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Monetary Policy and Output-inflation Volatility Interaction in Nigeria: Evidence from Bivariate GARCH-M Model

Onyukwu E. Onyukwu (corresponding author)
Department of Economics, University of Nigeria, Nsukka,
Enugu State, Nigeria
Tel: +234-8034741642 E-mail: oonyukwu@yahoo.com

Emmanuel O. Nwosu
Department of Economics, University of Nigeria, Nsukka
Enugu State, Nigeria
E-mail: emmanuel.nwosu@unn.edu.ng

Diejomaoh Ito
African Institute for Applied Economics
54 Nza Street, Independence Layout, Enugu, Nigeria
E-mail: idiejomaoh@aiaenigeria.org

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Abstract

This article reports on a recent study that applies bivariate GARCH methodology to investigate the existence of a tradeoff between output growth and inflation variability in Nigeria and to ascertain the impact of monetary policy regime changes (from direct control regime to indirect or market based regime) on the nature of the volatility tradeoffs. Investigations reveal the existence of a short run tradeoff relationship between output growth and inflation within and across both regimes. However, no strong evidence of long run volatility relationship could be established. Our results further reveal that regime changes affected the magnitude of policy effects on output and inflation. Monetary policy had a stronger effect on output growth than on price stability during the period of direct control while it has a much larger impact on inflation during the current period of market-based regime. Also volatility of output and inflation became more persistent during the period of indirect control.

Keywords: Monetary Policy, Output-Inflation Volatility, Bivariate GARCH-M Model

1. Introduction and Background to the Study

Over the past four decades, economists and policy makers have shown considerable interest in understanding causes of macroeconomic volatility and how to reduce it. Conceptually, macroeconomic instability refers to conditions in which the domestic macroeconomic environment is less predictable. It is of concern because unpredictability hampers resource allocation decisions, investment, and growth. This article focuses on the volatility interaction of the growth rate of output and the levels of inflation rates. Changes in the behavior of these endogenous variables usually reflect changes in the macroeconomic policy environment as well as external shocks.

Both Okonjo-Iweala & Phillip (2006) and Baltini (2004) have described the Nigerian macroeconomic environment as one of the most volatile among emerging markets. Among emerging market economies, Nigeria exhibits the highest inflation and exchange rate variability, the lowest output volatility, and an interest rate volatility that is slightly smaller than that of South Africa and much smaller than that of Brazil, but slightly larger than that of Chile (Baltini 2004).

Nigeria offers unique opportunity to the study of output-inflation volatility interaction and its relationship with monetary policy. This is due to the fact that monetary policy conduct in Nigeria has witnessed two alternative regimes since the mid-1970s, the direct control regime and indirect or market-based regime with different relative weights attached to output growth and price stability objectives.

1.1 Statement of the Problem

This study evaluates the effect of monetary policy regime changes, by estimating a bivariate GARCH-M model of output and, thus examines the nature of output-inflation variability trade-off as well as volatility persistence which are of major interest in macroeconomic policy debates. Our study further ascertains the efficacy of monetary policy regime change from direct to indirect approaches (Note 1) in reducing macroeconomic volatility, particularly in the light of the Taylor curve tradeoff hypothesis. Thus, our basic research objectives are:

- To ascertain if there is evidence of output-inflation volatility trade-off in Nigeria;
- To investigate if a change in monetary policy regime affects the nature of output growth-inflation volatility tradeoff.
- To ascertain how monetary policy shocks affect inflation and output growth variability dynamics.

What is remaining of this article has been organized into three sections. Section two is devoted to an overview of relevant theoretical framework and methodology of analysis. Section three presents and discusses the results of our analyses. Section four summarizes the study findings and makes some policy recommendations.

The period covered by the study is 1981 to 2007, essentially due to data availability. The study period cuts across two monetary policy regimes, thus affording us the opportunity to make sub-sample comparisons. The study uses quarterly data in the analysis in order to capture substantial variability in the variables of interest.

2. Methodology of Study

On the relationships between monetary policy, output volatility, and inflation volatility, one theory holds that the volatility of output and inflation will be smaller the stronger monetary policy reacts to inflation than output gap (Gaspar & Smets 2002) (Note 2). In this case it is customary to assume that the economy's social loss function is the sum of the variance of inflation and output. If the economy is hit by demand shocks, the central bank will never face a trade-off between output stability and inflation stability, that is, a monetary policy action that reduces output volatility is consistent with stable inflation.

However, in a more general case when the economy is hit by demand shocks as well as supply shocks, the central bank faces an inescapable tradeoff between output stability and inflation stability if it chooses, (as is commonly the case), to minimize the social loss function. Thus, monetary policy action which reduces the variance of inflation will increase the variance of output, and vice versa. These hypotheses have been jointly studied using bivariate GARCH-M class of models (Fountas et al 2002; Grier et al 2004; Lee 2002). According to Lee (2004), the GARCH approach has two major advantages over the conventional measure of volatility, such as moving standard deviations and squared residual terms in vector autoregression (VAR) models. The first advantage is that conditional volatility, as compared to unconditional volatility, better represents perceived uncertainty which is of particular interest to policy makers. The second advantage is that the GARCH model offers insights into the hypothesized volatility relationship in both the short run and the long run. Whereas time-varying conditional variances reveal volatility dynamics in the short run, the model also generates a long run measure of the output-inflation covariance that will be helpful in evaluating monetary policy tradeoffs. These inform the use of bivariate GARCH model in this study.

