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**Research Article**

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# Intervention Analysis of Daily Thailand Thai-Bath/Nigerian Naira Exchange Rates

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**Abstract** Time series plot of a realization of daily exchange rates of Thailand Thai-Bath/Nigerian Naira from May 2017 to November, 2017 shows the occurrence of an intervention on 4th August, 2017. It is believed that this intervention is the current Nigerian economic recession which is bedeviling the country. This paper is aimed at proposing an intervention model to explain this phenomenon. The method to adopt is the autoregressive integrated moving average (ARIMA) method. Pre-intervention series is observed to be stationary by the Augmented Dickey Fuller Test. Following the shown autocorrelation structure of the series, an adequate subset ARMA (12, 12) model is fitted to it. On the basis of this model forecasts are made for the post-intervention period. Difference between these forecasts and their corresponding actual observations are modeled to obtain the intervention transfer function and the desired overall intervention model. This is observed to be statistically significant and the forecasts based on it are very closely in agreement with the corresponding observations.

**Keywords** Thailand, Nigeria, Exchange rate, interrupted time series, Arima modeling

## Introduction

Thailand uses the Thai-Baht as its legal tender and it has an acronym THB (Thai-Baht). On the other hand naira is the Nigerian currency and is denoted NGN (for Nigerian Naira). An examination of the daily exchange rates of Thailand and Nigeria from May 2017 to November, 2017 shows an abrupt jump in the amount of NGN per THB on 4thAugust, 2017.

The exchange rate is price of one currency in terms of other and is a key financial variable that affects decisions made by foreign exchange investors, exporters, bankers, financial institutions, policy makers etc.

Stable exchange rate is one of the requirement for stable economy. The purpose of this work is to propose an intervention model for their exchange rate. It is believed that this intervention situation is due to the current economic recession in Nigeria. The approach to the intervention modeling of the exchange rates shall be the autoregressive integrated moving average (ARIMA) approach introduced by Box and Tiao (1975) [1]. This approach is well tested and successfully applied by many scholars. For instance Etuk and Eleki (2017) conducted an intervention study on exchange rates of the central African Franc and the Nigerian Naira still due to the current economic recession in Nigeria [2]. Classical and Bayesian approaches to time series intervention analysis have been compared and contracted by Santos *et al.*, (2017) with the inference that the former is the better approach in explaining intervention on some Brazilian economic time series [3]. Etuk & Sibeate (2017) have proposed a model for the intervention in the monthly household kerosene distributed in Nigeria [4]. Ebhuoma *et al.*, (2017) study the positive effect of the re-introduction of dichlorodiphenyltrichloroethane in the lowering of malaria incidence using ARIMA intervention analysis [5]. Masuhawa *et al.*, (2014) studied the impact of the introduction of a rotavirus vaccine on rates of hospitalization of children less than 5 years old for acute diarrhea [6]. Gilmour *et al.*, (2006) used intervention analysis to measure the health and social effects of a reduction in the supply of cocaine in Australia [7].

**Materials and Methods**

**Data**

All the data used for this work are of secondary sources. The data analyzed in this work are daily THB/NGN exchange rates from 26th May, 2017 to 21st November, 2017 from the website www.exchangerates.org.uk/THB-NGN-exchange-rate-history.html. They are read as the amount of NGN per THB. They are listed in the appendix.

**Intervention Modeling**

Let $\{X_t\}$ be a time series encountering an intervention at time t = T. Box and Tiao (1975) proposed that the pre-intervention part of the series be modeled by ARIMA techniques. That is, for t<T, suppose that the ARIMA (p, d, q) model.

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

(where $\nabla X_t = X_t - X_{t-1}$) $is fitted. model$ (1) $may\ be\ put\ as$

$$\Phi(L)(1-L)X_t = \Theta(L)\varepsilon_t \quad (2)$$

Where $L^k X_t = X_{t-k,} L^k \varepsilon_t = \varepsilon_{t-k,}$

$\Phi(L) = 1 - \propto_1 L - \propto_2 L^2 \ldots \ldots \propto_p L^p$ is the autoregressive (AR) operator and $\Phi(L) = 1 + \beta_1 L + \beta_2 L^2 + \ldots \ldots + \beta_q L^q$ is the moving average (MA) operator. The $\propto' s\ and\ \beta' s$ are chosen such that the zeroes of $\Phi(L) = 0$ are outside of the unit circle for model invertibility.

