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INTERVENTION ANALYSIS OF DAILY SOUTH AFRICAN RAND/NAIRA EXCHANGE RATES

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ABSTRACT

This research paper examined the daily exchange rate of the South African (ZAR) and the Nigerian Naira (NGN) which starts from 11th March, 2017 and 9th September, 2017 reveals an abrupt change on 4th August, 2017 in further favour of the Rand. This change is significant as the pre-intervention series was stationary. The pre-invention series was modeled as ARMA (3,12) model using Augmented Dickey Fuller unit root test which was adjusted to fit the model to be stationary. An intervention model was obtained and the post-intervention data closely agreed with the forecast data.
Keywords: Rand, Naira, Exchange rates, Intervention analysis, ARIMA modeling.

INTRODUCTION

Trade relationship between the country South Africa and the country Nigeria is based on the relative currencies of the South African Rand (ZAR) and the Nigeria Naira (NGN) in this research paper the daily exchange rate shall be modeled by Box Jenkins methods. The particular approach shall be the autoregressive integrated moving average (ARIMA) approach proposed by box and Jenkins (1976). This study has been on the exchange rates between the South African rand (ZAR) and the Nigeria Naira (NGN). For example Aboko and Etuk (2019) conducted a study of the daily exchange rates. They observed that, between March and September, the rand was appreciating relatively but gradually. This current study is motivated by an observation that there is a sudden jump in the level of the amount of Naira per Rand on August 4th 2017 to an even increasing level. This abrupt jump is a source of concern, as an attempt is made to propose and fit an intervention model to the data with a view to provide a basis for intervening to the economic situation of the country intervention modeling was introduced by Box and Tiao (1975) Ever since it was been successfully applied by many scholars. For instance Etuk and Sibeate (2016) conducted a study of the daily exchange rates. They observed that between October 2015 and April, the Yen was appreciating relatively. Etuk and Eleki (2007) have devised a model for intervention of the NGN against the central franc. An adequate representation of the US dollar /NGN exchange rates was given by Mosugu and Anieting 2016) Etuk *et al.,* (2019) have filled an adequate intervention model to daily Gambian, Dalasi. Nigeria. Nigeria Naira exchange rate am *et al.,* (2009) working on a business process activity model and performance measurement using a time series ARIMA intervention analysis, they determined the intervention effects of business process by re-engineering on the performance to some enterprise . Krishnamurthy *et al.,* (1986) studying on the intervention analysis of a field experiment to assess the buildup effect of advertising found out that there is an increased in advertising in an immediate build-up effect lasting through the purchase order cycle. This is only to maintain a few.

MATERIALS AND METHODS

Data

The data for this research work are 147 daily Rand-NGN exchange rates from 11th March, 2017 to 9th September, 2017 copied from the website www.exchangerates.org.uk/ZAR-NGN-exchange rate-history.html. These data are read as the amount of Naira in one rand. This website was accessed for this purpose on 10th September,2017.

Intervention Analysis

A time series $\{X_t\}$ is said to experience an intervention at time t=T if an event changes the course of the time series at that time. The event is called an intervention. The pre—intervention data may he modeled by an ARIMA model (Box and Tiao, 1975). Suppose this is an ARIMA (p, d, q) model. That means that

$$\nabla^d X_t = \alpha_1 \nabla^d X_{t-1} + \alpha_2 \nabla^d X_{t-2} + \ldots + \alpha_p \nabla^d X_{t-p} + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \ldots + \beta_q \varepsilon_{t-q} \quad (1)$$

Or

$$A(L)\nabla^d X_t = B(L)\varepsilon_t \quad (2)$$

Where $A(L) = 1 - \alpha_1 L - \alpha_2 L^2 - \ldots - \alpha_P L^P; B(L) = 1 + \beta_1 L + \beta_2 L^2 + \ldots + \beta_q L^q; L^k X_t = X_{t-k}$ and $\nabla = 1 - L$