2.1 Our Empirical Models

Following Fountas et al. (2002), Grier et al. (2004) and Lee (2002) we use a bivariate GARCH model to simultaneously estimate the conditional variances and covariance of inflation and output growth in order to address our first and second research questions. We employ the following bivariate VAR (p) model for estimating the conditional means of output and inflation:

$$X_t = \Phi_0 + \sum_{i=1}^{p} \Phi_{1i} X_{t-i} + \Phi_{2j} \sum_{j=1}^{p} Y_{t-j} + \varepsilon_t \ldots\ldots\ldots\ldots 1.1$$

where $\varepsilon_t / \Omega_t \sim N(0, H_t)$ and Ω is information set available up to time t - 1

such that $H_t = (h_{yt}, h_{\pi t})'$

$\Phi_0 = [\Phi_{yo}, \Phi_{\pi 0}]'$ is a 2x1 vector of constants

$X_t = [y_t, \pi_t]'$ is a 2 x 1 vector of real output growth y_t and inflation rate π_t.

Y_t is a vector of additional explanatory variables such as inflation uncertainty, etc

Φ_{1i}, Φ_{2j} are vectors of 2x2 matrices of parameters to be estimated.

$\varepsilon_t = [\varepsilon_{yt}, \varepsilon_{\pi t}]'$ is a 2x1 vector of output and inflation innovations.

The vector of conditional variances of output and inflation are specified as follows:

$$H_t = C_0' C_0 + A' H_{t-1} A + B' \varepsilon_{t-1} \varepsilon_{t-1}' B + D' F_{t-1} D \ldots\ldots\ldots\ldots 1.2$$

where $H_t = (h_{yt}, h_{\pi t})'$ is a 2x1 vector of the conditional variances of output and inflation,

C, A, B, and D are 2x2 upper triangular matrices of parameters, and F is a vector of explanatory variables,

that is, F = (ΔMPR, ΔOilprices, etc).

More explicitly the matrice of parameters can be specified in upper triangular form as:

$$C_0 = \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix}; A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}; B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}; \text{and } D = \begin{bmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \delta_{22} \end{bmatrix}.$$

2.2 Economic Meaning of Coefficients and Apriori Expectations

The diagonal elements in matrix C_o represent the means of conditional variances of output growth and inflation, while the off diagonal element represents their covariance. The Parameters in matrix A depict the extents to which the current levels of conditional variances are correlated with their past levels. In specific terms, the diagonal elements (a_{11} and a_{22}) reflect the levels of persistence in the conditional variances; a_{12} captures the extent to which the conditional variance of output is correlated with the lagged conditional variance of inflation. For the existence of output-inflation volatility trade-off, the variable is expected to have negative sign and be statistically significant. The parameters in matrix B reveal the extents to which the conditional variances of inflation and output are correlated with past squared innovations; b_{12} depicts how the conditional variance of output is correlated with the past innovation of inflation. This measures the existence of cross-effect from an output shock to inflation volatility. In order to estimate the impact of monetary policy on the conditional variances, we include one period lagged change in the Central Bank's monetary policy rate (MPR) (or VAR-based generated monetary surprises) in the vector F. The resulting coefficients in matrix D measure the effects of these variables on inflation and output volatility. For monetary policy to have a trade-off on the conditional variances, the diagonal elements have to alternate in signs.

In order to address the third research question we augment the VAR model specified in (1) by adding monetary policy variable in the vector X and then compute the generalized impulse responses and generalized variance decompositions to analyse the short run dynamic response of output growth and inflation monetary policy shocks/innovations. The generalized variance decomposition and impulse response functions are unique solution and invariant to the ordering of the variables in the VAR (Pesaran & Shin 1998). Also, it has been argued, however, that in the short run unrestricted VARs perform better than a cointegrating VAR. For example, Naka & Tufte (1997) studied the performance of VECMs and unrestricted VARs for impulse response analysis over the short-run and found that the performance of the two methods is nearly identical. We adopt unrestricted VARs in attempting to answer our third research question because of the short-term nature of the variance decomposition and impulse response analysis. AIC and SBC will be used for lag order selection.

2.3 Method of Estimation and Data Sources

The models are estimated by the method of Broyden, Fletcher, Goldferb and Shanno (BFGS) simplex algorithm. We employed the RATS software in the estimation of the system. This is due to the fact that RATS has an inbuilt bivariate GARCH system that supports simultaneous estimation and thus is able to implement different restrictions that might be assumed on the variance-covariance structure of the system.

The data used for the estimations are quarterly data from the Central Bank of Nigeria Statistical Bulletin of various years, the Annual Report and Statement of Account of various years.

Monetary Policy Measure: According to Nnanna (2001) the Minimum Rediscount Rate (MRR) is the nominal anchor, which influences the level and direction of other interest rates in the domestic money market. Its movements are generally intended to signal to market operators the monetary policy stance of the CBN. Similarly, Agu (2007) observes that "the major policy instrument for monetary policy in Nigeria is the minimum rediscount rate (MRR) of the Central Bank and notes that while both interest and inflation rates are high, a worrisome problem in the observed response to these macroeconomic imbalances is the lack of policy consistency and coherence. This could be on account of inadequate information on the nature and size of impact of the MRR on key macroeconomic aggregates." This type of inconsistency in the conduct of monetary policy is likely to increase rather than stabilize macroeconomic volatility. Hence, we shall use MRR (MPR) as a measure of monetary policy stance.

