Journal of Global Economics
ISSN: 2375-4389

Akbar, J Glob Econ 2016, 4:4
DOI: 10.4172/2375-4389.1000220

Research Article Open Access

Efficiency of Foreign Exchange Markets: The Case of Nigeria

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Abstract

Notwithstanding a particular economy, exchange rate plays a pivotal role in the determination of major macroeconomic policies. Hence, the efficiency of the foreign exchange market in a developing country like Nigeria is essential with respect to broader macroeconomic facets including the monetary dimension. Accordingly, the current study examines the weak and semi-strong form efficiency of the Nigerian foreign exchange market. Employing time series analysis and examining unit root test, Johansen cointegration test, Wald coefficient test, impulse response function and variance decomposition analysis, it was found that the Nigerian foreign exchange market is weak form efficient but is inefficient in the semi-strong dimension. This reflects that participants would not be able to devise measures to extract excess returns from the market based on historical information, but can engage in profitable transactions once accommodating publicly available information together with historic statistics. Specifically, the possibility of predicting exchange rates of the Naira with other currencies emanating from the Naira-USD exchange rate is very high. Reforms and government intervention should look into making the market more transparent and accountable, which would not only abandon excess returns from the market but will also support export-oriented industries in the economy, foreign exchange reserves and a range of other significant macro-economic facets.

Keywords: Foreign exchange market; Nigeria; Efficiency; Time-series analysis

Introduction

The history of the foreign exchange market dating back to the biblical times, it was only in the 1800s that the development of a formal foreign exchange market came into existence. The obligation for a foreign exchange market mainly evolved due to the need for countries to trade between themselves. Since the espousal of formal foreign exchange markets, nations have attempted to set low exchange rates in comparison to other nations' with an aim to attain a favourable trade position. The strategy would improve a country's trade position by making its exports more affordable and attractive, while making the imports expensive. Nevertheless, the arrangement took a back seat with the development of the Bretton-Woods System, in conjunction with other pegged exchange rate systems. However, it was not long before countries participating in the Bretton-Woods system realized that the process was partially inclined towards the US together being obstructive to other counterparts. Hence, the majority of the countries adopted a floating exchange rate in the 1970s to avoid the setback posed by the Bretton-Woods System. This meant that countries would allow their currencies to 'float', determining the exchange rate by supply and demand on currency markets. Nevertheless, it is the case that most of the countries still fine-tune their exchange rates with the mechanism of foreign exchange reserves, which in turn, comprises of gold reserves or foreign currencies.

Today's foreign exchange market, one of the most liquid financial markets in the world, is a gigantic and fast-paced market. Millions of traders traded approximately USD 3.98 trillion every day in April, 2010 in respect of USD 1.7 trillion in 1998 [1]. An example of the growth of such markets can be drawn from the US market which had an estimated turnover of USD 351 billion per day in 1998, which was a 43 per cent increase over 1995 and 60 times of the turnover in 1997 [2].

With the overwhelming significance of foreign exchange markets around the globe, it is the case that some foreign exchange markets are efficient while others being inheritably inefficient. In this respect, the notion of foreign exchange markets being inefficient cannot be attributed to the mechanisms of the market alone but dependence on other sectors of the economy. Accurately developed models can predict the exchange rate movements with precision if a foreign exchange market is inefficient. Thus, inefficient foreign exchange markets provide the opportunity for speculators, investors and financial analysts with profitable foreign exchange transactions. Conversely, an efficient foreign exchange market system will adjust itself without government intervention. Additionally, market participants will not be able to put together abnormal profits from foreign exchange transactions and such markets have policy implications of enormous importance [3].

The current study analyses on the foreign exchange market of Nigeria. A brief development of the Nigerian foreign exchange market would follow. The Nigerian market evolved up to its present state depending upon many dynamics such as the changing pattern of international trade, structural changes of the economy and shifts in the pattern of production and demand functions. With the establishment of the Central Bank of Nigeria in 1958, the Nigerian currency was pegged to the British Pound sterling at par - as a result of which delays were experienced with the development of an active foreign exchange market. With increased export of crude oil in the 1970s, the foreign exchange market of Nigeria experienced a boom and the commercial banks had a tough time accommodating the much enhanced levels of incoming foreign currencies. Nevertheless, crisis eventually set in 1982, which was counteracted by the application of a comprehensive exchange rate control. Yet still, the foreign exchange control system was not able to evolve an appropriate mechanism for foreign exchange, which led to the development of a second-tier foreign exchange market in 1986. However, volatility was still existent in the foreign exchange market and further reforms were introduced in 1994 to account for

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Received September 06, 2016; **Accepted** October 17, 2016; **Published** October 21, 2016

Citation: Akbar MI (2016) Efficiency of Foreign Exchange Markets: The Case of Nigeria. J Glob Econ 4: 220. doi: 10.4172/2375-4389.1000220

volatility. The reforms mainly included the formal pegging of the Naira, the centralisation of foreign exchange in the Central Bank, the restrictions of the Foreign Exchange Market Bureaux de Change as agents of the national Central Bank, the reaffirmation of the illegality of the parallel market and the discontinuation of open accounts and bills as means of payments sectors. With an aim to improve efficiency, the foreign exchange market was further liberalised in 1999 with the introduction of an Inter-bank Foreign Exchange Market.

Hence, it is evident that the foreign exchange market of Nigeria has experienced severe transformations in the preceding couple of decades. Thus, it becomes necessary to understand foreign exchange markets and its efficiency in the Nigerian context. However, it should be noted that a full-size parallel exchange market is existent in Nigeria. This aspect would not be covered in the present study and would be left for future endeavours. Also, future and other derivatives of the Nigerian market are outside the scope of the present study.

The rest of the paper is organized as follows. Section 4 presents the review of relevant literature together with empirical theories relevant for the current study. Section 3 marks the empirical methodology, based on which the following section, Section 8, reports the empirical results. Section 9 provides conclusions and policy recommendations.

Literature Review

Foreign exchange is the mechanism by which a person or firm transfers purchasing power from one country to another, obtains or provides credit for international trade transactions and/or minimizes exposure to foreign exchange risks. Being a form of exchange for the global decentralised trading of international currencies, the foreign exchange market assists international trade and investment by enabling currency conversion. The sheer volume of geographically dispersed market participant created liquidity state cannot be matched by any regulated exchange-traded product or instrument [4]. Based on this insight on the mechanism of foreign exchange markets, it is a venture that could easily be compromised by certain factors, largely dependent on the countries involved in the trading process. Abundant studies exist on the efficiency of the foreign exchange markets in the developed countries, but the case of foreign exchange markets in the developing world is still scarce.

Early tests of foreign exchange market efficiency began in the 1950s, with effective continuation thereafter [5]. Early analyses did not reject the hypothesis of efficiency while exclusively testing for the randomness of prices in a market. If prices were random, this would mean that new information is immediately absorbed in the current prices. On the other hand, inefficiencies in the foreign exchange market are regarded as 'anomalies' rather than the usual term dictating [5].

Considering diverse currencies and various regions, the following discussion presents the ongoing debate of the foreign exchange market efficiency. Kisaka et al. [6] find that the foreign exchange market in Kenya is inefficient with supplementary evidence of exchange rate undershooting and overshooting. Baillie et al. [7] analyze spot and forward exchange rates by modelling them as unrestricted bivariate autoregressions employing weekly data from the New York foreign exchange. Constructing the forward exchange rate to be an unbiased estimate of the future spot exchange rate as the null hypothesis, this hypothesis was rejected for each of the six currencies considered.

Employing cointegration models between forward and current spot rates and the former with the future spot rate, Zivot [8] tested foreign exchange market efficiency for the British Pound, Japanese Yen and the Canadian Dollar against the US Dollar. The study concluded that the hypothesis of foreign exchange market efficiency is rejected for each of the currencies. Another study by Hakkio et al. [9] also employed cointegration analysis to test for the foreign exchange market efficiency regarding the British Pound and the Deutsche Mark. Rejection of the hypothesis of market efficiency have also been the concluding remark of the authors; with the distinct finding that spot and forward rates within a country are cointegrated. In similar lines, Baillie et al. [10] also find that spot rates are cointegrated. Reasoning that the disequilibrium error can envisage potential changes in the spot rate, the authors conclude inefficiency in the foreign exchange market.

