Transactions of
The Nigerian Association of
Mathematical Physics
Journal homepage: https://nampjournals.org.ng

MODELING OF BALANCE OF PAYMENT AND EXCHANGE RATE IN NIGERIA

Chigozie, Kelechi Acha[1] and Uko, U. Uko[2]

[1,2]Department of Statistics, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria.

ARTICLE INFO

Article history:
Received xxxxx
Revised xxxxx
Accepted xxxxx
Available onlinexxxxx

Keywords:
Simultaneous equation,
Interest rate,
Inflation,
Deficit,
Surplus.

ABSTRACT

This paper discusses the Balance of Payment (BOP) and Exchange rates in Nigeria so as to account for the two-way cause-and-effect relationship between balance of payment and exchange rate in Nigeria. The relevance of this lies in the fact that it could help to monitor the Balance of Payments and Exchange rates and act as an early warning signal for economic crisis.Monthly data on Nigeria exchange rate, interest rate, inflation and balance of payment for the period January 2004 to December, 2020 were obtained from the 2022 CBN Statistical Bulletin. The data were analyzed using indirect least squares estimation method of the simultaneous equation model. Results of the analyses show that (i) the data satisfied the exogeineity and simultaneity assumptions of the specified model (ii) relationships exist between exchange rate and BOP. As shown in the result there is balance of payment deficit due the negative impact of exchange rate on it. To forestall this problem, we recommended that there should be a reduction in government spending; higher interest rates and higher taxes as these could all have the effect of dampening consumer demand reducing the demand for imports.

1.0 INTRODUCTION

The balance of payments, also known as balance of international payments and abbreviated BOP, of a country is the record of all economic transactions between the residents of the country and the rest of the world in a particular period (over a quarter of a year or more commonly over a year). These transactions are made by individuals, firms and government bodies. Thus the balance of payments includes all external visible and non-visible transactions of a country. It is an important issue to be studied, especially in international financial management field, for a few reasons. First, the balance of payments provides detailed information concerning the demand and supply of a country's currency. For example, if Nigeria imports more than it exports, then this means that the supply of naira is likely to exceed the demand in the foreign exchanging market, *ceteris paribus*. One can thus infer that the Nigerian Naira would be under pressure to depreciate against other currencies.On the other hand, if Nigeria exports more than it imports, then the Naira would be likely to appreciate. Second, a country's balance-of-payment data may signal its potential as a business partner for the rest of the world. If a country is grappling with a major balance-of-payment difficulty, it may not be able to expand imports from the

*Corresponding author: Chigozie K.A.
*E-mail address:*acha.kelechi@mouau.edu.ng
https://www.doi.org/10.60787/tnamp-19-79-88

outside world. Instead, the country may be tempted to impose measures to restrict imports and discourage capital outflows in order to improve the balance-of-payment situation. On the other hand, a country experiencing a significant balance-of payment surplus would be more likely to expand imports, offering marketing opportunities for foreign enterprises, and less likely to impose foreign exchange restrictions. Third, balance-of-payments data can be used to evaluate the performance of the country in international economic competition. Suppose a country is experiencing trade deficits year after year. This trade data may then signal that the country's domestic industries lack international competitiveness. To interpret balance-of-payments data properly, it is necessary to understand how the balance of payments account is constructed [1]; [2]. These transactions include payments for the country's exports and imports of goods, services, financial capital, and financial transfers. It is prepared in a single currency, typically the domestic currency for the country concerned. Sources of funds for a nation, such as exports or the receipts of loans and investments, are recorded as positive or surplus items. Uses of funds, such as for imports or to invest in foreign countries, are recorded as negative or deficit items.

When all components of the Balance of Payments accounts are included they must sum to zero with no overall surplus or deficit. For example, if a country is importing more than it exports, its trade balance will be in deficit, but the shortfall will have to be counterbalanced in other ways – such as by funds earned from its foreign investments, by running down currency reserves or by receiving loans from other countries.

Under a fixed exchange rate system, the central bank accommodates those flows by buying up any net inflow of funds into the country or by providing foreign currency funds to the foreign exchange market to match any international outflow of funds, thus preventing the funds flows from affecting the exchange rate between the country's currency and other currencies. Then the net change per year in the central bank's foreign exchange reserves is sometimes called the balance of payments surplus or deficit. Alternatives to a fixed exchange rate system include a managed float where some changes of exchange rates are allowed, or at the other extreme a purely floating exchange rate (also known as a purely *flexible* exchange rate). With a pure float the central bank does not intervene at all to protect or devalue its currency, allowing the rate to be set by the market, and the central bank's foreign exchange reserves do not change, and the balance of payments is always zero.