3. Presentation of Results and Discussion

Table 1 shows the summary statistics of the variables used in the study. Inflation and GDP growth rates are calculated as annualized quarterly growth rates of consumer price index (CPI) and real GDP respectively. As the table indicates, average nominal GDP was almost two times greater in 1995-2007 period compared to 1981-1994 period. But, the consumer price index for the period, 1995-2007, was almost twenty fold of that in the period, 1981-1994. For this reason average real GDP for the period 1995 to 2007 was lower than that of 1981-1994.

However, the average growth rate of real GDP was higher in the second period compared to the first; while average inflation rate for the second period was lower compared to the first period. This shows that the economy performed better on the average under market-based monetary regime compared to the controlled regime. The standard deviation of inflation is lower in the second period implying lower unconditional volatility and there is no significant change in the unconditional volatility of real GDP growth which appears to suggest that real quarterly GDP fluctuations are modest over the two periods but slightly higher in the second period. The minimum rediscount rate, a measure of monetary policy stance of the Central Bank of Nigeria (CBN) was on the average lower during the controlled regime period compared to the indirect regime period. This suggests that monetary policy became tighter during the period of indirect or market-based regime aimed specifically to control inflation by reducing the rate of money growth.

Oil prices being used to control for exogenous shocks in the model had a low average during the period of controlled regime. At that time lower oil prices affected GDP growth adversely as the economy entered into a recession that led to the introduction the Structural Adjustment Programme (SAP), which further depressed the economy. The adverse supply effect resulting from SAP and lower oil revenue together with tighter controls on interest rate helped to put a strain on the economy. During the period of indirect monetary approach, oil prices began to increase rapidly in the international market and this resulted in positive output growth for most of the period and quick recovery of the economy from the adverse effects of SAP. However, the Central Bank has been very cautious with rising oil prices and as a result has been setting the minimum rediscount rate in order to accommodate the adverse effects of the rise in oil prices on inflation.

Table 2 shows the tests for serial correlation, autoregressive conditional heteroskedasticity effect, and normality. A series of Ljung-Box (1978) tests for serial correlation suggests that there is a significant amount of serial dependence in the data. Output growth is negatively skewed, and inflation is positively skewed and output growth failed to satisfy the Jarque-Bera tests for normality (Jarque & Bera 1980). The ARCH tests also reveal the presence of first order serial dependence in the conditional variances of output growth and inflation suggesting that our application of GARCH (1, 1) model is appropriate to the data.

Valid inference from GARCH model requires that the variables be stationary, at least in their conditional means (Lee 2002). As a result, unit root tests were conducted on the variables using the Dickey & Fuller (1981) methodology. The analysis, however, was eventually based on the augmented Dickey-Fuller unit root tests. The results are presented in table 3 below.

The results show that only inflation rate is level stationary while other variables are stationary in their first differences.

Table 4 shows the results from GARCH estimations of the two sub-samples and the overall sample. The results would help to address our concerns in the first and second research questions, which are: whether or not the change in the approach to monetary policy in Nigeria from direct to indirect led to a change in volatility interactions, transmissions and tradeoff between output growth and inflation. The results are in two parts. The first part shows the estimations of the conditonal mean equation while the second part shows the time-varying conditional variance equation which is of particular interest to us.

The first part of the conditional mean and conditonal variance eqautions represents output growth while the second vector denotes inflation rate. The conditional mean for GDP growth shows that inflation volatility does affect output growth negatively and this is statistically significant across the two regimes but was highly significant during the period of indirect regime. But the effect of inflation volatility on inflation was not certain as the cofficient was neither stable nor significant across the two periods. Past levels of inflation are found to have positive effects on currrent inflation levels and this is significant across the two samples while the coefficient was almost the same across the two periods.

Oil price shocks do not have any meaningful effect on inflation but do have positive and significant effects on output growth especially in the second period. This may be due to the fact that oil price increases which characterized most of the sample period from 1995 to 2007 may have contributed positively to the output growth in Nigeria as a largely oil dependent economy. This result should not be surprising as most studies have found positive output effect of oil price shocks in major oil-exporting countries.

We are especially interested in the conditional variance equations. The estimates show that the long run or unconditional volatilities of inflation and output growth were higher in the first period than in the second period. The estimates for the mean covariance terms are negative and but significant only in the first sample period. The estimates also indicate that over the sample periods, the mean unconditional variance of output is significant across the two sample periods.

The parameters in matrix A show the extents to which the current levels of conditional variance are correlated with their past levels. The higher estimates in the second period seem to suggest that a current shock will have relatively long lasting effects on the future levels of the conditional variances of output growth and inflation than it had in the first sample period. The estimates also reveal that following change in monetary policy regime, inflation volatility and output volatility have relatively become more persistent in Nigeria.

The off-diagonal elements in A that is A (1, 2), on the other hand, reveal the extent to which the conditional variance of one variable is correlated with the lagged conditional variance of another variable. The estimate for A (1, 2) appears with the expected negative sign and is statistically different from zero for all sub-samples and the overall sample. This confirms the existence of Taylor-curve volatility tradeoff in Nigeria. Interestingly the estimate for the sample period 1981 to 1994 is relatively larger than the estimates for the sample period 1995 to 2007 suggesting that low inflation variability is now associated with higher output gap variability. This seems to suggest that CBN's efforts to stabilize prices or specifically to target low inflation must come at a heavy cost of output fluctuations. This result is therefore, consistent with the finding by Castelnuovo (2006) that the tighter the monetary policy, the higher is the inflation-output gap volatility.

The parameters in B matrix reveal the extents to which the conditional variances of inflation and output are correlated with past squared innovations (deviations from their conditional means). Of particular interest is the off-diagonal elements B (1, 2) and B (2, 1) which depict how the conditional variance of inflation is correlated with the past squared innovations of output. In the first sample period there is a positive and significant volatility cross-effect from inflation to output. While in the second period there is positive and significant volatility cross effect from output growth to inflation variability.

