Intervention modeling of Bulgarian Lev/Nigerian Naira exchange Due to 2016 Nigerian Economic Recessions

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DOI: 10.56201/ijasmt.v10.no4.2024.pg49.62

Abstract

This research work examined the exchange rate of a comparative value of the Nigeria Naira with respect to Bulgaria lev and Turkish Lira to the two economic recessions of 2016 from 1 January to 31 December 2016 utilizing Box and Tiao's intervention analysis approach (1975). The Eview 10 package was used to evaluate the data. Time plot of daily exchange rate of Bulgaria Lev/Nigeria Naira shows horizontal trend then a vertical abrupt increase at 21 June 2016which prompted an intervention modeling. The pre-intervention dataset also indicated an upward movement showing that the series is not stationary. At a significance level of less than 5%, the pre-intervention series was shown to be stationary by the Augmented Dickey Fuller unit root test. Plotting the stationarized data's correlogram revealed that ARIMA (15,1,15) was suggestive. The accompanying observations and the intervention forecasts are in close agreement. The intervention impact is therefore noteworthy.

Keywords: *Intervention, Exchange Rates, Economic & Recessions*

1.1 INTRODUCTION

Studies have been conducted on the forecasting of financial and economic variables using a variety of fundamental and technical methodologies, with varying degrees of success. The exchange rate forecasting theory wherein many models yield varying prediction outcomes, either inside or outside of the angels sample (Onasanya and Adenij, 2013). The exchange rate is the cost of converting one currency into another, for example, the Nigerian Naira into the Nigerian Naira into the Bulgarian Lev. An economic time series of daily exchange rates, however, usually reflects known events and policy changes that occurred at a certain point in time. These kinds of foreseeable occurrences are called interventions. The idea of intervention analysis was first introduced by BOX and TIAO (1975) in relation to the impact of passing engine design laws, which are believed to have an impact on the degree of oxidant pollution in the Los Angeles region. One time series method that is frequently used to describe how an intervention from internal or external sources affects a time series that affects the data pattern is intervention analysis (Suhurtono,2007). Scholars and academics have utilized it extensively ever since to ascertain the various levels of intervention needed for a given time series.

Considering the daily exchange rates between the Turkish Lira and the Nigerian Naira, the Bulgarian Lev and the Nigerian Naira from January 1, 2016, to December 31, 2016,; additionally considering the fact that Nigeria went through its first recession in 2016, with the country's economy contracting by 1.6 percent due to shocks from low oil production and low oil prices that permeated the non-oil sector (World Bank, 2017). According to the World Bank (2017), GDP from non-oil sources fell by 0.2 percent, while GDP from oil sources declined by 14.4%. The Nigerian economy declined by 1.8% in 2020, the highest since 1983, less than five years after the recession of 2016 (World Bank, 2021). The economic collapse was mostly caused by the COVID-19 epidemic, while there were other external influences as well, including as capital flight, heightened risk aversion, low oil prices, and a decline in overseas remittances (World Bank, 2021). This is because the value of the Nigerian naira has sharply declined in relation to other national currencies, severely affecting the standard of living. It is presently valued 256.65 naira to 1 Bulgarian Lev and 23.62 naira to 1 Turkish Lira as of May 14, 2023. The depreciation of the Nigerian naira has caused the cost of products and services to increase, as evidenced by recent studies. This is particularly clear in the case of the Naira (N), which had a value of N0.6 to $1 (one US Dollar) in 1981 (CBN, 2022), an average of N102.11 to $1 in 2000 (CBN, 2022), N129.36 to $1 in 2003 (CBN, 2022), N125.83 to $1 in 2007 (CBN, 2022), N122.26 to $1 in 2010 (Exchange Rate UK, 2010), N197.88 to $1 in 2015 (Exchange Rate UK, 2015), N257.66 to $1 in 2016 (Exchange Rate UK, 2016), N380.26 to $1 in 2020 (Exchange Rate UK, 2020), N403.58 to $1 in 2021 (Exchange Rates UK, 2021), N423.72 to $1 in 2022 (Exchange Rate UK, 2022) and is currently trading at N459.21 as at 14th may 2023 (Exchange Rate UK 2023). The naira experienced one of the most challenging times in its more than five-decade history during these years, and the issue persists to this day. This situation presents a grim image of an uncertain future, and its resolution will need quick action (Nweze, 2021).

3.3 MATERIAL AND METHODS

The modeling of the intervention of the Bulgarian Lev/Nigerian Naira exchange rates because of the 2016 and 2020 Nigerian economic recessions is examined in this paper. Daily statistics from January 1, 2016 to December 31, 2016, on the exchange rates for Nigeria, Bulgaria. E-views 10 Statistical software utilized for conducting the investigation. The ARIMA Modeling Method was used.

