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Modelling intervention of Columbian peso to Nigerian naira exchange rates due to 2016 & 2020 Nigerian economic recessions

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Abstract
The modelling and forecasting of exchange rates yield valuable outcomes that contribute to informed financial decision-making. This study aims to analyze the impact of the intervention of the Columbian PESO on the exchange rates of the Nigerian Naira during the economic recessions of 2016 and 2020. By examining the fluctuations in the exchange rate, this research seeks to gain a deeper understanding of the bilateral commercial relationship between the two nations. The data pertaining to the daily exchange rates between the Nigerian Naira and the Columbian Peso for the periods spanning from 1 January to 31 August 2016 and from 1 September to 31 December 2020, were obtained from the official websites of the Central Bank of Nigeria. Based on the acquired results, it was noted that the exchange rates of COP/NGN together with their pre-intervention series, exhibited a linear trend, indicating their non-stationary nature. The exchange rates attained stationarity through the process of differencing of order one, and the fitted intervention model was deemed appropriate.

Keywords: Modelling, intervention, Columbian peso, Nigerian naira

Introduction

Nigeria is primarily dependent on revenue generated from oil exports, rendering it susceptible to the fluctuations and instability inherent in the global oil market. The year 2016 was characterised by a notable economic downturn in Nigeria, primarily due to a substantial decrease in oil prices. This reduction in oil prices resulted in considerable budgetary difficulties and a contraction of the economy. The regulation of exchange rates emerged as a crucial element in these actions. Foreign exchange rate policies play a crucial role in countries such as Nigeria, as they exert influence over the competitiveness of the nation's exports and imports, exert an impact on inflation rates, and has the potential to affect the general economic stability. In periods of economic turmoil, central banks frequently employ interventions in the foreign exchange market as a means to regulate the valuation of their currency.

The decision to prioritise the Colombian Pesos as currency of importance in this analysis is presumably motivated by their significance as trading partners with Nigeria. Colombia possesses substantial economic connections with Nigeria, characterised by the exchange and influx of trade and investment. An examination of the impact of interventions in the exchange rates of various currencies on the Nigerian Naira can provide insights into the efficacy of such policies in times of economic downturns. Similarly, the analysis is grounded in the backdrop of Nigeria's susceptibility to external shocks in its economy, specifically the variations in oil prices, and the difficulties presented by the collapse in oil prices in 2016. Thus, this work focused on examining the fluctuation in the relative worth of the Nigerian Naira in relation to the Columbian Peso (COP) during the economic downturn of 2016.

In past study, Mosugu and Anieting (2016) [9] employed intervention analysis as a methodological framework to evaluate the effects of governmental regime and policy alterations on foreign currency rates within the Nigerian context. Shittu (2009) [13] utilised intervention analysis as a methodological approach to examine the monthly variations in exchange rates between the Naira and the US Dollar within the time frame of 1970 to 2004.

The researcher successfully identified various intervention components during the course of their investigation.

In recent work on intervention, Inyang *et al* (2023) [6] worked on Time Series Intervention Modelling Based on ESM and ARIMA Models: Daily Pakistan Rupee/Nigerian Naira Exchange Rate. Etuk *et al* (2022) [3], investigated the impact of declaration of cooperation (DoC) on the Nigerian crude oil production.

Moffat and Inyang (2022) [8], investigated the impact of the Nigerian government amnesty programme (GAP) on her crude oil production. Etuk *et al* (2021) [4] used Arima-intervention Analysis in modelling Nigerian Automotive Gas Oil Distribution. Etuk and Amadi (2021) [5] modelled Nigerian Monthly Crude Oil Prices using Arima-intervention model. Shittu and Inyang (2019) [12] modelled Nigerian monthly crude oil prices using the ARIMA-Intervention model with a view to comparing the result with that of the intervention model using lag operator. Wiri and Tuaneh (2019) [14] modelled the Nigerian Crude Oil Prices Using ARIMA, Pre-intervention and Post-intervention Model. Mrinmoy *et al* (2014) [10] used time series Intervention Modelling for Modelling and Forecasting Cotton Yield in India. Jarrett and Kyper (2011) [7], used ARIMA Modelling with Intervention to Forecast and Analysed Chinese Stock Prices. Roy *et al* (2009) [11] used ARIMA – Intervention Analysis in Modelling the Financial Crisis in China's Manufacturing Industry.

Model Specification

The transfer function-noise model proposed by Box and Tiao (1975) [2] is given as

$$Z_t = c + \frac{\omega_s(B)}{\delta_r(B)} B^b X_t + N_t \qquad (1)$$

$$N_t = \frac{\theta(B)}{\emptyset(B)} a_t \qquad (2)$$

$$\omega_s(B) = \omega_0 + \omega_1(B) + \omega_1 B^2 + \cdots + \omega_s B^s \qquad (3)$$

$$\delta_r(B) = 1 + \delta_1(B) + \delta_2 B^2 + \cdots + \delta_s B^s \qquad (4)$$

$$\theta(B) = (1 - \theta_1 B - \theta_2 B^2 - \cdots - \theta_1 B^q) \qquad (5)$$

$$\emptyset(B) = (1 - \emptyset_1 B - \emptyset_2 B^2 - \cdots - \emptyset_1 B^p) \qquad (6)$$

Where,

Z_t is the response variable at t, b =delay parameter, ω_s=impact parameter, δ_r=slope parameter, $\emptyset$ =Non-seasonal autoregressive parameter, θ =Non-seasonal moving average parameter, a_t =White noise, X_t= Input function or Indicator variable

Mathematically, there exist two input functions:

$$X_t^{(t_0)} = \begin{cases} 0 \; if t \neq t_0 \\ 1 \; if t = t_0 \end{cases} \text{ (Pulse Function)}$$

$$X_t^{(t_0)} = \begin{cases} 0 \; if t < t_0 \\ 1 \; if t \geq t_0 \end{cases} \text{ (Step Function)}$$

Data Description

The dataset comprises daily exchange rates between the Nigerian Naira and the Columbian Peso, as well as the Mexican Peso, for the periods of January 1st to August 31st in 2016, and September 1st to December 31st in 2020. The exchange rates were obtained from the websites http://www.exchangerates.org.uk/COP-NGN-spot-exchange-rates-history-2016.html and http://www.exchangerates.org.uk/COP-NGN-spot-exchange-rates-history-2020.html.