In order to address the third research question we computed the impulse responses and variance decompositions from the VAR specification augmented by including monetary policy variable as one of the endogenous variables in equation (1.1) and then using oil prices as exogenous variable. We computed separate impulse responses and forecast error variance decompositions for each variable for the two regime periods in order to understand how output growth and inflation respond to innovations in monetary policy over the two regimes (see Figure 1 and Table 5 in the appendix). The impulse response functions are interpreted in conjunction with the variance decompositions. For example, in the period of direct control regime, inflation responded negatively to innovations in monetary policy but the variance decompositions show that this response was not significant because monetary policy only account for a small part of the forecast error variance of inflation and this seems to remain constant in the long run. During the period of indirect regime inflation also responded negatively to innovations to monetary policy but monetary shocks accounted for larger part of its forecast error variance, which is almost twice that of the direct control period.

Real GDP growth rate responded positively to innovations in monetary policy during the direct approach. This may be due to the positive effects of low interest rates pursued during most of that period. The variance decomposition of output growth shows that monetary policy accounted for a larger part of the forecast error variance of output growth during the period of direct control regime than it accounts for inflation. This result is expected because the primary objective of monetary policy then was to achieve rapid output growth. However, inflation innovations had larger effect on output growth in both periods of monetary regimes showing that inflation volatility is very crucial in determining movements in output variance.

During the two regimes output growth responded negatively to shocks on inflation. This finding is consistent with the results in the GARCH estimations. During the period of the indirect regime output growth responded negatively to innovations to monetary policy and this shows there is existence of policy tradeoff between inflation and output growth. The pursuance of low inflation objective during the period of indirect regime does trigger off negative output reactions. The variance decomposition shows that this reaction is not significant since monetary policy shocks account for an insignificant part of forecast error variance of output growth even in the long run.

4. Summary, Policy Recommendations and Conclusion

4.1 Summary of Findings

The study on which report this article focuses investigated the existence of tradeoff relationship between output growth and inflation in Nigeria and the impact of alternative monetary policy regimes on inflation and output growth. The study findings show evidence of short-run tradeoff relationship between the variability of output growth and inflation but no evidence strong long run volatility relationship was found. The study also found that monetary policy accounted for a larger part of the forecast error variance of output growth during the period of direct control monetary policy than in the period of indirect control monetary policy. This result was expected given that the objective of monetary policy during the direct control regime was to achieve rapid and stable output growth. On the other hand, the response of inflation to monetary policy changes in the period of indirect or market-based regime was larger compared to its response during the period of direct control. Again, this result is not surprising because the major focus of monetary policy in Nigeria during the period of indirect control was to achieve low inflation.

The results of the study further reveal that the volatility of output growth and inflation during the period of market-based policy regime are more persistent compared to the period of direct controls. Evidence of volatility cross-effect from output to inflation and vice versa was present but not significant across the two sample periods. The results fail to establish clearly any evidence to suggest that monetary policy tradeoff is a long run phenomenon. From these findings, the following policy recommendations could be made.

4.2 Policy Recommendations

Market-based or indirect control approach to monetary policy conduct in Nigeria should be carefully examined regularly in order to ascertain its desirability and workability. This would help to determine when changes in monetary policy stance actually affect the variability of output and inflation and in what direction. Policy makers should be careful not to believe too fervently that the market works in Nigeria. Policy changes could trigger off more volatility than demand or supply shocks. This reflects the fact that market imperfection is very typical of developing countries with underdeveloped financial markets. In Nigeria, it is hard to believe that inflation is caused by excessive money growth or the growth of credit. Instead, inflation has been driven largely by high cost of doing business, rising cost of energy prices and depreciating exchange rate that has made the cost of imported raw materials exceedingly high. This has intensified the effect of adverse supply shocks on inflation. Again, the size of the informal and non-monetized sector of the economy is quite substantial making it possible for monetary policy to have a big impact. In such a macroeconomic environment, tightening of monetary policy in response to high inflation would exacerbate an already heated environment by increasing the cost of credit to firms that depend on borrowing as the major source of finance.

Our study reveals that volatility tradeoff is higher during the period of indirect monetary regime than during the period of direct control and that output is responding negatively to monetary shocks. This implies that the Central Bank should be very cautious of the objective of targeting low inflation as such a policy could trigger off not only low output growth but also high output growth volatility.

Finally, we suggest that monetary policy instruments be supported by other fiscal and physical measures such as ensuring that energy cost, the cost of imported raw materials and possibly the cost of housing are reduced through other improved supply-side processes. While, attention is being focus on low inflation it is also pertinent to realize that high and stable output growth objective is equally important to Nigeria as a developing economy. There should be a balance between output growth objective and low inflation. The study reveals that monetary policy objective that targets low inflation would be likely achieved at a heavy cost in terms of adverse output growth effect.