Because of the fact that developing countries do not have a well-developed and independent financial system and forward markets can be totally absent in some of the developing economies, Giannellis and Papadopoulos proposed an alternative way for testing the foreign exchange market efficiency hypothesis for the developing countries. The methodology is based on the Behavioral Equilibrium Exchange Rate [11], concentrating primarily on the statistical properties of the misalignment rate. With the foremost conclusion that government intervention is an indication of market inefficiency, further conclusions state that macroeconomic performance, political stability and intervention measures by the central bank would additionally contribute to the inefficiencies in the foreign exchange market. Linking exchange rates, market efficiency and currency crisis robustly, the authors uncover two of the examined foreign exchange markets to be efficient, while tracing the rest of the markets to be inefficient.

Other dimensions of the foreign exchange market, for instance volatility, have been tested and so have been the momentum and rational expectation of investors. For instance, Johnson [12] tests a stochastic volatility model of exchange rates linking both the level of volatility and covariance. Investigating the association between realised trends and changes in volatility, the study found that foreign exchange returns display increasing volatility with the presence of consistent trends and decreases in case of reversals. Thus, a conclusion was reached that trend consequence is an important agenda in its own right. Another author, Bekaert [13], analysed the time variation of expected return regarding conditional means and variances. The author carried out vector auto-regression on exchange rate changes and forward premiums, which in turn, predicts future forward market returns. The conclusion that an enhancement of the forward-premium lowers future forward market returns was reached regarding the Japanese Yen, German Deutsche Mark and the British Pound. Additionally, it was also revealed that the most recent weekly change in the spot exchange rate has more predictive ability of envisaging future exchange rates in comparison to historical, monthly or quarterly exchange rates.

Another study by Baillie et al. [7] considered the forward exchange rate as an unbiased estimator of the future spot exchange rate (the null hypothesis). The null hypothesis was rejected for each considered pair of currencies. Disregarding rational expectations and risk neutrality, it was found that the forward rate is a biased predictor of upcoming exchange rates and thus, it becomes a reality that future spot exchange rates could be forecasted depending on the historical forward exchange rate information.

Two alternative approaches of market efficiency were derived by Pilbeam et al. [14], one of which measures the inefficiency of a foreign exchange market. Reaching a conclusion not in coherence with many of the above mentioned studies, the study reflects that the foreign exchange market is efficient for each of the bilateral dollar currency cases considered. The authors confidently stated that their econometric methodology is far favourable to the concept of foreign exchange market than the conventional regression analyses considered by other studies. Thus, they strongly affirm that the forward discount puzzle is merely a statistical phenomenon and the rejection of market efficiency occurs as a result of unbalanced character and negative bias in the case of conventional regressions.

Limited and dated studies exist relating to the efficiency of foreign exchange markets in Nigeria. Ayogu [15] tested daily data of foreign currencies in Nigeria's parallel market, deducing that the market is not weak-form efficient and therefore, historic trends can be employed to predict future prices. Additionally, Ayogu [16] argued in dissimilar lines that investors would not be able to extract hefty profits by forecasting Nigeria's parallel foreign exchange market. While the author agrees that there can be other feasible trading strategies for attractive profit-making opportunities, the study also states no evidence of price bubble in the parallel market. However, the study does not find ample evidence to support the fact that inefficiencies are caused by traders, which consequently indicates that policy makers should be concerned with the apparent inefficiencies. Furthermore, Umar et al. [17] studied a monthly sample of 108 months of Nigerian foreign exchange rates in an attempt to discover whether Inter Bank Foreign Exchange Market and Dutch Auction System converge to a long-run equilibrium. The study concludes that a long-run relationship exists when the Dutch Auction System is applied, but the affiliation becomes null with the application of Inter Bank Foreign Exchange Market arrangement.

Efficient Market Hypothesis

A market is said to be efficient if prices 'fully reflect' all available information [18]. The notion 'fully reflect' implies that one would expect actual price to be similar to equilibrium values with the actual returns conforming to their equilibrium returns. The hypothesis also implies that market agents will have rational expectations and the presence of transaction costs would be negligible in the frame of buying and selling of assets. Satisfying such condition in a particular market, an economic agent will not be able to extract economic profits (excess returns) on the basis of asymmetric information which prevail in the market space. Fama [18] developed this classical definition of efficient market hypothesis, which is applicable to foreign exchange markets[1].

Based on the information to form expectations of future prices, three forms of market efficiency can be distinguished [19]. The frailest is the weak-form efficiency in which prices reflects only the historical information. Giannellis and Papadopoulos notes that this market "…reflects information up to the point where the marginal benefit of information does not exceed the marginal cost of collecting it". Hence, in a weak-form efficient market, earning excess return, which is risk-adjusted, is impracticable. This is because prices would only reflect historical information, which would not be of any assistance in the forecasting of future prices or trends. Secondly, the semi-strong form of efficiency incorporates all publicly available information; while the third criteria, the strong-form efficiency, reflect all available information incorporating historical, public and privately accessible information. Therefore, in an efficient market, market participants cannot use either historical, publicly available or insider's information to formulate any modus operandi that can consistently out-do the market.

Random Walk Hypothesis

The Random Walk Hypothesis (RWH) entails that prices in a market are completely unpredictable, particularly in the short-run. Bachelier [20] was one of the first in suggesting that prices in an efficient market are dominated by random walk, with prices being normally distributed. Kendall [21] followed up this theory with the finding that stock price fluctuations are independent of each other and possess the same probability distribution. Thus, if prices in a market follow the random walk procedure, it would be appropriate to conclude that fundamental and technical analysis would not be able to provide for profit extraction. Hence, the hypothesis describes past prices to be entirely irrelevant in forecasting future prices, as prices would be determined randomly and not otherwise. In technical terms, the RWH entails that the foreign exchange rate returns would follow a unit root process in combination with no correlation.

A random walk being defined by the fact that price changes are independent of each other [22], the concept does not necessarily coincide with that of efficient market hypothesis with regard to rational investors. With arguments both against and in favour of the RWH, Dupernex [23] states that it is very difficult to reach a consensus due to the predicament of data mining.

Theoretical Estimation and Modelling

Data and methodology

Efficiency of foreign exchange markets can be scrutinized by either time series analysis incorporating key macroeconomic variables or a time series assessment based on moment conditions such as unit root and cointegration tests. The current study focuses on the latter methodology, deploying an analysis of the exchange rate time series' with no exogenous independent variables.

Secondary data sources have been employed in this study. The US Dollar-Naira exchange is of particularly importance in the current context as this legal tender is very prominently and frequently traded in the spot market while being the denominator of the majority of business transactions and asset valuations in Nigeria. Hence, initial analysis has been carried out considering Naira vis-à-vis US Dollar spot exchange rates (exchange rates have been considered on a daily, monthly and yearly basis[2]). Correspondingly, a second set of analysis incorporates monthly exchange rates of the Naira against the US Dollar, Pound Sterling, Australian Dollar, French Franc and Chinese Yuan and Japanese Yen. The sample period for the daily exchange rate covers the period from December 10, 2001 to September 20, 2013, while that of the yearly sample covers the period from 1960 to 2012 and that of the monthly rate ranges from April 30, 1994 till August 31, 2013.

Unit root test to determine stationarity: A time series analysis requires investigation of the time-series properties of the variables in question before proceeding further with the econometrics. To begin with the unit root test, this test identifies the stationarity of a time series. A long-run relationship only exists between variables if the variables are non-stationary at level (I (0)), while becoming stationary at first difference, (I (1)). Employing unit root tests to test whether the spot exchange rates are difference stationary in the present study (the null hypothesis- there is presence of unit root) or trend-stationary (alternative hypothesis –the series is stationary) [6], it is to be noted here that the RWH is already contained in the null hypothesis.

Two unit root tests are carried out at the present juncture for the purpose of testing stationarity. The Augmented Dickey-Fuller (ADF)

[1]The definition is applicable to other markets as well
The Efficient Market Hypothesis is also known as Information Efficiency (Hallwood and MacDonald, 1994).