From (2) the noise part of the intervention model is

$$V_t = \frac{\Theta(L)\varepsilon t}{\Phi(L)(1-L)^d} \quad (3)$$

Firstly, on

The basis of the model, forecasts are obtained for the post intervention part of the time series. Suppose these are $F_t, t \geq T$. Then for $t \geq T$.

$$Z_t = X_t - F_t = \frac{C(1)x\,(1-c(2)^{t-T+1})}{(1-c(2))} \quad (4)$$

(The pennsylvania state university, 2016 [8])

This is the transfer function of the intervention model. The model is then given by combining (3) and (4) to have.

$$V_t = \frac{\Theta(L)\varepsilon t}{\Phi(L)(1-L)^d} + 1_t Z_t \quad (5)$$

Where $1_t$ is an indicator variable such that $1_t = 1$ in the post intervention period and zero otherwise.

Secondly still on the basis of the model, forecast are obtained for the post-intervention part of the time series. Suppose these are $F_t, t \geq T.\ Then\ f\ or\ t \geq T$

$$Z_t = X_t - F_t = c(1) + c(2)x(t-T+1) + c(3)x\,(t-T+1)^2 \quad (6)$$

This is the transfer function of the intervention model. The model is then given by combining (3) and (6) to have

$$Y_t = \frac{\Theta(L)\varepsilon t}{\Phi(L)(1-L)^d} + I_t Z_t \quad (7a)$$

Where $I_t$ is an indicator variable such that $I_t = 1$ in the post intervention period and zero otherwise.

In practice the model (2) is fitted first by the determination of the orders, p, d and q. The differencing order is determined sequentially stating from 0 if the series is stationary. If not, with d = 1, the series is tested for stationary. If non-stationary, d = 2. Stationary may be tested with the Augmented Dickey Fuller (ADF) unit root test procedure. The autoregressive (AR) order may be determined by the lap at which the partial autocorrelation function (PACF) cuts off. The moving average (MA) order may be estimated as the lap at which the autocorrelation function (ACF) cuts oft. Estimation of X's and β's may be done by the method of lest squares.

Computer Package:

Eviews 9 was used to do all computations in this work.

**Results and Discussion**

The time plot of the realization of the time series used in this work is shown in figure 1. After three spikes, there is a sudden sharp increase on 4th August 2017 after which there is no fall in the series. This is the point intervention. Prior to this point the exchange rates, apart from three spikes the exchange rates point 33 and 56 exhibit a fairly flat trend (see figure 2). They are adjudged stationary by the Augmented Dichey Fuller Test (See Table 1). Their correlogram of figure 3 shows evidence of seasonality of order 12. This inform the fitting of an ARMA (12, 12) model estimated in table 2 as

$X_t = 0.999976X_{t-12} - 0.750605\varepsilon_{t-12}$.

The autocorrelation structure of its residuals shown in figure 4 looks like that of a white noise an indication of model adequacy. On it basis the noise component of the model is

$$V_t = \frac{(1 - 0.750605L^{12})}{1 - 0999976L^{12}}\varepsilon t$$

The estimate in Table 2$\propto_{12} = 0.999976$ *and* $\beta_{12} = -0.750605$ are highly statistically significant.

On the basis of these estimate forecast have been made for the post intervention period. The observation/forcast is modeled using equation (4) and as obtained from table (3) c(1) = 1.550843 and c(2) = -0.135660. c(1) is statistically significant while c(2) is not statistically significant indicating that the model is not adequate.

This leads us to an alternative model. The observation/forecast difference is modeled using equation (6) and as obtained from table (4) c(1) = 1.515660, c(2) = -0.007512 and c(3) = 6.56E-05 and these coefficient are as well highly statistically significant indicating that the model is adequate.

The overall intervention model is therefore

$$Y_t = \frac{(1-0.750605\,L^{12})}{(1-0.999976L^{12}} + 1_t\,1.515660 - 0.007512\,\mathrm{x}(t-70) + 6.56\,E - 05 \times (t-70)^2 \quad (7b)$$

Where $1_t = 1, t \geq 70; zero\ else\ where.$

Forecasts and actual observations of the post-intervention period closely agreed (see fig 7).