3.4 Statistical Intervention Analysis

Assume that at time t=T, an intervention occurs in the time series Xt. The series' trend has changed because of this move. Box and Tiao [1] have suggested using an ARIMA model to simulate the pre-intervention series. Consider that this is an ARIMA (p, d, q). That is,

$$A(L)\psi^{\mathbf{d}}X_t = \boldsymbol{\beta}(\boldsymbol{L})\boldsymbol{\varepsilon}_{\boldsymbol{t}} \qquad (1)$$

Where A(L) is the autoregressive (AR) operator defined by

$$A(L) = 1 - \beta_1 L - \beta_1 L^2 \dots \dots \dots . \beta_i L^i. \qquad (2)$$

And B(L) is the moving average (MA) operator defined by

$$\beta(L) = 1 + \psi_1 L + \psi_2 L^2 + \cdots \dots \dots + \psi_i L^i. \qquad (3)$$

Moreover, $\psi = 1 - L$ and $L^k X_t = X_{t-k}$

The sequence {Ɛt} is a white noise process. Based on model (1), forecasts are derived for the post-intervention period.

$$X_t = \frac{\beta(L)\varepsilon_t}{A(L)\psi^d} \qquad (4)$$

Suppose these forecasts are F_t. The difference $Z_t = X_t - F_t$ can be modeled by

$$Z_t = \frac{C(1)*(1-C(2)(t-T+1))}{(1-C(2))} \qquad (5)$$

The final intervention model is given by combining (4) and (5) to have

$$Y_t = \frac{\beta(L)\varepsilon_t}{A(L)\psi^d} + \frac{(L_1(C(1)*c(2)^{(t-T+1)})}{(1-c(2))} \qquad (6)$$

