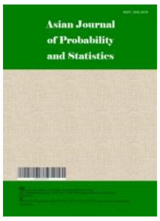

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Empirical Investigations of Direction of Causality among Exchange Rates of Naira to Some Foreign Currencies

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Authors' contributions

This work was carried out in collaboration between both authors. Author MKG designed the study, wrote the protocol. Author TTO performed the statistical analysis, wrote the first draft of the manuscript, the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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Abstract

The aim of this paper is to examine the direction of causality among some exchange rate of Nigeria Naira to US Dollar, Pounds Sterling and Euro. It made use of a time series data from the year 2005 to 2014. Toda and Yamamoto [1] procedure was used in analyzing the data. Augmented Dickey-Fuller, KPSS unit root test, the VAR selection method, Error correction model and Granger causality test based on Toda-Yamamoto procedure were used in this study as methods of analysis. The empirical analysis provides enough grounds to conclude that no causality relationship exists between the exchange rates.

Keywords: Causality test; exchange rate; VAR model; Toda-yamamoto test; unit root test; co-integration and time series model.

1 Introduction

Transaction of business among one another is a vital relationship that exist among countries, and since the currency of one country cannot be used for making payments in another country. Therefore, it became very important to convert money into the currency of other countries in order to pay for goods and services in those

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countries. This research examines the causality relationship between the various exchange rate used in this research: US dollar, Pounds and Euro i.e. will the increase in one affect the other and vice versa. This was done by determining the lag length by using the various information criteria for judgement, selecting the maximum order of integration for the variables and fit the multivariate time series model to the exchange rates of naira to Us dollars, Pounds and Euro.

2 Literature Review

The exchange rate is one of the factors that determine a country's relative level of economic health. Exchange rate plays a very important role in a country's level of trade, which is of high importance to most if not every free market economy in the world. Therefore, they are among the common government manipulated economic measures. The rates of exchange of currencies are important to smaller scale as well since they affect the main return of an investor's portfolio.

Exchange rates are very important for most country as they affect the value of imports goods into the country and exports goods from a country. If a country's currency increases with respect to a particular foreign currency, goods imported will be cheaper in the country's domestic markets and local companies would discover that their foreign competitors' goods become more valuable to customers. If the country has a good and stable currency then its products become more lucrative in the international market, this results in lots of competitiveness.

In carrying out the causality analysis, various methods have been considered and the most commonly used one are the Granger causality test and the Toda-Yamamoto causality test.

One of the common methods for testing the causality relationships between two variables is the Granger-Causality test which was proposed by Granger [2]. This test simply involves estimating the simple vector auto regression (VAR), which is expressed in equations i and ii

$$X_t = \sum_{i=1}^{n} \gamma_i X_{t-i} + \sum_{j=1}^{n} \alpha_j Y_{t-j} + e_{1t} \tag{i}$$

$$Y_t = \sum_{i=1}^{m} \beta_i Y_{t-i} + \sum_{j=1}^{m} \delta_j X_{t-j} + e_{2t} \tag{ii}$$

Here, it is assumed that e_{1t} and e_{2t} the disturbances, and they are uncorrelated, the equations above are such that variable X is decided by lagged variable Y and X, and also that the variable Y is decided by the lagged variables X and Y respectively. The Granger-Causality test is very easy to carry out and also easy to apply in many areas of the empirical studies, such as money [3], export-led growth (Xu, 1996), etc.

Furthermore, the Granger-Causality test has its limitations, which include;

A two-variable Granger-Causality test that does not consider the effect of other variables can be subjected to possible bias. It was pointed out by Gujarati [4], that a causality test is very sensitive to model specification and to the number of lags. A different result would be revealed if it is not included in the model and it is relevant in the model. Therefore, a two-variable Granger-Causality is fragile and often not reliable because of this problem.

Also, time series data are mostly non-stationary, and this could demonstrate the problem of spurious regression. Gujarati [4] also noted that when variables are integrated, the F-test procedure is no longer valid because it longer has a valid standard distribution. Although we can still further test for the significance of the various individual coefficients with the use of the t-statistic, one may not be able to use F-statistic to jointly test for the Granger-Causality. Furthermore, Enders [5] showed that in some special cases, using F- statistic to jointly test first differential VAR is permissible. The VAR model is one of the easy to use models for the analysis of multivariate time series, thus as developed by Sims [6] in a VAR of order p (VAR (p)), each component of the vector **x** depends linearly on its own lagged values up to **p** periods as well as on the lagged values of all other variables up to order **p**, with this kind of model we can therefore determine whether a specific Granger causal relation exists in the system. However, it has to be said that the number of variables that can jointly be analysed in such a system is quite small; at least in the usual econometric applications, this is limited by the number of observations which are available, thus, this are one of the short comings of the traditional granger causality.