[2]This has been done to add robustness to the analysis, which would have been absent if the frequency of the data was considered a constraint

unit root test was the first to be carried out. The event of a standard ADF regression would generally take the form:

$$y_t = \propto + \delta t + \sum \gamma_j \;\; y_{t-j} \quad \rho y_{t-} \; + \varepsilon_t$$

To make the methodology more robust, another unit root test was performed – the Phillips-Perron (PP) unit root test. While the ADF account for the problem of serial correlation experienced by the Dickey-Fuller test with the inclusion of the lags of y_t, the PP test has the necessary robust measures to account for serial correlation with the adoption of the Newey et al. [24] heteroskedasticity and autocorrelation consistent covariance matrix estimator [25]. Essentially, three groups of tests were identified by Perron [26] according to the following equations:

$$x_t = \alpha_0 + \alpha_1 DU_t + d(DTB)_t + \beta t + \rho x_{t-1} + \sum_{i=1}^{p} \varnothing_i \Delta x_{t-1} + \varepsilon_t$$

$$x_t = \alpha_0 + \gamma DT_t * + \beta t + \rho x_{t-1} + \sum_{i=1}^{p} \varnothing_i \Delta x_{t-1} + \varepsilon_t$$

$$x_t = \alpha_0 + \alpha_1 DU_t + d(DTB)_t + \gamma DT_t + \beta t + \rho x_{t-1} + \sum_{i=1}^{p} \varnothing_i \Delta x_{t-1} + \varepsilon_t$$

Where, DU_t is a dummy intercept representing a change in the level (DU_t =1 if (t > TB) and zero otherwise)

DT_t and DT_t* is a slope dummy representing a change in the slope of the trend function

TB is the break date (structural break)

DTB represent crash dummy (DTB=1 if t=TB +1, and zero otherwise)

Cointegration test: The next stride would be to determine if cointegration exists in the foreign exchange market of Nigeria. Engle et al. [27] stated that if two variables are cointegrated, this would indicate that there exists a long-run equilibrium relationship. 'If two or more series individually have unit root, but some linear combination of them has a stationary process, then the series is said to be cointegrated' [28]. Another procedure, the Johansen [29,30] method – an expansion of the Engle et al. [27] method, allows for more than one cointegrating equation employing the trace statistic and the maximum eigenvalue statistic. Keeping in mind that the unit root and serial correlation inferences only test the weak-form market efficiency, the main aim of the cointegration analysis is to determine long-run relationship, focusing on semi-strong form of market efficiency.

The present study employs the Johansen cointegration test, which typically takes the following form:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \varepsilon_t$$

The first step of the Johansen cointegration test is the determination of the order of integration of the variables, which refers to the number of times a variables needs to difference before the variable becomes stationary. This step has already been incorporated in the analysis of unit roots. The next step is to determine the optimum number of lags to be included in the cointegration test. The identification of the number of lags is an important feature because it is very important to establish on how many lags fit in the model. Amongst the methods available for lag determination, the current study employs the Akaike Information Criteria (AIC) – the lower the values of the AIC, the better fitted would be the model. Accordingly, respective lags taking the lowest AIC values would be the optimum lags for the model.

The number of optimal lags would then be used to establish the number of cointegrating ranks in the system. Cointegrating rank refers to the degree of association between the concerned variables. Trace statistic and maximum eigenvalue statistic would be employed in the cointegration test to identify the number of cointegrating ranks i.e., the number of cointegrating equations. The hypothesis which is tested is that there are 'r' cointegrating vectors against the alternative of 'r or more' (trace statistic) or 'r+1' (maximum eigenvalue statistic) cointegrating vectors.

If there exist at least one cointegrating relationship, a causal relationship can be approximated by employing the Vector Error Correction Model (VECM) (which is a restricted Vector Auto-Regression model (VAR)). If it is the case that no cointegrating relationship is found, a VAR model is the procedure. A typical VECM with a lag length *n* is modeled as:

$$\Delta x_t = a_1 + b_1 ect_{t-1} + \sum_{i=1}^{m} c_1 \Delta x_{t-i} + \sum_{i=1}^{n} d_1 \Delta y_{t-i} + \varepsilon_{1t}$$

$$\Delta y_t = a_2 + b_2 ect_{t-1} + \sum_{i=1}^{m} c_2 \Delta y_{t-i} + \sum_{i=1}^{n} d_2 \Delta x_{t-i} + \varepsilon_{2t}$$

Where, x_t and y_t are the variables which are cointegrated, m and n are the respective lag lengths of the variables, Δ is the difference operator, ect represents the residuals from the cointegrating equation and ε presents the white-noise residuals.

On the other hand, a VAR model with *p* lags would follow from:

$$y_t = \alpha + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots\ldots + \beta_p y_{t-p} + \varepsilon_t$$

After estimating the VAR/VECM (VAR in the current study), the Impulse Response Function (IRF) and Variance Decomposition (VD) analysis have been carried out. An IRF represents a shock to the VAR system. IRF observes the channels and conducts though which each variable affects the other one, given the exogenous shock. IRF identifies the responsiveness of endogenous variables in a system (typically VAR in the current space) when a shock is being applied to the error term. Essentially, a unit shock is applied to each variable and the effects on the overall VAR/VECM system are observed. IRF is essential for characterizing the dynamic responses estimated by the VAR/VECM (assuming that all the variables are endogenous).

A first-order VAR for the n-vector y_t would take the following form:

$$y_t = \mu + Ay_{t-1} + \varepsilon_t$$

Where, μ is the vector of intercepts and $\varepsilon_t \sim IN\ (0,\ \Sigma)$. The IRF of a shock, say IR, to a variable (e.g. exchange rate, ER) after k periods is:

$$IRF\left(ER, IR, k\right) = [Ey_{ER,t} | \varepsilon_{IR,t-k} = 1, \varepsilon_{\backslash IR,t-k} = 0, \varepsilon_{t-k+1} = 0, \ldots\ldots, \varepsilon_t = 0] - [Ey_{ER,t} | \varepsilon_{IR,t-k} = 0, \varepsilon_{\backslash IR,t-k} = 0, \varepsilon_{t-k+1} = 0, \ldots\ldots, \varepsilon_t = 0]$$

Where, $\varepsilon_{IR,t}$ is the vector ε_t excluding the IR element. Assuming that there are no other shocks at period *t-k* or other intervention periods (*t-k+1,…t*), the IRF measures the effect of a shock of 1 unit occurring at period *t-k* in IR on ER, *k* periods later. In this connection, Khan et al. [28] state that "IRF shows impulse responses of the select variable in the VECM system in regards to the time paths of the variable's own error shock against the error shocks to other variables in the system". Hence, an IRF would typically identify the responsiveness of the dependant variables (endogenous variables) in VAR/VECM when a shock is applied to the error term (error term/innovation/shock/impulse). The IRF measures the effect of a shock of 1 unit (typically 1 standard deviation) occurring at future periods (for example 10 months).

Empirical Results

Graphical presentation

To get a fundamental understanding of the respective time series, basic line graphs of daily, monthly and yearly spot (nominal) exchange rates of the Naira against the US Dollar are presented in Figures 1, 2 and 3 respectively.

It can be observed from figure 1 that the daily exchange rate (considering a 5-day week with exceptions of public holidays) has been following an upwards trend. Two outliers can be unambiguously identified from the graph. This can be approximately attributed to the period of initiation of the global financial crisis, but lack of evidence leaves this indication up to approximation.

Monthly exchange rate displayed in figure 2 also portrays an upwards trend of the foreign exchange rate in Nigeria, similar to that of the daily counterpart. Figure 3, displaying the yearly exchange rate, covers the period from 1960 to 2012, while that of the daily and monthly exchange rates are comparatively recent. It can be observed that the exchange rate was stable until late 1980s, but picked up significantly in the decades thereafter. The most alarming depreciation of the exchange rate came about in late 1990s, which were the years of liberalisation of the exchange rate in Nigeria. The transformation of the economy from a pegged exchange rate system to a floating one, which was an ongoing process in the 1990s, could have resulted in the unexpected depreciation of the local currency against the US Dollar.