Therefore from (2)

$$X_t = \frac{B(L)\varepsilon_t}{A(L)\nabla^d} \quad (3)$$

On the basis of model (3) forecasts are obtained for the post-intervention period. Suppose these are denoted by $F_t > T\text{-}1$. The difference between these forecasts and the original post-intervention observations, $Z_t = X_t - F_t$ may be modeled as

$$Z_t = \frac{c(1)(1-c(2)^{(t-T+1)})}{(1-c(2))} \quad (4)$$

For the intervention transfer function (4). The final intervention model is obtained by a combination of the noise component (3) and the transfer function (4) to give

$$Y_t = \frac{B(L)\varepsilon_t}{A(L)\nabla^d} + \frac{c(1)*(1-c(2)^{t-T+1})I_t}{(1-c(2))} \quad (5)$$

Where I_t is an indicator variable such that 1, =0, $t < T$ and $I_t = 1$, otherwise. In practice the difference order d is obtained sequentially with do initially, lithe realization of the time series $\{X_t\}$ to be analyzed is certified stationary, by for example the Augmented Dickey Fuller (ADF) Test, then d=0. Otherwise first order differencing of the realization is done. If the differences are declared stationary, then d=1. Otherwise, the process continues until stationary is achieved. Next are the autoregressive (AR) and the moving average (MA) orders p and q respectively. They are estimated as the cut-off lags. If any, of the partial autocorrelation function (PACF) and the autocorrelation function (ACF) respectively. Then the least squares procedure is used to estimate the α's and the β's so that model (1) is both stationary and invertible.

Computer Software

Eviews 10 was used for all computations in this research work.

Result and Discussion

The time plot of the data is given below in figure 1 shows intervention at T=141, that is on 4th August 2017.

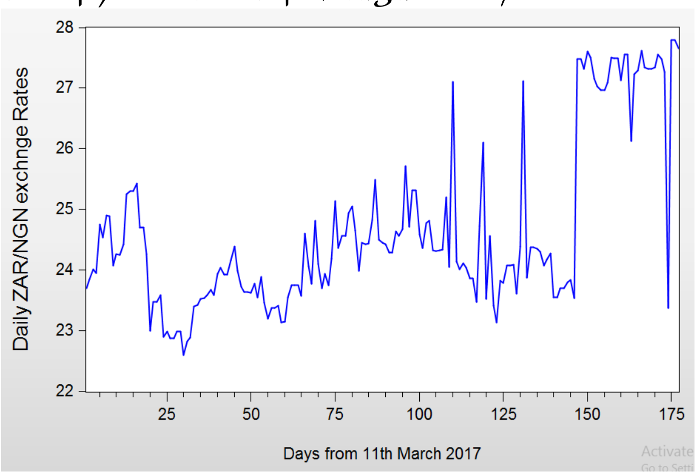

Figure 1: Time plot of ZAR/NGN Exchange Rate

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The pre-intervention series whose time plot shows below in figure 2 shows a stationary time series as seen in the following data.

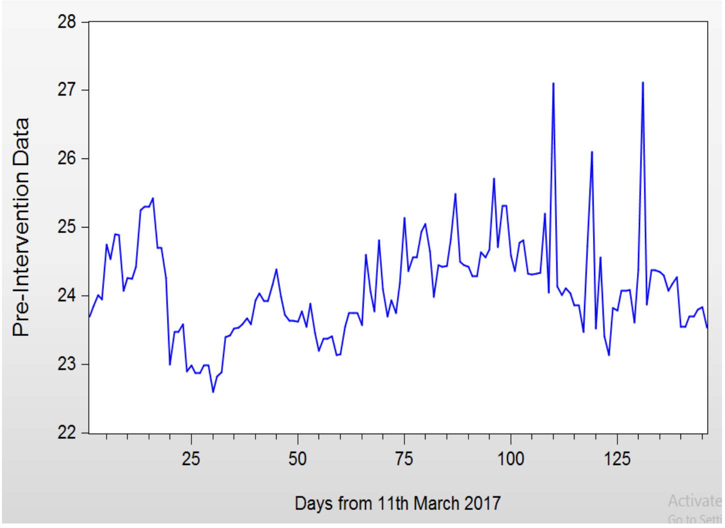


Figure 2: Time plot of the pre-intervention series

Table 1: Unit Root Text for the pre-intervention series.

