Journal of Economics and International Business Management
Vol. 2(2), pp. 42-49, June 2014
ISSN: 2384-7328
Research Paper

Empirical modeling of money shocks, price and output behaviour in Nigeria (1961 to 2011)

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Accepted 2nd June, 2014

Abstract. This study examined the nature of interaction between money shocks, price and output in Nigeria using time series data (1961 to 2011). The study employed VAR based on impulse response functions (IRFs) and variance decomposition (VD) analytical techniques. The results showed that both price and output respond positively to money shocks and that money shocks significantly influenced price and output. Money supply constituted the greater source of shocks to output and vice-versa. The implication is that money expansion has greater impact on output than on price. The findings verify the proposition that monetary policy is a veritable tool for price stabilization especially in high inflation countries like Nigeria. The study concluded that money is non-neutral and non-exogenous in the long-run.

Keywords: Money shocks, price, output, impulse response functions, variance decomposition, Nigeria.

INTRODUCTION

It is no gain say any longer that the efficacy and suitability of any monetary policy depends largely on how such macroeconomic variables namely money supply, price and output relate over the course of the business cycle. The ways these variables interact really matter to economic scholars and policy makers who have genuine interest in the use of monetary policy to advance the economy. The question of whether money supply is an endogenous factor determined by price and output or an exogenous factor affecting price and output in an economy has become something of great interest to researchers across economies and regions. This has become an issue and has received much attention from the economic writers of all ages.

Theoretically, the quantity theory of money states that, an increase in money supply would all things being equal leads to a proportionate increase in the overall price level. Expressing this theory in a simple way, it is simply saying that if money supply is doubled output will also double. This implies that money supply is an exogenous factor that affects the price level in an economy. However, Cagan (1965) sees money supply both as endogenous and exogenous. He actually proposed that money supply is endogenously determined by changes in the real sector of the economy. He stresses that in the long-run, secular trend movements in money supply are independent of real sector and are exogenously determined. To Keynes and the Keynesians, money supply does not play any significant role in output and price changes. They are of the view that output change causes changes in money supply through demand for money which implies a unidirectional causality from output to money. They argue further that structural factors are responsible for changes in the price level. To the monetarists, changes in money supply affect output and prices. An increase in money supply may raise output in the short-run, but only affects prices in the long-run. This school of thought sees the existence of Phillips curve as a vague. The emphasis is that there is unidirectional causality running from money to output and prices. These theoretical frameworks have provided a justification for empirical investigations to shift argument away from theoretical debate to that of empirical question. The debate on how these three macroeconomic variables interact both in the short-run and also in the long-run has become an empirical issue. More importantly, based on the author’s knowledge, there is no specific study on Nigeria exploring how price and output respond to money shocks using impulse response functions and variance decomposition techniques within the time frame of 1961 to 2011. This study therefore is set to determine the nature of interaction between money shocks, price and output using Nigeria as a specific country of study. The rest of this paper is organized as follows: review of some of the latest empirical literature related to the issue at hand; data and econometric methodology designed to be adopted; the empirical analysis and finally the conclusion of the paper.

LITERATURE REVIEW

There have been several studies in the literature trying to explore how money, price and output relate in an economy. Empirical findings are mixed on the nature of these relationships. Researchers have used different countries with variation in sample sizes and econometric methodology. This section briefly reviews some of the latest empirical studies on this topical issue.

In the work of Das (2003), the long-run relationship between money, price and output was determined for India, the study come out with three fold results; first a bidirectional causality between money and price; second, a bidirectional causality between output and price, and finally, a unidirectional causality from money to output showing that output is a result and not a cause. Ashra et al. (2004) conducted a study on same topic for India and found a bidirectional causality running from money to price and conclude that money is not neutral and that money is not exogenous in the long-run.

Mishra et al. (2010) in their own study on same topic for India employing VAR/VECM modeling technique and found a long-run bidirectional causality between money and output. They also found a long-run unidirectional causality running from price to money and from price to output. Also, their findings revealed a short-run bidirectional causality between money and price and short-run unidirectional causality running from output to price. Herwartz and Reimers (2006) conducted a study analyzing the dynamic relationships between money, price and output using an unbalanced panel of 110 countries. Their findings could not reject the hypothesis of homogeneity between price and money especially for high inflation economies. The study suggests that central bank, even in high inflation countries, can improve price stability by controlling money supply.

Saatcioglu and Korap (2008) in their own study explore the long-run relationships between money, price and real output in the quantity theory of money perspective for Turkey. The results show that money is non-exogenous for the long-run evolution of prices and real output. Sharma et al. (2010) investigate the relationships between money, price and output using a bivariate methodology developed by Lemmens et al. (2008). The study provides empirical evidence for money-output trade-off in the short-run while in the long-run, money supply determines prices but not output. Money supply is also found to be an exogenous factor.

