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OUTPUT, INFLATION, AND EXCHANGE RATE IN DEVELOPING COUNTRIES: AN APPLICATION TO NIGERIA

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I. INTRODUCTION

UNDERSTANDING the sources of fluctuations in output and inflation is an important challenge to empirical macroeconomists. It is an issue taken up in a large number of recent studies in the developed nations, Latin America, and Asian countries.[1] At the core of this issue is whether or not stabilization without recession is possible. While some theoretical models suggest that stabilization could be expansionary particularly for high inflation countries,[2] others argue that stabilization without recession is rather difficult to achieve.

The three major explanations of inflation include fiscal, monetary, and balance of payments aspects. While in the monetary aspect inflation is considered to be due to an increase in money supply, in the fiscal aspect, budget deficits are the fundamental cause of inflation in countries with prolonged high inflation. However, the fiscal aspect is closely linked to monetary explanations of inflation since government deficits are often financed by money creation in developing countries. In the balance of payments aspect, emphasis is placed on the exchange rate. Simply, the exchange rate collapses bring about inflation either through higher import prices and increase in inflationary expectations which are often accommodated or through an accelerated wage indexation mechanism.[3]

Several attempts have been made to conduct systematic econometric studies on the movements in output and inflation and their dynamics in Nigeria. However, many of these earlier studies were based on either simulation analysis or regression

[1] Some of the recent studies in the area were reported by Roemer (1989), Weir (1986), Shapiro (1988), Balke and Gordon (1989), James (1993), Edwards (1989), Agénor (1991), Morley (1992), Rogers and Wang (1995), Santaella and Vela (1996), Kamin and Rogers (1997), and Kamin and Klau (1998).

[2] Even if this outcome is anticipated, credible "shock" treatment approaches to disinflation should be adopted.

[3] Details of theories can be obtained in the report of Sargent (1982).

approach. Our study deviates from the previous ones in Nigeria by the adoption of vector autoregression (VAR) and its structural variant in which movements in inflation and output are driven by several fundamental disturbances—monetary, exchange rates (official and parallel), interest rate, and income.

II. REVIEW OF RELATED STUDIES

There is a vast body of empirical literature on the impacts of devaluation on output and prices. In many of the existing studies, it has been recognized that the possible effects of devaluation on output could be contractionary. To this extent, several channels through which devaluation could be contractionary have been identified. First, Diaz-Alejandro (1965) examined the impacts of devaluation on some macroeconomic variables in Argentina for the period 1955–61. He observed that devaluation was contractionary for Argentina because it induces a shift in income distribution towards savers, which in turn depresses consumption and real absorption. He equally observed that current account improved because of the fall in absorption relative to output.

Cooper (1971) also reviewed twenty-four devaluation experiences involving nineteen different developing countries during the period 1959–66. The study showed that devaluation improved the trade balance of the devaluing country but that the economic activity often decreased in addition to an increase in inflation in the short term. In a similar vein, Gylfson and Schmid (1983) also constructed a log-linear macro model of an open economy for a sample of ten countries using different estimates of the key parameters of the model. Their results showed that devaluation was expansionary in eight out of ten countries investigated. Devaluation was found to be contractionary in two countries (the United Kingdom and Brazil). The main feature of the studies reviewed above is that they were based on simulation analyses.

The few studies on contractionary devaluation based on regression analysis include those of Edwards (1989), Agénor (1991), and Morley (1992). In a pool-time-series/cross-country sample, Edwards (1989) regressed the real GDP on measures of the nominal and real exchange rates, government spending, the terms of trade, and measures of money growth. He observed that devaluation tended to reduce the output in the short term even where other factors remained constant. His results for the long-term effect of a real devaluation were more mixed; but as a whole it was suggested that the initial contractionary effect was not reversed subsequently.

In the same way, Agénor (1991) using a sample of twenty-three developing countries, regressed output growth on contemporaneous and lagged levels of the real exchange rate and on deviations of actual changes from expected ones in the real exchange rate, government spending, the money supply, and foreign income. The results showed that surprises in real exchange rate depreciation actually boosted output growth, but that depreciations of the level of the real exchange rate exerted a contractionary effect.

Morley (1992) analyzed the effect of real exchange rates on output for twenty-eight devaluation experiences in developing countries using a regression framework. After the introduction of controls for factors that could simultaneously induce devaluation and reduce output including terms of trade, import growth, the money supply, and the fiscal balance, he observed that depreciation of the level of the real exchange rate reduced the output.

Kamin and Klau (1998) using an error correction technique estimated a regression equation linking the output to the real exchange rate for a group of twenty-seven countries. They did not find that devaluations were contractionary in the long term. Additionally, through the control of the sources of spurious correlation, reverse causality appeared to alternate the measured contractionary effect of devaluation in the short term although the effect persisted even after the introduction of controls.

Apart from the findings from simulation and regression analyses, results from VAR models, though not focused mainly on the effects of the exchange rate on the output per se, are equally informative. Ndung'u (1993) estimated a six-variable VAR—money supply, domestic price level, exchange rate index, foreign price index, real output, and the rate of interest—in an attempt to explain the inflation movement in Kenya. He observed that the rate of inflation and exchange rate explained each other. A similar conclusion was also reached in the extended version of this study (Ndung'u 1997).

Rodriguez and Diaz (1995) estimated a six-variable VAR—output growth, real wage growth, exchange rate depreciation, inflation, monetary growth, and the Solow residuals—in an attempt to decompose the movements of Peruvian output. They observed that output growth could mainly be explained by "own" shocks but was negatively affected by increases in exchange rate depreciation as well. Rogers and Wang (1995) obtained similar results for Mexico. In a five-variable VAR model—output, government spending, inflation, the real exchange rate, and money growth—most variations in the Mexican output resulted from "own" shocks. They however noted that exchange rate depreciations led to a decline in output.

Adopting the same methodology, though with slightly different variables, Copelman and Wermer (1996) reported that positive shocks to the rate of exchange rate depreciation significantly reduced a credit availability with a negative impact on the output. Surprisingly, they found that shocks to the level of the real exchange rate had no effects on the output, indicating that the contractionary effects of devaluation are more associated with the rate of change of the nominal exchange rate than with the level of the change of the real exchange rate. They equally observed that "own" shocks to real credit did not affect the output, implying that depreciation depressed the output through mechanisms other than the reduction of credit availability.

Besides, Kamin and Rogers (1997) and Santaella and Vela (1996) also noted that the depreciation shocks to some measures of exchange rate (real or nominal level or

rates of change) led to a decline of the output in Mexico. Hoffmaister and Vegh (1996) reached similar conclusions in a VAR model for Uruguay but unlike Copelman and Wermer, a negative shock to money strongly depressed the output.

