policy is discussed by Tomuleasa (2013). According to the analysis, the financial system is highly sensitive to the pressures that are present in the global financial markets. As a result, macroprudential policy and its instruments assist investor protection from the limiting effects of systemic risk and financial stability. Consequently, macroprudential policy, in addition to macroeconomic and financial policies, is crucial for guaranteeing financial stability. In light of this, Arregui et al. (2013) developed a straightforward and analytical methodology to evaluate the advantages and disadvantages of macroprudential measures. Although they suggest a measure of net benefits in terms of the probability of crisis and loss in output given crisis, their findings show that capital requirements and LTV tools are better suited than reserve requirements to limit the buildup of credit-related risks in financially open economies.

Additionally, Fendoglu (2016) evaluated the effectiveness of macroprudential policy measures in managing excessive loan cycles in emerging nations. A dynamic panel approach was utilized to measure the efficacy of macroprudential policy actions by creating an index of policy stances for commonly used macroprudential tools. The results demonstrate that a more restrictive macroprudential policy stance aids in reducing the credit-to-GDP gap in both long- and medium-run recursive trends. Similar to this, Ma (2017) investigates financial stability, growth, and macroprudential policy in emerging nations by introducing endogenous growth with sporadically binding collateral requirements, which enables consideration of the effects of optimal policy on financial stability and economic growth. The analysis's findings demonstrate that, while macroprudential policy lessens the frequency of crises and their effects on growth, it does so at the expense of decreasing borrowing and growth during good times.

Using the ARDL bound testing method, Iwegbu and Odior (2019) examine the possibility of macroprudential regulation to reduce the pro-cyclicality between Nigerian banks' capital and bank loans in the aftermath of the global financial crisis. According to the research, macroprudential controls minimize the procyclicality of bank loans and the amount of capital available to banks. This was discovered to be less effective during financial crises than in times of peace. Lim et al. (2011) evaluated the efficacy of macroprudential regulation in reducing systemic risk over time, across institutions, and markets in 49 countries. According to the data, most of the popular instruments are successful at lowering pro-cyclicality, and their efficacy varies depending on the kind of shock the financial sector is experiencing.

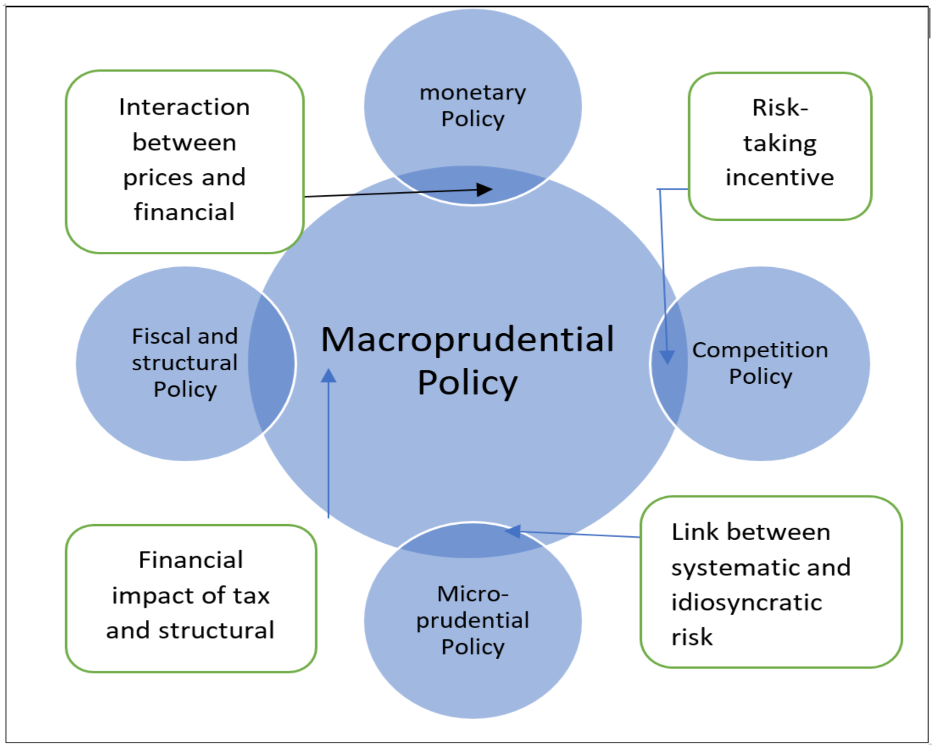
Rubio and Carrasco-Gallego (2013) employed a dynamic stochastic general equilibrium (DSGE) model to analyze the effects of macroprudential and monetary policies on business cycles, welfare, and financial stability. They concluded that the combination of macroprudential regulation and monetary policy significantly improves the financial system's stability. Gao et al. (2018) evaluate the effects of adopting borrower-targeted and financial institution-targeted macroprudential regulations on bank risk-taking and systemic risk for a sample of 3,357 banks from 77 countries throughout 1997-2016 using a difference-in-differences (DiD) technique. Their findings demonstrate how macroprudential policy tools reduce systemic risk and reduce bank risk-taking.

Accordingly, it is clear from the review that macroprudential policy tends to improve long-term financial stability across the board, not only for a single business but also for the entire financial system. However, a dearth of studies on the mechanisms of transmission, possible dynamics, and quantitative effects of macroprudential actions on Africa's financial stability warrants this study. These areas are poorly understood. This study attempts to fill the gap by measuring macroprudential policy with the deviation of capital adequacy ratio from its policy target and deviation of non-performing ratio from its target ratio. The effect of macroprudential policies on financial stability in Africa is calculated following this method adopted by Jibrin et al (2020). Thus, financial stability goals are linked with diverse macroprudential policy instruments to address the potential of systemic risk.

3.0 MACROPRUDENTIAL POLICY FRAMEWORK

Figure 1 illustrates how macroprudential and micro-prudential policies interact with other policies. The development of central banking and financial regulations has been reflected in the evolution of the macroprudential framework over time. Macroprudential policies must include a few critical components to be effective and efficient. These characteristics include in-depth knowledge, analysis of interactions with the larger economy, and systemic growth across the entire financial system. Central banks are in a good position to create macroprudential policy due to their degree of expertise and location at the core of the financial system.

Figure 1: Interaction between Macroprudential Policy and Other Policies



Source: Zulkhibri, and Naiya (2016).

Table 1 provides a comparison of macro- and micro-prudential viewpoints within the context of the current regulatory system. In terms of objective, focus, and approach, as well as in their assessments of risk and tool calibration, the two policies can be distinguished from one another. The macroprudential component focuses on the whole financial system by lowering the possibility of widespread financial distress and averting significant losses based on real output. The micro-prudential framework is focused on individual institutions and reduces the likelihood of failure of specific institutions while safeguarding consumers (investors and depositors) regardless of systemic consequences or effects on the larger economy. This may mean that systemic threats cannot be identified by micro-prudential regulation. In contrast to macroprudential, which sees risk as endogenous because institutions can collectively influence economic transactions, micro-prudential considers risk as exogenous because individual institutions often have little impact on the economy. The bottom-up micro-prudential framework, which takes into account historical and institutional differences, contrasts with the top-down macroprudential paradigm.

Table 1: Comparative Perspective: Macroprudential and Microprudential Policy

	Macroprudential	Microprudential
Proximate objective	Limit financial system-wide distress Maintain the stability of the overall system	Limit distress of individual institutions Maintain soundness of individual financial institutions
Ultimate objective	Avoid output (GDP) costs	Consumer (investor/depositor) protection
Characterization of risk	Seen as dependent on collective behaviour (“endogenous’’	Seen as independent of individual agents’ behaviour (exogenous)
Correlation and common exposures across institutions	Important	Irrelevant

Calibration of prudential controls	In terms of system-wide risk; top-down	In terms of risks of individual institutions; bottom-up

Source: Zulkhibri, and Naiya (2016).

4.0 METHODOLOGY

4.1 Data and Model Specification

Given the interdependence and intricate relationships between the various components of the financial system and the real economy, financial stability is more challenging to quantify than price stability. Thus, from the global financial development database, there are about 8 indicators for measuring financial stability. However, in this study, three indicators of financial stability are employed based on the availability of data in the selected countries in Africa. The ratio of bank credit to bank deposits, Bank Z-scores, liquid asset to deposit, and short-term funding ratio make up this group.

This analysis incorporates two macroprudential policy indices. These indicators include the capital adequacy ratio (CAR), which measures the ratio of regulatory capital to risk-weighted assets, and the percentage of Non-performing Loans to total loans (NPL). Following Jibrin et al. (2020), each macroprudential indicator is computed as the difference between the actual banking industry observation and the policy target. The creation of the indicators was necessitated by the lack of variation in the policy target itself. It should be highlighted that the policy target for nonperforming loans is a maximum threshold. This implies that negative deviations from the target are viewed as positive and vice versa. In contrast, the aim for CAR is a minimal threshold, therefore positive divergence from the policy target is viewed as advantageous and vice versa. Based on this calculation, the indices for macroprudential policy are:
CARdev = deviation of the observed capital adequacy ratio from the target
NPLdev =deviation of the observed non-performing ratio from the target

Other variables included as control variables are generated based on the study of Alam et al. (2019). These variables are the official exchange rate, real interest rate, inflation, and the ratio of broad money to GDP. Though these variables are monetary policy variables, they tend to influence the stability of the financial system. Also, building on the specification of Alam et al. (2019), the functional form of the equation for this study can be expressed as:

$$y_{it} = f(CARdev_{it}, NPLdev_{it}, BD_{it}, INF_{it}, REER_{it}, RIR_{it}) \quad (1)$$

Where y_{it} is a vector of dependent variables that measure financial stability using Bank Z-scores (BZS), bank credit to deposit ratio (BCBD), and a liquid asset to deposit and short-term funding ratio (LADS)? The set of explanatory variables includes measures of macroprudential policy such as deviation of actual capital adequacy ratio from the target (CARdev), the deviation of observed ratio of Non-performing loan to gross loans from the target (NPLdev); the ratio of broad money to GDP (BD); inflation rate (INF) as measured by the CPI; the official exchange rate (EXC); and the real interest rate variable (RIR). The data structure is a panel of 15 African countries[2] between 2010 and 2020. The time frame is chosen because most African countries started the effective implementation of the prudential policy after the global financial crisis. All the data are sourced from the World development indicator and Global Financial Development database. Two layers of the equation were specified. The first equation contains only macroprudential indices as the regressors while the second equation is the full model that contains both the macroprudential indices and the monetary policy variables. The models were specified as:

$$y_{it} = \beta_0 + \beta_1 CARdev_{it} + NPLdev_{it} + \varepsilon_{it} \quad (2)$$

$$y_{it} = \beta_0 + \beta_1 CARdev_{it} + NPLdev_{it} + \beta_2 BD_{it} + \beta_3 INF_{it} + \beta_4 REER_{it} + \beta_5 RIR_{it} + \varepsilon_{it} \quad (3)$$

Where ε_{it} is the error term

4.2 System Generalized Method of Moment

This study uses the dynamic panel data approach. This is because the number of countries (15) and the time make it almost difficult to use pooled regression without

[2] Algeria, Angola, Botswana, Burundi, Gambia, Ghana, Kenya, Lesotho, Mauritius, Mozambique, Nigeria, South Africa, Tanzania, Uganda, Zambia

losing the individual difference across countries. Since the time dimension is less than 30, the dynamic panel GMM technique proved to be the more robust estimate model. Generalized Method of Moments (GMM) estimation employs the appropriate lags of the instrumental variables to construct internal instruments while utilizing the pooled dimension of the panel data. In other words, it imposes no limitations on the length of each time dimension in the graph. Therefore, a suitable lag structure is utilized to exploit the dynamic specification of the data. The study estimated the system GMM of Blundell and Bond (1998), a variation of the dynamic GMM. This is because occasionally, the lagged values of the regressors are poor predictors of the first-differenced regressors. In such a scenario, one would supplement with system GMM. Using the levels equation, the system GMM estimator derives a system of two equations: one differenced and one on levels. By adding the second equation, one can acquire further instruments. Consequently, the variables in the levels of the second equation are instruments with their first differences, which typically boost efficiency (Baltagi and Griffin, 2001).

Thus, the system GMM was used since the difference GMM was found to have poor finite sample qualities in terms of bias and imprecision, especially when the lagged levels of the series were only weakly correlated with the subsequent initial differences (weak instruments). In addition, difference GMM may be prone to a substantial finite-sample downward bias, particularly when the number of accessible periods is quite limited. Hsiao (2022) argues that OLS levels will provide a skewed estimate of the coefficient of an AR(1) model in the presence of individual-specific effects, while within-group estimates will provide a severely biased estimate of the coefficient in short panels (Nickel, 1981). While estimating the system GMM, the Sargan's test (1958, 1988) and Hansen's J test (1982) were employed to validate the instruments' reliability. This was done to guarantee the instruments' validity and that the number of instruments generated by the lag interval did not exceed the number of groups (countries) in the model. This estimator's general framework can be specified as follows:

$$y_{it} = w_{it}\delta + X_{it}\beta + \varepsilon_{it} \quad i = 1, \ldots, N; \qquad t = 1, \ldots, T \tag{4}$$

$$\varepsilon_{it} = u_i + \eta_{it} \tag{5}$$

Where w_{it} are a vector of predetermined covariates (which may include the lag of y) and endogenous covariate, all of which may be correlated with u_i ; y_{it} represents the regressand for individual i over period t; X_{it} denotes the exogenous regressors, ε_{it} is the error term; u_i is the individual specific effects and η_{it} is the remainder disturbance term. The estimation equation for the system GMM can be specified as:

$$y_{it} = \beta_0 + \delta y_{it-1} + \beta_1 CARdev_{it} + \beta_2 NPLdev_{it} + \beta_3 BD_{it} + \beta_4 INF_{it} + \beta_5 REER_{it} + \beta_6 RIR_{it} + \varepsilon_{it} \quad (6)$$

5.0 DISCUSSION OF RESULTS

5.1 Descriptive Statistics

In Table 2, the descriptive statistics of the series are performed to examine the statistical behaviour of the data. In the table, while the spread of the data was described in terms of the mean, minimum, maximum, and standard deviation, the distribution is accounted for by the nature of skewness and degree of kurtosis. The standard deviation showed deviation from the mean and BD had the highest deviation followed by BCBD. CARdev had the least deviation and all the series were positively skewed apart from CARdev which was negatively skewed. Also, most of the series were leptokurtic except for REER, RIR, BZS, and BCBD whose kurtosis values were below 3. Therefore, they were platykurtic.

Table 2: Descriptive statistics of the Variables

	Std. Dev.	Mean	min	max	kurtosis	skewness
NPLdev	3.513	-0.006	-8.945	14.876	6.004	1.098
CARdev	1.392	0.000	-7.36	3.526	7.253	-0.712
INF	4.997	7.353	-2.815	30.695	7.208	1.667
REER	14.316	93.753	66.297	129.729	2.565	0.138
RIR	7.062	7.478	-9.878	24.132	2.928	0.2
BD	25.302	42.725	16.393	163.65	6.491	1.768
BZS	5.147	14.184	3.869	26.869	2.519	0.095
LADS	13.568	35.153	11.769	81.858	3.238	0.714
BCBD	20.729	67.176	17.519	117.762	2.949	0.194

Source: Authors' Computation

5.3 Estimation Results

Table 3 shows an estimation of the effect of macroprudential policy measures on financial stability without the monetary policy variables. Three models were estimated based on the measures of financial stability. For the three measures of financial stability, CARdev had positive effects on all the measures of financial stability even though only the BZS model was statistically significant. This means that the more the capital adequacy ratio outperformed the policy target, the higher the level of stability in the financial system. On the relationship of NPLdev with all three measures of financial stability, the effects of NPLdev were negative but not statistically significant. This indicated that the more banks exceeded the stipulated minimum NPL ratio, the higher the level of instability in the financial system. These two measures of macroprudential policy confirmed the efficacy of the policy in improving financial stability in Africa. This is in line with Iwegbu and Odior (2019) that found macroprudential controls to minimize the procyclicality of bank loans and the amount of capital available to banks. The Wald tests for all three models were statistically significant and the Hansen tests confirmed the validity of the instruments.

Table 3: Results of the Effect of Macroprudential Policy on Financial Stability without the Monetary Policy Variables

Equation	BZS	BCBD	LADS
Constant	0.0750***	0.7666***	.26917***
	(0.0091)	(0.0672)	(0.0332)
y_{it-1}	0.4425***	-0.0998	0.2318***
	(0.0555)	(0.0895)	(0.0820)
CARdev	0.7172**	0.25968	0.2669
	(0.2907)	(0.7519)	(0.6576)
NPLdev	-0.09956	-0.2825	-0.27612
	(0.1168)	(0.3608)	(0.3900)
Wald test	8009.98***	3151.60***	7046.53***
Arellano-Bond test for AR(1)	-1.83**	-2.73**	-3.16***
Arellano-Bond test for AR(2)	1.30	1.06	1.01
Sargan test	4.75	8.95**	12.17***
Hansen test	9.59	9.61	9.94

*Source: Author's Computation. Note: ***,**, and * denote 1 percent, 5 percent, and 10 percent levels of significance respectively. Figures in parentheses are probability value.*

To assess the effectiveness of the macroprudential policy in the presence of monetary policy measures, a full model that captures the two measures was estimated in Table 4. Similarly, based on the three measures of financial stability, which serve as the dependent variable, three models were estimated. The model that employed the bank Z-score (BZS) as the dependent variable is the first model to be taken into account. The majority of variables in the model were significant, and financial stability was improved by CARdev. This showed that if the capital adequacy ratio outperformed the policy target, by one percentage point, financial stability would improve by 0.71

percentage points. Similar to the first estimation without the monetary policy variables, the NPLdev was still not significant in this model. However, it is consistent with the theoretical prediction. Thus, if NPLdev exceeded the minimum threshold of the NPL ratio, financial instability became worse. The exchange rate had a positive impact on financial stability while broad money, inflation, and real interest rates had negative effects. Thus, the loosening of the money supply worsened financial stability. This is plausible given that expansionary monetary policy frequently results in higher-than-anticipated inflation, which has an impact on the ability of various borrowers to pay back their debt. If borrowers' income does not rise sufficiently to balance the increased cost of consumption and investment brought on by inflation, they will find it difficult to pay back their debts. The model's findings that the money supply has a detrimental impact on financial stability are supported by the negative influence of inflation on financial stability in the model.

Table 4: Results of the Effect of Macroprudential Policy on Financial Stability in the Presence of Monetary Policy Measures

Equation	BZS	BCBD	LADS
Constant	-.043365	.99817***	-.2286988
	(.03917)	(.39749)	(.15532)
y_{it-1}	.65934***	-2.5454***	2.86409***
	(.08961)	(.65721)	(.323528)
CARdevit	0.9513***	0.9905	1.5751**
	(0.3190)	(0.9557)	(0.6210)
NPLdevit	-0.0367	-0.5932***	-1.4597***
	(0.1667)	(0.1923)	(0.4718)
BD_{it}	-0.0485**	-0.7062***	-0.3762***
	(0.0189)	(0.1081)	(0.0725)
INF_{it}	-0.0996**	-1.0937***	-0.7547
	(0.0438)	(0.2658)	(0.6290)
$REER_{it}$	0.0934***	-0.0557	0.3218***
	(0.0268)	(0.23969)	(.10287)
RIR_{it}	-0.1218	-0.9651***	-0.3199***
	(0.0793)	(0.2653)	(0.1080)

Wald test	87054.43***	8793.37***	710.18***
Arellano-Bond test for AR(1)	-3.13***	-3.63***	-4.17***
Arellano-Bond test for AR(2)	-0.21	-0.71	-1.35
Sargan test	34.97***	45.56***	21.45***
Hansen test	8.59	9.44	4.20

*Source: Author's Computation. Note: ***,**, and * denote 1 percent, 5 percent, and 10 percent levels of significance respectively. Figures in parentheses are probability value.*

Additionally, the negative impact of the real interest rate on financial stability showed that the rate is higher than the threshold of the financial stability rate over which real interest rates in an economy start to cause systemic instability and financial constraint. However, the exchange rate regime that predominates in Africa could account for the positive impact of exchange rates on financial stability. The predominant exchange rate system in the majority of African countries continues to be managed floating, in which the central bank frequently intervenes in response to demand from the foreign exchange market. This regular central bank involvement reduces the negative impact of exchange rate volatility on price stability and makes it possible for prices to respond rather fast when trading is open. Therefore, a rising exchange rate lowers domestic borrowing costs, which in turn causes credit to increase and eventually improves financial stability.

Similar findings were obtained when the bank credit-to-deposit ratio (BCBD) and the liquid asset-to-deposit ratio (LADS) were used as proxies for financial stability. Both CARdev and NPLdev were now statistically significant in the presence of monetary policy measures. Although the performance of the control variables did not consistently explain the behavior of financial stability, the macroprudential policy tool was consistent and effective in managing financial stability in the three models, according to the conclusions drawn from the estimation. Also, the combination of macroprudential policy with monetary policy was more effective than the sole use of macroprudential policy in addressing financial stability. This is consistent with studies by Grace (2015) and Alam et al. (2019), which asserted that macroprudential policy is the most effective tool for containing financial instability. Additionally, while crucial for achieving price stability, monetary policy variables might not always result in financial stability. This was confirmed by the negative effects of monetary policy indicators in the models. However, the presence of monetary policy measures enhanced the effectiveness of the macroprudential policy framework on financial stability. The results were robust to various sensitivity checks. The null hypotheses of the Arellano-Bond test for AR(2) were not rejected for the models. This validated the applicability of the system GMM estimator for the models. Also, the Hansen tests showed that the instruments used in models were valid as the null hypotheses were not rejected. The Wald test results indicated that all the explanatory variables jointly affected financial stability as the Chi-square values were significant at 1 percent. All these tests buttressed the robustness of the models.

6.0 CONCLUSION

This study was motivated to examine the effectiveness of macroprudential policy on financial stability in selected countries in Africa between 2010 and 2020. The motivation stemmed from the fact that many African countries adopted macroprudential policy as a viable framework after the 2007/2008 global financial crisis. The severe financial crisis has given policies to improve financial stability in most African countries more momentum. Africa's central banks increasingly combine monetary policy with micro- and macroprudential regulation. This emphasized the significance of taking measures that minimize the risks to the whole financial system beyond the supervision and control of individual financial institutions. The study focused on two measures of macroprudential policy based on the availability of data. The measures are the deviation of the capital adequacy ratio from the policy target and the deviation of the ratio of non-performing loan ratio from its target ratio. Three models were analyzed based on the three measures of financial stability (Bank Z-score, ratio of bank credit to bank deposits, and liquid asset to deposit and short-term funding ratio).

Using the system GMM methodology, two estimations were carried out (the one with macroprudential policy measures as the sole regressors and the other with a combination of macroprudential policy and monetary policy indicators). From the findings, the use of macroprudential policy alone was effective in controlling financial stability. While the use of monetary policy indicators had moderate impacts on financial stability, their combination with macroprudential policy measures improved the effectiveness of macroprudential policy on financial stability. Irrespective of the measure of financial stability, macroprudential policy measures improved financial stability. It is, therefore, clear that to achieve financial stability in Africa, macroprudential policy tools prove more effective than monetary policy indicators and the combination of the two performs better. Governments and Central banks in Africa should intensify efforts on the use of macroprudential policy in lowering systemic risks in their economies.

A recommendation for future studies is that they should look at how factors such as financial development, micro-prudential prudential policy, political unrest, and pandemic, among others could influence the impact of macroprudential policy on financial stability in Africa. Also, this study looked at just two measures of macroprudential policy, further studies should expand the measures of macroprudential policy to include other liquidity and asset-based instruments.

REFERENCE

Alam, Z., Alter, A., Eiseman, J., Gelos, G., Kang, H., Narita, M., Nier, E. and Wang, N. (2019). Digging deeper: Evidence on the effects of Macroprudential Policies from a new database. IMF Working Paper, WP/19/66.

Arellano, M. and Bond, S.(1991), “Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations”, Review of Economic Studies, 58(2), pp. 277-97.

Arellano, M. and Bover, O.(1995), “Another Look at the Instrumental Variable Estimation of Error-Components Models”, Journal of Econometrics, 68, pp. 29-51.

Arregui, N., Benes, J., Krznar, I. Mitra, S. and Santos, A. O. (2013). Evaluating the net benefits of macroprudential policy: A cookbook. IMF Working Paper WP/13/167

Baltagi, B. H., & Griffin, J. M. (2001). The econometrics of rational addiction: the case of cigarettes. *Journal of Business & Economic Statistics*, *19*(4), 449-454.

Blundell, R. and Bond, S.(1998), “Initial Conditions and Moment Restrictions in Dynamic Panel Data Models”, Journal of Econometrics, 87, pp. 115-143.

Borio C (2003) Towards a macroprudential framework for financial supervision and regulation? BIS Working Paper No. 128, February. Bank of International Settlements, Basel

Central Bank of Nigeria (2016). An econometric analysis of the impact of macroprudential instruments on the Nigerian economy

Cerutti E, Claessens S, Laeven L (2015) The use and effectiveness of macroprudential policies: new evidence, IMF Working Papers WP/15/61. International Monetary Fund, Washington, DC

Claessens S, Ghosh S, Mihet R (2013) Macro-prudential policies to mitigate financial system vulnerabilities. J Int Money Financ 39(C):153–185

De Nicolo, G, Favara, G. and Ratnovski, L. (2012). Externalities and macroprudential policy. IMF Staff Discussion Note

Duniya, Y. B. (2012). Macro-Prudential Policies and Financial Stability: A Theoretical Background, Economic and Financial Review, vol. 50, No.4

Number 4 Proceedings of the Seminar On "Macro-Prudential Framework and Financial System Stability in Nigeria

Fendoglu, S. (2016). Credit cycles and macroprudential policy framework in emerging countries. BIS Paper No. 86

Gao, W., Miller, T. W. and Taboada, A G. (2018). International evidence on the impact of macroprudential policies on bank risk-taking and systemic risk.

Grace T, Hallissey N, Woods M (2015) The instruments of macroprudential policy. Q Bull Articles

1(1):90–105, Dublin: Central Bank of Ireland

Greenwald, B. C., & Stiglitz, J. E. (1986). Externalities in economies with imperfect information and incomplete markets. The quarterly journal of economics, 101(2), 229-264.

Hsiao, C. (2022). *Analysis of panel data*. Cambridge university press.

Iwegbu, O. and Odior, E. S. O. (2019). Macroprudential policy instruments, procyclicality of capital and bank lending in Nigeria: from the post-global financial crisis. Jos Journal of Economics, vol. 8, No. 3.

Jibrin, Y., Adegbe, B. and Ogbonanaya-Orji, N. (2020). Macroprudential policy and the banking system stability in Nigeria, Economic and Financial Review, Vol.58, No. 3.

Lim, C., Columba, F., Costa, F., Kongsamut, P., Otani, A., Saiyid, M., Wezel, T. and Wu, X. (2011). Macroprudential policy: what instruments and how to use them? Lessons from country experiences. IMF working paper WP/11/238

Ma, C. (2017). Financial stability, growth, and macroprudential policy. Job Market Paper.

Masson, P. (2014). Macroprudential policies, commodity prices and capital inflows in Mohanty, M. S. (2014). The role of central banks in macroeconomic and financial stability, BIS Papers No. 76

Okafor, H., & Asuzu, O. (2018). The impact of prudential measures on the performance of deposit money banks in Nigeria. Economic and Financial Review, 26-40

Rubio, M. and Carrasco-Gallego, J. A. (2013). Macroprudential and monetary policies: Implication for financial stability and welfare, IFABS Conference (2013)

Tomuleasa, I. (2013). Macroprudential policy and systemic risk: An overview. Procedia Economics and Finance 20 (2015) 645 – 653

Villar, A. (2017). Macroprudential frameworks: objectives, decision and policy interactions. BIS Papers, No. 94.

Zulkhibri, M and Naiya, I (2016). Macroprudential Policy and regulation in a dual Banking system" An exploratory perspective in Zulkhibri, M., Ismail, A. G., and Hidayat, S. E. (2016). Macroprudential Regulation and policy for the Islamic financial industry: Theory and applications. Springer Internation Publishing Switzerland.

MODELLING OIL PRICE VOLATILITY WITH STRUCTURAL BREAK: A RE-EXAMINATION

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Abstract

This paper revisits the analyses of crude oil prices of two prominent oil prices namely the Brent and West Texas Intermediate (WTI) in the face of the COVID-19 pandemic using the Narayan and Popp (2010) and Bai and Perron (2003) tests. The paper identifies a structural break in 2020 which corresponds to the COVID-19 pandemic and analyses the performance of various symmetric and asymmetric volatility models in the presence of the COVID-19 structural break alone and combination with the breaks identified in Salisu and Fasanya (2013). The results suggest that the EGARCH (1,1) seems to offer a better fit, relative to all the other models estimated, suggesting that asymmetric models are superior to symmetric models when modeling oil price volatility. The findings also show that the inclusion of additional structural breaks does not significantly vary the results from the initial estimates obtained from the COVID-19 break date alone. The study recommends the inclusion of the COVID-19 structural break when modelling oil price volatility due to its superimposing effect on other break dates. Furthermore, portfolio managers and policymakers in oil-exporting and oil-importing economies need to contemplate pandemic risk as a critical risk factor in their analyses given its significant impact on crude oil prices and the resultant effect on their economies and financial markets.

Keywords: Crude oil price, COVID-19, structural breaks, volatility modelling
JEL classification: C01, C54, F13

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1.0 INTRODUCTION

Crude oil plays a major role in economic activities globally as it drives the world economy. The volatility of crude oil prices is a very important term to be understood in analyzing the global economy. Understanding the concept of volatility in oil prices has increasingly gained importance to both investors and policymakers (Pindyck, 2004). In the short term, the volatility of crude oil can affect the demand for storage, as greater volatility would lead to increased storage demand, spot prices, and marginal convenience yield. For instance, the COVID-19 pandemic affected a good number of energy markets and its impacts on oil markets were significantly severe because it reduced the circulation of individuals and merchandise, sparking a significant downswing in demand for fuel. Oil price is one of the most volatile prices which has a significant impact on the macroeconomic behavior of many developed and developing economies. Long-term uncertainty in future oil prices can alter the incentives to develop new oil fields in oil-producing countries (Pindyck, 2004). In addition, structural change in the oil industry has introduced more complexity into both the oil industry and oil pricing policies and has led to considerable oil price volatility since 2014 (Aghababa and Barnett, 2016). Volatility in oil prices can also hinder the implementation of alternative energy policies in oil-consuming countries due to the effect of oil price volatility on the government and investors' decision-making.

Furthermore, in high-frequency oil price data, there is the possibility of conditional heteroscedasticity which may result in huge losses or gains to oil-producing and exporting nations, especially the oil-dependent economies. This has been established in literature both empirically and theoretically (Ferderer, 1996; Narayan and Narayan.2007; Salisu and Fasanya, 2013; Devpura & Narayan, 2020). It should be noted that previous works often assume a stable structure of parameters in the oil return volatility process. This assumption means that the unconditional variance of crude oil returns is constant and leads to ignoring the fact that crude oil markets can be exposed to periods of large price changes as commonly observed since the liberalization of these markets in the mid-1980. Examples of such periods may include the Gulf War, Asian crises, worries over Iranian nuclear plans, the US and global recession, and most recently COVID-19 outbreak of the year 2020. These shocks can cause breaks in the unconditional variance of oil price changes.