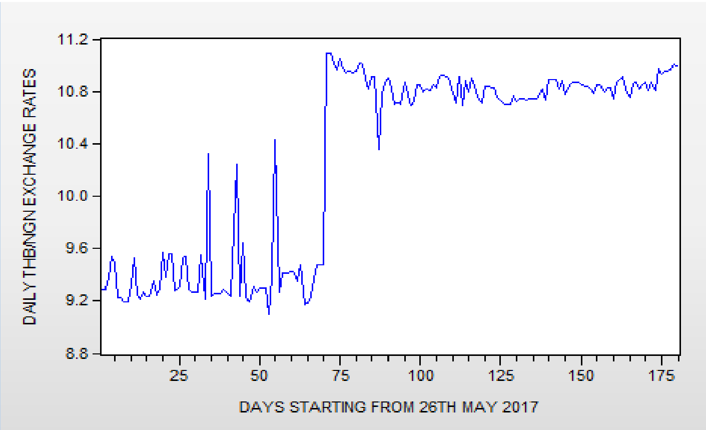



*Figure 1: Time plot of daily THB/NGN exchange rates*

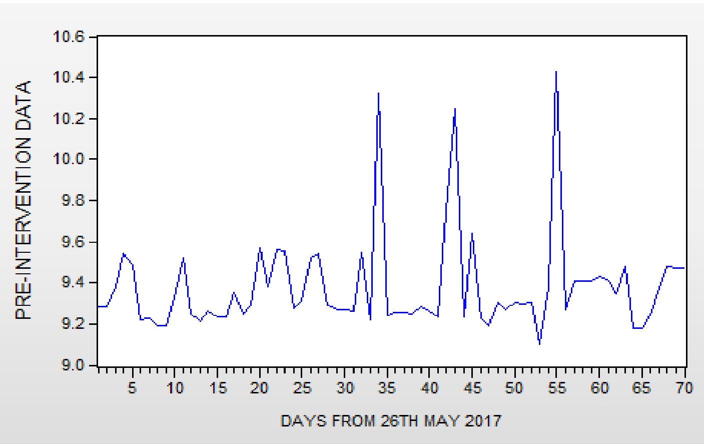



*Figure 2: Time plot of the pre-intervention data*

**Table 1:** Stationarity test for pre-intervention data

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

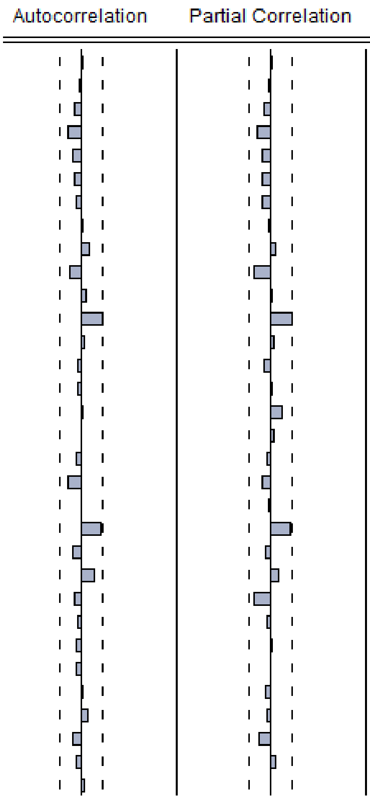
| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -8.021371 | 0.0000 |
| Test critical values: | 1% level | -3.528515 | |
| | 5% level | -2.904198 | |
| | 10% level | -2.589562 | |