Montiel (1989) utilized a five-variable VAR model—money, exchange rate, wages, prices, and income—to examine the sources of acceleration of inflation in Argentina, Brazil, and Israel. He concluded that among other key factors, exchange rate movements explained inflation in the three countries. Dornbusch, Sturzenbegger, and Wolf (1990) utilizing a three-variable VAR model (inflation, the real exchange rate, and a proxy for fiscal deficits) for several high inflation countries, found that the real exchange rate was an important source of inflation in Argentina, Brazil, Peru, and Mexico, but not in Bolivia.

Kamas (1995) study on Colombia extended the works of Montiel (1989) and Dornbusch, Sturzenbegger, and Wolf (1990) by separating the base money into domestic credit and reserves, with a view to identifying the domestic monetary impulses as well as analyzing their effects on the balance of payments. He observed that exchange rates did not play an important role in explaining the variation in inflation in Colombia and that inflation appeared to be primarily inertial with respect to the exchange rate but largely determined by demand shocks.

Khan (1989) applying two different econometric approaches—an atheoretical vector autoregression and a structural production function—concluded that the net effect of a decline in the value of the dollar is a temporary increase in inflation and real output, followed by a permanent reduction in output and level of real wages.

In several other studies the relationship between exchange rates and inflation has also been investigated. It was explicitly concluded that exchange rate devaluation is a major factor for the upsurge of inflation (Kamin 1996; Odedokun 1996; London 1989; Canetti and Greene 1991; Calvo, Reinhart, and Vegh 1994; Elbadawi 1990). Kamin (1996) showed that the level of the real exchange rate was a primary determinant of the rate of inflation in Mexico during the 1980s and 1990s while Calvo, Reinhart, and Vegh (1994) identified correlations between the temporary components of inflation and the real exchange rate in Brazil, Chile, and Colombia. Elbadawi (1990) also noted that precipitous depreciation of the parallel exchange rate exerted a significant effect on inflation in Uganda. Odedokun (1996), Canetti and Greene (1991), Egwaikhide, Chete, and Falokun (1994), and London (1989) reached similar conclusions for some selected African countries.

In conclusion, most of the econometric analyses indicated that devaluations (either increases in the level of the real exchange rate or in the rate of depreciation) were associated with a reduction in output and increase in inflation. The few VAR studies reviewed above equally supported the existence of a contractionary devaluation in the sampled countries.

However, we observed that most cases of contractionary devaluations had been focused on Latin America and other developed nations. Only few studies had been

conducted on the issue in sub-Saharan Africa, particularly Nigeria. More importantly, there are few data on contractionary devaluation in Nigeria based on regression and simulation analyses. Our study intends to demonstrate the existence of contractionary devaluation in Nigeria by applying the restricted vector autoregressive model, drawing from previous studies conducted in the other countries reviewed above. This approach may enable to identify other shocks that might exert important influences on output and inflation in Nigeria. To achieve this objective, a six-variable VAR was estimated (official exchange rate, parallel exchange rate, prices, income, money supply, and interest rate).

III. METHODOLOGY AND IDENTIFICATION OF RESTRICTIONS

First, we describe the econometric methodology applied. Thereafter, we specify the identification restrictions adopted to best capture the joint behavior of the market fundamentals in the Nigerian economy.

In this study, we adopted the approach of Blanchard and Watson (1986) and Bernanke (1986) among several others. The basic features of this approach are that it imposes restrictions on the contemporaneous causal relations. This approach is less restrictive than the straight-forward Cholesky decomposition adopted by Sims (1980), which requires a complete causal ordering of the endogenous variables. Bernanke's method of moments technique allows for not only some contemporaneous feedback relationships but all possible feedback impacts with lags, thus making it suitable for our studies.

A. *Methodology*

We are interested in the joint behavior through time of a vector of economic variables. The joint process of the variable can be written as:

$$X_t = \sum_{i=0}^{n} \mathbf{A}_i X_t + \mathbf{B}\mu_t, \tag{1}$$

where X is an $(n \times 1)$ vector of observations at time t on the economic variables under consideration (i.e., e = official exchange rate, r = interest rate, l = parallel exchange rate, y_x = real income, p = inflation, and m = money balances), $\mathbf{A}_i$ is a sequence of n-by-n matrices of coefficients. μ_t is an $(n \times 1)$ vector of disturbances to the system and $\mathbf{B}$ is an $(n \times n)$ matrix of coefficients relating the disturbances to the X vector.

The reduced form of the system can be written as:

$$X_t = \sum_{i=1}^{n} \mathbf{C}_i X_{t-1} + \varepsilon_t, \tag{2}$$

$$\varepsilon_t = G\mu_t,$$

where $\mathbf{C}_i = (1 - \mathbf{A}_0)^{-1}\mathbf{A}_i$ and $G = (1 - \mathbf{A}_0)^{-1}\mathbf{B}$. This is the form in which the VAR is estimated.[4] However, for policy analysis, restrictions on the structure of the $\mathbf{A}_0$ and $\mathbf{B}$ matrices must be imposed. To be able to recover the structural disturbance (μ_t) from the reduced-form disturbance (ε_t), we assume that $\mathbf{B}$ is a diagonal matrix while the $\mathbf{A}_0$ matrix is lower triangular (i.e., causal ordering among the variables).

The relationship between the structural and reduced-form disturbances can be given as:

$$\mu_t = \mathbf{B}^{-1}(1 - \mathbf{A}_0)\varepsilon_t. \tag{3}$$

If $\mathbf{B}$ is the identity matrix, then to calculate the structural disturbances we must have enough information to estimate the nonzero elements of $\mathbf{A}_0$ and the n unknown variances of the vector μ_t. The information available consists of the $n(n + 1)/2$ distinct sample covariances from the covariance matrix of the reduced-form residuals. The requirements that $\mathbf{A}_0$ be lower triangular, and that $\mathbf{B}$ be the identity matrix can be interpreted as an order condition for identification in that the number of nonzero elements of $\mathbf{A}_0$ must not exceed $n(n - 1)/2$; the number of degrees of freedom remaining once the n variables of the structural disturbances have been calculated.[5]

The technique involves first the estimation of the unrestricted VAR to obtain the estimates of the first step innovations. The model is identified by postulating a structure for $\mathbf{A}_0$ and is estimated using the method of moments (see Bernanke 1986).

Specifically consider[6]

$$\hat{\mathbf{Z}} = (1 - \hat{\mathbf{A}}_0)\mathbf{M}(1 - \hat{\mathbf{A}}_0)^1, \tag{4}$$

where $\hat{\mathbf{Z}} = \mu\mu'$ and $\mathbf{M} = (\Sigma\hat{\varepsilon}_{t\varepsilon}\hat{\varepsilon}_{t'\varepsilon})/T$ which are defined as estimated covariance matrix of fundamental shocks and the sample covariance matrix of the first-stage residuals respectively. The estimator selects elements of $\mathbf{A}_0$ such that the estimated covariance matrix of fundamental shocks, $\mathbf{Z}$, is a diagonal. As noted earlier, there are $n(n + 1)/2$ distinct elements of the symmetric matrix $\mathbf{M}$. Thus with n equation variances to estimate, in a just identified system, $n(n - 1)/2$ nonzero elements of the $\mathbf{A}_0$ matrix may be estimated.[7]

B. *Identification of Restrictions*

Before proceeding to the estimation of the VAR model in equation (3), we specify

[4] It is not possible to use the VAR in this form for the purpose of policy analysis, since the disturbances to the reduced form depend on the matrix of contemporaneous relationships among the variable of interest, $\mathbf{A}_0$, and the disturbance coefficient matrix $\mathbf{B}$.

