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Daily Egyptian Pound / Nigerian Naira Exchange Rates Intervention Modelling

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ABSTRACT

A look at the time plot of the exchange rates of the Egyptian pound EGP and the Nigerian Naira NGN across the year 2017 reveals an abrupt jump in the amount of the latter in one unit of the former on the 4th of August 2017 and thenceforth prompting an intervention modeling. This situation is due to the ongoing economic recession Nigeria has fallen into. With a realization starting from March 17, 2017 and ending September 8, 2017, the pre-intervention data are adjudged stationary by the Augmented Dickey Fuller test. Fitted to it is an ARMA (13, 12) on which basis post-intervention forecasts are obtained. Intervention modeling produces very close post-intervention forecasts to the real data.

Keywords: Egyptian pound, Nigerian Naira, Arima modeling, intervention modeling.

INTRODUCTION

The exchange rate between the currencies of two nations is very important in the transaction of business between the two countries. It measures the relative strength of the two currencies. Egyptian pound EGP is the legal tender in Egypt. It is divided into 100 piastres, or ersh or 1000 milliemes. (Wikipedia, 2019). Nigerian Naira NGN is made up of 100 kobo. The notes are in denominations of 50 naira, 100 naira, 200 naira, 500 naira and 1000 naira and the coins which are hardly used are 5, 10 and 50 kobo only. It has been observed that there was jump in the value of the naira per EGP on 4th August 2017 in the exchange rate series of that year. Since the series has not returned back it is seen that an intervention analysis is called for. The modeling approach adopted is the one proposed by Box and Tiao (1975), an approach widely applied successfully. For instance, Lakshman *et al.* (1989) applied this approach in a field experiment with test and control panels connected to a split-cable TV system. Gilmour *et al.* (2006) show that Australian Heroin shortage of 2001 improved crime rate amongst the populace. Igboanugo and Ekhuemelo (2007) have provided adequate representation of 7-year monthly road accident statistics in Edo State of Nigeria. This approach was used by Min (2008) to evaluate the impact of the September 21 Earthquake in 1999 and the Severe Acute Respiratory Syndrome of 2003 on Taiwan's inbound tourism. Changes in heart rate of cows receiving both programmed and non-programmed cues have been observed and noted by Anderson *et al.* (2010). Masukawa *et al.* (2014) have verified that a statistically significant reduction on hospitalization rates of children 1 year or younger after an introduction of rotavirus vaccine. An adequate representation of the US Dollar / NGN exchange rates was given by Mosugu and Anieting (2016). Etuk *et al.* (2019) have fitted an adequate intervention model to daily Gambian Dalasi / Nigerian Naira exchange rates.

MATERIALS AND METHODS

Data

The data used for this work are 177 daily exchange rates of the Egyptian pounds / Nigerian naira exchange rates from 17th March 2017 to 9th September 2017 copied from the website www.exchangerates.org.uk/EGP-NGN-exchange-rate-history.html accessed on 10th September 2017. They are to be read as the amounts of NGN in one EGP.

Intervention Analysis

Let $X_1, X_2 \ldots X_n$ be an n-point time series. Suppose that it is stationary. It is said to follow an autoregressive moving average time series of order p and q denoted ARMA (p, q) if $X_t - \alpha_1 X_{t-1} - \alpha_2 X_{t-2} - \ldots - \alpha_p X_{t-p} = \varepsilon_t + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \ldots + \beta_q \varepsilon_{t-q}$(1) Or $\Phi(L)X_t = \Theta(L)\varepsilon_t$ (2) where $\{\varepsilon_t\}$ is a white noise process , $\Phi(L) = 1 - \alpha_1 L - \alpha_2 L^2 - \ldots - \alpha_p L^p$, $\Theta(L) = 1 + \beta_1 L + \beta_2 L^2 + \ldots + \beta_q L^q$ and L is the backshift operator defined by $L^k X_t = X_{t-k}$. Theα's andβ's are constants defined such that the model is stationary and invertible. If the series $\{X_t\}$ is nonstationary then according to Box and Jenkins (1976) if it is differenced the differenced series ∇X_t if stationary may be modeled as an ARMA (p, q). If not, further differencing may be done, until stationarity is attained and then modeling done. If the series needed to be differenced d times before modeling, we say that the original series is modeled as an autoregressive integrated moving average model of order p, d and q denoted by ARIMA(p, d, q). Let this model be denoted by $\Phi(L)\nabla^p X_t = \Theta(L)\varepsilon_t$ (3) where $\nabla = 1 - L$. Let there be an intervention on the time series at the point t = m. According to Box and Tiao (1975), the preintervention series if fitted with an ARIMA (p, d, q) of the type (3). On the basis of this model, a forecast is made of the postintervention part of this series. Let it be F_t, $t \geq m$. Define $Z_t = X_t - F_t$, $t \geq m$. Then Z_t = c(1)*(1-c(2)^(t-m+1))/(1-c(2)), t ≥ (4) (The Pennsylvania State University, 2016) So that the intervention model is given by $Y_t = \Theta(L)\varepsilon_t/[\Phi(L)\nabla^p] + I_t$. c(1)*(1-c(2)^(t-m+1))/(1-c(2)) (5) where $I_t = 1$, $t \geq m$, zero otherwise.