4.3 Conclusion

This study has shown that there is very little empirical evidence to suggest that monetary policy regime change necessarily alters existing inflation-output growth variability tradeoff. It could not find strong evidence of long run tradeoff between output growth and inflation, which is required in order to ascertain the effectiveness of monetary policy regime changes from that perspective. This is not altogether surprising as half of the studies undertaken on this same issue in other jurisdictions have thus far found no evidence of long run policy tradeoff (see Lee 2004 for example). However, most studies did find that volatility tradeoff changed when monetary policy regime changed, this study seems to corroborate the same findings. It is perhaps important to observe here that the availability of good quality macroeconomic data at short-time intervals like monthly or quarterly series remains a major challenge to policy-relevant research in Nigeria. However, the situation is not very much different in most other developing countries. Using extrapolated quarterly GDP data in empirical studies of this nature may influence the research outcomes since such data were econometrically generated under certain assumptions. Further research is therefore recommended in this issue in the future, particularly as high frequency and good quality data begin to be available. It would indeed be very informative to policy makers in Nigeria who are currently experimenting with the adoption of inflation targeting monetary policy regime to read this research output. It will perhaps assist them in appreciating the cost of such regime in terms of output growth volatility.

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Notes

Note 1. Other studies failed to distinguish the two periods in their analyses and thus evaluate the effectiveness of the CBN's monetary policy even over the period when monetary policy in Nigeria had overbearing political interference.

Note 2. Gaspar, Victor and Frank Smets (2002) "Monetary Policy, Price Stability and Output Gap Stabilization." International Finance, 5:2, 193-211

