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Daily Ethiopian Birr/Nigerian Naira Exchange Rates Intervention Analysis

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ABSTRACT

Daily Ethiopian Birr / Nigerian Naira exchange rates are the subject of this research work. It has been observed that in the realization between 20th March 2017 and 12th September 2017 that there is a hike in the time plot of the amounts of the Naira in a Birr as from 4th August 2017, and there is no return of the upward movement. This is an intervention scenario with 4th August 2017 as the point of intervention. An augmented Dickey Fuller unit root test adjudges the pre-intervention series as stationary at 5% significance level. The correlogram suggests a 12-monthly seasonal ARMA model which is fitted as $X_t = 0.7772X_{t-1} + 0.2228X_{t-12} - 0.6691\varepsilon_{t-1} + 0.0239\varepsilon_{t-12} + \varepsilon_t$, where X_t is the series at time t and $\{\varepsilon_t\}$ a white noise process. On the basis of this model post-intervention forecasts are obtained. An intervention model is obtained and the post-intervention forecasts closely agree with the real post-intervention series. The cause of this intervention is assumed to be the recession in the Nigerian economy. This intervention model shall help in the devising of an intervention to redeem the Naira.

Keywords: Ethiopian Birr, Nigerian Naira, Exchange rates, Intervention modeling, ARIMA model

INTRODUCTION

The legal tender of Ethiopia is the Birr (ETB) whereas the Naira (NGN) is its Nigerian counterpart. Business transaction between the two countries is by the exchange rates of the two currencies. The ETB operates the following coins: 10 santim, 50 santim, 1 birr, 1 santim, 5 santim and 25 santim, and the notes: 10 birr, 1 birr, 100 birr, 50 birr and 5 birr. On the other hand the naira operates the following coins 2 naira, 1 naira and 50 kobo and the following notes: 5 naira, 10 naira, 20 naira, 50 naira, 100 naira, 200 naira, 500 naira and 1000 naira. A look at the realization of daily ETB / NGN exchange rates from 20th March 2017 to 12th September 2017 shows an abrupt rise in the amount of NGN in an ETB as from the 4th of August 2017 and continues like that to the series end at 12th September 2017. This is an intervention scenario with the 4th of August as the point of intervention. This work is an attempt to fit n intervention model to the series.

The approach we shall adopt is the Box-Tiao (1975) approach, which has been severally and successfully applied. For instance, Welsh and Stewart (1989) proposed an intervention model to water quality data for two streams in North Eastern Victoria. In a thesis Agyemang (2012) proposed an intervention model for major crimes in Ghana. Huitema *et al.* (2014) reached a conclusion that the introduction of Pedestrian Countdown Timer signals Detriot reduced pedestrian crashes to about one third of the pre-intervention level. Swamy (2015) devised intervention models for share index data for banks in Bangladesh. The effect of change of the malaria control intervention policy was observed on the low and sustained malaria transmission in Kwa Zulu-Natal was observed by Ebhuoma *et al.* (2017). Etuk and Eleki (2017) have devised a model for intervention for the NGN against the Central African Franc. Gqargoum and El-Basyouny (2018) noticed that legislative

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changes were associated with drops in province-wide fatal accidental automobile collisions.

MATERIALS AND METHODS

Data

The data for this work obtained from the website www.exchangerates.org.uk/ETB/NGN/exchange-rate-history.html star t from 20th March 2017 to 12th September 2017. They are to be read as the amounts of NGN in one ETB. The data series is provided in the appendix of this work.

Intervention Modelling

A stationary time series $\{X_t\}$ is said to follow an autoregressive moving process of order (p, q) if it satisfies the following difference equation

$$X_t = \alpha_1 X_{t-1} + \alpha_{t-2} X_{t-2} + \cdots + \alpha_p X_{t-p} + \varepsilon_t + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \cdots + \beta_q \varepsilon_{t-q} \qquad (1)$$

where the $\{\varepsilon_t\}$ are a white noise series and the $\{\alpha_i\}$ and the $\{\beta_i\}$ are series of constants chosen so that (1) be stationary as well as invertible.

Generally $\{X_t\}$ will not be stationary in which case differencing it up to a certain integral order would render it stationary. Let this order be d. Then $\nabla^d X_t = (1-L)^d X_t$ is stationary where L is the backshift operator defined by $L^k X_t = X_{t-k}$. Insertion of $\nabla^d X_t$ in place of X_t in (1) yields an autoregressive integrated moving average process of order (p, d, q) in $\{X_t\}$. This is designated as an ARIMA (p, d, q) model.