In addition to data description and forecasting, the VAR model is also used for structural inference and policy analysis. In structural analysis, certain assumptions about the causal structure of the data under investigation are imposed, and the resulting causal impacts of unexpected shocks or innovations to specified variables on the variables in the model are summarized. These causal impacts are usually summarized with impulse response functions and forecast error variance decompositions.

However, model building in VAR models depends mainly on the selection of the appropriate variables, the specification of dynamic structure relies mainly on the proper test for appropriate lag length using the sample data. As argued by Sims [6] that one of the critical contributions of the VAR approach is that it can prove to define the "battleground" of empirical debates about multiple time series data, which can be done by providing a model of the dynamic and empirical regularities of a set of integrated time series, the various equations of this system can thud be estimated using ordinary least square. To estimate the system, the order **p** i.e. the maximum lag of the system, has to be determined. In order to fix **p,** any of the following criteria can be used: The Schwarz Criterion (SC), Final Prediction Error (FPE), the Akaike Information Criterion (AIC) and the Hannan-Quinn Criterion (HQ).

The VAR methodology has been applied to a vast range of empirical areas, including exchange rate, monetary and fiscal policy analysis and short terms economic forecasting. Also in the fields of regional science and spatial economics the scope of issue that could be addressed by means of properly identified structural VARs appears to be wide and includes: the analysis of the regional propagation of demand shocks via trade linkages in assessment of long-run spatial spill over effects from local public expenditures to private sector performance
The VAR model can be defined as

$$\boldsymbol{X_t = c + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \cdots + \alpha_p X_{t-p} + \varepsilon_{it}} \quad \mathbf{t= 1, ..., T}$$

where $Xt= \{X1t, X2t, \ldots, Xnt\}$, p is the lag length, αi is an (n×n) matrix of coefficients, t is the time period, n denotes the numbers of endogenous variables. Also, first differential VAR also has its limitations.

Therefore, because of the above limitations, the improved Granger-Causality procedure shall be adopted in preferences to the usual Granger- Causality procedure, for the purpose of examining the relationships between the various exchange rates.

3 Data and Methods

3.1 Sources of data

This research was carried out using a time series model. The data use for this research is a daily time series data (2005-2014), with a total of 2442 observations for each variable. The data on US Dollar ($), Euro (€) and Pound Sterling (£) were obtained from the Statistical Bulletin of Central Bank of Nigeria.

3.2 Unit root test

This study employs the Augmented Dickey-Fuller (ADF) test for which the null hypothesis is non stationary and the Kwiatkowski-Phillip-Schmidt-Shin (KPSS) test for which the null hypothesis is stationary. The variables have to be tested for the presence of unit root(s) to be able to determine the maximum order of integration of each series. Appropriate lag length for the above mentioned two tests is determined by following the AIC, FPE, HQ and SC criterions.

3.3 Toda and yamamoto causality testing

A multivariate VAR model can be used as a solution for the biases in which the various variables are subjected to, although it will still suffer from the non-stationary problems. Moreover, the non-stationary problem is much complicated and worse in multivariable VAR because there exists a very low probability of finding these time series variables which consist of the same stochastic trend. Frequently, in testing the multivariate Granger-Causality, the most difficult part is how to confirm the co-integration relationship and how the VAR estimates can be accurately estimated when its system is integrated. The two common and useful methods to test the co-integration are the procedures by Johansen [7] and the Stock and Watson [8], this method depends on the relationship between the rank of matrix of the VAR model and its characteristic roots. Johansen and Juselius [9] made use of this co-integration technique was applied by involving the transformed VAR into error corrected model (ECM) and then help to define the coefficients that is associated with the causality. Although many researchers interest may not lie in the co-integration relationship but rather in the hypothesis testing and in the significance of the various VAR model coefficient. However, some researchers' interest is not in the co-integrating relationship, but in the hypothesis test or the significance of coefficients of a VAR model. However, some works have tried to put a decrease in the biases that is cause by integration, as argued by Rambaldi and Doran (1996), Toda and Phillip [10]; Mosconi and Giannini [11] that "the virtues of simplicity and ease of application have been largely lost". Therefore, in avoiding this issue of integration and by passing the complexity that we thereby adopt the Toda-Yamamoto [1] procedure for this research. Toda and Yamamoto (1995) procedure to improve the power of the Granger-Causality test. Toda and Yamamoto procedure is a method in statistical inference, this will make the estimation of parameter valid even though the VAR system is not co-integrated. The procedure for the Toda-Yamamoto is however briefly explained below.

