INTERVENTION MODELING OF DAILY NORWEGIAN KRONER/NIGERIAN NAIRA EXCHANGE RATE.

VICTOR-EDEMA UYODHU AMEKAUMA, GEORGE SOKARI DANIEL

Abstract -This study specifically developed an appropriate intervention model for the daily Norwegian Kroner (NOK) /Nigerian Naira(NGN) exchange rate. The data with 180 observations (October 24th, 2017 – April 21st 2018) was sourced from Nigerian Bureau of Statistics (NBS). The point of intervention is spotted at T=81 and was characterized by step function. The pre-intervention plot indicates that there was an initial negative trend and later an upshot to positive trend which did not favour the Naira. The plot further shows that the pre-intervention rates are non- stationary but became stationary after first difference was taken. The ACF and the PACF of the differenced exchange rate data showed a white noise pattern. Forecast was made .The difference between the forecast and the post-intervention series was modeled after the intervention transfer function and was seen to be statistically significant ($P_{0.0002}$ <0.05,0.01), this is an indication of model adequacy. There was a close agreement between the intervention model and the post intervention data. The model so fitted may be used to help strengthen the Nigerian Naira.

Index Terms: Intervention model, Naira, Kroner, stationary, exchange rate, model adequacy, pre intervention, post intervention.

1 INTRODUCTION

Data collected chronologically over time are often affected by different external occurrences commonly referred to as interventions. Exchange rates data are not exceptions. They are affected by major political and/or economic policy initiatives and at other times, policy changes. Once interventions are identified, in some cases their effects are evaluated and in others, they are embodied into the time series model to help enrich the parameter estimates of the model.

Intervention or intervention analysis is a term frequently used to describe an extension of the Auto Regressive Integrated Moving Average (ARIMA) model [1],[2],[3]. Its main purpose is to measure the effect of change either in policy, event etc, on the possible outcome of a variable. Doing intervention requires careful observation to see a significant interruption in the stable pattern of behaviour of a time series of interest caused by intervention and that it is essential to implicitly model its impact [4]. Intervention modeling generalizes the univariate Box-Jenkins methods by allowing the time path of the response variable to be influenced by the time path of the explanatory or intervention variables [3]. Furthermore, intervention analysis in statistics is an evolving regression used to check the impact of an event on the time series of interest [5]. If an intervention is known, it is necessary to find out if there is evidence that such changes in the time series really occurred as expected. And if it is true that the expected change in time series actually occurred, what can be said of the nature, pattern and magnitude of its occurrence.

Several interventions have been modeled concerning daily exchange rates of Nigeria naira and some other currencies. In [6] Etuk et al modeled and analyzed the intervention of daily Yuan-naira exchange rates using the ARIMA. Another study was done by Etuk [7]. He modeled the intervention analysis of daily GBP-USD which was occasioned by BREXIT. In another two separate studies, [8] Etuk et al modeled the intervention of Yen-Naira exchange rates and [9] modeled the exchange rate of the Cedi-USD. These studies were geared toward studying the intervention behavior pattern of various exchange rates.

The Nigeria's naira is popularly placed against the US Dollar, GB Pounds, CH Yuan and a few others. Not very much is regionally known about the economic and currency relationship between the Norwegian Kroner and the Nigerian Naira.

The pre-intervention time plot from the data obtained for this study shows an initial negative trend and later a positive trend. The explosive issue or jump of the time plot of the exchange rate which does not return to the status quo however continued in the new level indicates an intervention problem. It becomes a problem because the jump in the exchange rate does not favour the Naira. Although, quite a number of daily exchange intervention studies have been done recently by some scholars, attention has not been given to modeling the daily exchange rate intervention between the Nigerian naira and the Norwegian Kroner. Hence, the main purpose of the study is to provide an appropriate time series intervention model of daily Norwegian Kroner/Nigerian Naira exchange rate.

2 MATERIALS AND METHODS

2.1 Data

The data is the daily exchange rate of the Norwegian Kroner to the Nigerian naira. The data starts from October 24th, 2017 to April 21st, 2018, covering a total period of one hundred and eighty (180) days and was obtained from the Nigerian Bureau of Statistics (NBS).

