Cross-Border Transmission of Interest Rate Shocks:
A VAR Analysis of the Nigerian Economy

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Abstract
This paper examined if interest rate shocks from the U.S are transmitted to Nigeria. For this purpose, we collected data on four Nigerian variables (real GDP, CPI, exchange rate and interest rate) and two foreign variables (U.S FFR and the world CPI) for the period 1983-2011. The impulse response analysis of our VAR model shows that Nigerian variables respond insignificantly to shocks from foreign variables. We therefore concluded that shocks in Nigeria are basically home-made. We recommended that monetary authorities in Nigeria should base their policy making on domestic shocks, as considering external factors might mislead them.
Keywords: Interest rate shock, International transmission, Nigeria, U.S.A., VAR.

1. Introduction

The macroeconomic effects of monetary policies can no longer be over emphasized. It is globally argued that in the era of globalization, macroeconomic policies (fiscal and monetary) implemented in one country can affect some other countries, either positively or negatively. This issue brought on focus, the study of the international transmission of monetary shocks. Over the decades, one of the major problems facing monetary economists across the globe, especially the developing countries has been the macroeconomic effects of interest rate changes. Interest rate is a major macroeconomic variable whose changes contribute immensely towards determining the position of every economy. Hence, it is traditionally believed that how a child behaves is always a function of how his/her parent(s) or elders behave. Consider a Nigerian resident entrepreneur who has enough money to invest in the home country. On the verge of making this investment, the United States' Federal Reserve announces an increase in interest rate. Conventionally, the positive slope of the LM curve would require a corresponding increase in output of the United States. Why? Because globalization and its accompanying openness of national borders is expected to allow into the U.S., free inflow of investment capital, due to high interest rate. Consequently, the prospective Nigerian investor may automatically be expected to move his investment fund to the United States. The immediate effect of this financial cross over is an increase in the output of the United States and a decrease in Nigeria's output. The decrease in Nigeria's output would immediately take the country's supply below its demand thereby causing demand-pull inflation. However, after several macroeconomic analysis and eventual confirmation of the causes of the inflation, the central bank of Nigeria in an attempt to curb inflation via output increase, may be expected to co-move with the United States by also increasing its interest rate. When this is done, foreign investors are attracted into Nigeria. This would also increase Nigeria's output.

In 2008, Nigeria had her interest rate increased from 10.3% to 12.0%. During this period, the interest rate of the United States reduced from 5.02 to 1.92 percent. In 2009, during which the United States interest rate decreased further to 0.19%, Nigeria's interest rate remained on its path as it increased further to 13.3%. Between 2008 and 2010, Nigeria experienced great increase in the rate at which her GDP grew (from 6.0% in 2008 to 7.0% in 2009 and then 7.8% in 2010). In 2011, there was a slight fall in the rate to 6.7%. Nigeria's inflation rate increased from 11.6% in 2008 to 12.5% in 2009 and then 13.7% in 2010 before decreasing to 10.2% in 2011.

Consequent to the analysis above, if we should follow the argument of Edwards (2010), that interest rate hikes by the Federal Reserve contributed significantly to some of the most important currency crisis in recent times, such as the Mexican Tequila crisis of 1994-1995 and the Argentine Peso crisis of 2001-2002, it may not be unwise if we suspect that the same interest rate changes in the United States have contributed to major changes (fluctuations) in some developing countries' (Nigeria in particular) macroeconomic indicators, including interest rates, prices and output.

Research wise, the macroeconomic implication of such claims made by Edwards (2010) have led to some empirical studies aimed at understanding the way in which possible reforms in the international financial architecture affect different countries. Most of these studies were carried out using data for the developed and developing countries of Europe, Asia and America. Currently there is no such study completed for the Nigerian economy, despite huge macroeconomic volatility in the country. Hence, the problem at hand is whether or not the interest rate changes in the advanced countries are transmitted to the underdeveloped countries, in this paper proxied by Nigeria. In responding to the above stated problem, this paper seeks to:

- ascertain if Nigeria's interest rates respond to interest rate shocks in the United States?
- find out if interest rate shocks in the United States affect other basic macroeconomic variables of the Nigerian economy.