We shall assume that the series $\{X_t\}$ shows an intervention pattern at time T. Then according to Box and Pierce (1975) the pre-intervention series will be fitted with an ARIMA(p, d, q). On the basis of this model, forecasts are made for the post-intervention period. Let these be F_t, $t > T-1$. Then a model of $Z_t = X_t - Ft$ against t is called an intervention model.

A common transfer function used for this is given by

$$Z_t = \frac{c_1(1-c_2{}^{t-T+1})}{1-c_2} \qquad (2)$$

Then an intervention model is given by

$$Y_t = F_t + I_t Z_t \qquad (3)$$

Where $I_t = 0$, $t < T$, and $I_t = 1$, otherwise.

The Augmented Dickey Fuller (ADF) unit root Test was used to ascertain whether the series was stationary or not. Eviews 10 was used in the computational needs of this work.

RESULTS AND DISCUSSIONS

The time plot of the data is given in Figure I. At the 138th day, i.e. 4th August 2017 there was an abrupt rise in the level of the series and throughout the range of the series the level is maintained.

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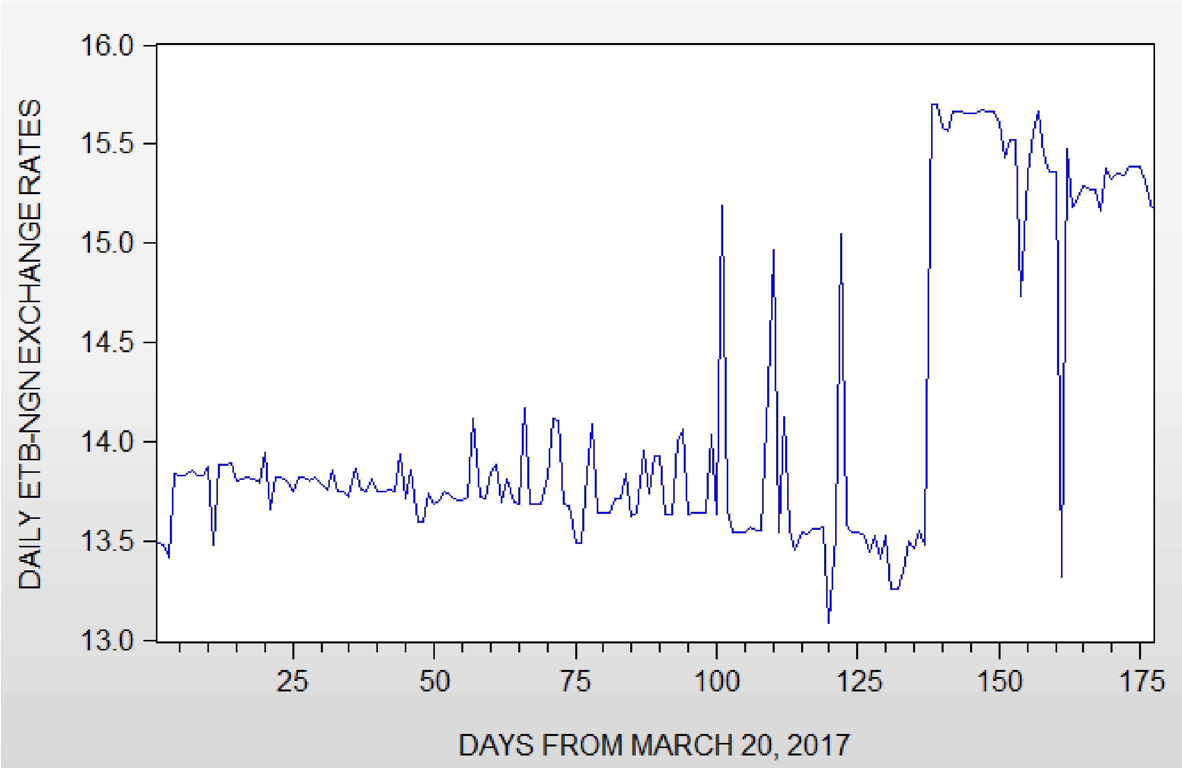

Figure 1: Time Plot Of the Series

Figure 2 is a time-plot of the pre-intervention series. Application of the ADF test on it shows that the pre-intervention series is stationary. See Table I. On the basis of its correlogram of Figure 3, and as seen in Table 2, the model

