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Daily Gambian Dalasi/Nigerian Naira Exchange Rates Intervention Analysis

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ABSTRACT
A realization of the daily Gambian Dalasi (GMD) / Nigerian Naira (NGN) exchange rates from 30th May 2017 to 25th November 2017 is the subject of this research work. It has been noticed that there has been a sharp rise in the rate of the amount of naira in the dalasi on 4th August 2017, and there has not been decline ever since necessitating treatment of this relationship as an intervention case. The pre-intervention series is adjudged as stationary by the Adjusted Dickey Fuller test. A white noise model is suitable for the series. The transfer function model is parabolic. This model may be useful for modeling the intervention relationship between the two currencies.
Keywords: Gambian Dalasi, Nigerian Naira, intervention model, Arima modeling

INTRODUCTION AND LITERATURE REVIEW
Any trade relations between Gambia and Nigeria will involve the exchange rates between the two currencies Gambian Dalasi GMD and the Nigerian Naira NGN. The GMD came into existence in 1971 and is made up of 100 bututs. Currently in circulation are banknotes of 5, 10, 25, 50 and 100 dalasis. The coins are 10, 5, 1, 25 and 50 bututs and 1 dalasi [1]. On the other hand, the NGN which came into being as from 1973 is the legal tender in Nigeria and operates as 5, 10, 20, 50, 100, 200, 500 or1000 naira banknotes and essentially no coins.The purpose of this research work is to build an intervention model to the exchange rates of GMD and the NGN. It has been observed that the exchange rates from 30th May to 25th November 2017 follow an intervention pattern with the point of intervention at 4th August (See Figure 1). The approach adopted is the autoregressive integrated moving average (ARIMA) approach which was introduced by Box and Tiao [2]. This has been successfully used by many researchers. For instance Bonham and Gangnes [3] studied the effect of the 5% Hawaii hotel room tax on the hotel room revenues and observed a non-significant effect. This ARIMA approach has been shown to outdo some other techniques (See [4]). Adubisi and Jolayemi [5] have shown that the global economic downturn has had a significant impact in the reduction of crude oil exports in Nigeria since 2008. According to [6], Indian domestic gold price have been significantly lowered by imposition of certain government policies in 2013. Oreko *et al.* [7] have found that the establishment of the Federal Road Safety Corps in Nigeria in 1987 has caused a significant reduction of road traffic accidents in the country.

MATERIALS AND METHODS
Data
The data used for this work are daily GMD/NGN exchange rates from 30th May to 25th November 2017 collected from the website www.exchangerates.org.uk/GMD-NGN-

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exchange-rate-history .html. They are to be read as the amounts of NGN in one GMD and are listed in the appendix of this work.

INTERVENTION MODELLING

Let $X_1, X_2, \ldots, X_n$ be a realization of a time series which encounters an intervention at point $t = k$. Let the pre-intervention data be fitted by an ARIMA(p, d, q) model

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

where $\nabla = 1 - L$ and $L^s X_t = X_{t-s}$. Model (1) might be put as

$$\Phi(L)\nabla^d X_t = \Theta(L)\varepsilon_t \quad (2)$$

where $\Phi(L) = 1 - \alpha_1 L - \ldots - \alpha_p L^p$ and $\Theta(L) = 1 + \beta_1 L + \ldots + \beta_q L^q$. On the basis of the model forecasts are obtained for the post-intervention part of the series. Let these be F_t, $t \geq k$. Then $Z_t = X_t - F_t$, $t \geq k$, is fitted with a transfer function for the intervention. This could be

$$Z_t = c(1)*(1-c(2)\hat{}(t-k+1))/(1-c(2)) \quad (3)$$

(The Pennsylvania State University [8]).

Generally a befitting transfer function may be obtained by an inspection of the relationship between Z_t and t. The final form of the intervention model is

$$Y_t = X_t + I_t Z_t \quad (4)$$

where $I_t = 0$, $t < k$ and $I_t = 1$ elsewhere.

COMPUTER SOFTWARE

Eviews 10 was used in this work. It uses the least squares technique for model estimation.