Exchange rate is the rate at which one currency will be exchanged for another. It is also regarded as the value of one country's currency in relation to another currency, [3]. Exchange rates are determined in the foreign exchange market, which is open to a wide range of different types of buyers and sellers, and where currency trading is continuous: 24 hours a day except weekends. The spot exchange rate refers to the current exchange rate. The forward exchange rate refers to an exchange rate that is quoted and traded today but for delivery and payment on a specific future date.

Whenever the Balance of Payments registers a purchase of a foreign asset or a sale of a domestic commodity abroad, this implicitly indicates that there is a change in the demand for or in the supply of the foreign currency. The international transaction cannot be completed unless one of the parties of the transaction is willing to exchange his/her domestic currency for foreign currency. Therefore changes in any of the components of the BOP affect the supply of and demand for foreign currency. The key variable that allows the supply of and demand for foreign currency to be equilibrated is the exchange rate. So if a domestic resident wants to buy the currency of another country, the exchange rates states the price for each unit of foreign currency.

2.0 Literature review

[4] used aggregate data from 1970 to 2012 to investigate balance of payments adjustment and productivity growth in Nigeria by specifying a small macro-econometric model to analyze the various channels through which the economy's BOP position could be enhanced. The empirical model identifies real exchange rate, government expenditure/revenue, real trade, and foreign direct investment as the various channels that drive

productivity growth of the Nigerian economy. The simultaneous equation model was analyzed using the ECM-error correction model approach rather than the conventional Ordinary Least Square (OLS) to overcome simultaneity bias while the unit roots and co-integration tests were carried out using ADF and Johansen techniques respectively. Among the findings of the study is that there is a relationship between changes in real exchange rate misalignment and changes in actual exchange rate. This, therefore suggest that the monetary authorities can use exchange rate alignments to develop the external sector of the Nigerian economy, via the non-oil export thereby solving the BOP disequilibrium problem. [5] investigated the impact of exchange rate adjustment (devaluation) simultaneous equation modeling of 78 econometric variables in Nigeria's balance of payments using the instrumental variable approach. He observed that the Central Bank of Nigeria has carried out complete neutralization of the domestic money supply within the sampled period of 1960 to 1993. [6] explored the applicability of the monetary approach to the balance of payments in Nigeria between the periods 1960 to 1995 using the two stage least square (2SLS) estimation technique. He observed that Nigeria's balance of payments has been dominated by monetary variables. His result confirmed the postulation that reserve accumulation is negatively related to the rate of growth of domestic output. Furthermore, [7] investigated adjustment policies under current account behaviour in Nigeria between the periods of 1970 to 2008, employing co-integration and error correction technique. He observed that the causality between exchange rate and current account is uni-directional while the same holds true for current account and trade openness. [8], [9], [10], and [11] examined exchange rate variations and balance of payments position in Nigeria under regulated and deregulated periods. He posits that the nation's balance of payments position has been under constant pressure since the 1980s as a result of several factors such as fluctuations in the prices of crude oil, poor performance of non-oil exports, high taste for foreign goods and services, etc. The main objective of his study was to analyze policies initiated by the Federal Government of Nigeria in attaining a realistic exchange rate and improving the balance of payments position. To achieve this objective, the econometric techniques of ordinary least squares, co-integration and error correction mechanism were used to analyze the sourced data. The results showed that exchange rate had more impact on the balance of payments position during the deregulated period than the regulated period in Nigeria. Based on the results, the study recommends that to improve the balance of payments position in the country, governments should increase their capital expenditure; exports should be stimulated and diversified in the non-oil sector such as agriculture and manufacturing sector; a contractionary monetary policy should be implemented to discourage importation of luxurious goods and the Naira should be devalued to make exports cheaper in the international market. Other researchers like [3], [12], [13], [14] [15] and [16] have worked extensively on balance of payments, inflation rate and exchange rate but none of them have ascertain the two way cause-and-effect relationship between Balance of Payment (BOP), Exchange Rate, and Inflation Rate in Nigeria using appropriate simultaneous equation model.

3.0 MATERIALS AND METHODS

Here, we shall discuss the source of the research data, the method of data analysis and the various steps involved in the implementation of the chosen method of analysis as well as the methods of testing the underlying assumptions.

The data are annual Balance of Payment, exchange rate and other macro-economic variables (e.g. inflation rate and interest rate) of Nigeria from 2004-2020, retrievable from the Data and statistics publication of the Central Bank of Nigeria website:www.Cenbank.org

The method adopted in the analysis of research data for this study is the Simultaneous Equation Model (SEM).