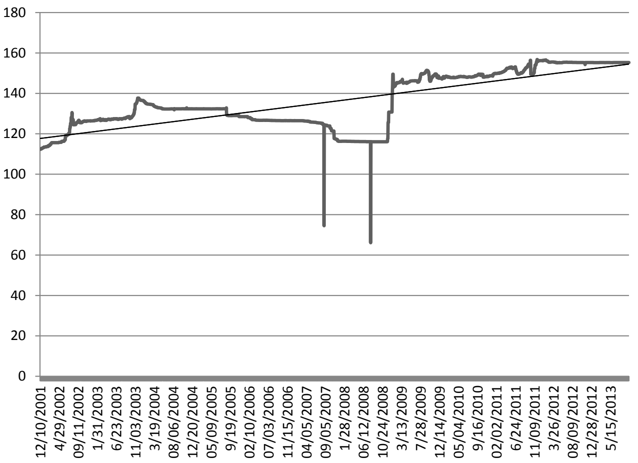


Figure 1: Line graph of daily exchange rate of the Naira against the US dollar.

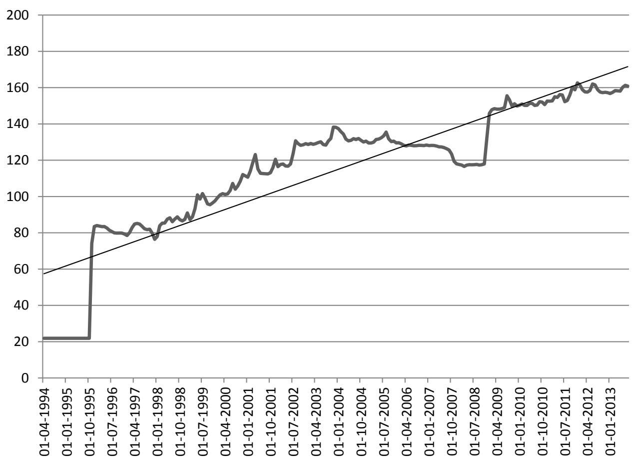


Figure 2: Line graph of monthly exchange rate of the Naira against the US dollar.

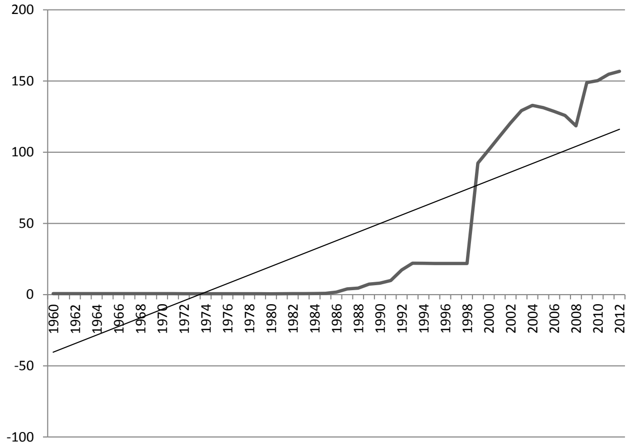


Figure 3: Line graph of yearly exchange rate of the Naira against the US dollar.

	Daily exchange rate	Monthly exchange rate	Yearly exchange rate
Mean	136.0881	114.5164	37.83739
Median	132.3500	126.9358	1.754523
Maximum	156.7600	162.6347	156.8097
Minimum	66.09000	21.88600	0.546781
Std. Dev.	13.72304	36.81828	56.27457
Skewness	0.022448	-1.079430	1.120601
Kurtosis	1.954037	3.770650	2.452956
Jarque-Bera	131.5721	51.01317	11.75328
Sum Sq. Dev.	542366.8	314496.0	164675.0
Observations	2881	233	53

Table 1: Descriptive statistics of daily, monthly and yearly exchange rates (Naira-USD).

It is evident from each of the graphs that there is presence of trend component in the exchange rate of Naira vis-à-vis the US Dollar. This characteristic is typical of foreign exchange rate series, not generally displaying seasonal and/or cyclical properties.

Summary statistics

Table 1 provides descriptive statistics of the respective exchange rates. The table helps in identifying the type of distribution of the time series together with classification of other distributive properties. With mean returns on each of the series being positive, this could possibly imply that, on an average, the exchange rate has been depreciating. This follows from the graphical representations as well. The standard deviation, a measure of the variance of the data, can be observed to be the lowest for the daily exchange rate, followed by the monthly and yearly exchange rates. This is not surprising as the day-to-day variations in exchange rate would be cumulatively embodied by the yearly representation of the data.

The daily and the yearly data are positively skewed while the monthly data is negatively skewed, revealing assorted occurrence. Following from statistics, it has to be the case the exchange rate tends to appreciate on a monthly basis while the inclination to depreciate is prominent in the daily and yearly time frames. Furthermore, an examination of the kurtosis of each of the time series reveals that none of the exchange rate series are normally distributed, although in close proximity. The yearly series would be followed by the monthly and the daily series, ordered according to close approximation to the benchmark of kurtosis for normal distribution.

Unit root test

This section identifies the unit root properties of each of the time series. It is also necessary to confirm the order of integration of the variables upfront before the model can be estimated and tested for cointegration. Table 2 lists the ADF and PP unit root tests of daily, monthly and yearly Naira-USD rates, both for level and differences. It should also be noted that two scenarios have been depicted: firstly, employing the models with only an intercept and secondly, with intercept and trend. With the null hypothesis implying presence of non-stationarity (unit root), the alternative hypothesis depicts stationarity (no unit root).

Considering columns 1 and 2 where the ADF and PP tests are carried out allowing for an intercept, it can be observed that all of the series (daily, monthly and yearly) have unit root at level at each of the significance levels. Thus, the hypothesis cannot be rejected, marking the existence of unit root. After allowing for first difference, each one of the variables becomes stationary at the 1% significance level. The hypothesis can be rejected now after differencing and it can be stated that the series' have become stationary undergoing transformation. In other words, the exchange rates series are integrated of order one, I (1).

Furthermore, columns 3 and 4 in table 2 presents ADF and PP unit root tests with the application of an intercept and trend. The results coincide with that of the previous findings, with the exception that the daily exchange rate is stationary at level at 10% significance level in the PP test. Other than this, the rest of the series' follow non-stationary at level, with respective stationarity being displayed with the first difference of the series'. Hence, each of the exchange rate time series is integrated of order 1.

Observing each of the series to be non-stationary at level, this implies that past values could not predict future values. An efficient foreign exchange market would require the exchange rate time series to be non-stationary, so that the data does not contain any predictability information about the market. Consequently, it can be stated upfront that the foreign exchange market of Nigeria is weak-form efficient.

Johansen cointegration test

The time series' which have been considered for the cointegration analysis include Naira against the US Dollar, Pound Streling, Australian Dollar, Frencs Franc, Chinese Yuan and Japanese Yen (monthly exchange rates). Table 3 shows the respective unit root tests of the rates, from where it can be inferred that each of the series are stationary only with the first difference of the data (with the only exception being the Naira-Franc exchange rate employing ADF statistic incorporating intercept and trend) and non-stationary at level. Hence, all the time series are integrated of order 1 [I (1)]. Keeping in mind the pre-condition that a data series would have to be integrated of the same order to perform a cointegration test, table 3 accordingly provides justification regarding the necessary precondition for the cointegration analysis.

Table 4 presents the Johansen [29,30] cointegration test results, with an aim to investigate the long-run relationship between the variables of the model. However, questions may come up regarding the assumptions of the Johansen cointegration framework. Since most of the variables in the analysis exhibit some sort of trending, the analysis has allowed for both intercept and deterministic trend, although excluding the possibility of quadratic trends in the data.