Let $\{yt\}$ be generated by the following linear function:

$$y_t = \beta_0 + \beta_1 t + \cdots . + \beta_p + \mu_t \tag{iii}$$

Let assume that $\{\mu_t\}$ sequence is a vector autoregression with k lag length and it may be presented thus

$$\mu_t = J_1 \mu_{t-1} + \cdots . + J_k \mu_{t-k} + \varepsilon_t \tag{iv}$$

k is the optimal lag length is and εt is random vector.

Transform (iii) into: $\mu_t = y_t * \beta_0 * \beta_1 t *$ ...Then substitute it into (iv),

To get

$$y_t = y_0 + y_1 t + \cdots + y_q t^q + J_1 y_{t-1} + \cdots + J_k y_{t-k} + \varepsilon_t \tag{v}$$

As order of integration d tends to zero, the order of trend γ might be lower than order q. Assume $d=1$ and $q=1$, y2 = y3 =$\cdots$= 0 in equation (v). Then (iii) becomes (vi).

$$y_t = y_0 + y_1 t + J_1 y_{t-1} + \cdots + J_k y_{t-k} + \varepsilon_t \tag{vi}$$

Toda and Yamamoto procedure is mostly concerned with the significance of coefficients of lagged y in (vi), not the stationary position of the VAR. Therefore, the null hypothesis is to test with the vector $\boldsymbol{J}$ jointly:

$$H_0\colon J_1 = J_2 = \cdots = J_k = 0$$

Consider the VAR below:

$$y_t = \hat{y}_0 + \hat{y}_1 t + \cdots + \hat{y}_q t^q + \hat{J}_1 y_{t-1} + \cdots + \hat{J}_k y_{t-k} + \cdots + \hat{J}_p y_{t-p} + \hat{\varepsilon}_t \tag{vii}$$

where the above coefficients represent estimated value and $p \geqq k+d$.

Equation (vii) includes at least d more lags than k in equation (vi). Because k is assumed to be optimal lagged length, the coefficients of additional lag are indifferent from zero. Consequently, the null hypothesis remains the same. The primary factors of Toda and Yamamoto [1] is to find the null hypothesis by estimating the above equation (vii). We first have to construct a Wald statistic to test the null hypothesis. Then we can prove that Wald statistic is asymptotically distributed as chi-square with usual degree of freedom if $p \geqq k+d$. It is important to that the asymptotic property does not depend on whether y_t is integrated or co-integrated. Also, the Toda and Yamamoto [1] suggested that we could estimate a $(k+d_{max})$ order VAR, where d_{max} is the maximal order of integration, and then jointly test k order lagged coefficients.

One of the numerous advantages of Toda and Yamamoto procedure is that it is easier to test the Granger-Causality, i.e. we do not have to transform the VAR model into ECM or test for co-integration. It was proved by Rambaldi and Doran [12] that the *VAR* process created by Toda and Yamamoto that a test could be built into seemingly unrelated regression form as applied to the Granger non-causality test. For example, a three variable (*X, Y* and *Z*) VAR can be expressed in the following SUR form:

$$\begin{bmatrix} X_t \\ Y_t \\ Z_t \end{bmatrix} = A_0 + A_1 \begin{bmatrix} X_{t-1} \\ Y_{t-1} \\ Z_{t-1} \end{bmatrix} + \cdots + A_k \begin{bmatrix} X_{t-k} \\ Y_{t-k} \\ Z_{t-k} \end{bmatrix} + A_{k+1} \begin{bmatrix} X_{t-k-1} \\ Y_{t-k-1} \\ Z_{t-k-1} \end{bmatrix} + \cdots + A_{k+d} \begin{bmatrix} X_{t-k-d} \\ Y_{t-k-d} \\ Z_{t-k-d} \end{bmatrix} \qquad \text{(viii)}$$

The above matrix equation allows us to test the relationship between any two variables.

Suppose one want to see if *Y* Causes *X*, then we have to test the null hypothesis with chi-square statistics:

$$H_0: \alpha^{(12)} = \alpha^{(12)} = \cdots = \alpha^{(12)} = 0$$

Where $\alpha^{(12)}$ are the coefficients of *Y*. If the null hypothesis is rejected, then the one-way effect can be confirmed. The alternative null hypothesis test reverses the influential direction:

$$H_0: \alpha^{(21)} = \alpha^{(21)} = \cdots = \alpha^{(21)} = 0$$

Where $\alpha^{(21)}$are the coefficients of *X*. As both null hypotheses are rejected, one can say that X and Y have a Causal relationship. Since this method has been developed, it has been use by a lot of econometrics researchers in their literature, they include; Shan and Wilson [13], Huang and Kao (2003) and Shan and Sun [14]. Before the Granger causality test can be carried out, the unit root and model selection criteria are necessary steps that must take place to test for the selection of d_{max} and *k*, respectively. This research made use of the augmented Dickey-Fuller (ADF) regression proposed by Dickey and Fuller [15] to test for the stationary of the time series variables used. The ADF test is based on the following model function:

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_1 t + \sum \beta_i \Delta y_{t-i} + \varepsilon_t \qquad \text{(ix)}$$

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum \beta_i \Delta y_{t-i} + \varepsilon_t \qquad \text{(x)}$$

Where ε_t is the white noise with mean zero and constant variance. Under the null hypothesis which state that there exists a unit root or not stationary, if the variables that are been tested still has a unit when testing the equations (ix) and (x) above, then the regression still has to be differentiated once. And at first difference, if the ADF regression is then stationary, the series is then referred to as integrated of order 1, or *I(1)*, and the $d_{max}=1$, i.e. all the variables are stationary at level 1.

One of the common and general methods of the optimal lag length *k* selection are the Akaike Information Criterion (AIC), and the Schwartz Information Criterion (SIC). They have similar role in the criterion selection by running the VAR at a different lag length and then selecting the lag length that makes the VAR possess a higher explanatory power more than the other length, therefore, the smaller the AIC and SIC, the better the model.

In various time series study, the most commonly use data are monthly, seasonal or daily data, therefore this research made use of a daily data over the span of ten years.

Some of the major advantages of the Toda Yamamoto procedure over the Granger causality test as described in the Toda and Yamamoto [1] are stated below:

1. The test can be applied without pretesting for co-integration.
2. It does not require use of an estimated co-integration equation into the analysis.
3. The test can be applied for any arbitrary level of integration.
4. It uses a modified Wald test to test restriction on the parameters of the VAR (k) model. It follows an asymptotic Chi-square distribution with k degrees of freedom (χ^2(k)).

Toda and Yamamoto [1], explained causality as an economic series that could be an integration of different orders or non-co-integrated. Therefore, they proposed an alternative test that irrespective of Y or X order of integration, i.e. *I(0), I(1), I(2),* whether they are co-integrated or not, i.e the proposed test of causality without pre-testing co-integration. This technique has an advantage over the conventional Granger causality technique because the maximum lag length is determined in the VAR system which does not change, hence produces reliable results (Leshoro, 2018). For a VAR (p) process and each series is at most I(k), then estimate the augmented VAR(p+k) process even the last k coefficient matrix is zero, and perform the usual Wald test.

Toda and Yamamoto causality test is based on equations xi to xiii:

$$X_t = \varphi + \sum_i^p \vartheta_i X_{t-i} + \sum_{i=p+1}^{p+dmax} \vartheta_i X_{t-i} + \sum_i^p \theta_i Y_{t-i} + \sum_{i=p+1}^{p+dmax} \theta_i Y_{t-i} + \sum_i^p \delta_i Z_{t-i} + \sum_{i=p+1}^{p+dmax} \delta_i Z_{t-i} \tag{xi}$$

$$Y_t = \omega + \sum_i^p \beta_i Y_{t-i} + \sum_{i=p+1}^{p+dmax} \beta_i Y_{t-i} + \sum_i^p \gamma_i X_{t-i} + \sum_{i=p+1}^{p+dmax} \gamma_i X_{t-i} + \sum_i^p \alpha_i Z_{t-i} + \sum_{i=p+1}^{p+dmax} \alpha_i Z_{t-i} \tag{xii}$$

$$Z_t = \varphi + \sum_i^p \delta_i Z_{t-i} + \sum_{i=p+1}^{p+dmax} \delta_i Z_{t-i} + \sum_i^p \partial_i X_{t-i} + \sum_{i=p+1}^{p+dmax} \partial_i X_{t-i} + \sum_i^p \emptyset_i Y_{t-i} + \sum_{i=p+1}^{p+dmax} \emptyset_i Y_{t-i} \tag{xiii}$$

X_t= Exchange rate for Us dollars, Y_t= Exchange rate for Pounds, Z_t = Exchange rates for Euro.

d is the maximum order of integration of the variables
p is the optimal lag length of Y_t, X_t and Z_t respectively
β, α, ϖ, ϕ, ɵ are the parameters of the model.

The Toda-Yamamoto approach requires the estimation of the augmented VAR which helps guarantee the chi-square distribution using the MWALD test, we would be able to test the causality relationship between the variables.

The following are the procedural steps for implementing the Toda Yamamoto technique for investigating the existence of causality.