Computer Software

The computer package used for this work is the eviews 10. It adopts the maximum likelihood estimation procedure.

RESULTS 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.

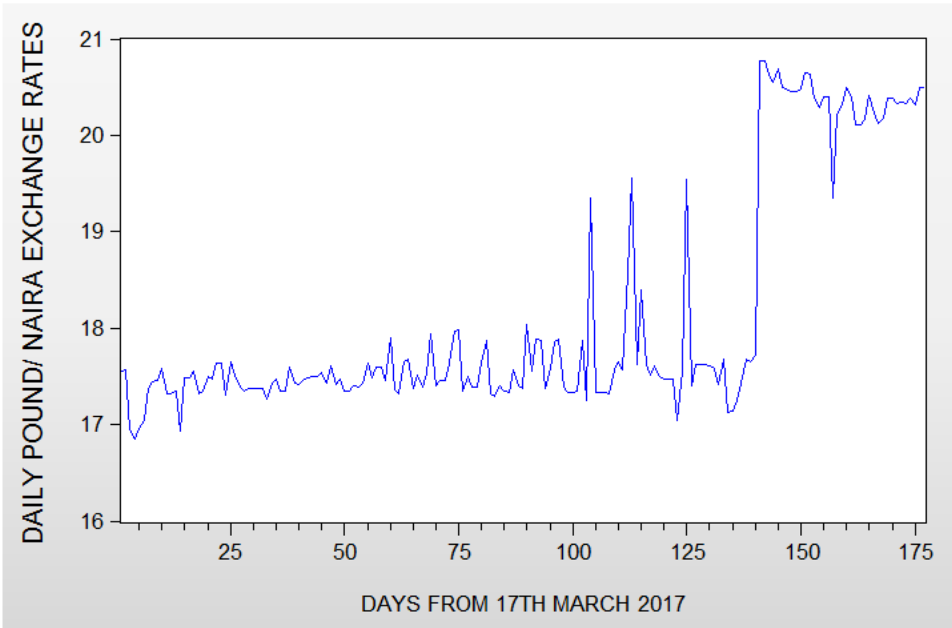

Figure 1: Time plot of EGP / NGN exchange rates.

The pre-intervention series whose time plot appears below in Figure 2 shows a stationary nature as seen in the following table 1.