The first column of table 4 states the null hypothesis for each of the cases, to be analysed by Trace and Maximum Eigenvalue statistics in the columns thereafter. Observing the first row together with the second and third columns of the table, it can be observed that the trace statistic under the null of r=0 (no cointegration) is 111.6556 while the critical value stands at 117.7082. Since the calculated value is less than the critical value at 95%, the null hypothesis of no cointegration cannot be rejected. The fourth column (the probability column) also indicate

Column 1		**Column 2**		**Column 3**		**Column 4**	
Intercept		**Intercept**		**Intercept and Trend**		**Intercept and Trend**	
Augmented Dickey-Fuller Test		**Phillips-Peron Test**		**Augmented Dickey-Fuller Test**		**Phillips-Peron Test**	
Variable	Level Test-statistic	Variable	Level Test-statistic	Variable	Level Test-statistic	Variable	Level Test-statistic
Daily exchange rate	-1.367701	Daily exchange rate	-2.234691	Daily exchange rate	-1.868140	Daily exchange rate	-3.217042*
Monthly exchange rate	-2.259434	Monthly exchange rate	-2.225166	Monthly exchange rate	-2.962493	Monthly exchange rate	-2.694381
Yearly exchange rate	0.839820	Yearly exchange rate	0.805825	Yearly exchange rate	-1.186039	Yearly exchange rate	-1.200417
Variable	First Difference Test-statistic	Variable	First Difference Test-statistic	Variable	First Difference Test-statistic	Variable	First Difference Test-statistic
Daily exchange rate	-34.72788***	Daily exchange rate	-137.8136***	Daily exchange rate	-34.72307***	Daily exchange rate	-137.8470***
Monthly exchange rate	-12.48819***	Monthly exchange rate	-12.36703***	Monthly exchange rate	-12.53888***	Monthly exchange rate	-12.40385***
Yearly exchange rate	-6.550577***	Yearly exchange rate	-6.562752***	Yearly exchange rate	-6.928507***	Yearly exchange rate	-6.928445***

Note: *** indicates significance at the 1% level
** indicates significance at the 5% level
* indicates significance at the 10% level
The Phillips-Peron test has two z statistics: z(rho) and z(t)
The table tabulates z(t)

Table 2: Unit root test for the daily, monthly and yearly exchange rate of the Naira vis-à-vis USD.

Column 1		Column 2		Column 3		Column 4	
Intercept		Intercept		Intercept and Trend		Intercept and Trend	
Augmented Dickey-Fuller Test		Phillips-Peron Test		Augmented Dickey-Fuller Test		Phillips-Peron Test	
Variable	Level Test-statistic	Variable	Level Test-statistic	Variable	Level Test-statistic	Variable	Level Test-statistic
Naira-USD	-2.259434	Naira-USD	-2.225166	Naira-USD	-2.962493	Naira-USD	-2.694381
Naira-GBP	-2.365539	Naira-GBP	-2.328014	Naira-GBP	-2.636564	Naira-GBP	-2.410918
Naira-AUD	-1.368505	Naira-AUD	-1.263445	Naira-AUD	-2.981226	Naira-AUD	-2.641168
Naira-FRF	-2.305519	Naira-FRF	-2.263893	Naira-FRF	-3.211688*	Naira-FRF	-2.936344
Naira-CNY	-1.226479	Naira-CNY	-1.155462	Naira-CNY	-3.088003	Naira-CNY	-2.754617
Naira-JPY	-1.637557	Naira-JPY	-1.542950	Naira-JPY	-2.784909	Naira-JPY	-2.438331
Variable	First Difference Test-statistic	Variable	First Difference Test-statistic	Variable	First Difference Test-statistic	Variable	First Difference Test-statistic
Naira-USD	-12.48819***	Naira-USD	-12.36703***	Naira-USD	-12.53888***	Naira-USD	-12.40385***
Naira-GBP	-12.80827***	Naira-GBP	-12.70360***	Naira-GBP	-12.88751***	Naira-GBP	-12.74577***
Naira-AUD	-11.40681***	Naira-AUD	-11.28043***	Naira-AUD	-11.39332***	Naira-AUD	-11.26505***
Naira-FRF	-12.69809***	Naira-FRF	-12.57435***	Naira-FRF	-12.73617***	Naira-FRF	-12.60284***
Naira-CNY	-12.42497***	Naira-CNY	-12.24612***	Naira-CNY	-12.40747***	Naira-CNY	-12.22398***
Naira-JPY	-11.85687***	Naira-JPY	-11.70434***	Naira-JPY	-11.85978***	Naira-JPY	-11.69886***

Note: *** indicates significance at the 1% level
** indicates significance at the 5% level
* indicates significance at the 10% level
The Phillips-Peron test has two z statistics: z(rho) and z(t)
The table tabulates z(t)

Table 3: Unit root test for exchange rate of the Naira vis-à-vis US Dollar, Pound Sterling, Australian Dollar, French Franc and Chinese Yuan and Japanese Yen.

Null Hypothesis: No cointegration						
No. of CE(s) [H_0]	Trace Statistic	95% Critical Value	Probability**	Max-Eigen Statistic	95% Critical Value	Probability**
r=0*	111.6556	117.7082	0.1135	35.86049	44.49720	0.3163
r≤1	75.79510	88.80380	0.2982	28.46237	38.33101	0.4237
r≤2	47.33274	63.87610	0.5372	20.13206	32.11832	0.6416
r≤3	27.20067	42.91525	0.6694	14.16759	25.82321	0.7081
r≤4	13.03308	25.87211	0.7356	7.655471	19.38704	0.8512
r≤5	5.377611	12.51798	0.5430	5.377611	12.51798	0.5430

* denotes rejection of the null hypothesis at the 5% level
** MacKinnon-Haug-Michelis (1999) values

Table 4: Johansen cointegraion test.

similar conclusion. Table 4 also reports another measure to identify the number of cointegrating vectors – the Maximum Eigenvalue marker. Observing the fifth and the sixth columns with the first row, it can be seen that the Maximum Eigenvalue statistic is 35.86049 and the critical value at 95% is 44.49720. The null hypothesis of no cointegration cannot be rejected with this alternative statistic (the Maximum Eigenvalue statistic) as well.

Therefore, both the Trace and the Maximum Eigenvalue statistics indicate no cointegration between Naira vis-à-vis other currencies at the 5% significance level (when all the exchange rates are considered together). Although unnecessary, but comparing the calculated statistics (both Trace and Maximum Eigenvalue) with the critical values for other hypotheses (r≤1, r≤2, r≤3, r≤4 and r≤5), it is the case that the hypothesis is rejected for each of the instances.

Hence, no long-run cointegrating relationship exists between the different exchange rates of the Naira, when the considered exchange rates are estimated cumulatively. The case would be made clear at latter stages of the paper with VD analysis, where each of the exchange rate's variance would be estimated with respect to the rest. Establishing the hypothesis of no cointegration for the pairs of exchange rates (confirming non-existence of a long-run relationship), it can be inferred that the VAR would be the appropriate estimation procedure for the data series. Table 5 presents a detailed outline of the VAR process.

Autoregressive processes are sensitive to the number of lags being considered. Chaudhuri et al. [31] state that it is necessary to specify the number of lags in an autoregressive process in choosing the specification of the cointegration model. The number of lags to be included in the model was determined through the process of trial and error. The VAR estimation was repeated time and again, altering the number of lags and noting the Akaike Information Criteria (AIC). AIC is given foremost consideration to determine the optimal lag length, but other criterions including the Likelihood Ratio, Final Prediction Error, Schwarz Information Criterion and Hannan-Quinn Information Criterion have also been given preference. AIC is the preferred criteria if the number of observations is less than 250 (the current study considers only 231 observations). Hence, AIC is considered to be the optimal criteria (a better fit for the model) for optimal lag length determination for the current study. With a small sample such as the one considered for this study, the SIC may choose too small a model, and furthermore, it would be a graver setback to select too few lags (the problem of dynamic misspecification) than to select too many. After allowing for lags in the range of zero to 50, it was found that the model accommodates the lowest AIC with 2 lags (AIC=7.115753