The research was conducted with EViews statistical software packages.

Results and Discussions

Analysis of the 2016 Columbian Peso to Nigerian Naira Exchange Rate

The data used for the analysis covers the period from January 1st to August 31st, 2016.

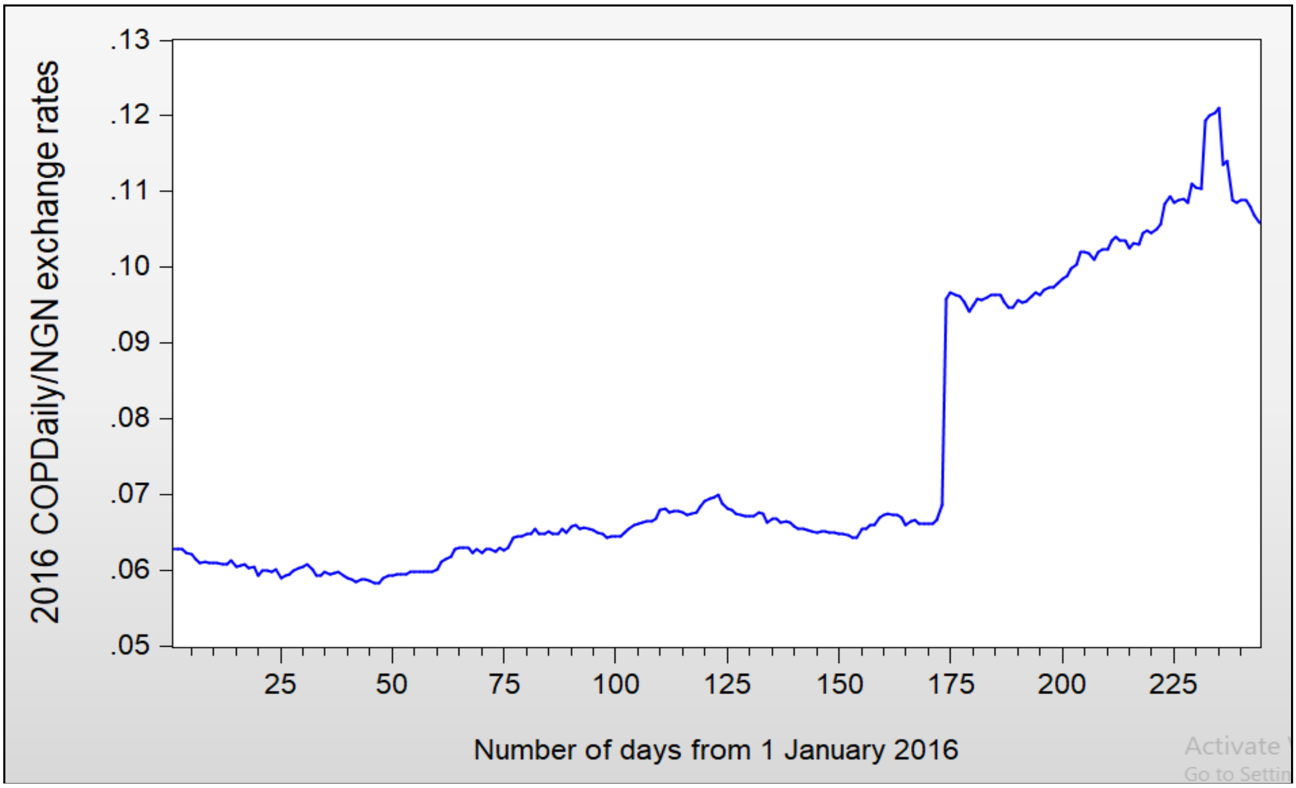

Fig 1: Time Plot of COP/NGN Exchange Rate for 2016

Figure 1 displays the temporal representation of the 244 daily exchange rates between the Columbian Peso (COP) and the Nigerian Naira (NGN) recorded throughout the year 2016.