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(THNN)
Method: Least Squares
Date: 06/27/18 Time: 22:40
Sample (adjusted): 2 70
Included observations: 69 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| THNN(-1) | -0.979649 | 0.122130 | -8.021371 | 0.0000 |
| C | 9.191098 | 1.145858 | 8.021149 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.489883 | Mean dependent var | 0.002761 |
| Adjusted R-squared | 0.482269 | S.D. dependent var | 0.338780 |
| S.E. of regression | 0.243764 | Akaike info criterion | 0.043327 |
| Sum squared resid | 3.981207 | Schwarz criterion | 0.108083 |
| Log likelihood | 0.505229 | Hannan-Quinn criter. | 0.069018 |
| F-statistic | 64.34239 | Durbin-Watson stat | 1.999803 |
| Prob(F-statistic) | 0.000000 | | |




| | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | 0.020 | 0.020 | 0.0300 | 0.862 |
| 2 | -0.016 | -0.016 | 0.0481 | 0.976 |
| 3 | -0.070 | -0.069 | 0.4173 | 0.937 |
| 4 | -0.153 | -0.152 | 2.2139 | 0.696 |
| 5 | -0.097 | -0.098 | 2.9504 | 0.708 |
| 6 | -0.076 | -0.088 | 3.4026 | 0.757 |
| 7 | -0.061 | -0.092 | 3.7028 | 0.813 |
| 8 | 0.024 | -0.022 | 3.7484 | 0.879 |
| 9 | 0.095 | 0.049 | 4.4890 | 0.876 |
| 10 | -0.121 | -0.175 | 5.7180 | 0.838 |
| 11 | 0.055 | 0.018 | 5.9800 | 0.875 |
| 12 | 0.244 | 0.244 | 11.142 | 0.517 |
| 13 | 0.038 | 0.037 | 11.273 | 0.588 |
| 14 | -0.045 | -0.073 | 11.457 | 0.650 |
| 15 | -0.032 | 0.015 | 11.549 | 0.713 |
| 16 | 0.020 | 0.118 | 11.585 | 0.772 |
| 17 | -0.007 | 0.030 | 11.589 | 0.824 |
| 18 | -0.050 | -0.029 | 11.833 | 0.856 |
| 19 | -0.143 | -0.098 | 13.854 | 0.792 |
| 20 | 0.002 | -0.020 | 13.854 | 0.838 |
| 21 | 0.207 | 0.213 | 18.281 | 0.631 |
| 22 | -0.093 | -0.059 | 19.192 | 0.633 |
| 23 | 0.133 | 0.093 | 21.087 | 0.576 |
| 24 | -0.079 | -0.186 | 21.769 | 0.593 |
| 25 | -0.041 | -0.043 | 21.955 | 0.638 |
| 26 | -0.058 | 0.011 | 22.345 | 0.670 |
| 27 | -0.053 | -0.000 | 22.677 | 0.702 |
| 28 | 0.013 | -0.049 | 22.697 | 0.748 |
| 29 | 0.071 | -0.036 | 23.320 | 0.762 |
| 30 | -0.087 | -0.137 | 24.266 | 0.760 |
| 31 | -0.065 | 0.045 | 24.805 | 0.776 |
| 32 | 0.035 | -0.008 | 24.970 | 0.807 |

*Figure 3: Correlogram of the pre-intervention data*

**Table 2:** Estimation of the pre-intervention arima model

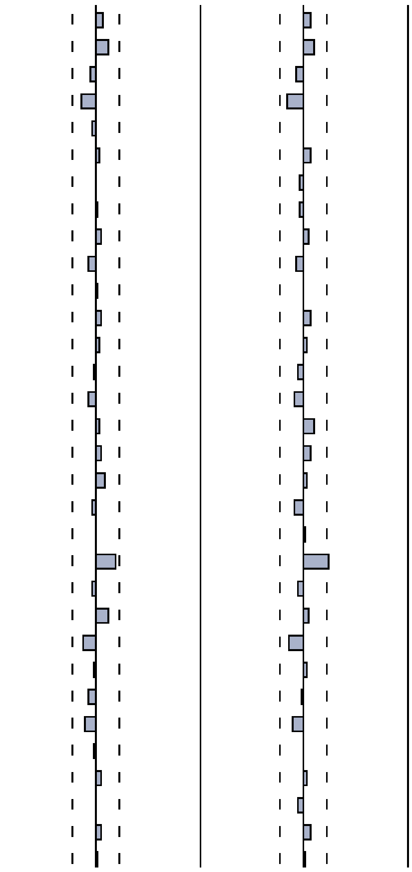
Dependent Variable: THNN
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 06/27/18 Time: 22:53
Sample: 1 70
Included observations: 70
Convergence achieved after 111 iterations
Coefficient covariance computed using outer product of gradients