The first step involves conducting the unit root tests to find orders of integration of all variables. Set d = maximum order of integration. The second step is to determine the optimum lag length k of VAR using the various selection criterion such as the Akaike Information Criterion (AIC), Final Prediction Error (FPE), Hannan-Quinn (HQ) Information Criterion, and the Schwarz Information Criterion (SIC).

The Augmented Dickey-Fuller (ADF) test for which the null hypothesis is non-stationary as well as the Kwaitkowski-Phillip-Schmidt-Shin (KPSS) test for which the null hypothesis is stationary to determine the maximum order of integration. The KPSS was use as a cross check. Then we proceed on estimating an augmented VAR(k+d) in levels of variables. This VAR must be stable. Check the roots. And lastly the Wald test on the first k parameters of other variable in the VAR(k+d) was conducted. If significant, then reject null of non-causality.

4 Empirical Findings and Discussion

One main reason for conducting the unit root test is to determine the extra lags to be added to the vector autoregressive (VAR) model for the Toda and Yamamoto test. The ADF unit root test has weak power in rejecting the null hypothesis of no stationarity which is why the KPSS unit root test is elaborated to bring perfection to the ADF unit root test [16].

From the ADF test, we reject the null hypothesis for all the variables used for this research, that is we reject the null hypothesis for US Dollar, Pounds Sterling and Euro and conclude that they are all stationary at levels; therefore, there is no need for further differencing.

Also, for the KPSS test, we do not reject the null hypothesis for Euro, US dollars and Pounds Sterling, so we can conclude that Euro, US dollars and Pounds Sterling are also stationary at levels for the KPSS test as well.

Table 1. Summary of ADF and KPSS unit root test results

Augmented Dickey-Fuller (ADF) Unit Root Test at levels		
Variables	**I(0)**	**p-values**
US dollar	-3.9245*	0.01275
Pounds Sterling	-4.9067*	0.01
Euro	-13.248*	0.01
Kwiatkowski-Phillip-Schmidt-Shin (KPSS) Unit Root Test at levels		
Variables	**I(0)**	**p-values**
US dollar	0.07234	0.162
Pounds Sterling	0.083008	0.13
Euro	0.24202	0.1

** Denotes the rejection of the null hypothesis of the unit root test at 5%level*

4.1 Confirmatory Analysis

The confirmatory analysis conclusion is drawn from the two-unit root test, the Augmented Dickey–Fuller(ADF) and the Kwiatkowski-Phillip-Schmidt-Shin(KPSS) test shown in Table 1 above which shows that only all the variables use in these research is Stationary at level. With this conclusion, the VAR models do not need to add an extra lag to the analysis for the causality analysis, since the order of integration is I (0). Hence we determine the appropriate lag length using the various selection criterions for the VAR model, the once selected for use in these analyses is: Akaike Information Criterion (AIC), Hannan-Quin (HQ) Information Criteria, Final Prediction Error (FPE), and Schwarz Information Criterion (SC).

Table 2. Confirmatory analysis

Variables	ADF	KPSS	Decision
US Dollar	I(0)	I(0)	Stationary
Pounds Sterling	I(0)	I(0)	Stationary
Euro	I(0)	I(0)	Stationary

4.2 Var model selection

This section looks at the direction of causality between the exchange rates. This is necessary due to the fact that in some cases an increase in one variable may lead to an increase in another variable but actually, there may be no causal relationship between them. In a bivariate distribution, if the variables have the cause and effect relationship they are bound to vary in sympathy with each other and therefore, there is bound to be a high degree of correlation between them. In other words, causation always implies correlation but the converse is not always true. To conduct Granger causality test based on Toda-Yamamoto procedure, a VAR model selection is necessary. The various information criteria suggest that the fit is good at lag 4 and the optimum lag length is 4 as shown below.

Table 3. Lag order selection

Lags	AIC	HQ	SC	FPE
1	2.544077e+01	2.545378e+01	2.547654e+01	1.118890e+11
2	2.530218e+01	2.532299e+01	2.535941e+01*	9.740894e+10
3	2.528118e+01	2.530978e+01	2.535986e+01	9.538418e+10
4	2.527040e+01*	2.530680e+01*	2.537053e+01	9.436117e+10*
5	2.527362e+01	2.531782e+01	2.539521e+01	9.466559e+10
6	2.527960e+01	2.533161e+01	2.542266e+01	9.523404e+10
7	2.528645e+01	2.534626e+01	2.545096e+01	9.588817e+10
8	2.529256e+01	2.536017e+01	2.547853e+01	9.647644e+10
9	2.529820e+01	2.537361e+01	2.550563e+01	9.702187e+10
10	2.530453e+01	2.538774e+01	2.553342e+01	9.763822e+10

**indicates lag order selected by the criterion*

4.3 Stability Analysis

Firstly, to check whether the chosen VAR model is serially correlated we employed the Portmanteau test statistics for testing for autocorrelation in the residuals of a model.