[5] It is necessary to impose identification restrictions that limit Sims's claim (1980) to have developed an "atheoretical" method of conducting empirical macroeconomic research.

[6] Essentially equation (4) provides the relationship between the covariance matrix of the structural innovations and the matrices $\mathbf{B}$ and $\mathbf{A}_0$.

[7] For details of the estimation technique, one may consult the reports of Bernanke (1986), or Blanchard (1989), James (1993), and Fackler (1990).

the identification restrictions adopted to best capture the joint behavior of the market fundamentals in the Nigerian economy. The model specification is shown in equation (5).

$$\begin{vmatrix} \mu_e \\ \mu_r \\ \mu_1 \\ \mu_{yx} \\ \mu_p \\ \mu_m \end{vmatrix} = \begin{vmatrix} e_0 \\ r_0 \\ l_0 \\ y_{x0} \\ p_0 \\ m_0 \end{vmatrix} + \begin{vmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ a_{31} & 0 & 1 & a_{34} & 0 & 0 \\ 0 & a_{42} & a_{43} & 1 & a_{45} & 0 \\ a_{51} & 0 & a_{53} & a_{54} & 1 & a_{56} \\ a_{61} & 0 & a_{63} & a_{64} & a_{65} & 1 \end{vmatrix} \begin{vmatrix} \varepsilon_e \\ \varepsilon_r \\ \varepsilon_1 \\ \varepsilon_{yx} \\ \varepsilon_p \\ \varepsilon_m \end{vmatrix}. \quad (5)$$

where e_0, r_0, l_0, y_{x0}, p_0, and m_0 stand for constants of the six-vector variables mentioned earlier and a_{ij} represents coefficients. As pointed out from equation (5), innovations in the nominal exchange rate, ε_e, are entirely due to "own" shocks (i.e., the official exchange rate policy). By implication, this restriction shows that official exchange rate innovations do not depend on innovations from other variables in the model. Prior to the adoption of the Structural Adjustment Program in September 1986, Nigeria's exchange rate system was administratively managed (adjustable peg). The country's currency experienced a continuous appreciation (except for a few years), amidst a noticeable macroeconomic disequilibrium reflected in the bourgeoning non-oil trade deficit, balance of payments crisis, and fiscal deficits. Even when a free-floating exchange rate system was adopted, the monetary authorities were criticized for not allowing the market fundamentals to determine the operations of the market. The genuineness of these allegations is reflected in the ever-widening premium between the official and parallel exchange rates.[8] This was even more pronounced between 1993 and 1995 when the exchange rate was again controlled, resulting in the increase of the premium from 3.12 in 1992 to 24.30 and 68.37 in 1993 and 1995,[9] respectively. This margin was however narrowed down remarkably (to about 2.48) in 1995 when the autonomous foreign exchange system was introduced. Thus, the official exchange rate did not reflect the dictate of the market fundamentals.

Also, innovations in interest rates, ε_r, are assumed to respond contemporaneously to "own" shocks. For a larger part of the period under consideration, interest rates were administratively fixed. And even when they were deregulated, a particular problem with interest rate data in high-inflation countries like Nigeria is that it is

[8] By the parallel exchange rate, we refer to the black market exchange rate. Contrary to the official (i.e., government-recognized) exchange rate, the parallel exchange rate gained prominence among market agents because of the low transaction cost, absence of documentation, thereby making transactions faster, and absence of information disclosure, thus making it easily accessible. Whenever there is a boom in this market, it often reflects the gross inefficiency in the official market. Developments in this market usually reflect the dictate of market fundamentals.

[9] The figures covered the end of December in the respective years.

unlikely that the available interest rate series reflect market forces. This confidence problem is also reflected in the studies of Rogers and Wang (1995). Thus, we assume that innovations from other variables of interest do not affect interest rate innovations, except for "own" shocks.

In line with the dictates of market fundamentals, innovations in the parallel exchange rate respond contemporaneously to innovations in output, ε_y, official exchange rate, ε_e, and "own" shocks which reflect shocks (μ_l) to speculative capital movements as shown in the disturbances that reflect changes in investors' preferences as well as modifications of restrictions in international capital flow.

Innovations in output, ε_{yx}, are assumed to reflect the developments in the relationship between a family of saving and investment schedules (IS) curve, i.e., innovations in interest rate and inflation rate. They are again assumed to be influenced by the innovations in the parallel exchange rate and "own" shocks (μ_{yx}). Price setting equation allows price innovations, ε_p, to depend on changes originating in both goods and money markets (i.e., ε_y and ε_m). They are further assumed to be related to contemporaneous innovations in the official exchange rate (ε_e) and parallel exchange rate (ε_l), especially where imported inputs dominate the production process. Even where some economic agents are not directly involved in these operations, the markup pricing rule often associated with currency depreciation by traders could also affect the innovations in prices. They depend on the price-setting shocks (μ_p), which reflect such factors as changes in markups or in prices of inputs not included in the system, like labor costs and prices of utilities. Finally, money supply innovations are allowed to respond to innovations in the official exchange rate (ε_e), output (ε_{yx}), prices (ε_p) as well as to shocks in the monetary rule of the Central Bank of Nigeria (μ_m).

In line with the framework of Ndung'u (1993, 1997), Montiel (1989), Rodriguez and Diaz (1995), and Kamas (1995), this model emphasizes monetary factors. This does not imply that the effects of fiscal policy are negligible, but, following the argument of Sargent and Wallace (1981) according to which even where fiscal policy is dominant (and as the case in Nigeria), deficits are always monetized. Also, in connection with the empirical strategy used in this paper, Hoffmaister, Roldos, and Wickham (1997) assumed that in the long term the impact of fiscal policy on output is negligible and not appreciably different from zero. This, therefore, is in agreement with the argument of Blanchard and Quah (1989) who stated that the identification of macroeconomic shocks is robust, provided that the effect of fiscal policy on long-term output is negligible relative to other shocks. This therefore indicates our emphasis on monetary shocks.

In addition, the way the military authorities in Nigeria, over the past three decades had managed the public sector budgets, has called into question the efficacy of fiscal policy in the country. During this period, extra-budgetary spending, misappropriation of funds, among others which were common, have resulted in suspicion

on the part of the public about the relevance of fiscal policy to development management in the country.