$X_t = 0.7772X_{t-1} + 0.2228X_{t-12} - 0.6669\varepsilon_{t-1} + 0.0239\varepsilon_{t-12} + \varepsilon_t$

On which basis forecasts were made for the post-intervention period. Let Z_t represent the difference between the post-intervention observations and the corresponding forecasts. Using (2) and as seen in Table 3,

$Z_t = \frac{1.9626}{1+0.1816}(1 - (-0.1816)^{137-t})$

According to (3), the intervention model is given by

$Y_t = (1\text{-}0.6669L + 0.0239L^{12})\varepsilon_t/(1\text{-}0.7772L\text{-}0.2228L^{12}) + I_t.Z_t,\ I_t\ \text{-}1, t \geq 138,\ I_t = 0,\ t < 137$ (4).

A superimposition of the graphs in Figure 4 of X_t and Y_t show a close agreement.

CONCLUSION

It may be concluded that formula (4) yields the intervention model of the daily exchange rates. This could be the basis of any management decision to remedy the relationship on the part of the Nigerian Naira. Government officials, planners and administrators shall find this kind of work useful.

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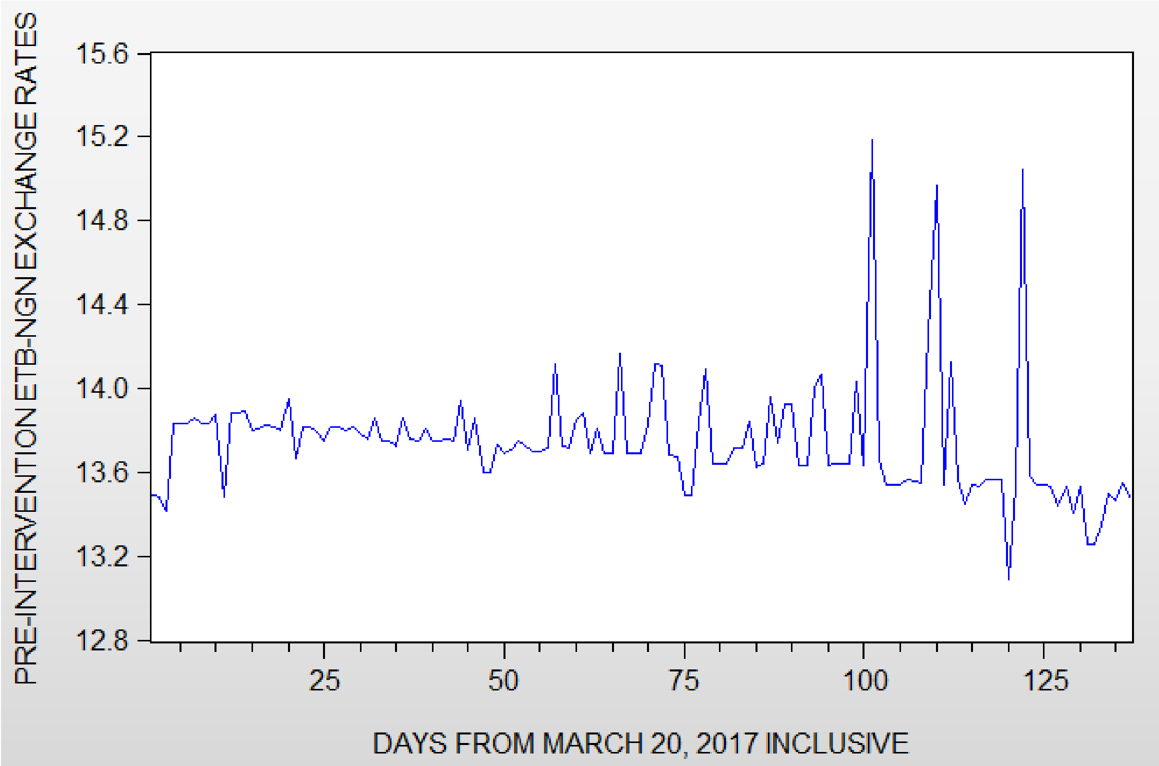

Figure 2: Time Plot of Pre-Intervention Series

Table I: ADF Test on the Pre-Intervention Series

Null Hypothesis: ETBN has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.842608	0.0000
Test critical values:	1% level	-3.478911	
	5% level	-2.882748	
	10% level	-2.578158	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ETBN)
Method: Least Squares
Date: 12/16/17 Time: 11:04
Sample (adjusted): 2 137
Included observations: 136 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ETBN(-1)	-0.839471	0.085289	-9.842608	0.0000
C	11.53555	1.172239	9.840607	0.0000