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

RESULTS

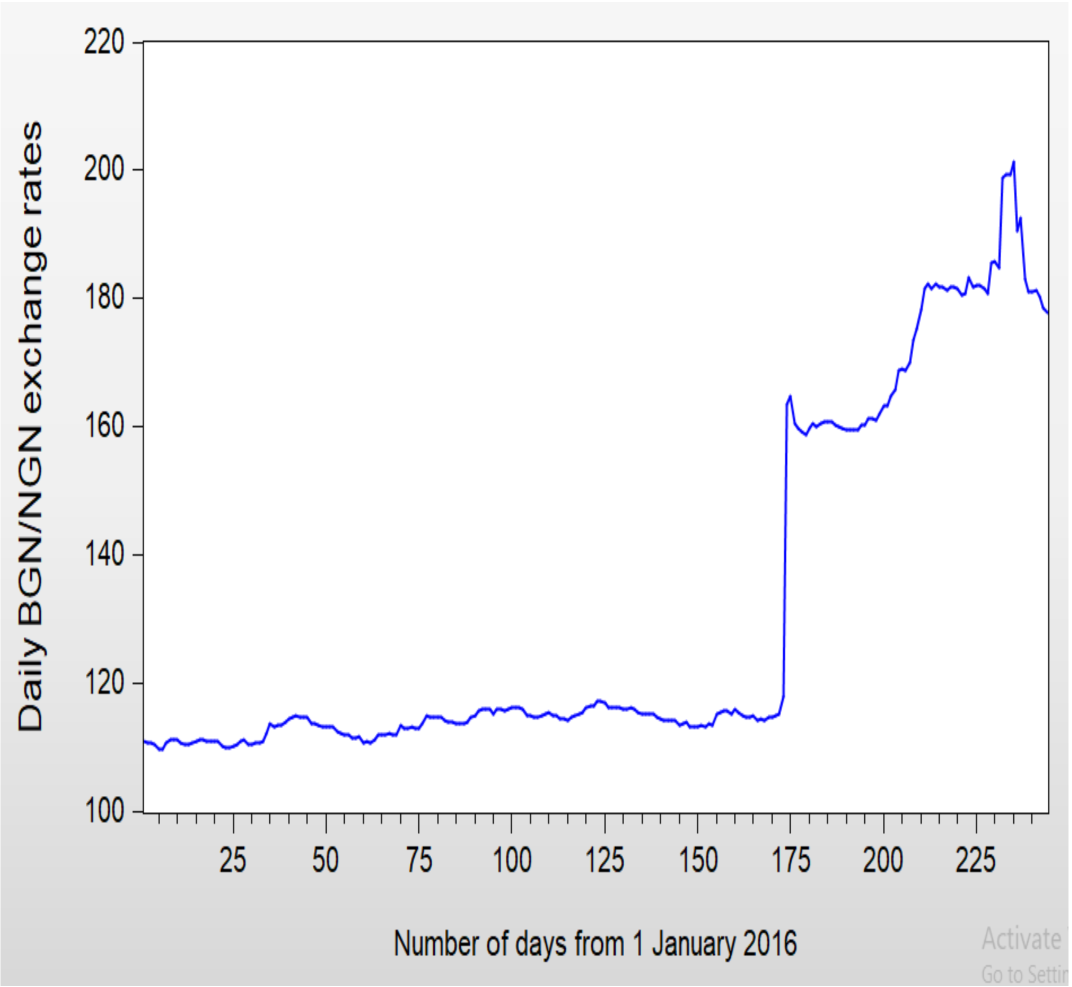

Figure 4.1:Trend Analysis for2016 Daily BGN/NGN Exchange Rates
Source: Authors Drawing by Eviews 10

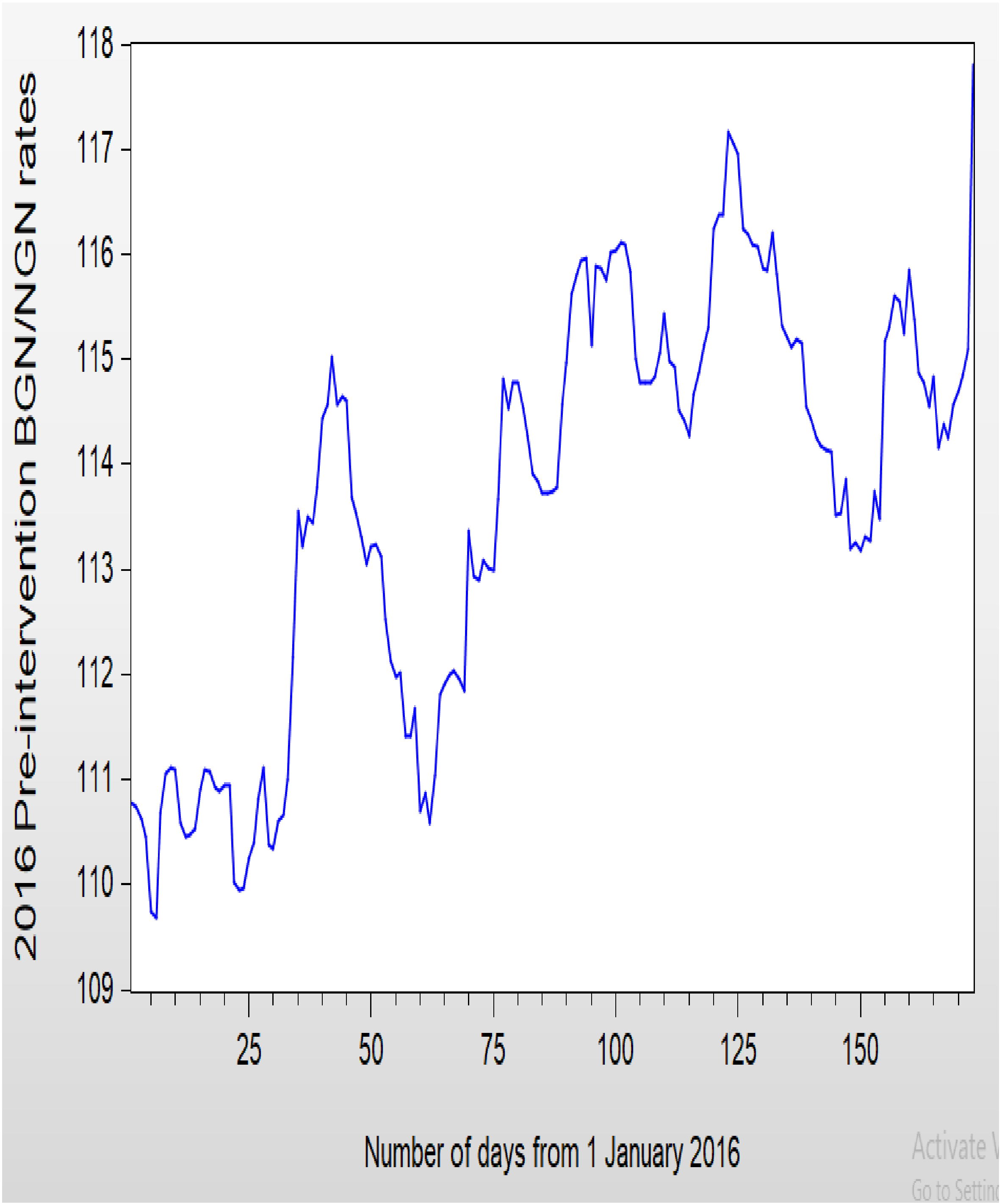

Figure 4.2: 2016 Pre-Intervention BGN/NGN Exchange Rates
Source: Authors Drawing by Eview 10

