Exchange Rate Pass Through into Consumer Price Inflation in Nigeria: An Empirical Investigation

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ABSTRACT

The paper examines the macroeconomic shocks effect on exchange rate pass through into domestic consumer price inflation using structural vector auto regression methodology. The results show that exchange rate pass through to consumer price inflation in Nigeria is low and incomplete. Moreover, the speed of adjustments to structural shocks, such as those from the exchange rate, output, monetary policy rate, and money supply is high. The effects of such shocks are highly volatile and therefore can potentially distort the status quo. The results from forecast variance decomposition analysis show that the consumer price inflation own shocks, positive money supply shocks and output shocks dominate over other factors in explaining consumer price inflation in the Nigerian economy. Therefore, Nigeria should strive for more effective monetary policy through conscious efforts by the monetary authority. The authority should adopt fully-fledged inflation targeting. This will help to bring expectations of inflation down and strengthen the expectations channel. This will in turn make the anticipated effects of monetary policy to require less aggressive monetary policy rate changes.

Keywords: ERPT, Macroeconomic shocks, Inflation, SVAR, Nigerian economy.

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1 Introduction

In some countries, such as Australia, Canada, and the United Kingdom, the enhanced credibility of monetary policy through the adoption of an inflation targeting frame work for monetary policy has resulted in a lower pass through of the exchange rate to domestic consumer prices. Similarly, monetary policy credibility in the United States was enhanced through maintaining a commitment to low inflation and eventually a relatively low exchange rate pass through to domestic consumer prices. In fact, this commitment underscores the importance of effective monetary policy. Taylor's (2000) proposition states that the degree of pass through of exchange rate to domestic prices is linked to the relative inflation persistence in an economy; the lower (higher) the level of inflation persistence so also the lesser (higher) the degree of exchange rate pass through (ERPT).

The subsequent literature has tested this proposition with a variety of econometric techniques. Campa and Goldberg (2002) applied OLS in a log linear model of import price pass through to find out whether pass through is a micro or micro issue. Their findings suggest that ERPT is less than one in the short run, but closer to one in the long run. The average pass-through across OECD member countries is 60% over a quarter and 75% over the fourth quarter. The US has the lowest pass through followed by Germany. Takhtamanova (2008) supports the Taylor hypothesis for a set of fourteen OECD countries (see Razafimahefa, 2012). Many industrialized countries seem to have experienced a decline in exchange rate pass through to consumer prices in the 1990s, despite large exchange rate depreciation in many of them.[1] Although monetary policy is not solely responsible for the decline in exchange rate pass through, effective monetary policy should consider the consequences of policy changes on the pass-through of prices into the domestic economy.

The majority of recent research on exchange rate pass through relies on some type of reduced-form time series econometrics: vector auto regression (VAR), structured vector auto regression (SVAR) or vector error correction (VECM).[2] The strength of using an SVAR

[1] Starting in the early 1990s, many industrialized countries reduced their inflation rates and entered a period of relative price stability. Although several factors are thought to have contributed to this trend, it is generally agreed that a shift towards more credible monetary policy regimes played an important role (see Bailliu and Fujii, 2004).

[2] Some recent examples are the single-equation models in Campa & Goldberg (2005) and Marazzi *et al*. (2005), and the VAR and structural VARs in (McCarthy, 2000; Hahn, 2003; Mwase, 2006; Ito and Sato, 2007; Cazorzi *et al.*2007; and Sanusi, 2010) McCarthy, 2000; Choudri, et al, 2005; Faruqee, 2006

approach is that it takes explicit account of endogeneity of the exchange rate and allows for the easy estimation of the pass through to a set of prices (e.g., import prices, producer prices, and consumer prices) which are also endogenously determined. Sometimes oil prices for export-oriented economies are used as a measure of output gap, wages and even interest rates (see Bache 2007). Empirical literature on pass through reveals the multiplicity of econometrics methodologies and estimation techniques presently used in applied macro econometrics.

Generally, there are three channels by which exchange rate changes pass through to consumer prices (i) prices of imported consumption goods, (ii) domestically produced goods priced in foreign currency and (iii) prices of imported intermediate goods. The effect of exchange rate movements is direct in the first two channels.[3] In the last channel exchange rate movements affect domestic prices indirectly by changing the costs of production (see Sahminan, 2002). Lafleche (1996:23) asserts that there are two broad channels through which exchange rate movements can affect domestic prices: direct and indirect channels, an assertion later reaffirmed in Hyde and Shah (2004:3). Following this line of argument, exchange rate movements can affect domestic prices directly through changes in the price of imported finished goods and imported inputs (e.g., raw materials and capital goods). When the currency of the domestic country appreciates, the domestic price of imported, finished goods falls. Likewise, when the currency of the domestic currency depreciates, higher import prices are more likely to be passed on to consumers. Currency depreciation also causes a rise in imported inputs which may result in an increase in the marginal cost of production for domestic firms. Hence, the prices of domestically-produced goods increase. The indirect channel, however, is said to occur when the exchange rate of the domestic country depreciates. The prices of the domestic products decrease relative to goods produced elsewhere, making them relatively cheaper for foreign buyers. This will induce an increase in the demand size of exports and an increase in aggregate demand, resulting in an increase in domestic prices.

The aim and value added of this study is to re-estimate exchange rate pass through elasticity with more sophisticated methodology. We us an SVAR to compute the exchange rate pass through elasticity and assess the inflation dynamics for the Nigerian economy. After doing

[3] The pass-through process consists of two stages. In the first stage, exchange rate movements are transmitted to import prices. In the second stage, changes in import prices are transmitted to consumer prices.

so, our next goal is to analyze exchange rate pass through at a macro-economic level. Particularly, we aim to discover the monetary policy reaction to exchange rate shock as highlighted above.

Although previous studies have sought to answer similar questions for Nigeria, the methodologies employed in these studies have not successfully integrated economic theory into the estimation. Adedayo (2012) and Aliyu *et al.* (2009) have applied a single equation estimation technique and vector error correction model, respectively. The advantages of using the SVAR in this study are: first it solves the endogeneity problem that arises under the single equation method; second, this technique applies restrictions to identify structural shocks within the macroeconomic system; third, it enables us to investigate the effect of exchange rate and pass-through elasticity via accumulated impulse response. For a structural model to be estimated, certain restrictions are needed about which variables are allowed to affect each other. Thus, the SVAR methodology possibly allows one to identify explicit "structural" shocks disturbing the system, which paves the way for specifying embedded features of an economy. In this case, we estimate a structural exchange rate shock and monetary policy transmission channel that is identified with ex ante, theory-justified restrictions. The SVAR methodology allows the use of impulse response functions to compute exchange rate pass through elasticity and inflation dynamism. We conduct a forecast error variance decomposition from the SVAR results in order to examine the significance of the identified shocks in explaining domestic consumer price variation.