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| AR(12) | 0.999976 | 5.40E-05 | 18507.05 | 0.0000 |
| MA(12) | -0.750605 | 0.104031 | -7.215188 | 0.0000 |
| SIGMASQ | 0.067141 | 0.007245 | 9.267728 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | -0.177163 | Mean dependent var | 9.380561 |
| Adjusted R-squared | -0.212302 | S.D. dependent var | 0.240547 |
| S.E. of regression | 0.264853 | Akaike info criterion | 1.588842 |
| Sum squared resid | 4.699863 | Schwarz criterion | 1.685206 |
| Log likelihood | -52.60947 | Hannan-Quinn criter. | 1.627119 |
| Durbin-Watson stat | 1.700530 | | |

| | | | | |
|---|---|---|---|---|
| Inverted AR Roots | 1.00 | .87-.50i | .87+.50i | .50+.87i |
| | .50-.87i | .00+1.00i | -.00-1.00i | -.50+.87i |
| | -.50-.87i | -.87-.50i | -.87+.50i | -1.00 |
| Inverted MA Roots | .98 | .85+.49i | .85-.49i | .49+.85i |
| | .49-.85i | -.00-.98i | -.00+.98i | -.49-.85i |
| | -.49+.85i | -.85+.49i | -.85-.49i | -.98 |

Autocorrelation Partial Correlation



| | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | 0.078 | 0.078 | 0.4410 | |
| 2 | 0.119 | 0.114 | 1.4896 | |
| 3 | -0.057 | -0.076 | 1.7378 | 0.187 |
| 4 | -0.153 | -0.160 | 3.5188 | 0.172 |
| 5 | -0.032 | 0.006 | 3.5988 | 0.308 |
| 6 | 0.026 | 0.067 | 3.6504 | 0.455 |
| 7 | -0.007 | -0.030 | 3.6543 | 0.600 |
| 8 | 0.010 | -0.029 | 3.6620 | 0.722 |
| 9 | 0.045 | 0.055 | 3.8308 | 0.799 |
| 10 | -0.072 | -0.067 | 4.2645 | 0.833 |
| 11 | 0.017 | 0.008 | 4.2894 | 0.891 |
| 12 | 0.054 | 0.078 | 4.5430 | 0.920 |
| 13 | 0.029 | 0.027 | 4.6184 | 0.948 |
| 14 | -0.016 | -0.064 | 4.6407 | 0.969 |
| 15 | -0.081 | -0.084 | 5.2375 | 0.970 |
| 16 | 0.040 | 0.104 | 5.3868 | 0.980 |
| 17 | 0.043 | 0.067 | 5.5621 | 0.986 |
| 18 | 0.084 | 0.027 | 6.2533 | 0.985 |
| 19 | -0.039 | -0.085 | 6.4046 | 0.990 |
| 20 | 0.006 | 0.022 | 6.4084 | 0.994 |
| 21 | 0.189 | 0.260 | 10.097 | 0.951 |
| 22 | -0.030 | -0.058 | 10.191 | 0.965 |
| 23 | 0.123 | 0.044 | 11.803 | 0.945 |
| 24 | -0.138 | -0.142 | 13.899 | 0.905 |
| 25 | -0.024 | 0.032 | 13.963 | 0.928 |
| 26 | -0.076 | -0.022 | 14.629 | 0.931 |
| 27 | -0.114 | -0.114 | 16.157 | 0.910 |
| 28 | -0.015 | 0.001 | 16.185 | 0.932 |
| 29 | 0.054 | 0.036 | 16.544 | 0.942 |
| 30 | -0.002 | -0.058 | 16.545 | 0.957 |
| 31 | 0.060 | 0.073 | 17.003 | 0.962 |
| 32 | 0.014 | 0.024 | 17.029 | 0.972 |

*Figure 4: Correlogram of the pre-intervention arima model residuals*

**Table 3:** Estimation of the intervention transfer function

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 06/27/18 Time: 23:33
Sample: 71 180
Included observations: 110
Convergence achieved after 17 iterations
Coefficient covariance computed using outer product of gradients
Z=C(1)*(1-C(2)^(T-70))/(1-C(2))

