Econometric Analysis of Effect of Import of Oil and Some Other Economic Indicators on Stability of Exchange Rate Using Simultaneous Equation

By R.A. Adeleke, Olubiyi A.O., O.D. Ogunwale, D.O. Owoseni

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\section{1. INTRODUCTION}

The dramatic deterioration in agriculture and external accounts of many African countries and the international debt crisis of the early 1980s have been attributed to inappropriate exchange rate policies pursued by most of these countries in the 1970s.

Thus, exchange rate policy offers a price incentive purported to increase the demand for Nigeria's domestically produced goods and services by residents of foreign countries. The policy also creates a disincentive to the resident of Nigeria to increase demands for goods and services produced outside the domestic economy. The management of exchange rate policy is one of the most discussed economic policy subjects in which a consensus is hard to reach.

As noted by Guitan (1992); this state of affairs reflects the complex interrelationship between exchange rate management and domestic economy policy, as well as the importance of these two policy areas of economic performance.

Exchange rate policy is designed to defend the external value of domestic currency as well as promote external sector competitiveness and price stability, among other functions. To achieve these desired objectives, several strategies have been adopted, to manage exchange rate policy in Nigeria since independence. But in spite of the tremendous efforts made in this direction, the country is still in search of a more realistic and stable exchange rate of the naira.

According to the research work by Obioma (2001) on exchange rate policy analysis and management he came to a conclusion that more consistent efforts are needed to boost the supply of foreign exchange, as this is a major factor that determines the extent to which the government can intervene in the foreign exchange market in order to maintain exchange rate stability.

Exchange rate changes also influence the level of imports; where a domestic currency is overvalued, the importation of all sorts of products will be cheap relative to exports.

However, most of the theories of Exchange rate (policy) show that these other factors are dependent on exchange rate; but one finds that in most cases the prevailing situation is far from normal and might be one of the reasons why we have not been able to obtain a very good estimate.

To this extent, this research work focus on how to determine the various factors that affect the stability of exchange rate in Nigeria and also to fit a model that will effectively determine the value of exchange rate and know their effect on the economy.

\section{II. MATERIALS AND METHODS}

The data used in this paper were collected from various issues of the Central Bank Annual Report and Statement of accounts for a period of 33 years. The study will be based on Import of oil, Exchange rate, Inflation, Gross Domestic Product (GDP) and Total expenditure on Agriculture.

The data collected were analysed using the following analysis techniques.

\textit{a) Simultaneous Equation Model :}

This is to describe the mathematical form of the demand functions. A simultaneous equation is used
here because in estimating the stability of exchange rate in Nigeria, we know that some of these economic indicators affect it i.e. the value of a country currency is determined by the strength of her economy. Consequently, the model cannot be treated as a single-equation model because it will yield biased and inconsistent estimates.

A linear model is postulated for each equation by assuming that the annual exchange rate has a linear relationship with import of oil and Total Expenditure on Agriculture. The second equation likewise has a linear relationship. Import of oil has a linear relationship with Inflation rate and Gross Domestic Product (GDP). Also, the third equation has a linear relationship with Annual Average Exchange rate, GDP and Lagged GDP.

The model:

\[ A_t = \beta_0 + \beta_1 I_t + \beta_2 T_t + U_{1t} \]

\[ I_t = C_0 + C_1 I_n + C_2 G_t + U_{2t} \]

\[ I_n = \alpha_0 + \alpha_1 A_t + \alpha_2 G_t + \alpha_3 G_{t-1} \]

Where

\( \beta_0 \) is the intercept or slope of the first equation
\( C_0 \) is the intercept or slope of the second equation
\( \beta_1, \beta_2, C_1, C_2, \alpha_1, \alpha_2 \) and \( \alpha \) are the coefficients of the parameters \( I_t, T_t, I_n, G_t, A_t, G_{t-1} \)

The above equations can be written as:

\[ \beta Y_t + \Gamma X_t = U_t \]

To facilitate easy computation. We have the equation in the form

\[ Y_{1t} = \delta_{11} + \beta_{12} Y_{2t} + \delta_{12} X_1 + U_{1t} \]

\[ Y_{2t} = \delta_{21} + \beta_{23} Y_{3t} + \delta_{23} X_2 + U_{2t} \]

\[ Y_{3t} = \delta_{31} + \beta_{31} Y_{1t} + \delta_{32} X_2 + \delta_{34} X_3 + U_{3t} \]

Where \( A_t = Y_{1t}, I_t = Y_{2t}, Y_{3t} = I_n, T_t = X_1, G_t = X_2 \), \( G_{t-1} = X_3 \)