This study is of relevance to the Nigerian economy, as it provides evidence on how the adoption of credible monetary policy and inflation targeting is associated with a lower ERPT and improvement of the overall economic performance. This study will inform Nigeria, a small open economy, on the linkages between and timing of monetary policy transmission and ERPT[4].

The results from the impulse response shows that the exchange rate pass through to consumer price inflation in Nigeria is incomplete and relatively low. Moreover, the speed of adjustment to structural shocks, (e.g., the exchange rate, output, monetary policy rate, and money supply shocks) is high. The effects of such shocks are highly volatile and therefore can

[4] The study of probable causes of economic oscillations has been the major concern in macroeconomics in recent years. The question is central if one shall gain understanding into the mechanisms of the economy, and aid in the design and conduct of economic policy.

potentially distort the status quo. The results from forecast variance decomposition analysis show that the largest determinants of consumer price inflation in the Nigerian economy are consumer price inflation own shocks, positive money supply shocks, and output shocks.

This paper is organized as follows. Section 1 provides an overview of the theoretical and empirical studies on exchange rate pass through (ERPT), Section 2 describes the methodology used in the study, section 3 describes the identification constraints of the model and Section, 4 contains the data, and the main empirical results. Section 5 concludes

2. Econometric Methodology

This study imposes restrictions to retrieve the exchange rate innovations, while a contemporaneous association holds among the variables to short run fluctuations in the exchange rate, inflation and monetary policy. We consider a multivariate system of the economy which includes the consumer price index (CPI), output or aggregate demand (Y), the monetary policy rate (MPR), the nominal effective exchange rate (NEER), and the broad money (M2).[5] M2 is included to capture the monetary aggregate targeting in the economy. Similarly, M2 can influence both the private and public sector activity in the short run. As such, the M2 also captures the effect of the decisions of these agents when the inflation rate increases or decreases. The MPR is the monetary policy tool used by the monetary authorities to influence the overall economic activity. It also captures the lite inflation targeting in the Nigerian economy. It is worth noting that both the monetary policy rate and the broad money supply are included in the model to capture the general conduct of the monetary policy and its effects on the price level in the Nigerian economy. In our five-variable SVAR model, we incorporate theory-consistent assumptions or restrictions that identify the causal influence of exchange rate and monetary policy on domestic price innovations using a Sims-Bernanke, (1986) structural decomposition.[6]

[5] The macroeconomic data set used in this study is taken from the IMF's International Financial Statistics (IFS) database, and Central Bank of Nigeria (CBN) statistical bulletin and Report. All variables are transformed to their natural logarithm

[6] The Lag length of the ADF regression was selected according to the schwartz Bayesian Information Criterion. In practice, the SBC will select a more parsimonious model than will either AIC or t-test (Enders, 2004; 193). Once a tentative lag length has been determined diagnostic checking should be conducted. Plotting the residuals is a most important diagnostic tool. There should be always being absence of evidence of structural change and serial autocorrelation. Therefore, the correlogram of the residual are examine and should appear to be a white noise process (Enders, 2004; 192). In line with this reasoning, we examine the correlogram of the levels and first

The baseline empirical model is estimated as a standard VAR with five endogenous variables to model the Nigerian economy. This study follows Mwase (2006) and Sanusi (2010) which assumes that the economic agents' expectation tends to rely on past developments, implying that expectations are principally adaptive. The reason for assuming adaptive expectations in this paper is as follows: a track record of prudent and credible monetary policy in controlling inflation developments can strongly influence the expectations of the agents. If the government policy stance is prudent, credible and has a strong monetary discipline the agents will have confidence for most of the periods expecting inflationary pressure to be ameliorated. Hence, it is assumed that the expectations are equivalent to a linear projection based on lags of the endogenous variables in the VAR.

The VAR can be interpreted as the standard form of a structural VAR. The standard form representation of the model may be written as:

$$X_t = A_0 + A_1 X_{t-1} + e \qquad (1)$$

Given that X_t = [*ΔY ΔM2 ΔMPR ΔNEER ΔCPI*] is a 5×1 row vector of the endogenous variables observed at time t, where *ΔY is* log nominal output, ΔM2 denotes the log of a monetary aggregate such as M2, and ΔMPR gives the monetary policy rate, ΔNEER represents the log of nominal effective exchange rate, ΔCPI is the log Consumer price index. An equivalent representation is given by

$$\mathbf{A(L)} x_{\mathbf{t}} = e_{\mathbf{t}} \qquad (2)$$

Where $\mathbf{A(L)} = I - \sum_{i=1}^{k} A_i L^{i}$ is an 5x5 matrix polynomial in the lag operator L ($L^j X_t \equiv X_{t-j}$), A_1, $A_2, \ldots, A_k$ are 5×5 matrices of autoregressive coefficients.

Now the next step is to derive the characterizing equation of our model given that the SVAR model can also be represented in structural form as follows.

$$BX_t = \Gamma_0 + \Gamma_1 X_{t-1} + \varepsilon_t \qquad (3)$$

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difference of the series data. It indicates that it is stationary. Finally, we conclude that the time series data is difference stationary (DS) and intergrated in the first order.