IV. DATA AND ESTIMATION RESULTS

A. *Data and Data Sources*

Quarterly values of real GDP, money supply (broad money), official exchange rate, parallel exchange rate, prices (consumer price index: CPI), and lending rates were used in the study. The sample point for the variables is the period 1970.1–1995.4. Quarterly GDP was interpolated through exports. This variable as GDP interpolator has been used in the literature, e.g., Ajakaiye and Odusola (1995). In order to avoid wide fluctuations in GDP series from one quarter to another, real GDP was used to interpolate the GDP series rather than the nominal series. Real GDP was obtained by adjusting the nominal GDP for CPI. The annual nominal GDP was obtained from the *International Financial Statistics Yearbook, 1995* (line 99b) while the export values (annual and quarterly) were obtained from the various issues of the *Statistical Bulletin* of the Central Bank of Nigeria (CBN). The inflation rate was calculated through the log-difference in level of the Nigerian CPI which was obtained from the *International Financial Statistics* monthly (various issues). The official naira exchange rate series per U.S. dollar was obtained from the CBN *Statistical Bulletin* (various issues). Parallel exchange rate, on the other hand, came from two sources: (i) 1970.1–1990.4, from *Pick Currency Yearbook* and (ii) 1991.1–1995.4, from the *Nigeria's Deposit Insurance Corporation Quarterly* of the Nigerian Deposit Insurance Corporation (NDIC). Money supply and commercial bank lending rate were obtained from the CBN *Statistical Bulletin* (various issues).

All the variables are expressed in nominal values, except for income. Besides, all the variables are measured at log difference of their actual levels. Because inferences drawn from VARs and variants may be sensitive to specification (levels of first differences and inclusion or exclusion of a time trend), the time series properties of the data must be carefully evaluated.[10] The tests conducted include the Augmented Dickey Fuller (ADF) and Philip-Peron (PP). The results of the tests suggest that first differencing is sufficient or that these macro-variables do not have two-unit roots.[11] The cointegration test suggests that the variables are cointegrated. Therefore, measures of all the variables except for the real income interpolated by export appear as rates of change rather than in level.

B. *Reduced-Form Estimation Results*

As previously mentioned, the model is a six-variable system using the log differ-

[10] This has been discussed by Ohanian (1988), Stock and Watson (1989), and Todd (1990).

[11] The results of the unit root test briefly discussed below are available from the authors upon request.

TABLE I

SUMMARY OF THE REDUCED-FORM ESTIMATION (1970.1–1995.4)

Test Statistics	Official Exchange Rate (e)	Interest Rate (r)	Parallel Exchange Rate (l)	Real Income (y_x)	Inflation (p)	Money (m)
Cointegrating equation	–0.035	0.161	–0.020	0.592	0.027	1.519
	(–0.55)	(2.28)	(–0.19)	(5.36)	(0.38)	(3.37)
Goodness of fit statistics						
Adjusted R^2	0.57	0.39	0.52	0.81	0.34	0.66
SEE	0.10	0.11	0.17	0.17	0.11	0.73
Correlation among reduced-form errors:						
Official exchange rate (e)	1.00	–0.13	0.19	–0.04	0.01	0.05
Interest rate (r)	0.00	1.00	–0.16	–0.24	0.07	–0.08
Parallel exchange rate (l)	0.00	0.00	1.00	0.25	0.11	–0.05
Real income (y_x)	0.00	0.00	0.00	1.00	–0.02	0.15
Inflation (p)	0.00	0.00	0.00	0.00	1.00	0.02
Money (m)	0.00	0.00	0.00	0.00	0.00	1.00

Note: The model was estimated using a four-quarter lag structure per equation. The cointegrating equation presents the error correction estimate (with t-statistic in parenthesis) since the model was run through the vector Error Correction Method. SEE stands for the standard error of the equation.

ence of the official exchange rate, lending rate, parallel exchange rate, real income, prices, and money. Since the model uses quarterly series, a four-quarter lag structure was adopted. Given four lags in each VAR equation, and taking into account differencing, the VARs were estimated over the period 1971.3 to 1995.4. The results of the estimation are summarized in Table I. The fact that the variables are cointegrated indicated the use of a vector error correction (VEC) model. The VEC model allows the long-term behavior of the endogenous variables to converge to cointegrating (i.e., long-term equilibrium) relationships while allowing a wide range of short-term dynamics. The cointegrating relationships are shown in the first panel of Table I. Evidence from Table I indicates that the lending rate, real income, and money are adjusted to the deviations from their long-term paths within four quarters, unlike the official and parallel exchange rates and prices. This long-term relationship corresponds to 1 per cent for money and real income, and 5 per cent for the lending rate (Table I). Official exchange rate, parallel exchange rate, and inflation tend to show that there is an absence of convergence to equilibrium paths, which indicates that the adjustment process takes a longer time.[12]

As the entries in the second panel of Table I show, the model explains a significant

[12] Charemza and Deadman (1993, p. 200) point out that using long lags may be inconsistent with economic sense, especially if the aim is to use the estimated cointegrating vector(s) for further analysis of the VAR model.

proportion of the variability of the series, mainly for real income and money, followed by the official exchange rate and parallel exchange rate and least for the interest rate and prices. Altogether, the standard errors of the equations are plausibly low.

The summary of the correlation matrix is also presented in the last panel. The contractionary impact of devaluation on output; the contractionary effect of a high lending rate on output as postulated by Van Wijnbergen (1985); the inverse relationship between output and prices as well as the positive relationship between the money supply and prices seem to be implied by the correlation matrix of the reduced-form errors.

C. *Impulse Response Functions*

Table II and Figure 1 depict the impulse response functions of the variables described above, using a horizon of ten quarters. Figure 1 shows the responses of a particular variable to a one-time shock in each of the variables in the system. The interpretation of the impulse response functions should take into consideration the use of first differencing of the variables as well as the vector error correction estimates. Thus, a one-time shock to the first difference in a variable is a permanent shock to the level of that variable. This allows to address particularly, issues concerning the impact of the naira depreciation on the output.

The conclusions from the analysis of the impulse response functions are as follows. First, as can be seen from Table II and Figure 1, the contractionary impact of the naira depreciation on the output could only be represented in the first quarter. Thereafter, the naira depreciation generated expansionary impacts on the output, especially in the third quarter. This is in agreement with Edwards's study (1989) on twelve developing countries, Reinhart and Reinhart's study (1991) on Colombia, and Kamin and Klau's study (1998) in which it was found that devaluation is not contractionary in the long term for twenty-seven countries, and partially (at least with first quarter response) with Kamin and Rogers (1997) for the Mexican experience. The responses of inflation to the official exchange rate shocks were consistently positive (Table II), thereby confirming the earlier findings of Egwaikhide, Chete, and Falokun (1994), and Ajakaiye and Ojowu (1994). It also conforms with the findings of Dordunoo and Njinkeu (1997) for some African countries and Ndung'u (1997) for Kenya. Official exchange rate shocks (depreciation) are also followed by increases in the money supply and parallel exchange rate (Table II).