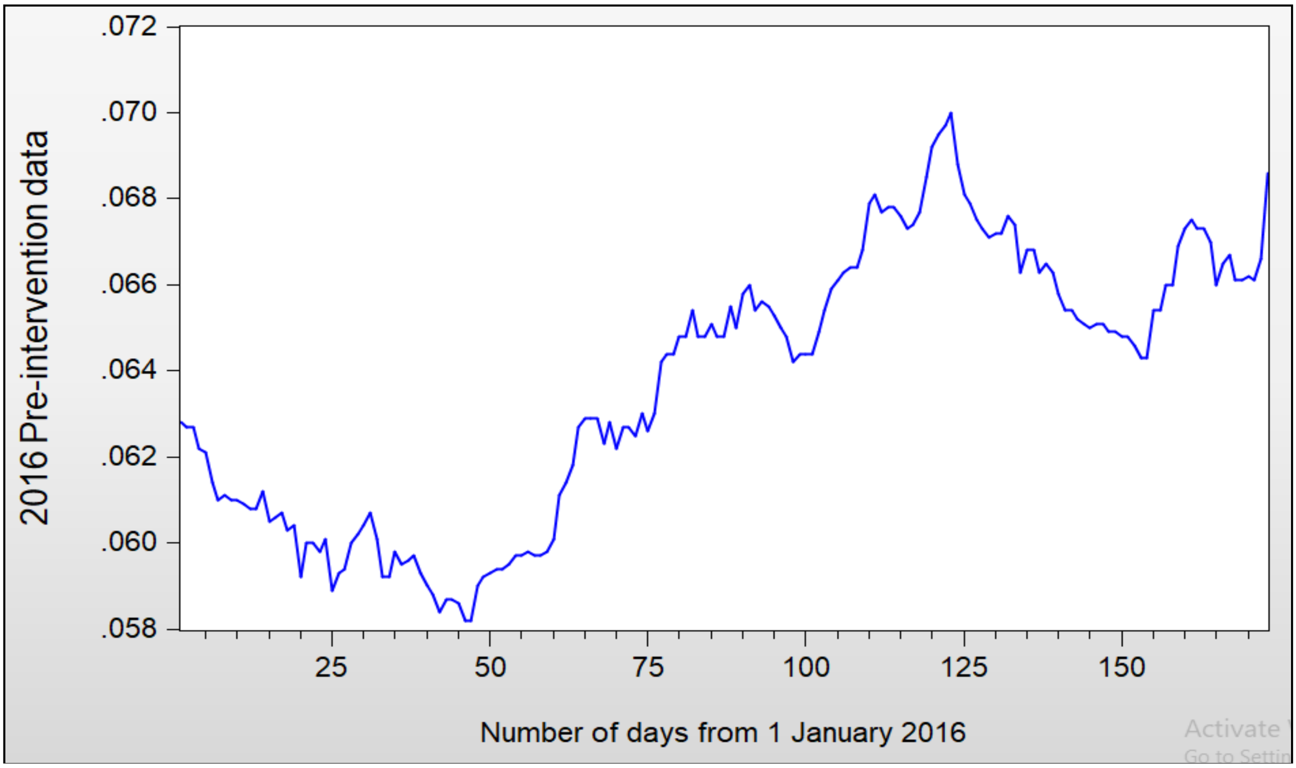

Fig 2: Time Plot of Pre-intervention of COP/NGN Exchange Rate for 2016

Conversely, Figure 2 illustrates the time plot of the 173 daily exchange rates observed during the pre-intervention period, spanning from January 1st, 2016 to June 21st, 2016.

Table 1: Unit Root Test for2016 Pre-intervention Period Daily COP/NGN Exchange Rate

Null Hypothesis: COPN 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		-2.223595	0.4731
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(COPN)
Method: Least Squares
Date: 03/17/22 Time: 00:52
Sample (adjusted): 2 173
Included observations: 172 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COPN(-1)	-0.042138	0.018950	-2.223595	0.0275
C	0.002461	0.001125	2.187317	0.0301
@TREND("1")	2.97E-06	1.19E-06	2.488645	0.0138

R-squared	0.035978	Mean dependent var	3.37E-05
Adjusted R-squared	0.024570	S.D. dependent var	0.000456
S.E. of regression	0.000450	Akaike info criterion	-12.55610
Sum squared resid	3.43E-05	Schwarz criterion	-12.50120
Log likelihood	1082.825	Hannan-Quinn criter.	-12.53383
F-statistic	3.153619	Durbin-Watson stat	1.757525
Prob(F-statistic)	0.045221		

The result in Table 1 favored the null hypothesis that the pre-intervention series has a unit root (i.e. that the pre-intervention series is non-stationary) since the probability value of 0.4731 is greater than 0.05.

Since the pre-intervention series is non-stationary the series was differenced and the time plot of the order 1 differenced pre-intervention series is given in Figure 3.

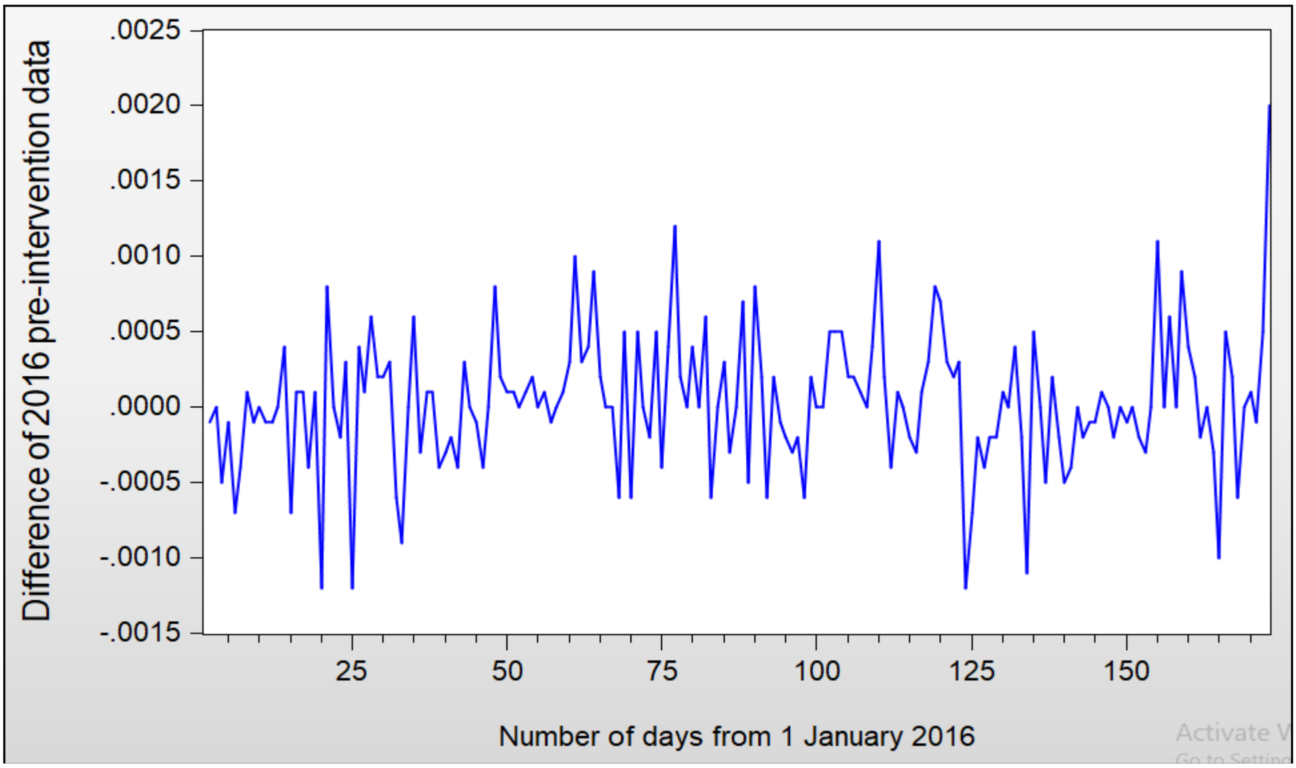

Fig 3: Differenced of Pre-intervention of COP/NGN Exchange Rate for 2016

Table 2: Unit Root Test for the 2016 Differenced Pre-intervention Period Daily COP/NGN Exchange Rate

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

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.41432	0.0000
Test critical values:	1% level	-3.468749	
	5% level	-2.878311	
	10% level	-2.575791	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DCOPN)
Method: Least Squares
Date: 03/17/22 Time: 01:00
Sample (adjusted): 3 173
Included observations: 171 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCOPN(-1)	-0.928010	0.081302	-11.41432	0.0000
C	3.29E-05	3.50E-05	0.939355	0.3489

R-squared	0.435324	Mean dependent var	1.23E-05
Adjusted R-squared	0.431983	S.D. dependent var	0.000607
S.E. of regression	0.000457	Akaike info criterion	-12.53026
Sum squared resid	3.54E-05	Schwarz criterion	-12.49351
Log likelihood	1073.337	Hannan-Quinn criter.	-12.51535
F-statistic	130.2868	Durbin-Watson stat	1.903758
Prob(F-statistic)	0.000000		

From Table 2 the probability value of 0.000 implies that the pre-intervention series becomes stationary after differencing.