Table 4.1: ADF Unit Root Test at Level for Pre-Intervention 2016 BGN/NGN Exchange Rates

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.209042	0.4812
Test critical values:	1% level	-4.012296	
	5% level	-3.436163	
	10% level	-3.142175	

*MacKinnon (1996) one-sided p-values.
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BGN/NGN)
Method: Least Squares
Date: 11/15/23 Time: 07:07
Sample (adjusted): 1/02/2016 6/21/2016
Included observations: 170 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BGNNGN(-1)	-0.060573	0.027421	-2.209042	0.0285
C	6.746117	3.047001	2.214018	0.0282
@TREND("1/01/2016")	0.002030	0.001068	1.900755	0.0590

R-squared	0.028899	Mean dependent var	0.040878
Adjusted R-squared	0.017406	S.D. dependent var	0.469164
S.E. of regression	0.465063	Akaike info criterion	1.323999
Sum squared resid	36.55189	Schwarz criterion	1.378897
Log likelihood	-110.8639	Hannan-Quinn criter.	1.346273
F-statistic	2.514609	Durbin-Watson stat	1.610402
Prob(F-statistic)	0.083918		

Source: Authors use of Eviews 10

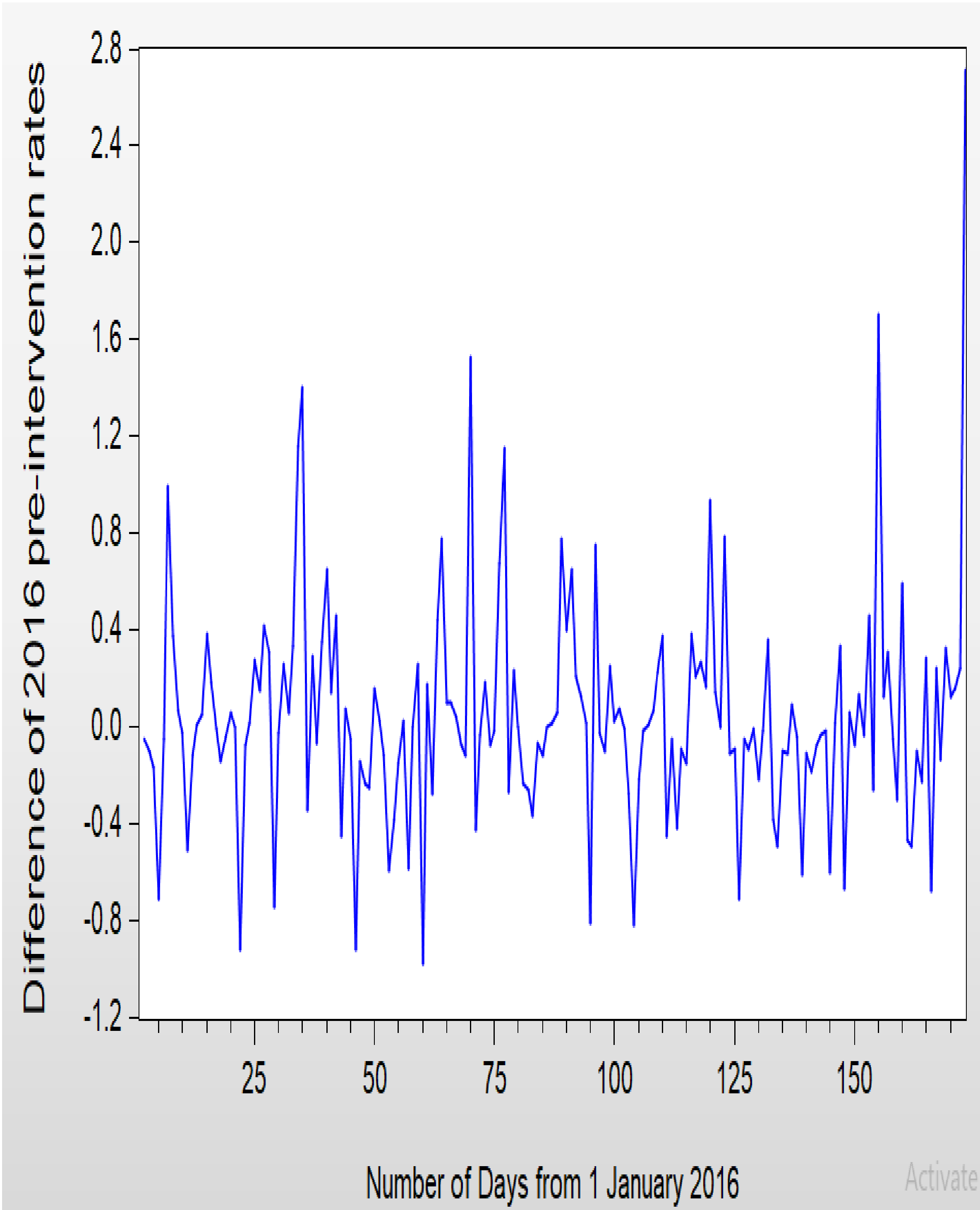

Figure 4.3:Difference of 2016 Pre-Intervention Rates
Source: Authors Drawing by Eview 10

Table 4.2: ADF Unit Root Test at First Difference for Pre-Intervention 2016 BGN/NGN Exchange Rates

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.52991	0.0000
Test critical values:	1% level	-4.012618	
	5% level	-3.436318	
	10% level	-3.142266	

*MacKinnon (1996) one-sided p-values.
Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BGN/NGN,2)
Method: Least Squares
Date: 11/15/23 Time: 07:47
Sample (adjusted): 1/03/2016 6/21/2016
Included observations: 168 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BGNNGN(-1))	-0.899689	0.085441	-10.52991	0.0000
C	0.013654	0.073134	0.186703	0.8521
@TREND("1/01/2016")	0.000290	0.000730	0.396803	0.6920

R-squared	0.398741	Mean dependent var	0.016163
Adjusted R-squared	0.391583	S.D. dependent var	0.604062
S.E. of regression	0.471175	Akaike info criterion	1.350214
Sum squared resid	37.29699	Schwarz criterion	1.405331