From this review, we can see that empirical findings are mixed as relate to money-price-output relation across countries and regions. However, studies vary in sample size, measurement of variables and econometric methodology employed. This study intends to contribute to this debate by focusing on the nature of interaction between money shocks, price and output using Nigerian economy as a specific case.

METHODOLOGY

This study intends to contribute to the debate on money-price-output relation in an economy by focusing on the nature of interaction between money shocks, price and output in Nigeria. Time series data spanning the period from 1961 to 2011 were collected on variables such as money proxy by broad money aggregate (M2), domestic prices proxy by (CPI) and real output proxy by (RGDP). These data were sourced from Central Bank of Nigeria (CBN) statistical bulletin, 2012 edition augmented with World Development Indicators of the World Bank CD-ROM version 2012. All variables are expressed in their natural logarithm forms to checkmate the problem of heteroscedasticity.

Model specification

The study begins by specifying the functional forms of the ensuing relationship between money, price and output. Each equation expressed a variable as a function of its own lag and lags of other variables. We thus have:

$$Y = \boldsymbol{f}(\boldsymbol{lagY}, \boldsymbol{lagM}, \boldsymbol{lagP}) \, . \quad (1)$$

$$M = \boldsymbol{f}(\boldsymbol{lagY}, \boldsymbol{lagM}, \boldsymbol{lagP}) \quad (2)$$

$$P = \boldsymbol{f}(\boldsymbol{lagY}, \boldsymbol{lagM}, \boldsymbol{lagP}) \quad (3)$$

Where,
Y = Output, M = Money, P = Price
We proceed by specifying the VAR version of Equations 1 to 3. We obtain the three variables, 2^{nd} order VAR model of the form:

$$Y_t = \beta_0 + \beta_{11} Y_{t-1} + \beta_{12} M_{t-1} + \beta_{13} P_{t-1} + \alpha_{11} Y_{t-2} + \alpha_{12} M_{t-2} + \alpha_{13} P_{t-2} + \epsilon_{Yt} \quad (4)$$

$$M_t = \phi_0 + \theta_{21} Y_{t-1} + \theta_{22} M_{t-1} + \theta_{23} P_{t-1} + \varphi_{21} Y_{t-2} + \varphi_{22} M_{t-2} + \varphi_{23} P_{t-2} + \epsilon_{Mt} \quad (5)$$

$$P_t = \Omega_0 + \lambda_{31} Y_{t-1} + \lambda_{32} M_{t-1} + \lambda_{33} P_{t-1} + \delta_{31} Y_{t-2} + \delta_{32} M_{t-2} + \delta_{33} P_{t-2} + \epsilon_{Pt} \quad (6)$$

Table 1. Result of unit root test.

Variable	ADF-test			PP-Test		
	Level	1st Difference	Order of integration	Level	1st Difference	Order of integration
LGDP	P>0.05	P<0.05	I(1)	P>0.05	P<0.05	I(1)
LM2	P>0.05	P<0.05	I(1)	P>0.05	P<0.05	I(1)
LCPI	P>0.05	P<0.05	I(1)	P>0.05	P<0.05	I(1)

In a more compact form, the trivariate VAR (2) model in Equations 4 to 6 can be expressed in matrix form as:

$$\begin{bmatrix} Y_t \\ M_t \\ P_t \end{bmatrix} = G_0 + G_1[\mathrm{L}] \begin{bmatrix} Y_{t-1} \\ M_{t-1} \\ P_{t-1} \end{bmatrix} + G_2[\mathrm{L}] \begin{bmatrix} Y_{t-2} \\ M_{t-2} \\ P_{t-2} \end{bmatrix} + \begin{bmatrix} U_{Yt} \\ U_{Mt} \\ U_{Pt} \end{bmatrix} \quad (7)$$

Where,

$\boldsymbol{G_0}$ is a 3×1 intercept vector of VAR, G_1[L] and G_2[L] are 3×3 matrix polynomials in the lag operator L, and $U_{Yt}, U_{Mt}\ and\ U_{Pt}$ are serially independent error terms.

The VAR system can be transformed into its moving average representation in order to analyze the system's response to money shocks. The moving average representation is used to obtain the forecast error variance decomposition and the impulse response functions. The variance decomposition shows the proportion of the unanticipated change of a variable that is attributable to its own innovations and shocks to other variables in the system.