The COVID-19 pandemic negatively impacted economies and financial markets, especially the oil industry. First, it created a demand shock as it reduced global demand for crude oil, increased uncertainty, and triggered economic recessions in most developed and emerging countries. Second, it also created a supply shock as the pandemic resulted in supply chain disruptions and an oil trade war between the major oil-producing nations (Saudi Arabia and Russia). Both shocks led to very high levels of oil price volatility (Bourghelle et al, 2021). According to Devpura & Narayan (2020) and Le et. al (2021), COVID-19 cases and deaths led to an increase in daily oil price volatility by between 8% and 22%. Crude oil recorded negative prices for the first time in history as the price of the West Texas Intermediate (WTI) crude plummeted to -US$37 per barrel on April 20, 2020, marking an unprecedented 300% drop in price. Interestingly, Yu et al (2022) noted that the speed of information transmission between oil prices and economic activities was greater in the era of the COVID-19 outbreak as compared to other global financial crises.

Several studies on oil price volatility have taken different dimensions to model the volatility for instance: Hou and Suardi (2012) use parametric GARCH models to characterize crude oil price volatility. They also consider an alternative approach involving a nonparametric method to model and forecast oil price return. Abdulkareem and Abdulhakeem (2016) employed the GARCH model and its variants (GARCH-M, EGARCH, and TGARCH) on daily, monthly, and quarterly data, focusing on two prominent crude oil markets, Brent and West Texas Intermediate (WTI). Kristjanpoller and Minutolo (2016) used a hybrid model of ANN-GARCH to analyze and predict oil price return volatility. Salisu and Fasanya (2013) also analyze oil prices of West Texas Intermediate (WTI) and Brent using the two recently developed tests by Narayan and Popp (2010) and Narayan and Liu (2015) both of which allow for two structural breaks, employing several GARCH-type models (GARCH (1,1) GARCH-M (1,1) TGARCH (1,1) EGARCH (1,1)). Zhang & Zhang (2023) used GARCH models to characterize crude oil price volatility, noting that the flexible Fourier form (FFF)-GARCH-type models outperform Markov regime switching MRS-GARCH for forecasting crude oil price volatility and portfolio performance. Narayan and Narayan (2007) also attempted to model oil price volatility using various sub-samples to judge the robustness of their results. Zhang & Zhang (2023) used GARCH models to characterize crude oil price volatility, noting that the flexible Fourier form (FFF)-GARCH-type models outperform Markov regime switching MRS-GARCH for forecasting crude oil price volatility and portfolio performance. Cerović Smolović, et.al (2017) also investigated the performance of eight GARCH models and revealed that the TS GARCH, T GARCH, and EGARCH models perform the best at predicting volatility in the Montenegrin emerging market. Mbwambo & Letema (2023). also employ a family of GARCH models specifically the *GJRGARCH* to forecast crude oil price volatility. Luo et al. (2022) used the HAR-RV model of Corsi (2009) and its various extensions that also incorporate structural breaks to investigate the oil and gold volatilities using sentiment indicators and found significant results.

Given the inimical impact of crude oil price volatility on fiscal accounts, economic planning, and macroeconomic stability of oil exporting and oil importing countries, it is vital to empirically evaluate the impact of the COVID-19 pandemic on the volatility of crude oil prices. This is particularly important as the findings of this paper will guide policymakers of oil-dependent economies on possible actions to take in the wake of another pandemic. The findings also have implications for the investors in financial markets influenced by oil market fluctuations, as heightened volatility arising from pandemics will affect their returns. Thus, the main objective of this paper is to revisit the modelling of oil prices considering the impact of the COVID-19 pandemic and the Russia-Ukraine War on the oil market. Drawing from Salisu and Fasanya (2013), the study employs the Narayan and Popp (2010) test alongside GARCH-type models to capture the COVID-19 structural break and employs the Bai and Perron (2003) break test for robustness.

This paper analyses the performance of various volatility models within the GARCH family for the two prominent oil prices namely Brent and WTI. The paper also allows for structural breaks both in the symmetric as well as asymmetric GARCH models. The remainder of this paper is structured as follows. Section two is the review of relevant literature while section three provides data and pre-estimation analysis. Section four presents the methodology and discusses the results while section five provides the concluding remarks.

2.0 LITERATURE REVIEW

There is a vast number of studies on volatility in literature. This is due to the impact of volatility on macroeconomic policy and investment analysis. Recent studies on oil price volatility have covered different areas and issues and how these can affect the decision-making of both government and private investors. Such studies include mostly time series analysis on oil prices and financial series. Such studies used both parametric and non-parametric models for analysis and arrived at different conclusions. For instance, using the exponential generalized conditional heteroskedasticity (EGARCH) model to gauge the features of crude oil price volatility such as asymmetry and persistence of shocks, Narayan & Narayan (2007) found that across the sub-samples analyzed, there was inconsistent evidence of asymmetry and persistence of shocks over the full sample period. The evidence suggested that shocks have permanent and asymmetric effects on volatility. These findings imply that the behavior of oil prices tends to change over short periods. The effect of volatility also differs between economies. This is also evident in Bourghelle et al (2021) where oil price volatility reacted substantially to the pandemic-induced shocks by creating both demand and supply shocks in most developed and emerging countries and oil-producing nations, respectively.

Oil price was found to be ten times more volatile during the onset of the COVID-19 pandemic compared to the pre-COVID-19 period by Devpura and Narayan (2020), who examined the evolution of hourly oil price volatility using multiple measures of oil price volatility. Furthermore, after controlling for conventional predictors of oil price volatility, the study showed that COVID-19 cases and deaths led to an increase in daily oil price volatility by about 8% to 22%. Regarding the effect of oil price volatility on the strategic investment decisions of firms, Sadorsky (2011) developed a model of a company's strategic investment and showed how changes in oil price volatility can impact strategic investment decisions using generalized method of moment (GMM) estimation techniques for panel data sets of US firms. The results established a U-shaped relationship between oil price volatility and firm investment because higher oil price volatility is associated with more energy input uncertainty. The impact of volatility is also time-varying as seen in Chen & Zhang (2023). Their findings show that the risk spillovers of crude oil price shocks exhibit typical time-variant characteristics in different periods where crude oil-importing countries are the recipients of these risks.

Studies vary in the type of volatility models used. Lin *et al.* (2020) compared un-regime GARCH-type models with Markov and hidden Markov (HM) switching regimes in forecasting WTI and Daqing crude oil markets. They found that a HM-EGARCH model outperforms the competitive models, namely the regular GARCH-type models and Markov regime-switching models as well as the other models with hidden Markov regimes. HM-EGARCH not only performed well in developed crude oil markets but also in emerging crude oil markets. The results confirmed that MRS-EGARCH and HM-EGARCH models reflect the asymmetric effects on volatility when considering different degrees of states on volatility.

Similarly, Klein & Walther (2016) compared the recently proposed Mixture Memory GARCH (MMGARCH) model to other discrete volatility models (GARCH, Risk Metrics, EGARCH, APARCH, FIGARCH, HYGARCH, and FIAPARCH). They incorporated an Expectation-Maximization algorithm for parameter estimation of the MMGARCH and found different structures in volatility level as well as shock persistence. Based on their findings, MMGARCH is also able to capture asymmetric and long-memory effects. Furthermore, they observed a dissimilar memory structure in the variance of WTI and Brent crude oil prices. Their results also show that MMGARCH outperforms the aforementioned models due to its dynamic approach in varying the volatility level and memory of the process. Liu, et al (2020) examined the dynamic relationship between crude oil prices and the U.S. exchange rate within the structural break detection context. Employing a time-varying parameter vector autoregressive TVP-VAR model, their results showed that shocks to crude oil prices have immediate and short-term impacts on movements in the exchange rate which are emphasized during the confidence intervals of structural breaks. Similarly, Chatziantoniou, et al (2021) also employed a TVP-VAR model to investigate the impact of oil supply, oil demand, oil inventory, financial market uncertainty, financial interbank, and financial trends in different currencies on monthly data.

Studies on oil price volatility with structural breaks are few. Salisu and Fasanya (2013) analyzed the oil prices of two prominent markets namely West Texas Intermediate (WTI) and Brent using the Narayan and Popp (2010) and Liu and Narayan (2010) tests and symmetric and asymmetric volatility models. They identified two structural breaks that occurred in 1990 and 2008 which coincidentally correspond to the Iraqi/Kuwait conflict and the global financial crisis, respectively. Their results also find evidence of persistence and leverage effects in the oil price volatility with the EGARCH model providing the best fit.

The review of the literature reveals a dearth of studies that analyze oil price volatility with structural breaks in the COVID-19 era. This is particularly important given the pervasive impact of crude oil prices on economies and financial markets in addition to the possibility of other pandemics in the future. Notably, most of the studies reviewed failed to accommodate more than one structural break test in their analyses for robustness or to even account for up to three structural breaks in their volatility models. Given that crude prices have undergone several structural changes, it is important to account for as many structural breaks as possible when modelling them. This is a major contribution of this study.

2.1 Theoretical framework

The volatility of oil prices is crucial because persistent changes in volatility can expose producers and industrial consumers to risk, thus affecting investments in oil inventories and facilities for production and transportation (Narayan and Narayan.2007). Typically, the volatility of financial instruments and commodities in general, and oil price returns are modeled by using Generalized Autoregressive Conditional Heteroskedasticity (GARCH) processes introduced by Engle and Bollerslev (Klein & Walther, 2016). Volatility also determines the value of commodity-based contingent claims. Thus, its behavior is important for derivative valuation, hedging decisions, and decisions to invest in physical capital. All these are tied to the production or consumption of natural gas and oil (Pindyck, 2004).

Furthermore, Pindyck (2004) argues that volatility can affect the total marginal cost of production, thus affecting the value of the firms' operating options and thus the opportunity cost of current production. The more volatile crude oil prices become the more uncertainty it creates, leading to economic instability for both oil-exporting and oil-importing countries. Higher crude oil prices contribute to inflation; the result is a recession in oil-dependent countries. One side of this literature demonstrates that oil prices hurt economic growth (Narayan and Narayan, 2007). Oil price volatility can impact investment decisions because higher oil price volatility is associated with more energy input uncertainty which affects the marginal product of capital (Pindyck, 1991). Consistent with the literature on real options, in the face of increased uncertainty, companies often postpone investment decisions because there is an option value of waiting to resolve uncertainty (Pindyck, 1991; Dixit and Pindyck, 1994; Henriques and Sadorsky (2011).

3.0 DATA AND PRE-ESTIMATION ANALYSIS

To achieve the objective of this study, daily oil price data covering 06/01/1987 - 07/18/2022 was employed due to data availability. This section presents the descriptive statistics for oil price and its returns and provides the unit root test results using the NP unit root test with structural breaks in addition to the ARCH LM test results.

The descriptive statistics of Brent and WTI oil prices and their returns are presented in Table 1. The results suggest the presence of significant variations in the oil prices and returns as seen by the sizeable difference between the minimum and maximum values. Comparatively, the standard deviation reveals that the Brent oil price is more volatile than the WTI oil price, while WTI returns seem more volatile than Brent returns. WTI also recorded the highest and lowest returns.

Concerning the statistical distribution of the oil prices, both WTI and Brent are positively skewed implying the presence of a long right tail. About kurtosis, both series are platykurtic indicating the presence of flat distribution relative to the normal distribution. Similarly, the Jarque Bera (JB) statistic also indicates that both oil prices are non-normal. Regarding the oil price returns, both series are negatively skewed, leptokurtic, and non-normally distributed. Consequently, the appropriate inferential statistics to be adopted are alternatives that follow non-normal distributions such as the student-t distribution, and the generalized error distribution (GED) (see Salisu and Fasanya, 2013). The Akaike Information Criterion (AIC), Schwartz Information Criterion (SIC), and Hannan– Quinn Information Criterion (HQC) were employed to determine the best alternative inferential statistic and the student-t distribution outperformed other error distributions; therefore, this study presents only results obtained with the student-t distribution.

Table 1: Descriptive Statistics of Brent and WTI

Statistics	BRENT		WTI	
	P_t	r_t	P_t	r_t
Mean	46.6158	0.0192	45.3458	-0.0245
Median	33.7300	0.0000	35.4100	0.0000
Maximum	143.9500	41.2022	145.3100	42.5832
Minimum	0.0000	-64.3698	-36.9800	-301.9661
Std. Dev.	33.1766	2.4779	29.8464	4.2780
Skewness	0.7868	-1.9258	0.7289	-41.0159
Kurtosis	2.4936	76.1711	2.5133	2789.974
Jarque-Bera	1043.639	2050232	902.1331	2.97E+09
Probability	0.0000	0.0000	0.0000	0.0000
Sum	427234.5	176.8467	415594.3	-224.8856
Sum Sq. Dev.	10086723	56268.88	8163386	167713.9
Observations	9165	9165	9165	9165

Note: P_t = oil price, and r_t = returns.

Figure 1: A combined graph for Brent price (Pt) and Brent (rt), 06/01/1987 - 07/18/2022

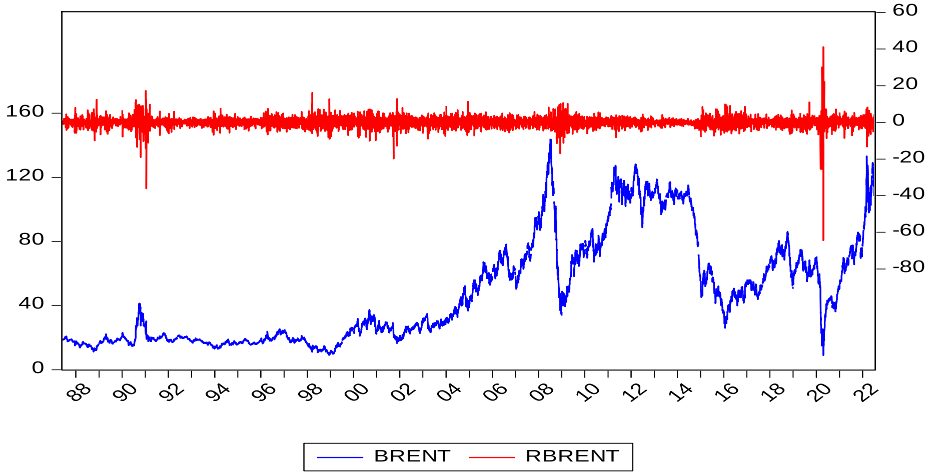


Figure 2: A combined graph for WTI price (Pt) and WTI (rt), 06/01/1987 - 07/18/2022

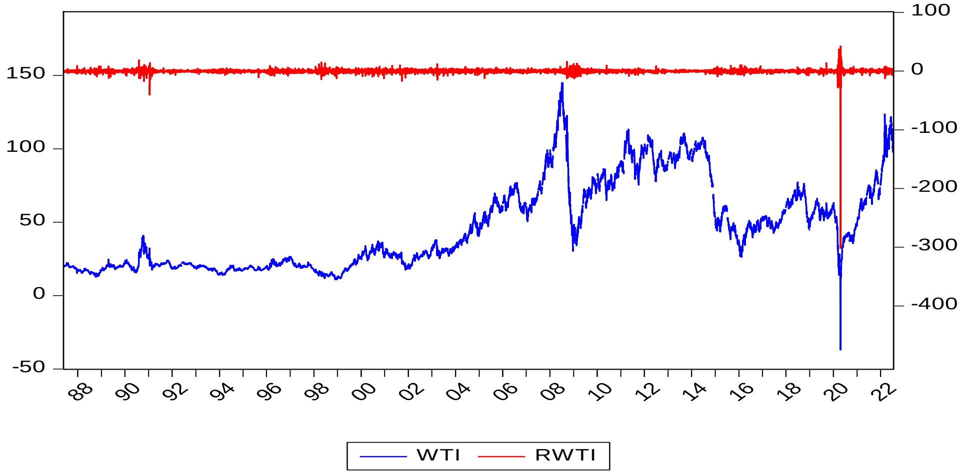
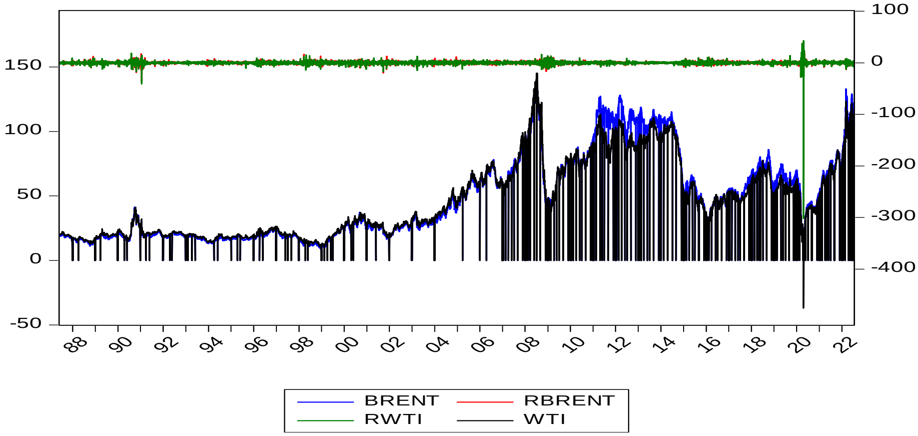


Figure 3: A combined graph for Brent price, WTI price, Brent returns (rt), and WTI returns (rt), 06/01/1987 - 07/18/2022.



From the dynamics of the two markets illustrated in Figures 1, 2, and 3, there is evidence of volatility clustering in both return series, especially the Brent returns as periods of high volatility are succeeded by periods of relatively low volatility. The significant spikes in the return series suggest the presence of structural breaks in the series particularly during the peak of the COVID-19 pandemic. This is corroborated by Table 1, which shows the highest volatility in both series occurring during the COVID-19 pandemic. The spike during the COVID-19 pandemic is more pronounced in the WTI return series than the Brent return series as it seems to obscure other periods of notable volatility in the Brent return series such as the 2014 oil glut, global financial crisis, and the 1990 Iraqi/Kuwait conflict and Gulf war. This suggests that the COVID-19 pandemic exerted a more sizeable impact on the WTI returns than the Brent returns. Table 2 presents the results for examining the existence of ARCH effects in both return series using a univariate model specified as follows:

$$r_t = \omega + \sum_i^k \rho_i r_{t-i} + \varepsilon_t; \quad i = 1, \dots, k; \quad t = 1, \dots, T; \quad \varepsilon_t \sim IID(0, \sigma^2); |\rho_i| < 1 \quad (1)$$

Note that r_t represents oil price returns and is calculated as

$$r_t = 100 \times [\Delta \log(P_t)] \quad (2)$$

Where P_t is oil price and Δ denotes the first difference.
The ARCH LM test conducted to determine the presence of volatility is in the spirit of Engle (1982), where Eq. 1 is estimated using OLS to obtain fitted residuals. The square of the fitted residuals is then regressed on a constant and lags of squared residuals as shown below:

$$\hat{\varepsilon}_t^2 = \tau_0 + \tau_1 \hat{\varepsilon}_{t-1}^2 + \tau_2 \hat{\varepsilon}_{t-2}^2 + \cdots + \tau_p \hat{\varepsilon}_{t-p}^2 + U_t \quad (3)$$

Finally, the LM test is employed to assess the null hypothesis of no ARCH effect in Eq. 3.

Table 2 confirms the presence of ARCH effects in both return series as shown by the results of the *nR*^{2} and *F*-test up to the 10th lag. At all the selected lags, the test statistics are statistically significant at the 1% level, thus rejecting the “no ARCH effect” null hypothesis for both return series, which is consistent with the existence of large movements in oil prices observed in the descriptive statistics.

Table 2: ARCH test

Dependent Variable: oil price returns (r_t)												
Model	P = 1				P = 5				P = 10			
	F-test		nR^2		F-test		nR^2		F-test		nR^2	
	WTI	Brent	WTI	Brent	WTI	Brent	WTI	Brent	WTI	Brent	WTI	Brent
k=1	19.72*	1154.21*	19.67*	1013.50*	227.87*	74.89*	1174.30*	357.02*	227.67*	137.70*	1700.69*	1143.49*
K=2	231.35*	1034.56	224.97*	917.48*	321.22*	92.33*	1319.75*	434.79*	221.30*	141.01*	1654.73*	1161.21*
K=3	265.31*	1059*	257.90*	934.92*	282.85*	133.33*	1182.78*	610.60*	222.60*	153.54*	1651.53*	1238.87*

Note: Model follows the autoregressive process in Eq. (1) of order k = 1, 2, 3, respectively and p is the lag length for the test statistics based on Eq. (3). *=1% level of significance; **=5% level of significance.

Table 3: NP unit root test with two break dates

Oil Benchmark	M1			M2		
	Test statistic	TB1	TB2	Test statistic	TB1	TB2
WTI	-72.94	20/4/20	21/4/20	-73.462	20/4/20	21/4/20
Brent	-20.17	20/4/20	21/4/20	-21.247	20/4/20	21/4/20

Note: Critical values at the 1% and 5% levels are 4.672 and 4.081, respectively, in model 1 and -5.287 and -4.692 in model 2, respectively. M1 = model 1, M2 = model 2, TB1 = break date 1 and TB2 = break date 2.

Table 3 presents the results from the Narayan and Popp (2010) test that allows for two structural breaks in a series (See Salisu and Fasanya (2013) for details on derivations). The results suggest that we can reject the null hypothesis of a unit root in the oil prices of both markets when we account for structural breaks. Consequently, the identified structural breaks should be accounted for when modelling the volatility in the WTI and Brent oil markets. Similar to Salisu and Fasanya (2013), the identified break dates for both models were not far apart. Surprisingly, the first (TB1) and second (TB2) breaks for both return series occurred in 2020 unlike Salisu and Fasanaya (2013) who identified different breaks in 1990 and 2008. The identified break occurs in April 2020 for both markets which coincided with the peak of the COVID-19 pandemic when global demand for crude oil crashed and inventories increased significantly, triggering a crash in crude oil prices with the WTI oil price recording negative values. This unprecedented crash in oil prices relative to previous periods may be responsible for the detection of only one structural break. This is similar to the results of the Bai-Perron (2003) test which identified April 2020 as the break date for both crude oil prices (see Appendix). Consequently, the oil price volatility is modelled to capture this notable swing in oil prices corresponding to the COVID-19 pandemic. For robustness, the same analysis is also conducted including two other break dates (01/08/1990 and 26/06/2008 for WTI and 25/06/1990 and 03/04/2008 for Brent) as identified in Salisu and Fasanya (2013) to evaluate the impact of additional break dates on the modelling of oil price volatility.

4.0 VOLATILITY MODELS AND EMPIRICAL ANALYSIS

This section considers different symmetric and asymmetric models for measuring the volatility of WTI and Brent oil price returns and compares the performance of these models using several model selection criteria such as AIC, SIC, and HQC. To validate the estimated volatility models, some post-estimation analyses using the ARCH LM test are also provided. A notable contribution of our paper in modeling oil price volatility is the inclusion of the COVID-19 structural break. This is in addition to the accommodation of three structural break dates selected from the NP unit root test and Salisu and Fasanya (2013) in the symmetric and asymmetric models. The estimated symmetric volatility models are the GARCH (1, 1) and GARCH- Mean (1, 1) models, while the Exponential GARCH [EGARCH] (1,1) and the Threshold GARCH [TGARCH] (1,1) models are the asymmetric volatility models considered.

Symmetric Models

The mean equation of the GARCH (1, 1) model is given as:

$$r_t = \omega + \rho r_{t-1} + \alpha_1 B_{1,t} + \alpha_2 B_{2,t} + \varepsilon_t; \tag{4}$$

Given that $B_{1,t} = 1$ if $t \geq TB_i$ and zero otherwise; $TB_i (i = 1,2)$ represents the selected break dates as illustrated in Table 3. Note TB denotes break dates. If $\varepsilon_t = \sigma_t e_t$ and $e_t \sim (0.1)$, the variance equation for the GARCH (1,1) model can be written as:

$$\sigma_t^2 = \alpha + \beta \hat{\varepsilon}_{t-1}^2 + \varphi \sigma_{t-1}^2; \ \alpha > 0, \beta \geq 0, \varphi \geq 0 \tag{5}$$

According to Eq. 5 when there is evidence of volatility in the series, the variance increases in size, however, the variance is smaller when there is no evidence of volatility.

The GARCH-M model includes the variance in the mean equation to capture the effect of the conditional variance in determining the behavior of a series. Consequently, Eq. 4 can be modified into:

$$r_t = \pi + \mu \sigma_t^2 + \rho r_{t-1} + \alpha_1 B_{1,t} + \alpha_2 B_{2,t} + \varepsilon_t; \tag{6}$$

Asymmetric Models

The EGARCH and the TGARCH models are the asymmetric models considered in this study and the EGARCH (1,1) model is specified as follows:

$$ln(\sigma_t^2) = \omega + \xi \left| \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} \right| + \eta \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \delta\, ln(\sigma_{t-1}^2) \quad (7)$$

Where, ξ represents the effect of the conditional shock on the conditional variance and η captures the asymmetric effect, while δ measures the persistence of shocks to the variance. When $\eta < 0$, negative shocks increase volatility more than positive shocks of the equivalent magnitude, and $\eta = 0$, indicates the absence of asymmetric effects.
Including a dummy variable (I_{t-1}) in equation (5), transforms the symmetric GARCH (1,1) model into the asymmetric TGARCH (1,1) model as follows:

$$\sigma_t^2 = \alpha + \beta\hat{\varepsilon}_{t-1}^2 + \varphi\sigma_{t-1}^2 + \pi\varepsilon_{t-1}^2 I_{t-1} \quad (8)$$

Such that $I_{t-1} = 1$ if $\varepsilon_{t-1} > 0$ and $I_{t-1} = 0$ otherwise. Thus, asymmetric effects exist if $\pi < (>)0$, which implies that positive (negative) shocks reduce the volatility of oil price returns more than negative (positive) shocks of an equivalent amount.

Discussion of Results

The results for both Brent and WTI from all the models suggest the existence of a slow mean reverting variance process, given that the ARCH and GARCH terms are very close to 1. This implies that shocks are more likely to have permanent effects on the volatility of Brent returns. This also means that shocks to Brent volatility tend to persist as they do not die out quickly over time. The results also suggest that the volatility in the Brent oil price is more persistent than the volatility in the WTI oil market. This has implications for investors with different risk appetites as risk-averse investors would be more inclined to invest in WTI crude oil.

Table 4: Estimation results of volatility models with one structural break for Brent

Variable	GARCH (1,1)	GARCH-M (1,1)	TGARCH (1,1)	EGARCH (1,1)
Mean equation				
η	0.0379 (2.2129)**	-0.0173 (0.6763)	0.0327 (1.8890)	0.0283 (1.6703)
δ	0.0294 (2.8328)*	0.0293 (2.8220)*	0.0300 (2.8872)*	0.0296 (2.9427)*
α_1	0.2722 (3.5368)*	0.2615 (3.3940)*	0.2680 (3.4749)*	0.2709 (3.5218)*
ϕ	-	0.0064 (1.0880)		
Variance equation				
γ	0.0616 (6.3776)*	0.0609 (6.3576)*	0.0625 (6.4818)*	-0.0879 (-12.8336)*
α	0.0820 (13.1561)*	0.0815 (13.1531)*	0.0669 (8.6108)*	-
β	0.9109 (153.6470)*	0.9115(154.4716)*	0.9102 (153.3823)*	-
ϑ			0.0298 (3.0455)*	-
ψ				0.1501 (14.8614)*
τ				-0.0277 (-4.3755)*
ρ				0.9853 (454.2458)*
Observations	9164	9164	9164	9164
Diagnostics				
SIC	4.1494	4.1501	4.1494	4.1455
AIC	4.1440	4.1439	4.1432	4.1393
HQC	4.1458	4.1460	4.1453	4.1414
ARCH LM test				
F-test	1.4865	1.4787	2.2140	8.9707*
nR^2	29.7017	29.5465	4.4274	17.9122*

Note: *, ** indicate 1% and 5% levels of significance, respectively. *η = constant, δ = lagged return series, α_1 = structural break 1, ϕ = GARCH in mean, γ = constant in variance equation, α = ARCH term, β = GARCH term, ϑ = TGARCH term, τ = asymmetry effect term, ρ =log (GARCH1-))*

Table 5: Estimation results of volatility models with one structural break for WTI

Variable	GARCH(1,1)	GARCH-M(1,1)	TGARCH(1,1)	EGARCH(1,1)
Mean equation				
η	0.0495 (2.7311)*	0.0079 (0.1739)	0.0470 (2.5648)**	0.0445 (2.4465)**
δ	-0.0200 (-1.897)	-0.0197 (-1.8746)	-0.0199 (-1.8895)	-0.0223 (-2.2623)**
α_1	0.2820 (3.5828)*	0.2746 (3.4820)*	0.2807 (3.5678)*	0.2951 (3.6370)*
ϕ	-	0.0365 (1.0230)		
Variance equation				
γ	0.1438 (8.4179)*	0.1437 (8.4215)*	0.1453 (8.4654)*	-0.0769 (-11.9788)*
α	0.1112 (14.1809)*	0.1110 (14.1808)*	0.1038 (10.0986)*	-
β	0.8693 (118.3432)*	0.8(118.4543)*	0.8685 (118.2235)*	-
ϑ			0.0150 (1.1428)	-
ψ				0.1448 (15.6095)*
τ				-0.01225 (1.9069)**
ρ				0.9816 (433.5621)*
Observations	9164	9164	9164	9164
Diagnostics				
SIC	4.2603	4.2613	4.2612	4.2551
AIC	4.2549	4.2551	4.2550	4.2488
HQC	4.2567	4.2572	4.2571	4.2510
ARCH LM test(5)				
F-test	0.0230	0.0233	0.0220	0.0061
nR^2	0.1155	0.1166	0.1102	0.0306

Note: *, ** indicate 1% and 5% levels of significance, respectively. η = *constant,* δ = *lagged return series,* α_1 = *structural break 1,* ϕ = *GARCH in mean,* γ = *constant in* *variance equation, α = ARCH term, β = GARCH term, ϑ = TGARCH term, τ = asymmetry effect term, ρ =log(GARCH1-))*

Among the symmetric volatility models, the SIC value indicates that the GARCH (1,1) model outperforms the GARCH-M(1,1) model for both markets. This is corroborated by the insignificant coefficient of the variance of r_t i.e., ϕ, included in the mean equation, which adds no value to the volatility of WTI and Brent. Considering the asymmetric models, the EGARCH (1,1) model outperforms the TGARCH (1,1) model for both markets, based on the SIC value. Overall, the EGARCH (1,1) seems to offer a better fit, relative to all the other models estimated, suggesting that asymmetric models are superior to symmetric models when modeling oil price volatility. The EGARCH (1,1) model also suggests the existence of leverage effects in both markets, given that the coefficient that measures leverage is negative and significant. This implies that negative shocks tend to induce volatility more than positive shocks, as such, bad news in both markets increases volatility more than good news. In other words, negative shocks appear to fuel higher volatility than positive shocks of the same magnitude. As such financial market operators in markets influenced by both crude oil prices should be weary of bad news.

Figures 3 and 4 illustrate the conditional variance of oil prices from the Brent and WTI markets. The most notable spikes in both graphs correspond to the break date identified by the NP unit root test, lending further credence to the need to capture structural breaks when modeling oil price volatility. This implies that over the 06/01/1987 - 07/18/2022 period the COVID-19 shock has had the most significant impact on both markets. This suggests that pandemic-induced volatility may outweigh other causes of volatility in magnitude. Remarkably, while smaller spikes that correspond to the break dates identified in Salisu & Fasanya (2013), Iglesias & Rivera-Alonso (2022), and Zhang et al (2022) can be observed in Figure 3, no such spike is observable in Figure 4, suggesting that the effect of the COVID-19 pandemic shock was more significant on the WTI market relative to the Brent market. This is not surprising given the negative value recorded in the WTI price at the peak of the pandemic. As such risk-averse investors are better off investing in markets influenced by Brent crude oil.

Figure 3: Estimated conditional variance for Brent price from EGARCH model, 06/01/1987 - 07/18/2022.

