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Modeling of the Intervention of Daily Swiss Franc (CHF)/ Nigerian Naira (NGN) Exchange Rates

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ABSTRACT

This research work is concerned with the modeling of daily exchange rates of Swiss Franc (CHF) and the Nigerian Naira (NGN). The data started from 18th May 2016 to 16th November 2016. The time plot shows an abrupt rise on 21st June 2016 in the quantity of Naira to the Franc. This is the intervention point. It is believed that this is due to the current epression in the Nigerian economy. The pre-intervention rates show a generally upward trend and are adjudged stationary by the Augmented Dickey Fuller (ADF) test. First-order differencing rids it of non-stationarity. Going by its autocorrelation structure a subset AR(5) is fitted to it. Forecasts on the basis of it were made for the post-intervention part of the series. Difference between these forecasts and their corresponding actual observations was modeled to get the transfer function and this function was observed to be statistically significant. This indicates model adequacy. No wonder there is a very close agreement between the intervention forecasts and their corresponding post-intervention exchange rates. This model may be used as the basis of management of the situation.

Keywords: *Swiss Franc, Nigerian Naira, exchange rates, Arima modeling*

INTRODUCTION

Swiss Franc (CHF) is the legal tender of Switzerland and the Naira (NGN) that of Nigeria. The latter came into existence on 1st January 1973 with an initial value of two naira to the British pound sterling. The daily quantities of NGN per CHF from 18th May 2016 to 16th November 2016 are the data for this work. It has been observed that the series moved from a value of 207 on 20th June 2016 through 213 on 21st June 2016 and then to 294 on 22nd June 2016. This informed the choice of 21st June 2016 as the point of intervention. This sudden change is attributed to the current depression in the economy of Nigeria. The ARIMA approach to intervention analysis proposed by Box and Tiao (1975) is adopted for this research work. This approach has been extensively used in the literature with remarkable success. For example Su and Deng (2014) used intervention analysis to study the effect of Niu's comment that Yu Ebao was a "vampire" on the yield of the internet financial product. It was observed that following his derogatory statement the yield nosedived considerably. Etuk *et al.* (2017a) modeled daily European Euro/ British pound exchange rates and saw reason to believe that pro-Brexit voting victory accounted for the sudden decline of the relative value of the pound. Etuk *et al.* (2017b) examined the impact of the current Nigerian economic recession on the comparative value of the NGN to the West African Franc (XOF). Shittu (2008) developed an intervention model of the exchange rates of the NGN to the US dollar in the face of financial and political instability. Jarrette and Kyper (2011) have modeled the Chinese stock market prices by ARIMA intervention analysis. Pridemore *et al.* (2013) used intervention analysis to explain the reduction in male suicide cases following 2006 Russian Alcohol legislation. This is to mention just a few cases.

MATERIALS AND METHODS

Data

The data for this work are daily CHF/NGN exchange rates from 18th May 2016 to 16th November 2016 downloaded from the website www.exchangerates.org.uk/CHF-NGN-exchange-rate=history.html accessed 17th November 2016. The data are to be read as the amounts of NGN in one CHF and are listed in the appendix.

Intervention Modelling

Suppose $\{X_t\}$ is a time series experiencing an intervention at time t=T. Box and Tiao (1975) propose that the pre-intervention data be modeled by an ARIMA(p,d,q). That is, for t < T,

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

Or

$$A(L)\nabla^p X_t = B(L)\varepsilon_t \quad (2)$$

where $A(L) = 1 - \alpha_1 L - \alpha_2 L^2 - \ldots - \alpha_p L^p$ and $B(L) = 1 + \beta_1 L + \beta_2 L^2 + \ldots + \beta_q L^q$ and L is the backshift operator defined by $L^k X_t = X_{t-k}$ and $\{\varepsilon_t\}$ is a white noise process. $\nabla = 1-L$. For stationarity of (1) or (2), the zeros of A(L) must lie outside of the unit circle and for invertibility, the zeros of B(L) must lie outside of the unit circle.

On the basis of (1) or (2), forecasts are made for the post-intervention period i.e. with $t \geq T$. Let this be F(t). Let $Z(t) = X_t - F(t)$, $t \geq T$. The transfer function of the intervention is given by

$$Z(t) = c(1)*(1-c(2)^(1-c(2)^(t-T+1))/(1-c(2)) \quad (3)$$

(The Pennsylvania State University, 2016)

The intervention model is

$$Y_t = \frac{B(L)\varepsilon_t}{A(L)} + I_t Z_t \quad (4)$$

where $I_t = 1$ for $t \geq T$ and zero elsewhere.