2.2. Methodology

The data analysis here employs the Box-Jenkins method given its using statistical tool.

3. INTERVENTION MODEL.

An intervention model is represented by two separate components. There is the set of interventions on the series and a fundamental disturbance term [10]. Box and Tiao [1] stated the general form of intervention model as:

$$Y_t = V(B)I_t + N_t \quad (1)$$

where I_t is an intervention or dummy variable that is defined as:

$$I_t = \begin{cases} I, & t = T \\ 0, & t \neq T \end{cases} \quad (2)$$

The intervention of a policy programme beginning at time t=T is 1 is called a pulse function if it remains for just a period and a step function if it remains as 1 for the entire presence of the intervention exercise. To illustrate this we write;

$$Y_t = C + W_1 I_{1t} + \frac{\theta(L)}{\emptyset(L)}\varepsilon, \quad (3)$$

where

$$I_t = S_t^{(t)} = \begin{cases} 1, & T \geq t \\ 0, & otherwise \end{cases} \quad (4)$$

C is a constant and Y_t is the level of change with respect to gains or losses made in the value of reduction. The intervention variable I_{1t} corresponding to the policy programme here is a step function.

4. DATA ANALYSIS AND DISCUSSION

The time plot of the series in figure 1 indicates an intervention point exactly at T=81. After the intervention point, the exchange rate between the Norwegian Kroner (NOK) and the Nigerian Naira (NGN) was more than forty-five Naira (₦45.00) per Kroner. The intervention is characterized by a step function as a careful observation of the period after time T= 81 , revealed that the exchange rate remained at more than forty-five Naira (₦45.000) per Kroner.

Figure 2 shows the pre-intervention data of the exchange rate of Norwegian Kroner (NOK) and the Nigerian Naira (NGN). The pre-intervention period is from T = 1 to T = 81. The time plot above shows an initial negative trend and a later positive trend. This is an indication of a pattern-three intervention analysis of time series. The trends follows a gradual decrease in the mean level which later rapidly increased and levelled off at the new increased or higher mean level. This is clearly not favourable to the Nigerian Naira.

Table 1 shows the null hypothesis that both the Norwegian Kroner (NOK) and the Nigerian Naira (NGN) have unit root. The Augmented Dickey-Fuller test statistics before adjustment indicated (-2.186597) which is not less than the t-value (-3.515536) for 1% (0.01) critical level. Again the value (-2.186597) is greater than the t-value (-2.898623) at 5% (0.05) critical level. Again, the value (-2.186597) is also not less than the t-value of (-2.586605) at 10% (0.1) critical level. The P-value which is 0.2128 is far greater than the 0.05 critical level of significance. This therefore shows that the Augmented Dickey-Fuller test statistics for the exchange rates is not significant.

Figure 3 shows the time plot of the differenced pre-intervention exchange rate moving erratically and showing no definite trend.

Table 2 shows the Augmented Dickey-Fuller test statistics for the differenced pre-intervention exchange rate is (-10.51532) which is less than the t-value (-3.516676) at 1% (0.01) critical level. Again the value (-10.51532) is less than the t-value (-2.899115) at 5% (0.05) critical level. At the same time, the value (-10.51532) is also less the t-value of (-2.586866) at 10% (0.1) critical level. The P-value which is 0.0001 is also less than the 0.05 critical level of significance. This therefore shows that the Augmented Dickey-Fuller test statistics for the differenced exchange rates is significant.

Furthermore, the augmented Dickey-Fuller test after adjustment difference of the pre-intervention exchange rate shows a p-value of 0.0000 which is less than 0.05, and a C-value of 0.9220. This shows that the differenced pre-intervention series are stationary.

Figure 4 shows the Autocorrelation function (ACF) and Partial Autocorrelation Function (PACF) of the differenced exchange rates (DNOKN).

