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Assessing the impact of Nigeria's naira depreciation on output and inflation

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I. INTRODUCTION

The persistent decline in the foreign exchange rate of naira since the introduction of adjustment programme in 1986 has generated both concern over increased inflation and reduced hope for improvement in the output level. This concern derives from the experience of countries such as Mexico and Argentina where real depreciation of their domestic currencies have consistently been associated with decline in output and increases in inflation. Similarly, among the East Asian countries, more recently, the collapse in the currency values has taken place along side a sharp slowing-down of economic activity. The possibility that positive exchange-rate shock (devaluation) is contractionary has received considerable theoretical attention (see among others, Hirshman, 1949; Diaz Alejandro, 1965; Krugman and Taylor, 1978; Buffie, 1984; van Wijnbergen, 1986; Lizondo and Monteil, 1989). Empirical studies based on either simulation (Cooper, 1971; Gylfason and Schmid, 1983) or regression (Edwards, 1989; Agenor, 1991; Morley, 1992; Kamin and Klau 1998) have been provided in support of contractionary devaluation. More recently, Rodriguez and Diaz (1995) Rogers and Wangs (1995) Copelman and Warmer (1996) Kamin and Rogers (1997) among others have provided further empirical refinements using Vector Auto-Regressive Approach (VAR).

In the same way, empirical evidence in support of the argument that keeping real exchange rate persistently devalued may lead to a permanent higher level of inflation have been provided (Kamin, 1985; Calvo *et al.* 1994). However, probably because of the relatively recent origin of serious exchange rate depreciation in sub-Saharan Africa countries especially Nigeria, when compared with other regions e.g. Latin America and Asia, not many studies have been reported on the subject. The existing studies on effect of persistent exchange-rate depreciation in Nigeria are based on either regression or simulation approach rather than VAR approach. This present study intends to fill these gaps by not only focusing the study on Nigeria but also adopting restricted vector Autoregressive model thereby providing basis for comparison with existing results obtained for other countries.

The remaining discussions is organized into four sections. In Section II, the theoretical relationship among currency depreciation, output and inflation are discussed. The methodology of the study is provided in Section III. Section IV provides the data, estimation and evaluation of the empirical results. The last section contains the concluding remarks.

II. THEORETICAL ISSUES

This section describes a simple channel through which the effect of currency fluctuations is transmitted into aggregate output and domestic price level. The interplay between currency depreciation, output and price level has long been recognized in the literature. This discussion on the issue dates back to at least to Hirschman (1949) and Diaz Alenjandro (1965).[1] From an analytical point of view, currency fluctuation can affect the real sector of an economy through a number of channels. According to the more traditional views, positive exchange-rate shocks such as unanticipated depreciation of domestic currency either will have an expansionary effect on aggregate output, or

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[1] The literature on the macroeconomic effects of devaluations in industrial countries is too voluminous to summarize here. See Dornbusch (1980).

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in the worst of cases, will leave aggregate output unaffected. Positive exchange-rate shock (devaluation) in the face of under-utilized capacity will be expansionary, and total aggregate output will increase. However, under full employment, exchange-rate shock will translate into equiproportional increase in prices with real exchange rate and aggregate output constant. However, several theoretical arguments have been advanced why contrary to the traditional views, a positive exchange-rate shock can be contractionary and generate a decline in aggregate real activity, including increasing price level. One, positive exchange-rate shock through its increasing effect on prices will generate a negative real balance effect. This in turn will lower aggregate demand and under some circumstances, lower output. Moreover, positive exchange-rate shock can generate a redistribution of income from a group with a low marginal propensity to save with a high marginal propensity to save, resulting in a decline in aggregate demand and output (Diaz Alenjandro, 1965; Krugman and Taylor, 1978). In addition, where the price elasticities of imports and exports are sufficiently low, positive exchange-rate shock may worsen trade balance expressed in domestic currency thereby generating a recessionary effect. Also recently, van Wijnbergen (1986) has shown supply-side channels through which exchange-rate shocks may cause output to decline with increase in prices. He stressed the impact of exchange-rate shock on the local currency costs of intermediate inputs, on nominal wages in the presence of wage indexation and its negative effect on the volume of real credit to firms needing funds to finance working capital.

The assertion of van Wijnbergen may be particularly relevant to the less developed countries (LDCs) such as Nigeria considering the high dependency nature of the economy on imported inputs. For example, in Nigeria 66% of all the raw materials and components that local industry used in 1984 were imported. In view of this, positive exchange-rate shock might only precipitate increase in the cost of raw materials and new capital thereby leading to high production costs. Consequently, prices of locally produced goods and services might increase. The consequent fall in their demand might eventually lead to a decline in output. Besides this consideration, certain peculiar characteristics of the LDCs especially Nigeria may make positive exchange-rate shock to be contractionary. In the Nigeria situation, the consumption habit is not only high but also import oriented while the profligate lifestyle are more than commensurate with the productivity level. Under this circumstance, the real effect of positive exchange-rate shock would be on domestic price level, as import demand tends to remain insensitive to the exchange-rate depreciation.

However, in general the short run output effect results from economic agents' imperfect ability to distinguish real from nominal foreign exchange-rate shocks. However, the more common are nominal exchange-rate shocks in an economy, the more likely a real exchange-rate shock will be viewed, at least partly, as nominal. In the same way, the more common are real exchange-rate shocks in an economy, the more likely a nominal exchange shock will be viewed, at least partly, as real. In spite of this, the more common the shock, the more likely people will correctly deduce its nature. Therefore, a shock of any type will produce a larger price response and a smaller output response in an economy accustomed to another type of shock.