One issue that remains unsettled in the literature is the link between the parallel exchange rate and the official exchange rate. It is generally considered that official exchange rate depreciation reduces the significance of the parallel exchange rate (i.e., appreciation in value), thereby resulting in a negative relationship. Other authors suggest that the relationship could be positive. Our results show that the relationship is mostly positive thus, being in agreement with the latter view. The theo-

TABLE II

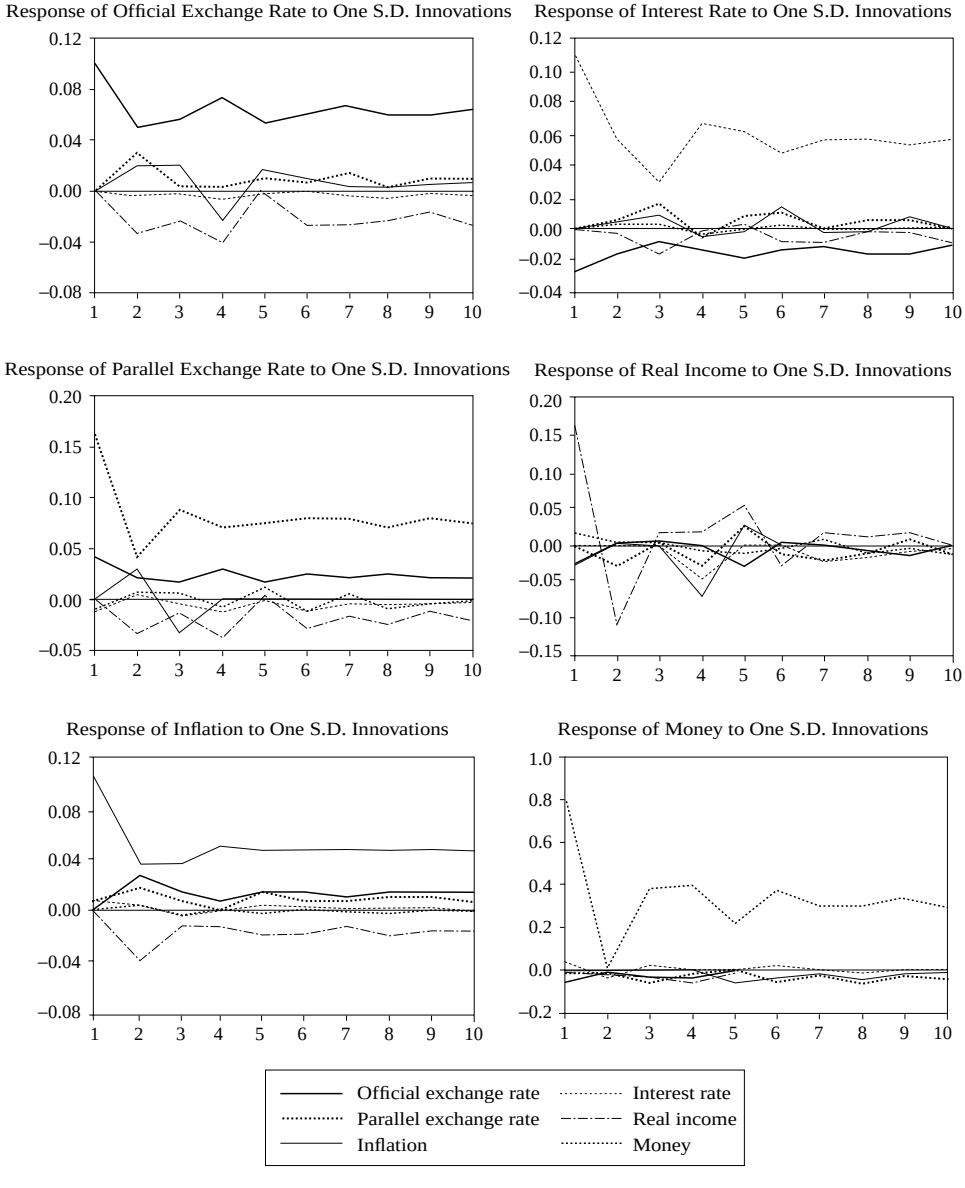
IMPULSE RESPONSES FROM THE REDUCED-FORM MODEL

Type of Innovations	Horizons/ Quarters	Official Exchange Rate (e)	Interest Rate (r)	Parallel Exchange Rate (l)	Real Income (y_x)	Inflation (p)	Money (m)
ε_e	1	8.84	–1.30	2.89	–0.63	0.14	3.16
	3	4.27	1.29	1.57	3.73	0.94	2.63
	6	4.31	–0.73	1.09	1.03	0.60	5.57
	9	4.46	0.11	1.18	0.22	0.42	1.06
	10	4.31	0.22	0.33	1.39	0.79	1.41
ε_r	1	0.00	9.76	–2.06	–3.84	0.68	–4.82
	3	0.22	4.21	–2.42	2.17	–1.19	–1.83
	6	–0.24	3.57	0.17	–5.06	–0.53	–1.82
	9	–0.73	3.44	–0.71	–1.78	–0.47	–1.64
	10	0.13	3.57	–2.24	–1.15	–0.08	–4.79
ε_l	1	0.00	0.00	14.45	3.54	1.25	–4.75
	3	0.89	–0.17	6.03	–0.50	1.47	–5.92
	6	0.37	–0.91	4.89	0.76	0.70	–4.66
	9	0.43	0.22	3.98	0.74	1.33	0.84
	10	0.48	–0.10	3.96	0.39	0.59	–4.28
ε_{yx}	1	0.00	0.00	0.00	14.45	–0.33	0.00
	3	0.62	–1.40	2.07	2.68	0.98	0.38
	6	–0.88	–0.59	–0.56	0.79	–1.46	–1.98
	9	0.94	–0.28	1.01	2.42	–0.53	–2.27
	10	–0.31	–0.56	0.54	0.61	–0.51	–2.12
ε_p	1	0.00	0.00	0.00	0.00	9.84	–0.85
	3	0.22	–0.17	–3.52	1.00	2.07	–0.62
	6	–0.42	0.84	–0.33	0.96	3.67	0.74
	9	–1.34	0.23	–1.83	0.29	3.54	–0.49
	10	–0.98	–1.12	0.02	1.92	3.16	2.24
ε_m	1	0.00	0.00	0.00	0.00	0.00	61.46
	3	0.38	–0.96	0.75	0.38	–0.30	9.49
	6	0.01	–0.55	–0.28	–1.98	–0.12	7.44
	9	0.53	–1.47	–0.25	–2.27	0.49	7.05
	10	–0.49	–0.81	–0.22	–2.12	0.60	7.72

Note: Entry (i, j) denotes the dynamic response of variable j to a one standard deviation shock in variable i. Here, the column heads show "i" variables while row entries (i.e., ε_e, ε_r, ε_l, ε_{yx}, ε_p, ε_m) represent "j" variables. All the variables correspond to percentage increases of the level of each variable from the baseline e, r, l, y_x, p, and m are as defined in equation (5).

retical propositions often deduced for this relationship can be found in Nowak (1984) and Kamin (1991). They postulate that the relationship is ambiguous. They argue that the effect depends on the degree to which fraudulent transactions react to changes in the premium and the rationing scheme of the central bank. It was argued that the

Fig. 1. Impulse Response Functions



Note: S.D. stands for standard deviation.

greater the degree of under-invoicing and the greater the central bank's tendency to hoard foreign exchange receipts, the more likely it is that the parallel market rate will depreciate (rather than appreciate), though less than proportionately.[13] Hence, the relationship becomes positive.