Where B and Γ_1 are (nxn) and Γ_0 is an (nx1) matrices. To normalize the vector appearing on the LHS of equation 3, we need to multiply the equation by the inverse of the matrix B (B^{-1}). Hence, we the following:

$$B^{-1}BX_t = B^{-1}\Gamma_0 + B^{-1}\Gamma_1 X_{t-1} + B^{-1}\varepsilon_t \qquad (4)$$

From (1) and (4) we obtained (6), which is an important characteristic we use in our model that can be expressed as:

$$X_t = B^{-1}\Gamma_0 + B^{-1}\Gamma_1 X_{t-1} + B^{-1}\varepsilon_t = A_0 + A_1 X_{t-1} + e_t \qquad (5)$$

$$e_t = B^{-1}\varepsilon \qquad (6)$$

where

$$e_t = \left[e^{ny} e^{bm}\, e^{mr} e^{er} e^{pi}\right] \qquad (7)$$

is a 5×1 row vector of error terms.[7] The errors are assumed to be serially independent. Similarly, the elements in the vector of innovations or structural shocks are assumed to be independently and normally distributed with mean zero and variance-covariance matrix i.e. $\varepsilon_t \sim i.i.d(0,\sigma^2_{\varepsilon i})$ .The ε_t innovation could be called "shocks" and they are economically identifiable (i.e., output shocks, money supply shocks, monetary policy rate shocks, exchange rate shocks, and consumer price inflation shocks). Therefore, the structural shocks vector is represented by:

$$\varepsilon_t = \left[\varepsilon^{ny} \varepsilon^{bm}\, \varepsilon^{mr} \varepsilon^{er} \varepsilon^{pi}\right] \qquad (8)$$

where $\varepsilon^{ny}, \varepsilon^{bm}, \varepsilon^{mr}, \varepsilon^{er}, \varepsilon^{pi}$ represent the output, broad money, monetary policy rate, nominal exchange rate, and consumer price index shocks respectively.

A(L) = B^{-1} is the 5x5 matrix defined in equation (9):

[7] The matrix B represents the contemporaneous interaction among the variables. This general form cannot be estimated, since the matrix B is not known. Thus the form in which the VAR is is reduced to standard form.

$$\begin{bmatrix} e^{ny} \\ e^{bm} \\ e^{mr} \\ e^{er} \\ e^{pi} \end{bmatrix} = \begin{bmatrix} 1 & \eta_{12} & \eta_{13} & \eta_{14} & \eta_{15} \\ \eta_{21} & 1 & \eta_{23} & \eta_{24} & \eta_{25} \\ \eta_{31} & \eta_{32} & 1 & \eta_{34} & \eta_{35} \\ \eta_{41} & \eta_{42} & \eta_{43} & 1 & \eta_{45} \\ \eta_{51} & \eta_{52} & \eta_{53} & \eta_{54} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon^{ny} \\ \varepsilon^{bm} \\ \varepsilon^{mr} \\ \varepsilon^{er} \\ \varepsilon^{pi} \end{bmatrix} \tag{9}$$

The first variable (i.e. the output) is a representative of the real sector. The second, third, fourth, and fifth variables represent the monetary sector. Our theory assumes that the monetary policymaker and the fiscal policymaker independently and simultaneously account for shocks that might emanate from each other. The aim of including monetary and real sector variables at the same time is to take into account the fact that policy maker's reactions to shocks are different in relation to exchange rate regime in place designed to give a positive result and to achieve monetary policy objectives. In other words, the variable ordering allows us to take into consideration the exchange rate regime in view of inflation or monetary targets. This is important in analyzing the latest exchange regime and the monetary policy stance of inflation targeting initiated in 2007 and intensified in 2009. A key goal of this project is to see how this monetary policy framework explains ERPT sin Nigeria's economy. Therefore we employ an SVAR to impose contemporaneous short run restrictions for non-recursive system on the B^{-1} as the transition matrix in view of the exchange rate pass through and the latest monetary policy position of the Nigerian economy.

3. Identification Constraint

In this work we adopt the SVAR methodology developed by Bernanke (1986). Two types of restrictions are mentioned in the literature; short-run restrictions and long-run restrictions. To identify the structural shocks, we choose to identify the system with short-run constraints. In other words, we will constrain certain variables not to have long-term effects.

In our model of $n = 5$ endogenous variables, there should be $n^2=25$ independent restrictions on parameters of the structural form.[8] We set the variance-covariance matrix of the structural shocks ε_t to the identity matrix. Thus $n(n-1)/2 = 10$ restrictions are needed for full

[8] The test of over identifying restrictions cannot reject the validity of the constraints imposed on the short-run responses

identification. Throughout this study, as noted above, we will make use of short-run restrictions only. These are restrictions that are directly imposed on B^{-1} which determines the contemporaneous reactions of the variables to structural innovations.

The identification of shocks in a system of 5 variables requires 10 constraints. The right-hand side, is a mixture of the structural shocks, (exogenous forces of the system), and of the matrix B^{-1} which describes the coefficients associated to these shocks.[9]

$$B^{-1} = \begin{bmatrix} 1 & \eta_{12} & \eta_{13} & \eta_{14} & \eta_{15} \\ \eta_{21} & 1 & \eta_{23} & \eta_{24} & \eta_{25} \\ \eta_{31} & \eta_{32} & 1 & \eta_{34} & \eta_{35} \\ \eta_{41} & \eta_{42} & \eta_{43} & 1 & \eta_{45} \\ \eta_{51} & \eta_{52} & \eta_{53} & \eta_{54} & 1 \end{bmatrix} \quad (10)$$

The following constraints are drawn from the theoretical assumption commonly accepted since the work of Blanchard and Quah (1989) that distinguishes the difference between supply and demand shocks. Economic theory supposes that supply shocks (the output equation as a supply shock) can affect economic activity both in the short term and long term. Demand shocks affect economic activity only in the short term (e.g. monetary shocks). This enables us to identify four restrictions (η_{12} ; η_{13}; η_{14} ; $\eta_{15} = 0$). Similarly, we also impose another four restrictions on the two demand shocks in the second and fourth equations η_{23} ; η_{24} ; η_{25}; $\eta_{45} = 0$, which are the monetary and exchange rate shocks, respectively. Finally, the last two restrictions are on the third equation related to the monetary policy reaction function ($i.e., \eta_{34}$; $\eta_{35} = 0$) as shocks that have both short term and long term effects on consumer price inflation with exchange rate shock as the catalyst.[10]

[9] Identification remains at the core of successful SVAR modeling.

[10] The structural shocks (ε_t) in each period *t* are determined by expectations conditional on available information at the end of period *t-1, (Et-1(.)),* and an error term (e_t). Therefore the one period ahead forecasting error in inflation or pass through to consumer prices due to variability in the structural shocks say $\varepsilon^{ny}\varepsilon^{bm}\varepsilon^{mr}\varepsilon^{er}$. recalling that $e_t = B^{-1}\varepsilon$ (see equation 6a), as such inflation forecast error is: $e^{pi} = \eta_{51}\varepsilon^{ny} + \eta_{52}\varepsilon^{bm} + \eta_{53}\varepsilon^{mr} + \eta_{54}\varepsilon^{er} + \varepsilon^{pi}$ which is the last equation, this inflation forecast errors can be caused by exchange rate shocks and other shocks implicit in the system as analyzed.