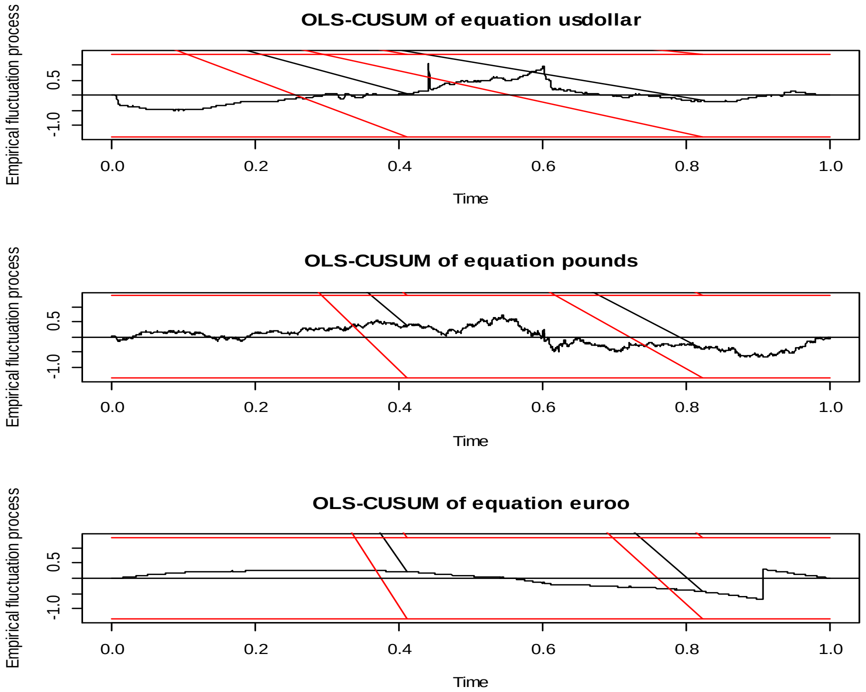
Since the p-value is greater than α=0.05, we have to accept the null hypothesis that the model is not serially correlated. Furthermore, we can also check for the stability analysis using Erdogan Cevher stability root test: this is carried out as stated below:

1/roots(V.7)= 1.407727. that is by following the Erdogan Cevher approach, we find the inverse of the root of the Model of the chosen lag, once the result is greater than 1, we can conclude that the stability looks fine.

Also in checking for the stability, the stability plot was use and we can conclude from the stability plot below that the since the empirical fluctuation process in the plot is moderate for each the variables, US dollar, Pounds and Euro we can therefore conclude that the chosen model is not serially correlated and that the stability plot looks fine.

Table 4. Portmanteau test

X^2	Df	p-value
131.65	108	0.067



Plot 1. Stability plot

4.4 The causality analysis

Since one of the advantages of the Toda-Yamamoto causality test is that we don't necessarily have to test for the co integration test and we can proceed to testing for the direction of the causality using the MWALD test. In estimating the MWALD test, a certain procedure has to be taken into consideration. This include checking for the stability of the choosing model, it was also checked whether the chosen model is serially correlated with any other model or not, estimation of the VAR model for Euro, Pounds and Us dollars, this will help show the causality between them and then the Toda-Yamamoto Causality test for the direction of the causality.

4.5 Estimations of var models

The result for the VAR model estimate are presented in Table 5 below.

The results of the estimates obtained for the US dollar model, Pounds model and Euro models are given in the tables below with their corresponding$s$, estimates coefficients, standard errors, t-values and P-values, From the estimates result for US dollar, the values are found to be statistically significant at most of the lags, therefore the VAR model of Us dollar can be written as:

$$X_t = \alpha + \sum \beta_i X_{t-i} + \sum \theta_i Y_{t-i} + \sum \pi_i Z_{t-i} \qquad \text{i = 1, 2, ..., 8.}$$

Also, the estimates for the VAR models of Pounds are significant most of the lags, and the VAR model is written as:

$$Y_t = \alpha + \sum \theta_i Y_{t-i} + \sum \beta_i X_{t-i} + \sum \pi_i Z_{t-i} \qquad \text{i = 1, 2, ..., 8.}$$