RESULTS AND DISCUSSION

The time plot of the original series in Figure 1 shows a series with a more or less horizontal trend before shooting up on the 4th August 2017 and not returning to lesser levels thereafter signifying an intervention. Figure 2 is a display of the pre-intervention series and an Adjusted Dickey Fuller (ADF) Test on it in Table 1 certifies it as stationary. The correlogram on Figure 3 indicates a white noise fit of the series. With this from (3) and as estimated in Table 2

$$Z_t = 1.061164*(1-(-0.190354)\hat{}(t-66))/1.190354 \quad (5)$$

The plot of this intervention model in Figure 4 shows a straight line.

A plot of Z_t versus t in Figure 5 reveals a parabolic relationship. This yields the quadratic curve as estimated in Table 3 as

$$Z_t = 1.14181 - 0.00581*(t-66) + 0.00002*(t-66)^2 \quad (6)$$

which outdoes (5) on all counts; in Akaike information criterion, in Schwarz Criterion, in Hannan-Quinn, in R-squared, etc. Hence the intervention model is given by

$$Y_t = \varepsilon_t + I_t\,(1.14181 - 0.00581*(t-66) + 0.00002*(t-66)^2 \quad (7)$$

This model is plotted in Figure 6.

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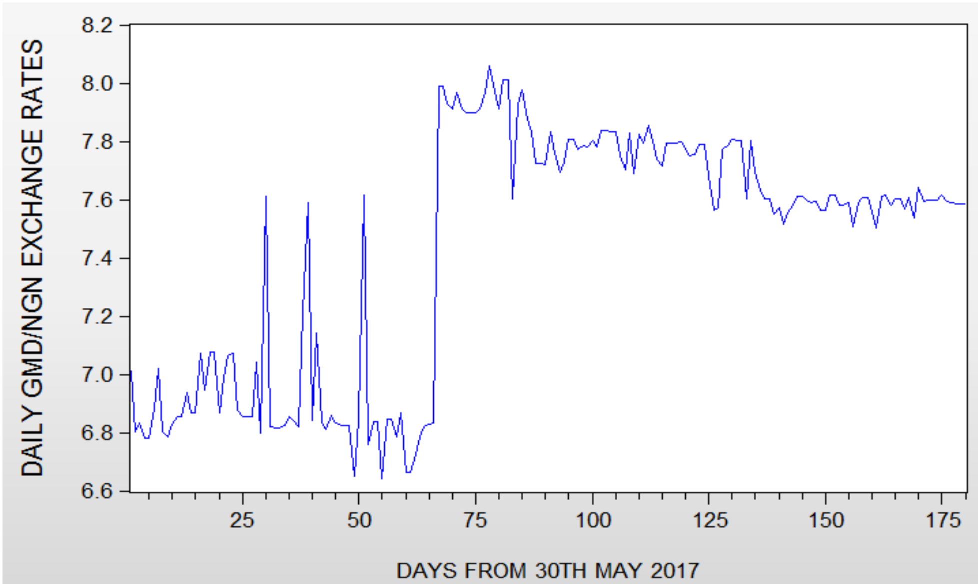

Figure 1: Time Plot of the exchange rates

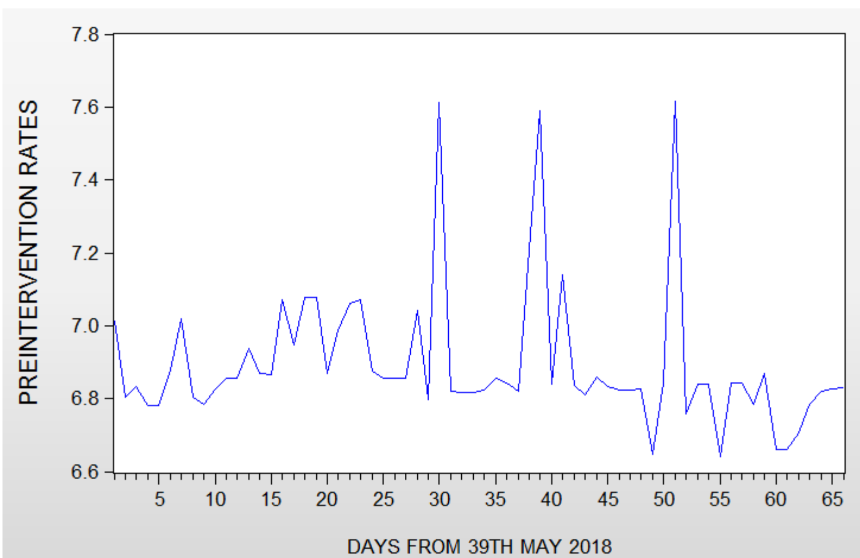

Figure 2: Time Plot of the pre-intervention rates

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Table 1: Stationarity test for the pre-intervention series