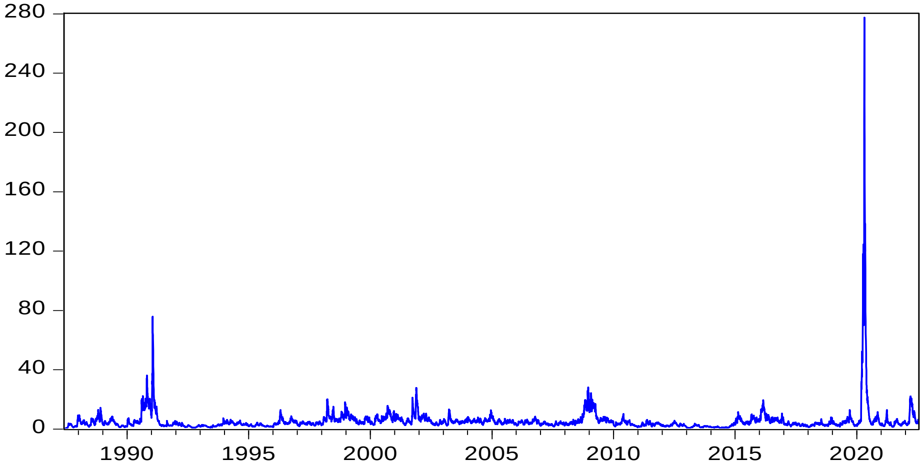
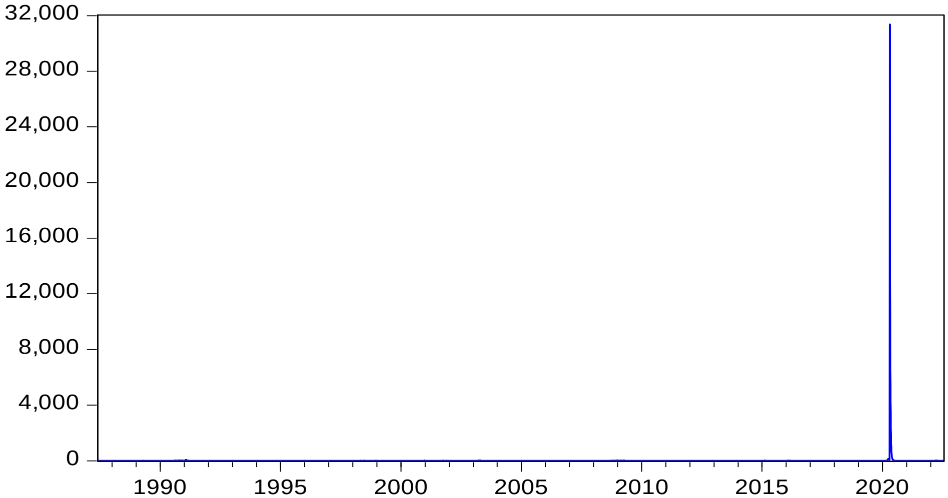


Figure 4: Estimated conditional variance for WTI price from EGARCH model, 06/01/1987 - 07/18/2022.



Post-estimation ARCH diagnostic tests were conducted on all the models to ascertain the existence of ARCH effects in both markets given the results from the pre-estimation tests. The *F*-test and the chi-square distributed nR^2 test results suggest that we do not reject the null hypothesis of no ARCH effects in most models for both markets. However, we fail to reject the null hypothesis of no ARCH effects in the EGARCH (1,1) model in the Brent oil price market. This suggests that the TGARCH (1,1) model may be more suitable for modeling volatility in the Brent oil market.

Robustness Checks

To evaluate the impact of additional break dates on the modelling of oil price volatility, the same analysis above was conducted including the two break dates (01/08/1990 and 26/06/2008 for WTI and 25/06/1990 and 03/04/2008 for Brent) identified in Salisu and Fasanya (2013). The findings suggest that the addition of the 2008 GFC and 1990 Gulf does not significantly vary the results from the initial estimates obtained from the COVID-19 break date alone. Similar to Tables 4 and 5, the EGARCH (1,1) model outperforms all the other models in both markets, implying that the asymmetric model is a better fit for modelling oil price volatility. Like Table 4, the post-estimation diagnostic test of the EGARCH (1,1) model for Brent fails to reject the null hypothesis of no ARCH effect.

Interestingly, only the coefficient of the COVID-19 break date is statistically significant in the Brent oil market models, whereas all the break dates are statistically significant in the WTI oil market models. This is similar to the findings of the Bai and Perron (2003) break test.

Table 6: Estimation results of volatility models with three structural breaks for Brent

Variable	GARCH(1,1)	GARCH-M(1,1)	TGARCH(1,1)	EGARCH(1,1)
Mean equation				
η	0.0164 (0.3160)	-0.0001 (-0.0008)	0.0069 (0.1335)	0.0078 (0.1729)
δ	0.0292 (2.8184)*	0.0291 (2.8099)*	0.0298 (2.8730)*	0.0296 (2.9473)*
α_1	0.0458 (0.8006)	0.0408 (0.7113)	0.0544 (0.9537)	0.0475 (0.9271)
α_2	- 0.0452 (-1.2316)	-0.0409 (-1.1121)	-0.0537 (-1.4704)	-0.0493 (-1.3782)
α_3	0.2931 (3.6665)*	0.2813 (3.5119)*	0.2928 (3.5179)*	0.2933 (3.6849)*
Φ	-	0.0059 (1.0003)		
Variance equation				
γ	0.0619 (6.3822)*	0.0612 (6.3627)*	0.0630 (6.5037)*	-0.0879 (-12.7846)*
α	0.0820 (13.1424)*	0.0815 (13.1334)*	0.0661 (8.5340)*	-
β	0.9107 (153.1960)*	0.9118(153.8958)*	0.9101 (152.9758)*	-
ϑ			0.0313 (3.1820)*	-
ψ				0.1502 (14.8242)*
τ				-0.0281 (-4.4144)*
ρ				0.9852 (451.7876)*
Observations	9164	9164	9164	9164
Diagnostics				
SIC	4.1511	4.1520	4.1511	4.1473
AIC	4.1442	4.1442	4.1434	4.1395
HQC	4.1458	4.1469	4.1460	4.1421
ARCH LM test				
F-test	1.4859	1.4785	2.3038	3.6015*

nR^2	29.6896	29.5414	4.6068	71.6295*

Note: *, ** indicate 1% and 5% levels of significance, respectively. *η = constant, δ = lagged return series, α_1 = structural break 1, α_2 = structural break 2, α_3 = structural break 3, ϕ = GARCH in mean, γ = constant in variance equation, α = ARCH term, β = GARCH term, ϑ = TGARCH term, τ = asymmetry effect term, ρ =log(GARCH1-))*

Table 7: Estimation results of volatility models with three structural breaks for WTI

Variable	GARCH(1,1)	GARCH-M(1,1)	TGARCH(1,1)	EGARCH(1,1)
Mean equation				
η	0.0434 (0.7171)	-0.0013 (-0.0185)	0.0400 (0.6591)	0.0468 (0.8310)
δ	- 0.0201 (-1.9102)	-0.0198 (-1.8852)	- 0.0200 (-1.9029)	-0.0223 (-2.2678)**
α_1	- 0.3370 (-2.0272)**	-0.3634(-2.1729)**	- 0.3254 (-1.9732)**	-0.3057(-1.8040)***
α_2	0.3470 (2.2251)**	0.3691 (2.3597)**	0.3366 (2.1785)**	0.3060(1.9029)***
α_3	0.2781 (3.5259)*	0.2697 (3.4123)*	0.2770 (3.5123)*	0.2928 (3.5979)*
Φ	-	0.0427 (1.1882)		
Variance equation				
γ	0.1445 (7.2887)*	0.1444 (8.4276)*	0.1458 (8.4641)*	-0.0772 (-12.0277)*
α	0.1113 (14.0065)*	0.1112 (14.1560)*	0.1047 (10.1586)*	-
β	0.8691 (134.5926)*	0.8692(118.1887)*	0.8683 (117.8847)*	-
ϑ			0.0135 (0.2998)	-
ψ				0.1456 (15.6661)*
τ				-0.0115(-1.7873)***
ρ				0.9815 (431.2357)*
Observations	9164	9164	9164	9164

Diagnostics				
SIC	4.2620	4.2628	4.2629	4.2568
AIC	4.2550	4.2550	4.2551	4.2490
HQC	4.2573	4.2577	4.2577	4.2517
ARCH LM test(5)				
F-test	0.0231	0.0234	0.0222	0.0061
nR^2	0.1157	0.1171	0.1109	0.0307

Note: *, **, and *** indicate 1%, 5%, and 10% levels of significance, respectively. *η = constant, δ = lagged return series, α_1 = structural break 1, α_2 = structural break 2, α_3 = structural break 3, ϕ = GARCH in mean, γ = constant in variance equation, α = ARCH term, β = GARCH term, ϑ = TGARCH term, τ = asymmetry effect term, ρ =log(GARCH1-))*

5.0 CONCLUDING REMARKS

This paper revisits the modelling of oil price volatility with structural breaks in the WTI and Brent oil markets using daily data from 1987 to 2022. The analysis extends the work of Salisu and Fasanya (2013) by conducting the Narayan and Popp (2010) test, which allows for two structural breaks in the COVID-19 era to capture the impact of the pandemic. The study also estimates several symmetric and asymmetric GARCH models to determine the most appropriate model for capturing oil price volatility in the presence of structural breaks. The Narayan and Popp (2010) test identified two structural breaks, both of which correspond to the COVID-19 pandemic, suggesting that the COVID-19 structural break overshadows the effect of other breaks, similar to Iglesias & Rivera-Alonso (2022) and Zhang et. al. (2022). This is supported by the estimated conditional variance which illustrates the dominating effect of the COVID-19 structural break and the near-absence of the 1990 and 2008 structural breaks identified in Salisu and Fasanya (2013). This is like the findings of the Bai and Perron (2003) break test. The findings from the estimated conditional variance also show that the effect of the COVID-19 pandemic shock was more significant on the WTI market relative to the Brent market.

The results reveal the presence of persistence in the crude oil price volatility of WTI and Brent even though the latter appears more persistent. The results also suggest the existence of leverage effects in both markets, which implies that negative shocks appear to fuel higher volatility than positive shocks of the same magnitude. This has implications for oil-dependent economies, as substantial declines in crude oil prices are inimical to budget targets and impair the economies' capacity to achieve developmental goals. The findings further reveal that the EGARCH (1,1) seems to offer a better fit, relative to all the other models estimated, suggesting that asymmetric models are superior to symmetric models when modeling oil price volatility. Furthermore, the inclusion of additional structural breaks does not significantly vary the results from the initial estimates obtained from the COVID-19 break date alone, implying that the pandemic shock outweighed the effect of previous shocks. As such, it is instructive for portfolio managers and policymakers in oil-exporting countries to incorporate pandemic risks in their risk assessments and outlooks. The study recommends the inclusion of the COVID-19 structural break when modelling oil price volatility due to its superimposing effect on other break dates.

REFERENCE

Abdulkareem, A., & Abdulkareem, K. A. (2016). Analysing oil price-macroeconomic volatility in Nigeria. *CBN Journal of Applied Statistics (JAS)*, *7*(1), 1.

Aghababa, H., & Barnett, W. A. (2016). Dynamic structure of the spot price of crude oil: does time aggregation matter? *Energy Economics*, *59*, 227-237.

Bai, J., & Perron, P. (2003). Computation and analysis of multiple structural change models. Journal of applied econometrics, 18(1), 1-22.

Bourghelle, D., Jawadi, F., & Rozin, P. (2021). Oil price volatility in the context of Covid-19. International Economics, 167, 39-49.

Cerović Smolović, J., Lipovina-Božović, M., & Vujošević, S. (2017). GARCH models in value at risk estimation: empirical evidence from the Montenegrin stock exchange. *Economic research-Ekonomska istraživanja*, *30*(1), 477-498.

Chatziantoniou, I., Filippidis, M., Filis, G., & Gabauer, D. (2021). A closer look into the global determinants of oil price volatility. Energy Economics, 95, 105092.

Chen, J., & Zhang, J. (2023). Crude oil price shocks, volatility spillovers, and global systemic financial risk transmission mechanisms: Evidence from the stock and foreign exchange markets. Resources Policy, 85, 103875.

Devpura, N., & Narayan, P. K. (2020). Hourly oil price volatility: The role of COVID-19. *Energy Research Letters*, 1(2), 13683.

Dixit, R. K., Dixit, A. K., & Pindyck, R. S. (1994). *Investment under uncertainty*. Princeton university press.

Engle, R. F. (1982). Autoregressive Conditional Heteroskedasticity with Estimates of Variance of United Kingdom Inflation. *Econometrica: Journal of Econometric Society*, 987-1007.

Ferderer, J. P. (1996). Oil price volatility and the macroeconomy. *Journal of Macroeconomics*, 18(1), 1-26.

Henriques, I., & Sadorsky, P. (2011). The effect of oil price volatility on strategic investment. *Energy Economics*, *33*(1), 79-87.

Hou, A., & Suardi, S. (2012). A nonparametric GARCH model of crude oil price return volatility. *Energy Economics*, *34*(2), 618-626.

Iglesias, E. M., & Rivera-Alonso, D. (2022). Brent and WTI oil prices volatility during major crises and Covid-19. Journal of Petroleum Science and Engineering, 211, 110182.

Klein, T., & Walther, T. (2016). Oil price volatility forecast with mixture memory GARCH. Energy Economics, 58, 46-58.

Le, T. H., Le, A. T., & Le, H. C. (2021). The historic oil price fluctuation during the Covid-19 pandemic: What are the causes? Research in International Business and Finance, 58, 101489.

Lin, Y., Xiao, Y., & Li, F. (2020). Forecasting crude oil price volatility via an HM-EGARCH model. *Energy Economics*, 87, 104693.

Liu, Y., Failler, P., Peng, J., & Zheng, Y. (2020). Time-varying relationship between crude oil price and exchange rate in the context of structural breaks. Energies, 13(9), 2395.

Luo, J., Demirer, R., Gupta, R., & Ji, Q. (2022). Forecasting oil and gold volatilities with sentiment indicators under structural breaks. *Energy Economics*, *105*, 105751.

Mbwambo, H. A., & Letema, L. G. (2023). Forecasting volatility in oil returns using asymmetric GARCH models: evidence from Tanzania. *International Journal of Research in Business and Social Science (2147-4478)*, *12*(1), 204-211.

Narayan, P. K., & Narayan, S. (2007). Modelling oil price volatility. *Energy policy*, 35(12), 6549-6553.

Narayan, P.K. & Popp, S. (2010). A new unit root test with two structural breaks in level and slope at an unknown time. *Journal of Applied Statistics* 37 (9),1425–1438.

Narayan, P. K., & Liu, R. (2015). A unit root model for trending time-series energy variables. *Energy Economics*, *50*, 391-402

Pindyck, R. S. (2004). Volatility and commodity price dynamics. *Journal of Futures Markets: Futures, Options, and Other Derivative Products*, 24(11), 1029-1047.

Pindyck, R. S. (2004). Volatility in natural gas and oil markets. *The Journal of Energy and Development*, 30(1), 1-19.

Pindyck, R. S. (1993). A note on competitive investment under uncertainty. *The American Economic Review*, *83*(1), 273-277.

Sadorsky, P. (2011). Financial development and energy consumption in Central and Eastern European frontier economies. *Energy policy*, *39*(2), 999-1006.

Sadorsky, P. (2011). Some future scenarios for renewable energy. *Futures*, *43*(10), 1091-1104.

Salisu, A. A., & Fasanya, I. O. (2013). Modelling oil price volatility with structural breaks. *Energy policy*, 52, 554-562. https://doi.org/10.1016/j.enpol.2012.10.003

Salisu, A. A., & Oloko, T. F. (2015). Modeling oil price–US stock nexus: A VARMA–BEKK–AGARCH approach. *Energy Economics*, 50, 1-12. https://doi.org/10.1016/j.eneco.2015.03.031

Kristjanpoller, W. Marcel C. Minutolo (2016). Forecasting volatility of oil price using an Artificial Neural Network-GARCH model. Expert Systems with Applications (2016), doi 10.1016/j.eswa.2016.08.045

Yu, Y., Guo, S., & Chang, X. (2022). Oil prices volatility and economic performance during COVID-19 and financial crises of 2007–2008. Resources Policy, 75, 102531.

Zhang, D., Farnoosh, A., & Lantz, F. (2022). Does something change in the oil market with the COVID-19 crisis? International Economics, 169, 252-268.

Zhang, Y., He, M., Wang, Y., & Liang, C. (2023). Global economic policy uncertainty aligned: An informative predictor for crude oil market volatility. International Journal of Forecasting, 39(3), 1318-1332.

Zhang, Y. J., & Zhang, H. (2023). Volatility forecasting of the crude oil market: which structural change-based GARCH models have better performance? The Energy Journal, 44(1).

APPENDIX 1

Appendix 1A: Bai-Perron Multiple Break Test on Brent Oil Price Returns

Multiple breakpoint tests
Compare information criteria for 0 to M globally determined breaks
Date: 07/25/23 Time: 22:17
Sample: 6/01/1987 7/18/2022
Included observations: 9165
Breaking variables: C
Break test options: Trimming 0.05, Max. breaks 5
Test statistics employ HAC covariances (Bartlett kernel, Newey-West fixed bandwidth) assuming common data distribution

Schwarz criterion selected breaks:	1
LWZ criterion selected breaks:	0

Breaks	# of Coefs.	Sum of Sq. Resids.	Log-L	Schwarz* Criterion	LWZ* Criterion
0	1	56268.88	-21320.66	1.815745	1.818246
1	3	56143.31	-21310.42	1.815502	1.823005
2	5	56037.21	-21301.76	1.815601	1.828106
3	7	56021.14	-21300.44	1.817305	1.834812
4	9	55988.81	-21297.80	1.818719	1.841227
5	11	55978.12	-21296.92	1.820519	1.848029

* Minimum information criterion values displayed with shading

Estimated break dates:
1: 4/22/2020
2: 7/11/2018, 4/22/2020
3: 1/21/2016, 7/02/2018, 4/22/2020
4: 4/21/2014, 1/21/2016, 7/02/2018, 4/22/2020
5: 12/11/1998, 4/21/2014, 1/21/2016, 7/02/2018, 4/22/2020

Appendix 1B: Bai-Perron Multiple Break Test on WTI Oil Price Returns

Multiple breakpoint tests
Compare information criteria for 0 to M globally determined breaks
Date: 07/25/23 Time: 22:27
Sample: 6/01/1987 7/18/2022
Included observations: 9165
Breaking variables: C
Break test options: Trimming 0.05, Max. breaks 5
Test statistics employ HAC covariances (Bartlett kernel, Newey-West fixed bandwidth) assuming common data distribution

Schwarz criterion selected breaks:	2
LWZ criterion selected breaks:	0

Breaks	# of Coefs.	Sum of Sq. Resids.	Log-L	Schwarz* Criterion	LWZ* Criterion
0	1	167713.9	-26325.29	2.907863	2.910364
1	3	167567.1	-26321.28	2.908978	2.916481
2	5	166947.4	-26304.30	2.907264	2.919769
3	7	166927.9	-26303.77	2.909138	2.926645
4	9	166906.1	-26303.17	2.910998	2.933507
5	11	166885.8	-26302.61	2.912868	2.940378

* Minimum information criterion values displayed with shading

Estimated break dates:
1: 4/22/2020
2: 7/11/2018, 4/22/2020
3: 2/12/2016, 7/11/2018, 4/22/2020
4: 4/22/2014, 2/12/2016, 7/11/2018, 4/22/2020
5: 1/22/2002, 7/15/2008, 2/12/2016, 7/11/2018, 4/22/2020

OIL PRICE VOLATILITY AND STOCK RETURNS NEXUS IN THE COVID-19 PANDEMIC ERA: A GLOBAL EVIDENCE

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Abstract

This paper investigates the impact of oil price volatility on global stock returns, adopting three major scenarios. We use a global sample of selected 30 countries, which we further separate into 15 net oil exporting and 15 net oil importing countries. Daily data for five years (2017 to 2022) was used to analyse the oil price volatility with the EGARCH model. We adopt GMM estimation techniques to examine the effects of oil price volatility on global stock returns. Oil price volatility only has significant effects on stock returns in the net oil exporting countries, but is insignificant for net oil importing countries. The same findings were obtained for both the full data sample and the COVID-19 pandemic period. The stability of oil prices is required for stocks listed in net oil exporting countries.

Keywords: *Oil Price, Stock Returns, COVID-19, Volatility, EGARCH*
JEL Classification: *G15, I12, Q41*

1.0 INTRODUCTION

There has been a renewed interest in the relationship between stock returns and oil prices in recent times. The important question would be, why is the relationship important? There is the conventional wisdom that an increase in oil price will raise the cost of inputs of business, thereby increasing inflation expectations and dampening the expected rate of economic growth over short-term horizons. The possible dip in economic growth has the potential of invariably impacting companies' earnings negatively. Moreover, during periods of high oil prices, investors'

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expectations for corporate earnings become more uncertain which, in turn, may lead to higher equity risk premia, putting additional pressure on stock prices.

The dynamics in the correlation of the stock market and oil prices are subject to the fundamentals of various economies under review and the extent of development, as well as whether those economies are oil importers or exporters nations. For instance, economies that heavily depend on crude oil imports are likely to face serious impacts on the value of portfolio stocks, while this impact is often less in oil-exporting countries. Therefore, providing insights into the interplay between these variables are very imperative, considering the role that the stock market plays in accelerating countries' economic growth. The stock market serves as a transmission channel where savings are effectively allocated to various economic sectors in the economy. The market provides investors with the needed access to a variety of investment opportunities and the necessary support and platform that facilitate the effective allocation of capital for long-term productive investments, thus enhancing the prospects of long-term economic growth.

Over the years, oil prices have experienced fluctuation on the international market scene with its accompanying effects on countries' earnings, especially the oil-dependent economies. In 2008, international oil prices crashed from about US$133.38 per barrel to as low as US$39.09 per barrel. This development was associated with the financial crisis of 2007/2008. The second episode of the oil price crash was recorded in mid-2014, before Covid-19, when oil prices fell drastically from over US$$100.0 per barrel in mid-2014 to around US$30.00 per barrel. This was attributed to the discovery of Shale oil in the United States and other Advanced Economies. The third episode of the oil crash experienced all over the globe was the accompanying impact of the emergence of the Novel Covid-19 Pandemic which ravaged world economies, hindered economic activities, lowered global oil demands, and hence the decline of international oil prices.

The objective of this paper, therefore, is to examine the effect of crude oil price fluctuations on the performances of stock markets (stock returns), especially during the Covid Era. The focus on the volatilities is particularly motivated by the understanding that the changes in the series, for example, depreciation or appreciation of a currency, or stock returns, by itself may not necessarily matter, but the uncertainties associated with the movements in these variables that may adversely impact investment decisions. The contribution of this study to the body of knowledge stemmed from the selection criteria of Countries across the globe used in the study. The selections are based on whether such economies are ‘net exporters’ or ‘net importers’ of crude oil. It can be noted that the effect of oil price volatility spillover on stock returns ordinarily would impact more on economies that import crude oil rather than those that export. The Covid-19 era ushered in a decline in global economic activities, which leads to low global energy demands, hence causing volatility in crude oil prices. This invariably impacts stock market activities. Moreover, capturing developments during the pre-and post-Covid-19 periods will serve as an addition to the body of literature, in terms of further re-establishing how different phases of economic cycles affect activities in the global stock markets. This would serve as a pointer to Portfolio investors in terms of decision-making and hedging.

Following the introductory section of the paper, the rest is structured into five sections. Section two provides a review of relevant literature, while section three deals with data, model specification, and estimations. Section four covers a discussion of results and interpretations, while section five summarizes and concludes the paper.

2.0 LITERATURE REVIEW

Various perceptions have emerged from diverse scholars on the relationship between oil price volatility and the stock market globally. Though independent relationships exist between the energy sector, financial markets, and the economy (Basher & Sadorsky (2006), Omorokunwa (2015)). Generally, when the demand for oil output exceeds supply, it triggers price increases which eventually leads to disruption in economic fundamentals such as inflation, output, stock prices, etc. In this section, we shall analyse relevant empirical literature around the subject.

The fundamentals of oil price volatility and stock market returns have been ascribed to various studies for the advanced, developing, oil exporters/importers economies. Some studies have revealed that advanced economies characterized by diverse and robust stock market portfolios experienced little or no impact during periods of oil price shock while developing economies experienced more shocks and vulnerability of their stock market during periods of oil price volatility. Apergis & Miller (2009) for instance, investigated how exogenous drivers affected oil price changes and their impacts on stock market returns in 8 (eight) advanced economies of the United States, United Kingdom, France, Germany, Canada, Australia, Italy, and Japan. The paper discovered that changes in the oil market have little effect on the returns on the global stock markets.

However, studies by Shaharudin, Samad & Bhat (2009) amongst others evaluated the impact of oil price trends on the stock price of the oil and gas sector in the United States, United Kingdom, and Indian economies. They established that oil prices and stock prices have evidence of significant short-run and long-run relationships having considered the effect of the other macro variables such as interest rate and the stock index. It was revealed that the transmission of oil price volatility has a long-lasting impact on the volatility of stock prices of oil companies across the selected Countries.

There exists a general perception of whether advanced economies that are ‘oil exporters’ may not be as vulnerable to shocks in the global market, Hamdi, Aloui, Alqahtani & Tiwari (2019) examined the relationship between the oil price volatility and sectoral stock markets in oil-exporting economies using the wavelet nonlinear denoised based quantile and Granger-causality analysis. The study used the quantile regression analysis (QRA) for the return series and denoised series for the period 2006–2017 to investigate the degree of volatility between oil price and sectoral indices in the Gulf Cooperation Council (GCC) nations for four sectors. The results revealed that although oil price volatility is found to be interconnected across all sectors, the banking and insurance industries are immune to it in the 10th, 25th, and 75th quantiles. Additionally, the aggregate market index, transportation, and telecommunication sectors are not sensitive to oil price volatility between the 75th and 90th quantiles, according to QRA results for wavelet nonlinear denoising with a soft-thresholding series. However, all sectors are interdependent on oil price volatility.

Similarly, using the quantile regression techniques for ten oil-importing economies, Joo & Park (2021) examined the impact of fluctuating oil prices on the stock markets of these economies: China, France, Germany, India, Italy, Japan, Korea, the Netherlands, Spain, and the United States from the period 2001 to 2019. The empirical findings revealed that oil price uncertainty affects stock returns asymmetrically; furthermore, these asymmetric behaviours differ depending on both the magnitude of stock return and the state of the oil market.

No doubt, there are general postulations regarding the effect of oil prices on stock prices, especially in times of volatility occasioned by a shock of global dimensions like the recent COVID-19 pandemic which exacerbated pressure on global economies, thus, reducing global oil/energy demands and prices. We expect oil-importing economies to be more vulnerable to external shocks. In an attempt to evaluate this impact arising from the pandemic, Prabheesh, Padhan & Garg (2020) explored the data gathered during the COVID-19 periods for net oil importing countries and found a positive co-movement between stock price returns and oil price returns during the pandemic periods. This suggests that declining oil prices send the stock market a bad signal.

It was established that net oil exporting countries experienced more shocks than net oil importing countries. Salisu, Gupta & Demirer (2022) investigated the connection between oil price uncertainty shocks and global equity markets for twenty-six advanced and emerging stock markets, from 1979Q1 through 2019Q4. The findings revealed the presence of a negative and stronger impact of oil price uncertainty shocks for emerging economies as well as net oil-exporting nations. Global stock markets, however, showed a lot of variability in their recovery from oil uncertainty shocks, with some experiencing swift corrections in stock valuations and others experiencing protracted declines.

Volatility in exchange rate usually occurs during periods of dwindling oil prices, especially for oil exporters. Al Janabi, Hatemi & Irandoust (2012) seek to determine whether Gulf Cooperation Council (GCC) Countries comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates equity markets are informationally efficient in terms of oil and gold price shocks, from 2006 to 2008. The empirical results demonstrate the information efficiency of the GCC equities markets concerning the gold and oil price indices. The findings suggest that there may not be profitable short-term arbitrage opportunities in the equities markets of these nations hence a negative relationship.

Further studies from Adenekan, Hilili & Okereke (2020) also supported the stance. They probed further on the linkages between oil prices, stock market, and exchange rate performance and showed that no long-run relationship existed between the variables. However, shocks to the crude oil market boosted shares in the first two periods but had little effect thereafter. On the other hand, one standard deviation change in the exchange rate innovation, hurt shares, implying that exchange rate volatility may cause uncertainty in the stock market. The results of the volatility series estimations also mimic the findings of the return series. Therefore, the findings indicate that the transmission mechanism of oil price and exchange rate developments to the stock market has inherent structural or institutional rigidity.

Whether oil prices are rising or falling, changes in oil prices have a beneficial impact on the stock returns of oil companies. Phan, Sharma & Narayan (2014) probed that not all consumer sub-sectors are impacted by changes in oil prices, and when they are, the effects are varied. They discovered that stock returns for most sub-sectors are asymmetrically affected by oil price returns. While both consumers and producers of oil can achieve statistically significant financial gains, they also developed straightforward trading techniques and discovered that investors in the oil producer sectors do so more frequently than those in the oil consumer sectors. A significant negative impact on most European stock market returns was established between oil price volatility and stock returns. Cunado & de Gracia (2014) examined the effects of oil price shocks on stock returns for 12 European oil-importing countries from 1973 to 2011 and found evidence that an oil price shock has a negative impact. Although, the effects of oil price shocks on stock prices can take varying dimensions, Mugaloglu, et al, 2021, noted that though the negative relationship between oil prices and stock market prices has been proven, it has also been observed that the stock prices of oil-producing companies increased with the oil prices.

3.0 THEORETICAL FRAMEWORK AND METHODOLOGY

3.1 Theoretical Framework

The Arbitrage Price Theory (APT) comes in handy when explaining the drivers of stock returns. According to Ross (1976), the theory postulates that the macroeconomic variables are very prominent variables that characterised the anticipated return of a financial asset. When there is a pricing discrepancy, an arbitrager's job is to bring the price back into alignment. To explain the discrepancies in stock returns in the selected stock markets, this study took particular interest in oil price volatility. Moreover, economic policy uncertainty and real effective exchange rate were included in the model as control variables.

This study adopts the APT, following the illumination provided by Ross, (1976). According to this theory, an asset's returns will depend on the nature of the relationship between the expected return on the asset and macroeconomic factors that normally affect the asset risks. Generally described as a ‘’multi-factor asset pricing model’’, the APT model is predicated on the notion that returns on assets can be determined or estimated relying on the linear relationship between the asset's expected return and some macroeconomic variables which take account of systematic risk. Hayes (2020), points out that this pricing model is a useful tool for the analyses of investment portfolios from a value investing perspective as it helps the potential investor to identify stocks/securities that in the short run, may be wrongly priced and then take advantage of the temporary low-price regime for greater returns in a future course.

A key feature of the APT model is its assumption that markets sometimes incorrectly price securities before the market eventually corrects and securities move back to fair value. Hayes, (2020). By using APT, arbitrageurs would normally ‘’hope to take advantage of any deviations from fair market value’’. Thus, the APT model is different from the traditional Capital Asset Pricing Model (CAPM) that automatically assumes that markets are perfectly efficient.

In this study, we reiterate that Stocks are assets. Returns on stocks, in line with the theoretical model, can be described as a linear function between expected returns and some macroeconomic factors that have a connection with these stocks' risks. We argue that a prominent macroeconomic factor in our context is the fluctuations in oil prices, otherwise known as oil price volatility. Economic policy uncertainty, real effective exchange rate, gross domestic product (GDP), commodities prices, and market indices, are some of such other macroeconomic factors that can affect stock risks and we shall be looking at some of these factors as we progress in our discourse.