In short, positive exchange-rate shock, such as an unanticipated depreciation of the domestic currency will lead to an unambiguous increase in price. Output effects are unclear, however, at least in the short run if the shock is an unanticipated increase in the real exchange rate, output temporarily falls. If the shock is unanticipated and nominal, output temporarily increases. In the long run, output falls if the shocks cause an adverse shift in the production possibilities frontier. Hence, on theoretical grounds, the prospective impact of a sustained real depreciation on growth is uncertain. However, if the peculiar characteristics of such an economy as Nigeria are taken into consideration (high raw materials import dependence, preference for foreign goods, etc.) the real exchange-rate depreciation will no doubt lead to lower output and increase domestic price level. This calls for empirical analysis. This is needed to sort out the relative importance of these effects in the case of Nigeria. The study adopts the VAR methodology and its structural variant discussed in the next subsection.

III. METHODOLOGY

This study uses the Structural Version of the reduced form VAR (which separates the influence of shocks from those of structure) to capture the nexus of interactions among the variables of interest in the work. Specifically, Blanchard and Watson's (1984) structural version of the reduced form of VAR is adopted. This approach differs from the conventional VAR approach in the way it orthogonalizes the estimated VAR residuals into the 'true' underlying structural disturbances, instead of extracting the disturbances via the standard Choleski decomposition (a procedure sometimes treated as neutral but which in fact embodies strong assumptions about the underlying recursive economic structure). This method explicitly calculates the disturbances by inverting an estimated structural model of the relationship among the contemporaneous VAR residuals.

Following Blanchard and Watson's (1984) and Bernanke's (1986) expositions, it is assumed that Z_t is an $n \times 1$ vector of macroeconomic variables, observed at time t, whose joint behaviour it is intended to study. The dimensionality of Z_t is six (i.e. $n = 6$) in the model.

It is assumed that the economy is described by a system of six equations: an exchange-rate policy equation, an output equation, a price-setting equation, a money market equilibrium equation, a money supply rule and parallel exchange-rate equation. This is represented by a six-component vector defined thus,

$$Z_t = (E_t, Y_t, P_t, R_t, M_t, L_t) \tag{1}$$

where

$E =$ Changes in nominal exchange rate

$Y =$ Real income

$P =$ The rate of price change

$M =$ Money supply (M^2)

$R =$ Money market lending rate

$L =$ Parallel market exchange rate

$t =$ Time subscript

It is further assumed that the dynamic behaviour of Z_t is governed by the following structural model:

$$Z_t = \sum_{i=0}^{n} B_i Z_{t-i} + A\mu_t \tag{2}$$

where μ_t is referred to as the vector of 'structural disturbances' and is serially uncorrelated. $E(\mu_t \mu_t) = D$ and it is a diagonal matrix while E represents the expectation sign. B_is characterize the propagation mechanism. Also $A = 1$, thus A is an $n \times n$ nonsingular matrix whose diagonal elements are normalized to equal one but which may have arbitrary off-diagonal elements. Taking A to be $n \times n$ implies that the number of observed macroeconomic variables Z_t and the number of unobserved fundamental shocks, μ_t are the same.

As mentioned above, the structural disturbances are taken to be serially uncorrelated, but since B_i is not zero, each impulse or structural disturbance may affect all variables contemporaneously.

A problem often associated with Equation 2 is that it has potentially many unknown parameters. To achieve computational simplification in estimating Equation 2, Blanchard and Watson (1984) and Bernanke (1986) imposed no restrictions on the B_i for $i > 0$ (except for specifying the maximum lag length) and thus concentrated on modelling contemporaneous relationships. The reduced form model associated with Equation 2 may be written thus,

$$Z_t = \sum_{i=1}^{n} C_i Z_{t-1} + \varepsilon_t \tag{3}$$

where $C_i = (I - B_0)^{-1} B_i$ and ε_t is a serially uncorrelated vector of residuals.

This is the form in which the VAR is estimated. Since the disturbances to the reduced form depend on the matrix of contemporaneous relationships among the variables of interest, B_0 and the disturbance coefficient of matrix A, it is not possible to use VAR in this form of policy analysis. The vector, ε_t referred to as 'innovations' in Equation 3 with a covariance matrix Ω (i.e. $\Omega = E(\varepsilon_t \varepsilon_t')$ now satisfies

$$\varepsilon_t = B\varepsilon_t + A\mu_t \tag{4}$$

To carry out policy analysis, restrictions on the structures of the B_0 and A matrices become necessary. Thus, in order to be able to recover the structural disturbance (μ) from the reduced form disturbances (ε_t), it is assumed that the A matrix is diagonal and that the B_0 matrix is lower triangular (i.e. casual ordering restrictions among the variables). The relationships between the structural and the reduced form disturbance can be obtained by rearranging Equation 4 and multiplying both sides by A^{-1}

$$\mu_t = A^{-1}(1 - B_0)\varepsilon_t \tag{5}$$

If A is an identity matrix then to calculate the structural disturbance it is necessary to have enough information to estimate information to estimate the nonzero elements of B_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. Thus, the requirement that B_0 be lower triangular, and A be the identity matrix, can be seen as an order condition for identification in that the number of nonzero elements of B_0 must not exceed $n(n-1)/2$, the number of degrees of freedom remaining once the n variance of the structural disturbances have been calculated. It is the necessity of imposing this kind of identifying restrictions that limits Sims' claim to have found an 'atheoretical' method of conducting empirical macroeconomic research. The estimation technique involves first estimating the unrestricted VAR out of which the estimates of the first step innovations are obtained. The model is identified by postulating a structure for B_0 and is estimated using the sequential Two Stage Least Squares (2SLS) approach. (See Blanchard and Watson, 1986; Blanchard, 1989.)[2]

Identifying restrictions

Before proceeding with the estimation of the VAR model in Equation 3, the identification restrictions are specified, which are taken to best capture the joint behaviour of the market fundamentals in the Nigerian economy. The model specification is shown in Equation 6:

[2] See Bernanke (1986) and Blanchard (1989) for more discussion on the estimation technique.

$$\begin{vmatrix} \mu_e \\ \mu_l \\ \mu_1 \\ \mu_{yi} \\ \mu_p \\ \mu_m \end{vmatrix} = \begin{vmatrix} e_0 \\ r_0 \\ l_0 \\ y_0 \\ p_0 \\ m_0 \end{vmatrix} + \begin{vmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ a_{31} & 0 & 1 & a_{34} & 0 & 0 \\ 0 & a_{42} & a_{43} & 1 & a_{45} & 0 \\ a_{51} & 0 & a_{53} & a_{54} & 1 & a_{56} \\ a_{61} & 0 & a_{63} & a_{64} & a_{65} & 1 \end{vmatrix} \begin{vmatrix} \varepsilon_e \\ \varepsilon_r \\ \varepsilon_1 \\ \varepsilon_y \\ \varepsilon_p \\ e_m \end{vmatrix} \quad (6)$$

where $e_0 r_0 l_0 y_{0_i} p_0$ and m_0 are constants and a,j, represents coefficients. As pointed out from Equation 6, innovations in the nominal exchange rate ε_e are entirely attributed 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 Structural Adjustment Programme in September 1986, Nigeria's exchange-rate system was administratively managed (adjustable peg). The country's currency experienced a continuous appreciation (excepting for a few years), amidst noticeable macroeconomic disequilibrium reflected in bourgeoning non-oil trade deficit, balance of payment crisis, and fiscal deficits. Even when a free-floating exchange-rate system was adopted, several allegations were made against the monetary authorities for not allowing the market fundamentals to determine the operations of the market. The genuineness of this allegation is reflected in the ever-widening premium between the official and parallel exchange rates. This was even more pronounced between 1993 and 1995 when the exchange rate was again controlled thereby making the premium to rise from 3.12 in 1992 to 24.3 and 68.37 in 1993 and 1995,[3] 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 to 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 there is little confidence that the available interest-rate series reflect market forces. This confidence problem is also reflected in the works of Rogers and Wang (1995). Thus, it is assumed that innovations from other variables of interest do not affect interest-rate innovations, except own shocks.

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

Innovations to output, ε_y are assumed to reflect the developments in 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_y). 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 official exchange rate (ε_e) and parallel exchange rate (ε_l). This is especially so where imported inputs dominate the production process. Even where some economic agents are not directly involved in these operations, the mark-up pricing rule often associated with currency depreciation by traders could also affect the innovations in prices. They also depend on the price-setting shocks (μ_p), which reflects such factors as changes in mark-ups or in prices of inputs not included in the system, such as labour costs and prices of utilities.

Finally, money supply innovations are allowed to respond to innovations in official exchange rate (ε_e), output (ε_y), prices (ε_p) as well as to shocks in the monetary rule of the Central Bank of Nigeria (μ_m).

IV. DATA AND ESTIMATION RESULTS

Data and data sources

Quarterly values of real GDP, money supply (broad money), official exchange rate, parallel exchange rate, prices (CPI), and lending rates were used in the study. The sample point for the variables is 1970.1–1995.4. Quarterly GDP was interpolated through index of industrial production.[4] 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 nominal GDP for CPI. Index of industrial production, which is available in both quarterly and annual series was also used to interpolate annual GDP into quarterly series. The data for the index of industrial production was obtained from *Annual Report and Statement of Accounts* of the Central Bank of Nigeria (1986, 1989, 1996). The annual nominal GDP was

[3] The figures were for end of December in the respective years.
[4] The use of this variable as GDP interpolator has been extant in the literature e.g. Makinsky (1997) and Bernanke (1981) for index of industrial production, among others.

obtained from the *International Financial 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 IFS monthly (various issues). The official Naira exchange rate series per US 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 came from Pick Currency Yearbook, and (ii) 1991.1–1995.4 came from the NDIC Quarterly of the Nigerian Deposit Insurance Corporation. Money supply and commercial bank lending rate were obtained from the CBN *Statistical Bulletin* (various issues).

All variables are in nominal values, except income. Besides, all variables are measured at log difference of their actual levels.

Time series properties of the macro variables

The prevalence of substantial co-movements among most economic time series data has seriously undermined the policy implications that could be inferred from such modelling constructs. Granger and Newbold (1974) showed that when the dependent and independent variables have unit roots, traditional estimation method using observations on levels of those variables will likely find a statistically significant relationship, even when meaningful 'economic' linkage is absent. Thus, for any meaningful policy analysis, it is important to distinguish between a correlation that arises from a shared trend and one associated with an underlying casual relationship. To achieve this goal, the data were subjected to a variety of tests to establish their univariate time series behaviour in order to determine the basic unit of observation. The tests include the Augmented Dickey–Fuller (ADF) and Phillip–Perron (PP)[5] as explained in Engle and Granger (1987) and Phillips (1987). The implication of this test is to determine whether the subsequent estimation should use the level or first difference (or percentage change) of each time series. The tests are as shown in Table 1.

The first column of the table records statistics based on the assumption that there is no drift, while the second column posits a significant drift. The first panel tests for the presence of a single unit root while the second panel tests for the presence of two unit roots. Critical values are given in the third panel of the table. As shown in Table 1, only real income, parallel exchange rate and money market interest rate variables have their test statistics fall beyond the critical values at 1% with no drift case while only money market interest is stationary for the drift case. The result for two-unit roots test shows they are all stationary at 1% for both drift and no drift cases. Thus, the evidence suggests that first differencing is sufficient for modelling the variables.

