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Arima Intervention Analysis of Monthly Xaf-Ngn Exchange Rates Occasioned By Nigerian Economic Recession

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Abstract: Time-plot of monthly Central African Franc (CFAFr or XAF) and Nigerian Naira (NGN) exchange rates from January 2004 to January 2017 shows a slight positive trend up to May 2016 after which there is an abrupt astronomical rise which calls for intervention. The intervention point is therefore June 2016 around which time the Nigerian economy sank into recession. At 1% level of significance the pre-intervention rates are non-stationary and differencing the series once renders it stationary. This pre-intervention series has the autocorrelation structure of white noise. This white noise model structure is confirmed by a non-significant ARIMA (6,1,6) fit. Post-intervention forecasts are obtained on the basis of the pre-intervention white noise model. The difference between post-intervention forecasts and actual observations is modelled to obtain the intervention model. The intervention model is statistically significant and may be useful as basis for intervention in the circumstance.

Keywords: CFAFr, NGN, Exchange Rates, Intervention Analysis.

1. Introduction

Studies have been done on the exchange rates between the Central African Franc (CFAFr or XAF) and the Nigerian Naira (NGN). For instance, Etuk *et al.* (2013) worked on the monthly CFAFr-NGN exchange rates from January 2004 to June 2013 and fitted an additive SARIMA model to them. In this study an extension of the series up to January 2017 is analyzed. The motivation of this study is the observation that there is an intervention since June 2016 with an astronomical rise in the amount of the Naira per Franc. This intervention is the recession of the Nigerian economy. It is noteworthy that this recession was announced to the Nigerian populace in that same month. It is the aim of this research work to propose an intervention model which could act as a basis for intervention by the Nigerian Government.

The approach to be adopted is the autoregressive integrated moving average (ARIMA) intervention modelling proposed by Box and Tiao (1975), which has been extensively applied by researchers. For instance, Enders and Sandler (1993) studied the effectiveness of six antiterrorism policies in the United States. Tiwari *et al.* (2014) examined the pattern of changes in character and temperament of patients after certain treatments. Valadkhani and Layton (2004) studied the effect of Goods and Services Tax on the Consumer Price Index in Australia. They observed that it increased the index by 2.8%. An intervention model for road accidents in Malaysia has been proposed by Yaacob *et al.* (2011). The impact of the National Economic and Empowerment Strategy (NEEDS) on Nigerian inflation was studied by Okereke *et al.* (2016). They observed an abrupt temporary effect. This is to mention just a few cases.

2. Materials and Methods

2.1. Data

The data analyzed in this research work are monthly CFAFr/NGN exchange rates from January 2004 to January 2017 from the website of the Central Bank of Nigeria www.cbn.gov.ng/rates/exrate.asp they are read as the amount of NGN in one CFAFr.

2.2. ARIMA Modelling

A stationary time series {Xt} is said to follow an *autoregressive moving process of order p and q* denoted by ARMA(p,q) if

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

This may be written as

$$A(H)X_t = B(H)\varepsilon_t \quad (2)$$

where $A(H) = 1 - \alpha_1 H - \alpha_2 H^2 - \ldots - \alpha_p H^p$ and $B(H) = 1 + \beta_1 H + \beta_2 H^2 + \ldots + \beta_q H^q$ where H is the backshift operator defined by $H^k X_t = X_{t-k}$.

For a non-stationary time series {Xt}, Box *et al.* (1994) proposed that differencing up to a sufficient order could make it stationary. Suppose that the integer d is the least order of differencing for which the series is stationary. That is $\{\nabla^d X_t\}$ is stationary where $\nabla = 1-H$. A replacement of X_t by $\nabla^d X_t$ in (1) yields an autoregressive integrated moving average model of order p, d and q denoted by ARIMA(p,d,q). Then

$$X_t = \frac{B(H)\varepsilon_t}{A(H)(1-H)^d} \quad (3)$$

In practice, d is determined by putting it equal to 1, and testing the series for stationarity. If the series is found to be stationary, d=1. Otherwise difference the series again in which case d=2 if confirmed to be stationary, and so on. Often, d <3. To check for series stationarity the Augmented Dickey Fuller (ADF) Test shall be used.