Null Hypothesis: GMNN has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

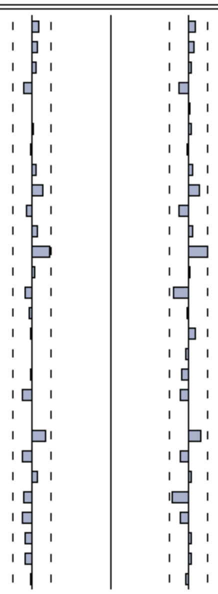
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.212581	0.0000
Test critical values:	1% level	-3.534868	
	5% level	-2.906923	
	10% level	-2.591006	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GMNN)
Method: Least Squares
Date: 07/08/18 Time: 12:38
Sample (adjusted): 2 66
Included observations: 65 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GMNN(-1)	-0.902581	0.125140	-7.212581	0.0000
C	6.222804	0.863492	7.206560	0.0000

R-squared	0.452275	Mean dependent var	-0.002800
Adjusted R-squared	0.443581	S.D. dependent var	0.259028
S.E. of regression	0.193218	Akaike info criterion	-0.419706
Sum squared resid	2.351999	Schwarz criterion	-0.352802
Log likelihood	15.64046	Hannan-Quinn criter.	-0.393308



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.097	0.097	0.6522	0.419
		2	0.081	0.073	1.1175	0.572
		3	0.054	0.040	1.3269	0.723
		4	-0.106	-0.122	2.1400	0.710
		5	-0.001	0.013	2.1401	0.829
		6	0.017	0.032	2.1611	0.904
		7	-0.019	-0.013	2.1889	0.949
		8	0.060	0.047	2.4676	0.963
		9	0.154	0.150	4.3304	0.888
		10	-0.080	-0.115	4.8451	0.901
		11	0.073	0.060	5.2765	0.917
		12	0.235	0.253	9.8597	0.628
		13	0.025	0.010	9.9127	0.701
		14	-0.083	-0.190	10.501	0.725
		15	-0.042	-0.025	10.656	0.777
		16	-0.024	0.091	10.709	0.827
		17	-0.004	-0.027	10.711	0.871
		18	-0.015	-0.085	10.732	0.905
		19	-0.137	-0.109	12.529	0.862
		20	0.005	-0.003	12.531	0.897
		21	0.175	0.172	15.589	0.792
		22	-0.117	-0.110	16.996	0.764
		23	0.072	0.032	17.531	0.782
		24	-0.099	-0.206	18.579	0.774
		25	-0.137	-0.100	20.637	0.713
		26	-0.087	0.026	21.479	0.717
		27	-0.090	0.041	22.403	0.717
		28	-0.014	-0.040	22.428	0.761

Figure 3: Correlogram of the pre-intervention series

Table 2: Estimation of the First Transfer Function

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 08/29/18 Time: 13:18
Sample: 67 180
Included observations: 114
Convergence achieved after 17 iterations
Coefficient covariance computed using outer product of gradients
Z =C(1)*(1-C(2)^(T-66))/(1-C(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.061164	0.128646	8.248693	0.0000
C(2)	-0.190354	0.144642	-1.316033	0.1909

R-squared	0.020574	Mean dependent var	0.892645
Adjusted R-squared	0.011829	S.D. dependent var	0.139121
S.E. of regression	0.138296	Akaike info criterion	-1.101453
Sum squared resid	2.142088	Schwarz criterion	-1.053449
Log likelihood	64.78279	Hannan-Quinn criter.	-1.081971
Durbin-Watson stat	0.347312		