Table 1. *Time series properties of the variables used (1970:1–1995:4)*

	Intercept without drift* ADF**	Intercept with drift ADF
Test for one unit root		
Parallel exchange rate (L)	−3.99	−3.59
Official exchange rate (E)	−3.47	−3.59
Real income (Yi)	−3.75	−3.77
Prices (P)	−0.54	−1.29
Money supply (M)	−0.40	−1.04
Lending rate (R)	−4.91	−4.88
Error correction variable	−4.23	
Test for two unit roots		
Parallel exchange rate (L)	−5.68	−5.59
Official exchange rate (E)	−5.73	−5.70
Real income (Yi)	−7.83	−7.72
Prices (P)	−4.62	−4.78
Money supply (M)	−8.21	−8.54
Lending rate (R)	−7.33	−7.29
Error correction variable	−4.22	
Critical values***	No drift	Drift
1%	−3.49	−4.05
5%	−2.89	−3.46
10%	−2.58	−3.15

Note: *Yi* stands for real income interpolated using index of industrial production.
* Four quarters lag structure was used.
** ADF stands for Augmented Dickey–Fuller.
*** Mackinnon critical values for rejecting hypothesis of a unit root.

Reduced form estimation results

As mentioned earlier, the model is a six variable system using the log difference of 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 1971.1–1995.4. The results of the estimation are summarized in Table 2. The fact that the variables are cointegrated informed the use of a vector error correction (VEC) models. The VEC model allows the long-run behaviour of the endogenous variables to converge to their cointegrating (i.e. long-run equilibrium) relationships while allowing a wide range of short-run

[5] Only ADF is reported in the study.

Table 2. *Summary of the reduced-form estimation: 1990.1–1995.4*

Test statistics	Official exchange rate (e)	Interest rate (r)	Parallel exchange rate (l)	Real income (yi)	Price (p)	Money (m)
Cointegrating equation	−0.012	0.391	−0.229	−0.249	0.008	2.252
	(−0.14)	(4.22)	(−1.46)	(1.78)	(0.07)	(3.38)
Goodness of fit statistics						
Adj. R^2	0.61	0.50	0.51	0.65	0.30	0.65
SEE	0.09	0.10	0.17	0.16	0.12	0.74
Correlation among reduced-form errors						
Official exchange rate (e)	1.00	−0.045	0.23	−0.04	0.12	0.04
Interest rate (r)	0.00	1.00	−0.12	−0.04	0.02	−0.18
Parallel exchange rate (l)	0.00	0.00	1.00	0.03	0.12	−0.00
Real income (yi)	0.00	0.00	0.00	1.00	−0.74	0.13
Price (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

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

dynamics. The cointegrating relationships are in the first panel of Table 2. Evidence from Table 2 shows that lending rate, real income and money adjust to the deviations from their long-run paths within four quarters. This long-run relationship is established at 1% for money and lending rate, and 10% for real income. However, official exchange rate, parallel exchange rate and inflation tend to show that there is absence of convergence to their equilibrium paths. This perhaps, indicates that the adjustment process takes a longer period.[6]

As the entries in the second panel of Table 2 attest, the model explains a significant proportion of the variability of the series, doing best for real income and money, doing well for official exchange rate and parallel exchange rate and least for 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 high lending rate on output as postulated by Van Wijnbergen (1986); inverse relationship between output and prices as well as the positive relationship between money supply and prices seem to be suggested by the correlation matrix of the reduced form errors.

Impulse response functions. Table 3 and Fig. 1 contain the impulse response functions of the variables mentioned 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 issues to be addressed concerning the impact of Naira depreciation on output.

The following conclusions emerge from the examination of the impulse response functions. First, as could be seen from Table 3 and Fig. 1 the contractionary impacts of devaluation on output over the ten-quarter horizons adopted is established. This tends to support the evidence from Morely (1992) on 28 developing countries and Gylfasion and Schmid (1983) on UK and Brazil,[7] Kamin and Rogers 1997 for Mexico, and Hoffmaister and Vegh 1996. Official exchange rate-shocks (depreciation) are followed by increases in price, money supply and parallel exchange rate. Evidence from Table 3 shows that the impact of official exchange rate depreciation is much felt on parallel exchange rate and prices in the first quarter, and for money supply, it is the second and third quarters. The response of lending rate to official exchange-rate shock is mostly positive over the period, albeit with the first quarter effect always negative.

Second, innovations in parallel exchange rate also generate some dynamic responses from other variables. Their impacts on lending rate are mostly negative (expecting quarters 1- and 2- from Table 3). The impacts of parallel exchange-rate innovations on official exchange-rate innovations are positive, (excepting quarters 6- and 9- from

[6] 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.

[7] For Nigeria, this finding seems more realistic since index of individual production mirrors more accurately the developments in the production sector.