Again, the correlogram of the differenced pre-intervention series given in Table 3 indicates a white noise fit for the series.

Table 3: The Correlogram of the Differenced 2016 Pre-intervention COP/NGN Exchange Rate

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.064	0.064	0.7185	0.397
		2	0.065	0.061	1.4640	0.481
		3	0.157	0.151	5.8466	0.119
		4	-0.102	-0.127	7.6938	0.103
		5	0.002	-0.002	7.6944	0.174
		6	-0.073	-0.088	8.6658	0.193
		7	-0.019	0.030	8.7283	0.273
		8	-0.036	-0.043	8.9641	0.345
		9	-0.007	0.027	8.9720	0.440
		10	0.004	-0.014	8.9750	0.534
		11	0.014	0.030	9.0101	0.621
		12	0.013	-0.009	9.0414	0.699
		13	0.196	0.211	16.278	0.234
		14	0.076	0.035	17.386	0.236
		15	-0.069	-0.097	18.284	0.248
		16	0.133	0.074	21.700	0.153
		17	0.054	0.089	22.262	0.175
		18	-0.007	0.009	22.271	0.220
		19	0.018	-0.015	22.334	0.268
		20	-0.097	-0.101	24.197	0.234
		21	-0.052	-0.030	24.733	0.259
		22	-0.072	-0.046	25.771	0.262
		23	-0.099	-0.058	27.746	0.226
		24	-0.024	-0.012	27.859	0.266
		25	-0.048	-0.035	28.329	0.293
		26	0.094	0.070	30.159	0.261
		27	0.043	0.006	30.540	0.290
		28	0.034	0.058	30.779	0.327
		29	0.069	-0.014	31.764	0.330
		30	-0.055	-0.112	32.402	0.349
		31	-0.077	-0.092	33.658	0.340
		32	-0.040	-0.001	33.997	0.372
		33	-0.050	0.013	34.543	0.394
		34	-0.028	0.020	34.714	0.434
		35	-0.052	-0.064	35.310	0.454

Table 3 shows that the fitted model is a white noise model since $F_1 = 0.0686$

Having established the stationarity of pre-intervention series and a white noise fit for series the transfer function for the intervention model for the 2016 COP/NGN exchange rate series was obtained as shown in Table 4.

Table 4: The Determination of the Transfer Function of the 2016 COP/NGN Exchange Rate Intervention Model

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 03/17/22 Time: 02:33
Sample: 174 244
Included observations: 71
Convergence achieved after 46 iterations
Coefficient covariance computed using outer product of gradients
Z=C(1)*(1-C(2)^(T-173))/(1-C(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.020885	0.004963	4.207889	0.0001
C(2)	0.395998	0.145569	2.720341	0.0082

R-squared	0.027516	Mean dependent var	0.034285
Adjusted R-squared	0.013422	S.D. dependent var	0.006914
S.E. of regression	0.006868	Akaike info criterion	-7.096251
Sum squared resid	0.003254	Schwarz criterion	-7.032513
Log likelihood	253.9169	Hannan-Quinn criter.	-7.070904
Durbin-Watson stat	0.086605		

The intervention model Z given in Table 4 where C(1) and C(2) are the coefficients and T is time after the series started, was used to make an intervention forecast of the 2016 post-intervention COP/NGN exchange rate and the graph of the superimposition of the forecast to the observed data is given in Figure 4.

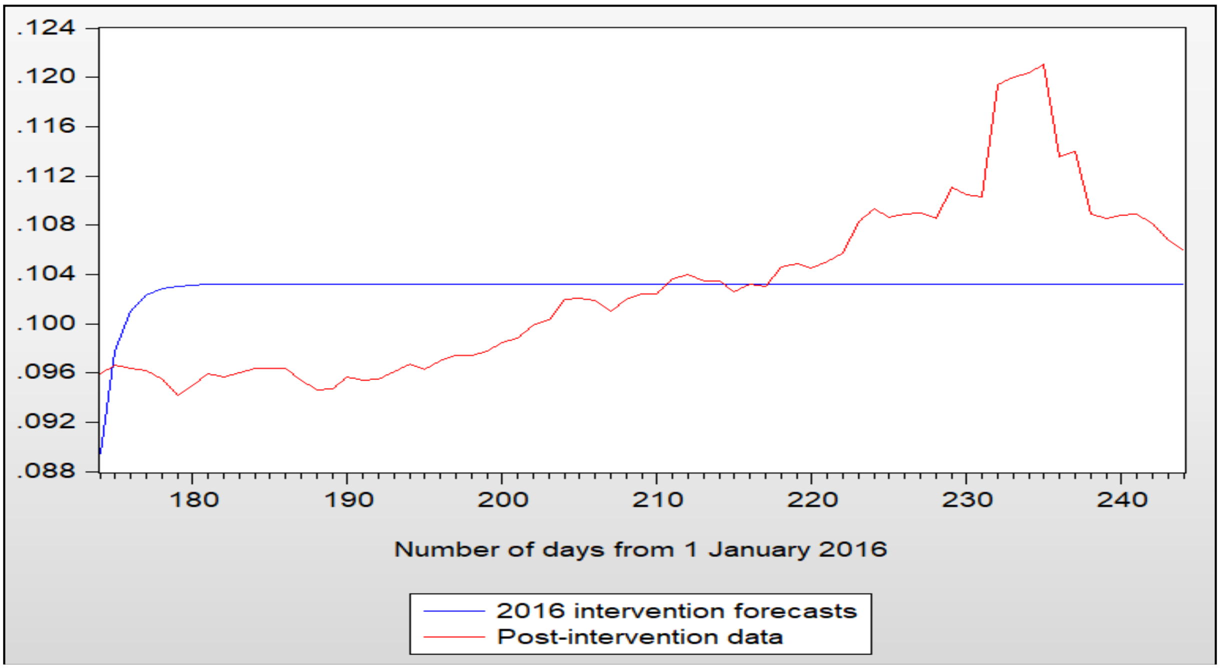

Fig 4: Superimposition of the Intervention Forecast of 2016 COP/NGN Exchange Rate on the Observed Exchange Rate