Null Hypothesis: ZRNN has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.163461	0.0011
Test critical values:	1% level	-3.476143	
	5% level	-2.881541	
	10% level	-2.577514	

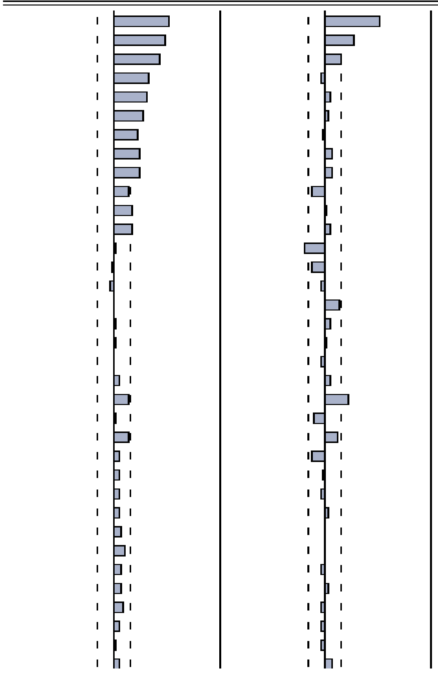
*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ZRNN)
Method: Least Squares
Date: 10/01/19 Time: 07:15
Sample (adjusted): 3 146
Included observations: 144 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ZRNN(-1)	-0.320460	0.076970	-4.163461	0.0001
D(ZRNN(-1))	-0.296152	0.080527	-3.677681	0.0003
C	7.727359	1.857074	4.161041	0.0001

R-squared	0.294617	Mean dependent var	-0.002131
Adjusted R-squared	0.284612	S.D. dependent var	0.707863
S.E. of regression	0.598715	Akaike info criterion	1.832551
Sum squared resid	50.54279	Schwarz criterion	1.894422
Log likelihood	-128.9437	Hannan-Quinn criter.	1.857692
F-statistic	29.44571	Durbin-Watson stat	2.094446
Prob(F-statistic)	0.000000		

Date: 10/01/19 Time: 07:19
Sample: 1 146
Included observations: 146



	AC	PAC	Q-Stat	Prob
1	0.542	0.542	43.842	0.000
2	0.502	0.294	81.630	0.000
3	0.457	0.164	113.24	0.000
4	0.340	-0.029	130.84	0.000
5	0.332	0.059	147.77	0.000
6	0.295	0.037	161.17	0.000
7	0.238	-0.012	169.97	0.000
8	0.259	0.068	180.51	0.000
9	0.259	0.074	191.13	0.000
10	0.148	-0.122	194.59	0.000
11	0.176	0.019	199.58	0.000
12	0.173	0.054	204.41	0.000
13	0.019	-0.190	204.47	0.000
14	-0.009	-0.124	204.48	0.000
15	-0.045	-0.031	204.82	0.000
16	0.001	0.132	204.82	0.000
17	0.021	0.049	204.89	0.000
18	0.018	0.023	204.94	0.000
19	-0.008	-0.030	204.96	0.000
20	0.052	0.061	205.41	0.000
21	0.156	0.234	209.60	0.000
22	0.022	-0.108	209.68	0.000
23	0.150	0.119	213.64	0.000
24	0.052	-0.128	214.13	0.000
25	0.042	-0.010	214.44	0.000
26	0.044	-0.041	214.78	0.000
27	0.043	0.032	215.11	0.000
28	0.079	0.003	216.24	0.000
29	0.111	-0.005	218.54	0.000
30	0.075	-0.025	219.58	0.000
31	0.068	0.036	220.44	0.000
32	0.090	-0.033	221.98	0.000
33	0.056	-0.032	222.58	0.000
34	0.013	-0.025	222.61	0.000
35	0.046	0.077	223.01	0.000