Figures

Impulse Response Functions

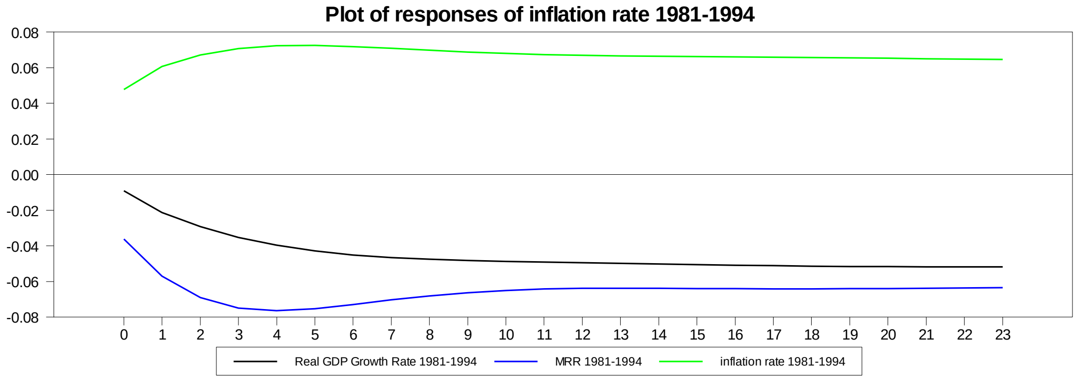

Figure 1. Plot of responses of inflation rate 1981-1994

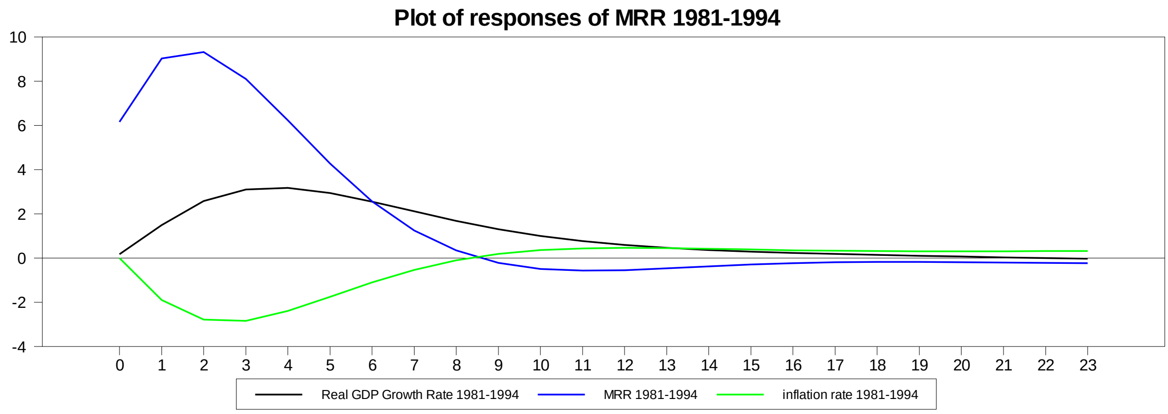

Figure 2. Plot of responses of MRR 1981-1994

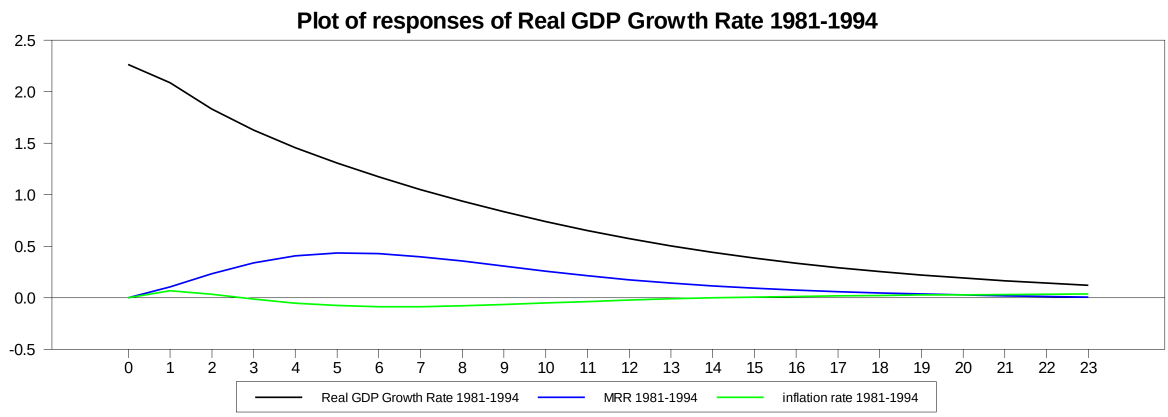

Figure 3. Plot of responses of Real GDP Growth Rate 1981-1994

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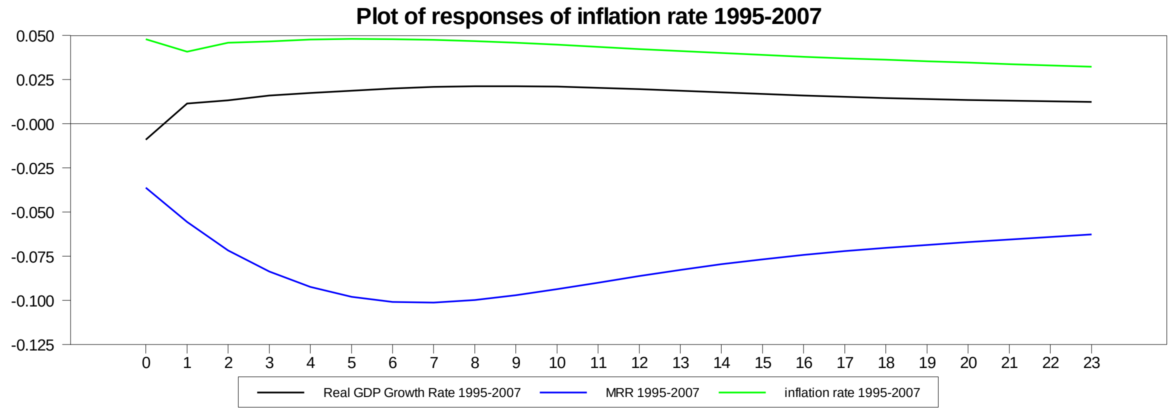