The original post-intervention COP/NGN exchange rate (COPN), the corresponding intervention forecast (EXPTD) with their Chi-square values given as,

$$\chi^2 = \sum \frac{(COPN - EXPTD)^2}{EXPTD} = 0.039123$$

The null hypothesis, H_0: COPN (post intervention data) and INFL (intervention forecast) agree (there is no significant change in the mean of the COP/NGN process from pre-intervention series to the post-intervention series in 2016) is not rejected since $\chi^2 = 0.039123 < \chi^2_{0.05,71-1} = 90.531$.

Analysis of the 2020 Columbian Peso to Nigerian Naira Exchange Rate

The data used for the analysis covers the period from September 1st to December 31st, 2020.

Figure 5 depicts a time plot illustrating the daily exchange rates between the Columbian Peso (COP) and the Nigerian Naira (NGN) from September 1st to December 31st, 2020. On the other hand, Figure 6 presents a time plot showcasing the daily COP/NGN exchange rates specifically within the pre-intervention period of September 1st to November 19th, 2020, consisting of 80 recorded rates.

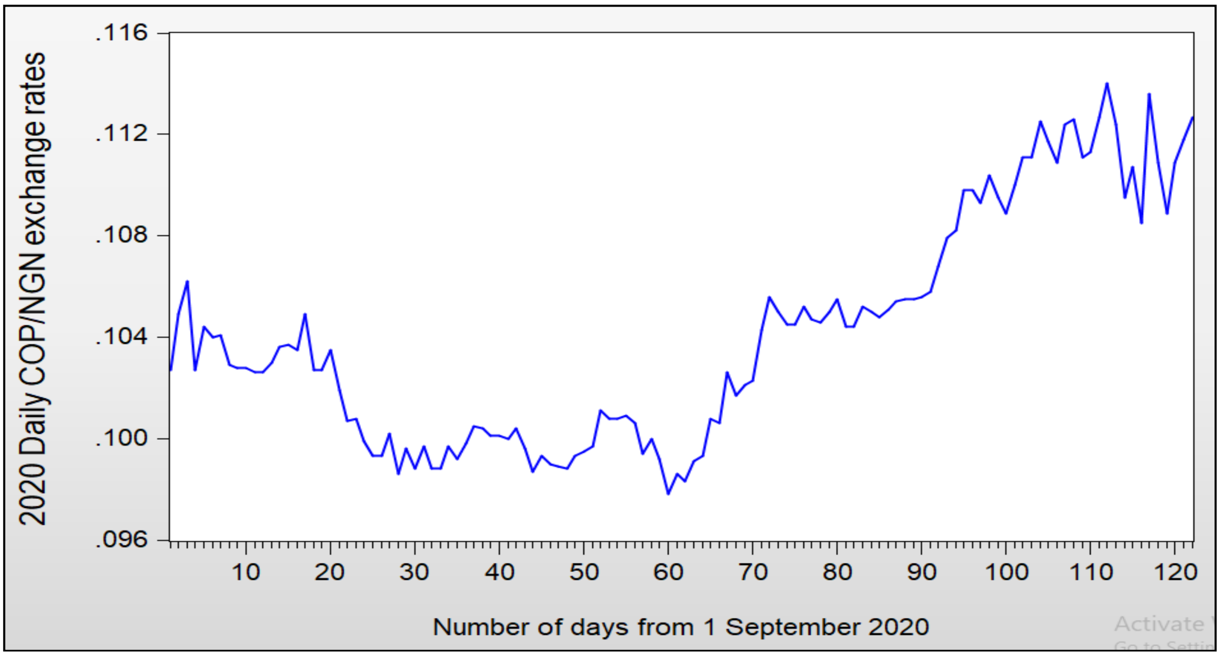

Fig 5: Time Plot of the 2020 Daily COP/NGN Exchange Rate

From Figure 5 it can be deduced that the daily COP/NGN exchange rates collected are not stationary.