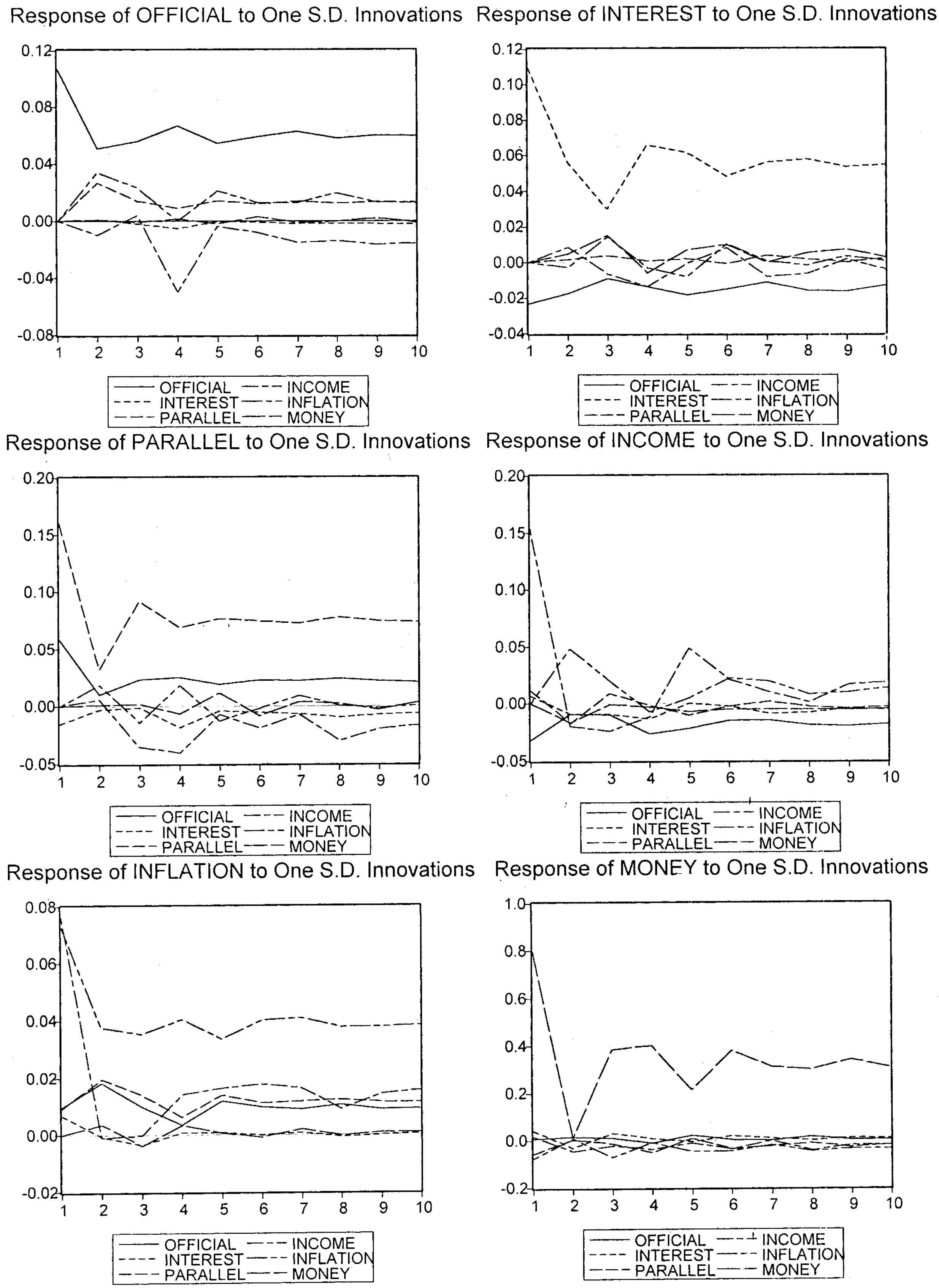

Fig. 1. *Impulse response function*

Table 3. *Impulse responses from the reduced-form model*

Type of innovation	s/horizons (quarters)	e	r	l	y	p	m
ε_e	1	8.40	−0.44	3.65	−0.54	1.28	2.69
	3	4.38	1.38	1.10	−0.19	0.98	5.78
	6	3.19	0.64	0.26	−0.93	0.59	5.58
	9	4.31	0.68	0.26	−1.75	0.53	0.26
	10	4.09	0.79	0.12	−0.92	0.84	3.69
ε_r	1	0.00	8.28	−1.62	0.55	0.31	−11.25
	3	−0.19	0.27	−0.51	1.65	0.69	−6.39
	6	−0.36	2.00	1.45	0.23	−0.35	−7.17
	9	0.39	2.23	0.38	2.69	0.30	−6.96
	10	0.08	2.77	−1.04	0.13	−0.11	−5.07
ε_l	1	0.00	0.00	14.44	0.58	0.97	−1.91
	3	0.10	0.56	6.05	1.89	1.49	−3.53
	6	−0.07	−0.58	5.28	0.57	1.11	−3.53
	9	0.07	−0.32	3.44	−0.45	0.68	0.38
	10	−0.04	−0.01	3.91	−0.11	0.81	0.06
ε_y	1	0.00	0.00	0.00	13.37	7.57	9.01
	3	1.02	−0.06	−1.83	1.42	1.46	0.44
	6	−0.24	0.88	−0.62	3.51	2.49	2.71
	9	−1.29	0.75	−0.64	6.74	3.37	0.66
	10	−1.33	−0.18	0.11	4.24	2.49	2.99
ε_p	1	0.00	0.00	0.00	0.00	6.72	−12.07
	3	−1.55	0.58	−3.15	−3.49	1.19	−4.25
	6	−1.58	0.52	−1.04	−4.44	3.02	0.36
	9	−1.65	−0.80	−2.35	−2.53	1.48	−5.11
	10	−1.81	−0.48	−0.52	5.21	2.72	3.18
ε_m	1	0.00	0.00	0.00	0.00	0.00	60.56
	3	−0.26	−1.95	2.01	1.77	0.22	5.87
	6	−0.04	−0.26	1.42	−0.29	0.31	8.55
	9	−0.13	−2.01	0.33	0.68	0.08	8.79
	10	0.27	−2.10	1.67	0.37	0.07	5.68

Notes: entry (i,j) is the dynamic response of variable j to a one standard deviation shock in variable i. All variables are per cent increases of the level of each variable from baseline. e, r, l, y, p and m are as defined in Table 3.

Table 3) albeit marginal.[8] The expansionary response of output to innovations in parallel exchange is more prevalent (e.g. all quarters excepting quarters 1–6) than the contractionary impacts.[9] The resulting dynamic response on price movements is largely positive. Innovations in parallel exchange rate are mostly accompanied by accommodating monetary policies from the monetary authorities, especially in the short- and medium-terms horizons. Naira depreciation in the parallel market is often accompanied by liquidity mop-up exercises. This perhaps tends to make their inflationary impacts relatively marginal.