The moving average representation of the VAR system thus becomes:

$$Z_t = \omega_0 + \sum_{i=0}^{k} \phi_i U_{t-i} \quad (8)$$

Where

Z_t *represents the endogenous variables in the language of the VAR,*

ω_0 is the mean of the process

ϕ_i *is* the identity matrix

To identify the order of integration of each of the variables in the VAR system, the study employed Augmented Dickey Fuller (ADF) and Philips-Peron (PP) unit root tests. The study specified Augmented Dickey-Fuller (ADF) unit root regression equation of the form:

$$Z_t = \eta_0 + \eta_{1t} + \eta_2 Z_{t-1} + \sum_{j=1}^{p} \eta_j \Delta Z_{t-j} + e_{1t} \quad (9)$$

The equation regressed the first differences of the series on a constant, time trend, one lag of the series at level and lags of the series at first differences.

In order to apply Philips-Peron unit root test, the study followed a regression equation of the form:

$$K_t = \Psi_0 + \mu_{1t} + \rho K_{t-1} + \phi[t - \frac{T}{2}] + \sum_{i=1}^{m} \xi_i \Delta K_{t-i} + e_{2t} \quad (10)$$

The regression equation (9) was implemented for this study because of the possibility of any slight structural break in the data especially in 1968 during the Nigerian civil war bearing in mind that the time frame for this study is from 1961 to 2011. In both the Equations 9 and 10, Δ represents the first difference operator, $Z_t\ and\ K_t$ are the time series under examination, η_0 , Ψ_0 are constants terms, e_{1t} and e_{2t} are covariance stationary random error terms, p and m are the lag length to be used in the estimation. The lag length will be chosen based on Schwarz Information Criterion (SC).The null hypothesis of unit root is tested using the t-statistic with critical values calculated by Mackinnon (1991). The null hypothesis of unit root is rejected in both Equations 9 and 10 if η_2 and ρ are less than zero that is, if they are statistically significant.

RESULTS

Here, we present the results of the analysis with brief discussion based on the econometric findings.

Unit root test

The study employed Augmented Dickey Fuller (ADF) and Philips-Peron (PP) unit root tests. The results of the ADF and PP test are presented in Table 1. From Table 1, it is obvious that all the variables used in this study are non-stationary, that is, they follow a I(1) process. The hypothesis of unit root was rejected only on the first differences of each of the variables at 5% level of significance.

Cointegration test

After the unit root test, the study proceeded by testing for cointegration using the two maximum likelihood ratio test statistics namely the trace statistic and Max-Eigen statistic traceable to Johansen and Juselius (1990). A vector of I(1) variables is cointegrated if there exists linear combination of the variables, which are stationary. This statement is evidenced in the work of Damodar NG (1995), Johansen S (1988), Johansen S (1989) and Johansen S (1995). Following this approach, the results as presented in Table 2a and b revealed that there exists no cointegration relationship among the variables. The two test statistics indicate that the hypothesis of no cointegration cannot be rejected.

Table 2a. Result of Johansen multivariate cointegration test - Unrestricted cointegration rank test (trace).

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.228772	12.46904	21.13162	0.5021
At most 1	0.106192	5.388691	14.26460	0.6922
At most 2	0.000466	0.022380	3.841466	0.8810

Trace test indicates no cointegration at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) p-values.

Table 2b. Result of Johansen multivariate cointegration test - Unrestricted cointegration rank test (maximum eigenvalue).

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical value	Prob.**
None	0.228772	12.46904	21.13162	0.5021
At most 1	0.106192	5.388691	14.26460	0.6922
At most 2	0.000466	0.022380	3.841466	0.8810

Max-eigenvalue test indicates no cointegration at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) p-values

Table 3. Result of impulse response functions (IRFs).