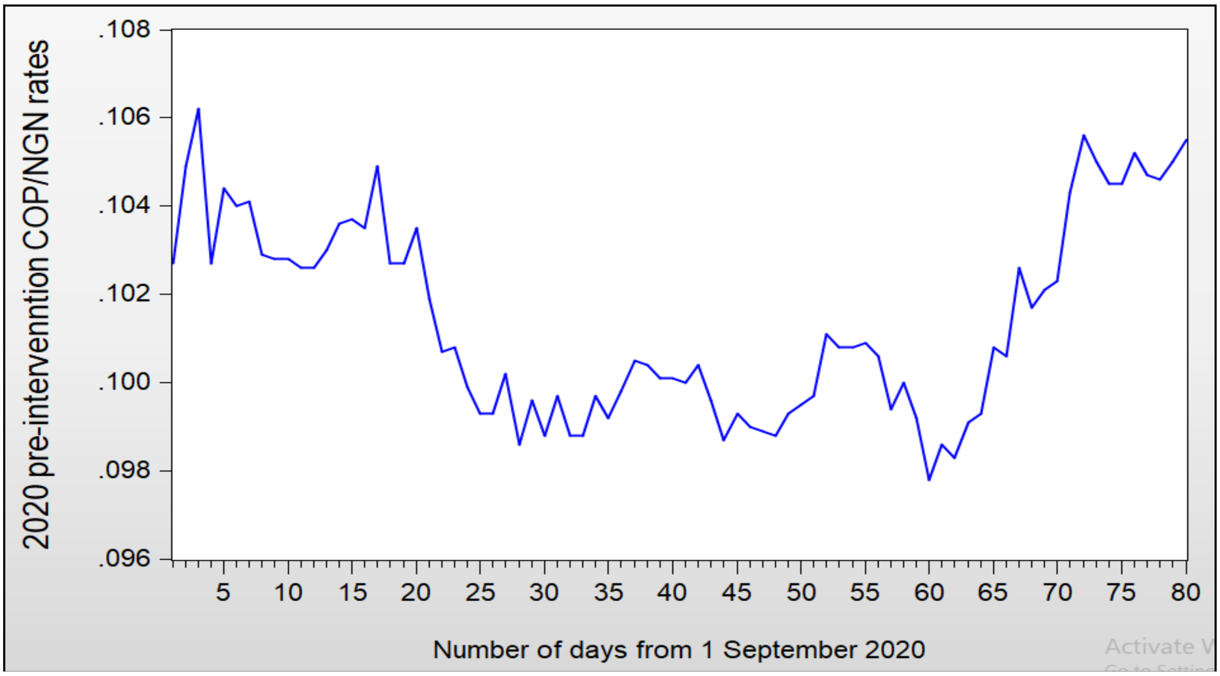

Fig 6: Time Plot of the 2020 Daily COP/NGN Pre-intervention Exchange Rate

Table 6: Unit Root Test for2020 Daily COP/NGN Pre-intervention Exchange Rate

Null Hypothesis: COPN1 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.496872	0.5301
Test critical values:	1% level	-3.515536	
	5% level	-2.898623	
	10% level	-2.586605	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(COPN1)
Method: Least Squares
Date: 03/17/22 Time: 03:32
Sample (adjusted): 2 80
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COPN1(-1)	-0.072086	0.048158	-1.496872	0.1385
C	0.007344	0.004883	1.503777	0.1367

R-squared	0.028276	Mean dependent var	3.54E-05
Adjusted R-squared	0.015656	S.D. dependent var	0.000949
S.E. of regression	0.000941	Akaike info criterion	-11.07377
Sum squared resid	6.82E-05	Schwarz criterion	-11.01379
Log likelihood	439.4140	Hannan-Quinn criter.	-11.04974
F-statistic	2.240624	Durbin-Watson stat	2.329938
Prob(F-statistic)	0.138515		

The probability value of 0.5301 in Table 6 leads to the acceptance of the null hypothesis that the 2020 daily COP/NGN pre-intervention exchange rates collected has a unit root.

Therefore, the daily COP/NGN pre-intervention exchanged rates were differenced to achieve stability and the time plot given in Figure 7.

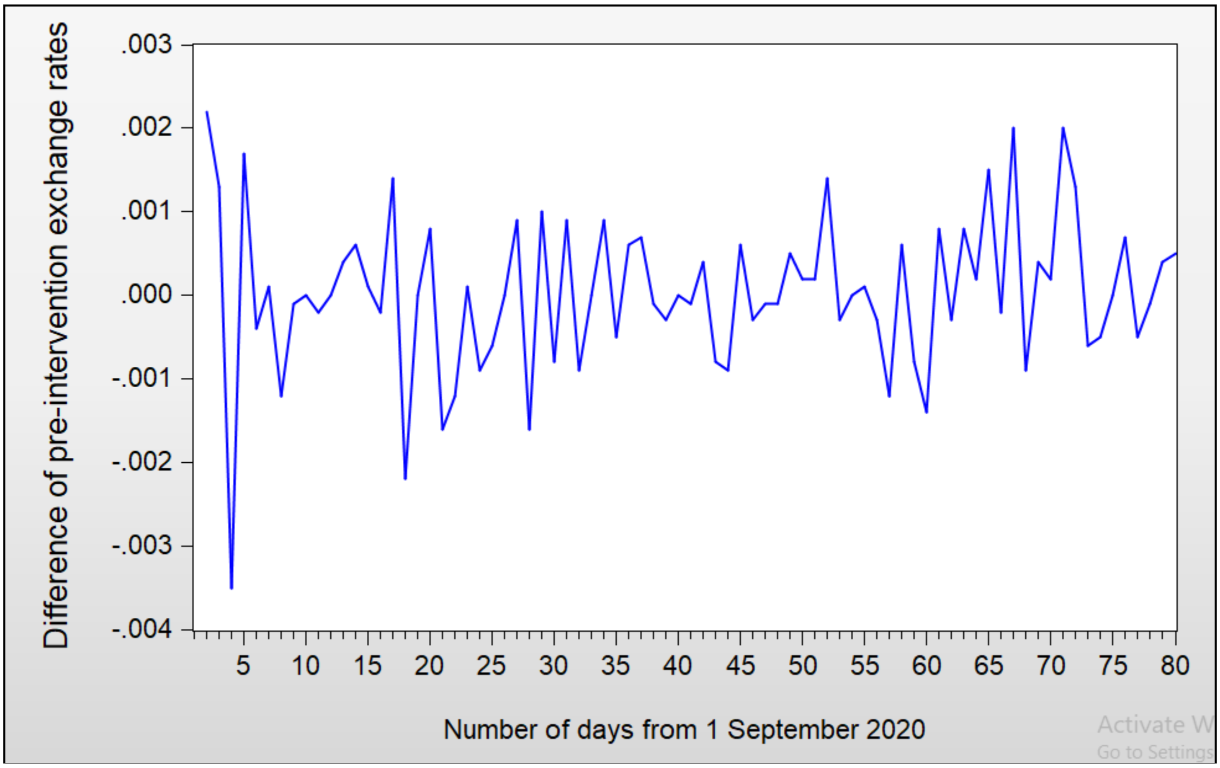

Fig 7: Time Plot of the Differenced 2020 Daily COP/NGN Pre-intervention Exchange Rate

The unit root test of the differenced 2020 daily COP/NGN pre-intervention exchange rate given in Table 7 shows that the series became stationary after differencing based on the probability value of 0.0001 obtained.