Third, the impact of output innovations on official exchange rate-movement are mixed and somehow weak. Evidence from Table 3 shows that a strong economy tends to strengthen Naira in the long run. The responses from parallel exchange rate are also similar to this, with the response being strong in the second quarter. This tends to suggest that one way of creating a stable and strong exchange rate is to put in place, a growing and stable economy.

The responses of price movements and money supply to output innovations are largely positive. Using the index of industrial production as GDP interpolator tends to impose private sector behaviours on the economy. Expectations which is the main drive of private sector's operations leads to acquisition of additional capacities in order to capitalize on market development thereby raising money supply. The accompanied increased money supply generates some demand-pull inflationary tendencies. Thus, a veritable way of stemming the inflationary pressure is for

[8] The theoretical explanations on the positive relationships could be found in the works of Kamin (1991) and Agenor (1992). Empirical study by the Central Bank of Nigeria and NISER (1998) supports this positive finding.
[9] This could be as a result of the marginal or (nil) transaction cost and immediacy attributes of the parallel exchange market.

the monetary authorities to establish a sustainable accommodating monetary policy.

Fourth, price shocks are accompanied by currency appreciation at both the official and parallel exchange rate in the medium and long time-horizons. This could be explained through wealth effect. This is shown in Table 3 with the wealth effect of price innovations being largely negative across the chosen horizons. This decline in wealth may weaken market agents' ability to demand for foreign exchange thereby making the Naira to appreciate.

The accommodating monetary policy is quite evident from Table 3. Innovations from prices generate mopping-up of liquidity from the economy thereby making money supply to decelerate. The dynamic responses generated by the lending rate and money innovations could also be interpreted along this line of reasoning.

Variance decomposition results. Table 4 and Fig. 2 present the variance decomposition of the variables based 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 salient results from the variance decompositions are as follows. In general 'own shocks' constitute the predominant sources of variations for all the variables in the model except for prices. Variation in exchange rate is explained by past exchange rates, prices and real income, but surprisingly, money is relatively unimportant. Interest rate is explained by past interest rate, money supply and official exchange rate. Parallel exchange rate is explained mainly by its past values, and perhaps, by official exchange rate, output, prices and money supply. Real income innovations are affected by past innovations in real income, interest rate and prices. Price innovations are explained mainly by output, followed by past price level, and perhaps by parallel exchange and official exchange rates. Finally, money supply is explained primarily by its past behaviours and by the behaviour of interest rate and prices. Thus, the variance decomposition provides evidence of feedback from

Table 4. *Variance decomposition from the reduced-form model*

Variables	Horizons/quarters	ε_e	ε_r	ε_l	ε_{yi}	ε_p	ε_m
Official exchange rate (e)	1	100.00	0.00	0.00	0.00	0.00	0.00
	3	94.76	0.98	1.21	0.89	2.02	0.11
	6	68.38	0.77	1.13	11.29	17.89	0.53
	9	71.45	1.14	0.98	9.72	16.27	0.43
	10	71.77	1.06	0.97	9.59	16.17	0.42
Interest rate (r)	1	0.25	99.75	0.00	0.00	0.00	0.00
	3	2.57	87.51	0.41	1.17	0.51	7.82
	6	7.20	66.55	0.55	2.15	3.41	20.13
	9	7.11	64.01	0.95	3.28	3.31	21.33
	10	6.95	63.67	0.88	3.07	3.21	22.19
Parallel exchange rate (l)	1	5.92	1.19	92.90	0.00	0.00	0.00
	3	5.61	1.25	85.21	2.52	3.43	1.96
	6	4.75	2.41	80.64	4.22	3.60	4.35
	9	4.52	2.52	79.57	4.71	4.29	4.36
	10	4.33	2.65	79.53	4.51	4.17	4.79
Real income (yi)	1	0.16	0.17	0.19	99.48	0.00	0.00
	3	0.16	1.51	2.71	90.45	3.58	1.57
	6	1.88	7.02	2.28	78.97	7.57	2.26
	9	2.26	7.38	3.09	77.32	7.45	2.39
	10	2.39	6.90	2.89	76.21	9.32	2.27
Inflation (p)	1	1.55	0.09	0.89	54.53	42.92	0.00
	3	4.29	0.48	7.91	49.89	37.32	0.08
	6	3.82	1.84	6.74	50.6	36.62	0.35
	9	4.33	1.69	7.43	51.89	34.28	0.39
	10	4.35	1.58	7.23	51.21	35.27	0.36
Money (m)	1	0.18	3.14	0.09	2.01	3.61	90.96
	3	1.02	3.21	0.65	1.56	3.33	90.22
	6	1.53	5.75	1.44	1.82	3.58	85.88
	9	1.44	7.02	1.86	1.94	4.31	83.41
	10	1.64	7.34	1.84	2.06	4.41	82.71

Note: Entry (i, j) is the percentage of forecast variance of variable i at different horizons attributable to innovations in variable j.