Period	LM2	LCPI	LGDP
1	0.155 (0.016)	0.000 (0.000)	0.000 (0.000)
2	0.205 (0.032)	0.003 (0.019)	0.060 (0.025)
3	0.222 (0.046)	0.013 (0.035)	0.078 (0.037)
4	0.227 (0.057)	0.025 (0.046)	0.087 (0.051)
5	0.228 (0.064)	0.036 (0.055)	0.088 (0.063)
6	0.229 (0.068)	0.047 (0.063)	0.085 (0.073)
7	0.230 (0.071)	0.055 (0.069)	0.079 (0.081)
8	0.230 (0.073)	0.062 (0.074)	0.073 (0.088)
9	0.231 (0.073)	0.068 (0.078)	0.066 (0.092)
10	0.231 (0.073)	0.072 (0.082)	0.059 (0.096)
LCPI			
1	0.016 (0.013)	0.089 (0.009)	0.000 (0.000)
2	0.074 (0.024)	0.127 (0.016).	0.006 (0.014)
3	0.125 (0.035)	0.139 (0.026)	0.002 (0.024)
4	0.160 (0.045)	0.137 (0.035)	-0.007 (0.036)
5	0.180 (0.053)	0.128 (0.044)	-0.016 (0.048)
6	0.191 (0.059)	0.118 (0.052).	-0.022 (0.059)
7	0.195 (0.062)	0.107 (0.058).	-0.025 (0.067)
8	0.197 (0.064)	0.096 (0.063)	-0.025 (0.074)
9	0.196 (0.065)	0.088 (0.067)	-0.022 (0.079)
10	0.195 (0.064)	0.080 (0.070)	-0.018 (0.083)
LGDP			
1	0.075 (0.024)	0.052 (0.022)	0.152 (0.015)
2	0.142 (0.037)	0.087 (0.028).	0.124 (0.030)
3	0.184 (0.048)	0.103 (0.038).	0.108 (0.038)
4	0.208 (0.058)	0.109 (0.048)	0.085 (0.051)
5	0.222 (0.065)	0.110 (0.056)	0.063 (0.063)

Table 3. Contd.

6	0.228 (0.070)	0.108 (0.063)	0.045 (0.074)
7	0.231 (0.073)	0.104 (0.070)	0.032 (0.082)
8	0.232 (0.074)	0.100 (0.075)	0.023 (0.089)
9	0.232 (0.075)	0.095 (0.079)	0.017 (0.094)
10	0.231 (0.075)	0.091 (0.083)	0.013 (0.098)

Table 4. Result of variance decomposition (VD).

Period	S.E	LM2	LCPI	LGDP
1	0.155	100.00	0.000	0.000
2	0.264	94.81	0.014	5.176
3	0.354	92.07	0.147	7.782
4	0.430	90.22	0.435	9.349
5	0.496	88.97	0.865	10.161
6	0.555	88.14	1.397	10.456
7	0.608	87.61	1.992	10.403
8	0.657	87.23	2.605	10.127
9	0.703	87.07	3.206	9.773
10	0.746	86.97	3.774	9.256
LCPI				
1	0.091	2.96	97.04	0.00
2	0.173	19.03	60.84	0.13
3	0.255	32.96	66.97	0.07
4	0.331	43.00	56.91	0.09
5	0.398	50.15	49.63	0.23
6	0.457	55.39	44.20	0.41
7	0.509	59.40	40.03	0.57
8	0.555	62.59	36.73	0.68
9	0.595	65.22	34.05	0.73
10	0.632	67.44	31.84	0.73
LGDP				
1	0.177	18.07	8.52	73.41
2	0.273	34.81	13.63	51.56
3	0.361	45.74	15.88	38.38
4	0.439	53.39	16.95	29.66
5	0.508	58.90	17.39	23.70
6	0.569	63.02	17.47	19.52
7	0.624	66.17	17.33	16.50
8	0.674	68.66	17.07	14.27
9	0.719	70.68	16.74	12.58
10	0.761	72.35	16.38	11.27

Impulse response functions (IRF)

This study employed the impulse response functions to trace out the response of current and future level of output and prices to one standard deviation change in the current value of money supply innovation. The impulse response functions help to trace out the response of output and prices to one standard deviation shock in money supply. The shock to money supply was identified based on a standard Cholesky factorization, ordering money supply first followed by prices and output. We thus assume that money supply does not respond contemporaneously to innovations to either the prices or output but price and output respond contemporaneously to innovations in money supply. This assumption is fairly reasonable considering the exogeneity nature of price and output to money supply. The result of the impulse response functions is presented both in tabular and graphical forms. The tabular form of this result is presented in Table 3 while the graphical form is presented in the appendix. It is clear from the table that both price and output respond positively to money shocks throughout the ten periods. It is also obvious from the table that money shocks have greater effect on output than on price throughout the ten periods.

Variance decomposition

The study employed variance decomposition to measure the proportion of forecast error variance in one variable explained by innovations in itself and that of other variables. The variance decomposition suggests that shocks to money supply as shown in Table 4, explained about 3% of shocks to price in the first period, it increases in effects to about 50% in the fifth period and further increases to 67% in the tenth period. Also, money shocks significantly contribute to shocks to price and output but with greater effects on output than on price. This is evidenced in Table 4 where money shocks explained about 18% of shocks to output in the first period. This has increased to about 72% in the tenth period. This suggests that money shocks turned out to have positive and significant effects on output.