The α's and β's of the model (1) are estimated by the least squares procedure such that the model is stationary and invertible.

2.3. Intervention Modelling

Let the normal trend of the series {Xt} be disrupted by an event and let the intervention time point be T. Box and Tiao (1975) proposed that an ARIMA model be fitted to the pre-intervention time series. Suppose it is given by the model (3). On the basis of this model forecasts are derived for the post-intervention period. The difference Z_t between these forecasts and the corresponding post-intervention observations is modelled to obtain the intervention transfer function given by

$$Z_t = c(1)(1-c(2)\wedge(t-T+1))/(1-c(2)) \quad (4)$$

(The Pennsylvania State University, 2016). The parameters c(1) and c(2) may be estimated by the least squares procedure too. Then the overall intervention model may be obtained by combining (3) and (4) as

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

where $I_t = 0, t < T+1, I_t = 1, t > T$.

2.4. Computer Package

Eviews 7 shall be used for all the data analysis in this work. It is based on the least (error sum of) squares procedure for parameter estimation.

3. Results and Discussion

The time plot of the data in Figure 1 shows a slight positive secular trend from 2004 till June 2016 after which there is an abrupt astronomical rise in the exchange rates. It is believed that this is due to the current economic recession in the Nigerian country. The pre-intervention series shown in Figure 2 exhibits a positive trend. At 5% level of significance it is adjudged as stationary by the ADF Test but not at 1% level.

First order differencing of the pre-intervention data makes it stationary by the ADF Test. The time plot is in Figure 3 and the correlogram in Figure 4 shows that they are white noise, all correlations and partial correlations being statistically non-significant. This white noise hypothesis is confirmed by the non-significance of the ARIMA(6,1,6) model of Table 1: the parameter estimates are non-significant and the R^2 is only 4%. On the basis of this white noise pre-intervention model, post-intervention forecasts are made. The difference between these forecasts and the real observations in the post-intervention period is modelled in Table 2 following equation (4). The intervention model by equation (5) is therefore given by

$$Y_t = \frac{\varepsilon_t}{1-H} + 0.6574(1 - 0{,}4571^{T-149})I_t \qquad (6)$$

where I_t =0 if t < 150, I_t =1, t > 149.

4. Conclusion

Figure 5 shows a superimposition of the intervention forecasts and the actual observations in the pre-intervention period. They are quite close. In Figure 6 they are being compared in the entire period of study and the agreement between them is remarkable. Intervention may therefore be based on model (6) to remedy the situation.

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Figure 1.

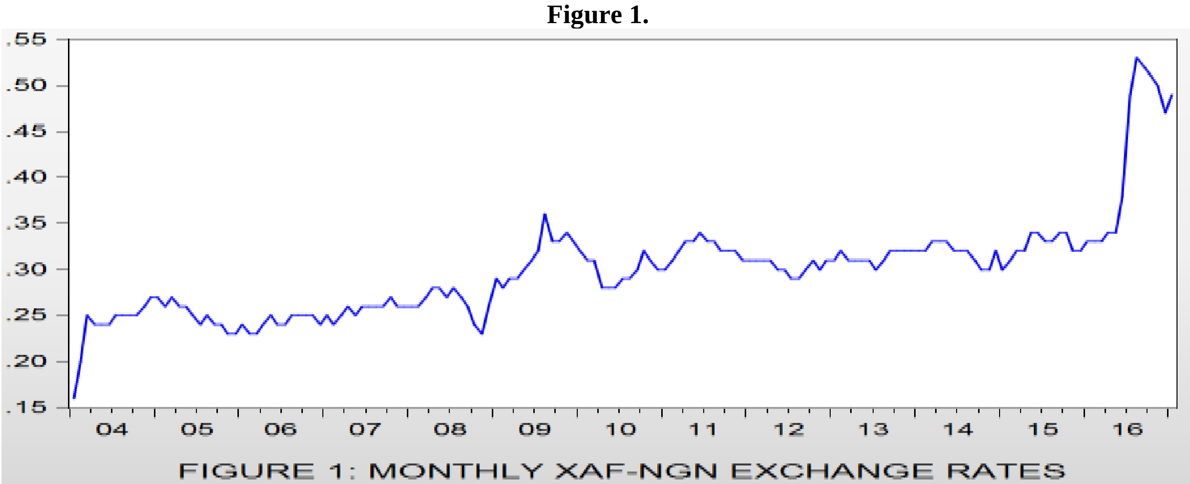


Figure 2.