Dependant	USD_NGN	GBP_NGN	AUD_NGN	FRF_NGN	CNY_NGN	JPY_NGN
USD_NGN_{t-1}	1.469621 (0.77092) [0.0568]	0.162536 (1.38531) [0.9066]	0.116973 (0.71291) [0.8697]	0.018152 (0.15439) [0.9064]	0.019348 (0.09570) [0.8398]	0.003028 (0.00931) [0.7451]
USD_NGN_{t-2}	-0.601763 (0.78497) [0.4435]	-0.088995 (1.41055) [0.9497]	-0.318307 (0.72590) [0.6611]	-0.032539 (0.15721) [0.8361]	-0.038013 (0.09744) [0.6965]	-0.004355 (0.00948) [0.6461]
GBP_NGN_{t-1}	-0.040875 (0.08100) [0.6139]	0.912630 (0.14555) [0.0000]	-0.109564 (0.07490) [0.1438]	-0.007212 (0.01622) [0.6567]	-0.008038 (0.01005) [0.4242]	-0.001184 (0.00098) [0.2263]
GBP_NGN_{t-2}	0.059480 (0.07686) [0.4391]	0.039119 (0.13811) [0.7770]	0.143123 (0.07107) [0.0442]	0.011103 (0.01539) [0.4708]	0.010922 (0.00954) [0.2525]	0.001355 (0.00093) [0.1447]
AUD_NGN_{t-1}	-0.079446 (0.12091) [0.5113]	0.552759 (0.21727) [0.0111]	1.336823 (0.11181) [0.0000]	-0.014376 (0.02422) [0.5528]	-0.009059 (0.01501) [0.5463]	-0.000578 (0.00146) [0.6926]
AUD_NGN_{t-2}	0.003033 (0.11655) [0.9792]	-0.587480 (0.20943) [0.0051]	-0.467696 (0.10777) [0.0000]	-0.001143 (0.02334) [0.9610]	-0.000171 (0.01447) [0.9906]	-8.46E-05 (0.00141) [0.9521]
FRF_NGN_{t-1}	-0.786439 (2.17308) [0.7175]	-0.675053 (3.90490) [0.8628]	-0.541716 (2.00954) [0.7875]	1.117952 (0.43520) [0.0103]	-0.092739 (0.26976) [0.7311]	0.007049 (0.02625) [0.7883]
FRF_NGN_{t-2}	0.826253 (2.12598) [0.6976]	0.414836 (3.82027) [0.9135]	0.928382 (1.96599) [0.6368]	-0.181537 (0.42577) [0.6699]	0.101211 (0.26391) [0.7014]	-0.006487 (0.02568) [0.8006]
CNY_NGN_{t-1}	-1.398102 (4.80069) [0.7709]	-1.673086 (8.62658) [0.8462]	-1.191767 (4.43941) [0.7884]	-0.105681 (0.96143) [0.9125]	1.165413 (0.59593) [0.0507]	-0.039761 (0.05799) [0.4931]
CNY_NGN_{t-2}	2.161647 (4.93063) [0.6612]	2.230322 (8.86008) [0.8013]	1.896514 (4.55958) [0.6775]	0.256138 (0.98746) [0.7954]	-0.061010 (0.61207) [0.9206]	0.050893 (0.05956) [0.3930]
JPY_NGN_{t-1}	11.05341 (9.81907) [0.2605]	12.16596 (17.6443) [0.4906]	17.21676 (9.08014) [0.5852]	1.576835 (1.96646) [0.4228]	1.460398 (1.21889) [0.2311]	1.397083 (0.11862) [0.0000]
JPY_NGN_{t-2}	-8.219186 (10.5310) [0.4353]	-14.51006 (18.9236) [0.4434]	-9.679387 (9.73847) [0.3204]	-0.949457 (2.10903) [0.6527]	-1.169698 (1.30727) [0.3711]	-0.422196 (0.12722) [0.0009]
Constant	3.380909 (1.08298) [0.0018]	4.012071 (1.94605) [0.0394]	1.836212 (1.00148) [0.0670]	0.702031 (0.21689) [0.0012]	0.413778 (0.13444) [0.0021]	0.032039 (0.01308) [0.0145]

Note: 2 lags have been included in the model
Values in first brackets are standard errors
Values in square brackets are p-values
*** indicates significance at 1% significance level
** indicates significance at 5% significance level
* indicates significance at 10% significance level

Table 5: Vector auto regression (VAR) analysis.

in comparison to 7.557254 with 1 lag, 7.234529 with 3 lags, 7.44441119 with 4 lags and correspondingly higher values with increasing lags).

Looking at table 5, short run causality can be deduced right away. It can be observed that USD_NGN (US Dollar-Nigerian Naira) is influenced by USD_NGN_{t-1} at 10% significance and by the constant term at 1% significance. The GBP_NGN (British Pound-Nigerian Naira) exchange rate is influenced by GBP_NGN_{t-1} at 1% significance, the constant term at 5% significance and by the AUD_NGN_{t-1} (Australian Dollar-Nigerian Naira) and AUD_NGN_{t-2} exchange rates (both at 1% significance). Similar to GBP_NGN, the AUD_NGN rate is influenced by the AUD_NGN_{t-1} and AUD_NGN_{t-2} at 1% significance, the constant term at 10% significance and by GBP_NGN_{t-1} at 5% level. Following from USD_NGN, The FRF_NGN (French Franc-Nigerian Naira) rate is not influenced by any variable other than FRF_NGN_{t-1} and the constant term, both at 1% significance level. The CNY_NGN (Chinese Yuan-Nigerian Naira) and JPY_NGN (Japanese Yen-Nigerian Naira) exchange rates are also influenced by their own lags and the constant term (CNY_NGN is influenced by CNY_NGN_{t-1} and constant while JPY_NGN is persuaded by JPY_NGN_{t-1}, JPY_NGN_{t-2} and constant).

It can be deduced from the causality of the respective time series that each of the exchange rate is influenced by its own historical information. Additionally and more to our exploitation, some of the series are cointegrated with other exchange rate series. Since not all the exchange rates are influenced by others, a conclusion cannot be derived at this point regarding the overall short-run cointegrating properties of the exchange rates. However, the fact that historical information influences the current exchange rate state again establishes weak-form efficiency of the Nigerian exchange rate, but leaves an ambiguous arena for the semi-strong form efficiency.

Moving on, the Wald Test (or Wald coefficient test) could be employed to check for the joint causality of each of the variable's lags. Specifically, the Wald test is a joint significance test to examine if lags of the independent variable can jointly influence the dependant variable. The Wald test has been essentially employed with an aim to differentiate the results pertaining from individual influence of the lags. Performing a Wald test for each of the exchange rates keeping USD_NGN as the dependant variable, it is found that it is only the lags of the series itself which jointly influence USD_NGN, while other lags are insignificant.

Citation: Akbar MI (2016) Efficiency of Foreign Exchange Markets: The Case of Nigeria. J Glob Econ 4: 220. doi: 10.4172/2375-4389.1000220

Considering GBP_NGN as the dependant variable, it is found that GBP_NGN and AUD_NGN jointly influence the dependant variable, at 1% and 5% significant levels respectively. Conversely, it is observed that each of the exchange rates GBP_NGN, AUD_NGN and JPY_NGN influence the AUD_NGN rate at 5%, 1% and 1% significance levels respectively. The FRF_NGN, CNY_NGN and JPY_NGN exchange rates give Wald test specifications similar to USD_NGN, in the manner that the series' are jointly influenced by their own lags only (significant at 1% level).