2. Literature Review

Transmission effects of shocks across international borders have been experimented in many theoretical and empirical works with varied range of predictions. The small-open economy model of Mundell-Fleming-Dornbusch has continued to be of influence in academic and political circles till the mid 1990s. Theoretically, Obstfeld and Rogoff (1995) assume that the purchasing power parity (PPP) always holds. As a result, the real interest rate parity holds between two countries. They predict that the domestic monetary shocks raise the level of domestic output but show an ambiguous effect on foreign output. A large empirical literature has investigated the international transmission of monetary and non-monetary shocks using small-scale structural Vector Auto-Regression (VAR) models. Clarida and Gali (1994) identified sources of real exchange rate fluctuations for post-Bretton Woods period for U.S., Japan, Germany, and Canada. The estimation of structural VAR in their study produced consistent results with the predictions of the Mundell-Fleming model showing that demand shocks lead to appreciation and monetary shocks leading to depreciation of the home currency. Eichenbaum and Evans (1995) also found the results similar to Clarida and Gali (1994). Kim (2001), on the other hand, estimated structural VAR to identify unidirectional effect of the US monetary policy shocks to the macroeconomic variables of G-7 countries and found that the U.S. monetary expansion has a positive spillover effects on real GDP and industrial production of non-U.S. G-6 countries. Other studies that found evidence of cross border transmission of monetary policies include Läufer K. and Sundararajan S. (1994), Peek and Rosengren (1996), Selover (1998), Canover, Jensen, and Johnson (1999), Forbes and Rigobon (1999), Kollman (1999), Frankel, Schmukler, and Serven (2000), Reinhart and Reinhart (2001), Reside (2004), Campa and Goldberg (2005) as well as Boivin and Giannoni (2006) among others. Studies that are either not in support or not in full support of international monetary transmission include Schmitt-Grohe (1997), Geiregat (2004) and Sahminan (2005).

From the literature reviewed, it is observed that the empirical findings of different researchers vary overtime. For a more acceptable and consensus result and conclusion, further studies need to be carried out for different economies with different economic conditions. However, since most of the existing studies in this area of international Monetary Economics were done using data for the advanced and developing countries of Europe, Asia and America, this study is an attempt at doing the same using data for the Nigerian economy.

3. Methodological Issues

3.1: The model:

It is globally argued that in the era of globalization, monetary policies implemented in one country (numeraire country) can affect some other countries, either positively or negatively. Based on this argument, Central Banks are always interested in determining the extent to which their countries' domestic interest rates diverge from world interest rates. Hence, the vital variable in this study is the differential between the Nigeria's interest rate and U.S. interest rate properly adjusted by country risk and currency risk. Specifically, interest rate differential is defined as:

$$e_t = r_t - r_t^* - \theta_t - \varepsilon_t \dots\dots\dots\dots\dots\dots\dots (1)$$

where r_t is the domestic currency nominal interest rate for securities of a certain maturity.

r_t^* is the international, nominal interest rate on foreign currency denominated securities of the same maturity.

θ_t is the expected rate of depreciation of the domestic currency,

ε_t is a measure of country risk.

However, the steady state equilibrium with perfect capital mobility requires that the interest rate differential should be approximately zero (see Ezeibe, 2008: unpublished). In this case, the speed at which convergence to long term equilibrium takes place is purely a function of specific countries' conditions, but under free capital mobility, should rather be very fast. Hence, in steady state equilibrium,

$$e = e^* \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where **e*** is the domestic interest rate.

The possibility of finding an equation (2) that is different from zero can only be determined empirically. It is only a function of several variables such as, degree of capital mobility and other forms of market frictions and transaction costs. With full capital mobility and in the absence of transaction costs of any form, we would expect that e^* would be approximately zero.

However, the most important issue we seek to address in this study is whether e^* is actually a function of international interest rate, proxied by the United States of America (numeraire country) Federal Fund Rate. Hence,

$$e^*_{it} = \beta_0 + \beta_1 FFR_t + \sum_{j=1}^{m} \rho_i K_{it} + \omega_t \ldots\ldots\ldots\ldots\ldots(3)$$

where FFR is the level of U.S. Federal Fund Interest Rates.

e^*_{it} is Nigeria's policy interest rates at time t. (i represents Nigeria)

β_0, β_1 and ρ_i are coefficients,

K_{it} is a vector of other possible determinants of e^*_{it}

ω_t is still an error term with its usual characteristics.

However, following Mojon and Peersman (2001), Frankel, et al, (2004), etc, we have decided to represent the set of other determinants of e^*_{it} (K_{it}) by world consumer price index. The use of price is important because it is related to the concept of monetary independence. Moreover, it is believed that much of the variations in nominal interest rates could just reflect variations in inflation differentials (Frankel, et al: 2004). It also helps to solve the so-called price puzzle: empirical finding in the Vector Autoregression (VAR) methodology literature that prices rise following an interest rate tightening (Mojon and Peersman, 2001). As a result, equation (3) could be transformed into:

$$e^*_{it} = \alpha + \beta FFR_t + \Psi WCPI_{it} + \gamma_{it} \ldots\ldots\ldots\ldots\ldots(4)$$

Where $WCPI_{it}$ represents the world consumer price index

γ_{it} is still an error term with zero mean and independently distributed across countries at different times, t.