Equally, the VAR estimates for Euro, the values are found to be statistically significant at most lags, therefore we can conclude that the VAR model is significant and the model can therefore be written as:

$$Z_t = \alpha + \sum \pi_i Z_{t-i} + \sum \beta_i X_{t-i} + \sum \theta_i Y_{t-i} \qquad \text{i= 1, 2, ..., 8.}$$

Table 5a. Vector autoregression model results for US dollars

	Estimate	Std.Error	t-value	Pr(>|t|)	
usdollar.l1	2.226e-01	2.048e-02	10.871	<2e-16	***
pounds.l1	8.886e-02	2.448e-02	3.629	0.000290	***
euroo.l1	3.145e-07	1.355e-06	0.232	0.816490	
usdollar.l2	1.819e-01	2.092e-02	8.696	<2e-16	***
pounds.l2	2.083e-02	3.254e-02	0.640	0.522146	
euroo.l2	2.585e-07	1.355e-06	0.191	0.848723	
usdollar.l3	1.481e-01	2.117e-02	6.999	3.33e-12	***
pounds.l3	-3.979e-03	3.264e-02	-0.122	0.902999	
euroo.l3	1.791e-07	1.355e-06	0.132	0.894886	
usdollar.l4	1.131e-01	2.129e-02	5.312	1.18e-07	***
pounds.l4	-3.563e-02	3.264e-02	-1.091	0.275218	
euroo.l4	1.404e-07	1.355e-06	0.104	0.917510	
usdollar.l5	9.309e-02	2.128e-02	4.374	1.27e-05	***
pounds.l5	-2.030e-02	3.265e-02	-0.622	0.534161	
euroo.l5	1.367e-07	1.354e-06	0.101	0.919638	
usdollar.l6	7.986e-02	2.117e-02	3.773	0.000165	***
pounds.l6	-2.976e-02	3.264e-02	-0.912	0.362079	
euroo.l6	2.421e-07	1.355e-06	0.179	0.858181	
usdollar.l7	7.674e-02	2.094e-02	3.665	0.000252	***
pounds.l7	-1.372e-02	3.252e-02	-0.422	0.673015	
euroo.l7	1.731e-07	1.355e-06	0.128	0.898372	
usdollar.l8	7.575e-02	2.053e-02	3.690	0.000230	***
pounds.l8	3.576e-03	2.438e-02	0.147	0.883389	
euroo.l8	1.030e-07	1.355e-06	0.076	0.939394	
Const	-1.123e+00	1.049e+00	-1.070	0.284539	
Trend	-2.882e-05	1.073e-04	-0.269	0.788177	

Table 5b. Vector autoregression model results for pounds

	Estimate	Std. Error	tvalue	Pr(>|t|)	h
usdollar.l1	3.589e-02	1.718e-02	2.089	0.03682	*
pounds.l1	8.846e-01	2.054e-02	43.063	<2e-16	***
euroo.l1	-2.858e-07	1.137e-06	-0.251	0.80155	

	Estimate	Std. Error	tvalue	Pr(>|t|)	h
usdollar.l2	8.583e-03	1.755e-02	0.489	0.62483	
pounds.l2	1.220e-01	2.730e-02	4.467	8.29e-06	***
euroo.l2	6.475e-09	1.137e-06	0.006	0.99546	
usdollar.l3	1.562e-02	1.776e-02	0.880	0.37914	
pounds.l3	4.564e-02	2.739e-02	1.666	0.09578	
euroo.l3	-3.971e-07	1.137e-06	-0.349	0.72694	
usdollar.l4	-9.568e-04	1.786e-02	-0.054	0.95728	
pounds.l4	-5.732e-02	2.739e-02	-2.093	0.03647	*
euroo.l4	-2.075e-07	1.137e-06	-0.183	0.85519	
usdollar.l5	-1.953e-02	1.786e-02	-1.093	0.27433	
pounds.l5	-3.001e-02	2.740e-02	-1.095	0.27350	
euroo.l5	-1.343e-06	1.137e-06	-1.181	0.23757	
usdollar.l6	-4.185e-02	1.776e-02	-2.356	0.01854	*
pounds.l6	-3.048e-02	2.739e-02	-1.113	0.26590	
euroo.l6	6.680e-07	1.137e-06	0.588	0.55678	
usdollar.l7	-6.097e-03	1.757e-02	-0.347	0.72860	
pounds.l7	7.514e-02	2.728e-02	2.754	0.00593	**
euroo.l7	5.145e-07	1.137e-06	0.453	0.65090	
usdollar.l8	-1.386e-03	1.723e-02	-0.080	0.93588	
pounds.l8	-1.621e-02	2.046e-02	-0.792	0.42816	
euroo.l8	-1.781e-07	1.137e-06	-0.157	0.87549	
Const	3.195e+00	8.804e-01	3.629	0.00029	***
Trend	-1.787e-04	8.999e-05	-1.986	0.04717	*