3.2 Methodology

3.2.1 Data and Estimation Techniques

The data set for this paper consists of daily crude oil prices, monthly stock returns, monthly economic policy uncertainty, and monthly real effective exchange rate. These data spanning 2018Q1 to 2022Q3 were collected from various sources. We considered two samples, the total sample and the subsample of 2020Q1 and 2022Q3. The daily oil price data, both Brent prices, and WTI were collected from the EIA database[6] for the period indicated previously. As denoted above, since the data frequencies were not the same, the daily crude oil price volatility was aggregated to a monthly frequency. That makes all the variables to be in the same monthly frequency. The stock returns for the 30 selected countries were computed by the authors, and the underlying stock price data were sourced from the Bloomberg Terminal. The economic policy uncertainty was extracted from the database (www.policyuncertainty.com). Lastly, the real effective exchange rate was obtained from the International Financial Statistics of the IMF database every month.

In line with the theoretical framework discussed previously, the model to be estimated is thus presented.

$$sreturns_{tk} = \beta_0 + \beta_1 \mathrm{vol\_rbrent_{tk}} + \beta_2 \mathrm{epu_{tk}} + \beta_3 \mathrm{reer_{tk}} + \xi_{tk}$$

Where *tk* is the time "*t*" in country "*k*", while β_0 to β_n are the coefficients of the respective variables. While *sreturns* represent stock returns, *vol_rbrent* is oil price volatility which was computed utilising the *EGARCH* univariate procedure of

[6] https://www.iea.org/data-and-statistics

volatility. *EPU* is denote economic policy uncertainty[7]. Lastly, *reer* represents a real effective exchange rate.

In this work, a variety of estimation techniques were applied. We began with the Fixed and Random Effects in the panel data estimator (including Ordinary Least squares). The individual intercept is treated by the Random Effect (RE) model as a random variable, allowing a deviation from the average value of all cross-sections and factoring it into the linear error term. However, the Fixed Effect (FE) model eliminates the heterogeneity bias by assuming that the unobserved heterogeneity connected with the variables is constant throughout time. It also permits serial correlation as a corollary. Furthermore, for both fixed and random scenarios, a combination of national and temporal effects results. The time-fixed effect, for instance, might regulate variables that remain constant across time yet.

However, the dynamic panel model, GMM Difference, and System models are used when the moment's assumptions are not met (Arellano and Bover, 1995; Blundell and Bond; 1998). The moment requirements are required because the difference estimator employs the regressors' lagged values as instrumental variables that are independent of the errors. This corrects for autocorrelation or non-stationarity, which causes biased estimation and erroneous regression, as well as for time-constant country-fixed effects that may be linked with the explanatory variables. However, even after the initial changes, the endogeneity issue may still exist if the variable series have a near-unit root. The system estimator is introduced to address this. As an example, this makes use of the endogenous variable's lagged level and initial differences.

4.0 RESULTS AND DISCUSSION

4.1 Oil Price Volatility in the COVID-19 Pandemic Period

The first part of this analysis is the computation of the oil price volatility in Nigeria with special consideration for the COVID-19 Pandemic structural breaks. The price in the Brent market was essentially used for this paper, the WTI price was utilised for the robustness check. Based on the descriptive statistics, substantial differences could

[7] https://www.policyuncertainty.com/

be observed between the prices in the two markets. In particular, the variations in the average, maximum, and minimum prices are noticeable. The same variation is obtainable when the returns are considered.

Table 1 Descriptive Statistics (Brent) and (WTI).

Statistics	**Brent**		**WTI**	
	pBrent	RBrent	Pwti	rWTI
Mean	77.03	0.00008	70.87	0.0002
Maximum	133.2	0.412	123.6	0.425
Minimum	9.12	-0.643	-36.9	-0.281
Standard Dev	26.7	0.028	23.05	0.028
Observations	3190	3189	3163	3163

Out of the 15 countries contained in both samples, each has 9 countries with positive average stock returns in the period under consideration. In particular, the average stock returns in the net oil exporting countries include Canada, Colombia, Ecuador, Kazakhstan, Norway, and Russia. It could be observed that the countries with negative returns recorded deeper negative returns. Similarly, Armenia, Korea, Singapore, Spain, Thailand, and the United States have negative average stock returns.

Before the volatility analysis, the dynamics of the crude oil prices are equally depicted in Figures 1 and 2. The unsteady pattern of the returns to the prices is noticeable. The interaction between the oil price volatility with stock price returns was depicted for the fifteen net oil exporting countries (Figure 1) and the other fifteen net oil importing countries (Figure 2). The trends suggest volatility clustering. Precisely, there are alternatives to periods of high and low volatility. The spike in the oil price particularly in early 2020 can only suggest high volatility during the period of the COVID-19 Pandemic. Moreover, the figures further indicate that there was larger volatility before the COVID-19 period, compared with the post-COVID-19 periods. In particular, the paper focused on examining the effects of oil price volatility on stock returns in three samples. In addition to the entire period estimation (2018Q1 to 2022Q3), in line with the title of the paper, we estimated the functions for the COVID-19 period (2020Q1 to 2022Q3).

Table 2: Descriptive Statistics of Stock Price Returns for Net Oil Exporting Countries

	Full Sample 2018Q1-2022Q3					**COVID-19 Pandemic Period 2020Q1-2022Q3**				
Countries	Mean	Max	Min	StdDev	Obs.	Mean	Max	Min	StdDev	Obs.
Brazil	1.0	17.2	-19.9	9.1	18	-0.4	17.2	-19.9	11.6	9
Canada	-9.2	9.1	-184.4	44.0	18	-16.6	9.1	-181.8	58.4	10
Colombia	-4.2	17.1	-40.6	12.1	18	-7.6	17.1	-59.4	20.3	10
Ecuador	-10.8	6.4	-195.6	46.3	18	-19.4	6.4	-184.3	58.0	10
Ghana	3.7	90.0	-13.5	23.1	18	6.7	55.9	-9.3	19.7	10
Indonesia	5.6	95.9	-17.6	23.7	18	10.1	82.0	-17.6	26.7	10
Kazakhstan	-22.8	16.7	-417.3	99.7	18	-41.0	16.3	-391.5	124.9	10
Malaysia	14.2	279.6	-6.3	66.3	18	25.6	258.2	-5.8	81.8	10
Mongolia	17.5	267.4	-13.8	63.8	18	31.5	255.9	-13.8	80.6	10
Nigeria	2.3	27.1	-12.4	12.2	18	4.1	27.1	-24.4	15.4	10
Norway	-20.9	12.0	-414.2	98.3	18	-37.5	12.0	-409.7	130.9	10
Oman	7.1	142.1	-12.7	34.0	18	12.8	119.4	-12.7	37.8	10
Qutar	6.0	72.6	-8.3	17.4	18	10.7	80.6	-8.3	25.2	10
Russia	-9.8	12.9	-171.3	42.6	18	-17.7	12.9	-147.9	49.3	10
UAE	8.2	75.7	-12.6	18.7	18	14.8	78.2	-12.6	24.1	10

Source: Bloomberg

Table 3: Descriptive Statistics of Stock Price Returns for Net Oil Importing Countries

	Full Sample 2018Q1-2022Q3					COVID-19 Pandemic Period 2020Q1-2022Q3				
Countries	Mean	Max	Min	StdDev	Obs.	Mean	Max	Min	StdDev	Obs.
Armenia	-2.3	11.0	-23.9	9.4	18	-2.9	11.0	-23.9	13.2	10
China	3.7	68.3	-12.0	17.3	18	6.7	55.6	-12.0	18.4	10
France	3.5	48.1	-16.3	13.0	18	6.3	50.6	-16.3	17.7	10
Germany	4.2	72.0	-11.8	18.2	18	7.5	68.5	-11.8	22.9	10
India	1.3	17.7	-31.4	11.4	18	2.3	17.7	-18.6	12.2	10
Italy	1.5	28.2	-19.8	10.7	18	2.8	27.6	-19.8	13.4	10
Japan	1.3	14.1	-6.9	5.7	18	2.3	14.1	-6.9	6.7	10
Korea	-13.5	20.6	-242.5	57.9	18	-24.3	20.6	-259.4	83.4	10
Mexico	16.6	309.0	-13.6	73.3	18	29.9	286.9	-13.6	90.7	10
Singapore	-15.1	13.1	-268.9	63.6	18	-27.1	13.1	-269.6	85.6	10
South Africa	17.0	292.4	-7.3	68.9	18	30.6	282.0	-4.1	88.5	10
Spain	-11.8	12.1	-185.3	43.8	18	-21.2	12.1	-201.0	63.8	10
Thailand	-9.1	14.7	-163.3	39.1	18	-16.4	14.7	-158.0	50.6	10
United Kingdom	8.5	154.9	-13.6	36.9	18	15.4	147.9	-13.6	46.9	10
United States	-3.4	12.4	-97.6	24.2	18	-6.1	12.4	-86.5	29.2	10

Source: Bloomberg

Figure 1: Oil Price Volatility (brent) and Stock Returns (sreturns) for Net Oil Exporting Countries

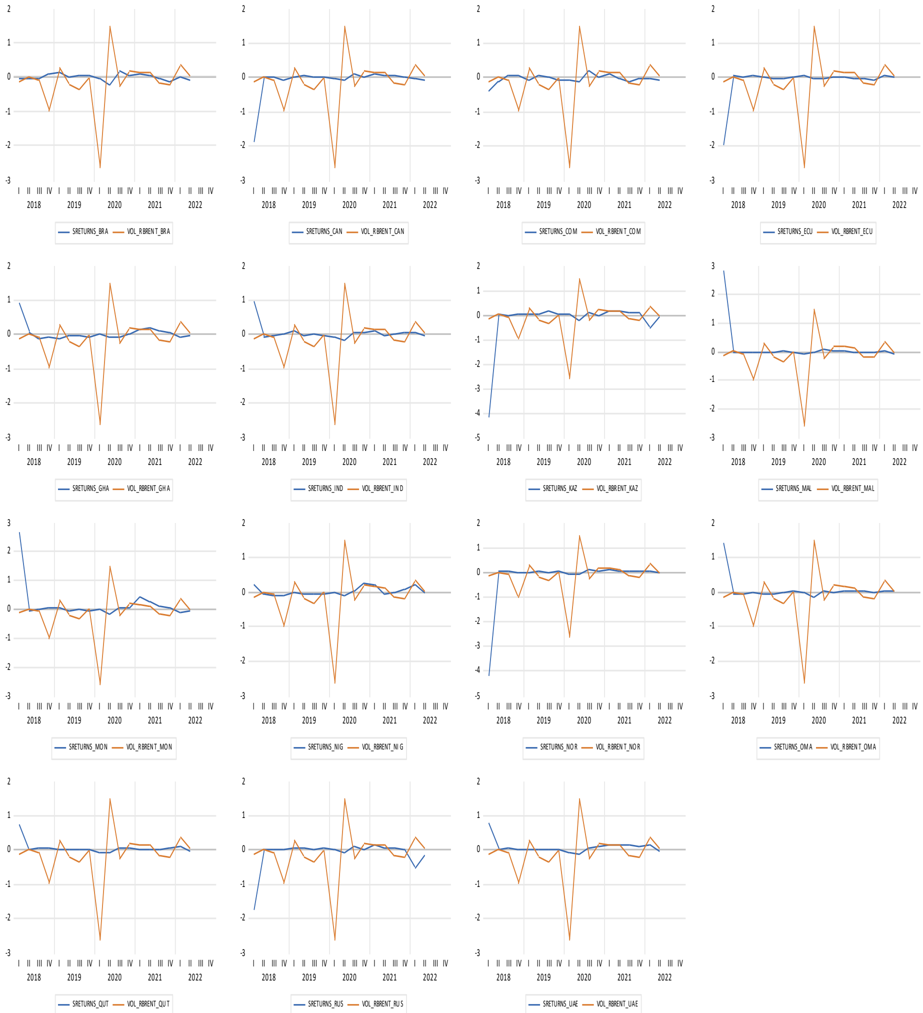
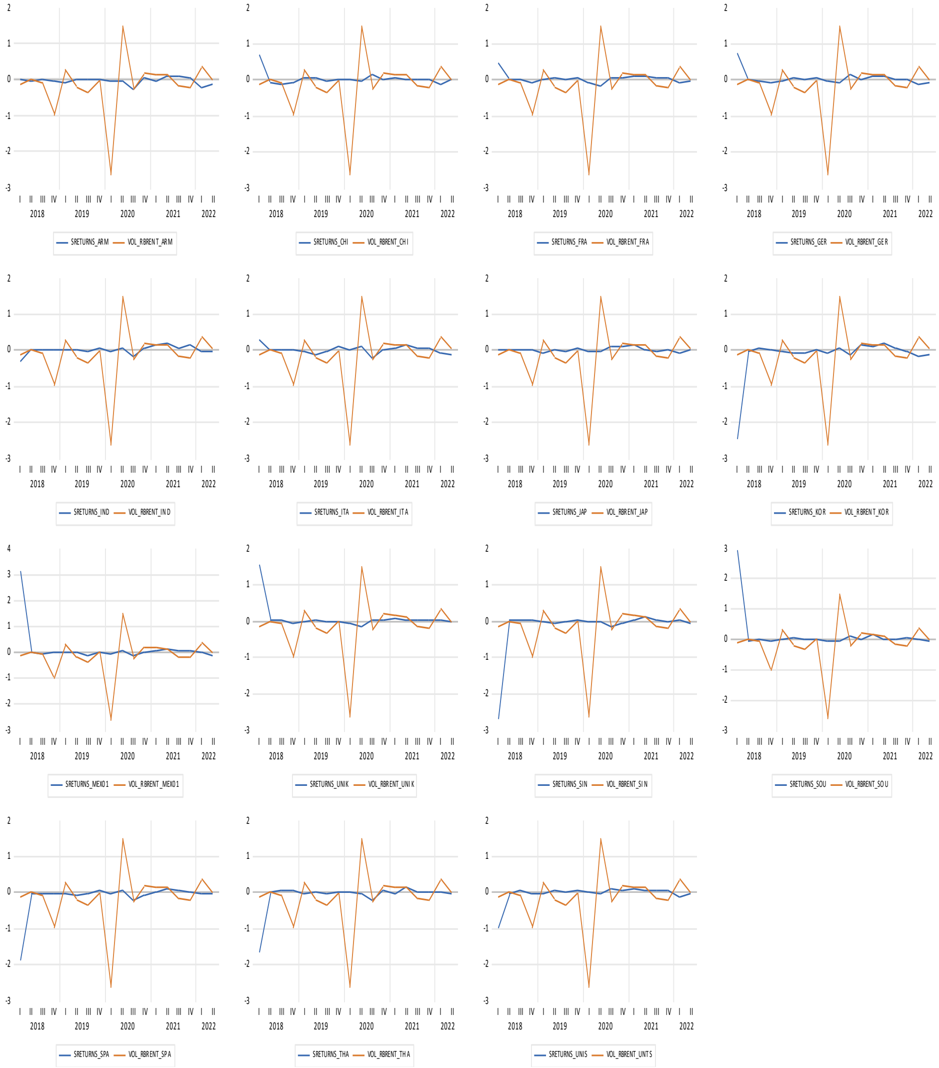


Figure 2: Oil Price Volatility (brent) and Returns (sreturns) for Net Oil Importing Countries



4.3 Effects of Oil Price Volatility on Stock Returns: Full Data Sample

We proceed to the main empirical analysis establishing the effects of oil price volatility on stock returns. First, we made a comparison of the cases of net oil exporting countries and net importing countries. Moreover, we combined the two sub-samples to establish the global effects of oil price volatility on stock returns. The results of the estimations are presented in Tables 4, 5, and 6 below. The first three columns on each table contained the pooled OLS, fixed effects, and random effects. Incidentally, neither oil price volatility nor any other control variable has a significant effect on stock returns in the three samples. The rest columns in the tables contained variants of dynamic GMM. Variants of the difference and system GMM were estimated, and the respective results were presented in the tables.

We turned to the dynamic estimations where some of the variables have statistical significance. First, the variable of interest, oil price volatility, has a positive impact on stock returns in the total sample of 30 leading importing and exporting countries. However, the impact is not statistically significant. Some previous studies have reported an insignificant impact of oil price volatility on stock return. For instance, Apergis and Miller, (2009) and Huang et al., (2017) reported an insignificant effect of oil price volatility on stock returns. We also obtained results for the subgroups: net oil importers and net oil exporters. While the impact of oil price volatility on stock returns in net oil importing countries is positive, the impact is negative for net oil exporting countries. It is interesting to note also that while the impact of oil price volatility on the stock in the net oil importing countries is significant, that of the net oil importing countries is insignificant. Similarly, the negative significant impact of oil price volatility on stock returns in net oil exporting countries is not out of place. Volatility has continued to be a challenge to oil-exporting countries, especially those that rely heavily on oil as a major source of revenue. Two control variables were introduced into the estimated model for the entire sample and the other two sub-samples.

Two control variables (Economic Policy Uncertainty and Real Effective Exchange Rate) were introduced into the estimated model for the full sample data and the other two sub-samples. Economic policy uncertainty played a prominent role in all the samples. Precisely, the impact of economic policy uncertainty has a significant effect on stock returns. Incidentally, the effect of economic policy uncertainty negatively impacted stock returns. The real effective exchange rate produced insignificant effects on stock returns in all the samples. The negative impact of the economic policy uncertainty obtained in this paper supports previous studies like Wu et al. (2021), Arouri et al. (2016), and Liu et al. (2015) that have reported a negative influence on stock returns. The increasing uncertainty across the globe has continued to influence investors' decisions, this justifies the negative impact of economic policy uncertainty on stock returns.

Table 4: Effects of Oil Price Volatility on Stock Returns in the Oil Importing Countries (Full Sample 2018Q1 -2022Q3)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	**POLS**	**FE**	**RE**	**DGMM1**	**DGMM1-CL-a**	**SGMM1**	**SGMM1-CL-a**	**SGMM2-CL-a**
Lnepu	-0.0967	-0.0879	-0.0966	-0.126***	-0.101***	-0.126***	-0.115***	-0.123***
	(0.108)	(0.108)	(0.108)	(0.0184)	(0.0203)	(0.0187)	(0.0139)	(0.0169)
Lnreer	-0.0378	1.090	-0.0377	0.00687	-0.142	-0.000632	0.0419	0.0631
	(0.0273)	(0.741)	(0.0281)	(0.0973)	(0.145)	(0.000863)	(0.0450)	(0.0771)
vol_rbrent	0.00299	0.00500	0.00299	0.00162	0.00573	0.00161	0.00472	0.00370
	(0.0328)	(0.0328)	(0.0328)	(0.00282)	(0.00553)	(0.00284)	(0.00436)	(0.00556)
L.sreturns				-0.00126	0.00440	-8.92e-05	0.00380	0.00985
				(0.00969)	(0.00651)	(0.00988)	(0.00718)	(0.0104)
Constant	0.716	-4.680	0.715			0.708***	0.442*	0.389
	(0.613)	(3.590)	(0.613)			(0.102)	(0.250)	(0.406)
Observations	269	269	269	239	239	254	254	254
R-squared	0.010	0.012						
firm effect	NO			YES	YES	YES	YES	YES
Rmse	0.402	0.401	0.402					
F-test	0.922	1.003						
Prob > F	0.431	0.392						
Number of countries		15	15	15	15	15	15	15
country effect		YES	YES					
F-test(u_i=0)		1.082						
Prob >		0.392						

F(u_i=0)								
Hansen_test				4.793	6.728	6.029	6.693	6.693
Hansen Prob				1	0.151	1	0.153	0.153
Sargan_test				264.1	8.923	290.9	9.002	9.002
Sargan Prob				0.0932	0.0631	1	0.0610	0.0610
AR(1)_test				-3.285	-3.388	-3.283	-3.373	-3.374
AR(1)_P-value				0.00102	0.000704	0.00103	0.000745	0.000741
AR(2)_test				2.347	2.507	2.362	2.518	2.550
AR(2)_P-value				0.0189	0.0122	0.0182	0.0118	0.0108
No. of Instruments				239	8	480	9	9
chi-squared			2.661					
Prob > chi2			0.447					
Prob > chi2			0.447					
chi-test(sigma_u=0)								

Table 5: Effects of Oil Price Volatility on Stock Returns in the Oil Exporting Countries (Full Sample 2018Q1 -2022Q3)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	POLS	FE	RE	DGMM1	DGMM1-CL-a	DGMM2	SGMM1	SGMM1-CL-a	SGMM2
Lnepu	0.0236	0.0198	0.0235	-0.116***	-0.149***	-0.112**	-0.114***	-0.131	-0.233
	(0.135)	(0.135)	(0.135)	(0.0355)	(0.0566)	(0.0516)	(0.0347)	(0.0901)	(0.534)
Lnreer	0.0367	0.205	0.0376	0.114	0.518***	1.797	0.0293*	-5.198	1.820
	(0.112)	(0.565)	(0.120)	(0.0804)	(0.123)	(2.952)	(0.0167)	(52.42)	(2.997)
vol_rbrent	-0.00655	-0.00530	-0.00655	-0.0129*	-0.0242***	-0.00588	-0.0135**	-0.0563	-0.0103
	(0.0410)	(0.0412)	(0.0408)	(0.00680)	(0.00623)	(0.0207)	(0.00686)	(0.341)	(0.0412)

L.sreturns				-0.00264	0.00385	0.101	-0.00179	0.0118	0.0853
				(0.00604)	(0.00581)	(0.339)	(0.00618)	(0.101)	(0.341)
Constant	-0.308	-1.058	-0.312				0.502**	24.61	-7.056
	(0.906)	(2.651)	(0.924)				(0.203)	(240.9)	(15.15)
Observations	269	269	269	239	239	239	254	254	254
R-squared	0.001	0.001							
firm effect	NO			YES	YES	YES	YES	YES	YES
Rmse	0.502	0.502	0.500						
F-test	0.0594	0.0668							
Prob > F	0.981	0.977							
Number of countries		15	15	15	15	15	15	15	15
country effect		YES	YES						
F-test(u_i=0)		1.009							
Prob > F(u_i=0)		0.977							
Hansen_test				11.58	2.080	11.58	11.09	2.301	11.09
Hansen Prob				1	0.721	1	1	0.681	1
Sargan_test				317.3	1.177	317.3	347	0.478	347
Sargan Prob				0.000275	0.882	0.000275	1	0.976	1
AR(1)_test				-1.945	-1.845	-1.020	-1.924	-0.779	-0.973
AR(1)_P-value				0.0518	0.0650	0.308	0.0544	0.436	0.330
AR(2)_test				-0.221	-0.989	0.126	-0.210	0.0888	-0.129
AR(2)_P-value				0.825	0.323	0.900	0.834	0.929	0.897
No. of Instruments				239	8	239	480	9	480
chi-squared			0.170						
Prob > chi2			0.982						
Prob > chi2			0.982						
chi-test(sigma_u=0)									

Table 6: Effects of Oil Price Volatility on Stock Returns in Thirty Selected Countries (Full Sample 2018Q1 -2022Q3)

	(1)	(2)	(3)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	POLS	FE	RE	DGMM1	DGMM1-CL-a	DGMM2	SGMM1	SGMM1-CL-a	SGMM2
Lnepu	-0.0168	-0.0190	-0.0169	-0.119***	-0.124***	-0.109***	-0.118***	-0.103	-0.336
	(0.0867)	(0.0867)	(0.0865)	(0.0196)	(0.0302)	(0.0281)	(0.0194)	(0.161)	(0.348)
Lnreer	0.0177	0.448	0.0188	0.0930	0.309	0.0271	0.0192*	4.703	-0.876
	(0.0766)	(0.438)	(0.0794)	(0.0635)	(0.196)	(2.606)	(0.0106)	(40.17)	(0.814)
vol_rbrent	-0.000820	0.00125	-0.000815	-0.00559	-0.00936*	-0.00694	-0.00594	0.0109	-0.0224
	(0.0264)	(0.0264)	(0.0263)	(0.00391)	(0.00501)	(0.0106)	(0.00395)	(0.171)	(0.0208)
L.sreturns				-0.00137	0.00438	-0.111	8.55e-05	-0.00146	-0.0815
				(0.00536)	(0.00470)	(0.494)	(0.00532)	(0.0523)	(0.448)
Constant	0.00664	-1.940	0.00198				0.573***	-20.85	5.865
	(0.594)	(2.041)	(0.600)				(0.112)	(183.8)	(4.921)
Observations	539	539	539	479	479	479	509	509	509
R-squared	0.000	0.002							
firm effect	NO			YES	YES	YES	YES	YES	YES
Rmse	0.457	0.457	0.456						
F-test	0.0305	0.362							
Prob > F	0.993	0.781							
Number of countries		30	30	30	30	30	30	30	30
country effect		YES	YES						
F-test(u_i=0)		1.045							
Prob > F(u_i=0)		0.781							
Hansen_test				27.50	5.862	27.50	24.95	0.878	24.95
Hansen Prob				1	0.210	1	1	0.928	1
Sargan_test				577.3	1.622	577.3	634.9	0.389	634.9
Sargan Prob				0.000877	0.805	0.000877	1	0.983	1
AR(1)_test				-3.235	-3.299	-0.772	-3.205	-0.541	-1.058

AR(1)_P-value				0.00122	0.000972	0.440	0.00135	0.589	0.290
AR(2)_test				1.326	1.502	0.0769	1.314	0.273	0.0827
AR(2)_P-value				0.185	0.133	0.939	0.189	0.785	0.934
No. of Instruments				479	8	479	960	9	960
chi-squared			0.0941						
Prob > chi2			0.993						
Prob > chi2			0.993						
chi-test(sigma_u=0)									

Table 7: Effects of Oil Price Volatility on Stock Returns in Oil Exporting Countries (COVID-19 Period, 2020Q1 -2022Q3)

	(1)	(2)	(3)	(4)	(5)	(6)	(8)	(9)	(11)
VARIABLES	POLS	FE	RE	DGMM1	DGMM1-CL-a	DGMM2	SGMM1	SGMM1-CL-a	SGMM2-CL-a
Lnepu	-0.313	-0.317	-0.313	-0.134**	-0.0772	-0.00838	-0.135**	-0.0881	-0.0622
	(0.237)	(0.236)	(0.234)	(0.0655)	(0.0792)	(0.143)	(0.0655)	(0.0976)	(0.0595)
Lnreer	0.0643	0.739	0.0659	-0.168	0.590***	5.250	0.0381	-1.418	-0.822
	(0.173)	(1.835)	(0.195)	(0.425)	(0.202)	(6.473)	(0.0278)	(6.356)	(1.342)
vol_rbrent	0.0601	0.0630	0.0601	-0.0633***	-0.0735***	0.0602	-0.0616***	-0.0677***	-0.0663***
	(0.0560)	(0.0565)	(0.0553)	(0.0109)	(0.0148)	(0.137)	(0.0116)	(0.0257)	(0.0248)
L.sreturns				0.00185	0.00583	1.192	0.00685	0.0253	0.0162
				(0.0108)	(0.00868)	(1.888)	(0.00826)	(0.0673)	(0.0139)
Constant	1.442	-1.630	1.434				0.603	7.026	4.154
	(1.535)	(8.444)	(1.575)				(0.390)	(28.79)	(6.337)
Observations	149	149	149	119	119	119	134	134	134
R-squared	0.024	0.027							
firm effect	NO			YES	YES	YES	YES	YES	YES
Rmse	0.636	0.632	0.628						

F-test	1.184	1.208							
Prob > F	0.318	0.309							
Number of cont		15	15	15	15	15	15	15	15
country effect		YES	YES						
F-test(u_i=0)		1.146							
Prob > F(u_i=0)		0.309							
Hansen_test				9.783	2.238	9.783	7.913	0.427	0.427
Hansen Prob				1	0.692	1	1	0.980	0.980
Sargan_test				144.6	0.960	144.6	181.1	0.246	0.246
Sargan Prob				0.0323	0.916	0.0323	0.996	0.993	0.993
AR(1)_test				-1.763	-1.715	-0.141	-1.739	-1.429	-1.859
AR(1)_P-value				0.0779	0.0863	0.888	0.0821	0.153	0.0631
AR(2)_test				-0.822	-0.910	0.507	-0.832	-0.505	-0.396
AR(2)_P-value				0.411	0.363	0.612	0.405	0.614	0.692
No. of Instruments				119	8	119	240	9	9
chi-squared			3.619						
Prob > chi2			0.306						

Table 8: Effects of Oil Price Volatility on Stock Returns in Oil Importing Countries (COVID-19 Period, 2020Q1 -2022Q3)

	(1)	(2)	(3)	(4)	(5)	(6)	(8)	(9)	(10)
VARIABLES	POLS	FE	RE	DGMM 1	DGMM1 -CL-a	DGMM 2	SGMM 1	SGMM1-CL-a	SGMM2
Lnepu	-0.213	-0.207	-0.213	-0.248***	-0.203***	-0.214***	-0.247***	-0.225***	-0.152
	(0.198)	(0.199)	(0.198)	(0.0394)	(0.0298)	(0.0424)	(0.0395)	(0.0355)	(0.791)
Lnreer	-0.0702	0.611	-0.0701	-0.0626	-0.901**	-4.185***	0.00205	-0.00821	0.310

	(0.0483)	(1.271)	(0.0499)	(0.215)	(0.367)	(1.155)	(0.00212)	(0.0346)	(2.414)
vol_rbrent	0.00279	0.00459	0.00285	0.0234	0.0212	0.00676	0.0260	0.0258	0.00882
	(0.0468)	(0.0470)	(0.0466)	(0.0202)	(0.0290)	(0.0372)	(0.0206)	(0.0267)	(0.136)
L.sreturns				-0.0195*	-0.0269**	-0.0670*	-0.0122	-0.0146	-0.0297
				(0.0115)	(0.0122)	(0.0355)	(0.00916)	(0.0106)	(0.113)
Constant	1.526	-1.736	1.526				1.367***	1.294***	-0.617
	(1.132)	(6.202)	(1.131)				(0.212)	(0.232)	(13.63)
Observations	149	149	149	119	119	119	134	134	134
R-squared	0.022	0.011							
firm effect	NO			YES	YES	YES	YES	YES	YES
Rmse	0.531	0.532	0.530						
F-test	1.107	0.484							
Prob > F	0.348	0.694							
Number of countries		15	15	15	15	15	15	15	15
country effect		YES	YES						
F-test(u_i=0)		0.956							
Prob > F(u_i=0)		0.694							
Hansen_test				7.190	4.684	7.190	12.64	4.197	12.64
Hansen Prob				1	0.321	1	1	0.380	1
Sargan_test				122.9	8.845	122.9	144.7	14.18	144.7
Sargan Prob				0.290	0.0651	0.290	1	0.00673	1
AR(1)_test				-2.855	-2.831	-1.320	-2.891	-2.895	-1.645

AR(1)_P-value				0.00430	0.00464	0.187	0.00384	0.00379	0.0999
AR(2)_test				1.476	1.888	1.701	1.541	1.659	0.693
AR(2)_P-value				0.140	0.0590	0.0889	0.123	0.0972	0.488
No. of Instruments				119	8	119	240	9	240
chi-squared			3.191						
Prob > chi2			0.363						

Table 9: Effects of Oil Price Volatility on Stock Returns in Thirty Selected Countries (COVID-19 Period, 2020Q1 -2022Q3