The correlogram of the differenced exchange rate is the autocorrelation structure of white noise. The observations of both the autocorrelation function (ACF) and partial autocorrelation function (PACF) of the differenced exchange rates show no spikes at any of the lags under consideration. This means that they all fall within the mean range of the ACF and PACF.

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On the basis of the white noise model of the differenced pre-intervention data, forecasts (F_t) are obtained for the post intervention period. This is given as

$$Z_t = X_t - F_t \qquad [5]$$

where, X_t is the original series at time t.
F_t is the forecast at time t.

$$Z_t = C(1) * \frac{(1-C(2))^{(t-80)}}{1-C(2)} \qquad l6]$$

Equation [6] is the transfer function and it is further written as;

$$Z_t = 0.2388 * \frac{(1-(0.8064))^{(t-80)}}{1-(0.8064)} \qquad [7]$$

The transfer function shows clearly, a close agreement between the intervention model and the post-intervention observations. Fig. 5 shows the graph of post intervention and intervention forecasts.

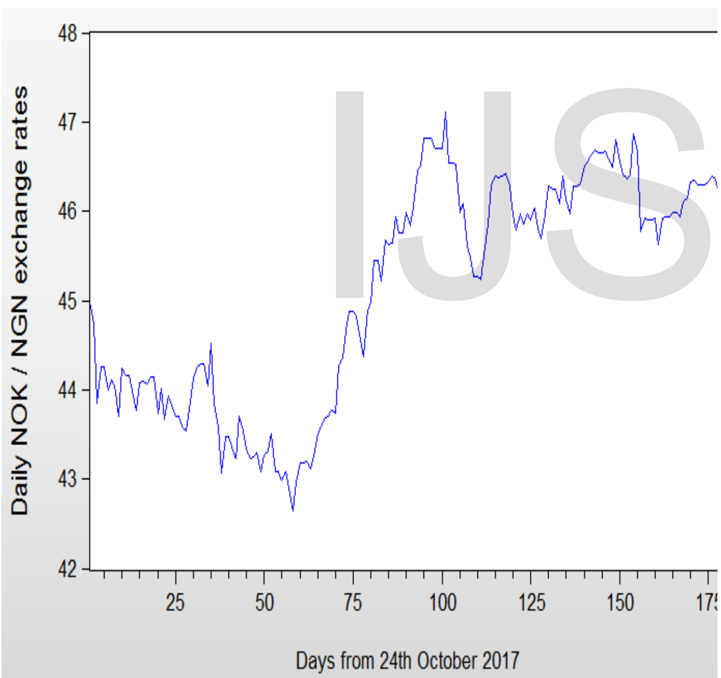

Figure 1: Time plot of daily Norwegian Kroner/Nigerian Naira Exchange Rates-NOKN

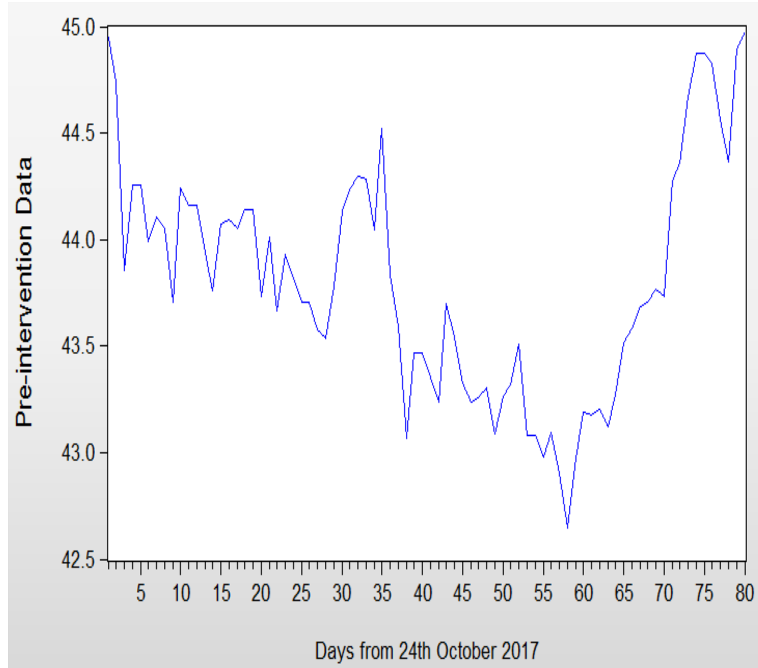

Figure 2: Pre-intervention Exchange Rates

Table 1 Stationarity Test for pre-intervention Exchange Rates

Null Hypothesis: NOKN has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.186597	0.2128
Test critical values:	1% level	-3.515536	
	5% level	-2.898623	
	10% level	-2.586605	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(NOKN)
Method: Least Squares
Date: 04/26/18 Time: 14:14
Sample (adjusted): 2 80
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
NOKN(-1)	-0.118404	0.054150	-2.186597	0.0318
C	5.185593	2.371545	2.186588	0.0318

R-squared	0.058463	Mean dependent var	0.000368
Adjusted R-squared	0.046236	S.D. dependent var	0.264392
S.E. of regression	0.258208	Akaike info criterion	0.154887
Sum squared resid	5.133689	Schwarz criterion	0.214873
Log likelihood	-4.118021	Hannan-Quinn criter.	0.178919

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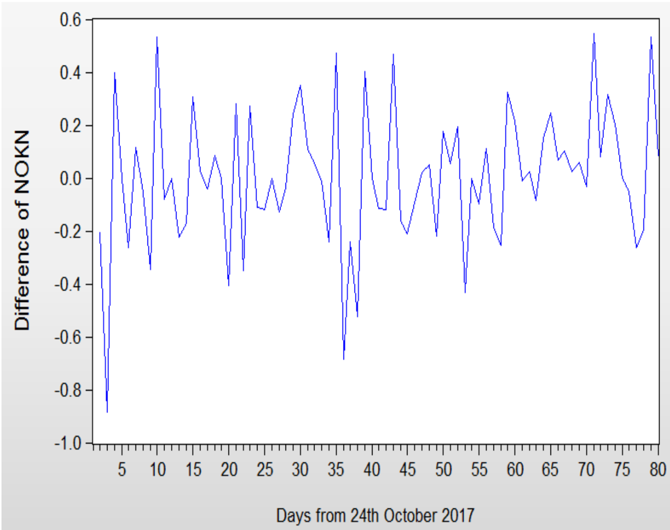
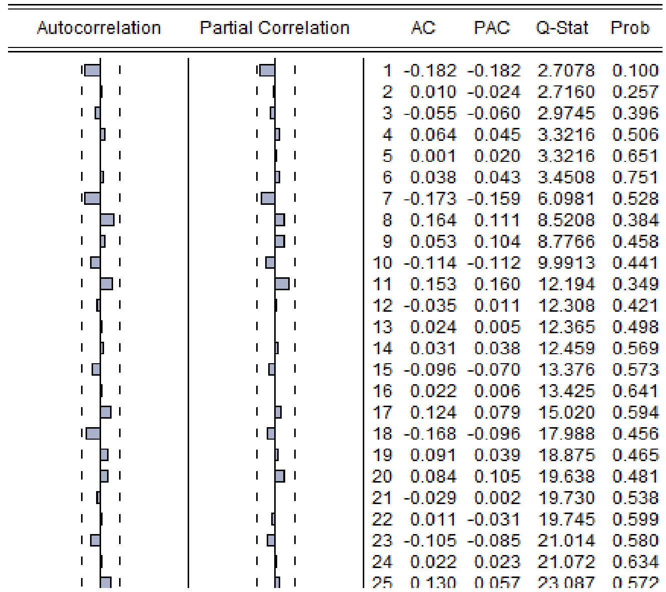