3.1 Simultaneous equation model

Simultaneous Equation Model (SEM) is a system of equations representing a set of relationships among variables. By this definition, we determine the values of one set of variables (called endogenous or jointly determined variables) in terms of another set of variables (called predetermined variables). Thus, the model consists of a series of equations with each equation serving to explain one variable whose values are determined within the model on the basis of the variables whose values are determined outside the model. The general M linear simultaneous equation model in M endogenous variables is given in [17] as

$$\begin{aligned}
Y_{1t} &= \beta_{12}Y_{2t} + \beta_{13}Y_{3t} + \ldots + \beta_{1M}Y_{Mt} + \gamma_{11}X_{1t} + \gamma_{12}X_{2t} + \ldots + \gamma_{1K}X_{Kt} + \mu_{1t} \\
Y_{2t} &= \beta_{21}Y_{1t} + \beta_{23}Y_{3t} + \ldots + \beta_{2M}Y_{Mt} + \gamma_{21}X_{1t} + \gamma_{22}X_{2t} + \ldots + \gamma_{2K}X_{Kt} + \mu_{2t} \\
Y_{3t} &= \beta_{31}Y_{1t} + \beta_{32}Y_{2t} + \ldots + \beta_{3M}Y_{Mt} + \gamma_{21}X_{1t} + \gamma_{22}X_{2t} + \ldots + \gamma_{2K}X_{Kt} + \mu_{3t} \\
&\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
Y_{Mt} &= \beta_{M1}Y_{1t} + \beta_{M2}Y_{2t} + \ldots + \beta_{M,M-1}Y_{M-1,t} + \gamma_{M1}X_{1t} + \gamma_{M2}X_{2t} + \ldots + \gamma_{MK}X_{Kt} + \mu_{Mt}
\end{aligned} \quad \cdots\cdots (3.1)$$

Equation (2.1) can be alternatively written as

$$\begin{aligned}
&\beta_{11}Y_{1t} + \beta_{12}Y_{2t} + \ldots + \beta_{1M}Y_{Mt} + \gamma_{11}X_{1t} + \gamma_{12}X_{2t} + \ldots + \gamma_{1K}X_{Kt} = \mu_{1t} \\
&\beta_{21}Y_{1t} + \beta_{22}Y_{2t} + \ldots + \beta_{2M}Y_{Mt} + \gamma_{21}X_{1t} + \gamma_{22}X_{2t} + \ldots + \gamma_{2K}X_{Kt} = \mu_{2t} \\
&\beta_{31}Y_{1t} + \beta_{32}Y_{2t} + \ldots + \beta_{3M}Y_{Mt} + \gamma_{31}X_{1t} + \gamma_{32}X_{2t} + \ldots + \gamma_{3K}X_{Kt} = \mu_{3t} \\
&\quad\vdots \\
&\beta_{M1}Y_{1t} + \beta_{M2}Y_{2t} + \ldots + \beta_{MM}Y_{Mt} + \gamma_{M1}X_{1t} + \gamma_{M2}X_{2t} + \ldots + \gamma_{MK}X_{Kt} = \mu_{Mt}
\end{aligned} \quad \cdots\cdots (3.2)$$

The model as specified in (3.2) can be regarded as the theory explaining the determination of the endogenous variables in terms of the predetermined variables and disturbance terms. The theory will in general state that some of the β and γ coefficients are zero, otherwise the M equations will not be distinguishable from one another. Also, a constant term may be included in each equation by setting one of the X-variables equal to unity. The β and γ coefficients are known as the structural parameters.

Putting (3.2) into matrix form, we obtain

$$\boldsymbol{\beta}\mathbf{Y}_t + \boldsymbol{\Gamma}\mathbf{X}_t = \boldsymbol{\mu}_t \quad \cdots\cdots\cdot (3.3)$$

3.2 Assumptions of the simultaneous equation model

Some of the assumptions underlying the use of the simultaneous equation model include:

(i) The disturbance terms are homoscedastic,

(ii) There is no serial correlation among the successive values of the disturbance term in an equation.

(iii) Contemporaneous covariance are equal and are independent of time, i.e. covariance of error term in different equation at the same time period are equal

(iv) No contemporaneous covariance are zero, i.e. covariance of error term in different equation at the same time period are zero.

3.3 Estimation of parameters of a simultaneous equation model

Methods of estimation of simultaneous equation systems are either single-equation methods (ILS and 2SLS) which are applied to one equation at a time or complete system methods (3SLS, FIML which are applied to the system as a whole. In this study, emphasis shall be made only on the single-equation methods.