Thus, the matrix representing the effects of structural shocks on the variables of our model is as follows:

$$\begin{bmatrix} e^{ny} \\ e^{bm} \\ e^{mr} \\ e^{er} \\ e^{pi} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ \eta_{21} & 1 & 0 & 0 & 0 \\ \eta_{31} & \eta_{32} & 1 & 0 & 0 \\ \eta_{41} & \eta_{42} & \eta_{43} & 1 & 0 \\ \eta_{51} & \eta_{52} & \eta_{53} & \eta_{54} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon^{ny} \\ \varepsilon^{bm} \\ \varepsilon^{mr} \\ \varepsilon^{er} \\ \varepsilon^{pi} \end{bmatrix} \qquad (11)$$

Note that each line can be viewed as an equation. This may be seen by multiplying through each term on the right-hand side. Each reduced-form shock is a weighted average of the selected structural shocks. The elements $\eta_{12} \dots\dots\dots \eta_{45}$ represent the weights attached to the structural shocks. For example, the equations are:

$$e^{ny} = \varepsilon^{ny} \qquad (12)$$

$$e^{bm} = \eta_{21}\varepsilon^{ny} + \varepsilon^{bm} \qquad (13)$$

$$e^{mr} = \eta_{31}\varepsilon^{ny} + \eta_{32}\varepsilon^{bm} + \varepsilon^{mr} \qquad (14)$$

$$e^{er} = \eta_{41}\varepsilon^{ny} + \eta_{42}\varepsilon^{bm} + \eta_{43}\varepsilon^{mr} + \varepsilon^{er} \qquad (15)$$

$$e^{pi} = \eta_{51}\varepsilon^{ny} + \eta_{52}\varepsilon^{bm} + \eta_{53}\varepsilon^{mr} + \eta_{54}\varepsilon^{er} + \varepsilon^{pi} \qquad (16)$$

The first variable in the ordering is contemporaneously affected only by the shock to the first equation; the second variable is affected by the shocks to the first and second equation and so on. The last variable in the ordering is contemporaneously affected by all the shocks in the system. It is clear that, unless the reduced form innovations are uncorrelated, the impulse response functions will not be invariant to the ordering of the variables in the VAR.[11]

One way of depicting this identification would be to interpret the first and last equations as an aggregate supply and aggregate demand model with an upward sloping AS curve and downward-sloping AD curve. The last equation moves the price level and real output, so it

[11] Drawing from Bernanke–Sims decomposition it important to that the plausible ordering of variables does not matter however, we the LR-test must be conducted as proposed by Sims. As such, both channels of the effect of exchange rates on economy are analyzed Kim and Roubini (2000), using Bernanke-Sims decomposition. It also follows that the non-recursive identification relaxes the assumption of no contemporaneous relationships between the variables of interests.

indicates a shift of the AS curve. The first equation moves real output only; it represents a shift in the AD curve. The second equation could be interpreted as a money demand equation derived from the quantity theory of money equation: MV = PY, where V stands for velocity and Y for real income. Hence, the second equation can be interpreted as a velocity shock or money demand shock, if we take real output to represent real income. The third equation could represent a monetary policy reaction function or monetary policy aggregate target such as inflation targeting and its effect on the exchange rate shock.[12] Consequently, the fourth equation, representing the shock to the nominal exchange rate, will have cumulative momentum on the last equation, the consumer price inflation equation, given the preceding shocks in the fourth equation.

The central bank systematically responds to equations (12) - (15) as well as lags of all variables. Any change in equation (16) (i.e. consumer price inflation) not accounted for by this response, would be an exogenous shock whose effects indicate the extent of exchange rate pass through into the economy. This work imposes restrictions to retrieve exchange rate structural innovations from the other innovations, while allowing for contemporaneous response adjustment of parameters to the exchange rate innovations using structural decomposition. In the next section, we report results from estimating the above equation.

4. SVAR Model Estimates

The estimated system of the shocks from the SVAR can be seen from equations (17) to (21) given below.[13] The coefficients of the structural shocks (impulse response coefficients) $\varepsilon^{ny}, \varepsilon^{bm}, \varepsilon^{mr}, \varepsilon^{er}$ and ε^{pi} represent the given standard deviations of the variables in the system, the respective *p–values* are given in parenthesis below the coefficient estimates.[14] It can be seen

[12] See Hahn (2003) that also places the monetary policy variable prior to the exchange rate and prices. Interestingly, McCarthy (2000) orders the monetary policy variables (interest rate and the money supply) at the bottom of a VAR model and domestic prices are placed just prior to the monetary policy variables.

[13] Refer to the appendix for diagnostic tests results.

[14] Imposition of identification restrictions resulted to the following shocks in equation 12 to 16 above

that all the coefficients carry the correct signs. Of relevance to note, the contemporaneous relationship among our variables holds implicitly in the system.[15]

$$e^{ny} = 0.103736\varepsilon^{ny} \quad (17)$$

(0.0000)

$$e^{bm} = 0.011937e^{ny} + 0.060793\varepsilon^{bm} \quad (18)$$

(0.8354) **(0.0000)**

$$e^{mr} = 0.075649\, e^{ny} - 0.201384e^{bm} + 0.120661\varepsilon^{mr} \quad (19)$$

(0.5073) (0.3008) **(0.0000)**

$$e^{er} = -0.407758\, e^{ny} - 0.076511e^{bm} - 0.021640e^{mr} + 0.088714\varepsilon^{er} \quad (20)$$

(0.0000) (0.5948) (0.7641) **(0.0000)**

$$e^{pi} = 0.06986e^{ny} + 0.108660e^{bm} + 0.054652e^{mr} - 0.081860e^{er} + 0.03228\varepsilon^{pi} \quad (21)$$

(0.0391) **(0.0382)** **(0.0373)** (0.218) **(0.0000)**

The next step is the examination of exchange rate pass through to consumer price inflation using innovation accounting which is a combination of impulse response and variance decomposition assessment. We present these results in the remainder of the paper.[16] We analyze the impulse responses of consumer price inflation variable to exchange rate, monetary policy rate, money supply, and output shocks (in the amount of 1 percentage point for all variables), and the proportion of the variance of prediction error or variance decomposition of consumer price inflation variable accounted for by these shocks. Apart from measuring the size of the accumulated influence of the unit shocks on the observed variables, the analysis of impulse

[15] The variables in the model are categorized into two groups: the non-policy vectors, which include the log of output, the log of consumer price index, and the policy vectors, which include the log of the exchange rate and the log of money supply, and monetary policy rate. The goal is to examine how exchange rate shock as a policy variable affects consumer price index in structural VAR.