Figure 4. Plot of responses of inflation rate 1995-2007

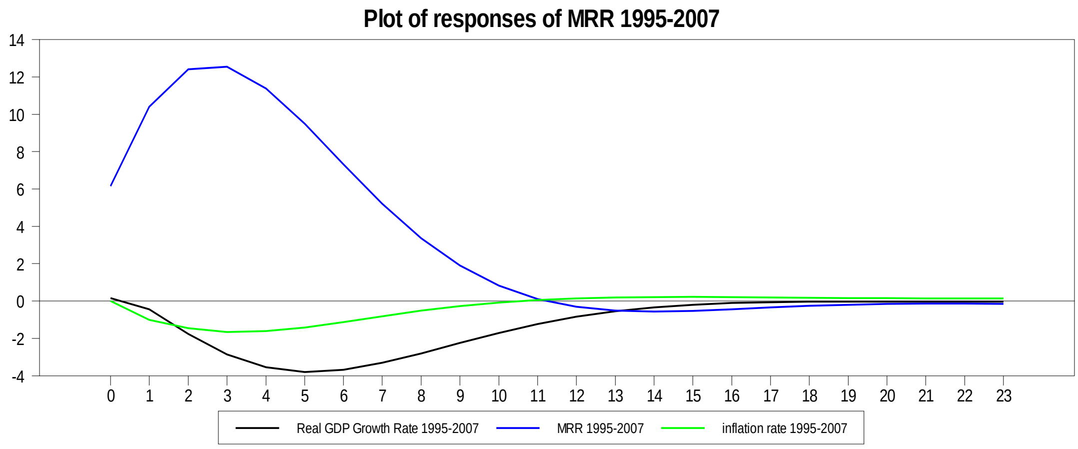

Figure 5. Plot of responses of MRR 1995-2007

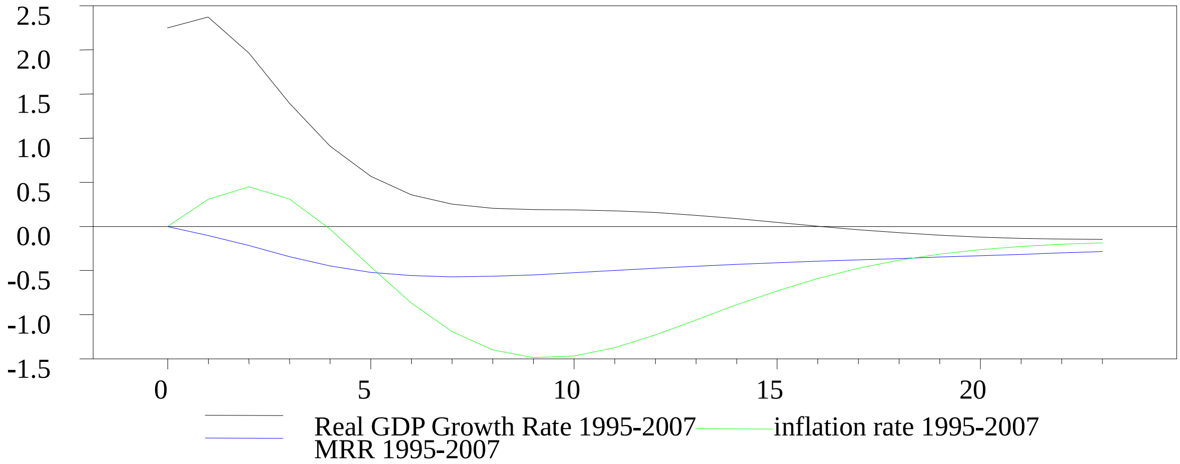

Figure 6. Plot of responses of Real GDP Growth Rate 1995-2007

Tables

Table 1. Summary Statistics of Study Variables

Series	Sample	obs	mean	Std Dev	Minimum	Maximum
GDP	1981:1 2007:1	108	409541.01	220926.82	205045	1317391.3
	1981:1 1994:4	56	283126.25	44004.84	205045	347271.1
	1995:1 2007:4	52	545679.97	252724.21	348746.7	1317391.3
CPI	1981:1 2007:1	108	2459.17	2697.68	47.9	8722.6
	1981:1 1994:4	56	291.44	320.28	47.9	1458.4
	1995:1 2007:4	52	4793.65	2107.46	1669.9	8722.6
INFLAcbn	1981:1 2007:1	108	23.66	19.91	1.3	77.9
	1981:1 1994:4	56	27.77	19.89	3.0	66.7
	1995:1 2007:4	52	19.23	19.14	1.3	77.9
Oilprices	1981:1 2007:1	108	28.07	15.23	11.4	90.7
	1981:1 1994:4	56	23.56	6.94	13.6	38
	1995:1 2007:4	52	32.94	19.71	11.4	90.7
Mrr	1981:1 2007:1	108	14.07	4.41	6	26
	1981:1 1994:4	56	13.28	5.24	6	26
	1995:1 2007:4	52	14.93	3.12	8	20
LOGRGDP	1981:1 2007:1	108	10.7	1.43	9.0	14.1
	1981:1 1994:4	56	11.94	0.81	10.1	13.1
	1995:1 2007:4	52	9.35	0.20	9.0	10.0
GDPGRT	1981:1 2007:1	107	0.54	1.1	-1.1	6.8
	1981:1 1994:4	55	0.31	1.02	-1.1	6.8

	1995:1 2007:4	52	0.77	1.1	-0.6	4.6

Table 2. Tests for Serial Correlation, ARCH and Normality

Tests for Serial Correlation, ARCH and Normality						
Series	Q(8)	Q(16)	Q(24)	ARCH(1)	ARCH(2)	JB-STAT
GDPGRWT	21.778[0.0006]	54.765[0.000]	82.40[0.000]	16.636[0.000]	5.846[0.00537]	2.228[0.3283]
INFLACBN	65.281[0.0000]	76.992[0.000]	82.846[0.00]	11.787[0.006]	40.51[0.0000]	21.037[0.07]

Table 3. Unit Root Tests of Variables of the Model

Variable	Level	First Difference	Lags
Logrgdp	-3.139162*	-3.755954**	1
Inflacbn	-2.450268**	-3.935362**	1
Oilprices	1.576064	-4.293117**	1
Logoilprices	-0.001255	-4.789354**	1
MRR	-2.890303	-5.668382**	1
GDPGRT	-2.385600	-7.695887**	3

Table 4. Bivariate GARCH Estimations of Output Growth and Inflation

BIVARIATE GARCH ESTIMATIONS OF OUTPUT GROWTH AND INFLATION			
CONDTIONAL MEAN EQUATIONS			
	1981:1 2007:4	1981:1 1994:4	1995:1 2007:4
Variables	Mod1	Mod11	Mod21
CONSTANT	-7.51810**	-5.546*	-3.43389
Trend	0.07571**	-0.011	0.021079
GRGDP{1}	0.05173	0.073	-0.1475
INFLA_VOL	-0.09100**	-0.0897*	-0.1000**
OILP_SHOCK	3.98553**	6.7809	6.3037**
CONSTANT	7.65128**	10.3289**	-0.1001
Trend	-0.07907**	-0.10556	0.009257
INFLACBN{1}	0.70064**	0.7497**	0.70817**
INFLA_VOL	0.2668**	0.28209	-0.10738
OILP_SHOCK	0.05470	-18.9548**	0.10766
CONDITIONAL VARIANCE EQUATIONS			
C(1,1)	2.55319**	4.4927**	3.7733**
C(1,2)	-0.51521	-4.57815**	-0.4757
C(2,2)	1.9726**	0.7345	0.000055
A(1,1)	0.9095**	0.1876	0.87385**
A(1,2)	-0.41810**	-1.0158**	-0.37536**

A(2,2)	0.73918**	0.15856	0.74536**
B(1,1)	0.63512**	0.7660**	0.24098
B(1,2)	-0.1518	-0.10767	0.2372**
B(2,1)	0.3460**	0.5393**	-0.23189
B(2,2)	-0.6345**	0.05555	-0.23189
Convergence	72 Iters	54 Iters	55 Iters

Table 5. Variance Decompositions

Decomposition of Variance for Series MRR 1981-1994				
Step	Std Error	MRR	INFLACBN	LOGRGDP
1	2.2635274	100.000	0.000	0.000
2	3.0798643	99.840	0.113	0.047
3	3.5912226	99.454	0.503	0.043
4	3.9572332	98.817	1.146	0.037
5	4.2363533	98.038	1.915	0.047
6	4.4549927	97.254	2.674	0.073
7	4.6272535	96.569	3.328	0.104
8	4.7622814	96.030	3.838	0.132
9	4.8671344	95.642	4.205	0.153
10	4.9477657	95.383	4.451	0.166
11	5.0092686	95.221	4.606	0.172
12	5.0559098	95.127	4.698	0.175
13	5.0911552	95.076	4.749	0.174
14	5.1177424	95.052	4.775	0.173
15	5.1377856	95.042	4.787	0.172
16	5.1528939	95.040	4.790	0.171
17	5.1642808	95.041	4.789	0.171
18	5.1728585	95.043	4.786	0.171
19	5.1793125	95.046	4.782	0.173
20	5.1841599	95.048	4.777	0.175
21	5.1877921	95.049	4.773	0.177
22	5.1905074	95.050	4.769	0.181
23	5.1925336	95.049	4.766	0.184
24	5.1940455	95.048	4.763	0.189
Decomposition of Variance for Series INFLACBN 1981-1994				
Step	Std Error	MRR	INFLACBN	LOGRGDP
1	6.1520145	0.071	99.929	0.000
2	11.1840983	1.802	95.291	2.907