R-squared	0.419604	Mean dependent var	-7.50E-05
Adjusted R-squared	0.415273	S.D. dependent var	0.354709
S.E. of regression	0.271237	Akaike info criterion	0.242947
Sum squared resid	9.858295	Schwarz criterion	0.285780
Log likelihood	-14.52041	Hannan-Quinn criter	0.260353

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Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.159	0.159	3.5610	0.059
		2	0.047	0.022	3.8671	0.145
		3	0.015	0.004	3.8982	0.273
		4	-0.042	-0.047	4.1464	0.387
		5	-0.012	0.001	4.1682	0.525
		6	0.023	0.029	4.2476	0.643
		7	0.006	-0.001	4.2522	0.750
		8	0.076	0.074	5.1022	0.747
		9	0.142	0.121	8.0926	0.525
		10	-0.032	-0.078	8.2506	0.604
		11	0.091	0.103	9.5083	0.575
		12	0.231	0.221	17.612	0.128
		13	0.051	-0.010	18.011	0.157
		14	-0.036	-0.073	18.208	0.197
		15	-0.043	-0.028	18.494	0.238
		16	0.056	0.106	18.988	0.269
		17	0.023	-0.016	19.069	0.325
		18	-0.051	-0.100	19.482	0.363
		19	-0.152	-0.148	23.232	0.227
		20	-0.036	-0.033	23.439	0.268
		21	0.177	0.183	28.569	0.125
		22	-0.045	-0.092	28.901	0.148
		23	0.067	0.026	29.645	0.160
		24	-0.067	-0.167	30.392	0.172
		25	-0.118	-0.106	32.742	0.138
		26	-0.107	-0.008	34.707	0.118
		27	-0.051	0.037	35.154	0.135
		28	0.041	0.050	35.452	0.157
		29	0.078	-0.005	36.524	0.159

Figure 3: Correlogram of the Pre-Intervention Series

Table 2: ARMA Fit on the Pre-Intervention Series

Dependent Variable: ETBN
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 06/04/19 Time: 05:46
Sample: 1 137
Included observations: 137
Failure to improve objective (non-zero gradients) after 25 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.777220	0.143888	5.401555	0.0000
AR(12)	0.222774	0.012122	18.37693	0.0000
MA(1)	-0.669058	0.144842	-4.619236	0.0000
MA(12)	0.023850	0.119786	0.199108	0.8425
SIGMASQ	0.072118	0.004241	17.00628	0.0000

R-squared	0.029806	Mean dependent var	13.73960
Adjusted R-squared	0.000406	S.D. dependent var	0.273642
S.E. of regression	0.273586	Akaike info criterion	0.361280
Sum squared resid	9.880119	Schwarz criterion	0.467849
Log likelihood	-19.74771	Hannan-Quinn criter.	0.404587
Durbin-Watson stat	1.868454		

Inverted AR Roots	1.00	.85-.41i	.85+.41i	.51-.73i
	.51+.73i	.05-.86i	.05+.86i	-.39-.75i
	-.39+.75i	-.72-.43i	-.72+.43i	-.84
Inverted MA Roots	.80+.17i	.80-.17i	.58+.49i	.58-.49i
	.24+.69i	.24-.69i	-.15+.69i	-.15-.69i
	-.48+.51i	-.48-.51i	-.67-.19i	-.67+.19i

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Table 3: Computation of the intervention transfer function

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 06/04/19 Time: 09:37
Sample: 138 177
Included observations: 40
Convergence achieved after 21 iterations
Coefficient covariance computed using outer product of gradients
Z=C(1)*(1-C(2)^(T-137))/(1-C(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.962643	1.496531	1.311461	0.1976
C(2)	-0.181640	0.907291	-0.200201	0.8424

R-squared	0.001465	Mean dependent var	1.666960
Adjusted R-squared	-0.024813	S.D. dependent var	1.576680
S.E. of regression	1.596120	Akaike info criterion	3.821736
Sum squared resid	96.80881	Schwarz criterion	3.906180
Log likelihood	-74.43471	Hannan-Quinn criter.	3.852268
Durbin-Watson stat	2.163799		