Log likelihood	-112.4433	Hannan-Quinn criter.	1.372578
F-statistic	55.70692	Durbin-Watson stat	1.831890
Prob(F-statistic)	0.000000		

Source: Authors use of Eview 10

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.080	0.080	1.1263	0.289
		2	0.090	0.084	2.5388	0.281
		3	0.054	0.042	3.0608	0.382
		4	-0.037	-0.052	3.3023	0.509
		5	-0.013	-0.015	3.3344	0.649
		6	-0.033	-0.026	3.5286	0.740
		7	0.043	0.055	3.8570	0.796
		8	-0.016	-0.019	3.9038	0.866
		9	0.012	0.008	3.9282	0.916
		10	-0.076	-0.084	4.9903	0.892
		11	-0.097	-0.084	6.7417	0.820
		12	-0.072	-0.049	7.7012	0.808
		13	-0.042	-0.007	8.0368	0.841
		14	0.014	0.029	8.0755	0.885
		15	-0.112	-0.117	10.486	0.788
		16	-0.073	-0.078	11.503	0.777
		17	-0.039	-0.018	11.804	0.812
		18	0.049	0.086	12.278	0.833
		19	-0.046	-0.049	12.696	0.854
		20	0.004	-0.012	12.700	0.890
		21	-0.033	-0.066	12.911	0.912
		22	-0.072	-0.070	13.939	0.904
		23	-0.030	-0.029	14.123	0.923
		24	0.039	0.071	14.431	0.936
		25	-0.112	-0.142	16.963	0.883
		26	0.079	0.060	18.241	0.867
		27	0.011	-0.035	18.264	0.895
		28	-0.020	-0.022	18.346	0.917
		29	-0.041	-0.052	18.698	0.929
		30	0.010	0.025	18.720	0.946
		31	0.007	-0.029	18.731	0.959
		32	0.053	0.040	19.324	0.962
		33	0.062	0.027	20.139	0.962
		34	-0.147	-0.185	24.835	0.874
		35	0.128	0.138	28.401	0.777

Figure 4.4: Correlogram of the Pre-Intervention Series
Source: Authors Drawing by Eview 10

Table 4.3: Estimation of the Arima (15,1,15) Model Fitted to Pre-Intervention Data

Dependent Variable: D(BGNNGN)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 01/10/24 Time: 10:46
Sample: 1/02/2016 6/21/2016
Included observations: 170
Convergence achieved after 204 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(15)	0.718456	0.301424	2.383543	0.0183
AR(16)	-0.134982	0.197327	-0.684055	0.4949
AR(17)	-0.001122	0.373731	-0.003003	0.9976
MA(15)	-0.855287	0.296944	-2.880299	0.0045
MA(16)	0.118176	0.158418	0.745979	0.4568
MA(17)	-0.010778	0.307169	-0.035090	0.9721
SIGMASQ	0.210259	0.025879	8.124763	0.0000