	(1)	(2)	(3)	(4)	(5)	(6)	(8)	(9)	(10)
VARIABLES	POLS	FE	RE	DGMM1	DGMM1-CL-a	DGMM2	SGMM1	SGMM1-CL-a	SGMM2
Lnepu	-0.196	-0.194	-0.196	-0.191***	-0.139***	-0.180***	-0.189***	-0.175***	-0.179***
	(0.194)	(0.193)	(0.192)	(0.0407)	(0.0386)	(0.0403)	(0.0402)	(0.0505)	(0.0373)
Lnreer	0.00233	-0.540	0.00102	-0.00529	0.328	-0.736	0.0452**	1.100	0.431
	(0.138)	(1.215)	(0.149)	(0.275)	(0.337)	(3.363)	(0.0203)	(4.415)	(1.931)
vol_rbrent	-0.154*	-0.158*	-0.154*	0.0219	-0.00296	0.0297	0.0199	0.0148	0.0431
	(0.0842)	(0.0843)	(0.0834)	(0.0333)	(0.0378)	(0.0426)	(0.0339)	(0.0569)	(0.0523)
L.sreturns				0.00416	0.0167	-0.00697	0.0112	0.0169	-0.00617
				(0.0123)	(0.0121)	(0.0850)	(0.0120)	(0.0165)	(0.0257)
Constant	1.097	3.556	1.103				0.861***	-4.022	-0.949
	(1.241)	(5.607)	(1.257)				(0.238)	(19.93)	(8.812)
Observations	269	269	269	209	209	209	239	239	239
R-squared	0.026	0.030							
firm effect	NO			YES	YES	YES	YES	YES	YES
Rmse	0.620	0.616	0.614						
F-test	2.328	2.417							
Prob > F	0.0749	0.0671							
Number of countries		30	30	30	30	30	30	30	30

country effect		YES	YES						
F-test(u_i=0)		1.117							
Prob > F(u_i=0)		0.0671							
Hansen_test				27.39	2.354	27.39	25.37	1.896	25.37
Hansen Prob				1	0.671	1	1	0.755	1
Sargan_test				265.2	0.834	265.2	338.8	1.072	338.8
Sargan Prob				0.00292	0.934	0.00292	0.997	0.899	0.997
AR(1)_test				-2.420	-2.361	-1.941	-2.395	-2.474	-2.094
AR(1)_P-value				0.0155	0.0182	0.0522	0.0166	0.0134	0.0363
AR(2)_test				0.0676	0.357	0.117	0.0610	0.199	0.312
AR(2)_P-value				0.946	0.721	0.907	0.951	0.842	0.755
No. of Instruments				209	8	209	420	9	420
chi-squared			7.117						
Prob > chi2			0.0683						

Table 10: Effects of Oil Price Volatility on Stock Returns in Net Oil Importing Countries (Using WTI Oil Price)

	(1)	(2)	(3)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
VARIABLES	POLS	FE	RE	DGMM1	DGMM1-CL-a	DGMM2	SGMM1	SGMM1-CL-a	SGMM2	SGMM2-CL-a
Lnepu	-0.0961	-0.0872	-0.0960	-0.124***	-0.102***	0.106	-0.125***	-0.114***	0.00493	-0.121***
	(0.107)	(0.107)	(0.107)	(0.0178)	(0.0204)	(0.419)	(0.0181)	(0.0135)	(0.471)	(0.0167)
Lnreer	-0.0378	1.103	-0.0377	0.0169	-0.130	0.811	-0.000611	0.0413	0.340	0.0644
	(0.0273)	(0.742)	(0.0281)	(0.0897)	(0.145)	(2.799)	(0.000867)	(0.0442)	(3.013)	(0.0776)
vol_rwti	0.0105	0.0156	0.0105	0.00968	0.00991	-0.0227	0.00964	0.00995	-0.0216	0.0102
	(0.0464)	(0.0464)	(0.0463)	(0.00638)	(0.0101)	(0.0320)	(0.00640)	(0.00854)	(0.0308)	(0.0110)
L.sreturns				-0.00111	0.00422	-1.835**	0.000107	0.00373	-1.705*	0.00987
				(0.00988)	(0.00676)	(0.877)	(0.0100)	(0.00745)	(0.962)	(0.0106)
Constant	0.713	-4.745	0.712				0.700***	0.442*	-1.630	0.373

	(0.607)	(3.595)	(0.607)				(0.0990)	(0.246)	(16.46)	(0.411)
Observations	269	269	269	239	239	239	254	254	254	254
R-squared	0.010	0.012								
firm effect	NO			YES	YES	YES	YES	YES	YES	YES
Rmse	0.402	0.401	0.402							
F-test	0.937	1.033								
Prob > F	0.423	0.378								
Number of countries		15	15	15	15	15	15	15	15	15
country effect		YES	YES							
F-test(u_i=0)		1.086								
Prob > F(u_i=0)		0.378								
Hansen_test				5.549	6.751	5.549	5.129	6.711	5.129	6.711
Hansen Prob				1	0.150	1	1	0.152	1	0.152
Sargan_test				264.3	9.014	264.3	291.2	9.113	291.2	9.113
Sargan Prob				0.0920	0.0607	0.0920	1	0.0583	1	0.0583
AR(1)_test				-3.386	-3.414	2.026	-3.384	-3.414	1.729	-3.426
AR(1)_P-value				0.000709	0.000640	0.0427	0.000715	0.000641	0.0837	0.000613
AR(2)_test				2.538	2.590	-1.540	2.558	2.619	-1.765	2.608
AR(2)_P-value				0.0111	0.00958	0.124	0.0105	0.00882	0.0775	0.00910
No. of Instruments				239	8	239	480	9	480	9
chi-squared			2.704							
Prob > chi2			0.440							
Prob > chi2			0.440							
chi-test(sigma_u=0)										

Table 11: Effects of Oil Price Volatility on Stock Returns in Net Oil Exporting Countries (Using WTI Oil Price)

	(1)	(2)	(3)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
VARIABLES	POLS	FE	RE	DGMM1	DGMM1-CL-a	DGMM2	SGMM1	SGMM1-CL-a	SGMM2	SGMM2-CL-a
Lnepu	0.0231	0.0193	0.0230	-0.113***	-0.143***	-0.110**	-0.111***	-0.114	-0.206	-0.0691
	(0.134)	(0.134)	(0.133)	(0.0332)	(0.0520)	(0.0541)	(0.0322)	(0.137)	(0.689)	(0.140)
Lnreer	0.0362	0.191	0.0370	0.102	0.456***	0.599	0.0289*	-5.483	-0.481	-0.821
	(0.112)	(0.566)	(0.120)	(0.0823)	(0.125)	(3.172)	(0.0168)	(57.43)	(1.618)	(44.54)
vol_rwti	-0.0195	-0.0176	-0.0195	-0.0242***	-0.0394***	-0.0245	-0.0252***	-0.0901	-0.0412	-0.0338
	(0.0579)	(0.0583)	(0.0577)	(0.00706)	(0.00742)	(0.0305)	(0.00730)	(0.553)	(0.0493)	(0.445)
L.sreturns				-0.00264	0.00392	0.0755	-0.00184	0.0121	0.122	0.00252
				(0.00585)	(0.00546)	(0.386)	(0.00597)	(0.108)	(0.343)	(0.0891)
Constant	-0.304	-0.995	-0.307				0.489***	25.83	3.357	4.389
	(0.900)	(2.648)	(0.917)				(0.188)	(263.3)	(10.80)	(206.4)
Observations	269	269	269	239	239	239	254	254	254	254
R-squared	0.001	0.001								
firm effect	NO			YES	YES	YES	YES	YES	YES	YES
Rmse	0.502	0.502	0.500							
F-test	0.0889	0.0919								
Prob > F	0.966	0.964								
Number of countries		15	15	15	15	15	15	15	15	15
country effect		YES	YES							
F-test(u_i=0)		1.008								
Prob > F(u_i=0)		0.964								
Hansen_test				12.65	2.219	12.65	12.21	2.085	12.21	2.085
Hansen Prob				1	0.696	1	1	0.720	1	0.720
Sargan_test				324.5	1.335	324.5	355.3	0.568	355.3	0.568
Sargan Prob				9.65e-05	0.855	9.65e-05	1	0.967	1	0.967
AR(1)_test				-1.888	-1.840	-0.981	-1.871	-0.731	-1.145	-0.853
AR(1)_P-value				0.0591	0.0657	0.327	0.0613	0.465	0.252	0.394
AR(2)_test				-0.277	-0.830	-0.176	-0.263	0.0962	-0.0973	-0.0289
AR(2)_P-value				0.782	0.407	0.861	0.793	0.923	0.923	0.977
No. of Instruments				239	8	239	480	9	480	9
chi-squared			0.259							

Prob > chi2			0.968							
Prob > chi2			0.968							
chi-test(sigma_u=0)										

Table 11: Effects of Oil Price Volatility on Stock Returns in Net Oil Exporting Countries (Using WTI Oil Price)

	(1)	(2)	(3)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
VARIABLES	POLS	FE	RE	DGMM1	DGMM1-CL-a	DGMM2	SGMM1	SGMM1-CL-a	SGMM 2	SGMM2-CL-a
Lnepu	-0.0172	-0.0197	-0.0172	- 0.117***	-0.121***	- 0.108***	- 0.116***	-0.107	-0.304	-0.109
	(0.0859)	(0.0858)	(0.0857)	(0.0184)	(0.0280)	(0.0263)	(0.0182)	(0.110)	(0.298)	(0.0819)
Lnreer	0.0176	0.446	0.0187	0.0918	0.293	-0.179	0.0192*	4.621	-0.869	7.319
	(0.0766)	(0.438)	(0.0794)	(0.0636)	(0.199)	(2.621)	(0.0106)	(38.27)	(0.749)	(11.18)
vol_rwti	- 0.00371	-5.34e-05	- 0.00370	-0.00717	-0.0147*	-0.0121	-0.00781	0.0164	-0.0290	0.0308
	(0.0373)	(0.0374)	(0.0372)	(0.00569)	(0.00774)	(0.0162)	(0.00580)	(0.251)	(0.0225)	(0.0727)
L.sreturns				-0.00134	0.00450	-0.111	0.000107	-0.00137	-0.0745	-0.00499
				(0.00530)	(0.00454)	(0.501)	(0.00526)	(0.0501)	(0.450)	(0.0572)
Constant	0.00881	-1.928	0.00418				0.563***	-20.46	5.653	-32.72
	(0.590)	(2.041)	(0.596)				(0.105)	(174.8)	(4.318)	(50.58)
Observations	539	539	539	479	479	479	509	509	509	509
R-squared	0.000	0.002								
firm effect	NO			YES	YES	YES	YES	YES	YES	YES
Rmse	0.457	0.457	0.456							
F-test	0.0335	0.361								
Prob > F	0.992	0.781								
Number of countries		30	30	30	30	30	30	30	30	30
country effect		YES	YES							
F-test(u_i=0)		1.044								
Prob > F(u_i=0)		0.781								
Hansen_test				27.07	5.714	27.07	24.49	0.755	24.49	0.755
Hansen Prob				1	0.222	1	1	0.944	1	0.944
Sargan_test				578.2	1.625	578.2	636.1	0.375	636.1	0.375
Sargan				0.000802	0.804	0.000802	1	0.984	1	0.984

Prob										
AR(1)_test				-3.244	-3.306	-0.777	-3.214	-0.571	-1.079	-0.271
AR(1)_P-value				0.00118	0.000945	0.437	0.00131	0.568	0.281	0.787
AR(2)_test				1.358	1.558	0.0815	1.346	0.327	0.0908	0.488
AR(2)_P-value				0.175	0.119	0.935	0.178	0.744	0.928	0.626
No. of Instruments				479	8	479	960	9	960	9
chi-squared			0.103							
Prob > chi2			0.991							
Prob > chi2			0.991							
chi-test(sigma_u=0)										

4.4 Effects of Oil Price Volatility on Stock Returns: COVID-19 Pandemic Period

The main objective of this paper was to analyse the effects of oil price volatility on a stock return during the COVID-19 pandemic period. Therefore, in addition to the full sample period analysis, we estimated the model utilising the data for the COVID-19 pandemic period. The consideration for the COVID-19 period analysis was to compare with the full sample period. The result of the global evidence showed that the effects of oil price volatility on stock returns during the COVID-19 pandemic are positive but insignificant. The insignificant effect indicates a result similar to what was obtained for the full sample period. A similar result was previously obtained by Tabash et al., (2022) for the impact of oil price on stock returns both in pre-COVID-19 and overall sub-periods of the study. Economic policy uncertainty impacts stock returns negatively but is significant.

It should be recalled that we separated the thirty countries into two groups. The result for net exporting countries in the COVID-19 pandemic highlights interesting dynamics. Just like in the case of the full sample period, oil price volatility has a negative and significant impact on stock returns in the analysis of the COVID-19 pandemic period. However, Economic policy uncertainty no longer plays a significant role in stock returns during the COVID-19 period, as it was in the full sample period.

For the net oil importing countries, there is no difference in the result obtained for the role of oil price volatility and economic policy uncertainty in explaining the stock returns in both the full period and the COVID-19 period.

4.5 Robustness Checks

With the view of testing the robustness check for the estimations in this study, we attempted some alternative approaches. Specifically, utilized the WTI price as an alternative to the Brent oil price majorly used in the paper. The alternative price was used as the explanatory variable in the three samples. In addition, the combination of the countries was altered, rather than the net oil importing and net oil exporting utilized previously in the paper, we experimented with the samples of developed and developing countries. The results of the new estimations are very interesting. When the WTI prices were used, similar results as previously obtained with the Brent oil price were gotten. Also, the results for models estimated for developed and developing countries showed insignificant effects of oil price volatility on stock returns.

5.0 CONCLUSION

The dynamics of crude oil prices in the COVID-19 period portrayed a worrisome dimension. Although the crude oil price has continued to be susceptible to volatility, no time in history has the price turned negative. Expectedly, the unprecedented fall in the crude oil price is expected to impact all macroeconomic variables, stock price inclusive. This study analyses the effects of oil price volatility on stock returns. Presumably, we do not expect oil price volatility to have the same impact on stock returns in all countries. Given that, in addition to the combined sample of 30 net oil exporting and net oil importing countries, we estimate our equation for two other samples of 15 net oil exporting countries and 15 net oil importing countries.

We adopted the EGARCH model to analyse the oil price volatility using daily data for five years (2017 and 2022). In executing the main objective of analysing the effects of oil price volatility on stock price, variants of GMM estimation techniques were estimated. As regards our estimable equation, we estimated the oil price volatility as an explanatory variable to the stock price. We augmented the estimable model using the economic policy uncertainty and real effective exchange rate. The result provides evidence of the significant effects of oil price volatility on stock returns only in net oil exporting countries. On the contrary, we reported insignificant effects of oil price volatility on stock returns in the net oil-importing countries and the global sample. Economic policy uncertainty was found to play a prominent role in the variation in stock returns.

REFERENCES

Adenekan, A. T., Hilili, M. J., & Okereke, A. N. (2020). Oil Price, Exchange Rate and Stock Market Performance in Nigeria. *Central Bank of Nigeria Economic and Financial Review* Volume 58/4 December.

Al Janabi, M. A. M., Hatemi-J, A. & Irandoust, M. (2010). An Empirical Investigation of the Informational Efficiency of the GCC Equity Markets: Evidence from Bootstrap Simulation. *International Review of Financial Analysis*, 19(1), 47–54.

Alsalman, Z., & Herrera, A. M. (2015). Oil price shocks and the US stock market: do sign and size matter? *The Energy Journal*, 171-188.

Apergis, N., & Miller, S. M. (2009). Do structural oil-market shocks affect stock prices? *Energy Economics*, 31(4), 569-575.

Arekar, K. & Jain, R. (2017). Influence of Oil Price Volatility of Developed Countries on Emerging Countries Stock Market Returns by Using Threshold Based Approach. *Theoretical Economics Letters*, **7**, 1834-1847. doi: 10.4236/tel.2017.76125.

Brown, S., & Yucel, M. (2002). Energy Prices and Aggregate Economic Activity: An Interpretative Survey. *The Quarterly Review of Economics and Finance*, 2002, vol. 42, issue 2, 193-208.

Chudik, A, & Pesaran, M. H. 2016. Theory and Practice of GVAR Modeling. *Journal of Economic Surveys* 30: 165–97.

Cong, R.G., Wei, Y.M., Jiao, J.L., & Fan, Y. (2008). Relationships between oil price shocks and stock market: An empirical analysis from China. *Energy Policy*, 36, 3544-3553.

Cunado, J., & De Gracia, F. P. (2014). Oil price shocks and stock market returns Evidence for some European countries. *Energy Economics, 42*, 365-377.

Degiannakis, S., Filis, G., & Kizys, R. (2014). The Effects of Oil Price Shocks on Stock Market Volatility: Evidence from European Data. *The Energy Journal*, 35, 35-56. https://doi.org/10.5547/01956574.35.1.3

Degiannakis, S., Filis, G., & Arora, V. (2018). Oil prices and stock markets: a review of the theory and empirical evidence. *The Energy Journal*, *39*(5).

Dohner, R. S. (1981). Energy Prices, Economic Activity, and Inflation: Survey of Issues and Results. *Energy prices, inflation, and economic activity. Ballinger, Cambridge, MA*.

Filis, G., Degiannakis, S., & Floros, C. (2011). Dynamic Correlation between Stock Market and Oil Prices: The Case of Oil-importing and Oil-exporting Countries. *International Review of Financial Analysis*, *20*(3), 152-164.

Gounder, R., & Bartleet, M. (2007). Oil Price Shocks and Economic Growth: Evidence of New Zealand. In: *New Zealand Association of Economists, Annual Conference. Christ Church, New Zealand*, 27th-29th June 2007. Retrieved from: https://mpra.ub.uni-muenchen.de/16319/

Hamdi, B., Aloui, M., Alqahtani, F., & Tiwari, A. (2019). Relationship between the oil price volatility and sectoral stock markets in oil-exporting economies: Evidence from wavelet nonlinear denoised based quantile and Granger-causality analysis. *Energy Economics*, *80*, 536-552.

Hamilton, James D. (2011). Historical Oil Shocks. *NBER Working Paper* No. w16790, Available at SSRN: https://ssrn.com/abstract=1768548

Henriques, I., & Sadorsky, P. (2008). Oil prices and the Stock Prices of Alternative Energy Companies. *Energy Economics*, 30(3), 998-1010.

Jammazi, R., & Aloui, C. (2010). Wavelet Decomposition and Regime Shifts: Assessing the Effects of Crude Oil Shocks on Stock Market Returns. Energy Policy, 38(3), 1415-1435.

Joo, Y. C., & Park, S. Y. (2021). The Impact of Oil Price Volatility on Stock Markets: Evidence from Oil-importing Countries. *Energy Economics*, *101*, 105413.

Kling, J. L. (1985). 'Oil Price Shocks and Stock-Market Behavior. Journal of Portfolio Management,12,34-39. http://dx.doi.org/ 10.3905/jpm. 1985. 409034

Lutz K. and Cheolbeom, P. (2009). 'The Impact of Oil Price Shocks on the U.S. Stock Market'', International Economic Review, Nov. 2009, Vol. 50, No. 4 (Nov 2009), pp. 1267- 1287

Miramir Bagirov, Cesario Mateus, (2019). ''Oil prices, stock markets, and firm performance: Evidence from Europe'', International Review of Economics & Finance, Vol. 61, 2019, Pages 270-288, https://doi.org/10.1016/j.iref.2019.02.007

Mohanty, S. K., & Nandha, M. (2011). Oil Risk Exposure: The Case of the US Oil and Gas Sector. *Financial Review*, 46(1), 165-191.

Mohanty, S. K., Nandha, M., Turkistani, A. Q. & Alaitani, M. Y. (2011). Oil Price Movements and Stock Market Returns Evidence from Gulf Cooperation Council (GCC) countries. Global *Finance Journal*, 22(1), 42–55.

Mosab I. Tabash, Zaheeruddin Babar, Umaid A Sheikh, Ather Azim Khan & Suhaib Anagreh (2022) The linkage between oil price, stock market indices, and exchange rate before, during, and after COVID-19: Empirical insights of Pakistan, Cogent Economics & Finance, 10:1, DOI: 10.1080/23322039.2022.2129366

Narayan, P. K., Narayan, S. & Prasad, A. (2008). Understanding the oil price-exchange rate nexus for the Fiji Islands, *Energy Economics*, Volume 30, Issue 5, Pgs 2686-2696,

Oberndorfer, U. (2009). Energy Prices, Volatility, and the Stock Market: Evidence from the Eurozone. *Energy Policy*, 37(12), 5787-5795.

Prabheesh, K. P., Padhan, R., & Garg, B. (2020). COVID-19 and the Oil Price–Stock Market Nexus: Evidence from Net Oil-importing Countries. *Energy Research Letters*, *1*(2), 13745.

Salisu, A. A., Gupta, R., & Demirer, R. (2022). Oil Price Uncertainty Shocks and Global Equity Markets: Evidence from a GVAR Model. *Journal of Risk and Financial Management* 15 (8)

SHOULD MONETARY POLICY RESPOND TO PRODUCTIVITY AND DEMAND SHOCKS IN THE GAMBIA? A BAYESIAN DSGE INVESTIGATION

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ABSTRACT

Demand and productivity shocks may influence the direction of monetary policy, especially if the impacts of the shocks are lasting. For instance, the global financial crises in 2009 and the COVID-19 pandemic in 2020 led to the implementation of unorthodox monetary policy, which influenced the objectives of most central banks in the world including those of the Central Bank of The Gambia. This paper, therefore, analyses the dynamic response of the Monetary Policy Rate (MPR) to productivity and demand shocks in The Gambia, by employing recent quarterly data to estimate a Bayesian Dynamic Stochastic General Equilibrium (DSGE) Model. The findings indicate that MPR's response to both demand and productivity shocks is transient. Thus, we suggest to the monetary authority that monetary policy need not respond to demand and productivity shocks since the effects are short-lived.

Keywords: The Gambia, Monetary Policy, Monetary Policy Rate, Productivity Shocks, Demand Shocks, Bayesian DSGE model.

JEL Classification : C11, C32, C53, D58, E52, E58.

ACKNOWLEDGMENT

We wish to acknowledge and thank the Management of the West African Institute for Financial and Economic Management (WAIFEM) for organizing the virtual course

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on Advanced Modelling and Forecasting for Analysis for Senior Economists and Directors of Research (Bayesian DSGE Modelling). Given this, we appreciate the three facilitators of the course for their excellent facilitation. They are Prof. Afees Salisu (University of Ibadan), Prof. Yahya Simons OlaOluwa (University of Ibadan) and Dr. Jamaladeen Abubakar (Central Bank of Nigeria). This research paper is a product of our participation in the above-stated course.

Disclaimer: This research paper does not represent the views of the Central Bank of The Gambia (CBG), West African Monetary Institute (WAMI), and the West African Institute for Financial and Economic Management (WAIFEM) but those of the authors.

1.0 INTRODUCTION

Since the publication of "The General Theory of Employment, Interest, and Money" by Keynes in 1936, the use of demand management policies – fiscal and monetary policy – to counter macroeconomic fluctuations remains plausible for policymakers and researchers. Keynesian stabilisation policies during the great depression did not only lift most advanced countries out of the "woods" but also ignited stronger support for government commitment to higher employment and stable inflation (Snowdon et al, 2005, p.15). While there was some consensus on the efficacy of fiscal policy and the channel through which it impacts real economic activity (government spending and taxation), monetary policy potency remained a topic of debate in macroeconomic research. This was largely based on the Policy Ineffectiveness Proposition (PIP) hinged on the Lucas Critique as well as the view of money neutrality by Classical Economists. However, following the work of Friedman and Schwartz, and Friedman's presidential address, many Economists came to the agreement that, at least in the short run, monetary policy affects real economic variables such as output and employment (Mankiw and Reis, 2017). Therefore, this development establishes that not only does monetary policy have a real effect but could also be employed as an effective policy tool to stabilise macroeconomic fluctuations – could counter both demand and supply side shocks. While this is true, the effectiveness of monetary policy on real variables largely depends on the monetary policy transmission mechanism.

Monetary policy transmission refers to the process by which a central bank's monetary policy signals are passed on through the financial system to influence businesses and households' activities within an economy. Its effectiveness presupposes three factors: that the monetary authority is quick to recognize the need for a change in monetary policy and takes prompt action; that monetary policy has a real influence on the operations of the economy and lastly, monetary transmission is felt in a relatively short interval (Englewood, 1961). Currently, in many developing countries (including The Gambia), the reliability of the Monetary Policy Rate (MPR) as a signal for the conduct of monetary policy has become increasingly questionable, partly due to a phenomenon of weakening the transmission mechanism of the MPR. The past decades have seen the mandate of most central banks in developing and emerging economies expand beyond macroeconomic stability. Since the 1980s, almost all the developing countries in the sub-region have adopted an indirect (market-based) monetary policy with the primary objective of price stability as part of their financial sector liberalization programs. However, with the post-crisis view that when the monetary policy transmission is weak or completely broken down, direct intervention by central banks may be necessary for the attainment of monetary goals (WAMI, 2016).

Typically, as stated earlier, monetary policy is a demand management policy and as such, it usually affects the real economy through its effect on demand. In the same vein, standard macroeconomic models have shown that monetary policy also responds to demand disturbances in an economy. For example, a positive shock in consumer preference that leads to higher aggregate demand and thus overheats the economy is usually met with a restrictive monetary policy response to dampen demand and curb inflation. In addition, a recent paper by Baqaee et al. (2021) reveals that monetary policy also has supply-side effects. In other words, in addition to boosting real GDP by increasing employment, a contractionary monetary policy could boost output through increasing productivity, if macro-models account for firm heterogeneity. Thus, while demand shocks remain important in the conduct of monetary policy, monetary policy affects productivity and could also respond to productivity shocks in the pursuit of its objectives – price stability and growth.

The extent to which the recent COVID-19 pandemic and the ongoing Russia-Ukraine war have ignited both demand and supply shocks is a testament to the importance of recognizing productivity and demand shocks in the conduct of monetary policy. Monetary policy should be tailored to respond to these shocks. Because of this, over the years, most central banks have reacted to these developments by raising their policy rates to cool the pent-up demand and also, to respond to supply-side disturbances to keep inflation expectations anchored. Specifically, early research into the pandemic suggests that supply shocks (supply shock affects an economy's ability to produce goods and services at given prices) accounted for a larger share of the fall in work hours in the United States during the pandemic (Brinca et al. 2020). Thus, the fact that monetary policy responded to supply shocks to avoid a deep recession during the pandemic makes such shocks imperative to monetary policy and how such policy actions are transmitted to the real economy (see Baqaee et al., 2021; Kilian, 2006; Caballero & Simsek, 2020; Chanona et al., 2020).

Although the nexus between monetary policy and supply/demand shocks has been established in the empirical literature, they are mostly based on advanced economies with well-functioning financial markets. In other words, given the vulnerability of low-income economies to structural supply/productivity shocks – droughts, disease outbreaks, civil and political unrest – the need to investigate whether monetary policy should respond to demand, productivity, and demand shocks cannot be overemphasized. In addition, it has been argued that the under-development of the financial system in most developing countries constitutes a major constraint to the effective transmission of monetary policy goals (Mishra et al, 2011, 2014). For instance, in The Gambia, it has been observed that higher inflation has not kept pace with the unchanged MPR, particularly since the onset of the Covid-19 pandemic raising concerns about the potency of monetary policy through its influence on the demand side of the economy. It is in this context that this paper investigates whether monetary policy in The Gambia should respond to demand and productivity shocks. This paper contributes to the debate on whether monetary policy, in addition to responding to demand shocks, should also respond to productivity shocks, to keep inflation expectations anchored. Furthermore, findings from this study will shape policy direction, especially on the plausibility of using monetary policy tools to augment demand and productivity conditions in the wake of acute structural bottlenecks that the economy of The Gambia continues to grapple with.

To this end, this paper estimates a DSGE model with exogenous demand and productivity shocks using the MCMC under the Bayesian approach and the results are revealing. Firstly, we find that demand and productivity shocks are transitory in The Gambia. In other words, while statistically significant, the monetary policy response to demand and productivity shocks lasts up to two years before dissipating. Secondly, another key closely watched variable by CBG – inflation and output gap – also respond to demand and productivity shocks, albeit transient.

Following this introduction, the rest of the paper proceeds in the following fashion. Section 2 reviews the relevant literature while Section 3 presents an overview of the Monetary Policy Framework and Development in The Gambia. The framework and methodology are presented in Section 4, whilst Section 5 presents the results and discussion. The paper concludes with a brief discussion of the policy implication in Section 6.

2.0 LITERATURE REVIEW

Theoretical perspectives have revealed that the impact of monetary policy on the real economy is transmitted through the interest rate, credit, exchange, asset prices, and expectation channels (Beyer, et al., 2017). These channels are classified by Macroeconomists as belonging to either the Monetarists or the Keynesian School of Thought. The Keynesians view the monetary transmission mechanism channel as indirect via the interest rate, whilst the Monetarists view it as directly via the interest rate. For example, the interest rate channel as encapsulated by the Keynesian IS-LM model depicts a negative relationship between interest rate and output. An increase in money supply (i.e. monetary easing) is accompanied by a fall in interest rate due to the presence of price rigidities. The decline in interest rate means a lower cost of capital and an increase in interest-sensitive investment spending which in turn bolster aggregate demand. The Monetarists School of Thought on the other hand holds the view that there is a direct relation existing between money supply and prices/interest rate. Unlike the Keynesians' view, the Monetarists are of the view that money supply is an important determinant of output.

It is worth noting that while the interest rate channel of monetary transmission works through the liability side of the balance sheet of banks, the broad credit channel is concerned with the asset side of the balance sheet. The fact that banks can give out loans to firms and households means that monetary policy actions that affect bank's ability to create credit will directly impact the activities of those economic agents, who depend on bank credit. Thus, a tight monetary policy reducing bank deposits (or increasing lending rates) would force banks to cut back credit supply and this may force bank-credit-dependent firms and households to cut down their consumption and investment spending. This process amplifies the initial interest rate effect on output thus further dampening real economic activity (see Bernanke and Gertler, 1995; Mishkin, 1995). The exchange rate also plays a crucial role in the transmission of monetary policy to the real economy, especially for low-income countries affecting domestic demand and inflation through its impact on real marginal costs. Monetary policy action in a period of rising nominal interest rate 'softens' real marginal costs thereby cooling off inflationary pressures but dampens output through a worsening current account position. On the other hand, the asset price channel of monetary policy transmission works through its impact on key asset prices such as real estate and equity prices. Monetary policy actions that increase asset prices for instance, through Tobin's Q, increase the wealth of these asset holders and consequently their investment and consumption – Modigliani's life cycle hypothesis (see Mishkin 2001, 2006). Finally, agents' expectations about future monetary policy directly impact their medium to long-term decisions. For example, an expectation of a tight monetary policy in the future will signal to agents the possible higher inflation and interest rates in the future, thus altering their savings, consumption, and investment decision which eventually influence aggregate economic activity. While these transmission mechanisms are studied separately, the impact of a monetary policy shock on output and inflation depends on the combined effects of these channels.

On the empirical front, various studies indicate that international disparity in the transmission rate of monetary policy is strongly associated with differences in financial development. In developing nations, financial institutions may be unable to protect themselves against unexpected monetary policy actions. Factors causing this are varied; low levels of capitalization or modest sophistication of financial instruments available to the less complex financial system. Thus, they must respond rapidly to monetary policy shocks, hence accelerating the transmission rate (Havranek & Rusnak, 2013). In more financially developed countries, banks have opportunities to guard against surprises in monetary policy stances, further impeding the transmission speed of monetary policy shocks.