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C(1) | 1.550841 | 0.096985 | 15.99056 | 0.0000 |
| C(2) | -0.135662 | 0.071245 | -1.904166 | 0.0595 |

| | | | |
|---|---|---|---|
| R-squared | 0.040859 | Mean dependent var | 1.367027 |
| Adjusted R-squared | 0.031978 | S.D. dependent var | 0.102247 |
| S.E. of regression | 0.100598 | Akaike info criterion | -1.737345 |
| Sum squared resid | 1.092965 | Schwarz criterion | -1.688246 |
| Log likelihood | 97.55399 | Hannan-Quinn criter. | -1.717430 |
| Durbin-Watson stat | 0.984348 | | |

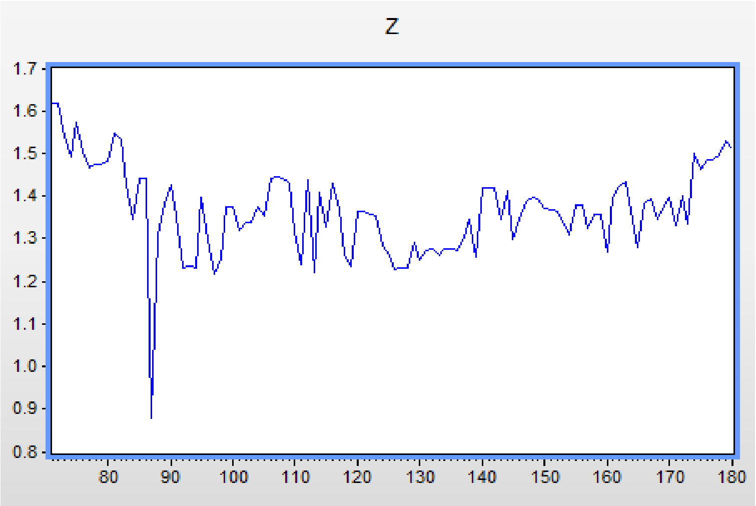



*Figure 5: Graph of intervention transfer function*

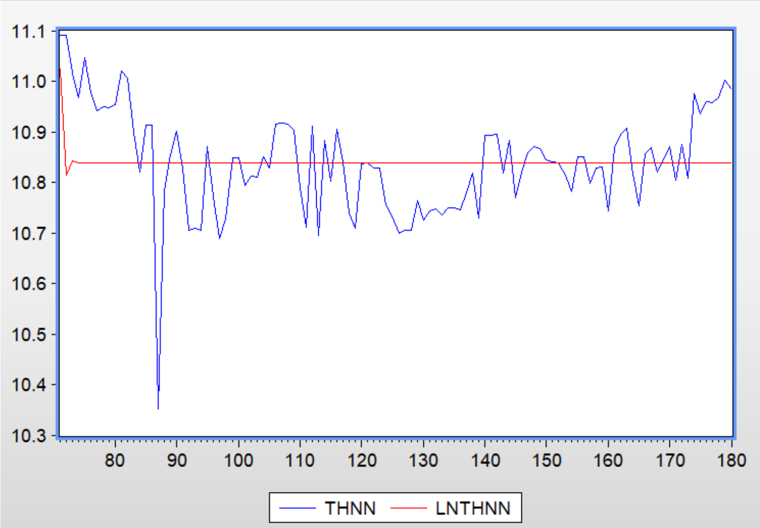



*Figure 6: Post Intervention observations and intervention forecasts of model 1*

**Table 4:** Estimation of the intervention transfer function

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 06/27/18 Time: 23:47
Sample: 71 180
Included observations: 110
Z=C(1)+C(2)*(T-70)+C(3)*(T-70)^2

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C(1) | 1.515651 | 0.024370 | 62.19446 | 0.0000 |
| C(2) | -0.007511 | 0.001013 | -7.411249 | 0.0000 |
| C(3) | 6.56E-05 | 8.85E-06 | 7.417199 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.342923 | Mean dependent var | 1.367027 |
| Adjusted R-squared | 0.330641 | S.D. dependent var | 0.102247 |
| S.E. of regression | 0.083652 | Akaike info criterion | -2.097401 |
| Sum squared resid | 0.748755 | Schwarz criterion | -2.023751 |
| Log likelihood | 118.3570 | Hannan-Quinn criter. | -2.067528 |
| F-statistic | 27.92123 | Durbin-Watson stat | 1.366361 |
| Prob(F-statistic) | 0.000000 | | |