Equation in matrix form

\[
\begin{pmatrix}
1 & \beta_{12} & 0 \\
0 & 1 & \beta_{23} \\
\beta_{31} & 0 & 1 \\
\end{pmatrix}
\]

\[
\begin{pmatrix}
\delta_{11} & \delta_{12} & 0 & 0 \\
\delta_{21} & 0 & \delta_{23} & 0 \\
\delta_{31} & 0 & \delta_{33} & \delta_{34} \\
\end{pmatrix}
\]

\[ \beta = \begin{pmatrix}
\delta_{11} & \delta_{12} & 0 & 0 \\
\delta_{21} & 0 & \delta_{23} & 0 \\
\delta_{31} & 0 & \delta_{33} & \delta_{34} \\
\end{pmatrix} \Gamma \]

The array of structural parameters is shown above from this array it will be easy to determine the equations identifiability. For the other condition, otherwise known as the necessary condition we have

\[ K^w = G - 1 \]

Where

\( K \Rightarrow \) total number of endogenous and exogenous variables in the model.
\( w \Rightarrow \) total number of endogenous and exogenous variables in a particular equation
\( K^w \Rightarrow k - w = \) total number of variables excluded in the particular equation.

For easy reading, it is tabulated

<table>
<thead>
<tr>
<th>Equation</th>
<th>k-w</th>
<th>G - 1</th>
<th>conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>2</td>
<td>Over identified</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>2</td>
<td>Over identified</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>2</td>
<td>Just identified</td>
</tr>
</tbody>
</table>

For equation (1)

\[ k = 6 \quad w = 3 \quad G = 3 \]

For equation (2)

\[ k = 6 \quad w = 3 \quad G = 3 \]

For equation (3)

\[ k = 6 \quad w = 4 \quad G = 3 \]

Rank Condition

\[-Y_{1t} + \beta_{12} Y_{2t} + 0Y_{3t} + \delta_{11} + \delta_{12} + 0X_2 + 0X_3 \]

\[-Y_{2t} + 0Y_{1t} + \beta_{23} Y_{3t} + \delta_{21} + 0X_1 + \delta_{23} X_2 + 0X_3 \]

\[-Y_{3t} + 0Y_{2t} + \beta_{31} Y_{1t} + \delta_{31} + 0X_1 + \delta_{32} X_2 + \delta_{34} X_3 \]

\[ A\Phi, \text{ where} \]

\[
\begin{pmatrix}
-1 & \beta_{12} & 0 & \delta_{12} & 0 & 0 \\
0 & -1 & \beta_{23} & 0 & \delta_{23} & 0 \\
\beta_{31} & 0 & -1 & 0 & \delta_{32} & \delta_{34} \\
\end{pmatrix}
\]
Equation (2) is over identified

\[
A\Phi_3 = \begin{bmatrix}
-1 & \beta_{12} & 0 & 0 & 0 \\
0 & -1 & \beta_{21} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
-1 & 0 & \delta_{32} & \delta_{34} & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
= \begin{bmatrix}
\beta_{12} & \delta_{12} \\
-1 & 0 \\
0 & 0 \\
0 & 0 \\
0 & 0
\end{bmatrix}
\]

Equation (3) is just identified

Since equation (1) and (2) are both over identified we make use of two-stage least squares method (2SLS) and also look at three-stage least squares method (3SLS)

b) Test for AutoCorrelation:

One of the basic assumptions of ordinary least squares is that the successive values of the random variables V are temporarily independent from the value, which it assumed in any previous period. This implies that

\[
\text{Cov} U_i V_j = E(u_i u_j)
\]

Suppose \( Y = X\beta + U \) and \( U \) follows Autoregressive (1) scheme i.e

\( Ut = \rho u_{t-1} + v_t \) we will test the following hypothesis

\( H_0: \rho \neq 0 \) (alternative hypothesis)

The Durbin-Watson Statistics is to be used

\[
d = \frac{\sum(c_t - c_{t-1})}{\sum c_t^2}
\]

III. RESULTS

The first two equations are over identified while the third equation is just identified, hence it is possible to solve \( \pi \) for \( \beta \) and \( \delta \) uniquely with two-stage least square methods where \( \pi = -\beta^{-1}\Gamma \). The \( \beta \) and \( \delta \) are substituted into the equation, we then have
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\[
Y_1 = 0.335984E-05Y_2 + 12.3279 + 0.217008E-02X_1
\]
\[
(0.641798E-05) \quad (0.353172E-03) \quad (5.69784)
\]
\[
R^2 = 0.6074 \quad \hat{R}^2 = 0.5812 \quad F = 23.20
\]

\[
Y_2 = -93254.1Y_3 + 0.255028E+07 + 7472.35X_2
\]
\[
(73227.0) \quad (0.175430E+09) \quad (154522)
\]
\[
R^2 = 0.6074 \quad \hat{R}^2 = 0.5812 \quad F = 23.20
\]

\[
Y_3 = -0.265070E-02Y_1 + 10.0297 + 0.041909X_2 + 2.10276X_3
\]
\[
(0.115820) \quad (9.17897) \quad (0.92308) \quad (0.87468)
\]
\[
R^2 = 0.6074 \quad \hat{R}^2 = 0.5812 \quad F = 23.20
\]

The first line under the coefficients shows the standard error and the second line displays the t-value.