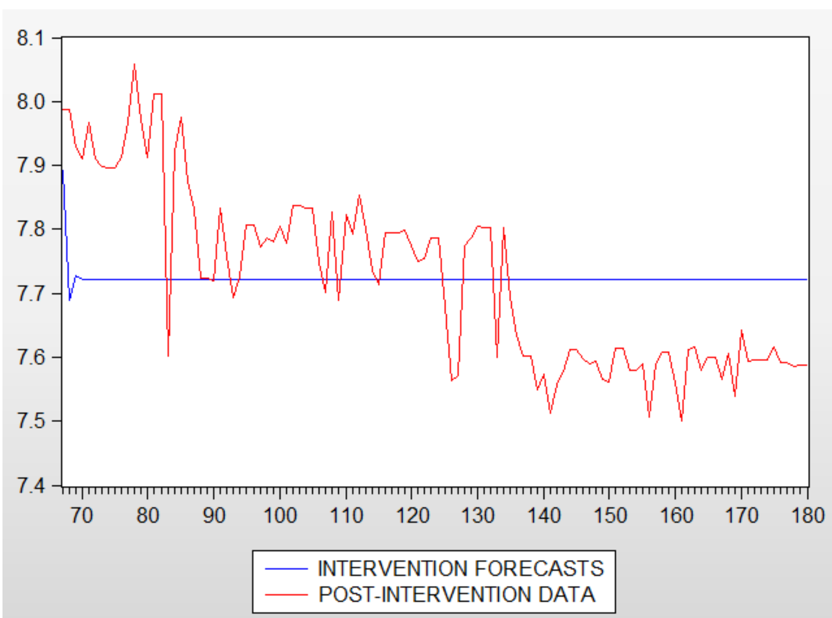


Figure 4: Intervention forecasts with post-intervention data from first transfer function

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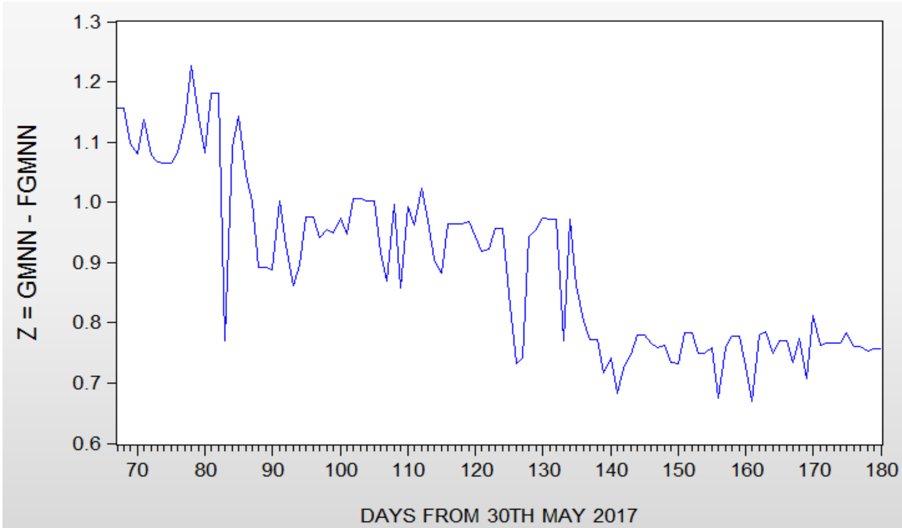

Figure 5: Plot of Z_t with t

Table 3: Estimation of Second Transfer function

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 08/29/18 Time: 10:24
Sample: 67 180
Included observations: 114
Z=C(1)+C(2)*(T-66)+C(3)*(T-66)^2

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.141809	0.020329	56.16640	0.0000
C(2)	-0.005812	0.000816	-7.121932	0.0000
C(3)	1.94E-05	6.87E-06	2.817561	0.0057

R-squared	0.743537	Mean dependent var	0.892645
Adjusted R-squared	0.738916	S.D. dependent var	0.139121
S.E. of regression	0.071086	Akaike info criterion	-2.423890
Sum squared resid	0.560907	Schwarz criterion	-2.351885
Log likelihood	141.1617	Hannan-Quinn criter.	-2.394667
F-statistic	160.9053	Durbin-Watson stat	1.240266
Prob(F-statistic)	0.000000		