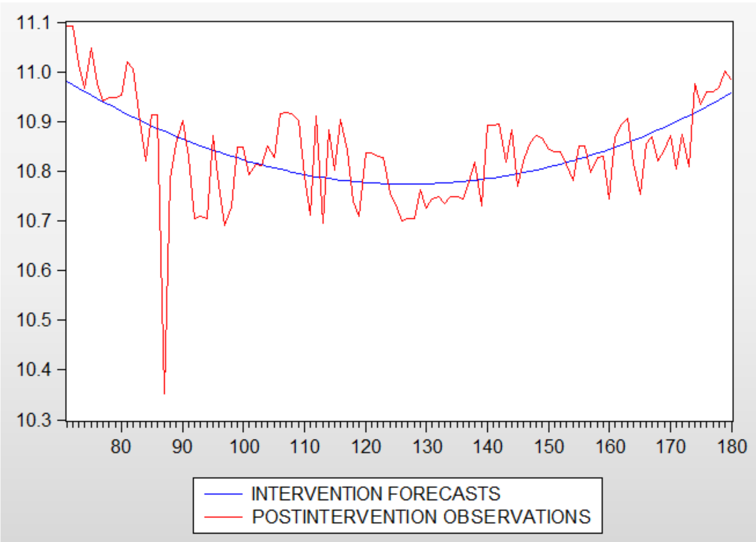



*Figure 7: Post-Intervention Observations and intervention forecasts of alternative model*

**Conclusion**

There is a close agreement between post-intervention observations and the forecast as may be seen in Figure 7. Hence the intervention model (7b) is adequate. The model explains the impact of the economic recession on the amount of Naira which is exchanged for a Thai-baht. This is certainly going to assist Nigeria managers and government officials to put up intervention measures to remedy the situation.

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**Appendix**

**Data**

May, 2017 (from 26th)

9.28229 9.2839 9.3821 9.5392 9.4841 9.2222

June, 2017

9.2291 9.192 9.1939 9.3261 9.5238 9.2485 9.21549.26139.23099.2307 9.3496 9.2482 9.2867 9.5694 9.38119.5639 9.5554 9.2736 9.3099 9.52389.5424 9.2877 9.2692 9.269 9.2652 9.5473 9.217 10.321 9.2393 9.2568

July, 2017

9.2557 9.2514 9.2827 9.259 9.2371 9.7474 10.2448 9.2358 9.6387 9.2303 9.195 9.3071 9.2656 9.3014 9.3003 9.3007 9.1 9.3828 10.4311 9.2666 9.4099 9.4089 9.4103 9.4269 9.41 9.3451 9.44801 9.177 9.181 9. 2396 9.3709

August, 2017

9.4769 9.4732 9.4734 11.0908 11.0908 11.0154 10.9673 11.046910.9769 10.9413 10.9488 10.9471 10.9539 11.0192 11.0053 10.9 10.8196 10.9137 10.9138 10.3517 10.782910.855 10.901 10.8273 10.7056 10.7086 10.7049 10.8705 10.772 10.6896 10.7272

September, 2017

10.8488 10.849 10.7931 10.8126 10.8103 10.8497 10.8276 10.9152 10.9176 10.9152 10.9028 10.77906 10.7121 10.9105 10.6954 10.8827 10.8013 10.9045 10.8409 10.7386 10.71 10.8373 10.8377 10.829 10.8276 10.756 10.733 10.6996 10.7057 10.7057

October, 2017

10.7633 10.7244 10.7439 10.7484 10.7348 10.7493 10.7492 10.745 10.7791 10.818 10.7294 10.8934 10.8926 10.8941 10.8172 10.8838 10.7704 10.8205 10.8578 10.8712 10.8675 10.8445 10.8399 10.8382 10.8139 10.7819 10.8509 10.8506 10.798 10.8282 10.8305

November, 2017

10.7431 10.8691 10.89449 10.9072 10.8159 10.753 10.8557 10.8684 10.8207 10.8441 10.8711 10.8033 10.8748 10.8088 10.975 10.9348 10.9586 10.9585 10.9682 11.0018 10.9829