The findings of CBN-NISER (1998) also support the positive relationship. It was argued that this positive relationship would be maintained unless some critical factors (e.g., transaction cost, immediacy, and disclosure) distinguishing the operations of the two markets are addressed. For instance, while the transaction cost (e.g., cost of processing and documentation) is marginal (or close to zero) in the parallel market, it is however substantial in the official market. Also, while immediacy is an important feature of parallel market operations, undue delays (ranging between sixty and ninety days) (CBN-NISER 1998, pp. 49–51) often characterize the official market. And since timeliness is an important factor in business operations, market agents tend to prefer the parallel market to the official one, especially in the purchase of spare parts. Besides, strict adherence to disclosure of information and documentation which is an important feature of the official market does not exist in the parallel market. All these factors tend to support the ever-increasing use of parallel market operations. Consequently, more pressure is put on the demand for foreign exchange in the parallel market and hence the widening gap between the two rates. Besides, innovations in the parallel exchange rate also generate some dynamic responses from other variables. Their impacts on the lending rate are mostly negative (except for quarter 6) as shown in Table II. The impacts of the parallel exchange rate innovations on official exchange rate innovations are positive, albeit marginal.

This tends to support Ndung'u (1997) study that parallel exchange rate Granger caused official exchange rate in Kenya. The expansionary response of output to innovations in the parallel exchange is more prevalent (e.g., all quarters, except for quarter 3 in Table II), than the contractionary impacts. This could result from the marginal (or nil) transaction cost and immediacy of the market examined above. The resulting dynamic responses to price movements are largely positive, as clearly shown in Table II. Innovations in the parallel exchange rate are mostly accompanied by accommodating monetary policies from the monetary authorities, especially in the short- and medium-term horizons. Naira depreciation in the parallel market is often accompanied by liquidity mop-up exercises, which may result in relatively marginal inflationary impacts.

Moreover, the impacts of output innovations on official exchange rate movements are mixed and somehow weak. Evidence from Table II shows that a strong economy tends to strengthen the naira in the long term, e.g., the opposite holds in the short term. The former results are in agreement with the findings of Ndung'u

[13] Also see Agénor (1992) for more explanations on the positive relationship.

(1997) on Kenya. The responses from the parallel exchange rate are also similar to this, with the response being strong in the second quarter. The reactions of money supply and price movements to output shocks are quite mixed. Evidence from Table II shows the existence of inverse relationships between them and output innovations. In fact, the response of the money supply becomes largely negative, the longer the horizon. This perhaps shows that monetary authorities implement an accommodating monetary policy when the level of economic activities expands in order to avoid an overheated economy that could generate a recession. The results from the table further indicate that supply shocks markedly influence the dynamics of inflation in Nigeria. The responses of price movements and money supply to output innovations are largely positive.

The study also reveals that price shocks are accompanied by currency appreciation at both the official and parallel exchange rates in the medium- and long-term horizons, presumably due to the wealth effect. The decline in wealth may weaken market agents' ability to ask for foreign exchange, thereby resulting in the appreciation of the naira. The accommodating monetary policy is quite evident from Table II. Innovations in prices generate mopping-up of liquidity from the economy, thereby leading to a deceleration of the money supply. The dynamic responses generated by the lending rate and money innovations could also be interpreted along this line of reasoning.

D. *Variance Decomposition Results*

Table III and Figure 2 present the variance decomposition of the variables used in the model. They show the fraction of the forecast error variance for each variable that is attributable to its own innovations and to innovations in the other variables in the system.

The predominant sources of variation in all the variables are the "own" shock. Price is an important source of the forecast variance errors in the official exchange rate, parallel exchange rate, and real income, particularly in the medium- and long-term horizons. Innovations in the parallel exchange rate account for about 6 per cent of the forecast error variance in real income and prices. The results equally reveal that output is an important source of forecast error variance in price and money supply particularly in the medium- and long-term horizons. Money supply is an important source of perturbations in lending rates and real income in the medium- and long-term horizons. Official exchange rate explains the variations in the lending rate, parallel exchange rate, real income, and price (particularly in the medium- and long-term horizons), although the percentage is less than 5 per cent in all the cases except in the sixth quarter for lending rate where it is about 5.18 per cent (see Table III). The lending rate is an important source of the forecast variance errors in the parallel exchange rate and real income in the medium- and long-term horizons.

TABLE III

VARIANCE DECOMPOSITION FROM THE REDUCED-FORM MODEL

Variables	Horizons/Quarters	ε_e	ε_r	ε_l	ε_{yx}	ε_p	ε_m
Official exchange rate (e)	1	100.00	0.00	0.00	0.00	0.00	0.00
	3	92.39	1.25	5.26	0.48	0.47	0.15
	6	76.79	0.88	3.27	1.43	17.17	0.46
	9	78.66	2.36	3.06	1.38	13.94	0.60
	10	79.50	2.21	2.94	1.32	13.38	0.64
Interest rate (r)	1	1.82	98.18	0.00	0.00	0.00	0.00
	3	3.43	91.86	0.48	2.73	0.04	1.44
	6	5.18	83.61	0.97	2.18	1.83	6.23
	9	4.44	82.62	0.85	2.31	2.62	7.15
	10	4.18	82.75	0.80	2.29	2.99	6.97
Parallel exchange rate (l)	1	3.80	1.91	94.29	0.00	0.00	0.00
	3	4.39	3.43	83.60	1.47	6.87	0.21
	6	3.96	6.46	79.39	1.83	7.34	1.01
	9	4.42	7.60	77.70	1.86	7.51	0.89
	10	4.25	8.33	77.54	1.84	7.18	0.86
Real income (y_x)	1	0.17	6.24	5.31	88.28	0.00	0.00
	3	4.20	5.84	3.84	75.77	1.90	8.43
	6	3.09	14.61	6.13	54.88	10.36	10.91
	9	4.01	13.47	5.49	50.56	9.05	17.42
	10	4.22	13.42	5.41	49.71	9.43	17.79
Inflation (p)	1	0.02	0.47	1.58	0.11	97.82	0.00
	3	3.31	0.52	5.99	4.64	85.46	0.07
	6	2.78	2.26	5.35	4.94	84.49	0.17
	9	2.90	2.11	6.46	4.09	83.55	0.88
	10	3.03	2.00	6.28	3.99	83.67	1.02
Money (m)	1	0.25	0.59	0.57	2.61	0.01	95.95
	3	0.35	0.62	1.33	3.45	0.04	94.19
	6	1.02	1.08	1.62	6.13	1.76	88.38
	9	1.01	1.19	2.32	6.97	1.71	96.79
	10	1.02	1.54	2.56	7.30	1.75	85.82

Note: Entry (i, j) denotes the percentage of forecast variance of variable i (that is the column heads—ε_e, ε_r, ε_l, ε_{yx}, ε_p, ε_m,) at different horizons attributable to innovations in variable j (i.e., the row entries).