α, β and Ψ are coefficients.

However, to examine if interest rate shocks in the United States affects other macroeconomic variables in Nigeria, we introduce the Structural Vector Autoregressive (SVAR) methodology used by Weber, etal (2011) to identify the monetary policy shocks in the Euro area.

The Baseline VAR Model.

Vector Autoregressive (VAR) models are widely used in the empirical analysis of monetary policy transmission. This methodology has undoubtedly the merit of avoiding the need for a complete specification of a structural model of the economy (Bagliano and Favero, 1997). Evidence from literature shows the methodology to be appropriate in measuring the impact of monetary policy shocks on macroeconomic performance of countries.

In this study, our interest is in ascertaining if interest rate shocks in the United States (U.S.A) are transmitted to Nigeria. As such, we proceed on a bilateral basis with the USA on one side and Nigeria on the other side. In our setup, any correlation between the USA and Nigeria is likely to be unidirectional. Consequent to this, the specification and the estimation of the statistical model could be significantly simplified (Canova, 2005)

In order to reflect the above setup in our model, we assume a block-exogenous VAR model in which the foreign variables (FFR and WCPI) are treated as exogenous to Nigerian variables. In other words, these exogenous foreign variables influence Nigerian variables but there is no feedback from Nigerian variables to these foreign variables. We therefore make allowance for a contemporaneous impact of these exogenous variables on the endogenous Nigerian variables. Moreover, the construction of a block-exogenous VAR model saves the degree of freedom. Therefore, using the content of equation (4) in specifying a SVAR model and introducing to the left-hand side other Nigerian macroeconomic variables yields equation (5). In (5), Z^{FR} is a vector of foreign variables

(FFR and WCPI) while Z^{NIG} is a vector of endogenous Nigerian variables (we shall define these variables later).

$$Z_{it} = \begin{bmatrix} Z_t^{FR} \\ Z_t^{NIG} \end{bmatrix}, \quad A(L) = \begin{bmatrix} A_{11}(L) & 0 \\ A_{21}(L) & A_{22}(L) \end{bmatrix}, \quad \mu_{it} = \begin{bmatrix} \mu_t^{FR} \\ \mu_t^{NIG} \end{bmatrix} \ldots\ldots\ldots\ldots\ldots(5)$$

where Z_t^{FR} and μ_t^{FR} are $m_1 * 1$ vectors, Z_t^{NIG} and μ_t^{NIG} are $m_2 * 1$ vectors, $A_{11}(L)$ is an $m_1 * m_1$ matrix, $A_{21}(L)$ is an $m_2 * m_1$ matrix, and $A_{22}(L)$ is an $m_2 * m_2$ matrix.

L is a lag operator.

However, due to parameter identification problems associated with the SVAR models, Ordinary Least Squares (OLS) estimation of the models yields inconsistent parameter estimates. This problem can be averted by re-writing the SVAR model (5) in a reduced form thus:

$$Z_{it} = \begin{bmatrix} RGDP_{it} \\ CPR_{it} \\ HEXR_{it} \\ HINT_{it} \end{bmatrix} = \alpha_1 + \alpha_2(L)Z_{it-1} + \beta_j \begin{bmatrix} WCPI_t \\ FFR_t \end{bmatrix} + \mu_{it} \ldots\ldots\ldots(6)$$

where HINT replaces e^* as Nigeria's interest rate. Z is a vector of endogenous variables and i represent Nigeria. Here, our baseline model consists of four endogenous and two exogenous variables for the home country, Nigeria. The endogenous variables are the country's key macroeconomic indicators of real gross domestic product (RG*DP)*; consumer prices (CPI); exchange rate (HEXR) and interest rate (HINT)**.** These endogenous variables depend on their own lags and a constant term. The exogenous variables included in the model are the already defined WCPI and FFR which as indicated earlier, are expected to have contemporaneous impact on the endogenous variables.

The objectives of this study would be achieved by estimating the VAR equation (6) and analysing the Impulse Response Functions (IRF). Traditionally, the IRF have been widely used as a means of analysing an estimated VAR model (Hamilton, 1994). Here, the IRF is expected to expose the degree to which domestic interest rates responds to shocks in foreign interest rate as well as how other domestic macroeconomic variables respond to foreign interest rate.