Computer Software: Eviews 10 was used for all computational work.

RESULTS AND DISCUSSION

The time plot of the series in Figure 1 shows an intervention point at June 21 2016. The pre-intervention data plot of Figure 2 shows an overall positive trend. Augmented Dickey Fuller (ADF) test adjudges the series as non-stationary (See Table 1). This calls for differencing and the first differences do not show any trend (See Figure 3) and are adjudged as stationary (See Table 2). Their correlogram of Figure 4 suggests an AR(5) fit. An estimate of this AR(5) is obtained in Table 3 as

$$X_t = 0.3444X_{t-5} + \varepsilon_t \quad (5)$$

The autocorrelation structure of the residuals of model (5) in Figure 5 shows that the model is adequate, all the autocorrelations being non-significant. Post-intervention forecasts are made on the basis of (5) and the difference of the forecasts and the corresponding post-intervention exchange rates is modeled (according to (3)) to obtain the transfer function as estimated in Table 4 as

$$Z(t) = 12.49448*(1-0.889301^(t-34))/(1-0.889301) \quad (6)$$

and so the intervention model (according to (4)) is given by

$$Y_t = \frac{\varepsilon_t}{(1-0.3444L^5)} + I_t Z_t \quad (7)$$

The intervention forecasts agree closely with their corresponding post-intervention exchange rates (See Figure 6), an indication of model adequacy.

CONCLUSION

It may be concluded that the intervention model, given by (6) and (7), is adequate for analysis of daily CHF/NGN rates occasioned by Nigerian economic recession. It is believed that it may be used by the Nigerian Government as a management tool to study and ameliorate the relative performance of the Naira relative to the Swiss Franc.