Monetary policy transmission and the response of monetary policy to demand and productivity shocks have attracted much attention from both Academics and Policymakers. However, empirical studies on the monetary transmission mechanism and response of MPR to demand and productivity shocks in The Gambia are very limited. The few studies that have been conducted include Jallow (2021), who employs five major economic sectors (i.e. agricultural sector, building & construction sector, distributive trade sector, and consumer credit) in The Gambia using a Structural Vector Auto Regressive Model to analyze the transmission of exogenous monetary shocks to these major economic sectors. He finds evidence that monetary policy shocks are transmitted to major economic sectors through banks' sectoral credit supply and impact occurs almost immediately for all sectors except for consumer credit. On the other hand, Komma (2014) employs the Optimum Currency Area (OCA) theory and the pre-conditions of inflation targeting to examine the choice between a common currency and inflation targeting for The Gambia. He finds that The Gambia does not satisfy most of the conditions to enter into a common currency. He also finds that central bank independence in The Gambia has been mainly hindered by fiscal dominance through the financing of budget deficits as a lender of last resort. However, the study concludes that inflation targeting is the appropriate monetary policy regime for The Gambia. In a related study, Sriram (2009) analyzed the demand for broad money and its implication for monetary policy conduct in The Gambia from January 1988 to June 2007. The study finds that demand for money is influenced in the long run by real GDP, interest rates on short-term deposits, yields on treasury bills, and expected inflation. The study also finds that factors that contributed to financial instability included the changing velocity of M2, political and weather-related shocks that affect output, changes in government policies impacting money growth and inflation as well as lack of good quality data on output, CPI, and interest rates. In conclusion, the paper recommends that CBG should apply the monetary targeting regime flexibly to achieve price stability. In addition, Mustapha and Kouassi (2016) examine the exchange rate pass-through into consumer prices for The Gambia, using monthly data from 2001 to 2012. Applying Johansen cointegration and VECM, while controlling for supply shocks and monetary policy effects, they find that both the adjustment to equilibrium is slow and that the exchange rate pass-through into consumer prices is incomplete. Estimates of the pass-through from the derived impulse responses show that a 1% depreciation in the exchange rate increases inflation by 0.12% in 24 months. Yet, the variance decomposition shows the exchange rate contributing up to 35% of changes in inflation in The Gambia for the period under study.

The dearth in the empirical literature is that not many studies have been undertaken on the response of monetary policy to demand and productivity shocks in The Gambia. Thus, this paper seeks to fill this gap in the empirical literature by analyzing the response of monetary policy to demand and productivity shocks in The Gambia using the Bayesian DSGE model. Put differently, this paper ascertains whether monetary policy should respond to demand and productivity shocks in The Gambia or not.

3.0 MONETARY POLICY FRAMEWORK AND DEVELOPMENT IN THE GAMBIA

The primary objective of the Central Bank of the Gambia (CBG) as stated in the 2018 Act is price stability. In addition, the Act requires the Bank to achieve and maintain exchange rate stability while supporting economic growth. Soon after its establishment, the bank was challenged by the effects of the collapse of the Bretton Woods System and the Smithsonian alignment of currencies. In March 1973, exactly two years after its establishment, the Bank had to manage the challenges associated with the instability in the international markets, particularly, the need to protect the domestic currency.

Since then, CBG has employed two exchange rate frameworks: a fixed exchange rate system up to mid-1980 and a monetary targeting framework with a flexible exchange system subsequently. Following the launching of the financial sector reforms under the Economic Recovery Programme (ERP) in the early 1980s, reforms were made to eliminate the direct control on credit, and exchange rates, resulting in the birth of the flexible exchange rate regime. In principle, this framework remains the framework of monetary policy in the Gambia, though, actual implementation has also paid increased attention to short-term interest rates. In its liquidity management policy throughout the period since 1986, the Central Bank of The Gambia has been ensuring that domestic interest rates are kept at levels that are in real terms appropriate. The focus on short-term interest rates has gained more attraction with the implementation of an interest rate corridor in 2018 when the CBG introduced the Standing Lending/Deposit Facilities to address liquidity issues in the short-term money market.

3.1 Monetary Policy Instrument

As a monetary targeting economy, the Bank sets targets for key monetary aggregates in line with its inflation objective. To meet these targets, the bank uses various tools at its disposal. Major among these instruments of monetary policy is the Monetary Policy Rate (MPR). The Monetary Policy Committee (MPC) meets every quarter to signal the monetary policy stance of the Bank by setting the key policy rates. To achieve the reserve money target, open market operations (weekly auctions of Central Bank Bills) continue to be the major tool for liquidity management. In addition to the MPR, the bank uses the statutory reserve requirement ratio, foreign exchange market interventions, and interest rate corridor.

As already mentioned, the Bank in September 2018 also added the interest rate corridor to its toolbox to improve liquidity management and the transmission of monetary policy. The interest rate corridor consists of overnight standing lending and deposit facilities. The Standing Lending Facility (SLF) is an overnight lending facility that provides funds to commercial banks at a predetermined interest rate to cover end-of-day liquidity shortfalls. The Standing Deposit Facility (SDF) is an overnight deposit facility that allows commercial banks to place excess funds at the Central Bank for remuneration at a predetermined rate. The rates are subject to review by the Monetary Policy Committee (MPC) of the Central Bank of The Gambia.

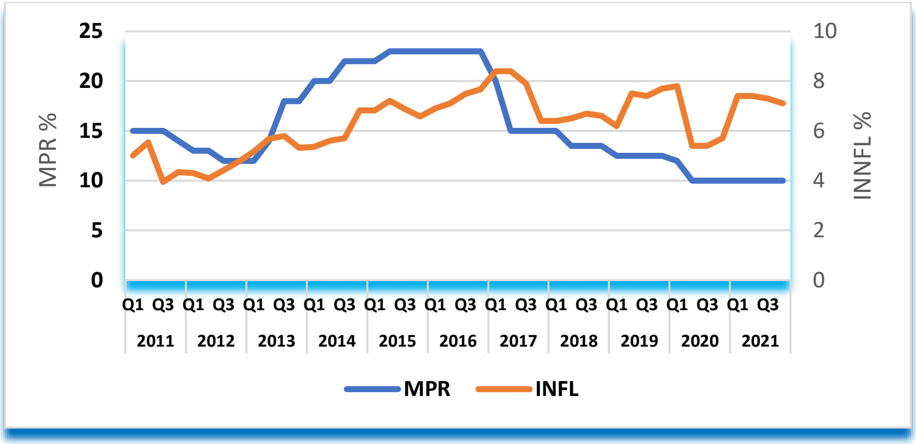
3.2 Trend in the Monetary Policy Rate and Other Economic Variables

Monetary Policy Rate (MPR) in The Gambia has undergone a jerky trajectory. The MPR had been declining steadily since 2004 until it reached 14 percent in 2007 after which it started to increase. From 2012, the MPR steadily rose until it peaked in 2016. This was followed by a drastic decline in 2017 to a current position of 10 percent. These developments were accompanied by two fundamental changes, namely a coherent fiscal policy with new leadership in the country and a reduction in MPR for the first time in over four years. The reduction in the MPR has led to a remarkable improvement and has helped spur economic growth supported by strong fiscal policies.

On the other hand, the inflation rate since 2013 has been above the medium-term target of 5 percent, the reason is still open to debate, but the fact is that inflation is still a single digit. The fourth quarter of 2016 and first quarter of 2017 showed a peak in inflation partly reflecting the impact of the political impasse that stunned the economy. A cursory examination of Figures 1 to 4 offers some preliminary insights about the relationship between the monetary policy rate and inflation, private sector credit, money supply, and nominal exchange rates in the Gambia. We note that the variables appear to exhibit certain relationships.

Figure 1 shows Monetary Policy Rate (MPR) and inflation generally moved in the same direction until 2017 when it started to move in an opposite direction. The widened gap between the monetary policy rate and inflation is observed to be narrowing in recent years.

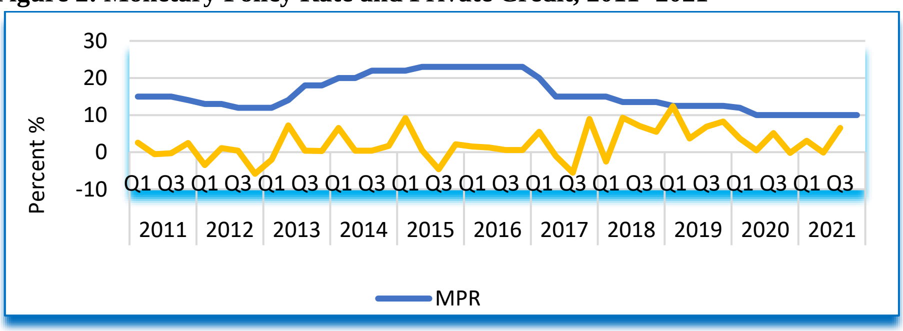
Figure 1: Monetary policy rate and inflation, 2011-2021



Note: MPR denotes Monetary Policy Rate whilst INFL denotes Inflation Rate.

Similarly, Figure 2 indicates a weaker symmetry of movements in monetary policy rate and private credit growth up to 2016. In 2017, the relationship changed, accompanied by an apparent stronger symmetric movement observed in the following years. This may be interpreted as suggesting that a stronger relationship exists between MPR and inflation during this latter period.

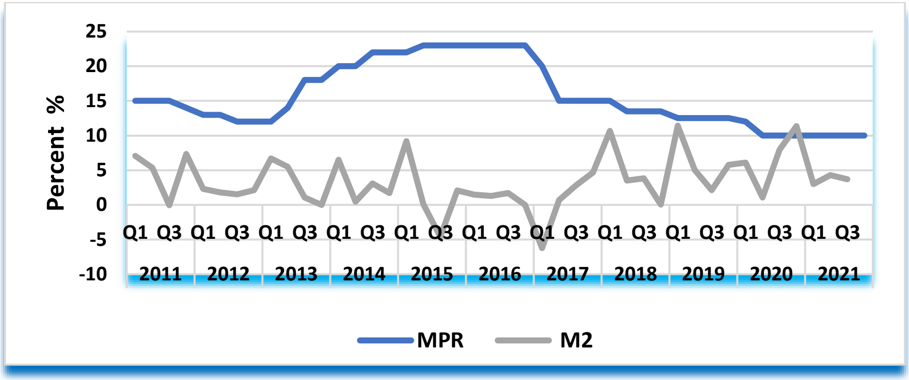
Figure 2: Monetary Policy Rate and Private Credit, 2011- 2021



Note: MPR denotes Monetary Policy Rate whilst PrC denotes Private Credit.

Figure 3, which shows the trend in Monetary Policy Rate and base money, indicates that both variables generally trended in opposite directions. In effect, a cursory look at Figures 2, and 3 indicates that any examination that is exclusively focused on these latter years is likely to show a relatively stronger relationship between private credit growth and broad money.

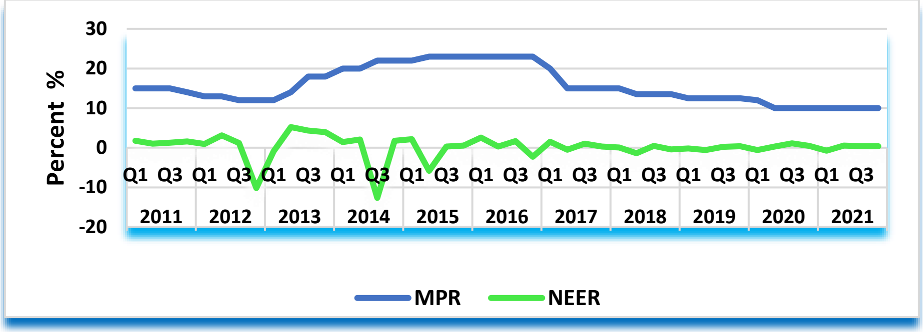
Figure 3: Monetary policy rate and Broad Money, 2011-2021



Note: MPR denotes Monetary Policy Rate whilst M2 denotes Broad Money.

Figure 4, which shows the trend in the monetary policy rate and Nominal Effective Exchange rate, indicates that both variables generally trended in opposite directions except for Q4:2012, Q3:2014, and Q2:2015 due to government pronouncement on the exchange rate (executive directive). In general, the nominal effective exchange rate is somewhat stable in the long run.

Figure 4: Monetary policy rate and Nominal Effective Exchange rate, 2011-2021



Note: MPR denotes Monetary Policy Rate whilst NEER denotes Nominal Effective Exchange Rate.

4.0 FRAMEWORK AND METHODOLOGY

4.1 Framework

The macro-econometric model that we adopt in this study, known as the Bayesian Dynamic Stochastic General Equilibrium (DSGE) model, is a small, dynamic, and open-economy representation of an economy within the context of a linearized New Keynesian model. We employ the Bayesian DSGE to analyse the response of monetary policy to productivity and demand shocks in The Gambia. The model is very apt because of the following reasons: First, it is built on a microeconomic foundation which is good for obtaining reliable results from calibration. Second, it can avoid the Lucas critique and allows priors to be set for various parameters (Hara et al., 2006). Furthermore, in principle, the model can identify sources of fluctuations, provide information about structural changes, forecast and predict the effect of policy changes, and perform counterfactual experiments (Coletti and Murchison, 2002). Macroeconometricians and Macroeconomists cannot deny the fact that DSGE models have come to stay and will remain central to Macroeconomic thought and policy (Christiano et. al, 2018).

The Bayesian DSGE model takes into account the optimization problems of the three main economic agents namely the household, the firm, and the government (herein represented by the Central Bank). Under this model, it is assumed that households maximize utility, taking the paths of real wage and real interest rate as given (Romer, 2012). Firms, which are owned by the households, on the other hand, maximizes the present discounted value of their profits subject to constraints on their price-setting (which vary across the different versions of the DSGE model). Finally, as per the model, the central bank (specifically, the Central Bank of The Gambia) determines the path of real interest rate through its conduct of monetary policy (Romer, 2012).

Thus, the optimization problem of the three main economic agents within the context of our Bayesian DSGE model is presented as follows:

4.1.1 The Household

The optimization problem of the household consequently leads to an Euler equation specified in the linear form:

$$x_t = E_t(x_{t+1}) - \{r_t - E_t(p_{t+1}) - g_t\} \quad (1)$$

where x_t is the output gap (modelled as an unobserved control variable), $E_t(x_{t+1})$ is the future expected output gap, r_t is the Monetary Policy Rate (which is modelled as an observed control variable), $E_t(p_{t+1})$ is the future expected inflation and g_t is a first-order autoregressive state variable.

4.1.2 The Firm

The optimization problem of firms generates what has come to be known in the literature as the Philips Curve equation. This equation links the current deviation of inflation from its steady state to the expected value of the deviation of inflation from its steady state in the future and to the ratio of actual output to the natural level of output. Thus, the Phillips Curve equation is specified linearly as:

$$p_t = \beta E_t(p_{t+1}) + \kappa x_t \quad (2a)$$

where β is the discount factor, which captures households' willingness to delay consumption, p_t is current inflation (which is modelled as an observed control variable and proxied by the Consumer Price Index), and the parameter, κ , measure the impact of the output gap on p_t. Equation (2a) implies that firms' pricing decisions are influenced by expected inflation and real marginal costs (here represented by the output gap).

The Gambia is a small open economy and under the assumptions of backward-looking price-setting firms and interest rate smoothing, Equation (2a) is modified as:

$$p_t = \rho_p Lp_t + (1-\rho_p)[\beta E_t(p_{t+1}) + \kappa x_t + \phi es_t] \tag{2b}$$

where Lp_t is defined as p_{t-1} (which is one period's lag of inflation), and es_t is the exchange rate (a measure of economic openness). The exchange rate is defined as the Nominal Effective Exchange Rate (NEER). The parameter, ρ_p, measures the effect of one period's lag of inflation on current inflation (i.e. inflation inertia), whilst the parameter, ϕ, captures the effect of exchange rate on current inflation (i.e. the exchange rate pass-through effect).

4.1.3 The Central Bank (i.e. Central Bank of The Gambia)

The Central Bank of The Gambia's policy response to inflation and exogenous shocks in ensuring price and exchange rate stability is represented by the interest rate equation, also known as the Taylor rule equation. The central bank adjusts the interest rate (also known as the Monetary Policy Rate or the Prime Rate) in response to inflation deviation from the target and other exogenous shocks. The interest rate equation or the Taylor rule equation is specified as:

$$r_t = \frac{1}{\beta} p_t + u_t \tag{3a}$$

where r_t is the short nominal Monetary Policy Rate (MPR) and u_t is a state variable that captures all movements in the interest rate that are not driven by inflation. Also, it is worth noting that u_t is the first-order autoregressive state variable and the parameter, $\frac{1}{\beta}$, measures the effect of inflation on MPR.

Building on the work of Woodford (2003) by assuming interest rate smoothing, Equation (3a) is modified as:

$$r_t = \rho_r Lr_t + \frac{1-\rho_r}{\beta} p_t + u_t \tag{3b}$$

where Lr_t is defined as r_{t-1} (which is one period's lag of Monetary Policy Rate), the parameters, ρ_r and $\frac{1-\rho_r}{\beta}$, are the Monetary Policy Rate (MPR) inertia and interest rate smoothing terms respectively. Specifically, the parameter, ρ_r, measures the effect of a period's lag of MPR on the current level of MPR, whilst the parameter, $\frac{1-\rho_r}{\beta}$, measures the effect of inflation on MPR. u_t in Equation (3b) is as previously defined in Equation (3a).

It is worth noting that all the variables of the linearized DSGE equations [i.e. Equations (1), (2a), (2b), (3a), and (3b)] are in logarithms.

4.1.4 Structural Shocks

The last set of equations of the Bayesian DSGE model describes the evolution of the state variables u_t, g_t, and es_t respectively. These equations are relevant because they constitute the stochastic components of the DSGE model. Specifically, they capture the dynamic effects of three shocks namely monetary policy shock (u_t), productivity shock (g_t), and demand shock (es_t). These structural shock equations are specified as first-order autoregressive processes in logarithmic forms as follows:

$$u_{t+1} = \rho_u u_t + \epsilon_{t+1} \quad (4a)$$

$$g_{t+1} = \rho_g g_t + \xi_{t+1} \quad (4b)$$

$$es_{t+1} = \rho_{es} es_t + v_{t+1} \quad (4c)$$

Equations (4a), (4b), and (4c) are the monetary policy shock, productivity shock, and demand shock equations respectively. The stochastic terms of Equations (4a), (4b), and (4c) are ϵ_{t+1}, ξ_{t+1}, and v_{t+1} respectively.

4.2 Estimation Technique

The estimation technique that we employ is the Bayesian approach to estimating a DSGE model. The technique uses the Markov Chain Monte Carlo (MCMC) method with the number of iterations measured by an MCMC size of 40, 000 draws. The technique also uses the Metropolis-Hastings sampling algorithm. The length of the burn-in period is set at 6, 000 with an average sample size of 71 observations for the variables. Furthermore, to analyze convergence diagnostics, the trace, histogram, autocorrelation, and density plots are employed. In addition, the block option in the Bayesian DSGE STATA command is employed to avoid the macro-econometric problem of high autocorrelation and non-stationarity among the respective distributions of the parameters.

4.3 Sources of Data, Description, and Summary Statistics

Data for the study spans from 2004 to 2021. The frequency of the data is quarterly series. Data for Consumer Price Index (CPI), Nominal Effective Exchange Rate (NEER), and Monetary Policy Rate (MPR) are obtained from the Central Bank of The Gambia. In the dataset, NEER is calculated as a weighted average of bilateral nominal exchange rates of the Dalasi against currencies of The Gambia's trading partners. Summary Statistics for the variables employed to estimate our Bayesian DSGE model are reported in Table 1.

Table 1: Summary Statistics of the Variables

Variables	Observatio ns	Mean	Std. Dev.	CV (%)	Min .	Max.
				29.5	44.1	
CPI (p_t)	70	69.55	20.49		2	113.6
Monetary Policy Rate(r_t)	71	16.63	5.45	32.8	10	34
Nominal Effective		199.6	196.9		72.6	
Exchange Rate (es_t)	72	1	8	98.7	9	768.89

Note: Authors' estimates are based on the dataset. The coefficient of Variation (CV) is computed as the ratio of standard deviation to the mean expressed as a percentage (i.e. CV $=\frac{\sigma}{\mu}$ x100, Where σ is the standard deviation and μ is the mean).

Table 1 indicates that CPI (a measure of inflation, p_t) has a mean of 69.55 with a coefficient of variation of 29.5%; Monetary Policy Rate (r_t) has a mean of 16.63 with a coefficient of variation of 32.8% and a Nominal Effective Exchange Rate (es_t) has a mean of 199.61 with a coefficient of variation of 98.7%. Thus, among our variables, Nominal Effective Exchange Rate (es_t) has the highest rate of volatility, whilst CPI (p_t)) has the lowest rate of volatility over the sample period (Table 1).

4.4 Prior Distributions of the Estimated Parameter

The priors used in the estimation of our Bayesian DSGE model are presented in Table 2. Prior distributions are determined by theory and institutional knowledge. Typically, beta (β) must lie between 0 and 1, with common values ranging between 0.90 and 0.99. Similarly, the kappa (κ) is theoretically assumed to be small and positive. The autocorrelation parameters (i.e. ρ_u, ρ_g, ρ_{es} and ρ_{sp}) must lie between -1 and 1 but are assumed to be positive and closer to 1 than to 0. Also, for stability to be maintained, the coefficient of inflation in the Taylor rule equation must lie between 0 and 1. Furthermore, the priors for estimating our Bayesian DSGE model are selected to match theoretical expectations. Table 2, therefore, highlights the priors for the parameters of our Bayesian DSGE model.

Table 2: Prior Distributions of the Estimated Parameters

Parameter	**Interpretation**	**Range**	**Nature of Distribution**	**Para(1)**	**Para(2)**
ρ_r	Interest rate smoothening parameter	(0,1)	Beta	0.70	0.30
ρ_p	Parameter measuring the effect of backward-looking price-setting behavior of firms on inflation	(0,1)	Beta	0.30	0.70
β	Discount factor	(0,1)	Beta	0.95	0.05
κ	Price adjustment parameter	(0,+∞)	Beta	0.30	0.70
ϕ	Pricing decision of the firm	(0,+∞)	Beta	0.30	0.70
ρ_u	AR(1) for monetary policy shock	(-1,1)	Beta	0.50	0.50
ρ_g	AR(1) for productivity shock	(-1,1)	Beta	0.75	0.25
ρ_{es}	AR(1) for demand shock	(-1,1)	Beta	0.50	0.50

σ_u	Standard deviation of the monetary policy shock	(0,+∞)	Inverse-gamma	0.01	0.01
σ_g	Standard deviation of the productivity shock	(0,+∞)	Inverse-gamma	0.01	0.01
σ_{es}	Standard deviation of the demand shock	(0,+∞)	Inverse-gamma	0.01	0.01

Note: Prior distributions are the theoretical assumptions of the nature of distributions of the DSGE parameters. They play an important role in the estimation of DSGE models in that they might down-weigh regions of the parameter space that are at odds with observations not contained in the estimation sample. The prior distribution might also add curvature to a likelihood function that is (nearly) flat in some dimensions of the parameter space and therefore strongly influence the shape of the posterior distribution. In principle, priors can be deduced from personal introspection to reflect strongly held beliefs about the validity of economic theories. However, in practice, most priors are chosen based on some observations (See An and Schorfheide, 2007).

5.0 RESULTS AND DISCUSSION

We first run some convergence diagnostics to ascertain whether or not our Bayesian DSGE parameters suffer from non-stationarity and autocorrelation. To achieve this, we run a convergence test for parameters without blocks and parameters with blocks. Our diagnostics results generally indicate that parameters without block have a trace that is not mean-reverting and also has autocorrelations that do not seem to decline over the various time lags (see Appendix A). Furthermore, for parameters without block, the first and second halves of the distribution are non-symmetric with the overall distribution (see Appendix A). Conversely, our convergence diagnostics results indicate that for parameters with block, the trace is mean-reverting, autocorrelations decline as the time lag increases and the first and second halves of the distribution are symmetric with the overall distribution (see Appendix A). This suggests that the estimated parameters with a block (see Table 3) do not suffer from non-stationarity, autocorrelation, and non-normality of their respective distributions.

On the other hand, we construct prior and posterior density graphs of the parameters to ascertain if our dataset is informative or not. The construct reveals that the density graphs for the prior and the posterior do not overlap each other (see Appendix D). This suggests that our dataset is indeed very informative.

The posterior means of the parameters indicate that the effects of monetary policy shock (ρ_u) are 44.4% and 25.8% respectively for the closed and open economy cases respectively (see Table 3). This implies that the degree of persistence of monetary policy shock in the closed economy case is higher than that of the open economy case, which is consistent with the findings by Owusu-Afriyie et al. (2022). Although varies from our findings, this result can also be compared to Mickelsson (2009), which finds that interest rate shocks exert higher and quicker effects on output and employment in an open economy than in a closed economy. Similarly, Table 3 indicates that the degree of persistence of productivity shock (ρ_g)in the closed economy case (68.6%) is higher than that of the open economy case (68.0%). Our finding is consistent with the assertion by Owusu-Afriyie et al. (2022) that exogenous shocks in a closed economy do not defuse to other economies and thus, has a longer-lasting effect on the domestic economy compared to the case where the economy is opened to the rest of the world. Again, our finding can be compared to Mickelsson (2009), which finds that shocks in interest rate, inflation, technology, and consumption have higher and quicker effects on output and employment in an open economy than in a closed economy. The policy implication of this finding is that longer-term monetary policy measures are more suitable to curb the effects of monetary policy and productivity shocks in a closed economy than in an open economy.

Table 3: Estimated Parameters of the Close Economy and Open Economy Models (Parameters with Block)

	Closed Economy Model		Open Economy Model With an Interest Rate Smoothing Term	
Parameters	***Mean***	***95% Cred. Interval***	***Mean***	***95% Cred. Interval***
β	0.930	[0.862, 0.976]	0.932	[0.862, 0.977]
1/ β	1.076	[1.025, 1.160]	----	----
K	0.035	[0.021, 0.053]	0.171	[0.122, 0.229]
ρ_r	----	----	0.373	[0.300, 0.448]
(1-ρ_r)/β	----	----	0.673	[0.588, 0.767]
ρ_p	----	----	0.221	[0.157, 0.292]
ϕ	----	----	0.418	[0.338, 0.500]
ρ_u	0.444	[0.370, 0.521]	0.258	[0.198, 0.325]
ρ_g	0.686	[0.590, 0.781]	0.680	[0.581, 0.775]
ρ_{es}	----	----	0.476	[0.384, 0.564]
$\sigma_{e.u}$	26.475	[22.427, 31.422]	29.242	[24.611, 34.845]
$\sigma_{e.g}$	18.437	[9.207, 32.026]	4.128	[2.349, 6.728]
$\sigma_{e.es}$	----	----	27.451	[23.231, 32.79]

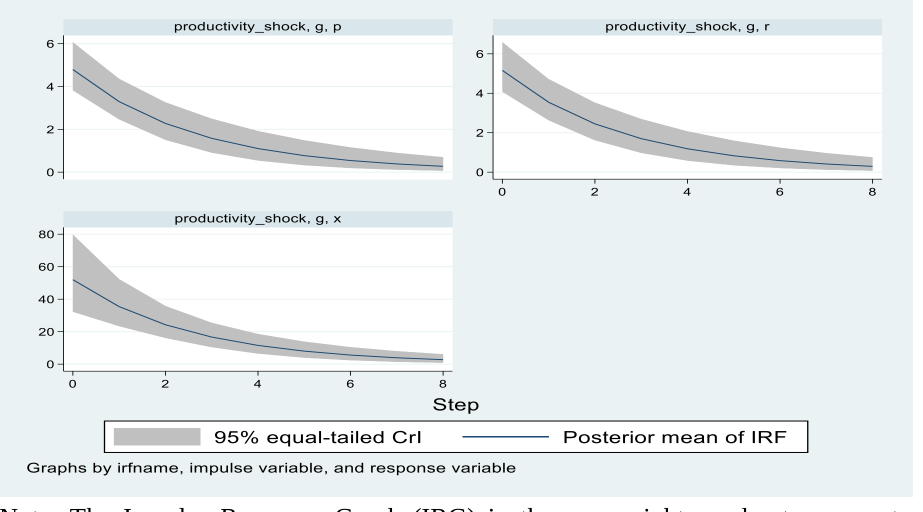
Note: MCMC Size is 40, 000 with a burn-in length of 6000. ---- indicates the absence of a parameter in the model.

Furthermore, our results indicate that the degree of persistence of demand or exchange rate shock (ρ_{es}) is 47.6% (Table 3). This suggests that the effect of productivity shock (68.0%) in The Gambia is the most persistent, followed by demand shock (47.6%) and lastly, monetary policy shock (25.8%). The high value of the persistence parameter of productivity shock indicates that supply shocks have a lasting impact on the economy of The Gambia. This has implications for monetary policy in terms of choosing between output and price stability.

5.1 Response of Monetary Policy Rate (MPR) to Productivity and Demand Shocks Under Closed Economy Gambia

Under the assumption that the economy of The Gambia has characteristics similar to that of a closed economy, the response of MPR to productivity shock is transient in that MPR decreases as the lead lags increase and reaches its steady state value in the eighth quarter (Figure 5). This response is triggered by the transient and monotonic effect of productivity shock on output gap and prices (see Figure 5). MPR responds positively to changes in prices caused by shocks in productivity, which in the long run stabilizes inflation. It is worth noting that under a closed economy assumption, a productivity shock to output gap has a direct effect on prices without an exchange rate-pass-through effect. This makes the effect of the shock quicker and faster in the closed economy scenario than in the open economy scenario.

Figure 5: Response of MPR to Productivity Shock (Closed Economy Gambia)

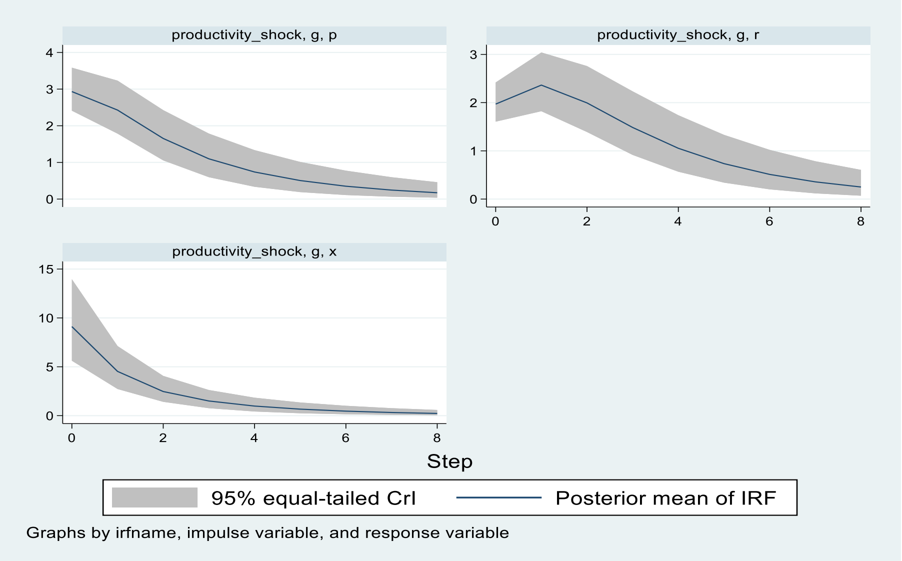


Note: The Impulse Response Graph (IRG) in the upper-right quadrant represents percentage deviations in Monetary Policy Rate (MPR) due to Cholesky one standard deviation shock to productivity, whilst the IRG in the upper-left quadrant represents percentage deviations in inflation due to Cholesky one standard deviation shock to productivity. The IRG in the lower-left quadrant represents percentage deviations in the output gap due to Cholesky's one standard deviation shock to productivity.

5.2 Response of Monetary Policy Rate (MPR) to Productivity and Demand Shocks Under Open Economy Gambia

On the contrary, under the open economy scenario (which depicts The Gambia's reality), the response of MPR to productivity shock is somewhat persistent (Figure 6). Specifically, MPR increases in the first quarter in response to productivity shock but begins to decline monotonically after the 1st quarter. However, MPR does not eventually decline to its steady state (Figure 6). In terms of shock transmission, productivity shock causes a change in output gap (x), which impacts prices (p). Thus, in response to this shock, it may be desirable to decrease MPR in the first quarter and thereafter, increase MPR to stabilize prices (Figure 6).