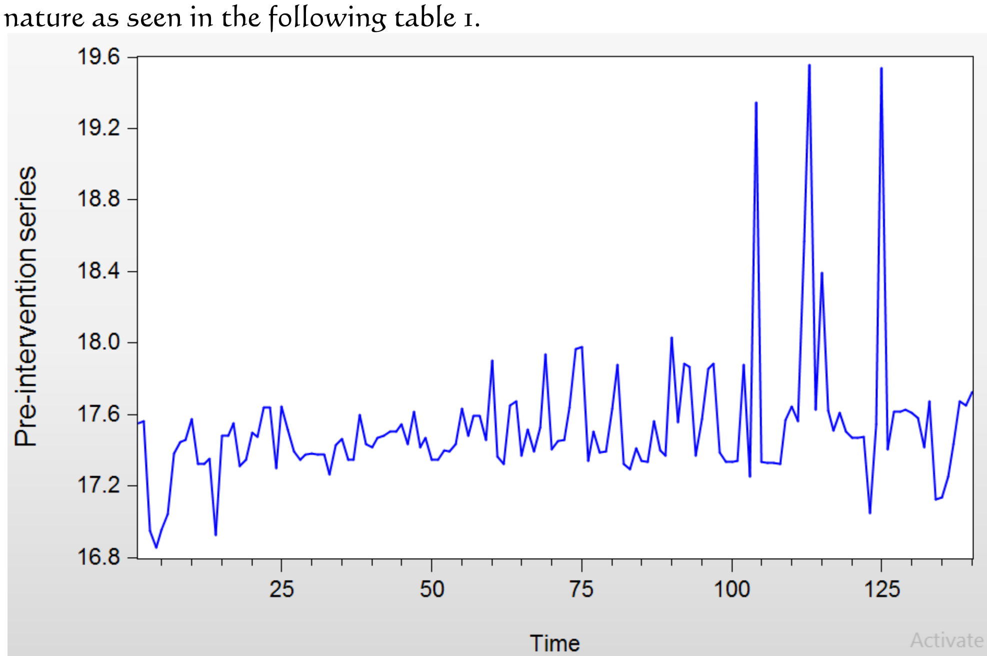

Figure 2: Time plot of the pre-intervention series

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Table 1: Unit Root Test for the Pre-intervention Series

Null Hypothesis: EGNN has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

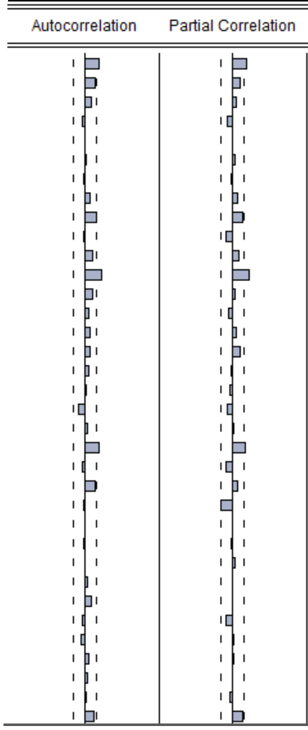
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.641918	0.0000
Test critical values:	1% level	-3.477835	
	5% level	-2.882279	
	10% level	-2.577908	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EGNN)
Method: Least Squares
Date: 11/25/18 Time: 22:52
Sample (adjusted): 2 140
Included observations: 139 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EGNN(-1)	-0.809500	0.083956	-9.641918	0.0000
C	14.19214	1.472123	9.640597	0.0000

R-squared	0.404261	Mean dependent var	0.001245
Adjusted R-squared	0.399913	S.D. dependent var	0.474928
S.E. of regression	0.367904	Akaike info criterion	0.852295
Sum squared resid	18.54342	Schwarz criterion	0.894518
Log likelihood	-57.23452	Hannan-Quinn criter.	0.869453
F-statistic	92.96658	Durbin-Watson stat	2.039967
Prob(F-statistic)	0.000000		



	AC	PAC	Q-Stat	Prob
1	0.190	0.190	5.1699	0.023
2	0.141	0.109	8.0359	0.018
3	0.089	0.046	9.1743	0.027
4	-0.038	-0.080	9.3904	0.052
5	-0.002	0.002	9.3910	0.094
6	0.019	0.031	9.4456	0.150
7	-0.015	-0.015	9.4796	0.220
8	0.076	0.075	10.341	0.242
9	0.167	0.151	14.558	0.104
10	-0.019	-0.091	14.615	0.147
11	0.110	0.084	16.496	0.124
12	0.245	0.235	25.834	0.011
13	0.104	0.037	27.542	0.010
14	0.052	-0.058	27.970	0.014
15	0.076	0.053	28.893	0.017
16	0.081	0.111	29.935	0.018
17	0.052	-0.010	30.380	0.024
18	0.018	-0.041	30.434	0.033
19	-0.084	-0.069	31.585	0.035
20	0.035	0.022	31.783	0.046
21	0.199	0.176	38.402	0.012
22	-0.034	-0.096	38.598	0.016
23	0.132	0.071	41.563	0.010
24	-0.019	-0.156	41.627	0.014
25	0.007	-0.003	41.635	0.020
26	-0.014	-0.012	41.668	0.027
27	0.006	0.027	41.674	0.035
28	0.032	0.000	41.853	0.045
29	0.085	0.002	43.152	0.044
30	-0.027	-0.090	43.284	0.055
31	-0.057	0.015	43.883	0.062
32	0.045	0.016	44.248	0.073
33	0.029	-0.002	44.401	0.089
34	0.012	-0.026	44.427	0.109
35	0.120	0.146	47.171	0.082