Figure 3: Correlogram of the pre-intervention series

Table 2: An ARIMA (3, 12) model for the pre-intervention series

Dependent Variable: ZRNN
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 10/01/19 Time: 07:24
Sample: 1 146
Included observations: 146
Failure to improve objective (non-zero gradients) after 181 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	1.425384	9.67E-05	14747.57	0.0000
AR(2)	-0.612766	0.000349	-1756.888	0.0000
AR(3)	0.187381	0.000623	300.8762	0.0000
MA(1)	-1.117005	0.104942	-10.64405	0.0000
MA(2)	0.541864	0.210974	2.568391	0.0113
MA(3)	-0.076815	0.248605	-0.308984	0.7578
MA(4)	-0.318943	0.228521	-1.395682	0.1652
MA(5)	0.244242	0.209598	1.165285	0.2460
MA(6)	-0.129785	0.207444	-0.625641	0.5326
MA(7)	0.145160	0.175343	0.827863	0.4093
MA(8)	-0.061486	0.162177	-0.379127	0.7052
MA(9)	0.070792	0.190148	0.372299	0.7103
MA(10)	-0.403501	0.216264	-1.865778	0.0643
MA(11)	0.707878	0.170408	4.154009	0.0001
MA(12)	-0.577461	0.119776	-4.821170	0.0000
SIGMASQ	0.300747	0.035626	8.441781	0.0000

R-squared	0.443193	Mean dependent var	24.11227
Adjusted R-squared	0.378946	S.D. dependent var	0.737464
S.E. of regression	0.581173	Akaike info criterion	1.971578
Sum squared resid	43.90908	Schwarz criterion	2.298549
Log likelihood	-127.9252	Hannan-Quinn criter.	2.104434
Durbin-Watson stat	2.008633		

Inverted AR Roots	1.00	.21-.38i	.21+.38i	
Inverted MA Roots	.99	.87-.39i	.87+.39i	.56-.72i
	.56+.72i	.21+.97i	.21-.97i	-.31-.90i
	-.31+.90i	-.76+.53i	-.76-.53i	-1.00

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This shows an ARIMA (3, 12) given by
$X_t = 1.4254X_{t-1} - 0.6128X_{t-2} + 0.1874X_{t-3} + 1.1170\varepsilon_{t-1} + 0.5419\varepsilon_{t-2} + 0.7079\varepsilon_{t-11} - 0.5775\,\varepsilon_{t-12} + \varepsilon_t$
on which basis we obtain the following forecasts from for the post-intervention data.

Table 3: Transfer function

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 10/02/19 Time: 23:43
Sample: 147 177
Included observations: 31
Convergence achieved after 273 iterations
Coefficient covariance computed using outer product of gradients
Z=C(1)*(1-C(2)^(T-146))/(1-C(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	3.108025	0.793501	3.916851	0.0005
C(2)	0.191094	0.211350	0.904157	0.3734

R-squared	0.018232	Mean dependent var	3.813574
Adjusted R-squared	-0.015622	S.D. dependent var	0.845765
S.E. of regression	0.852345	Akaike info criterion	2.580691
Sum squared resid	21.06829	Schwarz criterion	2.673207
Log likelihood	-38.00071	Hannan-Quinn criter.	2.610849
Durbin-Watson stat	2.048888		

Hence, the intervention model is given by;

$$Y_t = \frac{(1 - 1170B + 0.5419B^2 + 0.7079B^{11} - 0.5775B^{12})\varepsilon_t}{1 - 14254B + 0.6128B^2 + 0.1874B^3} + I_t \frac{3.1080\,(1 - 0.1911)^{t-147}}{(1 - 0.911)}$$