3.2: Data

The all items annual averages of Consumer Price Indices (CPI) are used as proxies for measuring the price levels of Nigeria's output. The United States is considered as the foreign country. All CPI data were obtained from the International Monetary Fund (IMF) World Economic Outlook database. The interest rate data of the USA were obtained direct from the U.S. Bureau of Labour Statistics (BLS), while all other dataset were obtained from the World Bank. All series are annual and span the period, 1983-2011. The choice of the period is based on data availability.

4. **Empirical Result.**

Our results reflect the response of this country to an interest rate policy shock in the United States which is identified as a one-standard-error increase in the Federal Fund Rate (FFR). The result further shows the response of this country's variables to shocks in the global consumer prices.

Table 1: Response of Nigerian variables to foreign shocks

	RGDP	CPI	HEXR	HINT
FFR	↔	↔	↔	↔
WCPI	↔	↔	↔	↔

NB: Two sided arrows denote insignificant responses of the endogenous variables to shocks in the exogenous variables.

In Nigeria, interest rate shocks in the United States as well as global consumer price shocks have almost no impact on the economy. The result of the impulse response analysis conducted using the Nigerian and foreign

data are summarized in table 1 above.

The country's output responded positively to United States interest rate shock for roughly six years (see figure A of the appendix). After the sixth year, it responded negatively for about eight years before going positive once again and later negative towards the end of our sample period. For about ten years, consumer prices in Nigeria responded negatively to interest rate shocks from the United States. Evidence from figure C of the appendix has shown that the response later turned positive after the tenth year. It responded positively for about ten years before returning to negative, a characteristic it possessed for the remainder of our sample period. Though not in the same magnitude, Nigerian exchange rate responded in the same manner as her consumer prices. Figure E of the appendix shows that exchange rate responded negatively for about six years before responding positively for another eight years. Nigeria's interest rate responded positively to foreign interest rate for about fifteen years from the beginning of our sample period (see figure G of the appendix). The variable later responded negatively for about nine years before slightly responding positively once again.

Evidence from figure B of the appendix shows that Nigeria's output (RGDP) responded positively to the global consumer price shock for about four years. After four years, it had a negative response for the next four years. The zigzag movement continued throughout the period covered in our study. For about three years from the beginning of our sample period, consumer prices in Nigeria did not respond to global consumer price shock (see figure D of the appendix). This may be attributed to low importation of foreign goods into the country. However, after the third year, there were positive responses, which continued for the next five years before becoming negative. There were fluctuations (from negative to positive) throughout the remainder of our study period. Figure F of the same appendix shows how exchange rate of Nigeria responds to global consumer price shocks. For the first five years of our sample space, the variable (HEXR) responded negatively before moving the positive direction where it stayed for another four years. Just like the other variables of the country, there were fluctuations around the zero line until the end of our study period. Prior to the fourteenth year of our sample, Nigeria's interest rate responded only slightly (negative and positive) to the global consumer price shock (see figure H of the appendix).

In summary, Nigeria's economy in general, responded insignificantly to foreign shocks. The impulse response analyses as presented in the appendix revealed this. This may imply that severe macroeconomic volatility in the country has only little to do with the external sector. The greater portion of our suffering is as a result of our sins.

5. Conclusion and Policy Recommendation

Our study investigated the transmission of United States interest rate shocks to Nigeria using a VAR approach. We found that the macroeconomic variables of the Nigerian economy responded only insignificantly to the foreign variables' shocks. Overall, our findings suggest that the Nigerian economy is not highly responsive to foreign shocks. However, this may imply that the huge macroeconomic volatility experienced by the country are home-made. Only an insignificant proportion of the domestic shocks can be linked to external shocks (shocks transmitted from advanced countries or even non-advanced trading partners).

Based on the findings of this study and the conclusion that followed, we hereby recommend that monetary authorities in Nigeria should continue with independent monetary policy making, especially as it concern interest rate control. By implication, they should ignore to a large extent what happens externally. They are expected to base their policy making on domestic shocks, as considering what happens in other countries might confuse policy makers in their decision making process. This is sequel to the fact that domestic variables responds insignificantly to foreign shocks. This recommendation is indeed in line with the view that the central issue for policy making in developing countries is how to stabilize the economy in response to foreign shocks provided that those foreign shocks have impacts on the developing countries. In Nigeria, they do have impacts but insignificantly.