[16] According to VAR literature, when there are cointegration relationships among the variables, that is when data are I (1) and cointegrated, one can estimate a VAR/SVAR model in levels. Thereby, allowing the long run structure unrestricted, only if the cointegration rank is high and the short run coefficients are ignored (Smets, 2007,). However, if not cointegrated VAR/SVAR is specified in first difference. Thus we are able to specify VAR in first difference, suggesting that the tests show no strong evidence for the existence of cointegrating vectors in the macro system. Thus, the model specification, follow that the variables are first differenced and no error-correction terms are included. See Sanusi (2010)

responses also enables an estimate of the duration of shock absorption and of the significance of a particular shock's influence on consumer price inflation.

In the SVAR model, it is assumed that there are 5 shocks in the economy, which include the output shocks, exchange rate (NEER) shocks, money supply shocks, monetary policy rate shocks, and consumer price index (CPI) shocks. The impulse response function shows the response of each variable to structural one standard deviation of each shock. We use impulse response analysis to investigate the dynamic and cumulative interactions among the endogenous variables in the system and their effects.

The fifth column (see table A3 in the appendix) shows the response of the price level to a one standard deviation shock to the exchange rate. These results indicate that the exchange rate pass through to consumer price inflation is incomplete and fairly gradual. It takes about 14 quarters to yield outright or full impact.[17] However, the effects of the respective shocks on the CPI differ. The immediate effect of a structural one standard deviation shock to the exchange rate (which corresponds to a 0.09 increase, or 9 percent appreciation) indicates a decrease in prices of about 0.007 (or 0.7 percent). With this appreciation of the exchange rate, the initial pass through elasticity is high, but less than one-for-one passage to consumer prices. This result implies that there is a high immediate impact elasticity of 0.77 percent of an exchange rate shock on consumer prices. Over 4 quarters, the price level decreases to around 0.01 percent and to 0.02 per cent in 8 quarters following the initial exchange rate shock. These results correspond to 0.11 and 0.22 impact elasticities, respectively. By the end of 12 quarters the price level decreases steadily to 0.02 percent, corresponding to a steady impact elasticity 0.22 like in the previous quarter.

From table A3 (see appendix), we can account for the money supply and monetary policy rate (monetary policy) effects on the CPI. Doing so requires the analysis of the structural one standard deviation of the corresponding shock on the CPI. While a 6.1 percent shock to the money supply results in a price level increase of 0.63 percent, a 12 percent shock to the monetary policy rate causes a 0.7 percent increase in the price level. Although the immediate impulse responses of price level to money supply and monetary policy rate shocks are close to each other,

[17]Signifying 0.09 percent appreciation of the exchange rate culminated to decrease in consumer prices to 0.03 percent with fervent dynamic exchange rate pass through elasticity of 0.33 percent (see Mohammed-gamji, 2015)

the respective elasticities differ at 0.10 and 0.05 respectively. This result is plausible given that the present monetary policy committee of the Central Bank of Nigeria kept the monetary policy rate at 12 percent over 8 quarters from 2011 until the end date of the dataset used in this paper. The effects increased substantially in the fourteenth quarter with an 8.2 and 2.1 percent increase in price level from the money supply and monetary policy rate shocks, respectively. These correspond to the elasticities of 1.35 and 0.17, respectively.

This relationship between money and prices has been established well in both theory and practice. For example, the Quantity Theory of Money (MV=PY), by assuming constant velocity of money and long-run output, suggests that monetary innovations feed directly and positively into domestic inflation. It is obvious from the results that the money stock elasticity is higher than the monetary policy rate. This indicates that the money supply is significant as a causal channel of inflation in the Nigerian economy rather than the monetary policy rate. It points out that the monetary authorities in Nigeria have to be vigilant in pursuit of multidirectional monetary policies to achieve macro-economic objectives in the Nigerian economy.[18]

The effect of money supply and monetary policy rate shocks on the price level looks similarly high in the beginning (see table A3). Rough comparison of exchange rate and monetary variable shocks suggest that the price level is susceptible to variability of the macroeconomic components. The reaction of the price level to the broad money and output shocks is relatively high. However, it is vital to note that each shock has its directional impact in causing the exchange rate to move, which in turn affect consumer prices. The monetary policy rate and money supply or broad money shocks can also be seen as the monetary policy shock. The monetary policy can influence consumer prices indirectly through exchange rates or directly through monetary targeting and inflation targeting.[19]

[18] See Nwase (2006) and Sanusi (2010) on Tanzanian and Ghanaian economy respectively

[19] Inflation targeting is a policy in which an estimated inflation target is made public and deliberately pursued using the instruments of monetary management such as interest rate to steer actual inflation towards the desire policy target.

SVAR Impulse Responses

Figure 1a: Accumulated Impulse Response of Consumer Prices to a Structural Standard Deviation Shock to the Exchange Rate (With Two Standard Error Band)

The middle line represents the impulse responses while the upper and lower dashed lines are two standard error bands (see Figure 1a-c). The vertical axis shows the percentage point change in the domestic price index or the percentage of pass-through and the horizontal axis shows the time (in quarters). We will present here only the responses of domestic prices with respect to NEER and MPR.