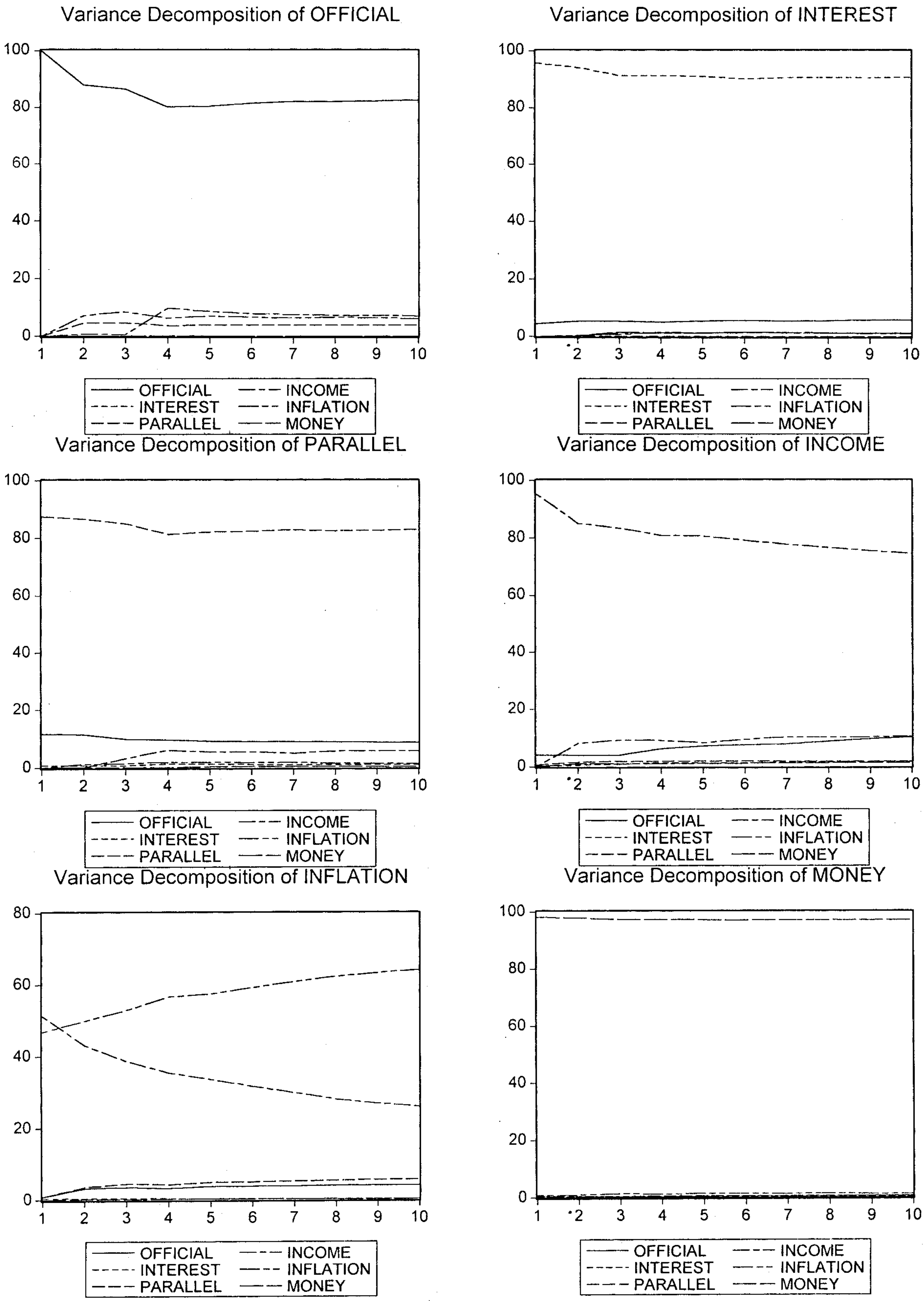

Fig. 2. *Variance decomposition from the reduced form model*

real output to Naira, but little evidence that Naira directly causes real income.

The structural model

The contemporaneous relationships modelled in Equation 6 are estimated here. The model was estimated using the sequentially two-stage least squares (2SLS) approach of Blanchard and Watson (1986). In this model, the instruments for the *i*th equation are the estimated residuals from Equations 1 through *i*1. The model is over identified since only 13 parameters are estimated from a total or 15 possible identifiable parameters.

A common feature of the structural VAR models is that most is that most coefficients do not appear to be estimated very precisely, perhaps because the techniques of constructing standard errors may not be very accurate.[10] In spite of this however the estimation generate some interesting results as shown in Table 5. The result shows that there is positive relationship between parallel exchange rate and official exchange-rate innovations, though not statistically significant.[11] However, inverse relationship was found between parallel exchange rate and real output innovations. This, perhaps, indicates that when there is a lull in economic activities demand for foreign exchange might be influenced by speculative and store of value motives rather than for the purchase of productive capitals and raw materials. If this holds, a lull in the economy divert market-agents attention from productive activities to speculation thereby putting pressure on the demand for foreign exchange.

Equation (6.4) shows that within a quarter real output innovations are inversely related to parallel exchange rate, lending rate and price innovations. The inverse relationship between the innovations of lending rate and output tends to contrast the Mckinnon–Sahw hypothesis of financial liberalization which posits that higher interest rates will lead to increased savings and financial intermediation, and efficiency in the use of savings thereby enhancing growth. The result therefore lends credence to the working capital effect of high lending rate as hypothesized by Van Wijnbergen (1982, 1993), which he trenchantly argued, as having some dampening effects on output. Expectedly, there is an inverse relationship between the price innovations and output innovations. This inverse relationship could be explained by the aggregate demand shocks. Unanticipated price increases tend to generate low real aggregate demand, and given the acceleration principle, this real demand shock would tend to reduce output. Alternatively, Kamin and Rogers (1997) have argued that inflation shocks could reduce output in the following ways: reducing business and consumer confidence, raising nominal interest rates and hence domestic debit-service burdens; and reducing the demand for money and hence supply of loanable funds. From the results, 1% rise in price innovations generates a decrease of 0.07% in the output innovations. Also, an increase in parallel exchange-rate innovations generates a decrease of about 0.99% in output.