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Vol.2, No.6, 2011

3	15.0407379	3.934	91.002	5.063
4	17.5910999	5.983	87.708	6.308
5	19.0795657	7.843	85.209	6.949
6	19.8504330	9.436	83.355	7.209
7	20.2077581	10.698	82.044	7.258
8	20.3628070	11.607	81.174	7.220
9	20.4350821	12.201	80.627	7.172
10	20.4786903	12.556	80.296	7.149
11	20.5120032	12.752	80.092	7.155
12	20.5388952	12.857	79.962	7.182
13	20.5596652	12.911	79.872	7.217
14	20.5748203	12.941	79.807	7.252
15	20.5855134	12.958	79.758	7.285
16	20.5930675	12.967	79.719	7.313
17	20.5985954	12.972	79.689	7.338
18	20.6028938	12.975	79.665	7.360
19	20.6064990	12.975	79.645	7.380
20	20.6097764	12.973	79.627	7.400
21	20.6129850	12.970	79.611	7.420
22	20.6163087	12.966	79.595	7.439
23	20.6198692	12.961	79.580	7.459
24	20.6237341	12.957	79.564	7.480
Decomposition of Variance for Series LOGRGDP 1981-1994				
Step	Std Error	MRR	INFLACBN	LOGRGDP
1	0.0606513	2.224	35.541	62.235
2	0.1051127	4.838	41.180	53.982
3	0.1455233	6.553	43.994	49.453
4	0.1817223	7.954	45.165	46.882
5	0.2136589	9.201	45.422	45.376
6	0.2416622	10.339	45.191	44.470
7	0.2662894	11.377	44.717	43.906
8	0.2881627	12.320	44.145	43.535
9	0.3078669	13.172	43.556	43.272
10	0.3258997	13.937	42.997	43.066
11	0.3426582	14.624	42.488	42.888
12	0.3584433	15.240	42.039	42.722
13	0.3734729	15.793	41.647	42.559
14	0.3878983	16.293	41.310	42.398

15	0.4018202	16.745	41.019	42.236
16	0.4153033	17.157	40.767	42.076
17	0.4283879	17.534	40.548	41.918
18	0.4410995	17.880	40.355	41.765
19	0.4534554	18.201	40.183	41.616
20	0.4654687	18.498	40.028	41.474
21	0.4771516	18.774	39.887	41.338
22	0.4885159	19.032	39.758	41.210
23	0.4995741	19.273	39.639	41.088
24	0.5103391	19.499	39.529	40.973
Decomposition of Variance for Series MRR 1995-2007				
Step	Std Error	MRR	INFLACBN	LOGRGDP
1	1.1350644	100.000	0.000	0.000
2	1.6579561	98.990	0.634	0.376
3	1.9518658	98.041	1.594	0.365
4	2.1059278	97.576	2.035	0.389
5	2.1890956	97.572	1.940	0.488
6	2.2471307	97.176	2.068	0.757
7	2.3094247	95.447	3.279	1.275
8	2.3891806	92.145	5.816	2.039
9	2.4856879	87.850	9.202	2.949
10	2.5901409	83.418	12.706	3.876
11	2.6920664	79.478	15.792	4.730
12	2.7834456	76.298	18.235	5.467
13	2.8600548	73.886	20.033	6.081
14	2.9210218	72.125	21.291	6.584
15	2.9676945	70.865	22.140	6.995
16	3.0025083	69.967	22.701	7.332
17	3.0281459	69.320	23.069	7.611
18	3.0470430	68.841	23.314	7.845
19	3.0611754	68.473	23.482	8.045
20	3.0720291	68.178	23.603	8.219
21	3.0806628	67.931	23.695	8.374
22	3.0878022	67.716	23.771	8.514
23	3.0939296	67.522	23.836	8.642
24	3.0993574	67.344	23.894	8.762
Decomposition of Variance for Series INFLACBN 1995-2007				
Step	Std Error	MRR	INFLACBN	LOGRGDP

1	2.6954031	5.347	94.653	0.000
2	5.4978721	7.572	89.068	3.360
3	8.1216124	11.195	84.123	4.682
4	10.2911556	14.430	80.076	5.494
5	11.9097715	17.231	76.848	5.921
6	13.0111184	19.547	74.326	6.127
7	13.6946354	21.374	72.430	6.196
8	14.0795505	22.727	71.083	6.191
9	14.2745317	23.651	70.196	6.153
10	14.3626479	24.223	69.665	6.113
11	14.3984216	24.535	69.380	6.085
12	14.4124976	24.679	69.246	6.075
13	14.4192880	24.730	69.190	6.080
14	14.4241316	24.737	69.168	6.095
15	14.4283203	24.729	69.157	6.114
16	14.4318686	24.718	69.149	6.133
17	14.4346655	24.708	69.140	6.152
18	14.4367583	24.701	69.131	6.167
19	14.4383088	24.696	69.123	6.181
20	14.4394976	24.692	69.116	6.193
21	14.4404705	24.689	69.109	6.203
22	14.4413283	24.686	69.102	6.212
23	14.4421380	24.683	69.097	6.221
24	14.4429453	24.680	69.091	6.229