The International Journal of Engineering and Science (IJES)
|| Volume || 10 || Issue || 9 || Series I || Pages || PP 01-12 || 2021 ||
ISSN (e): 2319-1813 ISSN (p): 20-24-1805

Forecasting Of Exchange Rate In Regime Switch: Evidence From Non –Linear Time Series Model

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---ABSTRACT---
Most of macro- economic variables exhibit cyclical behaviors, state dependency and regime switching and modeling such series using univariate linear time series models fails. This study test for non –linearity and linearity in the behavior of the Naira/US dollar exchange rate where the exchange rate exhibits a regime switching between the year 1970 and 1994 using a non- linear time series class model to describe the structure of the series. For this purpose, a logistic smooth transition regression was detected to fit a yearly data over the sample period 1970 to 2013. There is evidence of non-linearity in the behavior of the series and also evidence of continuous of regimes or allow of smoothing the series as it was revealed from the large value of the smoothing parameter. The model estimated was powerful and eligible in the sense of conformity to economic reality and sounds usefulness for decision makers, forecasters to forecast macro-economic variables that exhibit cyclical behavior through the use of this type non – linear class time series models.

Keywords: *Regime switching, Non –linear Time series, Linearity, Non –Linearity, Logistic smooth Transition regression, State Dependency, Cyclic behaviors*

Date of Submission: 20-08-2021 Date of Acceptance: 04-09-2021

I. INTRODUCTION

A data set containing observations on a single phenomenon observed over multiple time periods are called time series data. Data are usually collected over time. These data which have values and the ordering of the data points have meaning. These data occur in different areas for example in agriculture, economics where macro-economic variables are treated as stochastic random variables. Over the past decades (5-10) via 1930-80, Box Jenkins (1976) have dominantly explain much on time series data where by the forecasting the variables depend on the history of the series (theoretic) in the univariate case. Forecasting of such was based on linear model where the function of the regressor variables is linear. When the function relating the observed time series and the underlying error is linear, then it is called linear time series model. Box Jenkins (1976) pointed out different kinds of linear model to aid in forecasting via Autoregressive model, Moving average model, ARIMA (p,d,q) models and ARMA (p,q) models. The limitation of Box Jenkins (1976) was varied; firstly, where the mean and the variance of the series under study are systematically changing with time and secondly where the series under study exhibit some cyclical behaviors. The appropriate model proposed by Box –Jenkins doesn't suit the series that exhibit such cyclical behavior. The later was to describe by Non – linear time series model. Campbell et.al (1997) made an attempt to distinguish between linear time series and Non – linear time series in relation to the error or shock. A linear time series assumed that the error or shocks are to be uncorrelated but not necessary identically independently distributed but Non – linear models, the error or shock assumed to be identically and independently distributed but there is a linear function relating to the observed time series and the underlying shock. One of the most important of Non- linear class model is the SETAR model which is capable of fitting a series that exhibit cyclical behavior but the limitation of this model is that the transition between various regimes takes place in a discontinuous and sudden manner, but in a realistic modeling their transition should be smooth. Other class of Non-linear model that capture cyclical behavior, regime switching and state dependency are logistic smooth transition autoregressive models, exponential smooth autoregressive, exponential autoregressive models. Over past decades have shown in using these classes of Non-linear models to forecast macro-economic variables that exhibit regime switching since the introduction by Tong (1983) and further revised by Saikonnen & Luukonen (1988), Terasvirta (1994). The evidence of regimes are shown or may be revealed when there is change in government policies or may arise from the perceived shipping time following a profitable deviation Coleman, 1995), also it might be a diversity in agent's belief and heterogeneity in investors objectives Cerrato & Sarantis (2006) or within equilibrium frame work on changes in trade reforms, fiscal policy and soon.