R-squared	0.035041	Mean dependent var	0.040581
Adjusted R-squared	-0.000479	S.D. dependent var	0.468170
S.E. of regression	0.468282	Akaike info criterion	1.378162
Sum squared resid	35.74397	Schwarz criterion	1.507283
Log likelihood	-110.1438	Hannan-Quinn criter.	1.430558
Durbin-Watson stat	1.617207		

Inverted AR Roots	.96	.88-.40i	.88+.40i	.64+.73i
	.64-.73i	.29+.93i	.29-.93i	.20
	-.01	-.11+.97i	-.11-.97i	-.50+.85i
	-.50-.85i	-.80+.58i	-.80-.58i	-.97+.20i
	-.97-.20i			
Inverted MA Roots	.98	.90+.40i	.90-.40i	.65-.74i
	.65+.74i	.30+.94i	.30-.94i	.07+.09i
	.07-.09i	-.11+.98i	-.11-.98i	-.50-.86i
	-.50+.86i	-.81+.58i	-.81-.58i	-.98+.21i
	-.98-.21i			

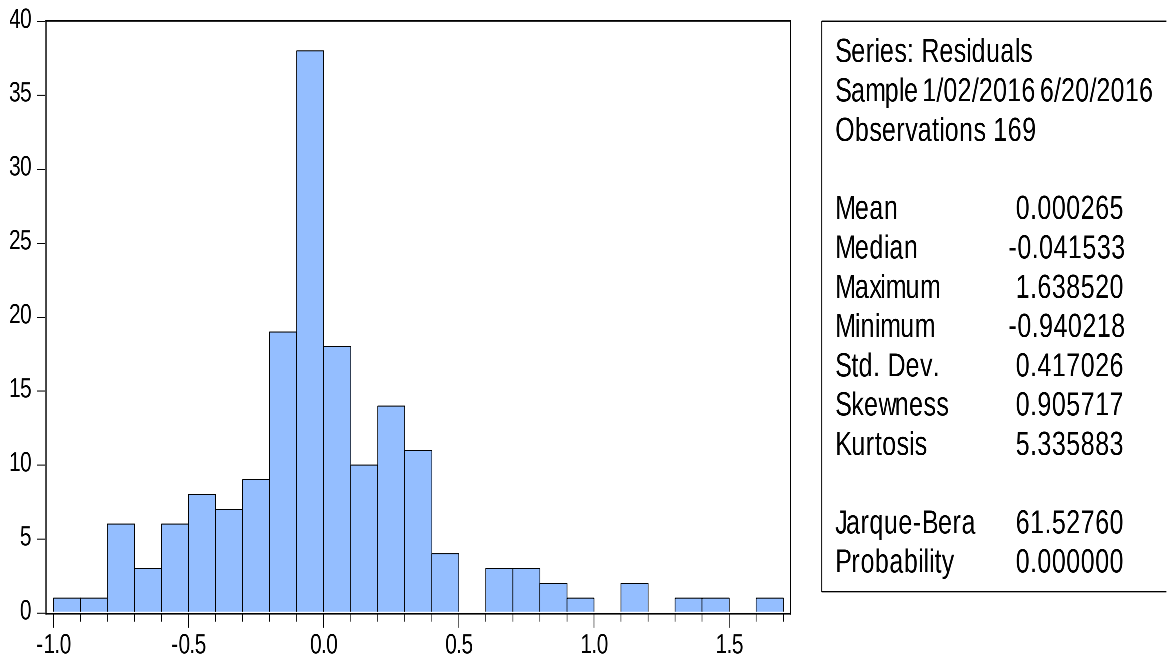

Figure 4.5: Histogram of the Residuals of the ARIMA (15, 1, 15) Model of Pre-Intervention Data

Source: Authors Drawing by Eviews 10

Table 4.4: Intervention Transfer Function Modelling

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 11/14/23 Time: 12:06
Sample 174 244
Included observation:71
Convergence achieved after 44 iterations
Coefficient covariance computed using outer product of gradients
Z=C(1)*(1-C(2)^(T-173))/(1-(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	5.074199	0.593368	8.551517	0.0000
C(2)	0.920961	0.010931	84.25012	0.0000