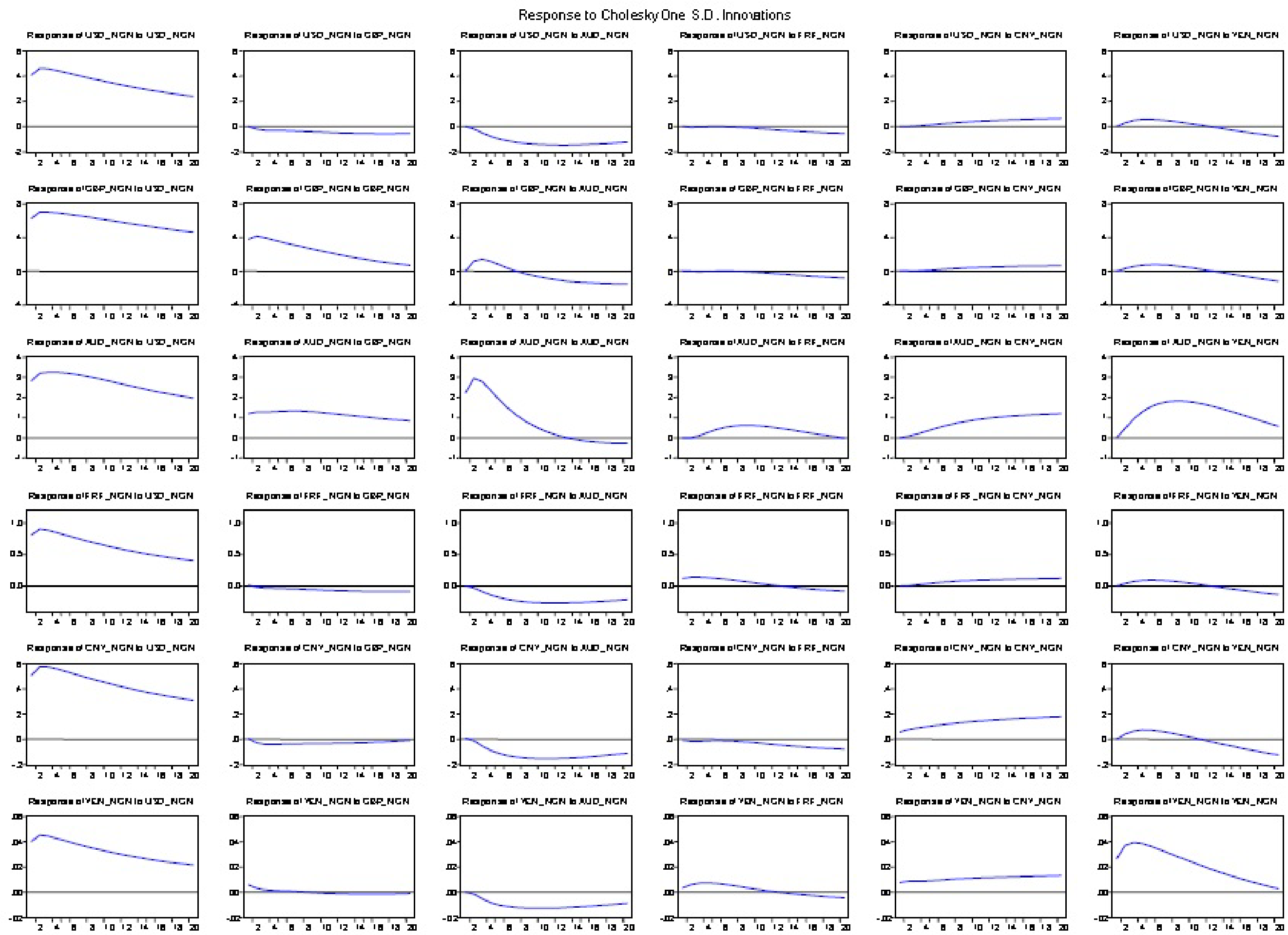
Diagnostic checking: A diagnostic check was carried out for each of the six models (USD_NGN, GBP_NGN, AUD_NGN, FRF_NGN, CNY_NGN and JPY_NGN) which were inclusive of the VAR process. The diagnostic test aims at checking whether the models were normally distributed, whether there was presence of serial correlation and whether heteroskedasticity was in attendance. Residual diagnostics were engaged for each of the facets. Performing the Bresuch-Godfrey Serial Correlation Lagrange Multiplier test with the null hypothesis of no serial correlation, it was found that the null hypothesis could not be rejected for five of the six models. With absence of serial correlation in the first five models, however, the last model with JPY_NGN as the dependant variable showed presence of serial correlation.

It is generally the case that time series data do not possess heteroskedasticity. Yet still, the Bresuch-Pagan-Godfrey test was carried out to test for heteroskedasticity. Finding that heteroskedasticity is absent from each of the models, it was also analysed if the residuals are normally distributed. Employing the histogram-normality test (considering the Jarque-Bera statistic and the corresponding p-values), it was observed that none of the models are normally distributed (rejecting the null hypothesis of normal distribution). However, such non-normal properties will not significantly distort results as the residuals are stable and non-autocorrelated.

Furthermore, the R^2 (R square statistic) of each of the models was above 95 percent. This shows that each of the models had superior explanatory power, with the models being complete in themselves as well. Additionally, the p-value of F-statistic was 0.0000 for each of the models. This again establishes the fact that the models were complete and robust.

Impulse response function

IRF analysis has been employed for a more comprehensive picture of the short-run dynamics of the exchange rate series. Figure 4 presents the IRF for each of the exchange rates (six models). IRF entails analysis



Note: The Cholesky ordering was USD_NGN, GBP_NGN, AUD_NGN, FRF_NGN, CNY_NGN and JPY_NGN

Figure 4: Impulse response functions.

of short-run incremental impacts in the presence of an external shock emanating from any of the variables. The forecast horizon is considered to be 20 months (periods) and data has been forecasted in figure 4 with exogenous shock being 1 standard deviation. With numerous impulse definitions to go with, the current exercise considers the Cholesky degrees of freedom adjusted impulse response function. The Cholesky ordering was as follows: USD_NGN, GBP_NGN, AUD_NGN, FRF_NGN, CNY_NGN and JPY_NGN.

It can be observed from the figure that each of the exchange rates is affected by their counterparts, although differing in their degree of effectiveness. The USD_NGN exchange rate is affected by itself, AUD_NGN and JPY_NGN. This is interesting because USD_NGN was affected by only its own lag in the VAR specification. However, it is observed here in IRF that USD_NGN would decline after approximately 10 periods due to the downward influence from AUD_NGN and JPY_NGN. Moving on and applying a shock to GBP_NGN, it is the case that this exchange rate is influenced by itself, USD_NGN, AUD_NGN and JPY_NGN. However, a look back at the VAR results indicates that USD_NGN and JPY_NGN are additions to the already determined influences of GBP_NGN. Interestingly, AUD_NGN is influenced by all other exchange rates – it seems that this exchange rate is volatile to the mechanisms of other exchange rates in the economy. FRF_NGN is majorly influenced by itself and USD_NGN. With the exception of the influence of GBP_NGN, both the exchange rates CNY_NGN and JPY_NGN are influenced by the rest of the exchange rates.

What can be made out from the IRF observations is that each of the exchange rates is affected by more than what was specified in the VAR specification. One of the reasons could be that the IRF considers longer time periods in the future, while the VAR took only two periods of historical information into consideration. Nevertheless, it can be made out from the observations that USD_NGN is an influential determinant of other Naira vis-à-vis other currencies (evident from the first column of Figure 4).

Variance decomposition analysis

Following the out-of-sample analysis of causality by IRF, the variance decomposition analysis would also serve the same rationale. VD would interpret how much of each exchange rate's own shock would be explained by the movements in its own variance and that of other exchange rate's variance over the forecast horizon. The Cholesky ordering has been followed (similar to that of IRF). Table 6 presents the variance decomposition analysis, reporting months 1, 5, 10, 15 and 20, with the application of a one-time shock.