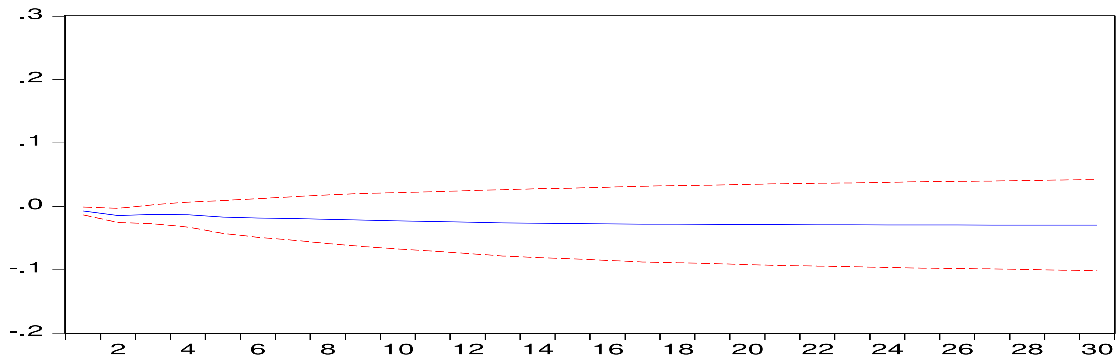

Figure 1b: Accumulated Impulse Response of consumer prices to a Structural Standard Deviation Shock to the Monetary Policy Rate (With Two Standard Error Band)

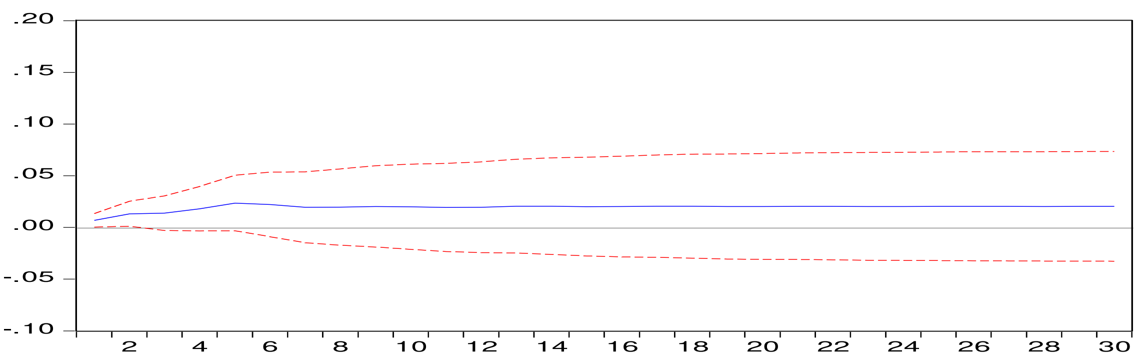

Figure 1c: Accumulated Impulse Response of Monetary Policy Rate to a Structural Standard Deviation Shock to the Exchange Rate (With Two Standard Error Band)

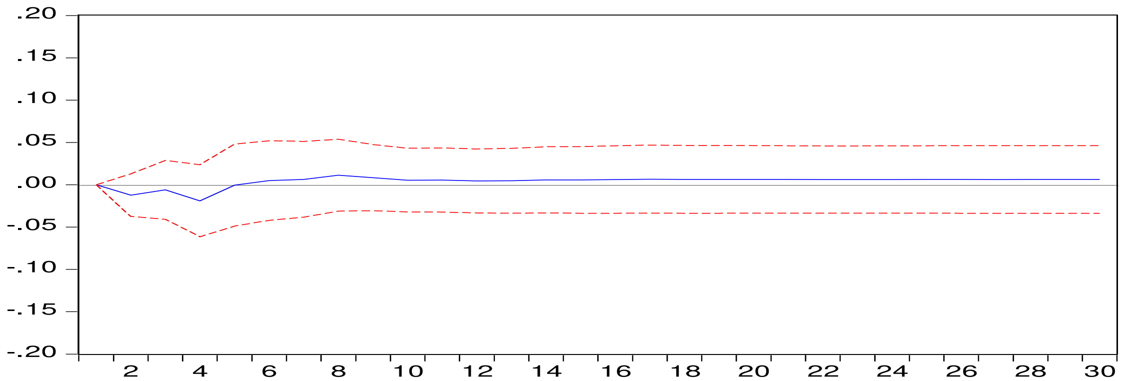

Figure 1a reports the accumulated responses of the CPI to a structural, one standard deviation shock of the exchange rate. This figure also includes one-standard error bands for each response, generated from a Monte Carlo integration simulation with 100 replications. Based on the estimated SVAR model parameters, we compute the accumulated impulse response functions of CPI to the variables in our model to all shocks. We analyze the impulse responses of exchange rate shock on consumer price inflation. Apart from measuring the size of the accumulated influence of unit shocks on the observed variables, the analysis of impulse responses also enables an estimate of the duration of shock absorption, exchange rate pass through elasticity and of the significance of a particular shock's influence on CPI to other variables.

Figure 1a shows that the initial impact of exchange rate depreciation on consumer prices is negative and remains so by the end of the 14 quarters. The size of the pass-through can be determined as the ratio of the accumulated response of the consumer price index to a 1% shock of the exchange rate. It can also be seen as the accumulated response of the structural one standard deviation shock to the exchange rate on consumer prices in period *t*.

Figures 1a and b show that monetary policy and nominal exchange rate shocks have a significant and continuous effect on domestic consumer prices. A sudden and transitory rise in the short-term monetary policy rate is accompanied by an increase in prices, with the impact taking off between 2 and 12 quarters after the shock (see figure 1b). A sudden and transitory rise in the nominal exchange rate implies appreciation and is accompanied by a decrease in domestic consumer prices, with the impact taking off between 4 and 14 quarters (see figure 1a).

Figure 1c shows the effect of monetary policy rate on exchange rate. The structural one standard deviation shock of monetary policy to exchange rate is positive and persistent. The exchange rate depreciates initially between 2 and 6 quarters. Later, the exchange rate appreciates slightly and leads to an increase in consumer prices. The effect of the exchange rate innovation on domestic prices is larger with an impact elasticity of 0.90. The speed is higher than that of monetary policy shock whose impact elasticity is 0.17 (see Figure 1a and b). This high impact elasticity of exchange rate to the consumer prices is shown in figure 1a in the above graph.

Table 1: Estimates From Variance Decomposition Response of Inflation

Forecast Horizon	***S.E***	***Output***	***M2***	***MPR***	***EX***	***CPI***
T=1	0.036170	9.728035	3.029660	3.542787	4.031100	79.66842
T=2	0.043652	15.40920	9.804392	4.539921	5.489247	64.75724
T=4	0.046531	15.16691	17.09885	4.853138	4.989612	57.89149
T=8	0.053696	20.47062	19.84670	5.007071	4.371980	50.30363
T=16	0.056299	23.40071	20.39371	4.626016	4.203287	47.37627
T=24	0.056616	23.93225	20.32772	4.584551	4.170196	46.98529

S.E denotes standard error; forecast horizon refers to a quarter. A 24-quarter forecast horizon is considered.