R-squared	0.104434	Mean dependent var	55.51356
Adjusted R-squared	0.091454	S.D. dependent var	12.11607
S.E. of regression	11.54875	Akaike info criterion	7.758797
Sum squared resid	9202.786	Schwarz criterion	7.822534
Log likelihood	-273.4373	Hannan-Quinn criter.	7.784143
F-statistic	3.181222	Durbin-Watson stat	0.075369
Prob(F-statistic)	0.000000		

Source: Authors use of Eviews 10

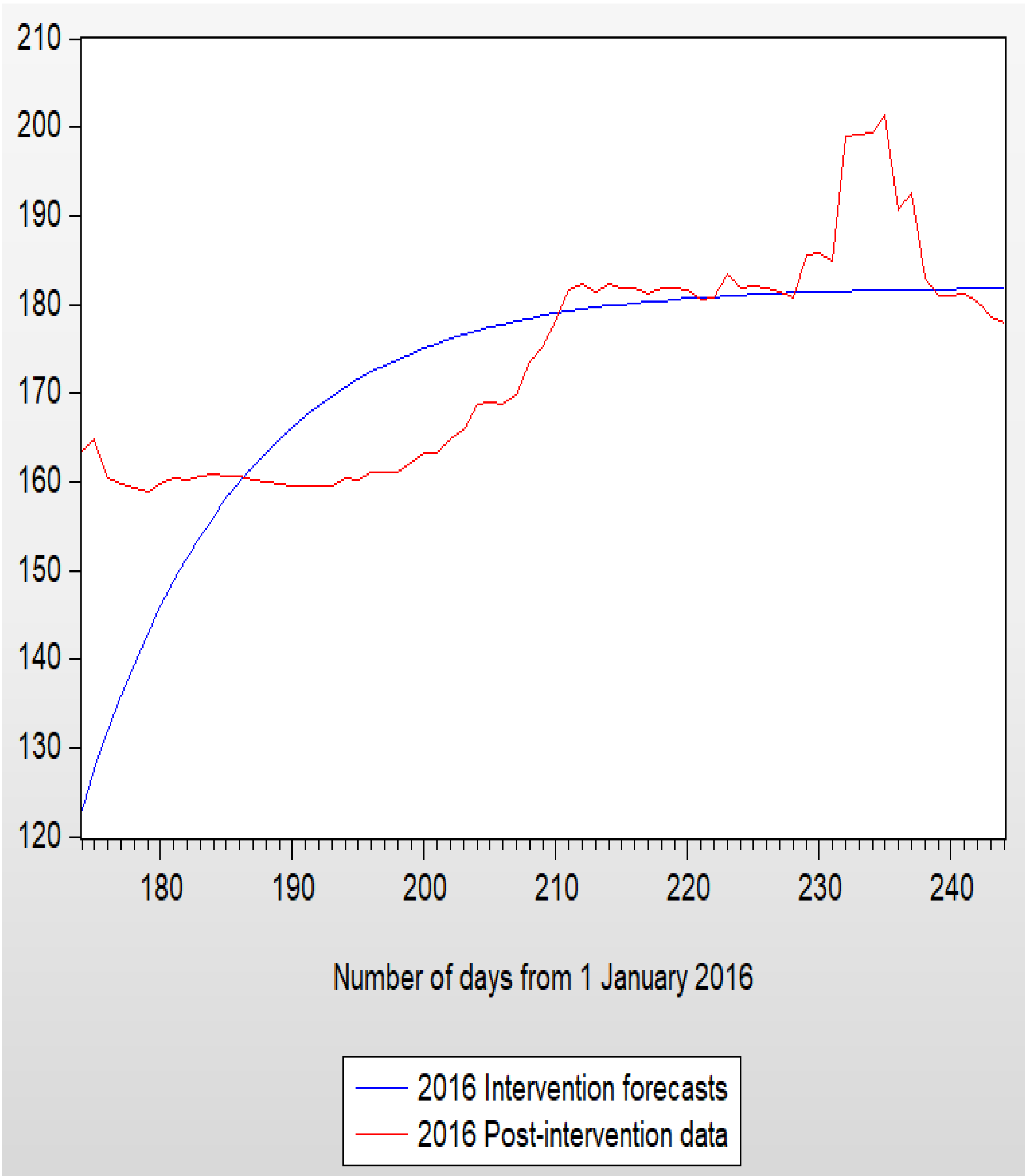

Figure 4.6: **Comparison between Post-Intervention Data and Intervention Forecast**
Source: Authors Drawing by Eviews 10