3.4 Test of simultaneity

The test of simultaneity is carried out by the Hausman's Specification Error test. In this test, the M equations will be used to derive the reduced-form equations as:

$$\underset{(M\times n)}{\mathbf{Y}} = \underset{(M\times K)}{\boldsymbol{\Pi}}\,\underset{(K\times n)}{\mathbf{X}} + \underset{(K\times n)}{\mathbf{V}} \quad \cdots\cdots (3.4)$$

$$\Pi = \begin{bmatrix} \Pi_{11} & \Pi_{12} & \cdots & \Pi_{1K} \\ \Pi_{21} & \Pi_{21} & \cdots & \Pi_{2K} \\ \Pi_{31} & \Pi_{32} & \cdots & \Pi_{3K} \\ \vdots & \vdots & \ddots & \vdots \\ \Pi_{M1} & \Pi_{M2} & \cdots & \Pi_{MK} \end{bmatrix} \quad \cdots\cdots (3.5)$$

where $\mathbf{\Pi} = -\boldsymbol{\beta}^{-1}\mathbf{\Gamma}$ ...... (3.6)

$\mathbf{V} = \boldsymbol{\beta}^{-1}\mathbf{U}$ ...... (3.7)

Next, we apply the OLS on the reduced form-equation individually and substitute the estimated equation into the successive structural equations. We then, conduct the test of null hypothesis that there is no simultaneity against the alternative that there is simultaneity. If the null hypothesis is rejected, then the system in (3.3) actually constitutes a simultaneous equation model.

3.5 Test for Exogeneity

According to [17], the X's are selected on a priori knowledge. To test whether or not the X's are actually exogenous, the Hausman's Specification Error test is again utilized in the manner of Granger causality test). The first step here is to obtain the reduced form for $\left(Y_2, Y_3, \ldots, Y_M\right)$. From the reduced-form, we obtain the predicted values $\left(\hat{Y}_2\hat{Y}_3, \ldots, \hat{Y}_M\right)$.Then substitute these in Y_i. Using the F-test, we now conduct test of hypothesis that the coefficients $\left(\hat{Y}_2\hat{Y}_3, \ldots, \hat{Y}_M\right)$ are zero. If this hypothesis is rejected, then the variables $\left(Y_2, Y_3, \ldots, Y_M\right)$ can be deemed endogenous, but if it is not reject, they can be treated as exogenous.

3.6 Rank and order conditions for identification

In a model of M simultaneous equations, in order for an equation to be identified, the order condition states that, the number of predetermined variables excluded from the equation must be greater than or equal to the number of included endogenous variables minus 1 [10].That is, $K - k \geq m - 1$, where K denotes the number predetermined variables in the model including the intercept; k denote the number of predetermined in a given equation and m denotes the number of endogenous variables in a given equation.

3.7 Model Specification

Having stated the general form of the simultaneous equation model in (3.1) through (3.7), it is worthwhile to narrow it down to the variables used in this model. To begin, we recall that exchange rate is the price of a country's currency in terms of another country's currency. On the other hand, the Balance of Payment is a summary statement of a country's economic and financial transactions with the rest of the world within a given period of time usually a year. Theory states that a country's balance of payment position is influenced by among other variables, its exchange rate because of its implications for countries exports since it is a crucial determinant of the competitiveness of a country's exportable. But then, a country's exchange rate is itself functionally dependent on her balance of payment position, given the crucial nature of the balance of payment position to the country's foreign reserve position, which it can be argued is fundamental to exchange rate determination. It can be argued then that the relationship between a country's exchange rate and the balance of payment is bi-directional.

From foregoing, if we admit that Inflation bear on the balance of payment position and that interest rate influences exchange rate, then we can specify the following model:

$BOP = f(Exchange \quad Rate, \quad Inflation)$ .... (3.8)

$EXCHR = f(BOP)$ .... (3.9)

4.0 DATA PRESENTATION AND ANALYSIS

The data used for this analysis are presented in Table 4.1 below;

Year	Balance of Payment (N' Billion)	Exchange Rate of the Naira (N/US$1.00)	Inflation Rate of the Naira (N/US$1.00)	Interest Rate of the Naira (N/US$1.00)
2004	314.1	102.1052	2.96	10.44
2005	24.7	111.9433	15.31	10.09
2006	563.5	120.9702	16.46	15.57
2007	162.3	129.3565	10.95	11.88
2008	1,124.2	133.5004	17.84	12.21
2009	2,394.9	132.1470	14.46	8.68
2010	2,206.5	128.6516	14.03	8.26
2011	1,811.8	125.8331	6.41	9.49
2012	2,463.4	118.5669	7.54	11.95
2013	3,927.5	148.8802	13.08	12.63
2014	2,276.2	150.2980	13.22	7.19
2015	810.1	153.8616	12.22	6.30
2016	787.3	157.4994	11.43	7.63
2017	4,205.7	157.3112	10.43	6.72
2018	2,074.8	158.5526	8.1	9.89
2019	12942	193.2792	8.44	8.26
2020	4420	253.4923	11.64	7.10