V. THE STRUCTURAL MODEL

The contemporaneous relationships modeled in equation (5) are estimated here. The model was estimated using the approach of Blanchard and Watson (1986). In this model, the instruments for the ith equation are the estimated residuals from equations (1) through ($i - 1$). The model is over-identified since only thirteen parameters are estimated from a total of fifteen possible identifiable parameters.

Fig. 2. Variance Decomposition from the Reduced-Form Model

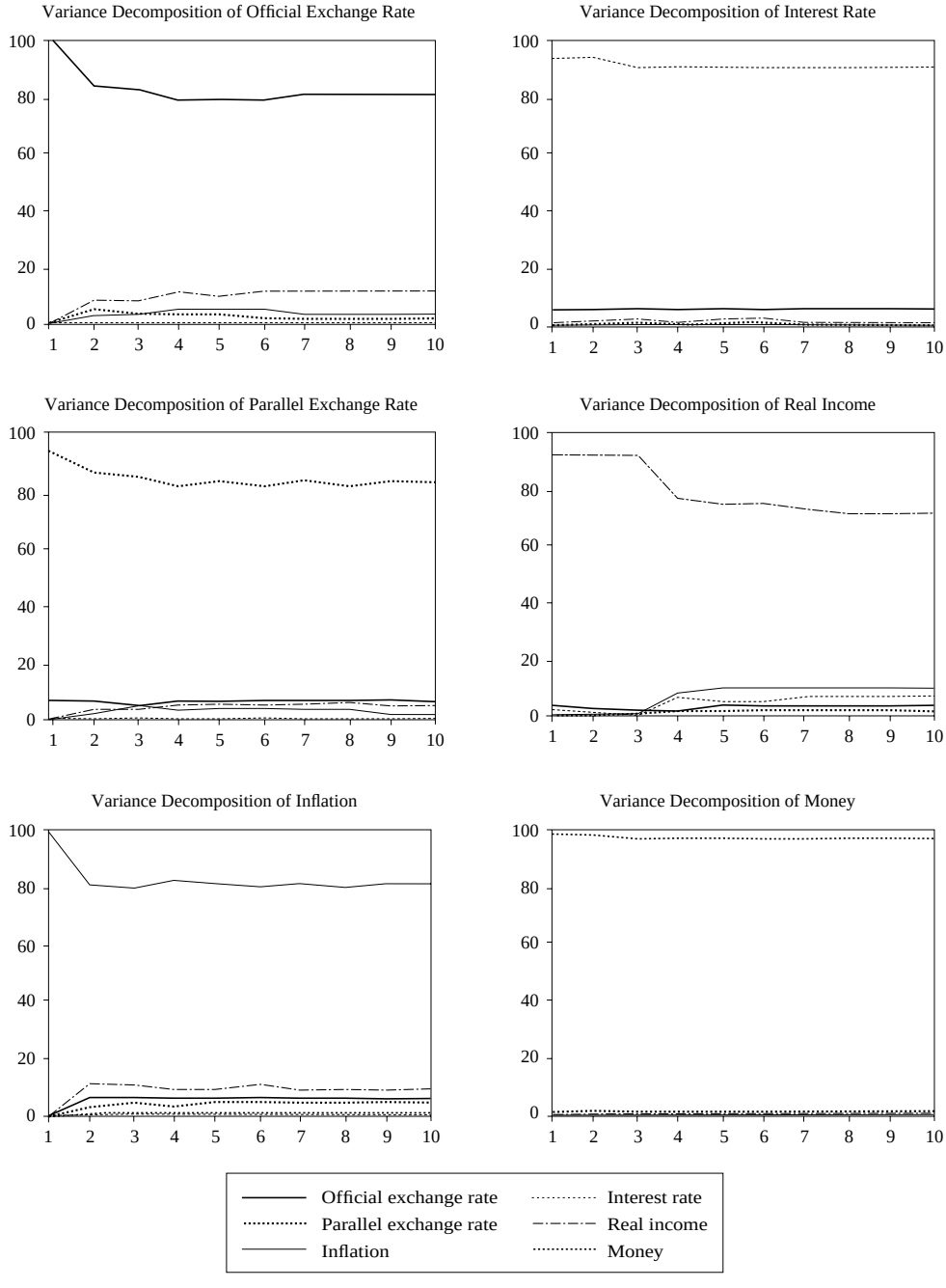


TABLE IV

STRUCTURAL VAR REGRESSION RESULTS

$$\varepsilon_e = \mu_e. \quad (5.1)$$

$$\varepsilon_r = \mu_r. \quad (5.2)$$

$$\varepsilon_l = \underset{(2.13)^{**}}{0.360\varepsilon_e} + \underset{(1.11)}{0.456\varepsilon_{yx}} + \mu_l. \quad (5.3)$$

$$\varepsilon_{yx} = \underset{(-0.07)}{-0.844\varepsilon_r} + \underset{(0.04)}{0.638\varepsilon_l} - \underset{(-0.05)}{9.360\varepsilon_p} + \mu_{yx}. \quad (5.4)$$

$$\varepsilon_p = \underset{(0.06)}{6.678\varepsilon_e} + \underset{(0.09)}{4.366\varepsilon_l} + \underset{(0.09)}{1.653\varepsilon_{yx}} + \underset{(0.08)}{1.137\varepsilon_m} + \mu_p. \quad (5.5)$$

$$\varepsilon_m = \underset{(0.44)}{0.334\varepsilon_e} - \underset{(-0.11)}{1.442\varepsilon_l} + \underset{(0.78)}{0.357\varepsilon_{yx}} - \underset{(-0.51)}{0.370\varepsilon_p} + \mu_m. \quad (5.6)$$

** Indicates significance at 5 per cent level.

A common feature of the structural VAR models is that most of the coefficients do not appear to be estimated very precisely, presumably because the technique of constructing standard errors may not be very accurate (Bernanke 1986, p. 70; Calomiris and Hubbard 1989, p. 445; Turner 1993, p. 151; Kiguel, Lizondo, and O'Connell 1997, p. 130). However, the estimation leads to some interesting results.