Figure 4.1 depicts the time plot of the whole series, which begins on January 1 and ends on June 21 with a largely horizontal trend. Following then, there was an abrupt vertical surge known as Intervention Point T, T = 174, which happened right away. The time plot of the 2016 BGN/NGN exchange rates prior to intervention is displayed in Figure 4.2. It appears that the time plot is moving in an upward trend. Figure 4.3 shows the difference of 2016 pre-intervention rates
Table 4.2 shows the ADF Unit Root Test at First Difference for Pre-Intervention 2016 BGN/NGN Exchange Rates. The Unit Root test results for the Pre-Intervention Series utilizing the Augmented Dickey Fuller test (ADF) are shown in Table 4.1. With a statistic value of -2.21, higher than the crucial values of 1%, 5%, and 10% of -4.01, -3.44, and -3.14, respectively, this Pre-Intervention Series is determined to be non-stationary with probability values of 0.4812. However, the series was first modified to be stationary by differencing, as seen in Figure 4.3. Its stationary qualities were validated in Table 4.2 with an ADF statistic value of -10.53 and a probability value of 0.0000.
The correlogram structure of the Pre-Intervention series is displayed by plotting the autocorrelation function and partial autocorrelation function against the lag duration in any analysis that seeks to construct or establish a model, as in this work (Figure 4.4). Usually, these graphs are used as a reference when choosing the model to fit. It also shows that the relevance isn't increasing. For the fluctuations in the pre-intervention dataset, this supports the white noise model hypothesis. Good exponential decay and a damped sine wave pattern are displayed by both functions. Due to the Correlogram functions showing the same pattern at lags of 15, 25, and 34, respectively, it is an ARIMA process. Consequently, three models are identified: ARIMA (15,1,15), ARIMA(15,1,25). Based on AIC, the ARIMA (15, 1, 25) is determined to be the most appropriate and fitted difference. Figure 4.5 shows the residual of the ARIMA (15, 1, 25) that is normally distributed at the 5% level.

For the Pre-Intervention Series, Table 4.3 displays an ARIMA (15,1,25). The model is Autocorrelation Integrated or Differencing Moving Average, as stated by this.

$$X_t = X_{t-1} + X_{t-15} - X_{t-15} = \varepsilon_{t-2} + \varepsilon_t \qquad (4.1)$$

Table 4.4 displays the modeling of the Intervention Transfer function. As demonstrated below, this is utilized to model the Pre-Intervention and Post-Intervention Series:

$$Z_t = \frac{5.0742(1-0.9210)^{(t+1)}}{(1-0.9210),} \qquad (4.2)$$

t >174
It is notable that the coefficients c(1) and c(2) have statistical significance. It serves as a gauge for the whole intervention's importance. Figure 4.6 compares the post-intervention data with the intervention predicted data. This demonstrates that the pre-intervention data and the post-intervention forecast have a strong correlation. Figure 4.6 for the 2016 Daily BGN/NGN Exchange rate intervention model shows that the intervention forecast and post-intervention data are closely aligned. Therefore, Giving the ARIMA(15,1,15) model with $\Delta Xt = 0.178456x_{t-15} - 0.134x_{t-16} - 0.0011x_{t-17} - 0.8553\varepsilon_{t-15} + 0.1182\varepsilon_{t,}$ its predictions, post-intervention observation, and adequacy plot.

6.1 Conclusion

In conclusion, the analysis of the BGN/NGN exchange rates reveals distinct trends before and after the intervention point (T = 174). Prior to the intervention, the exchange rates exhibited a non-stationary upward trend, confirmed by the ADF unit root test results. Following the intervention, a significant vertical surge occurred, leading to a relatively flat trend with no signs of recovery. The successful differencing of the pre-intervention series established its stationarity, enabling the identification of an ARIMA (15, 1, 25) model as the best fit based on AIC criteria. The residuals of this model were found to be normally distributed, indicating a robust model for capturing the dynamics of the exchange rates during the specified period. Overall, these findings contribute valuable insights into the behavior of the BGN/NGN exchange rates, underscoring the impact of interventions on financial metrics.

6.2 RECOMMENDATION

The following recommendations are given based on the full realization of the study.

1. It is essential to implement a robust monitoring system for exchange rates following significant interventions. This will help identify emerging trends and fluctuations in real-time, allowing for timely adjustments in policies or strategies to stabilize the currency.
2. Future studies should explore the underlying factors contributing to the observed trends in exchange rates, especially surrounding intervention points. Understanding these dynamics can provide insights into the causal relationships and inform more effective intervention strategies.
3. While the ARIMA (15, 1, 25) model proved effective, ongoing validation and refinement of this model are necessary. Incorporating additional variables, such as economic indicators or geopolitical events, may enhance the model's predictive capabilities and provide a more comprehensive understanding of exchange rate behavior.

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