Figure 3: Correlogram of the pre-intervention series

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Table 2: An ARIMA(1,0,1)(1,0,1) Model for the Pre-intervention Series

Dependent Variable: EGNN
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 11/25/18 Time: 23:11
Sample: 1 140
Included observations: 140
Failure to improve objective (non-zero gradients) after 34 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.491968	0.107622	4.571274	0.0000
AR(12)	0.607357	0.130395	4.657822	0.0000
AR(13)	-0.099329	0.002150	-46.20451	0.0000
MA(1)	-0.240162	0.119384	-2.011676	0.0463
MA(12)	-0.359555	0.119644	-3.005204	0.0032
MA(13)	-0.044685	0.075929	-0.588506	0.5572
SIGMASQ	0.129789	0.007244	17.91703	0.0000

R-squared	0.055625	Mean dependent var	17.53184
Adjusted R-squared	0.013021	S.D. dependent var	0.372052
S.E. of regression	0.369622	Akaike info criterion	0.979732
Sum squared resid	18.17049	Schwarz criterion	1.126814
Log likelihood	-61.58125	Hannan-Quinn criter.	1.039502
Durbin-Watson stat	2.226881		

Inverted AR Roots	1.00	.87+.47i	.87-.47i	.51-.82i
	.51+.82i	.16	.02-.95i	.02+.95i
	-.46-.83i	-.46+.83i	-.81-.48i	-.81+.48i
	-.94			
Inverted MA Roots	.95	.83+.46i	.83-.46i	.49-.79i
	.49+.79i	.03-.92i	.03+.92i	-.12
	-.43-.79i	-.43+.79i	-.77+.46i	-.77-.46i
	-.89			

So that the pre-Intervention Series is modeled by

$X_t = 0.4920X_{t-1} + 0.6074X_{t-12} -0.0993X_{t-13} -0.2402\varepsilon_{t-1} -0.3596\varepsilon_{t-12} + \varepsilon_t$

On the basis of that model forecasts are made for the post-intervention series and z_t are obtained and modeled on the basis of (4).

Table 3: Intervention transfer function modelling

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 05/28/19 Time: 13:52
Sample: 141 177
Included observations: 37
Convergence achieved after 17 iterations
Coefficient covariance computed using outer product of gradients
Z = C(1)*(1-C(2)^(T-140))/(1-C(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	2.990606	0.263632	11.34388	0.0000
C(2)	-0.102804	0.098246	-1.046391	0.3026

R-squared	0.037086	Mean dependent var	2.718549
Adjusted R-squared	0.009574	S.D. dependent var	0.270399
S.E. of regression	0.269102	Akaike info criterion	0.265085
Sum squared resid	2.534554	Schwarz criterion	0.352161
Log likelihood	-2.904069	Hannan-Quinn criter.	0.295783
Durbin-Watson stat	1.126859		

Hence the intervention model is given by

$Y_t = (1 - 0.2402L\text{-}0.3596L^{12})\ \varepsilon_t/(1\text{-}0.4920L\text{-}0.6074L^{12}+0.0993L^{13})+I_t.(2.9906)(1\text{-}(\text{-}0.1028)\,\hat{}\,(t\text{-}140))/1.1028$ (6)

Where $I_t = 1$, $t \geq 141$, zero elsewhere.

