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Intervention Analysis of Nigeria's Foreign Exchange Rate

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ABSTRACT: This paper investigated the impact of Nigeria's foreign exchange rate using classical multiple regression model under the assumptions of ordinary least squares method (OLS) and intervention model using lag operator L. Monthly time series data spanning 1980:1 to 2014:12 were used and a number of statistical tools are employed to verify this hypothesis. A useful approach is to test the significant change between the long-run mean effect before and after each intervention. Akaike's information criterion (AIC), Schwarz's Bayesian criterion (SBC or BIC) and Coefficient of Determination (R^2) were used to determine the model that best describe Nigeria's foreign exchange rate. © JASEM
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***Keywords*:** Intervention Analysis, Exchange Rate

Intervention analysis (impact assessment) or event study is used to assess the impact of a special event on the time series of interest. The main focus is to estimate the dynamic effect on the mean level of the series, but other effects can also be considered. Intervention analysis developed by Box and Tiao (1976a) has been widely used in a variety of application to quantify the effect of a known intervention at time t=T on data collected as a time series, y_t, t =1, n.

Even though the t-test is known to be robust with respect to the normality assumption, it is extremely sensitive to the violation of the independence assumption as shown by Box and Tiao (1965), which developed the intervention analysis to study a time series structural change due to external events.

Box and Hunter (1978) stated that it is well known that the two-sample procedures are not robust against alternatives involving autocorrelation.
They further stated that if the change agent is an event then it can be represented as a simple step function. If the change agent is not an event the step function should be modified to accommodate the known properties of the change agent.

There are two common types of intervention variables (Box and Tiao, 1975). One represents an intervention occurring at time T that remains in effect thereafter called step function. The other one represents an intervention taking place at only one time period called pulse function. Our interest in this study will be to determine whether foreign exchange intervention has an effect on exchange rates in Nigeria (the exchange rate in the study is defined as the number of naira per unit of foreign exchange). Specifically, the study intends to determine if there is any evidence of change in the mean level of the foreign exchange rate, given that a known intervention occurs at time T, and to compare which of the models approach is better and to determine the model that best described the reliability of the future forecast. We are using a set of secondary data collected from the Central Bank of Nigeria Statistical Bulletin for empirical verification. The data considered for the analysis is the monthly average official exchange rate of the naira vis-à-vis the United State dollar for the period 1980 to 2014.

Research Problems: In September 1986, the Second-Tier Foreign Exchange Market (SFEM) was introduced. Under SFEM, the exchange rate was floated when it became obvious that a rigid or controlled exchange rate would not ensure internal balance.

In 1991, there was a major increase in the price of petroleum and official increase in the minimum wage. This increased inflation, thus having an impact on the naira-dollar exchange rates. In 1992, under the military regime, the leadership commenced the implementation of series of financial and economic policies ranging from deregulation of financial market, exchange rate liberalization which entails devaluation of national currency against the currencies of the major trading partners. Various implications of naira deregulation are discussed in Babatope Obasa (2004). In 1999, there was a big jump in the naira-dollar exchange rates again as a

result of further devaluation of naira through increase in money supply from the implementation of about 300 percent increase in salaries and wages of public servants. Also in the year 2000 Nigeria's currency was further devalued to attract foreign investment among other reasons. All these policy implementations (interventions) have had impacts of varying magnitudes on the exchange rate of naira against the currencies of the trading partners of the World so also on the future salaries and wages of Nigerian workers as well as the future inflation, Batini (2004). This has also rendered the future forecast of naira-dollar exchange rates highly unrealistic and unreliable.

This research will therefore undertake an impact assessment of these changes in government policies and regimes on the Nigeria's foreign exchange rate.

MATERIALS AND METHODS

In this study, we analyze the data on naira – dollar exchange rates using the classical multiple regression model with a view to comparing the result with that of the intervention analysis developed by Box and Tiao (1965).

E views 4.1 packages were used for the parameters estimation.

Model Specification: Suppose the time plot of the collected data indicate one or two pulse or step function, we consider two models: first, the classical multiple regression model under the assumptions of ordinary least squares method (OLS) defined as

$$y_t = c_0 + \sum_{i=1}^{m} b_i S_i + \varepsilon_t \quad (3.1a)$$

where y_t is the response variable; m is the number of intervention variables in the series; c_0 is the intercept term; b_i is the least squares estimate of the impact of the variables S_i ; ε_t is assumed to have a standard normal distribution.

Following Enders, Sandler's, and Cauley (1990) we considered the intervention model using lag operator L as:

$$(1 - a_1 L) y_t = c_0 + \sum_{i=1}^{m} b_i S_i + \varepsilon_t \quad (3.1b)$$

where y_t is the response variable; m is the number of intervention variables in the series; c_0 is the intercept term; b_i is the maximum likelihood estimate of the impact of the variables S_i ; ε_t is the white noise disturbance term assumed to follow an ARMA(p,q) model ; a_1 is serial correlation coefficient satisfying the condition $|a_1| < 1$, it measures the behavior of permanent effect of the intervention, Wei (1990), while S_i is the intervention variable define by

$$S_{it} = \begin{cases} 0, & t < T \\ 1, & t \geq T \end{cases} \quad (3.1c) \text{ for I = 1, 2, m}$$

where m is the number of interventions identified.