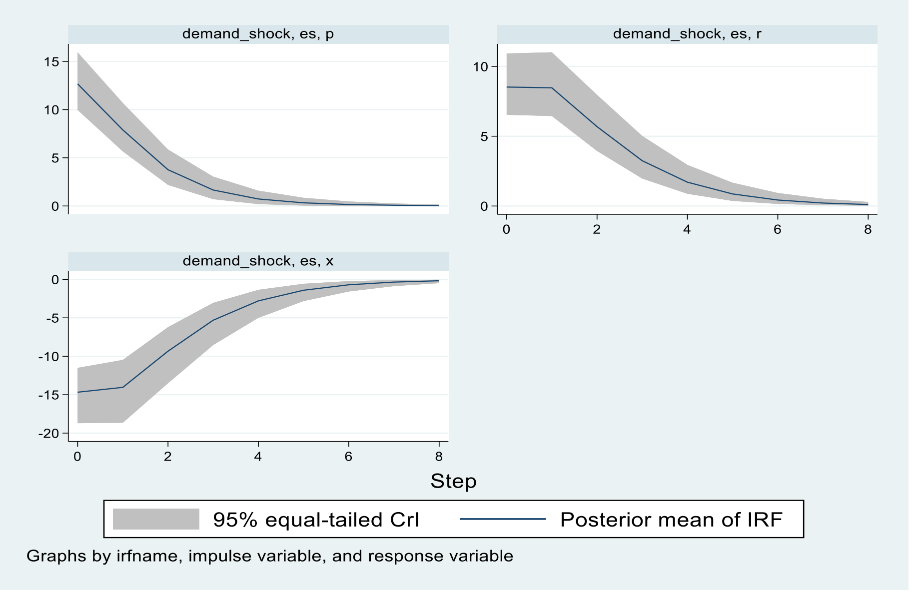
Figure 6: Response of MPR to Productivity Shock (Open Economy Gambia)



Note: The Impulse Response Graph (IRG) in the upper-right quadrant represents percentage deviations in Monetary Policy Rate (MPR) due to Cholesky one standard deviation shock to productivity, whilst the IRG in the upper-left quadrant represents percentage deviations in inflation (i.e. the general price level) due to Cholesky one standard deviation shock to productivity. The IRG in the lower-left quadrant represents percentage deviations in the output gap due to Cholesky one standard deviation shock to productivity.

The response of MPR to demand shock is that it is non-monotonic and transient (see Figure 7). Specifically, MPR increases a quarter after a demand shock but begins to decline thereafter. The decline in MPR continues to the 8th quarter, where the shock approximately dies out (see Table 5C in Appendix C). This is because if a demand shock (a positive shock as depicted by Figure 7) leads to rising prices, MPR must rise initially to offset inflationary pressures. This may equally keep the real interest rate positive to avert a decline in savings to support investment. In effect, aggregate demand is stabilized and hence, prices.

Figure 7: Response of MPR to Demand Shock (Under Open Economy Gambia)

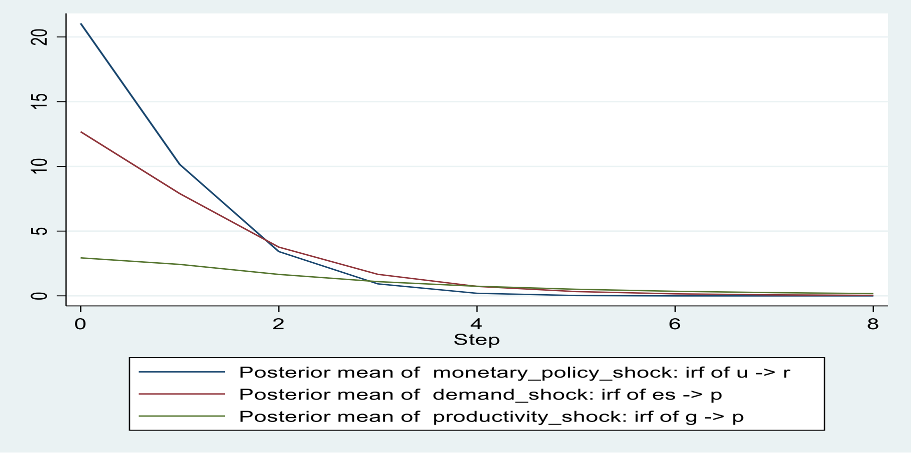


Note: The Impulse Response Graph (IRG) in the upper-right quadrant represents percentage deviations in Monetary Policy Rate (MPR) due to Cholesky one standard deviation shock to exchange rate, whilst the IRG in the upper-left quadrant represents percentage deviations in inflation (i.e. the general price level) due to Cholesky one standard deviation shock to exchange rate. The IRG in the lower-left quadrant represents percentage deviations in the output gap due to Cholesky one standard deviation shock to the exchange rate.

In relative terms, we find that MPR's response to productivity shock is more persistent in open economy Gambia than closed economy Gambia (see Tables 2C and 4C in Appendix C). This finding is consistent with the assertion by Owusu-Afriyie et al. (2022) that productivity shock in an open economy does not only affect consumption and investment components of aggregate demand but net export as well. The effect on net export also has a second-round effect on the exchange rate and a third-round effect on interest rates and capital flows. Hence, productivity shock tends to be more persistent in an open economy than in a closed economy.

Finally, in Figure 8, we compare MPR's responses to demand and productivity shocks respectively by using the posterior means of demand and productivity shocks (i.e. open economy scenario). The response of MPR to both demand and productivity shocks dies out in the 8th quarter (see Figure 8). This indicates that MPR's response to both demand and productivity shocks is transient in the open economy of Gambia. This could be explained by the reason that productivity and demand shocks may have a short time to work itself out through the economy, possibly due to the small size of the Gambian economy. This finding is consistent with the finding by Bondzie, Fosu, and Obu-Cann (2013) that productivity shock results in a temporary shrinkage in the final goods sectors due to the reallocation of labour from the final and intermediate goods sectors. The implication of the transient nature of the responses of MPR to both demand and productivity shocks could be attributed to the fact that the dynamic process in both the financial and goods markets through which monetary impulses are transmitted appears to be very fast in both markets.

Figure 8: Response of MPR to Productivity and Demand Shocks (Under Open Economy Gambia)



Note: The green Impulse Response Graph (IRG) represents percentage deviations in Monetary Policy Rate (MPR) due to Cholesky one standard deviation shock to productivity, whilst the red IRG represents percentage deviations in MPR due to Cholesky one standard deviation shock to exchange rate. The blue IRG represents percentage deviations in MPR due to Cholesky one standard deviation shock to MPR.

6.0 CONCLUSION AND POLICY IMPLICATIONS

Our study seeks to analyze the response of the Monetary Policy Rate (MPR) to productivity and demand shocks in The Gambia using a Bayesian Dynamic Stochastic General Equilibrium (DSGE) model. Particularly, our study seeks to analyze the response of MPR to productivity and demand shocks under two scenarios. The first scenario is when the economy of The Gambia is assumed to be that of a closed economy, whilst the second scenario is when it is an open economy, which depicts the reality.

Data for the analysis are obtained from the Central Bank of The Gambia. The frequency of the data is quarterly, which spans from 2004 to 2021. The study finds that in a small open economy known as The Gambia, demand and productivity impulses influence monetary policy in the short term. Specifically, we find that MPR's response to productivity shock is more persistent in open-economy Gambia than in closed-economy Gambia. This finding is consistent with Mickelsson (2009). We also find that MPR's response to both demand and productivity shocks is transient in the open economy of Gambia. Hence, we conclude that monetary policy should not respond to productivity and demand shocks in The Gambia.

Overall, we suggest to the Central Bank of The Gambia based on our findings that there should be no deliberate monetary policy response to demand and productivity shocks, since the shocks are very transient in nature and thus, their effects will die out in the short run.

REFERENCES

An, S. & Schorfheide, F. (2007). Bayesian Analysis of DSGE Models, Econometric Reviews, 26 (2-4), 113-172.

Baqaee, D., Farhi, E., & Sangani, K. (2021). The Supply-Side Effects of Monetary Policy. National Bureau of Economic Research No. w28345.

Beyer, A., Nicoletti, G., Papadopoulou, Niki & Papsdorf, R (2017, p17). The Transmission Channel of Monetary, Macro-and Microprudential Policies and their Interrelation. Occasional paper series, European Central Bank (ECB).

Bernanke, B. S., & Gertler, M. (1995). Inside the Black Box: The Credit Channel of Monetary Policy Transmission. Journal of Economic Perspectives, 9(4), 27-48.

Bondzie, E.A., Fosu, G.O. & Obu-Cann, E. (2013). Technological Shocks Mechanism on Macroeconomic Variables: A Dynamic Stochastic General Equilibrium Approach, MPRA Paper No. 69286,1-11.

Brinca, P., Duarte, J. B., & Castro, M. F. (2020). Measuring Sectoral Supply and Demand Shocks During COVID-19. Federal Reserve Bank of St. Louis, Research Division.

Caballero, R. J., & Simsek, A. (2022). A Note on Temporary Supply Shocks with Aggregate Demand Inertia. National Bureau of Economic Research No. w29815.

Christiano, L. J., Eichenbaum, M. S., & Trabandt, M. (2018). On DSGE Models. Journal of Economic Perspectives, 32(3), 113-40.

Coletti, D., & Murchison, S. (2002). Models in Policy-Making. Bank of Canada Review, 2002 (Spring), 19-26.

De Prabir and Neogi, C. (2011). Global Financial Crisis: Implications for Trade and Industrial Restructuring in India, Asian Development Bank Institute (ADBI) Working PaperSeries, No. 294 (July).

del Rio-Chanona, R. M., Mealy, P., Pichler, A., Lafond, F., & Farmer, J. D. (2020). Supply and Demand Shocks in the COVID-19 Pandemic: An Industry and Occupation Perspective. Oxford Review of Economic Policy, 36(Supplement_1), S94-S137.

Engle, R.F and Granger, C.W.J (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing, Vol. 55, No. 2.

Englewood, C. (1961), Money and Credit, Their Influence on Jobs, Prices and Growth. New Jersey, Publisher: N.-J.

Handa, J. (2000), Monetary Economics, Routledge.

Hara, N., Hirakata, N., Inomata, Y., Ito, S., Kawamoto, T., Kurozumi, T., & Takagawa, I. (2006). The New Estimates of Output Gap and Potential Growth Rate. Bank of Japan Review Series No. 2006-E-3.

Jallow, M.O (2021) The Transmission of Monetary Policy Shocks to Major Economic Sectors in The Gambia: Evidence from an SVAR. International Journal of Economics, Commerce and Management, Vol. IX, No. 12, pp. 178-194.

Kilian, L. (2006). Understanding the Effects of Exogenous Oil Supply Shocks. CESifo Forum, Vol. 7, No. 2, pp. 21-27.

Komma, M.(2014). What is the appropriate Monetary Policy regime for The Gambia? Diplomová práce. Univerzita Karlova, Fakulta sociálních věd, Institut ekonomických studií. Vedoucí práce Holub, Tomáš.

Mankiw, N. G., & Reis, R. (2018). Friedman's presidential address in the evolution of macroeconomic thought. Journal of Economic Perspectives, 32(1), 81-96.

Mickelsson, G. (2009). Monetary Policy in Closed and Open Economies. Unpublished Masters Thesis, Department of Economics, Uppsala University.

Mishkin, F. S. (1995). Symposium on the Monetary Transmission Mechanism. Journal of Economic Perspectives, 9(4), 3-10.

Mishkin, F. S. (2001). The Transmission Mechanism and the Role of Asset Prices in Monetary Policy. NBER Working Paper No. 8617.

Mishkin, F. S. (2006). How Big a Problem Is Too Big to Fail? A Review of Gary Stern and Ron Feldman's Too Big to Fail: The Hazards of Bank Bailouts. Journal of Economic Literature, 44(4), 988-1004.

Mishra, P., Montiel, P. J., & Spilimbergo, A. (2011). How Effective Is Monetary Transmission in Developing Countries? A Survey of the Empirical Evidence.

Mishra, P., Montiel, P., Pedroni, P., & Spilimbergo, A. (2014). Monetary Policy and Bank Lending Rates in Low-Income Countries: Heterogeneous Panel Estimates. Journal of Development Economics, 111(C), 117-131.

Mustapha, and Kouassi (2016). Exchange Rate Pass-Through and Consumer Prices: Empirical Evidence From The Gambia. International Journal of Economics, Commerce, and Management, Vol. 4, No.11, pp. 16-25.

Ncube, M. (n.d). Financial Systems and Monetary Policy in Africa, Working Paper No. 20, Graduate School of Business Administration, University of the Witwatersrand.

Owusu-Afriyie, J., Owusu-Afriyie, E. and Ayambire, A.F. (2022). Analysis of Monetary Policy Response to Productivity and Demand Shocks in Ghana: A Bayesian DSGE Approach. West African Economic Review, Vol. 22, No. 1, pp. 201-242.

Romer, D. (2012). Advanced Macroeconomics, 4e. New York: McGraw-Hill.

Snowdon, B., & Vane, H. R. (2005). Modern Macroeconomics: Its Origin, Development, and Current State. Edward Elgar Cheltenham, UK • Northampton, MA, USA.

Sriram, S.S. (2009). The Gambia: Demand for Broad Money and Implications for Monetary Policy Conduct. IMF Working paper No. WP/09/192.

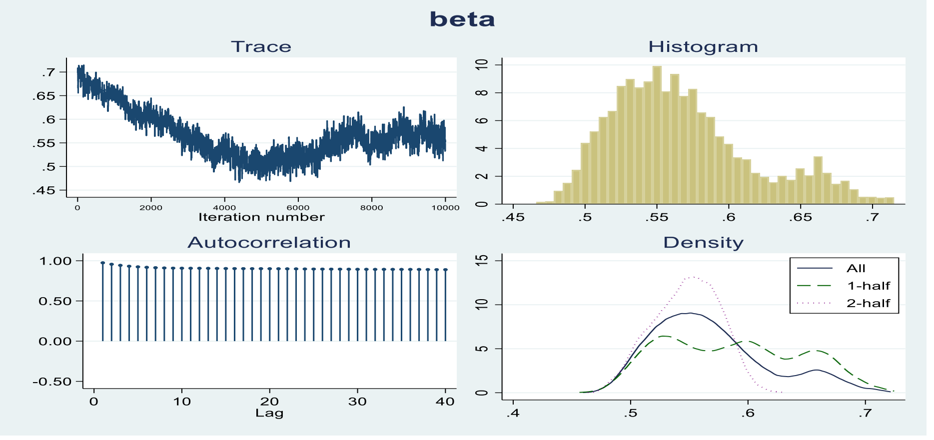
WAMI (2016). The Developmental Role of Central Banks in the West African Monetary Zone, Occasional paper series No. 11.

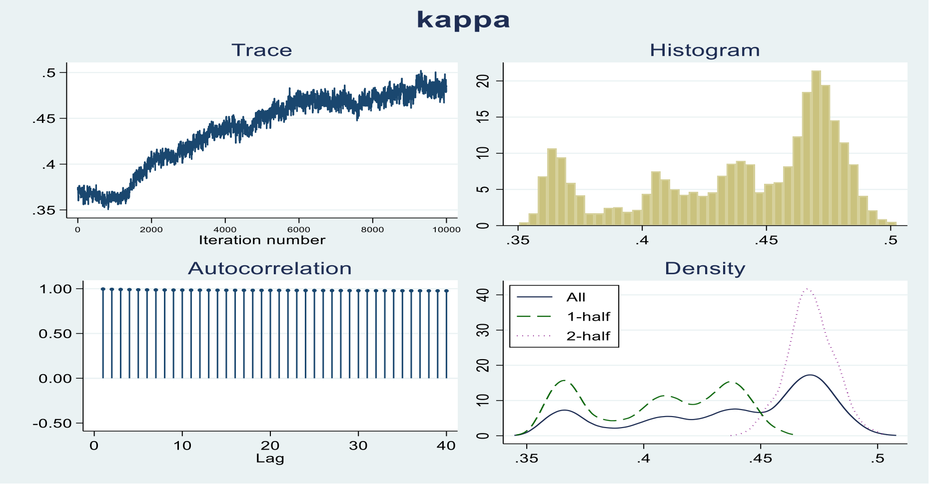
Woodford. M. (2003). Interest and Prices: Foundations of a Theory of Monetary Policy. Princeton University Press, Princeton, and Oxford.

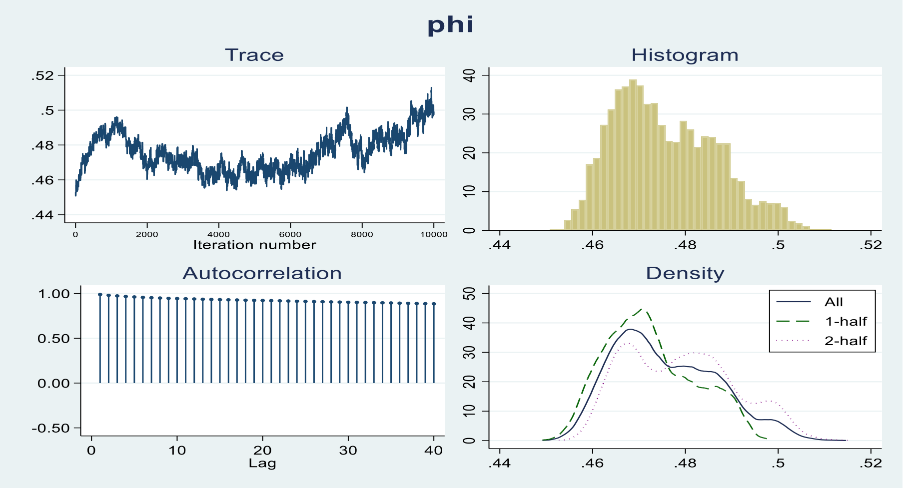
APPENDIX A
(CONVERGENCE DIAGNOSTICS)

1. Open Economy with Interest Rate Smoothing Model

A. *Convergence Diagnostics for Parameters without Block*



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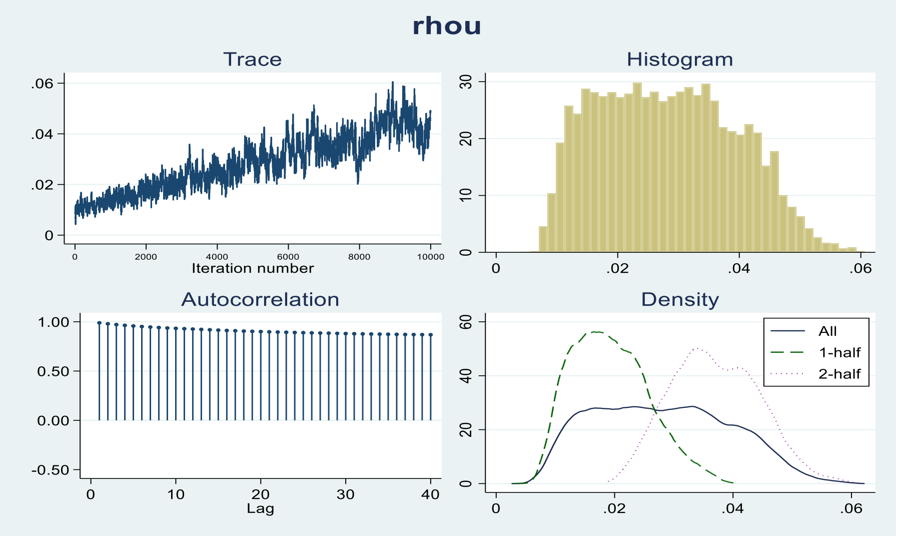
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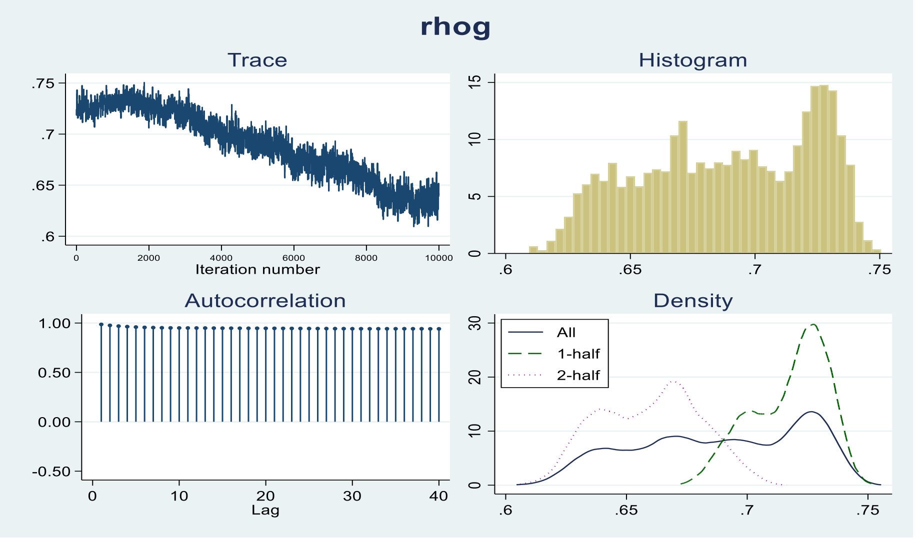
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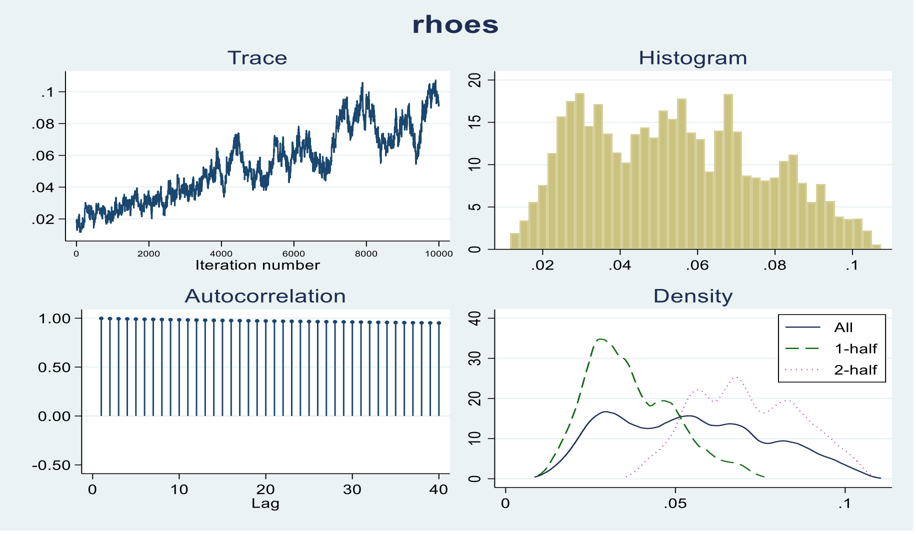
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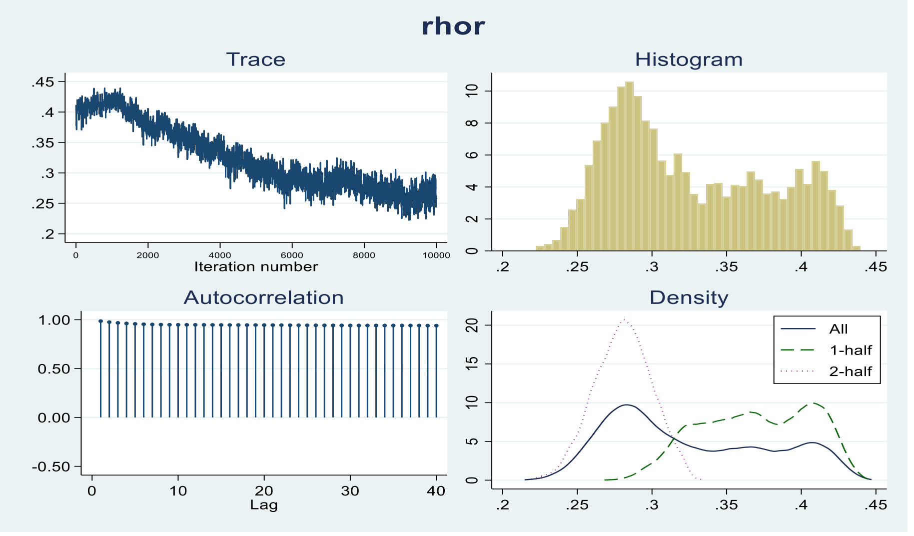
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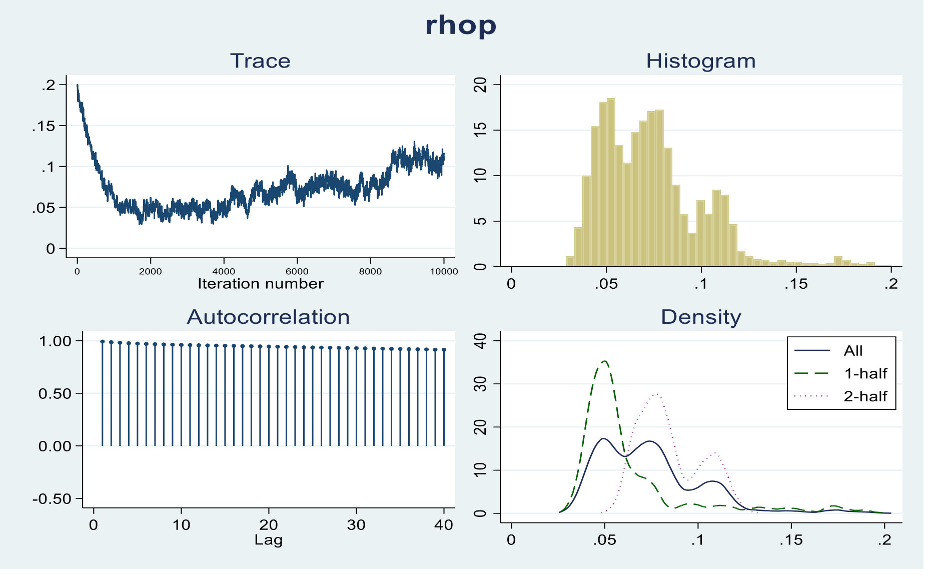
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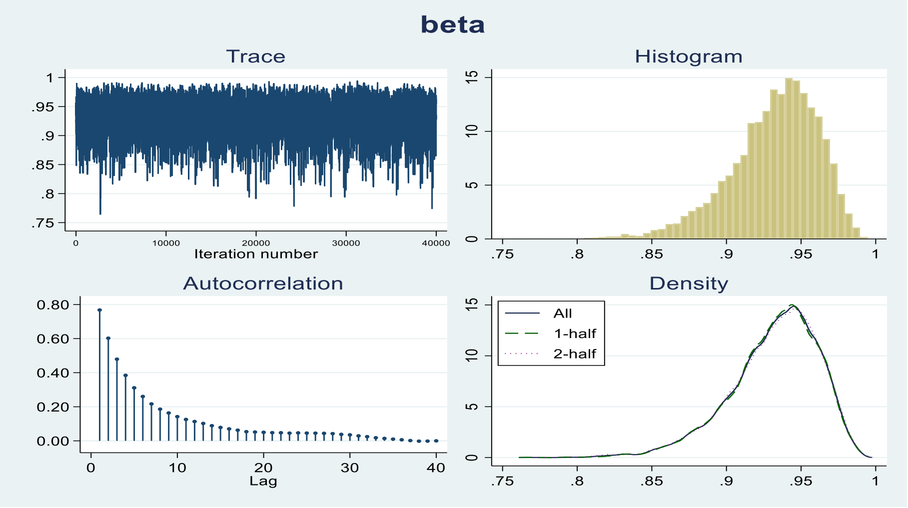
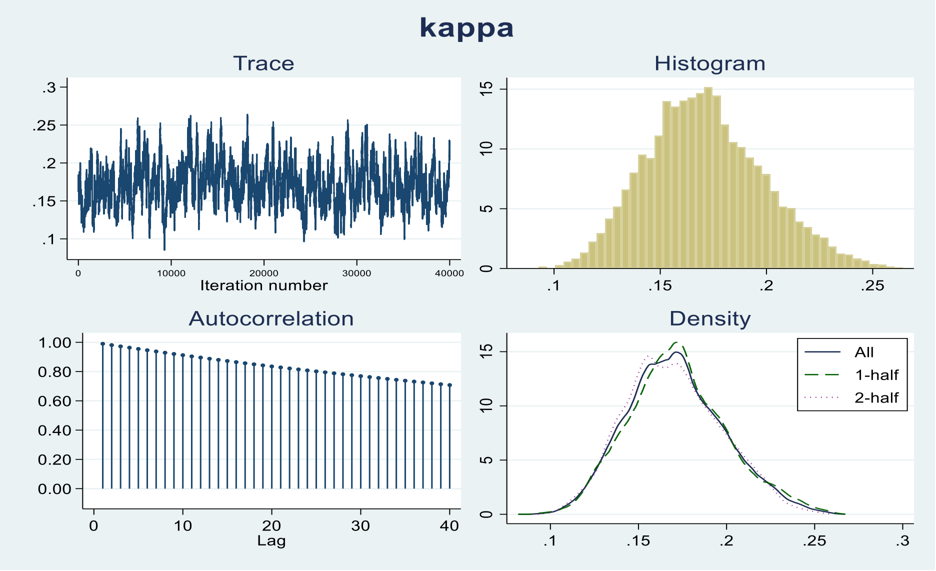
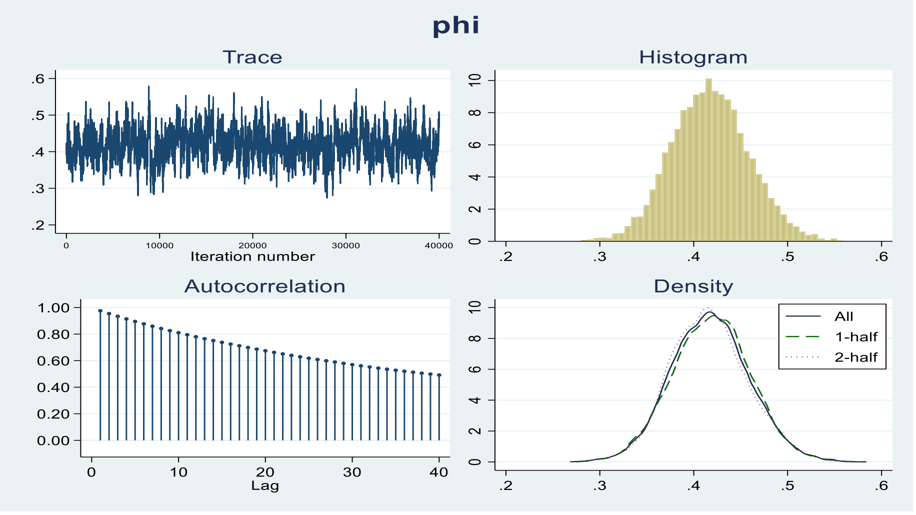
B. Convergence Diagnostics for Parameters with Block