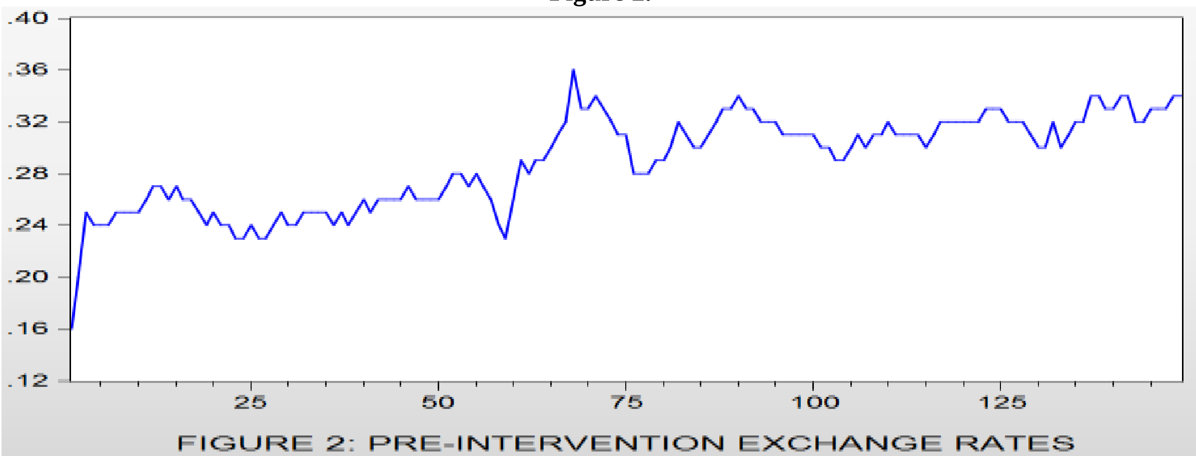


Figure 3.