Source: Central Bank of Nigeria website: www.cenbank.org (2005- 2022) data sets

We specified the model for simultaneous relation between Balance of Payment (BOP) and Exchange rate (EXCHR) in equations (3.8) and (3.9) respectively. Putting (3.8) and (3.9) into functional form given in equation (3.1), we obtain the following model:

$$Y_t = \beta_{10} + \beta_{11}X_t + \beta_{12}Z_t + U_{1t} \qquad \cdots\cdots\cdots (4.1)$$

$$X_t = \gamma_{10} + \gamma_{11}Y_t + \gamma_{12}I_t + U_{2t} \qquad \cdots\cdots\cdots (4.2)$$

4.1 Derivation of Reduced-Form Equations for Balance of Payments and Exchange Rate Model

The reduced-form equations can be obtained by substituting equation (4.2) into equation (4.1) and later equation (4.1) is put into equation (4.2). Therefore, if we put (4.2) into (4.1), we obtain

$$Y_t = \beta_{10} + \beta_{11}\left[\gamma_{10} + \gamma_{11}Y_t + \gamma_{12}I_t + U_{2t}\right] + \beta_{12}Z_t + U_{1t}$$

$$\Rightarrow \quad Y_t = \Pi_0 + \Pi_1 Z_t + \Pi_2 I_t + V_{1t} \qquad \cdots\cdots\cdots (4.3)$$

Substituting (4.1) into (4.2), we obtain

$$X_t = \gamma_{10} + \gamma_{11}\left[\beta_{10} + \beta_{11}X_t + \beta_{12}Z_t + U_{1t}\right] + \gamma_{12}I_t + U_{2t}$$

$$\Rightarrow \quad X_t = \Pi_3 + \Pi_4 Z_t + \Pi_5 I_t + V_{2t} \qquad \cdots\cdots\cdots (4.4)$$

Equations (4.3) and (4.4) are called the reduced-form equations for balance of payment and exchange rate respectively.

4.2 Estimation of reduced-form coefficients using ordinary least squares

Applying OLS to equations (4.3) and (4.4) respectively using data of Table 3.1, we obtain the estimated reduced-for4m models as:

$$\hat{Y}_t = -825560 + 50312Z_t + 72003I_t \qquad \cdots\cdots\cdots (4.5)$$

$$\hat{X}_t = 120 + 7.25Z_t - 0.68I_t \qquad \cdots\cdots\cdots (4.6)$$

4.3 Testing for simultaneity of balance of payment and exchange rate model

The Hausman-Specification Error Test can be used to test for simultaneity. Our interest in this test is to determine whether or not the endogenous explanatory variables are correlated with the disturbance terms. If they are, then the simultaneity problem exists.

To conduct the test, let us suppose that the estimated reduced form equation for balance of payments is

$$\hat{Y}_t = \hat{\Pi}_0 + \hat{\Pi}_1 Z_t + \hat{\Pi}_2 I_t \quad \cdots\cdots (4.7)$$

$$\Rightarrow \quad Y_t = \hat{Y}_t + \hat{V}_{1t} \quad \cdots\cdots (4.8)$$

Where $\hat{Y}_t$ are estimated values of Y_{1t} and $\hat{V}_{1t}$, the estimated values of V_{1t}.
Substituting (4.8) into (4.2), we obtain

$$X_t = \gamma_{10} + \gamma_{11}\left(\hat{Y}_t + \hat{V}_{1t}\right) + \gamma_{12} I_t + U_{2t}$$

$$\Rightarrow X_t = \gamma_{10} + \gamma_{11}\hat{Y}_t + \gamma_{12} I_t + \gamma_{11}\hat{V}_{1t} + U_{2t} \quad \cdots\cdots (4.9)$$

Applying OLS to equation (4.9) using data of Table 4.1, we obtain

$$X_t = 242 + 0.00164\hat{Y}_t - 13.2 I_t + 8.60\hat{V}_{1t} \quad \cdots\cdots (4.10)$$

The hypotheses being tested are stated as follows:

$$\begin{array}{l} H_0: \text{There is no simultaneity (i.e. } Y_t \text{ is not an endogenous variable) versus} \\ H_1: \text{There is simultaneity (i.e. } Y_t \text{ is an endogenous variable)} \end{array} \quad \cdots\cdots (4.11)$$