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Appendix: Impulse Response Functions
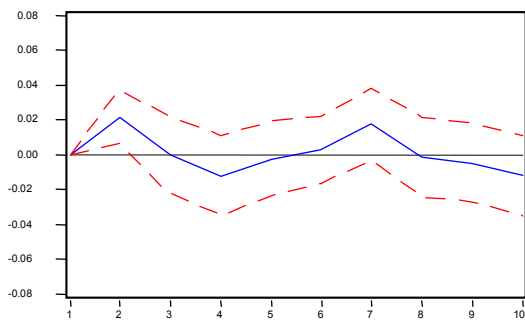
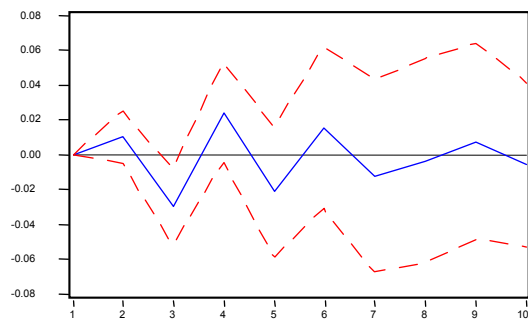| RESPONSE TO FFR	RESPONSE TO WCPI
FIG. A: RGDP	FIG. B: RGDP
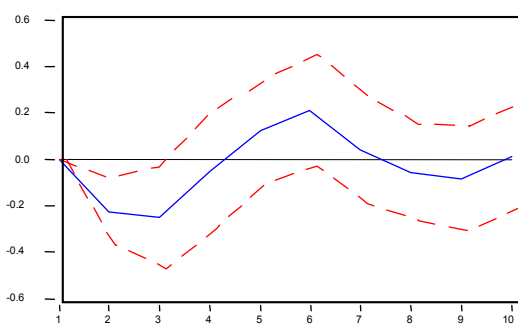
FIG. C: CPI	FIG. D: CPI
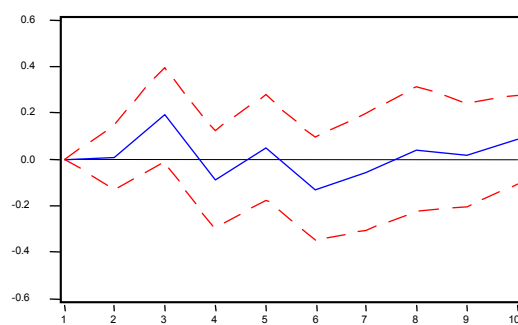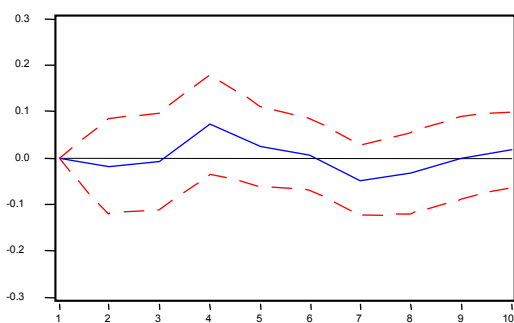
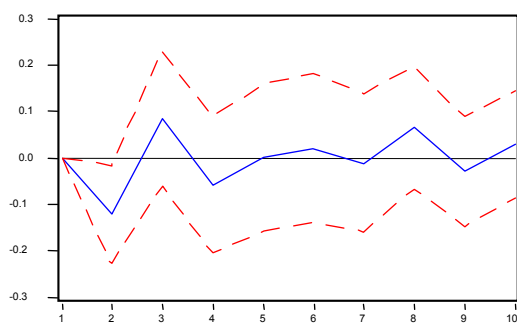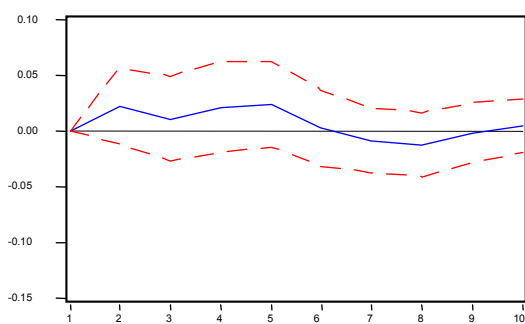| FIG. E: HEXR	FIG. F: HEXR

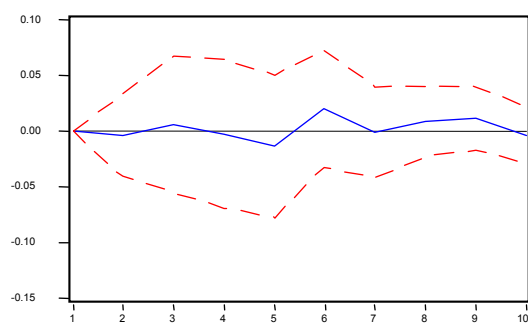| FIG. G: HINT	FIG. H: HINT

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