Table 7: Unit Root Test of the Differenced 2020 Daily COP/NGN Pre-intervention Exchange Rate

Null Hypothesis: DCOPN1 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.73557	0.0001
Test critical values:	1% level	-3.516676	
	5% level	-2.899115	
	10% level	-2.586866	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DCOPN1)
Method: Least Squares
Date: 03/17/22 Time: 03:40
Sample (adjusted): 3 80
Included observations: 78 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCOPN1(-1)	-1.255604	0.106991	-11.73557	0.0000
C	1.52E-05	0.000101	0.150202	0.8810

R-squared	0.644401	Mean dependent var	-2.18E-05
Adjusted R-squared	0.639722	S.D. dependent var	0.001491
S.E. of regression	0.000895	Akaike info criterion	-11.17410
Sum squared resid	6.09E-05	Schwarz criterion	-11.11367
Log likelihood	437.7900	Hannan-Quinn criter.	-11.14991
F-statistic	137.7236	Durbin-Watson stat	2.102251
Prob(F-statistic)	0.000000		

Table 8: The Correlogram of the Differenced 2020 Daily COP/NGN Pre-intervention Exchange Rate

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.255	-0.255	5.3188	0.021
		2	0.014	-0.055	5.3345	0.069
		3	0.090	0.086	6.0159	0.111
		4	0.143	0.204	7.7634	0.101
		5	-0.104	-0.013	8.7072	0.121
		6	-0.023	-0.076	8.7540	0.188
		7	0.009	-0.064	8.7620	0.270
		8	-0.111	-0.151	9.8630	0.275
		9	-0.011	-0.049	9.8750	0.361
		10	-0.009	0.000	9.8833	0.451
		11	-0.014	0.022	9.9019	0.539
		12	0.007	0.060	9.9071	0.624
		13	-0.074	-0.077	10.441	0.658
		14	0.194	0.157	14.137	0.440
		15	0.024	0.122	14.193	0.511
		16	-0.100	-0.087	15.206	0.510
		17	0.102	0.026	16.288	0.504
		18	0.095	0.050	17.244	0.506
		19	-0.112	-0.073	18.571	0.485
		20	0.047	0.049	18.812	0.534
		21	-0.006	-0.037	18.817	0.597
		22	0.041	0.084	19.006	0.645
		23	-0.165	-0.102	22.121	0.513
		24	0.079	-0.026	22.839	0.529
		25	-0.009	0.046	22.848	0.586
		26	-0.028	-0.006	22.943	0.636
		27	-0.055	-0.025	23.312	0.668
		28	-0.031	-0.106	23.435	0.711
		29	0.052	-0.036	23.785	0.739
		30	-0.103	-0.043	25.178	0.716
		31	0.036	-0.010	25.350	0.752
		32	0.048	0.043	25.670	0.778

The correlogram in Table 8 indicates that the differenced 2020 daily COP/NGN pre-intervention exchange rate produced a white noise fit. Given that the differenced 2020 daily COP/NGN pre-intervention exchange rate is stationary and have a white noise fit the intervention model was determined as shown in Table 9.

Table 9: The Determination of the Transfer Function of the 2020 COP/NGN Exchange Rate Intervention Model

Dependent Variable: Z1
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 03/17/22 Time: 03:52
Sample: 81 122
Included observations: 42
Convergence achieved after 35 iterations
Coefficient covariance computed using outer product of gradients
Z1=C(3)*(1-C(4)^(T-80))/(1-C(4))

	Coefficient	Std. Error	t-Statistic	Prob.
C(3)	0.000244	5.06E-05	4.833489	0.0000
C(4)	0.978916	0.015059	65.00384	0.0000

R-squared	0.709606	Mean dependent var	0.003752
Adjusted R-squared	0.702346	S.D. dependent var	0.002893
S.E. of regression	0.001579	Akaike info criterion	-10.01820
Sum squared resid	9.97E-05	Schwarz criterion	-9.935449
Log likelihood	212.3821	Hannan-Quinn criter.	-9.987866
Durbin-Watson stat	0.810336		

The intervention model Z1 given in Table 9 where C(3) and C(4) are the coefficients and T is time after the series started was used to forecast the post intervention 2020 daily COP/NGN and the forecast was superimposed on the 2020 daily COP/NGN post-intervention exchange rate is given in Figure 8.

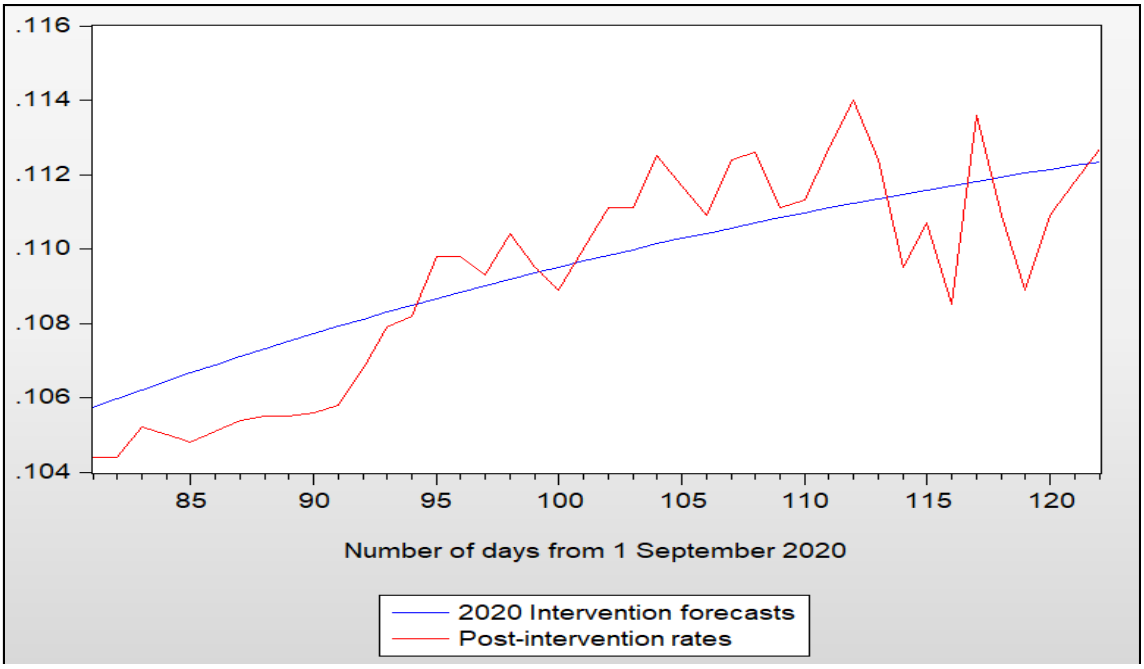

Fig 8: Superimposition of the Intervention Forecast of 2020 COP/NGN Exchange Rate on the Observed Post-intervention Exchange Rate

The 2020 daily COP/NGN post-intervention exchange rate and the corresponding intervention forecast obtained from the intervention model with their Chi-square values given as

$$\chi^2 = \sum \frac{(COPN - EXPTD)^2}{EXPTD} = 0.026082$$

The null hypothesis, H_0: COPN (2020 post intervention COP/NGN exchange rate) and INFL (intervention forecast) agree (there is no significant change in the mean of the COP/NGN process from pre-intervention series to the post-intervention series in 2020) is not rejected since $\chi^2 = 0.026082 < \chi^2_{0.05,42-1} = 67.505$.