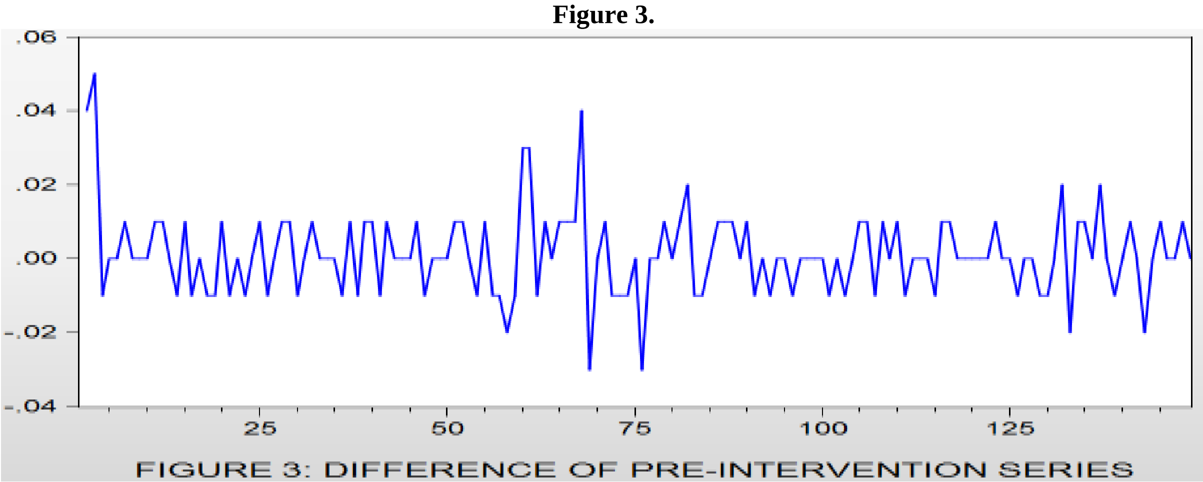


Figure 4. Correlogram of the Difference of the Pre-Intervention Series

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.012	0.012	0.0218	0.883
		2	-0.090	-0.090	1.2419	0.537
		3	0.031	0.033	1.3879	0.708
		4	0.031	0.022	1.5341	0.821
		5	0.016	0.021	1.5717	0.905
		6	-0.147	-0.146	4.9592	0.549
		7	0.062	0.071	5.5679	0.591
		8	-0.033	-0.065	5.7378	0.677
		9	-0.069	-0.047	6.4992	0.689
		10	-0.026	-0.033	6.6108	0.762
		11	-0.037	-0.040	6.8321	0.813
		12	-0.074	-0.101	7.7238	0.806
		13	-0.047	-0.026	8.0871	0.838
		14	-0.015	-0.045	8.1236	0.883
		15	-0.004	-0.015	8.1268	0.919
		16	-0.120	-0.131	10.537	0.837
		17	0.042	0.039	10.830	0.865
		18	0.090	0.039	12.201	0.837
		19	0.001	0.006	12.201	0.877
		20	0.041	0.037	12.498	0.898
		21	-0.044	-0.062	12.831	0.914
		22	0.129	0.093	15.785	0.826
		23	-0.102	-0.120	17.647	0.776
		24	-0.029	-0.007	17.795	0.813
		25	-0.061	-0.130	18.467	0.822
		26	0.107	0.142	20.569	0.764
		27	0.051	-0.014	21.041	0.784
		28	0.014	0.099	21.080	0.822
		29	0.045	-0.016	21.462	0.842
		30	-0.108	-0.073	23.639	0.788
		31	0.056	0.040	24.241	0.801
		32	-0.039	-0.037	24.526	0.825
		33	-0.085	-0.087	25.935	0.804
		34	-0.064	-0.048	26.728	0.808
		35	0.051	0.049	27.234	0.823
		36	-0.007	-0.052	27.243	0.853

Table 1. Estimation of the Arima(6,1,6) Model

Dependent Variable: DCFNN
Method: Least Squares
Date: 02/26/17 Time: 07:16
Sample (adjusted): 8 149
Included observations: 142 after adjustments
Convergence achieved after 6 iterations
MA Backcast: 2 7

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(6)	0.046452	0.148346	0.313130	0.7546
MA(6)	-0.267248	0.162112	-1.648539	0.1015

R-squared	0.038611	Mean dependent var	0.000634
Adjusted R-squared	0.031744	S.D. dependent var	0.010260
S.E. of regression	0.010096	Akaike info criterion	-6.339387
Sum squared resid	0.014270	Schwarz criterion	-6.297756
Log likelihood	452.0965	Hannan-Quinn criter.	-6.322470
Durbin-Watson stat	2.118508		

Inverted AR Roots	.60	.30+.52i	.30-.52i	-.30-.52i
	-.30+.52i	-.60		
Inverted MA Roots	.80	.40-.70i	.40+.70i	-.40-.70i
	-.40+.70i	-.80		

Table 2. Estimation of the Intervention Transfer Function

Dependent Variable: Z
Method: Least Squares
Date: 02/26/17 Time: 07:34
Sample: 150 157
Included observations: 8
Convergence achieved after 33 iterations
Z=C(1)*(1-C(2)^(T-149))/(1-C(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.089776	0.022866	3.926129	0.0077
C(2)	0.457118	0.168189	2.717882	0.0347

R-squared	0.579878	Mean dependent var	0.146250
Adjusted R-squared	0.509858	S.D. dependent var	0.046885
S.E. of regression	0.032824	Akaike info criterion	-3.782975
Sum squared resid	0.006465	Schwarz criterion	-3.763114
Log likelihood	17.13190	Hannan-Quinn criter.	-3.916925
Durbin-Watson stat	1.116801		

Figure 5.