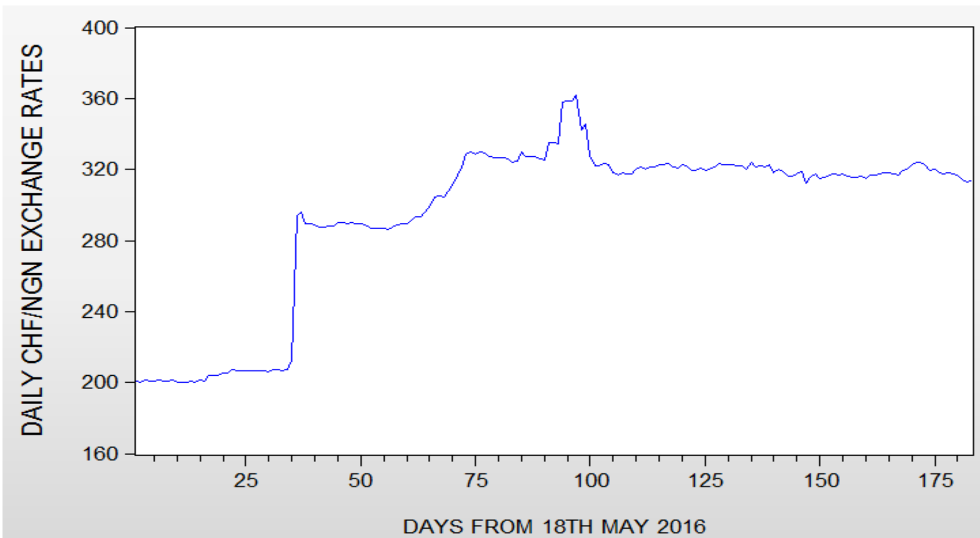


FIGURE 1: TIME-PLOT OF DAILY CHF/NGN EXCHANGE RATES

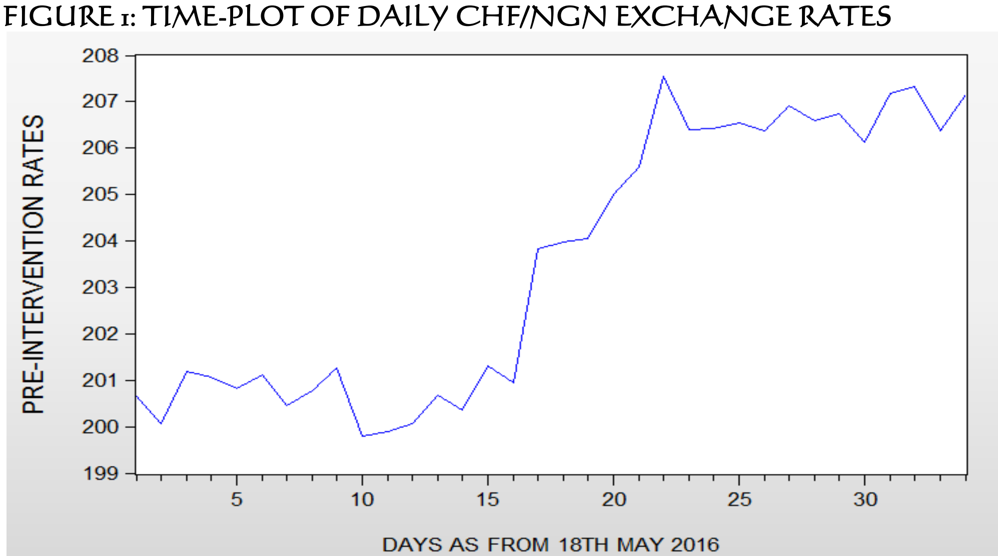


FIGURE 2: TIME PLOT OF THE PRE-INTERVENTION EXCHANGE RATES

TABLE 1: UNIT ROOT TEST OF THE PRE-INTERVENTION DATA

Null Hypothesis: CHNN has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.662512	0.8425
Test critical values:	1% level	-3.646342	
	5% level	-2.954021	
	10% level	-2.615817	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CHNN)
Method: Least Squares
Date: 02/07/18 Time: 00:11
Sample (adjusted): 2 34
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CHNN(-1)	-0.034955	0.052761	-0.662512	0.5125
C	7.308025	10.73453	0.680796	0.5011

R-squared	0.013961	Mean dependent var	0.196967
Adjusted R-squared	-0.017847	S.D. dependent var	0.854754
S.E. of regression	0.862348	Akaike info criterion	2.600375
Sum squared resid	23.05294	Schwarz criterion	2.691072
Log likelihood	-40.90619	Hannan-Quinn criter.	2.630892

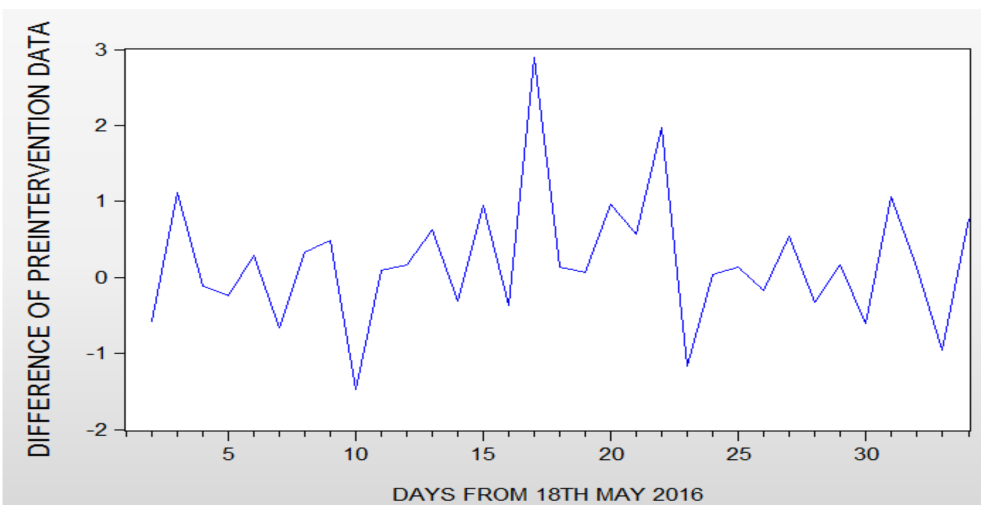


FIGURE 3: TIME PLOT OF THE DIFFERENCE OF PRE-INTERVENTION DATA

TABLE 2: UNIT ROOT TEST OF DIFFERENCE OF PRE-INTERVENTION DATA

Null Hypothesis: DCHNN has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.534885	0.0000
Test critical values:	1% level	-3.653730	
	5% level	-2.957110	
	10% level	-2.617434	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DCHNN)
Method: Least Squares
Date: 02/07/18 Time: 00:17
Sample (adjusted): 3 34
Included observations: 32 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCHNN(-1)	-1.302659	0.172884	-7.534885	0.0000
C	0.275321	0.149878	1.836967	0.0761

R-squared	0.654276	Mean dependent var	0.042503
Adjusted R-squared	0.642752	S.D. dependent var	1.388024
S.E. of regression	0.829625	Akaike info criterion	2.524776
Sum squared resid	20.64834	Schwarz criterion	2.616385
Log likelihood	-38.39642	Hannan-Quinn criter	2.555142