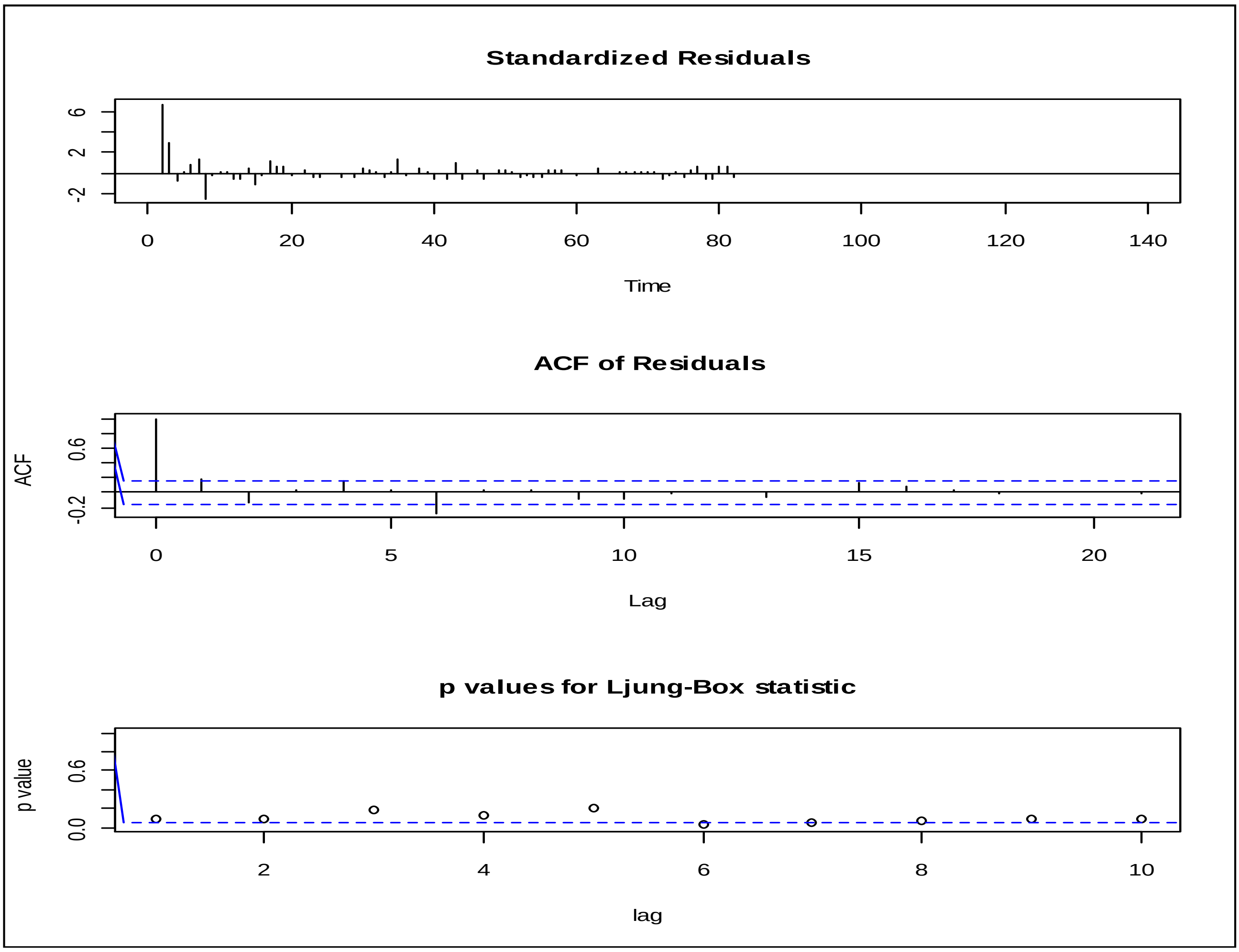

Fig 9: Display of p-value, residual ACF and standardized model adequacy of COL/NGN with intervention.

Results and Discussion

Non-stationarity is a prevalent characteristic observed in the majority of economic variables. The exchange rates exhibited non-stationarity, as evidenced by the data presented in Figures 1 and 5. The pre-intervention series exhibited non-stationarity, as evidenced by Figures 2, 6. The pre-intervention series achieved stationarity using first-order differencing, as illustrated in Figures 3, 7. This statement suggests that there is a linear relationship between the COP/NGN exchange rate. The results of the unit roots tests run on the exchange rate series indicate that the null hypothesis of non-stationarity cannot be rejected, as evidenced by the p-values of 0.4731, 0.5301, as presented in Tables 1, 6 respectively. However, the outcomes of the unit root test performed on the exchange rates after differencing indicate the rejection of the null hypothesis, suggesting stationarity. This conclusion is supported by the p-values of 0.000, 0.0001 derived from Tables 2, 7 respectively.

Another notable conclusion of this study is that the Autoregressive Integrated Moving Average (ARIMA) model demonstrates a strong suitability in predicting exchange rates. The residuals of the ARIMA model applied to pre-intervention COP/NGN exchange rates exhibit characteristics of a white noise series, as evidenced by the findings presented in Tables 3, 8. The computed coefficients of covariance for the transfer function of the intervention analysis yielded significant p-values. Similarly, in the intervention analysis of the COP/NGN exchange rate in 2016 & 2020, the coefficients obtained p-values of 0.000 and 0.000, respectively. Model checking, which is often referred to as diagnostic check or residual analysis, holds significant significance in the process of model construction. The adequacy of the fitted model was confirmed.

Conclusion

This study examines the fluctuations of the Columbian Peso (COP) in relation to the Nigerian Naira (NGN) throughout the years 2016 and 2020. The non-stationarity of the COP/NGN exchange rates, as well as their pre-intervention series, was evident based on the observed data. However, the exchange rates exhibited stationarity after being differenced for the first time. The Chi-square goodness of fit tests was conducted to assess the significance of the mean change in exchange rates between the pre-intervention and post-intervention series, based on the forecast generated by the intervention model.

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