Now we begin by investigating the importance of ERPT for consumer price fluctuations. The variance decomposition of inflation indicates that short run dynamics in consumer price inflation are explained mostly by its own fluctuations, followed by output shocks and money supply shock. The weight of its own shock ranges from over 79.6% to 46.9%. This percentage declines as the forecast horizon increases. The percentage of variance explained by exchange rates shock is quite low, ranging from 4% to 4.1%. Output shocks account for about 9.7 percent of the variation in consumer price inflation within the first quarter. Innovations in the monetary policy rate and money supply account for 3 and 3.5 percent of the variation in CPI within the same period, whereas the exchange rate changes explain 4 percent of this variation. In the medium term (e.g., by the eighth quarter), output and money supply shocks account for about 20.4 and 19.8 percent of the inflation variance. They become the second and third most significant explanatory factor in explaining the price index after its own shocks. Within a 24 quarter interval, output shocks explain about 23.9 percent of the consumer price inflation dynamics in Nigeria. Money supply, the monetary policy rate, and the exchange rate explain about 20.3%, 4.5%, and 4.1% percent respectively.

The output shocks explain much of the short-run variations in consumer price inflation which characterizes Nigeria as a rapidly growing economy. The explanation for the relatively high consumer price inflation is that aggregate demand rises over time at a faster pace than the full employment level of real output. The initial effect is the wealth effect which says that a rise in the price level will make people who have money and other financial assets to feel poorer and cause them to buy less. Nigerian residents want to buy cheaper-priced foreign goods, causing a fall in exports and a rise in imports (Foreign Sector Effect). This will lead to a reduction in net trade and, consequently, aggregate demand. The fall in aggregate demand may, in turn, affect the external balance of Nigeria in the medium and long term. Similarly, another consequence is the interest rate effect. That is, a rise in the price level because of output shocks causes a rise in inflation. The rise in demand for money causes a rise in interest rates with a deflationary effect on the economy. This assumes that the central bank (in our case the central bank of Nigeria) is setting monetary policy rates in order to meet a specified inflation target. This explains the adoption of lite inflation targeting in the Nigerian economy.

5. Conclusion

The results from the impulse response show that the ERPT to consumer price inflation in Nigeria remains incomplete and is relatively low. Moreover, the speed of adjustment to structural shocks, such as the exchange rate, output, monetary policy rate, and money supply shocks is high. The effects of such shocks are highly volatile and therefore can potentially distort the status quo. The results from the forecast variance decomposition analysis show that the consumer price inflation own shocks, positive money supply shocks, and output shocks retain dominance over other factors in explaining consumer price inflation in the Nigerian economy. Monetary policy credibility is crucial in order to reap the benefits of lower pass through. This credibility is linked with the choice of low inflation regime. We focus on the innovations (shocks) of money supply on the rest of the variables. Our results reveal that monetary policy contraction causes a small downward response in the price level as well as an increase in the short and long run monetary policy rates. This further causes aggregate output to increase and the exchange rate to depreciate. The results suggest that monetary policy has a limited persistent influence on the CPI. Although we cannot comment on monetary policy credibility, the results do not cast doubt on whether monetary policy tightening is effective and useful in controlling the evolution of consumer price inflation in the Nigerian economy. A long lasting and significant inflation reduction might require strong tightening of monetary policy, causing stability in price level at least in the short run.

In restoring international competitiveness in order to achieve financial integration in the global economy, Nigeria more than ever must find an effective monetary policy. More particularly, the monetary authority should adopt inflation targeting fully. This will bring inflation expectations down. Thereby, the expectations channels will become credible and stronger, which will in turn make the effects of monetary policy more anticipated and will thereby require less aggressive monetary policy rate changes. Such credibility will help monetary policy to become more reliable in achieving both internal and external balance.

References

Aliyu, S.U.R., Yakub, M.U., Sanni, G.K. and Duke, O.O. (2009). “Exchange Rate Pass-Through in Nigeria: Evidence from a Vector Error Correction Model” *MPRA Paper, JEL Classification: F31, F41.*

Adedayo, O. Adelowokan, (2012).” Exchange rate Pass through in Nigeria: A Dynamic Evidence” *European Journal of Humanities, Vol.16*

Bailliu, J., & Fujii, E. (2004).”Exchange Rate Pass-Through and the Inflation Environment in Industrialized Countries”: An Empirical Investigation. Bank of Canada, *Working Paper 2004–21.*

Bache, I. Wolden. (2007). “Econometrics of Exchange Rate Pass through.” *Doctoral Dissertation in Economics, Norges Bank.*

Bernanke, Ben. S. (1986). “Alternative explanations of the money-income correlation:” *Carnegie-Rochester Conference Series on Public Policy, 25: 49–99.*

Blanchard, Oliver J. and Danny Quah (1989). ‘The Dynamic Effects of Aggregate Demand and Supply Disturbances” *American Economic Review, 79(4): 655-673.*

Campa, Jose and Linda Goldberg. (2005). “Distribution Margins, Imported Inputs, and the Insensitivity of the CPI to Exchange Rates” *Manuscript.*

Campa, Jose and Linda Godlberg. (2002). “Exchange Rate Pass-through into import prices: a Macro or Micro Phenomenon” *NBER Working paper 8934, May.*

Ca'zorzi, M, Hahn, E and Sanchez, M, (2007). “Exchange rate pass-through in Emerging markets” European Central Bank, *Working Paper Series No. 739.*

Choudhri, E. and Hakura, D. (2006). “Exchange Rate Pass-Through to Domestic Prices: Does the Inflationary Environment Matter”? *Journal of International Money and Finance, 25, 614-639.*

Choudhri, Ehsan U., and Dalia S. Hakura, (2001). “Exchange Rate Pass-Through to CPI: Does the Inflationary Environment Matter?” *IMF Working Paper 01/194 (Washington: International Monetary Fund).*

Faruqee. Hamid, (2004). “Measuring the Trade Effects of the EMU” *International Monetary Fund Working Paper WP/04/154.*