Table 5c. Vector autoregression model results for Euro

	Estimate	Std. Error	tvalue	Pr(>|t|)
usdollar.l1	8.202e+01	3.080e+02	0.266	0.790
pounds.l1	2.058e+00	3.682e+02	0.006	0.996
euroo.l1	-2.429e-03	2.038e-02	-0.119	0.905
usdollar.l2	7.407e+01	3.146e+02	0.235	0.814
pounds.l2	-4.020e+02	4.894e+02	-0.821	0.411
euroo.l2	-1.900e-03	2.038e-02	-0.093	0.926
usdollar.l3	4.908e+01	3.184e+02	0.154	0.877
pounds.l3	-1.972e+02	4.910e+02	-0.402	0.688
euroo.l3	-1.831e-03	2.038e-02	-0.090	0.928
usdollar.l4	-4.670e+00	3.202e+02	-0.015	0.988
pounds.l4	3.429e+02	4.910e+02	0.698	0.485
euroo.l4	-1.536e-03	2.038e-02	-0.075	0.940
usdollar.l5	-2.350e+01	3.201e+02	-0.073	0.941
pounds.l5	1.683e+02	4.911e+02	0.343	0.732
euroo.l5	-1.534e-03	2.037e-02	-0.075	0.940
usdollar.l6	-2.843e+01	3.184e+02	-0.089	0.929
pounds.l6	3.937e+01	4.910e+02	0.080	0.936
euroo.l6	-1.763e-03	2.038e-02	-0.087	0.931
usdollar.l7	-4.921e+01	3.149e+02	-0.156	0.876
pounds.l7	1.351e+02	4.891e+02	0.276	0.782
euroo.l7	-2.172e-03	2.038e-02	-0.107	0.915
usdollar.l8	-6.132e+01	3.088e+02	-0.199	0.843
pounds.l8	-1.157e+02	3.667e+02	-0.316	0.752
euroo.l8	-1.999e-03	2.038e-02	-0.098	0.922
Const	-1.492e+02	1.578e+04	-0.009	0.992
Trend	1.702e+00	1.613e+00	1.055	0.291

4.6 Toda-yamamoto granger causality test

The empirical results of the Granger causality test estimated using the Toda-Yamamoto causality was estimated using the MWALD test and the result of the test analysis is shown in the table below. The estimate of the test shows that the test follows a chi-square distribution with 4 degrees of freedom. It is clear from the above table that there exist no causality relationship between dollar pounds and euro.

Table 6. MWald statistics (Toda and yamamoto granger causality test)

Null Hypothesis	Chi-square	P-Value	Granger causality
Dollar does not granger cause euro	5.83E-06	1.00000	No causality
Euro does not granger cause dollar	0.220479	0.8956	No causality
Dollar does not granger cause pounds	5.204385	0.0741	No causality
Pounds does not granger cause dollar	1.695846	0.4283	No causality
Pounds does not granger cause euro	0.107059	0.9479	No causality
Euro does not granger cause pounds	0.655870	0.7204	No causality

5 Summary and Conclusion

This paper studies whether there exists causality relationship among the exchange rates: US dollar, Pounds Sterling and Euro. The analysis of this study was based on the daily exchange rates between the years 2005-2014. Considering the analyses carried out, the following were findings from the study.

The three variables were detected to be stationary series at levels therefore there exist no need for further differencing. The optimal lag order was found at lag 4 using various selection criterion. The Vector Autoregressive (VAR) was model estimate was analyzed for the exchange rates: Euro, Pound Sterling and US Dollar. The kind of causality relationship that exist between the three variables was found using the Toda Yamamoto causality procedures.

To enable us estimate and examine the VAR model, the unit root tests was conducted using the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski- Phillip- Schmidt-Shin (KPSS) test, and to enable us select the appropriate number of lags, VAR model estimates and the Toda Yamamoto causality test were conducted. The unit root tests indicated that the exchange rates of Naira to Pound Sterling, US dollar and Euro were stationary at level. It was discovered that the appropriate number of lag was four and the VAR model indicates the significance of the model and the Toda Yamamoto causality test conducted indicates no causality relationship between the three exchange rates considered. That is US Dollar does not Granger cause Pounds and vice versa, also Pounds does not Granger cause Euro and vice versa and Euro does not Granger cause US Dollar and vice versa. Which means that an increase in US Dollar does not necessarily signify and increase in Pounds and vice versa, this is also applicable to the three exchange rates considered in this research.

Competing Interests

Authors have declared that no competing interests exist.

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