IV. Estimated Equation for Annual Exchange Rate Using Three Stage Least Square Method

Three stages least square is a system method, which is applied simultaneously to all the equation of an over-identified model. It is applicable here since the first two equations are over-identified.

\[
Y_1 = 12.3393 + 0.337164E-05Y_2 + 0.216688E-02X_1
\]
\[
(5.43149) \quad (0.611817E-05) \quad (0.335222E-03)
\]
\[
R^2 = 0.6074
\]

\[
Y_2 = 0.246394E07 - 95111.6Y_3 + 30037.1X_2
\]
\[
(0.167181E+07) \quad (69809.8) \quad (1.46667)
\]
\[
R^2 = 0.6074
\]

\[
Y_3 = 8.88895 - 0.267443E-02Y_1 + 0.286921X_2 + 2.0600X_3
\]
\[
(8.05554) \quad (0.093674) \quad (0.833687) \quad (0.814393)
\]
\[
R^2 = 0.6074
\]

Test for Autocorrelation

For equation (1)

\[d = 1.095, n = 33, \alpha = 0.05, k = 1\]

\[H_0 = \text{there is no positive 1st order autocorrelation}\]
\[H_1 = \text{there is positive 1st order autocorrelation}\]

\[d_L = 1.32 \quad d_u = 1.47\]

Since \(d < d_L\), reject \(H_0\) and conclude that there is first order autocorrelation

Equation (2)

\[d = 1.981\]

since \(d < d_u\) we accept \(H_0\) and conclude that there is no first order autocorrelation.

Equation (3)

\[d = 1.402, n = 33, \alpha = 0.05, k = 2\]

\[d_L = 1.24, \quad d_u = 1.56\]

since \(d_L < d < d_u\) the test is inconclusive
VII. Summary of Findings

The derived estimate using two-stage least square and three stage least square are the same.

From equation (1) we are able to explain about 61% of the variation in $\bar{Y}_1$, which is the annual average exchange rate by means of $\bar{Y}_2$ and $X_1$. This signifies a good linear association exists among these variables. The $F_{2,27}^{cal} = 2.58$ and the F-calculated 23.20 this shows a significance.

As regards the contribution of the variables themselves a look at t-value was helpful. At 5% level of significance with 27d.f the critical t-value is 1.703. These show that only $T_t$ (Total expenditure on Agriculture) is significant. At 1%, t-value is 2.473 this shows that only $T_t$ is significant which implies that Total expenditure on Agriculture are dependable and useful in explaining variations in the stability of exchange rate. Equation (2) signifies a poor fit. The two independent variables IN (inflation rate) and GT (Gross Domestic Product) together explain about 18% of the variation in $\bar{Y}_3$ which is inflation rate of Annual Exchange rate (At), Gross Domestic Product (GT) and lagged value of Gross Domestic Product (GT). The F calculated 0.8388 is not significant. The t-value was not significant at 5% and 1% which implies that none of the variable considered contribute effectively to the stability of exchange rate.

From equation (3) we have succeeded in explaining about 18% of the variation in $\bar{Y}_3$ which is inflation rate of Annual Exchange rate (At), Gross Domestic Product (GT) and lagged value of Gross Domestic Product (GT). This implies poor linear relationship among variables. The $F_{tab} = 2.58$ and $F_{cal} = 2.116$ and is not significant. As regards their contribution at 5% t-value is 2.473; these suggest that lagged values of GDP at previous period are dependable and useful in explaining variations in inflation rate.

There was no presence of multicollinearity in the data since VIF is less than 10.

VIII. Conclusion

We conclude that equation (1) is a good predictor of the value of exchange rate while the other two equations are not reliable predictors of stability and value of exchange rate making it impossible to make prediction about the value of exchange rate in some year’s time.

F-test was significant for Importation of oil and Total Expenditure on Agriculture; this makes us to know that the two variables contribute to the stability of Exchange rate.

It is recommended that the organization concern should try as much as possible to keep proper records so as to get better outcome in the future.

REFERENCES

1. Central Bank of Nigeria Annual Report and Statement of Account (several issues)

Test for Multicollinearity

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