$Where\ I_t = 0, \quad t < 147, \quad I_t = 1, \quad t \geq 148$

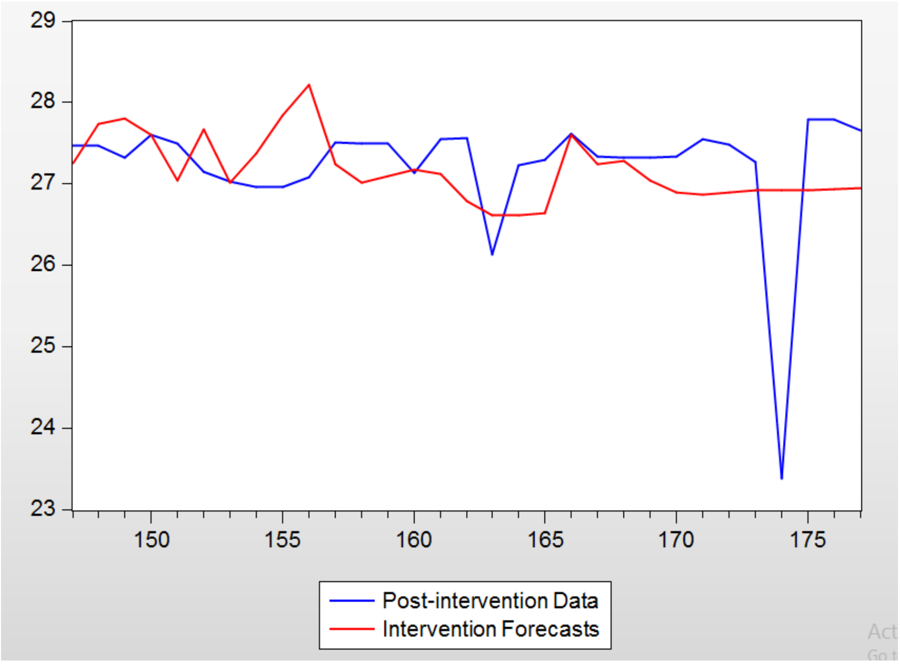

Figure 4: Comparison between the post-intervention data and their intervention forecasts.

CONCLUSION

An intervention model for the daily exchange rate between South African and Nigerian has been examined. Further evidence of its adequacy is on the basis of which there is close agreement between the post intervention forecast and the observations in which goodness of fit of the model across the entire series could be observed. Intervention can therefore be based on it by policy makers, planners and managers.

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DATA ON SOUTH AFRICAN
MARCH, 2017

1 ZAR= 23.7018 NGN 23.8465 24.0131 23.942 24.7547
24.5427 24.9045 24.8912 24.0716 24.2556 24.2532
24.4185 25.255 25.3045 25.3085 25. 4214 24.7011
24.702 24.2656 22.993 23.4708

APRIL, 2017

23.4708 23.5857 22.8915 22.9815 22.8687 22.8732
22. 9819 22. 9825 22.5949 22.8233 22.8872 23.3938
23.4175 23.5195 23.5289 23.5787 23.669 23.5908
23.8318 24.0345 23.9172 23.9172 24.1594 24.3869
23. 9853 23.7188 23.6305 23.629 23. 6237 23.7681

MAY, 2017

23.5492 23.8868 23.4604 23.2021 23.3659 23.3659
23.4116 23.1335 23.1521 23.546 23.5951 23. 7439
23.7439 23.5709 24.5963 24.0614 23.7668 23.8092
24.1028 23.6935 23.9378 23.7486 24.1943 25.1348
24.3583 24.5584 24.5621 24.9419 25.0445 24.6481

23.9868

JUNE, 2017

24.4448 24.4283 24.4318 24.8244 25.4841 24.5018
24.4439 24.4284 24.2915 24.2898 24.6364 24.5645
24.6745 25.709 24.7103 25.3182 25.3104 24.5916
24.7777 24.8158 24.321 24.3159 24.3233 24.3309
25.2022 24.0523 27.101 24.1359 24.0143

JULY, 2017

24.0146 24.0382 23.8657 23.8568 23.4679 24.7274
26.1048 23.5249 24.5589 23.4084 23.8288 23.7874
24.0755 24.0755 24.0801 23.6156 24.3837 27.1174
23.867 24.3793 24.3701 24.3485 24.2944 24.0763
24.1721 24.2736 23.5482 23.5471 23.6938 23.6923

AUGUST, 2017

23.8031 23.8368 23.5397 27.475 27.475 27.3212
27.6022 27.5007 27.1538 27.035 26.9673 26.9677
27.0885 26.5085 27.498 27.494 27.1319 27.5555
27.5604 27.1284 27.2352 27. 2911 27.6126 27.3427
27.3211 27.3424 27.3424 27. 5523 27.4856 27.2707
27.3757

SEPTEMBER, 2017

27.7879 27.7879 27.6565