Model 3.1b above can be re written as

$$y_t = \frac{c_0}{1 - a_1} + \sum_{j=1}^{m} b_j \sum_{i=1}^{\infty} a_1^i S_{t-i} + \sum_{i=1}^{\infty} a_1^i \varepsilon_{t-i} \quad (3.1d)$$

The various transitional effects can be obtained from the impulse response function y_t as follows:

The effect of each S_i is measured by b_i; the long-run mean effect of the series is given by

$\frac{c_0}{1 - a_1}$; (3.1e) *the* long-run mean effect of each S_i is given by

$\frac{c_0 + b_i}{1 - a_1}$ (3.1f) while the long- run mean effect after each Si is $\frac{c_0 + \sum_{i=1}^{j} b_i}{1 - a_1}$.(3.1g)

The statistical significance of the coefficients was tested using the standard t-test at conventional level of significance, and the usual diagnostic tools were used to test the adequacy of the model.

RESULTS AND DISCUSSIONS

About five jumps were identified on the time plot of the response variable. These points were suspected to be those points were intervention took place on naira-dollar exchange rates. These points were labeled by indicator functions as:

$$S_{1t}^{(T)} = \begin{cases} 0, & t < \text{Sept}, 1986 \\ 1, & t \geq Sept, 1986 \end{cases}$$

$$S_{2t}^{(T)} = \begin{cases} 0, & t < \text{June}, 1991 \\ 1, & t \geq \text{June}, 1991 \end{cases}$$

$$S_{3t\ 1t}^{(T)} = \begin{cases} 0, & t < \text{January}, 1999 \\ 1, & t \geq \text{January}, 1999 \end{cases}$$

$$S_{4t}^{(T)} = \begin{cases} 0, & t < \text{March}, 2000 \\ 1, & t \geq \text{March}, 2000 \end{cases}$$

$$S_{5t}^{(T)} = \begin{cases} 0, & t < \text{January}, 2009 \\ 1, & t \geq \text{January}, 2009 \end{cases}$$

*Model 3.1a***:** After fitting model 3.1a the maximum likelihood estimates and the t- statistics are as follows:

Table 1: summary of results for model 3.1a

Parameters	MLE	SE	t. Statistics
C_o	0.683	0.3199	2.136
b_1	5.459	0.6793	8.037
b_2	8.880	1.1758	7.556
b_3	6.870	1.1453	5.998
b_4	71.746	1.3239	54.230
b_5	26.58	1.3472	19.734

AIC = 5.871, SBC = 5.93, R^2 = 0.988

The above implies that the intercept is 0.683 and the impact of each intervention S_i; i = 1, 2, 5 on the naira-dollar exchange rate is measured by the coefficient b_i in table 1 above. The diagnostic check of the residuals of model 3.1a shows that they are still correlated meaning that the estimated model does not mimic the actual data generating process. It is suggested that some effect of the pre-intervention period for each variable could have been carried over to the post intervention periods.

Model 3.1b: The intervention model described in model 3.1b gives the following results:

Table 2: Summary of results for Model 3.1b

Parameters	MLE	S.E	t-Statistics
C_o	0.228	0.1745	1.308
a_1	0.669	0.0212	31.539
b_1	1.900	0.3856	4.928
b_2	3.208	0.6623	4.839
b_3	1.933	0.6407	3.017
b_4	27.475	1.5765	17.427
b_5	5.459	0.9914	5.206

AIC = 5.650; SBC = 4.717; R^2 = 0.997

The model selection criteria all indicated that the model 3.1b is a better model. Also the examination of the residuals shows no obvious evidence of inadequacies in the model.

The various transitional effects of the interventions are given as follows

Table 3: Summary of Transitional Effects of Intervention Variables

Interventions Original Impact Long run mean long run mean

Variables	mean	of S_i	effect of Si	after S_i
C_o	0.228			
b_1		1.900	6.432	6.432
b_2		3.208	10.381	16.121
b_3		1.933	6.529	21.961
b_4		27.475	83.695	104.962
b_5		5.459	17.181	121.459

All the parameters were all significant at 5% and 1% levels of significant except the intercept.

Conclusion: We have applied the intervention analysis to model the exchange rate of naira-dollar to measure the impact, the long-run mean effect before and after each intervention variable. Since the residuals fail to show any inadequacy in model 3.1b, we conclude that the distribution a posteriori of each S_1, S_2, S_3, S_4 and S_5 are very nearly normal and centered at the maximum likelihood estimate values with the approximate standard errors shown. Since there is a significant change between the long-run mean effect before and after each intervention, we therefore conclude that a postulated event does not cause a change in the foreign exchange rate. Also since the Forecast values from model 3.1b appear to be more reliable and closer to reality than that model 3.1a. We therefore conclude that intervention model using lag operator L is better than classical multiple regression model. Each effort made at devaluation of naira either through market deregulation, exchange liberalizations has always brought serious strain on the naira exchange rate and the consumer price index

(CPI), inflation rate hence on the real wages of workers. This is in line with the comments of Batini (2004) that "Change in CPI due to exchange rate is fully and automatically locked in future wages and price inflation".

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