Table 5. *Results of the structural model*

$$\varepsilon_e = \mu_e \tag{6.1}$$

$$\varepsilon_r = \mu_r \tag{6.2}$$

$$\underset{}{\varepsilon_l = \underset{(0.088)}{0.561}\varepsilon_e - \underset{(-0.149)}{2.34}\varepsilon_y < +\mu_l} \tag{6.3}$$

$$\varepsilon_{yi} = -\underset{(-0.10)}{0.747}\varepsilon_r - \underset{(-0.095)}{0.990}\varepsilon_l - \underset{(-0.005)}{0.076}\varepsilon_p + \mu_y \tag{6.4}$$

$$\varepsilon_p = \underset{(0.084)}{0.435}\varepsilon_e - \underset{(-0.081)}{0.206}\varepsilon_l + \underset{(0.008)}{0.056}\varepsilon_{yi} + \underset{(0.146)}{0.086}\varepsilon_m + \mu_p \tag{6.5}$$

$$\varepsilon_m = -\underset{(-0.007)}{0.326}\varepsilon_e - \underset{(-0.089)}{1.558}\varepsilon_l + \underset{(0.786)}{1.774}\varepsilon_{yi} - \underset{(-\ 0.327)}{2.372}\varepsilon_p + \mu_m \tag{6.6}$$

The price setting Equation (6.5) indicates that output, official exchange rate and money supply innovations contemporaneously generate positive innovations in inflation, while the result for parallel exchange rate innovations is negative. The positive link between output innovations and price innovations suggests that ε_y represents an aggregate supply shock. This result conforms with the findings of James (1993) and Turner (1993). Also 1% increase in official exchange-rate innovations led to 0.44% increase in price innovations as shown in Equation (6.5). The inverse relationships obtained between parallel exchange rate and price innovations is in line with that of Kaminsky (1997) for Mexico. The result also shows that a 1% increase in money supply innovations raise price innovations by 0.09%. This result tends to conform with Odedokun (1995) for some selected Sub-Saharan African countries and Kaminsky (1997) for Mexico.

Finally, money supply Equation (6.6) shows some interesting results. The monetary authorities seem to follow a 'leaning against the wind' type of policy with respect to inflation rate, reducing money supply when rate of inflation rises. This is an indication of moping-up-exercises of the Central Bank of Nigeria whenever inflation is becoming unbearable. The monetary authorities, on the other hand, follows a noncyclical (accommodating) type of policy with respect to output, increasing money supply when output rises. For instance, 1% increase in output generates 1.78% increase in the growth rate of money supply. However, government seems to follow a cyclical type of policy with respect to parallel and official exchange rate,

[10] This problem has been noted in the earlier studies by Bernake (1986, p. 70), Caclomiris and Hubbard, (1989, p. 445), Turner (1993, p. 151) and Kiguel *et al.* (1997, p. 30).

[11] The results conform with Ageno (1991) and Kamin (1991) theoretical expositions.

reducing money supply when the official exchange rate and parallel exchange rate fall. This is with a view to reducing the demand for foreign exchange rate thereby enhancing the value of the domestic currency.

V. CONCLUDING REMARKS

The links among Naira exchange rate, inflation and output in Nigeria have been examined. The results suggest the existence of contractionary impact of exchange-rate depreciation on output. Also it is found that prices, parallel exchange rate and real income are important sources of perturbations to official exchange rate. Lending rates and prices accounted for a significant proportion of the variations in the parallel exchange rates. Inflation is explained in the main by output, money supply and exchange rate. The results are consistent with virtually all prior analysis of exchange-rate depreciation and economic activity. The question, then, is what are the implications of these findings for Nigeria exchange rate policy at present?

One, the results show that Nigeria should encourage real appreciation in order to deflate quickly and encourage economic activity. However, caution should be exercised to ensure that real appreciation does not exceed the equilibrium level so as to encourage massive importation of goods while discouraging local production. This was, of course, the strategy that got Nigeria economy into trouble in the 1970s and early 1980s, which necessitated the introduction of the structural adjustment programme in mid 1986.

Moreover, it is not clear, just because positive exchange-rate shock and recession were associated with each other in the past, a sustained real depreciation necessarily would reduce output in the future. It is not impossible that with favourable internal and external environment such as stable financial markets access to international markets and high economic recovery, real exchange-rate shock might produce greater benefits with less inflation than in the past. In addition, as the country has been pursuing many economic reform policies over the past decade, it is likely that these might cause Nigerian output to be more positively responsive to depreciation, and inflation less responsive, than has been the case in the past.

However, the above qualifications notwithstanding, results show that it is risky to target real exchange-rate at too competitive a level. In essence, what this suggests is that the level at which the real exchange rate is targeted in the economy is of paramount importance. If the real exchange rate is targeted at too high a level, the risk in terms of output and inflation might be too high to imagine. However, there should be much less risk associated with adopting policies that maintain the real exchange rate at an equilibrium level by encouraging a sufficiently rapid depreciation of the nominal exchange rate and that prevent further real appreciation. The main problem is identifying the equilibrium level. Attempts to keep the real exchange rate at too low a level will have adverse effect on output and inflation as the results have indicated. Alternatively, allowing the exchange rate to appreciate too much would lay the foundations for economic crisis, as was the case before the introduction of liberalized exchange rate system in mid-1986.

In short, determining the equilibrium or sustainable real exchange rate should constitute the focus of policy makers in Nigeria. However, it must be stated that doing this requires considering several macroeconomic variables including the terms of trade, the level of tariffs, the stance of fiscal policy, world interest rate among others and estimating the economy's response to their movements in general equilibrium.

However, one clear evidence from the results is that suitable and sustainable monetary policies that stem the tide of inflationary pressure and enhance output are crucial for-stemming parallel exchange rate behaviour. Moreover, as a palliative, it might be required to make a case for adjusting monetary and or exchange rate policy to keep the real rate in the neighbourhood of its level in the early 1990s when output growth rate was at least modest, inflation rate low and real exchange rate close to historical average. These factors, no doubt, suggest that such a rate might be sustainable thus ensuring better economic performance.

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