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.299	-0.299	3.2207	0.073
		2	0.096	0.007	3.5630	0.168
		3	0.069	0.109	3.7466	0.290
		4	0.024	0.082	3.7703	0.438
		5	0.292	0.345	7.2837	0.200
		6	-0.226	-0.066	9.4779	0.148
		7	-0.101	-0.305	9.9322	0.192
		8	-0.166	-0.470	11.198	0.191
		9	0.127	-0.122	11.977	0.215
		10	-0.079	0.034	12.293	0.266
		11	-0.217	0.054	14.777	0.193
		12	-0.057	0.076	14.957	0.244
		13	-0.142	-0.132	16.116	0.243
		14	0.282	0.091	20.967	0.102
		15	-0.235	-0.137	24.523	0.057
		16	-0.029	-0.123	24.580	0.078

FIGURE 4: CORRELOGRAM OF THE DIFFERENCE OF PRE-INTERVENTION DATA

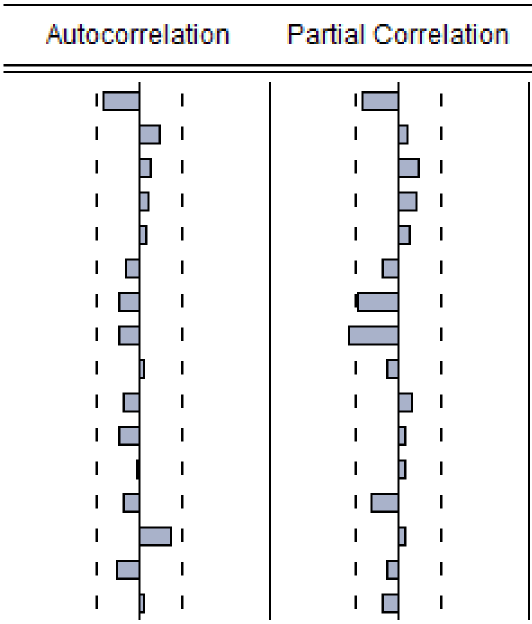
TABLE 3: ESTIMATION OF THE PRE-INTERVENTION AR(5) MODEL

Dependent Variable: DCHNN
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/07/18 Time: 00:34
Sample: 2 34
Included observations: 33
Convergence achieved after 8 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(5)	0.344454	0.173677	1.983303	0.0563
SIGMASQ	0.649184	0.103180	6.291770	0.0000

R-squared	0.083675	Mean dependent var	0.196967
Adjusted R-squared	0.054116	S.D. dependent var	0.854754
S.E. of regression	0.831304	Akaike info criterion	2.546186
Sum squared resid	21.42307	Schwarz criterion	2.636884
Log likelihood	-40.01207	Hannan-Quinn criter.	2.576703
Durbin-Watson stat	2.479616		

Inverted AR Roots	.81	.25-.77i	.25+.77i	-.65+.47i
	-.65-.47i			



	AC	PAC	Q-Stat	Prob
1	-0.294	-0.294	3.1132	
2	0.156	0.077	4.0221	0.045
3	0.089	0.169	4.3256	0.115
4	0.070	0.142	4.5182	0.211
5	0.051	0.084	4.6272	0.328
6	-0.109	-0.138	5.1391	0.399
7	-0.157	-0.327	6.2382	0.397
8	-0.159	-0.398	7.4107	0.387
9	0.037	-0.094	7.4771	0.486
10	-0.120	0.108	8.2005	0.514
11	-0.162	0.058	9.5755	0.478
12	-0.016	0.041	9.5897	0.568
13	-0.128	-0.225	10.530	0.570
14	0.256	0.062	14.509	0.339
15	-0.182	-0.093	16.640	0.276
16	0.027	-0.120	16.688	0.338

FIGURE 5: CORRELOGRAM OF THE ARIMA(5,1,0) MODEL RESIDUALS

TABLE 4: ESTIMATION OF THE TRANSFER FUNCTION

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 02/07/18 Time: 04:32
Sample: 35 183
Included observations: 149
Convergence achieved after 0 iterations
Coefficient covariance computed using outer product of gradients
Z=C(1)*(1-C(2)^(T-34))/(1-C(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	12.49448	1.044249	11.96504	0.0000
C(2)	0.889301	0.009655	92.11171	0.0000