It can be observed from the table that it is only USD_NGN which explains the majority of its own variance. Explaining 100 per cent of its variance in month 1, USD_NGN explained about 85 per cent of its own

Months	Variance in	Percentage of forecast variance explained by innovations in					
		USD_NGN	GBP_NGN	AUD_NGN	FRF_NGN	CNY_NGN	JPY_NGN
1	USD_NGN	100	0	0	0	0	0
5		96.79734	0.307984	1.882684	0.003624	0.042748	0.965616
10		92.41556	0.592549	5.676494	0.026516	0.330882	0.957999
15		88.81532	0.978983	8.445553	0.215703	0.758332	0.786106
20		85.53302	1.334757	9.984718	0.596339	1.25881	1.292355
1	GBP_NGN	73.18753	26.81247	0	0	0	0
5		74.37361	23.3637	1.757223	0.001204	0.009756	0.494505
10		78.11051	19.97433	1.169208	0.005648	0.117783	0.622518
15		80.17392	17.12317	1.80731	0.09734	0.285356	0.51291
20		80.64919	14.86459	2.752437	0.356389	0.466291	0.911108
1	AUD_NGN	55.47321	10.13413	34.39266	0	0	0
5		53.03995	8.661044	32.28162	0.26434	0.33901	5.414036
10		55.08979	9.597905	20.25874	1.151774	1.825203	12.07658
15		55.75151	9.952812	15.33894	1.304434	3.733572	13.91873
20		56.35411	10.10765	13.29692	1.158447	5.748576	13.3343
1	FRF_NGN	97.74353	0.040203	0.000837	2.215426	0	0
5		95.18332	0.107636	1.659809	2.330867	0.096464	0.621909
10		91.22349	0.279736	5.457712	1.804398	0.499918	0.734746
15		88.09275	0.567778	8.283414	1.42215	1.006297	0.627614
20		85.21597	0.85804	9.817587	1.431381	1.553628	1.123395
1	CNY_NGN	98.78513	0.008632	0.013783	0.032243	1.160215	0
5		94.71941	0.362431	1.575599	0.058545	2.298814	0.985206
10		90.04315	0.410241	4.531348	0.114875	4.05953	0.840857
15		86.14525	0.416745	6.213352	0.40028	6.004543	0.819826
20		82.19294	0.375384	6.751222	0.882194	8.021565	1.776691
1	JPY_NGN	66.71396	1.48814	0.000112	0.452927	2.472628	28.87223
5		55.5609	0.316595	1.249737	1.202903	2.283708	39.38616
10		54.49843	0.18814	3.375117	1.029791	3.278113	37.6304
15		55.32037	0.172976	4.798433	0.850053	4.644275	34.21389
20		56.119	0.173166	5.514377	0.921664	6.226085	31.04571

Note: Months in the first column refer to months after a one-off shock.
The Cholesky ordering was USD_NGN, GBP_NGN, AUD_NGN, FRF_NGN, CNY_NGN and JPY_NGN
Variance decomposition for the months 1, 5, 10, 15 and 20 has been reported only.

Table 6: Variance decomposition of the exchange rates.

variance in month 20. The only other exchange rate which seems to have an influence (although very minimally) on the variance of USD_NGN is AUD_NGN, which explained approximately 2 per cent of the variance in month 5 and going up to 10 per cent in month 20.

Considering GBP_NGN, it can be observed that about 70 to 80 per cent of the variation of this exchange rate is attributable to USD_NGN over the forecast horizon, while the rest of the variance is attributable to itself. Regarding the variance decomposition of AUD_NGN, it can be observed that about 50 per cent of the exchange rate has been influenced by USD_NGN over the forecast horizon. Needless to say that AUD_NGN is heavily dependent on USD_NGN (similar to GBP_NGN) regarding the determination of its own velocity, GBP_NGN is responsible for explaining approximately other 10 per cent of the variance of AUD_NGN throughout the 20 months. While AUD_NGN explained 34 per cent of its own variance in month 1, it could only justify 13 per cent in month 20. Decrease of the self-explanatory power of AUD_NGN could be attributed to CNY_NGN (explaining 0 per cent in month 1 and gradually rising to about 6 per cent in month 20) and JPY_NGN (explaining 0 per cent in month 1 and a gradual rise thereafter to approximately 13 per cent in month 20).

The composition of FRF_NGN is similar to that GBP_NGN, in the way that the majority of the variance is explained by USD_NGN alone. USD_NGN explains approximately 98 per cent of the variation in FRF_NGN in month 1. However, the integer goes down to 85 per cent in month 20. Additionally, AUD_NGN explains 0 per cent of FRF_NGN's variance in month 1, but it goes up to about 10 per cent in the last considered month. Interestingly, only 1 to 2 per cent of FRF_NGN's variance is explained by itself throughout the entire forecast period.

Coming to CNY_NGN, it can be observed that the variance of this exchange rate is dominated by USD_NGN, with as much as 99 per cent in month 1, 95 per cent in month 5, 90 per cent in month 10, 86 per cent in month 15 and 82 per cent in month 20. With very minimal self-explanatory command (throughout the entire forecast horizon), the rest of the variance of CNY_NGN is explained by itself and AUD_NGN as we move across the forecast period (after accounting for the effect of USD_NGN). 50 to 70 per cent of the variation of JPY_NGN is explained by USD_NGN. It is the case that JPY_NGN explains about 30 per cent of its own variation over the forecasted months. Hence, it can be decisively concluded that USD_NGN explains the majority of the exchange rates which have been analyzed, including itself.

The variance decomposition results indicate that each of the exchange rates is explained by other exchange rates, especially the USD_NGN exchange rate. Hence, a causal relationship between the currencies is revealed. These results dismiss the ambiguity arising from VAR and Wald test specifications, indicating that the semi-strong form efficiency of the Nigerian exchange foreign exchange market is not supported. This is because the causal relationships, as evident from the IRF and variance decomposition, can be employed to predict future rates of one currency with the aid of one or more of the other currencies.

Conclusion

Inefficiencies leading to resource misallocation are a far crucial phenomenon in the developing countries as a result of the developed countries enjoying advanced infrastructure to deal with such impression as compared to the counterparts. Specifically, the developed nations can manage and rectify asset market inefficiencies. Distortions that the developing countries face regarding foreign exchange market inefficiencies affect other macroeconomic aspects of the economy. Moreover, the paucity of data on economic fundamentals further hinders the developing countries' abilities to refer to the predicament and organise necessary policies. Notwithstanding a particular economy, exchange rate plays a pivotal role in the determination of major macroeconomic policies. Accordingly, the turbulence of exchange rate becomes an essential apprehension of government policies.

The current study, with an aim to investigate the foreign exchange market efficiency of Nigeria, examines the weak and semi-strong form efficiency of the foreign exchange market. While unit root tests examined the weak form efficiency, the semi-strong efficiency of the Nigerian foreign exchange market have been investigated using Johansen cointegration test, Wald coefficient test, impulse response function and variance decomposition analysis. With unit root tests suggesting non-stationarity in each of the time series (daily, monthly and yearly Naira-USD rates), this observation supports the efficient market hypothesis in its weakest form. This would mean that participants in the foreign exchange market of Nigeria would not be able to "devise some rule or technique that can be used to predict future movements of an exchange rate from its past values" [32].

However, tests to identify the semi-strong market efficiency yields results which side against the hypothesis of semi-strong efficiency. This observation has been established by the IRF and VD, while ambiguity cropped up in the Johansen cointegration and Wald tests. This would imply that participants of the Nigerian foreign exchange market would be able to predict one or more of the exchange rates from the movement of another exchange rate. Specifically, the possibility of predicting exchange rates of the Naira with other currencies emanating from the Naira-USD exchange rate is very high. Hence, participants can engage in profitable transactions (with the development of financial models or otherwise) in the foreign exchange market accommodating publicly available information together with historic statistics. Other authors have also documented inefficient foreign exchange markets, both in developing and developed counterparts [6,10,33].

In addition to the profit-making opportunities allowed by inefficient foreign exchange markets, governments can also benefit from such a scenario by determining the best way to influence exchange rates, devise methods to reduce exchange rate volatilities in an artificial format and/or evaluate the consequence of different economic policies relating to the impulsive exchange rate regimes. Alternatively, an efficient foreign exchange market calls for minimum government intervention with the participants being unable to formulate abnormal profits. Furthermore, the case of Nigeria, where parallel and official markets coexist simultaneously, the immediate goal of the policy-makers should be the convergence of the markets into a unified marketplace. Although efforts have been made lately, yet there is a requirement of robust measures to make the case stout.

With the inefficiency of the Nigerian foreign exchange market, this not only entails serious policy implications but also graver macroeconomic dilemmas. A non-efficient foreign exchange market will have adverse implications for the broader macro economy, while speculators and financial analysts would extract abnormal returns without committing to surplus risks. Reforms and government intervention should look into making it more transparent and accountable, so that the participants of the market cannot extract excess returns over the normal risk-adjusted return. The case rests with the Central Bank of Nigeria and related government agencies to provide a sound and efficient exchange rate regime, which would not only abandon excess returns from the market but will also support the export-oriented industries in the economy, foreign exchange reserves and a range of other significant macro-economic facets which would contribute greatly to the enhancement of the economic prosperity of Nigeria.

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