The results are presented in Table IV. From equation (5.3), we find that the parallel exchange rate innovations are positively related to the official exchange rate and output innovations. For instance, a 1 percentage point increase in the official exchange rate and output innovations raise the parallel exchange innovation by about 0.4 and 0.5 per cent, respectively. Albeit, only the former relationship could be statistically determined at 5 per cent level of significance. The low transaction cost, immediacy and absence of disclosure of the identity and nature of business peculiar to the operations of the parallel market in Nigeria, as opposed to the official market, still explain the positive relationship between the two rates. The results are also in agreement with the theoretical determinations of Nowak (1984) and Kamin (1991).

Equation (5.4), on the other hand, shows that within a quarter, real output innovations are positively related to innovations in the parallel exchange rate while they (output innovations) are inversely related to the lending rate and price innovations. The inverse relationship between the innovations of the lending rate and output tends to contradict the McKinnon-Shaw hypothesis of financial liberalization which postulates that higher interest rates will lead to increased savings and financial intermediation, and efficiency in the use of savings, thereby enhancing growth. The results therefore suggest that the high lending rate affects the working capital as hypothesized by Van Wijnbergen (1982, 1983, 1986) due to the dampening effects on output. As expected, there is an inverse relationship between the price innovations and output innovations. This inverse relationship which is in agreement with Odedokun's observation (1993) for forty-two developing countries could be ex-

plained by the aggregate demand shocks. Unanticipated price increases tend to generate a lower real aggregate demand which, based on the accelerator principle, may reduce the output. Alternatively, Kamin and Rogers (1997, p. 25) have argued that inflation shocks could reduce the output in the following ways: reduction of business and consumer confidence; increase of nominal interest rates and hence domestic debt-service burdens; and reduction of the demand for money and hence supply of loanable funds. As a result, 1 per cent rise in price innovations generates a decrease of 9.4 per cent in the output innovations. Also, an increase in the parallel exchange rate innovations generates an increase of about 0.64 per cent in the output.

The price setting equation (5.5) indicates that output, official exchange rate, parallel exchange rate, and money supply innovations contemporaneously generate positive innovations in inflation. The positive link between output innovations and price innovations suggests that ε_y represents an aggregate supply shock. This result is in agreement with the findings of Odedokun (1996), Kamin and Klau (1998) for some sub-Saharan African countries, and James (1993) and Turner (1993) for developed countries. Also 1 per cent increase in official exchange rate innovations leads to a 6.68 per cent increase in price innovations, as shown in equation (5.5), indicating a positive relationship. This tends to be in agreement with the general assumption on the link between inflation and the parallel exchange rate (see Odedokun 1996; Kamin and Klau 1998). The results also show that a 1 per cent increase in money supply innovations raises price innovations by 1.14 per cent. Our findings tend to be in agreement with Odedokun (1996) for some selected sub-Saharan African countries, Barungi (1997) for Uganda, and Kaminsky (1997) for Mexico.

Finally, money supply equation (5.6) reveals some interesting aspects. The monetary authorities seem to follow a "leaning against the wind" type of policy with respect to the inflation rate, by reducing the money supply when the rate of inflation rises. This is an indication of mopping-up exercises of the Central Bank of Nigeria whenever inflation is becoming unbearable. The monetary authorities, on the other hand, follow a noncyclical (accommodating) type of policy in terms of output, by increasing the money supply when the output rises. For instance, 1 per cent increase in output generates a 0.36 per cent increase in the growth rate of money supply. An accommodating monetary policy is also used for the official exchange rate. Since the government is the major supplier of hard currency in the official foreign exchange market, the monetary authorities tend to increase the money supply whenever the naira currency depreciates against the U.S. dollar. However, regarding the parallel exchange rate, any innovations in the parallel foreign exchange market generate some inverse innovations in the money supply. However, the relationship could not be statistically confirmed since the parameter estimates are relatively large.

VI. CONCLUSIONS AND POLICY RECOMMENDATIONS

The main focus of this study was to examine the link among the naira depreciation, inflation, and output in Nigeria. Evidence from the study revealed the existence of mixed results on the impacts of the exchange rate depreciation on the output. The impulse response functions exerted an expansionary impact of the exchange rate depreciation on the output in both medium and long terms. The opposite (contractionary impact) was however observed for the short-term horizon. These results tend to suggest that the adoption of a flexible exchange rate system does not necessary lead to output expansion, particularly in the short term. Issues such as discipline, confidence, and credibility on the part of the government (as argued by Dordunoo and Njinkeu 1997) are essential. However, these issues are apparently lacking in Nigeria, as partly reflected in several policy reversals. Results from the contemporaneous models also showed a contractionary impact of the parallel exchange rate on the output but only in the short term. Besides, official exchange rate shocks were followed by increases in prices, money supply, and parallel exchange rate. Prices, parallel exchange rate, and lending rate are important sources of perturbations in the official foreign exchange rate. Innovations in the parallel exchange rate are accompanied by an accommodating monetary policy, declining lending rate, and an improvement in the official exchange rate. Lending rate and prices accounted for a significant proportion of the variations in the parallel exchange rates.

Evidence from impulse response functions and structural VAR models suggested that the impacts of the lending rate and inflation on the output were negative. It was also demonstrated that shocks from these variables exerted much stronger effects on real income forecast errors. On the other hand, the output and parallel exchange rate are the major determinants of inflation dynamics in Nigeria.

Based on these findings, the following policy recommendations were formulated. Since evidence has shown that developments in the official exchange rate and market tend to generate some positive impacts on the parallel exchange rate, research efforts should therefore be directed at examining the reason for the relationship. Though an attempt has been made by the Central Bank of Nigeria to elucidate this aspect and the preliminary results are insightful,[14] further efforts need to be geared towards this direction. Besides, by drawing inferences from the impulse response functions, a stable and sustainable monetary policy stance, policies that stem the tide of inflationary pressures and policies that enhance income growth are crucial for taming the parallel exchange rate behavior.

[14] CBN-NISER (1998) survey of the informal foreign exchange market showed that some factors such as low transaction cost, immediacy and lack of disclosure in parallel market operations are the driving force that attracts people to use the market even when the official market is deregulated.

Evidence from the study further revealed that shocks to the lending rate and inflation generated substantial destabilizing impacts on the output, suggesting that the monetary authorities should play a critical role in creating an enabling environment for growth. The determination of the optimal lending rate should reflect the overall internal rate of returns in the productive sector with due attention to market fundamentals. This could be achieved along with appropriate monetary growth targeting that would not destabilize the price formation process. In line with this, the Central Bank of Nigeria should be given some instrument autonomy. Effective monetary targeting and accommodating monetary policies should be designed and implemented as the needs arise, without fear of intimidation from the politicians.

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