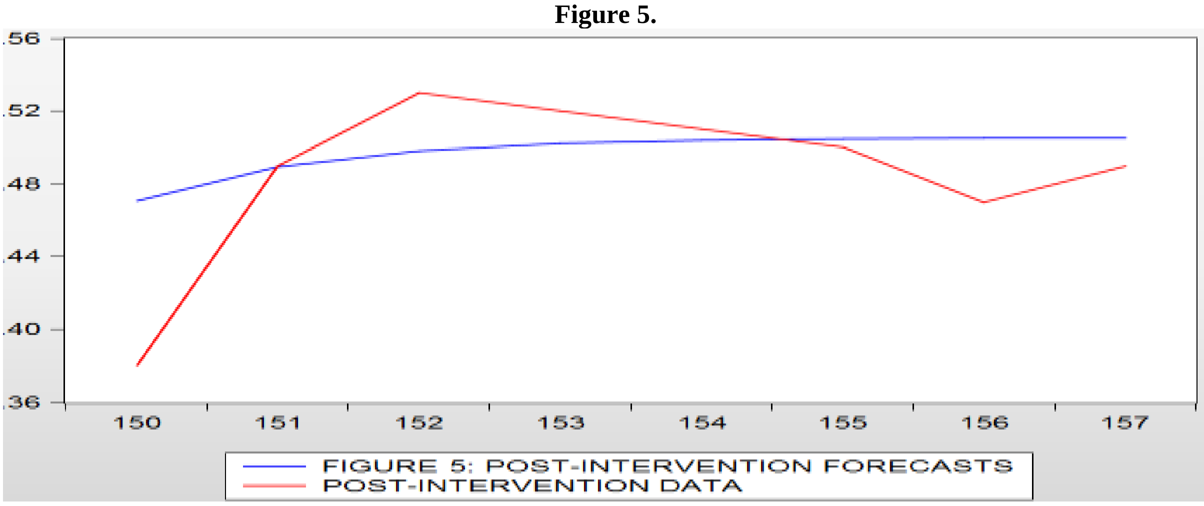
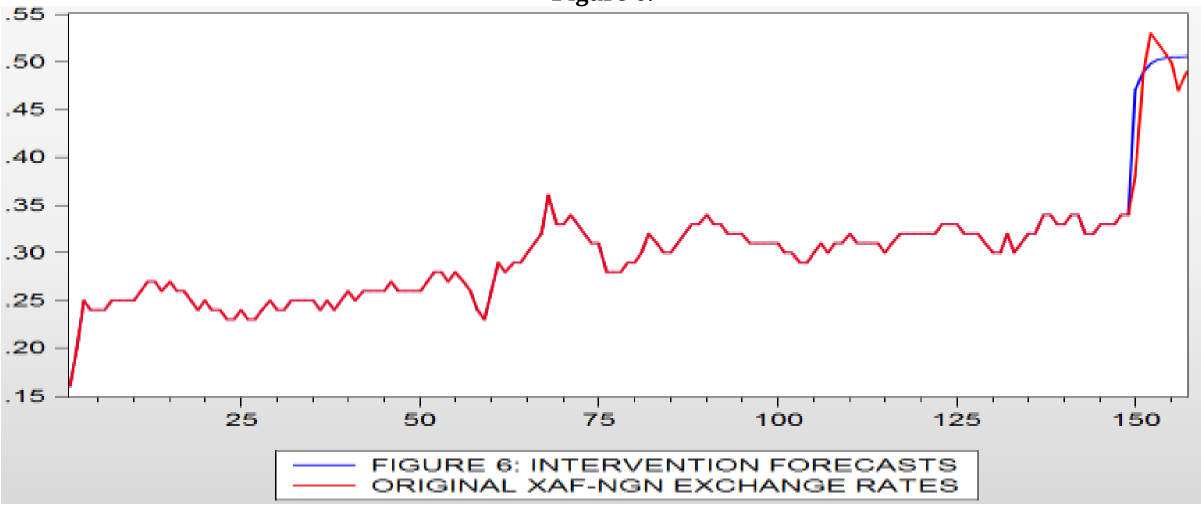


Figure 6.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25
50
75
100
125
150
FIGURE 6: INTERVENTION FORECASTS
ORIGINAL XAF-NGN EXCHANGE RATES