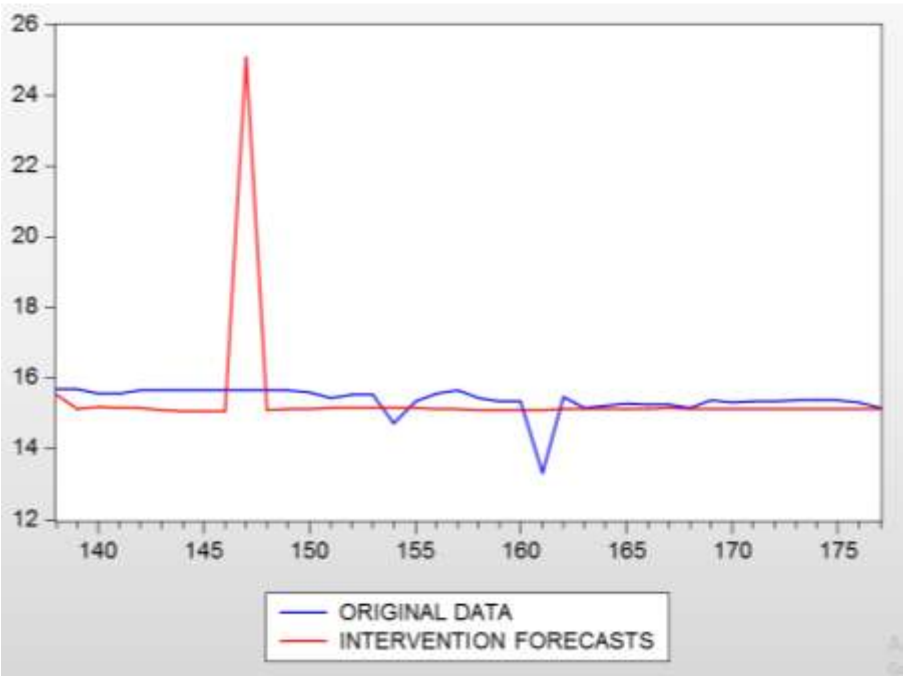

Figure 4: Comparison of the post-intervention data and forecasts.

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APPENDIX
DATA

March 2017 (Starting from the 20th)

13.4861 13.4797 13.4138 13.8344 13.8295 13.8296 13.8588 13.8321 13.8321 13.8726 13.4824 13.8836

April 2017

13.8836 13.8943 13.7986 13.8066 13.8218 13.8143 13.7954 13.9477 13.6611 13.8194 13.8160 13.7942 13.7467 13.8163 13.8164 13.8004 13.8174 13.7842 13.7579 13.8545 13.7501 13.7501 13.7244 13.8607 13.7558 13.7471 13.8110 13.7448 13.7448 13.7538

May 2017

13.7485 13.9387 13.7081 13.8556 13.5987 13.5987 13.7352 13.6866 13.7044 13.7505 13.7238 13.7001 13.7001 13.7172 14.1179 13.7231 13.7120 13.8505 13.8804 13.6909 13.8102 13.6915 13.6880 14.1650 13.6867 13.6880 13.6880 13.8221 14.1127 14.1063 13.6839

June 2017

13.6743 13.4883 13.4883 13.8374 14.0900 13.6380 13.6420 13.6368 13.7134 13.7134 13.8415 13.6264 13.6437 13.9570 13.7364 13.9270 13.9270 13.6289 13.6291 13.9954 14.0630 13.6345 13.6415 13.6415 13.6407 14.0324 13.6287 15.1879 13.6559 13.5427

July 2017

13.5427 13.5427 13.5646 13.5526 13.5472 14.2545 14.9679 13.5436 14.1246 13.5620 13.4512 13.5384 13.5325 13.5607 13.5607 13.5646 13.0889 13.5335 15.0483 13.5795 13.5430 13.5430 13.5280 13.4407 13.5283 13.4054 13.5275 13.2559 13.2559 13.3457 13.4985

August 2017

13.4607 13.5468 13.4759 15.7030 15.7030 15.5855 15.5651 15.6646 15.6661 15.6517 15.6555 15.6554 15.6724 15.6621 15.6685 15.6073 15.4330 15.5245 15.5245 14.7305 15.3426 15.5601 15.6602 15.4492 15.3559 15.3559 13.3182 15.4763 15.1772 15.2233 15.2903

September 2017

15.2720 15.2720 15.1650 15.3751 15.3280 15.3481 15.3453 15.3852 15.3851 15.3851 15.3129 15.1703