The test statistic is given as

$$\mathrm{t} = \frac{\hat{\beta}}{se\left(\hat{\beta}\right)} = \frac{0.00016389}{0.00006657} = 2.46 \quad \cdots\cdots (4.12)$$

Conclusion: Since $p - value(= 0.019) < \frac{\alpha}{2}(= 0.025)$, we reject H_0 and conclude that Y_t is indeed an endogenous variable.
Similarly, we can determine whether or not exchange rate is actually endogenous variable, by noting that the estimated reduced-form equation for exchange rate is

$$\hat{X}_t = \hat{\Pi}_3 + \hat{\Pi}_4 Z_t + \hat{\Pi}_5 I_t \quad \cdots\cdots (4.13)$$

$$\Rightarrow \quad X_t = \hat{X}_t + \hat{V}_{2t} \quad \cdots\cdots (4.14)$$

where $\hat{X}_t$ are estimated values of X_{1t} and $\hat{V}_{2t}$, the estimated values of V_{2t}.
Substituting (4.14) into (4.1), we obtain

$$56\, Y_t = \beta_{10} + \beta_{11}\left(\hat{X}_t + \hat{V}_{2t}\right) + \beta_{12} Z_t + U_{1t}$$

$$\Rightarrow Y_t = \beta_{10} + \beta_{11}\hat{X}_t + \beta_{12} Z_t + \beta_{11}\hat{V}_{2t} + U_{1t} \quad \cdots\cdots (4.15)$$

Applying OLS to equation (3.15) using data of Table 3.1, we obtain

$$Y_t = 9979699 - 105483\hat{X}_t + 815497 Z_t + 873\hat{V}_{2t} \quad \cdots\cdots (4.16)$$

The hypotheses being tested are stated as follows:

$$\begin{array}{l} H_0: \text{There is no simultaneity (i.e. } X_t \text{ is not an endogenous variable) versus} \\ H_1: \text{There is simultaneity (i.e. } X_t \text{ is an endogenous variable)} \end{array} \quad \cdots\cdots (4.17)$$

The test statistic is given as

$$\mathrm{t} = \frac{\hat{\gamma}}{se\left(\hat{\gamma}\right)} = -9.60 \quad \cdots\cdots (4.18)$$

Decision Rule: Reject the null hypothesis, H_0 if $p - value \leq \frac{\alpha}{2}$. Otherwise do not reject H_0.

Conclusion: Since $p - value(= 0.00551) < \frac{\alpha}{2}(= 0.025)$, we reject H_0 and conclude that X_t is indeed an endogenous variable.

4.4 Testing for exogeneity of inflation and interest rates

In order to determine whether or not inflation and interest rates are truly exogenous, we employ the Hausman test. Thus, equation (4.1) can be re-defined as:

$$Y_t = \beta_{10} + \beta_{11} X_t + \beta_{12} Z_t + \lambda_1 \hat{X}_t + U_{1t} \quad \cdots\cdots\cdots (4.19)$$

Where, $\hat{X}_t = \hat{\Pi}_3 + \hat{\Pi}_4 Z_t + \hat{\Pi}_5 I_t$.

Applying OLS to equation (4.19) using data of Table 3.1, we obtain

$$Y_t = 9979699 + 873X_t + 815497Z_t - 106356_1\hat{X}_t \quad \text{(4.20)}$$

$$\begin{aligned} &H_0 : \lambda_1 = 0 \text{ (There is no exogeneity ; i.e. } Z_t \text{ is not an endogenous variable) versus} \\ &H_1 : \lambda_1 \neq 0 \text{ (There is exogeneity i.e. } Z_t \text{ is an endogenous variable)} \end{aligned} \quad \text{(4.21)}$$

The test statistic is given as

$$t = \frac{\hat{\lambda}_1}{se(\hat{\lambda}_1)} = -10.61 \quad \text{(4.22)}$$

Decision Rule: Reject the null hypothesis, H_0 if $p-value \leq \frac{\alpha}{2}$. Otherwise do not reject H_0.

Conclusion: Since $p-value(=0.00548) < \frac{\alpha}{2}(=0.025)$, we reject H_0 and conclude that Z_t is indeed an exogenous variable.

Similarly, the equation for exchange rate can be re-defined as:

$$X_t = \gamma_{10} + \gamma_{11}X_t + \gamma_{12}I_t + \lambda_2\hat{Y}_t + U_{2t} \quad \text{(4.23)}$$

where $\hat{Y}_t = \hat{\Pi}_0 + \hat{\Pi}_1 Z_t + \hat{\Pi}_2 I_t$.