In Nigeria context of exchange rate regime, two regimes were observed; Structural Adjustment program (SAP) and Foreign Exchange Market (FEM). The SAP regime was the first regime where the exchange rate of the Naira depreciated against the major intervention currency (US dollar and Pounds Sterling) from 1970 – 1993. During this regime, investors and capital market were not functioning very well. Some few business tycoons only invested in the capital markets as a result of poor awareness. Also decision makers, business forecasters were not able to make concise forecast since the introduction of the SAP regime. Due to the failure of SAP, the government of Nigeria during the period of 1993 established another regime to strengthen the capital market by introducing the FEM in 1994. During this regime little depreciation of Naira was examined in 1994 and steady depreciation was examined in 1998 & 1999, and appreciated in 2005, 2006, a continuation of depreciation still exists till date since the introduction of FEM. This volatility in exchange rate encourages the business and decision makers to forecast the exchange rate using different econometrics and time series model approach. Onasanya (2014) pointed out that the instability of Naira exchange rate was due expansionary fiscal and monetary policy, structural deficiencies in the economy and inadequate funding, role of authorized dealers and other operational constraints, all these factors were in line with Cerrato & Sarantis (2006). A question is to be raised here, should the SAP regime jump to FEM regime or allowed to be smooth together with the FEM regime? This is the major objective of this research paper. The justification of this question is critically examined by one of the class of Non- linear time series model (STAR model) where its data generating process is to be modeled is viewed as a linear process that switches between a numbers of regime according to some rules. It is assumed that there is a continuum of switches i.e. there is a smooth transition from one regime to the other. These consist of specification, data break points, and estimation and evaluation stages. Thus this is similar to Box Jenkins (1976) linear models.

The second objective of this research work is to see how efficient of Non-linear class time series model aids in forecasting exchange rate when there is presence of regime switching and also thirdly it aims a simple application of the model propose for the understanding of new comer in the field.

The remaining work of this research paper is section as; section 2 focuses on the data sources and research methodology applied, section 3 describes the results & discussion, and finally section 4 focuses on conclusion and possible recommendations

II. DATA SOURCE, THEORY AND METHODOLOGY

2.1 Data source

The exchange rate data during the SAP regime is obtained from Central Bank of Nigeria Statistical Bulletin for the period 1970 to 1994 using the official exchange rate while also the exchange rate data for FEM regime is obtained from Central Bank of Nigeria Statistical Bulletin for the period 1994 to 2013 using official exchange rate. Both regime data are treated as time series data which will cover from 1970 to 2013 as a whole series. The below figure 1 display the graph of exchange rate when taken both series as a whole series and check appendix for individual regime series graphs.

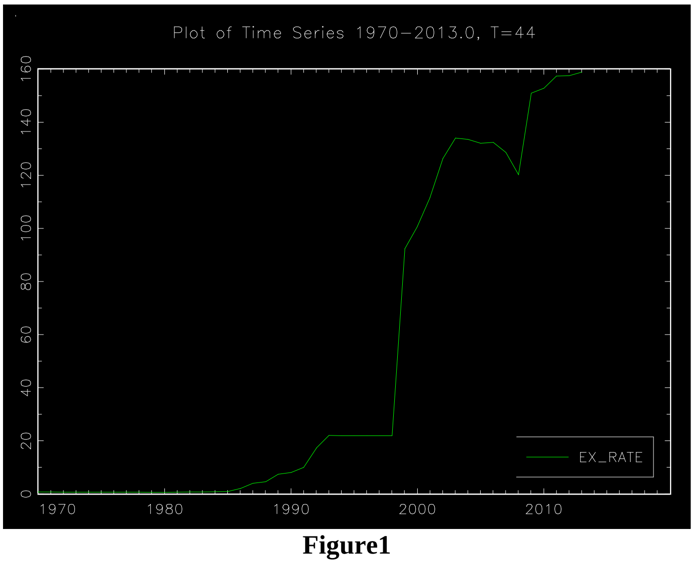

Figure1

The plot of Naira/dollar exchange rate for the period 1970 -2013(As a whole series)

2.2 Research Methodology

The main objective of this research is to check for continuous of regimes i.e. smooth transition from SAP regime to FEM regime, also check for forecasting ability of the model estimated which produces the large value of smoothing parameter. This research encompasses some basic steps to execute. These steps include test of data break points, specification stages, and estimation and evaluation stages. The first step is to critically examine the stationarity of the two series. Both series will be subjected to differencing and the plots of the differenced series will be examined; check appendix for the graphs of the difference series. If there is present of unit root i.e. the mean of the series is consistently moving with time, then the series under study is non-stationary or we conclude that there is linearity. After subjecting the series to stationarity we define clearly the descriptive statistics of both regimes to check which regime has low volatility and also check for series of discrepancies exhibited between the two regimes. Having done this, we proceed ahead to test for structural change or any presence of data break points. Before the test, maximum number of lag order (p) of autoregressive model need to be known and this will be chosen with the smallest possible value of AIC (Alkaike information criteria and BIC (Bayesian information criteria) and together with threshold value (the difference between the two regimes). Once both known, we fit three different equations as summarized as below:

$$y_t = B_{10} + B_{11} y_{t-1} + ...B_{1p} y_{t-p} \quad \left(\mathrm{t}_0 \le T\right)..............eq\left(1\right)$$

$$y_t = B_{20} + B_{21} y_{t-1} + ...B_{2p} y_{t-p} \quad \left(T \le T_1\right)..................eq\left(2\right)$$

$$y_t = B_0 + B_1 y_{t-1} + ...B_p y_{t-p} \quad \left(\mathrm{t} < T\right).....................eq\left(3\right)$$

The null hypothesis for the structural change does not exist against its alternative hypothesis is as follows:

$$H_{10} : B_{10} = B_{20}, B_{11} = B_{21}, B_{12} = B_{22}, ...B_{1p} = B_{2p} ...eq\left(*\right)$$

$$\text{against } \mathrm{H}_{11} : \text{atleast one of the equeation does not hold}$$

This type of break point test was attributed to Chow (1960) and the test was popularly known and extended to cover many econometric and time series model either linear or Non- linear models. For more recent treatments see Andrew & Fair (1988).

The test statistics (PF) is:

$$\frac{p\left(SSR_R - SSR_1 - SSR_2\right)/p}{\left(SSR_1 + SSR_2\right)/T - 2p} \sim X^2\left(K\right)...................eq\left(4\right)$$

Where p is the no. of parameters, SSR_R is the residual sum of squares of Eq (3), $SSR_1$and SSR_2 are the residual sum of squares of Eq (1) and Eq (2) respectively. The test statistics (PF) follow a chi square distribution with p degrees of freedom.

The decision: if H_{10} is not rejected when it is true, hence the p-value obtain would be greater than the observed probability else none of the equation (1-3) holds.

After finding presence of data break points, next is to examine a linearity and non- linearity test. Linearity means jumping from one regime to another regime but non- linearity means smoothing of the regimes or allowing for continuous of regimes. The aim is to reject linearity and accept *non-linearity*. The purpose of non-linearity is to allow for smoothness of both series but this depends on the smoothing parameter (γ). The large value of (γ) gives the more strength of smoothness.

2.3 Specification Stage (Linearity and Non-linearity)

Firstly, we fit a linear model (autoregressive model) at various lag on the stationary series (whole series) and determine the smallest AIC, and BIC value which gives the best lag order (p). the best lag order (p) is used to determine or test for non- linearity, choosing "S_t" transition variable and decide on which class of non- linear models LSTAR OR ESTAR model would be used. The type of transition variable used will determine the shape of distribution. The transition variable either takes the form of lagged dependent of the series under study or been define under a function of time.

To test for linearity /non-linearity, Terasvirta (1994) followed Davies procedures by defining

$$y_t = \phi' z_t + \theta' z_t G\left(\gamma, s_t, c\right) + u_t, \ \ \mathrm{u_t} \sim N\left(0, \sigma^2\right).........eq\left(5\right)$$

Where $G\left(\gamma, s_t, c\right)$ = transition function, (γ) > 0

Where $z_t = \left(w_t', x_t'\right)'$ is an $\left(\left(m+1\right)\times 1\right)$ vector of explanatory variable

With $w_t' = \left(1, y_{t-1}, ...y_{t-p}\right)$ and $x_t' = \left(x_{1t}, ...x_{kt}\right)'$. ϕ and θ are the parameter vector of the linear and the non- linear parts respectively. The transition function $G\left(\gamma, s_t, c\right)$ depends on the transition variable S_t, the slope parameter or smooth parameter (γ) and the vector of location parameter (C). Then the idea is applying a Taylor series expansion on $G(\gamma, s_t, c)$ when the form is known. In this research, the forms are logistic smooth transition autoregressive and exponential smooth transition autoregressive model. Then

$$G(\gamma, s_t, c) = \left[1 + \exp\left(-\gamma \prod_{i=1}^{k} \left(y_{t-d} - c_i\right)\right)\right]^{-1} \text{..........................} eq(6)$$