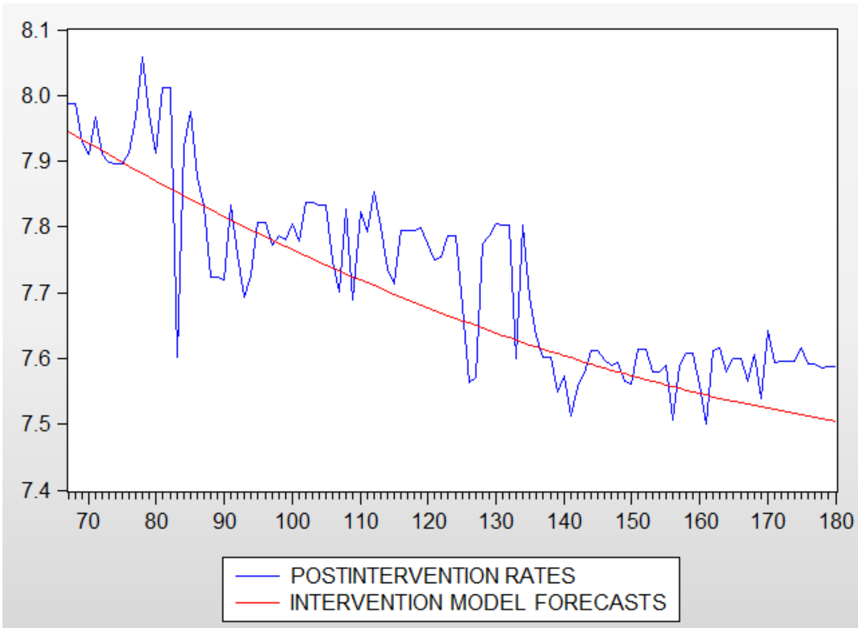

Figure 6: Intervention Model Forecasts and post-intervention rates for second transfer function.

CONCLUSION

The model (7) is clearly the better intervention model on all counts. This is just like the result of Udoudo and Etuk [9] in which a parabolic model was used to intervene in the relationship between the Indian Rupee and the NGN. The situation is caused by the prevalent downturn in the Nigerian economy. It may be used by anybody to manage the NGN relative to the GMD.

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APPENDIX
DATA

May 2017

7.0129 6.8037

June 2017

6.8323 6.7807 6.7807 6.8804 7.0206 6.8036 6.7840 6.8280 6.8557 6.8557 6.9383 6.8683 6.8661 7.0728 6.9472 7.0774 7.0774 6.8687 6.8972 7.0627 7.0728 6.8756 6.8553 6.8553 6.8547 7.0428 6.7971 7.6113 6.8194 6.8170

July 2017

6.8170 6.8222 6.8547 6.8428 6.8200 7.2095 7.5896 6.8410 7.4100 6.8369 6.8098 6.8586 6.8327 6.8239 6.8239 6.8259 6.6489 6.8437 7.6154 6.7585 6.8389 6.8389 6.8421 6.8437 6.8437 6.7833 6.8690 6.6613 6.6613 6.7064 6.7833

August 2017

6.8213 6.8272 6.8309 7.9875 7.9875 7.9278 7.9112 7.9681 7.9097 7.8983 7.8958 7.8958 7.9130 7.9661 8.0574 7.9720 7.9124 8.0111 8.0111 7.6014 7.9225 7.9747 7.8765 7.8315 7.7235 7.7235 7.7187 7.8339 7.7591 7.6923 7.7263

September 2017

7.8075 7.8075 7.7724 7.7860 7.7798 7.8038 7.7785 7.8370 7.8370 7.8327 7.8330 7.7480 7.7006 7.8272 7.6892 7.8239 7.7936 7.8535 7.8015 7.7367 7.7132 7.7944 7.7944 7.7944 7.7997 7.7749 7.7500 7.7532 7.7874 7.7874

October 2017

7.6795 7.5631 7.5720 7.7739 7.7860 7.8052 7.8029 7.8029 7.6003 7.8034 7.6931 7.6334 7.6024 7.6024 7.5486 7.5726 7.5132 7.5564 7.5785 7.6112 7.6112 7.5980 7.5894 7.5944 7.5651 7.5623 7.6149 7.6149 7.5803 7.5804 7.5890

November 2017

7.5058 7.5900 7.6086 7.6086 7.5593 7.5010 7.6114 7.6159 7.5798 7.6008 7.6008 7.5654 7.6057 7.5387 7.6431 7.5937 7.5967 7.5967 7.5967 7.6151 7.5924 7.5913 7.5848 7.5869 7.5869