Figure 3: Differenced exchange rates, DNOKN



	AC	PAC	Q-Stat	Prob
1	-0.182	-0.182	2.7078	0.100
2	0.010	-0.024	2.7160	0.257
3	-0.055	-0.060	2.9745	0.396
4	0.064	0.045	3.3216	0.506
5	0.001	0.020	3.3216	0.651
6	0.038	0.043	3.4508	0.751
7	-0.173	-0.159	6.0981	0.528
8	0.164	0.111	8.5208	0.384
9	0.053	0.104	8.7766	0.458
10	-0.114	-0.112	9.9913	0.441
11	0.153	0.160	12.194	0.349
12	-0.035	0.011	12.308	0.421
13	0.024	0.005	12.365	0.498
14	0.031	0.038	12.459	0.569
15	-0.096	-0.070	13.376	0.573
16	0.022	0.006	13.425	0.641
17	0.124	0.079	15.020	0.594
18	-0.168	-0.096	17.988	0.456
19	0.091	0.039	18.875	0.465
20	0.084	0.105	19.638	0.481
21	-0.029	0.002	19.730	0.538
22	0.011	-0.031	19.745	0.599
23	-0.105	-0.085	21.014	0.580
24	0.022	0.023	21.072	0.634
25	0.130	0.057	23.087	0.572

Figure 4: ACF and PACF of DNOKN

Table 2 Stationarity test for DNOKN

Null Hypothesis: DNOKN has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.51532	0.0001
Test critical values:	1% level	-3.516676	
	5% level	-2.899115	
	10% level	-2.586866	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DNOKN)
Method: Least Squares
Date: 04/26/18 Time: 14:18
Sample (adjusted): 3 80
Included observations: 78 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DNOKN(-1)	-1.181847	0.112393	-10.51532	0.0000
C	0.002916	0.029699	0.098199	0.9220

R-squared	0.592650	Mean dependent var	0.003668
Adjusted R-squared	0.587290	S.D. dependent var	0.408287
S.E. of regression	0.262293	Akaike info criterion	0.186601
Sum squared resid	5.228638	Schwarz criterion	0.247030
Log likelihood	-5.277446	Hannan-Quinn criter.	0.210792

Table 3 Estimation of the intervention transfer function

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 04/26/18 Time: 14:31
Sample: 81 180
Included observations: 100
Convergence achieved after 36 iterations
Coefficient covariance computed using outer product of gradients
Z=C(1)*(1-C(2)^(T-80))/(1-C(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.238767	0.061465	3.884579	0.0002
C(2)	0.806378	0.051621	15.62099	0.0000

R-squared	0.167647	Mean dependent var	1.181053
Adjusted R-squared	0.159154	S.D. dependent var	0.406328
S.E. of regression	0.372593	Akaike info criterion	0.883138
Sum squared resid	13.60492	Schwarz criterion	0.935242
Log likelihood	-42.15691	Hannan-Quinn criter.	0.904225
Durbin-Watson stat	0.343481		

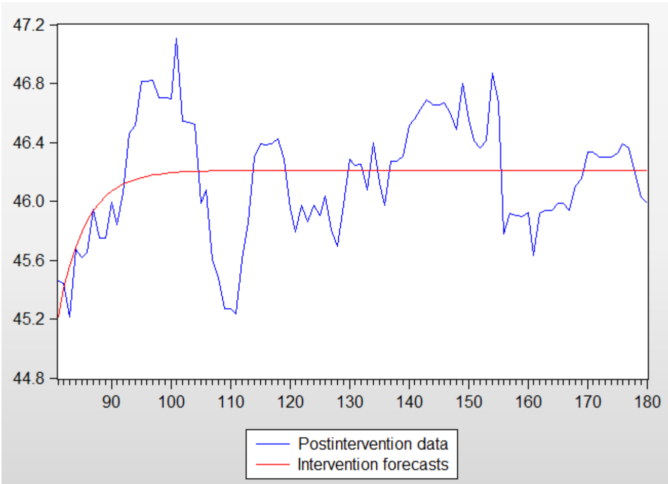


Figure 5: Post-intervention data and Intervention forecasts

5. CONCLUSION

This work modeled intervention in the daily exchange of the Norwegian Kroner to Nigerian Naira. All formal tests and graphical presentations prove the adequacy of the intervention model based on the sample data.

COMPETING INTERESTS

No competing interests exist among authors.

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