Hussain et al. (2017). “Oil and Non-Oil Foreign Direct Investment and Economic Growth in Nigeria: An Empirical Evidence from Autoregressive Distributed Lag Model” American *Journal of Economics, 7(4): 194-200 DOI: 10.5923/j.economics.20170704.05*

Hyder, Z and Shah, S. (2004). “Exchange Rate Pass-through to Domestic Prices in Pakistan. State Bank of Pakistan, *Working Paper No.5.*

Ito, T and Sato, Kiyatak. (2007). “Exchange Rate Pass Through and Domestic Inflation: A comparison Between East Asia and Latin American Countries” *Research Institute of Economy, Trade and Industry, Papers Series 07-E-040*

Lafleche, Thérèse (1996).” The Impact of Exchange Rate Movements on Consumer Prices” *Bank of Canada Review Winter 1996-1997, 21-32.*

Lutkepohl, H. (1991). Introduction to Multiple Time Series Analysis. *Berlin, Springer-Verlag.*

Marazzi, Mario, Nathan Sheets, and Robert Vigfusson. (2005). "Exchange Rate Pass Through to US Import Prices: Some New Evidence" *Federal Reserve Board of Governors, International Finance Discussion Paper no: 833, April.*

MacKinnon, James. G. (2005). "Bootstrap Methods in Econometrics" *Department of Economics Queen's University Kingston, Ontario, Canada, http://www.econ.queensu.ca/faculty/mackinnon/ K7L 3N6,*

McCarthy, Jonathan. (2000). "Pass-Through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialized Economies" *Federal Reserve Bank of New York Staff Report No; 111 (September).*

Mohammed et al. (2017). "Exchange Rate Pass through to Consumer Price in Nigeria and Taylor's Hypothesis: A Structural Vector Auto Regression Analysis", *American Journal of Economics, 7(5): 201-210 DOI: 10.5923/j.economics.20170705.01*

Mwase, N. (2006). "An Empirical Investigation of the Exchange Rate Pass-through to Inflation in Tanzania." *IMF Working Paper 150.*

Razafimahefa, I.F. (2012). "Exchange rate pass-through in sub-Saharan African economies and its determinants", IMF Working Papers, WP/12/141, International Monetary Fund.

Sahminan, (2002). "Exchange Rate Pass-Through into Import Prices: Empirical Evidences from Some Southeast Asian Countries" *Mimeo.*

Sanusi, A. R. (2010). "Exchange Rate Pass Through To Consumer Prices In Ghana: Evidence from Structural Vector Auto Regression" *MPRA Paper, No, 29491 March 2011.*

Smets, F., Wouters, R. (2007). Shocks and frictions in US Business cycles: A Bayesian DSGE Approach. *American Economic Review 97(3), 586–606*

Takhtamanova, Y. (2008). "Understanding Changes in Exchange Rate Pass-Through Federal Reserve Bank of San Francisco" *Working Paper 2008-13 Federal Reserve Bank of San Francisco, San Francisco.*

Taylor, John B. (2000). "Low Inflation, Pass-Through, and the Pricing Power of Firms" *European Economic Review, June volume 44 issue 7 pp. 1389-1408.*

APPENDIX A

Table A1; VAR Residual Covariance Matrix

	DLN_Y_	DLN_M2_	DLN_MPR_	DLN_NEER_	DLN_CPI_
DLN_Y_	0.010761	0.000128	0.000788	-0.004415	0.001170
DLN_M2_	0.000128	0.003697	-0.000735	-0.000319	0.000397
DLN_MPR_	0.000788	-0.000735	0.014767	-0.000585	0.000830
DLN_NEER_	0.004415	-0.000319	-0.000585	0.009707	-0.001170
DLN_CPI_	0.001170	0.000397	0.000830	-0.001170	0.001308

Table A2; VAR Residual Correlation Matrix

	DLN_Y_	DLN_M2_	DLN_MPR_	DLN_NEER_	DLN_CPI_
DLN_Y_	1.000000	0.020365	0.062527	-0.431947	0.311898
DLN_M2_	0.020365	1.000000	-0.099454	-0.053308	0.180375
DLN_MPR_	0.062527	-0.099454	1.000000	-0.048837	0.188861
DLN_NEER_	0.431947	-0.053308	-0.048837	1.000000	-0.328241
DLN_CPI_	0.311898	0.180375	0.188861	-0.328241	1.000000

Table A3: Estimated Accumulated Impulse Response of Consumer Price Level to Structural One Standard Deviation Shocks

Forecast Horizon	*Output*	*Broad Money*	*Monetary Policy Rate*	*Exchange Rate*	*Consumer Prices*
T=1	0.011281	0.006296	0.006808	-0.007262	0.032285
T=4	0.022333	0.036756	0.018056	-0.013173	0.049138
T=8	0.041431	0.064271	0.019595	-0.020441	0.067574
T=12	0.051812	0.079388	0.019547	-0.024960	0.076048
T=14	0.059318	0.082228	0.020592	-0.026600	0.080580
STRUCTURAL SD	0.103736	0.060793	0.120661	0.088714	0.032285

Notes A1; LR test for over-identification; Testing for Contemporaneous Correlation of Shocks

LR (H0/H1) = $2(l_u - l_r)$ *which is* χ^2 *distributed with 5 DF.*

Where l_u denotes the maximum likelihood under *H0* (unrestricted model) and l_r denotes the maximum likelihood for the (restricted model) model under *H1*.

Hypothesis

H0; restrictions are not valid, that is $\eta_{12}\ \eta_{13}\ \eta_{14}\ \eta_{15}\ \eta_{23}\ \eta_{24}\ \eta_{25}\ \eta_{45}\eta_{34}\ \eta_{35} = 0$

H1; restrictions are valid, that is$\eta_{12}\ \eta_{13}\ \eta_{14}\ \eta_{15}\ \eta_{23}\ \eta_{24}\ \eta_{25}\ \eta_{45}\eta_{34}\ \eta_{35} \neq 0$

LR= 2(676.5863-617.9432) =117.2862

The 5 percent critical value, with degree of freedom 5 indicates χ^2 value = 11.07

LR> CHISQUARE VALUE = 117.2862>11.07

The LR statistics is greater than the critical value. So we reject the null hypothesis that the restrictions are not valid. Therefore we can accept the imposed identification restrictions within matrix B^{-1}. This suggests shocks in the entire equations have contemporaneous correlation in the system.