CONCLUSION

The findings presented in this study was based on the results obtained from the econometric analysis of the Nigerian data covering variables such as money supply, consumer price index and gross domestic product from the period of 1961 to 2011. The findings demonstrate that money shocks have positive effect on output and price. Both price and output responds positively to shocks in money supply. However, the findings revealed that money supply constituted the larger source of shocks to output while output constituted the larger source of shocks to money supply. The results also demonstrated that the long-run effect of money shocks on price and output is greater than its short-run effect. This implies that money shocks have significant effect on price and output both in the short-run and in the long-run. On the whole, we found an empirical justification for the proposition that monetary policy is a veritable tool for price stabilization most especially in high inflation economies like that of Nigeria's. The study therefore concluded that money is non-neutral and non-exogenous in the long-run.

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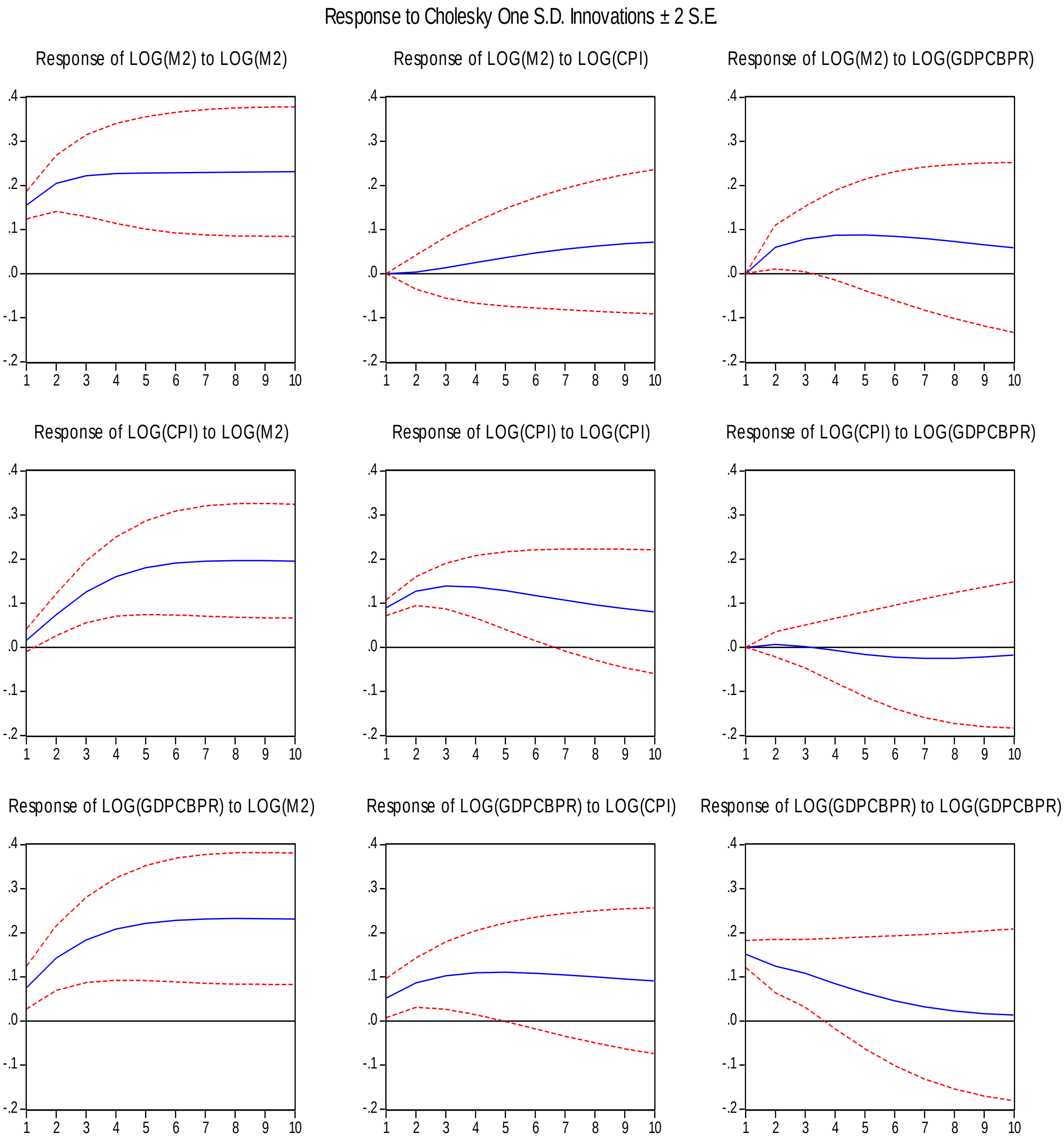
APPENDIX

Impulse response (graphical presentation)



Variance decomposition (graphical presentation)