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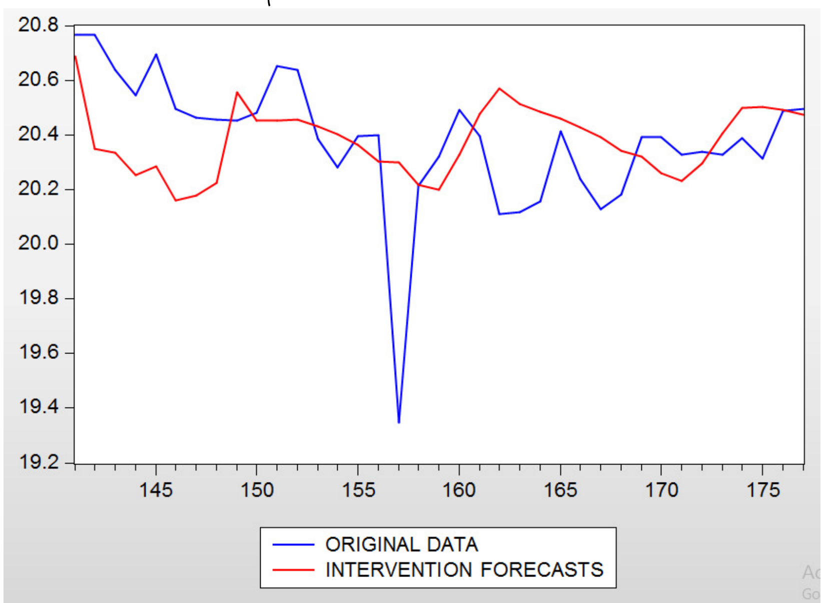

Figure 4: Comparison between the post-intervention data and their intervention forecasts

CONCLUSION

It may be noted the closeness of the post-intervention data and their intervention forecasts. Therefore the intervention model (6) is adequate for the exchange rates. Therefore decision should based on it to help manage the relationship between the two currencies.

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APPENDIX

DATA

March 2017 (Starting from the 17th) 17.5531 17.5628 16.9466 16.8534 16.9546 17.0412 17.3807 17.4481 17.4578 17.5761 17.3255 17.3255 17.3506 16.9272 17.4815. **April** 2017 17.4815 17.5522 17.3132 17.3463 17.5004 17.4744 17.6399 17.6398 17.2988 17.6443 17.5178 17.3921 17.3493 17.3784 17.3804 17.3761 17.3734 17.2647 17.4313 17.4653 17.3485 17.3485 17.5960 17.4338 17. 4161 17.4703 17.4803 17.5027 17.5028 17.5437. **May** 2017 17.4359 17.6127 17.4191 17.4690 17.3452 17.3452 17.3993 17.3909 17.4334 17.6308 17.4822 17.5900 17.5900 17.4559 17.9029 17.3623 17.3224 17.6495 17.6727 17.3688 17.5185 17.3950 17.5305 17.9360 17.4033 17.4535 17.4565 17.6391 17.9656 17.9767 17.3423. **June** 2017. 17.5046 17.3877 17.3916 17.6305 17.8773 17.3258 17.2932 17.4085 17.3410 17.3372 17.5636 17.4012 17.3677 18.0333 17.5563 17.8842 17.8679 17.3692 17.5767 17.8537 17.8862 17.3898 17.3352 17.3352 17.3404 17.8773 17.2542 19.3465 17.3270. **July** 2017. 17.3313 17.3246 17.5699 17.6468 17.5639 18.5690 19.5558 17.6270 18.3953 17.6189 17.5109 17.6080 17.5048 17.4714 17.4714 17.4760 17.0467 17.5481 19.5385 17.4054 17.6164 17.6164 17.6165 17.6124 17.5785 17.4168 17.6738 17.1257 17.1339 17.2533 17.4316. **August** 2017. 17.6742 17.6504 17.7262 20.7661 20.7661 20.6385 20.5442 20.6936 20.4963 20.4640 20.4565 20.4531 20.4804 20.6505 20.6388 20.3844 20.2818 20.3961 20.3979 19.3465 20.2128 20.3194 20.4916 20.3960 20.1103 20.1159 20.1581 20.4122 20.2378 20.1270 20.1807. **September** 2017 20.3912 20.3912 20.3290 20.3373 20.3296 20.3890 20.3147 20.4898 20.7943