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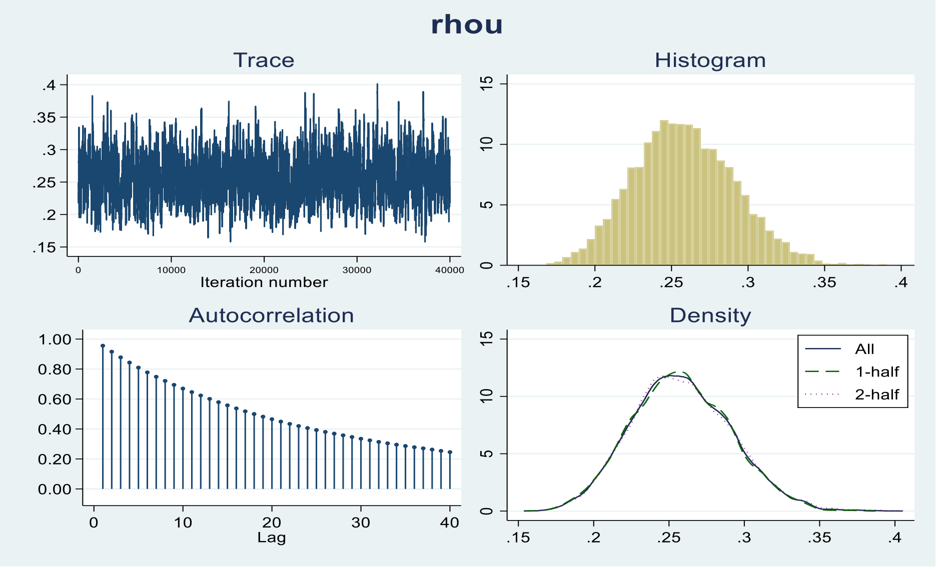
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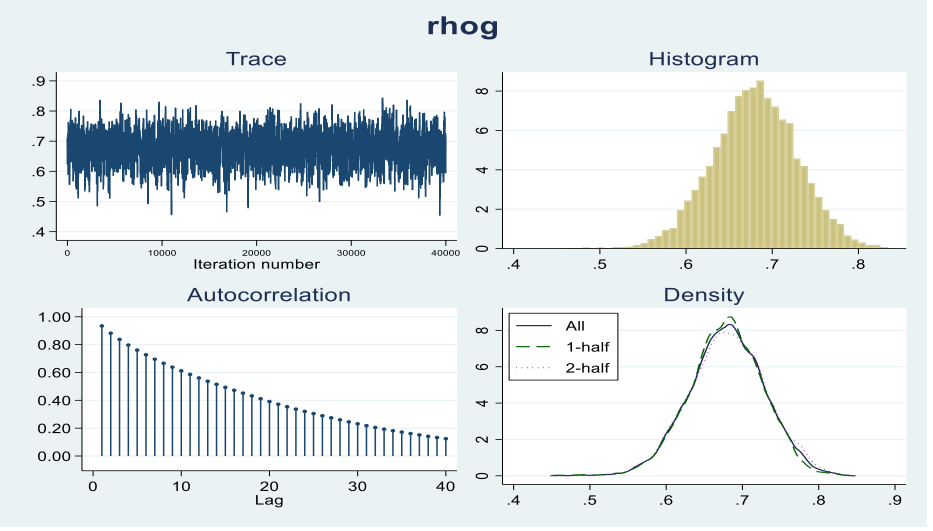
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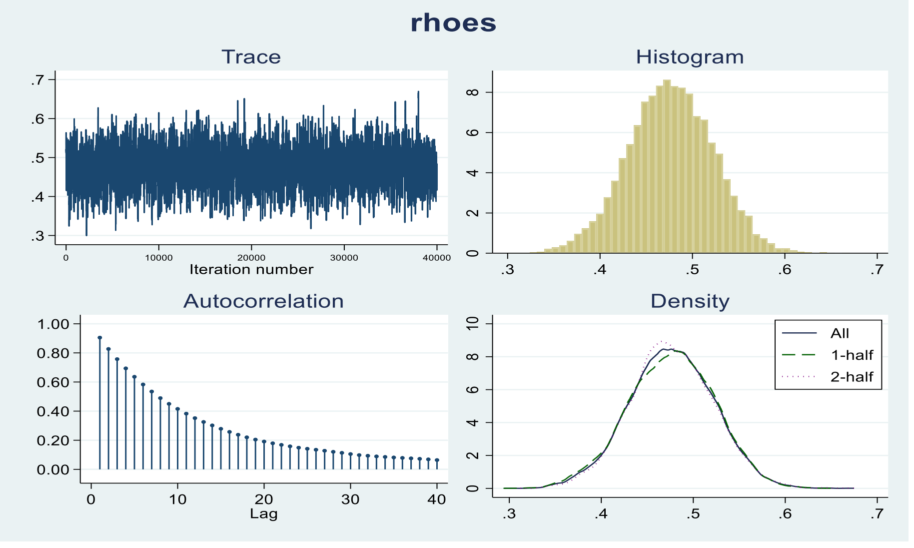
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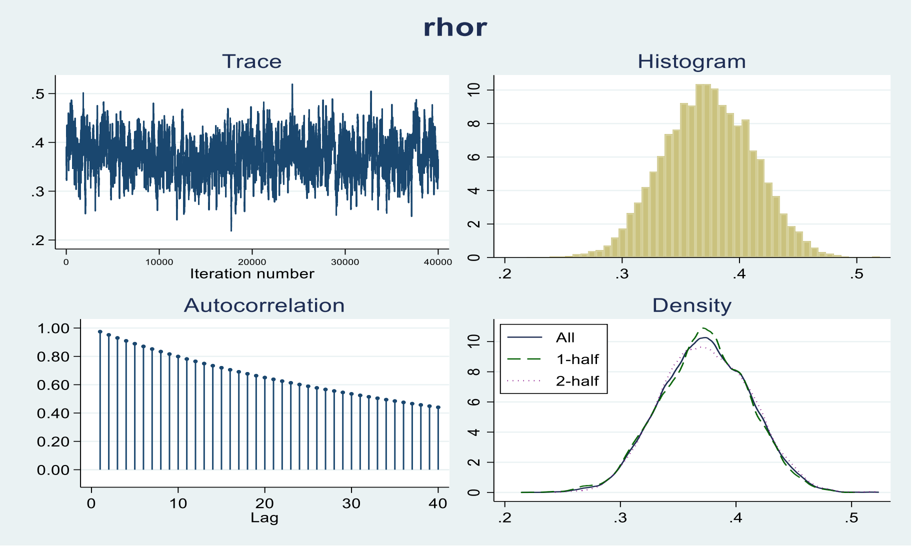
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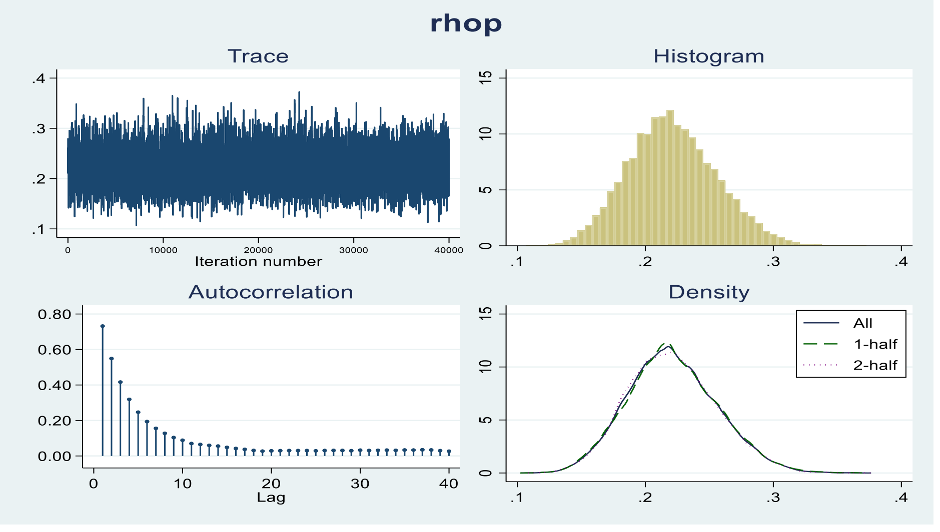
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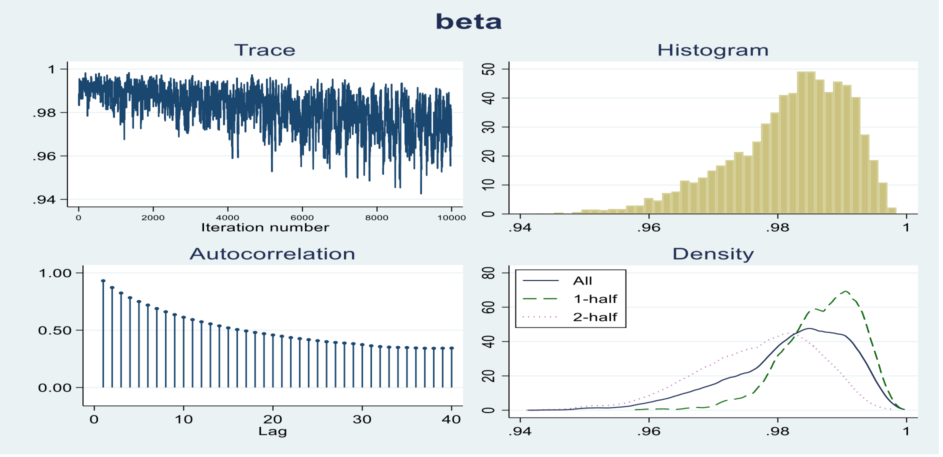
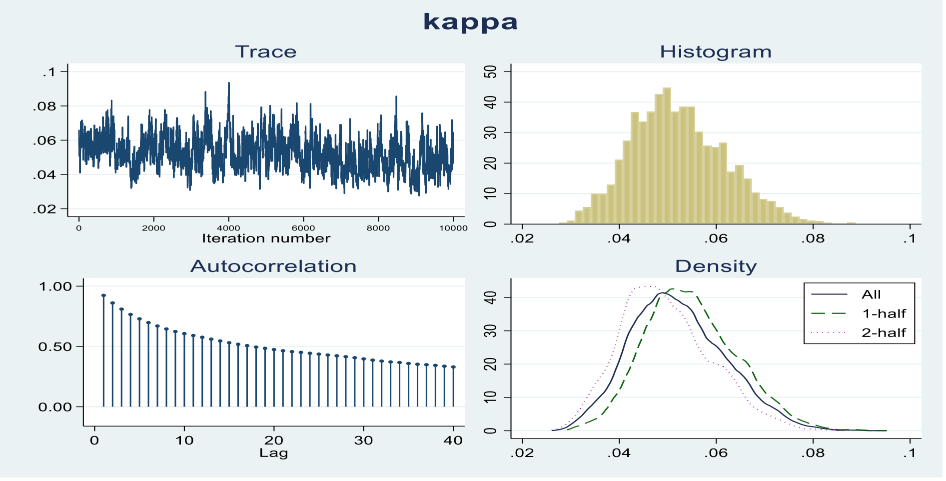
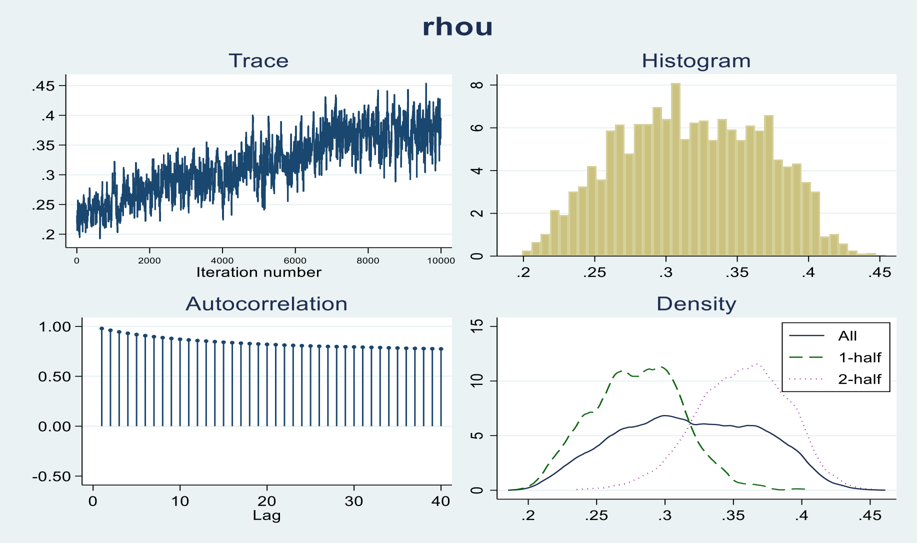
2. Closed Economy Model Without Interest Rate Smoothing

A. Convergence Diagnostics for Parameters without Block



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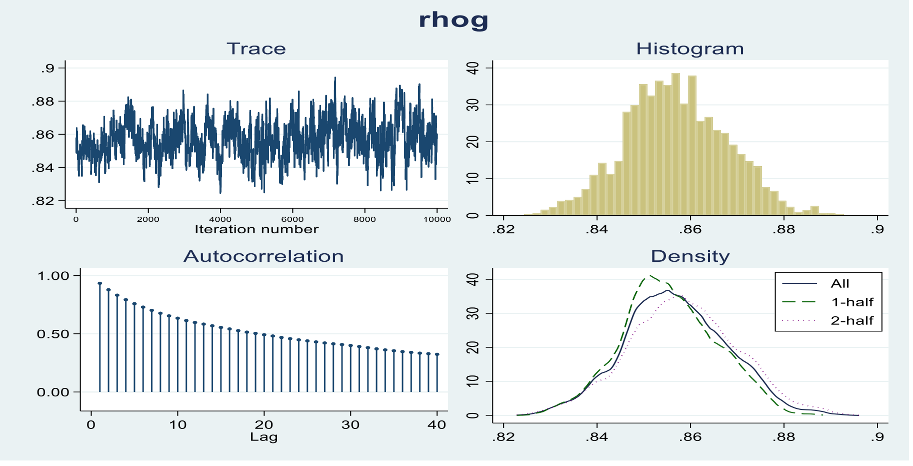
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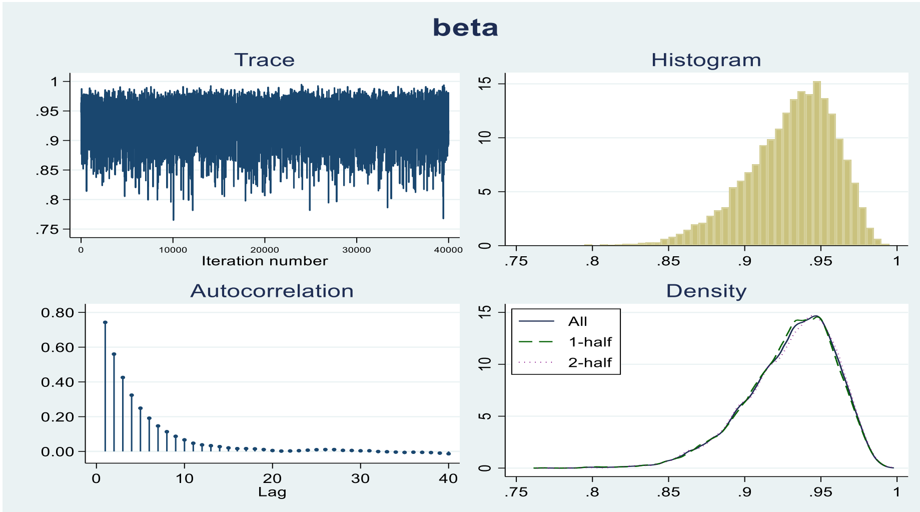
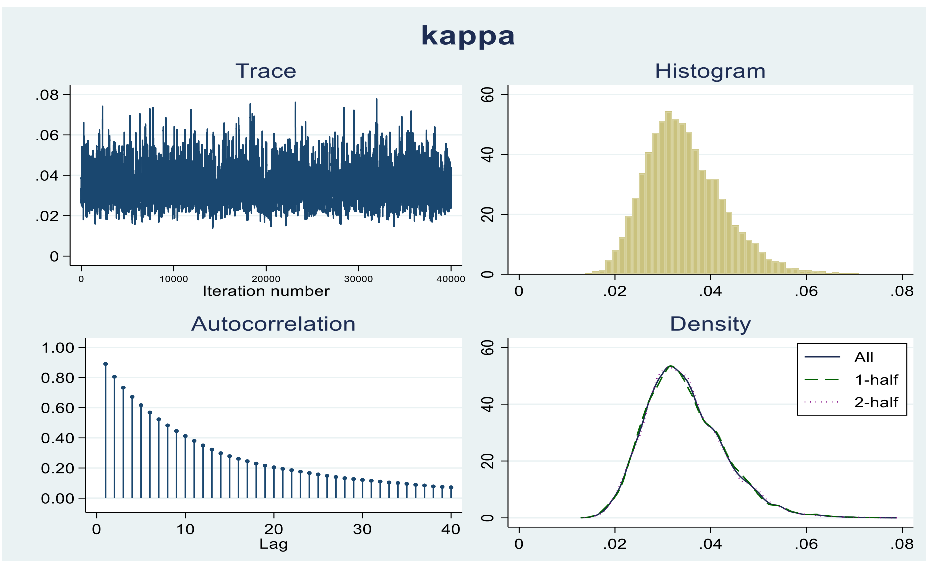
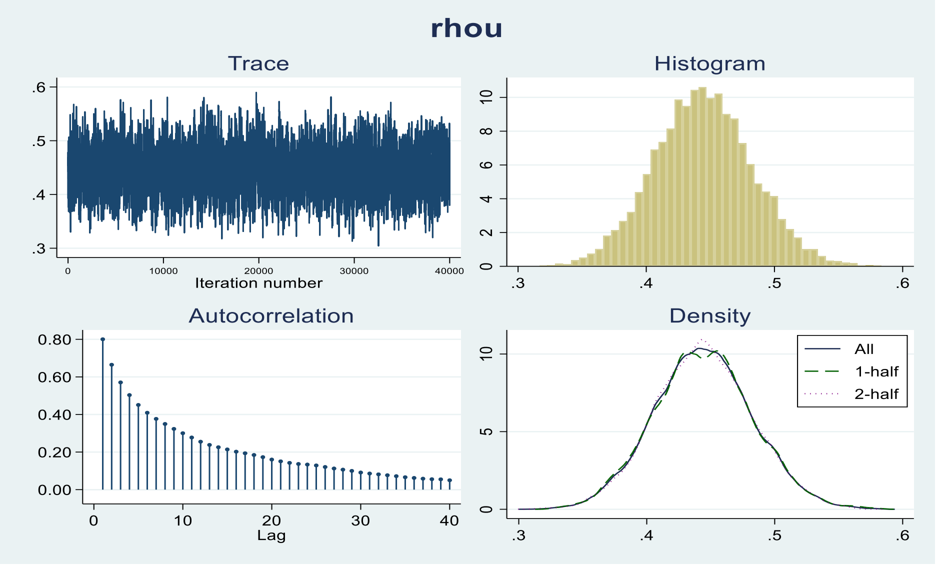
B. Convergence Diagnostics for Parameters with Block



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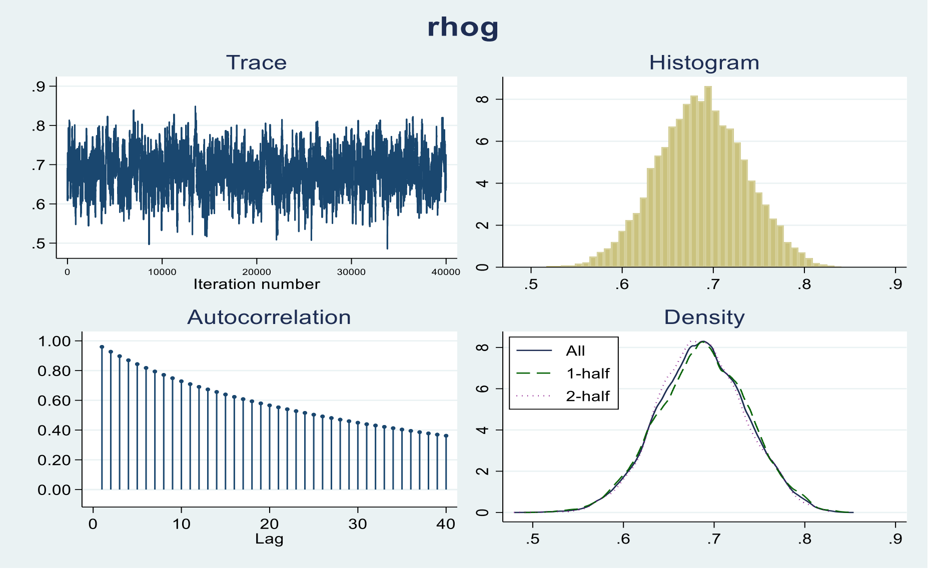
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APPENDIX B
(EFFICIENCY SUMMARIES)

Table 1B: Efficiency Summaries for the Estimated Parameters of the Closed Economy Model

	Without Block		**With Block**	
Parameters	***ESS***	***Efficiency***	***ESS***	***Efficiency***
β	30.45	0.0030	5509.07	0.1377
κ	68.38	0.0068	1357.36	0.0339
ρ_u	14.01	0.0014	1664.58	0.0416
ρ_g	129.64	0.0130	367.23	0.0092
$\sigma_{e.u}$	11.65	0.0012	8474.54	0.2119
$\sigma_{e.g}$	11.47	0.0011	317.03	0.0079

Note: MCMC Size is 10, 000 with a burn-in length of 2,500 for the model without block, whilst MCMC Size is 40, 000 with a burn-in length of 6,000 for the model with block. The average efficiency for the model without a block is 0.004427 but 0.07371 for the model with a block.

Table 2B: Efficiency Summaries for the Estimated Parameters of the Open Economy Model

	Without Block		**With Block**	
Parameters	***ESS***	***Efficiency***	***ESS***	***Efficiency***
β	12.50	0.0013	3742.85	0.0936
κ	10.87	0.0011	186.11	0.0047
ρ_r	11.20	0.0011	334.13	0.0084
ρ_p	14.36	0.0014	4268.45	0.1067
ϕ	14.54	0.0015	307.52	0.0077
ρ_u	12.46	0.0012	703.01	0.0176
ρ_g	11.17	0.0011	1066.87	0.0267
ρ_{es}	12.44	0.0012	1490.80	0.0373
$\sigma_{e.u}$	10.84	0.0011	4399.28	0.1100

$\sigma_{e.g}$	10.88	0.0011	397.34	0.0099
$\sigma_{e.es}$	10.88	0.0011	6809.26	0.1702

Note: MCMC Size is 10, 000 with a burn-in length of 2,500 for the model without block, whilst MCMC Size is 40, 000 with a burn-in length of 6,000 for the model with block. The average efficiency for the model without a block is 0.001201 but 0.05388 for the model with a block.

APPENDIX C
(IMPULSE RESPONSE FUNCTION TABLES)

A. Close Economy Case

Table 1C: Impulse Response Table for MPR Response to its Shock

	(1)	(1)	(1)
Step	irf	Lower	Upper
0	23.661	19.897	28.221
1	10.526	7.995	13.515
2	4.718	3.027	6.843
3	2.130	1.128	3.518
4	0.969	0.419	1.824
5	0.444	0.156	0.950
6	0.205	0.058	0.495
7	0.095	0.021	0.258
8	0.044	0.008	0.134

Note: irf represents the posterior means, whilst Lower and Upper represent 95% equal-tailed credible lower and upper bounds respectively.

Table 2C: Impulse Response Table for MPR Response to Productivity Shock

Step	(1) irf	(1) Lower	(1) Upper
0	5.158	4.076	6.590
1	3.545	2.630	4.721
2	2.449	1.616	3.525
3	1.700	0.975	2.696
4	1.185	0.581	2.071
5	0.831	0.345	1.600
6	0.585	0.205	1.243
7	0.414	0.121	0.965
8	0.294	0.072	0.753

Note: irf represents the posterior means, whilst Lower and Upper represent 95% equal-tailed credible lower and upper bounds respectively.

B. Open Economy Case

Table 3C: Impulse Response Table for MPR Response to its Shock

Step	(1) irf	(1) Lower	(1) Upper
0	8.526	6.536	10.930
1	8.473	6.447	11.016
2	5.689	3.944	7.966
3	3.245	1.965	5.021
4	1.708	0.876	2.946
5	0.864	0.365	1.668
6	0.430	0.147	0.933
7	0.213	0.058	0.522
8	0.106	0.022	0.291

Note: irf represents the posterior means, whilst Lower and Upper represent 95% equal-tailed credible lower and upper bounds respectively.

Table 4C: Impulse Response Table for MPR Response to Productivity Shock

	(1)	(1)	(1)
Step	irf	Lower	Upper
0	0.824	0.686	1.000
1	1.220	1.020	1.472
2	1.281	1.064	1.556
3	1.186	0.968	1.461
4	1.037	0.820	1.310
5	0.883	0.665	1.153
6	0.742	0.528	1.006
7	0.620	0.413	0.878
8	0.517	0.322	0.766

Note: irf represents the posterior means, whilst Lower and Upper represent 95% equal-tailed credible lower and upper bounds respectively.

Table 5C: Impulse Response Table for MPR Response to Demand Shock

	(1)	(1)	(1)
Step	irf	Lower	Upper
0	8.526	6.536	10.930
1	8.473	6.447	11.016
2	5.689	3.944	7.966
3	3.245	1.965	5.021
4	1.708	0.876	2.946
5	0.864	0.365	1.668

6 |	0.430	0.147	0.933
7 |	0.213	0.058	0.522
8 |	0.106	0.022	0.291

Note: irf represents the posterior means, whilst Lower and Upper represent 95% equal-tailed credible lower and upper bounds respectively.

APPENDIX D
(PRIOR AND POSTERIOR DENSITY GRAPH OF THE PARAMETERS)

A. Closed Economy Case

Figure 1D: Density of Beta

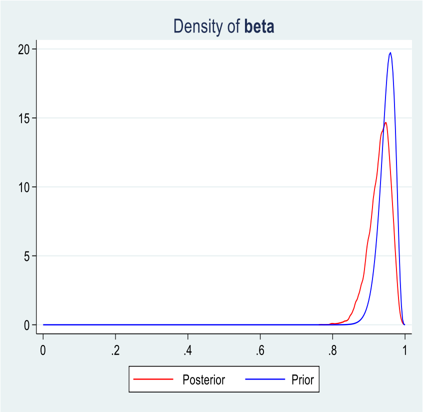


Figure 2D: Density of kappa

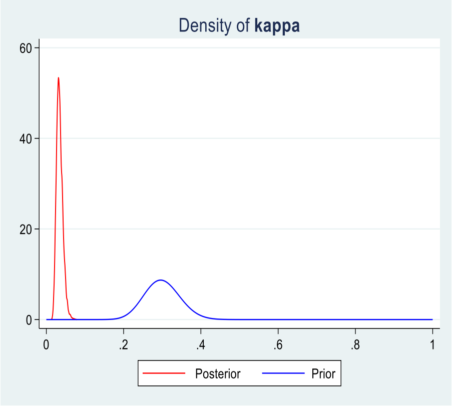
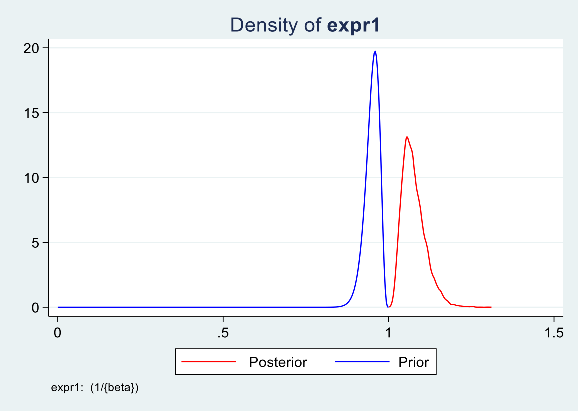


Figure 3D: Density of Inverse Beta



B. Open Economy Case

Figure 4D: Density of Beta

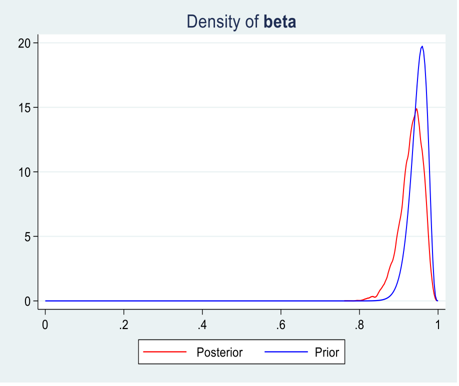


Figure 5D: Density of kappa

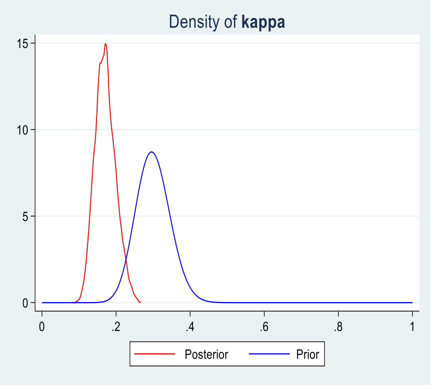


Figure 6D: Density of Rhor

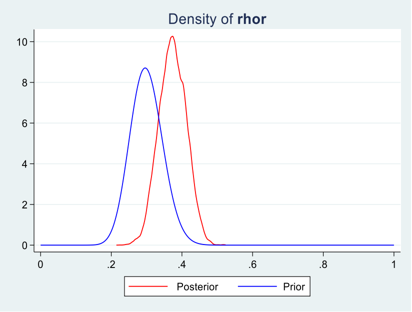


Figure 7D: Density of Rhop

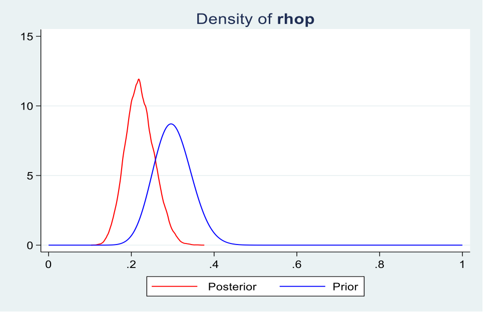


Figure 8D: Density of Phi

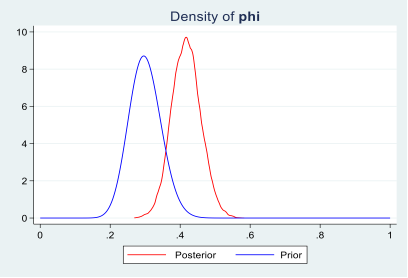


Figure 9D: Density of Rhou

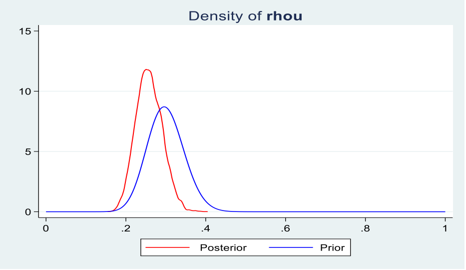


Figure 10D: Density of rhog

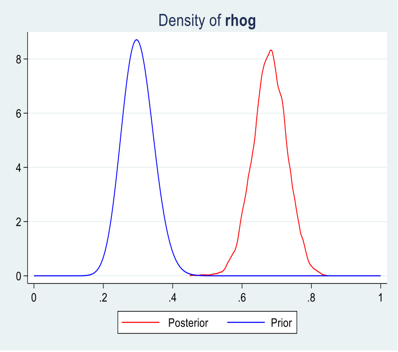
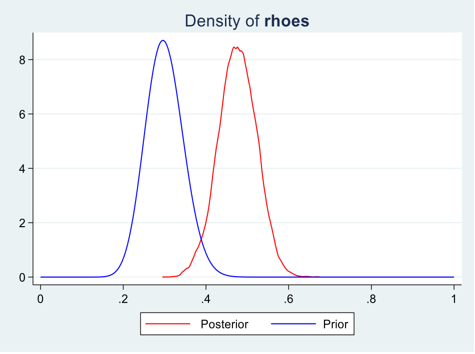


Figure 11D: Density of rhoes



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ISSN 0263-0699