Applying OLS to equation (4.23) using data of Table 3.1, we obtain

$$X_t = 221 + 0.000003Y_t - 11.1I_t + 0.000141\hat{Y}_t \quad \text{(4.24)}$$

$$\begin{aligned} &H_0 : \lambda_2 = 0 \text{ (There is no exogeneity ; i.e. } I_t \text{ is not an endogenous variable) versus} \\ &H_1 : \lambda_2 \neq 0 \text{ (There is exogeneity i.e. } I_t \text{ is an endogenous variable)} \end{aligned} \quad \text{(4.25)}$$

The test statistic is given as

$$t = \frac{\hat{\lambda}_2}{se(\hat{\lambda}_2)} = \frac{0.000141076}{0.0006634} = 2.12 \quad \text{(4.26)}$$

Decision Rule: Reject the null hypothesis, H_0 if $p-value \leq \frac{\alpha}{2}$. Otherwise do not reject H_0.

Conclusion: Since $p-value(=0.0041) < \frac{\alpha}{2}(=0.025)$, we reject H_0 and conclude that I_t is indeed an exogenous variable.

4.5 Identification test for balance of payments and exchange rate equations

We had earlier stated that, the possibility of calculating the structural coefficients of the model in 4.1 and 4.2, is based on whether or not the equations are identified. To assess the identifiability of the structural equations of the system, we employ the rank and order conditions, shown in table 4.2.

Table 4.2: The rank and order condition of identifiability

Equation	**K**	**K**	**m**	**K-k**	**m-1**	**Rank Condition: K-k=m-1**	**Order condition: Determinant**
BOP	4	3	2	1	1	Exactly	$\lvert\Delta_1\rvert \neq 0$
EXCHR	4	3	2	1	1	Exactly	$\lvert\Delta_2\rvert \neq 0$

From Table 4.2, we observe that both rank and order conditions of identification are satisfied. Therefore, the two equations: BOP and Exchange rate are exactly identified.

Estimation of structural parameters of the balance of payment and exchange rate equations

Having established that the structural equations for both balance of payments and exchange rates are exactly identified, the next task is to employ the indirect least squares method.

$$\hat{\beta}_{10}=\hat{\Pi}_3\left(\frac{\hat{\Pi}_0}{\hat{\Pi}_3}-\frac{\hat{\Pi}_2}{\hat{\Pi}_5}\right)=102\left(\frac{-825560}{102}-\frac{72003}{-0.68}\right)=9974890 \quad \text{(4.27)}$$

$$\hat{\beta}_{11}=\frac{\hat{\Pi}_2}{\hat{\Pi}_5}=\frac{72003}{-0.68}=-105886.7647 \quad \text{(4.28)}$$

$$\hat{\beta}_{12}=\left(\hat{\Pi}_1-\frac{\hat{\Pi}_2\hat{\Pi}_4}{\hat{\Pi}_5}\right)=\left(50312-\frac{72003\times 7.25}{-0.68}\right)=817991.0441 \quad \text{(429)}$$

$$\hat{\gamma}_{10}=\hat{\Pi}_0\left(\frac{\hat{\Pi}_3}{\hat{\Pi}_0}-\frac{\hat{\Pi}_4}{\hat{\Pi}_1}\right)=-825560\left(\frac{102}{-825560}-\frac{7.25}{50312}\right)=220.9639 \quad \text{(4.30)}$$

$$\hat{\gamma}_{11}=\frac{\hat{\Pi}_4}{\hat{\Pi}_1}=\frac{7.25}{50312}=0.000144 \quad \text{(4.31)}$$

$$\hat{\gamma}_{12}=\left(\hat{\Pi}_5-\frac{\hat{\Pi}_2\hat{\Pi}_4}{\hat{\Pi}_1}\right)=\left(-0.68-\frac{72003\times 7.25}{50312}\right)=-11.0557 \quad \text{(4.32)}$$

Using the results of equations (4.27) through (4.32), we define the estimated structural equations for balance of payments and exchange rates respectively as:

$$Y_t=9974890-105886.7647X_t+817991.0441Z_t \quad \text{(4.33)}$$

$$X_t=220.9639+0.0001Y_t-11.0557I_t \quad \text{(4.34)}$$

5.0 DISCUSSION OF RESULTS AND CONCLUSION

The coefficient $\hat{\beta}_{10}=9974890$ shows that if there is no exchange rate and inflation rate, then BOP would on the average stand at ₦9, 974,890.00. However, in practice, this result is difficult to materialize because rarely do exchange rate and inflation to zero. $\hat{\beta}_{11}=-105886.76$ Shows that if exchange rate increases by one unit, then BOP will decrease by ₦ 105886.76, this result indicates that, irrespective of the fact that Zt has a partial influence on BOP. It implies that a reduction in exchange rate encourages the BOP. $\hat{\beta}_{12}=817991.0441$ Shows that if inflation rate increases by 1 percent, then BOP increases by ₦ 817991.04. This means that the higher the rate of inflation, the higher the BOP. This result does not agree with the work of Anthony (2022). $\hat{\gamma}_{10}=220.9639$ Implies that, when BOP and interest rate drops to zero, then exchange rate would stand at ₦ 220.96 per US dollar. $\hat{\gamma}_{11}=0.000144$ Indicate an increase of one unit of BOP leads to an increase of ₦ 0.0001 million in exchange rate. Thus, BOP positively affects exchange rate. $\hat{\gamma}_{12}=-11.06$ Shows that when interest rate increases by one unit; then exchange rate decreases by ₦ 11.06.

This paper discusses fitting of simultaneous equation model to Nigeria balance of payment and exchange rate for the period January 2004 to December 2020 obtained from the CBN Statistical Bulletin. The ultimate objective is to construct a statistical model which may be used to obtain future values of Nigeria balance of payment and exchange rate necessary for policy formulation, implementation and monitoring. The result of data evaluation for the assumptions of simultaneous equation model shows that the data satisfied the simultaneity and exogeneity assumptions. The result of the rank and order condition of identifiability shows that the two equations: BOP and Exchange rate are exactly identified using the Indirect Least Squares estimation procedure. The result shows that interest rate inversely affect exchange rate, in other words, if interest rate is high, exchange rate would be low.

REFERENCES

[1] Cheol S. E. and Bruce G. R. (2013).International Financial Management. *China Machine*

[2] Sloman, J. (2004). Economics. *Penguin. pp. 516, 517, 555–59.*

[3]Steven, G. (2003)."Balance of payment policy in Developing countries in the quest for economic stabilization." Tony Killick Edition. London: Heinemann Education Books.

[4] Ezenekwe, R.U., Metu, A. G. and Kalu, C. U. (2015). Balance of payments adjustment and productivity growth in Nigeria: A small macroeconometric analysis. Journal of Economics and Sustainable Development, 6(10). www.iiste.org

[5] Nyong, M. O. and Obafemi, F. N. (1995) "Exchange Rate Policy and Macroeconomic Adjustment in Nigeria: A Theoretical and Empirical Analysis with Policy Implication" *Journal of Economic Studies*, 1(1), Department of Economics, University of Calabar.

[6]Akpansung A. O. (1998). *Applicability of Monetary Approach to Nigeria's Balance of Payments, 1960-1995*. Unpublished MSc (Economics) Thesis, University of Calabar, Nigeria.

[7]Udah, D. J. (2011). "Real response association with exchange rate action in selected upper credit" Tranche stabilization programs. *IMF StaffPaper 28* Washington, World Bank.

[8] Pindyck, R. S. and Rubinfeld, D. L. (2022) Econometric Models and Economic Forecasts. McGraw-Hill, New York.

[9] Olisadebe (2016). International Finance (2nd ed.). London: Macmillan Educa. Ltd.

[10]Pincheira, P. M. and Medel, C. A. (2015). Forecasting in ation with a simple and accurate benchmark: The case of the U.S. and a set of in ation targeting countries. Czech Journal of Economics and Finance, 65(1).

[11] Anthony I. I. (2022). Exchange Rate and Balance Of Payments Position in Nigeria, JORIND 13(2). ISSN 1596-8303

[12] Montgomery A. L. and Michael D. S. (2009), "Prospects for Personalization on the Internet", *Journal of Interactive Marketing*, 23 (2), 130-137. (Working Paper # 2008-E15)

[13] Imoisi, A. I. (2012): Trends in Nigeria's Balance of Payments: an Empirical Analysis from 1970-2010: *European Journal of Business and Management*, IISTE, U. S. A., vol. 4 (21), 210 –217, ISSN 2222 – 2839

[14] Oladipupo, A.O. and Onotaniyohuwo, F.O. (2011). Impact of Exchange Rate on Balance of Payment in Nigeria, *International Multidisciplinary Journal*, *Ethiopia Vol. 5 (4).*

[15] Aniekan O.A. (2013). A Review of Empirical Literature on Balance of Payments as a Monetary Phenomenon,*Journal of Emerging Trends in Economics and Management Sciences JETEMS) 4(2): 124-132.*

[16] Udude C. C. (2015). Monetary Policy and Balance of Payment in Nigeria (1981-2012), *Journal of Policy and Development Studies Vol. 9, No. 2.*

[17] Gujarati, D. N. and Porter, D. C. (2009) Basic Econometrics. 5th Edition, McGraw Hill Inc., New York.