R-squared	0.354362	Mean dependent var	107.6137
Adjusted R-squared	0.349970	S.D. dependent var	17.53395
S.E. of regression	14.13665	Akaike info criterion	8.148750
Sum squared resid	29377.19	Schwarz criterion	8.189072
Log likelihood	-605.0819	Hannan-Quinn criter.	8.165132
Durbin-Watson stat	0.251083		

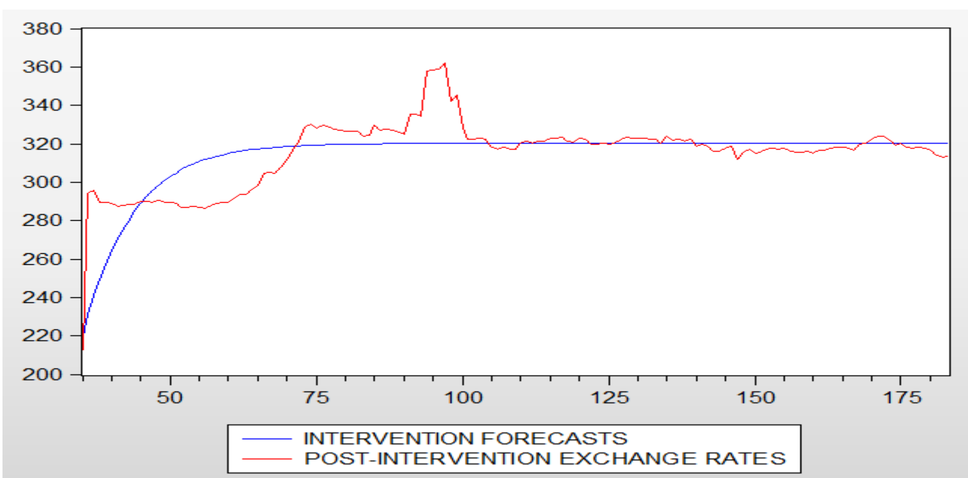


FIGURE 6: POST-INTERVENTION DATA AND FORECASTS

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APPENDIX

DATA (starting from 18th May 2016 and ending 16th November 2016)

May 2016

200.6468 200.0674 201.1778 201.0655 200.8221 201.1070 200.4438 200.7691 201.2618 199.7922 199.8884 200.0526 200.6733 200.3620

June 2016

201.3063 200.9362 203.8366 203.9776 204.0448 205.0103 205.5813 207.5538 206.3905 206.4253 206.5568 206.5794 206.9204 206.5873 206.7446 206.1383 207.1921 207.3252 206.3660 207.1467 212.6096 294.1984 295.7607 289.4252 289.4461 289.0621 287.6346 287.7809 288.3538 288.3828

July 2016

289.8804 290.1614 289.6198 290.4236 289.6634 289.5763 288.7922 286.6860 286.7649 287.1629 287.1255 286.4269 287.7231 288.8482 289.6263 289.6229 291.4834 293.5656 293.6525 296.0578 298.4989 304.5611 305.0632 304.3602 307.6814 311.2068 316.8422 3211.2839 328.8283 329.9815 328.2814

August 2016

329.5847 329.3056 327.4185 326.8127 326.5504 326.5178 326.2796 323.8539 324.5071 329.6348 327.1573 327.3218 327.0690 326.1261 325.0854 335.3206 335.2208 334.4405 357.8374 358.4335 358.6189 361.8685 342.0916 345.4410 327.8766 322.3330 322.3330 323.0564 322.5384 318.2952 317.0071

September 2016

317.9387 317.2603 317.2918 320.0838 321.3274
320.3417 321.5261 321.1777 322.8186 322.8257
323.3264 321.2388 321.0241 322.7883 322.3550
319.4957 319.5176 320.4760 319.7223 320.1977
321.5949 323.1860 322.9696 322.8326 322.7907
322.1022 322.1732 320.2374 323.8536 321.6638

October 2016

322.2600 321.2513 322.5037 318.4389 319.8841
318.4978 315.9432 316.0867 317.4613 318.5376
312.1546 315.6426 317.1941 315.1250 315.4346
317.0607 317.6994 316.9818 317.4005 316.1009
315.3874 315.5703 315.8958 315.2014 316.8152
316.7505 317.7271 318.3369 318.3839 317.4713
316.6839

November 2016

319.4967 320.1790 322.4434 323.7274 323.9528
321.7603 319.3252 320.0726 318.0129 317.6660
317.9804 317.3961 316.6214 314.2508 313.0857
313.4053