For logistic smooth transition function

$$G(\gamma, s_t, c) = \left[1 - \exp\left(-\gamma\left(s_t - c\right)\right)^2\right] \text{......................................} eq(7) \ \gamma \succ 0$$

For exponential smooth transition function

Hence the Taylor series of Eq (6) and Eq (7) can be summarized as

$$y_t = B_0' z_t + \sum_{j=1}^{3} B_j' z_t s^j{}_t + u_t \text{....................................} eq(8)$$ With $z_t = (1.z_t)'$. In case S_t is not part of z_t, hence

$$y_t = B_0' z_t + \sum_{j=1}^{3} B_j' z_t s^j{}_t + u^*{}_t \text{...................................} eq(9)$$ Where $s_t = y_{t-d}$, and d = delay parameter.

The null hypothesis tested is $H_0 : B_1 = B_2 = B_3 = 0$ against

At least one of the $B^{'s}$ is not equal to zero (non- linearity)

The test above is called Lagrange test in line with Luukonen approach (Arango and Gonazalez, 2001). In practice, the Lagrange multiplier test of linearity is replaced by F-test in order to improve the size and power of the test. This is the F –test incorporated in this research to determine the type of Non-linear type model use and also to determine the type of transition variable. What we need to do is to consider the value of "d" delay parameter and use a sequence of test nested in Eq (8) to choose between ESTAR (exponential smooth transition auto regression) and LSTAR. Such a sequence is:

$$H_{03} : B_{3j} = 0,\ j = 1......p, \text{..} eq(10)$$

$$H_{02} : B_{2j} = 0 / B_{3j} = 0,\ j = 1......p, \text{...........................} eq(11)$$

$$H_{01} : B_{1j} = 0 / B_{2j} = B_{3j} = 0,\ j = 1......p, \text{.........................} eq(12)$$

And these Eq (10-12) is been related to Eq (5) and Eq (6), Eq (7). If H_{03} is rejected, then a LSTAR model is selected. If H_{03} is accepted and H_{02} is rejected, then an ESTAR model is selected. If H_{03} and H_{02} is rejected a LSTAR model is selected (Non-linearity). However, Granger and Teravista (1993) and Teravista (1994) showed that the strict application of this procedure can lead to wrong conclusion. Instead, this study follows Sarantis (1999) where the p- values for each F-test are computed and the choice of STAR model is made base on the smallest p –value. Moreover, if the rejection of H_{03} or H_{02} is accompanied by the lowest p – value then LSTAR model is chosen. If the rejection of H_{02} is accompanied by the lowest p –value, then the ESTAR models is chosen. Once the model is selected by testing linearity against non- linearity, also determining the delay parameter, transition variable are all known we move ahead an estimate the model parameters in Eq (5).

2.4 Estimation stage

And this is done by non- linear least square (NLS) estimations or maximum likelihood and some optimization procedures (Fan and Yao, 2003). In the case where $u_t \sim N(0, \sigma^2)$, both methods are equivalents. Leybourne et.al (1998) pointed out that estimation can be made more efficient by making use of the fact that when γ and C are fixed, the model are linear in parameters. But the estimation of γ and C to start the estimation is difficult to estimate but the help of grid search method will give an idea of the value of the corresponding γ and C to enter non- linear equations, and the smallest residual sum of squares will be picked to give the best value of γ and C; but this work when S_t transition variable is known. Once good start value of γ and C are known then the unknown parameters of γ and C, ϕ, θ in Eq (5) would be estimated by Newton Raphson algorithm to maximize the condition likelihood function. The large value of γ is of interest. If γ is so small then there is weakness in transition from SAP regime to FEM regime but the reverse would be better of. Once the model is estimated we move ahead on model validation.

2.5 Evaluation Stage

The quality of the estimated non-linear model would be checked against misspecification in the linear case. Two misspecification tests are critically examined.

Test of No error – Autocorrelation: - Teravista (1998) applied Godfrey (1988) test of no error autocorrelation. The procedure is to regress the estimated residual obtain in Eq (5) on lagged residual $u_{t-1}................u_{t-q}$.

The H_0 : No error autocorrelation

H_1 : There is error autocorrelation

Test statistics = $F_{LM} = \dfrac{SSR_0 - SS1_1/q}{SSR_1/T-n-q}$

Where n is the no of parameters in Eq (5), SSR_0 is the sum of residual of STAR model chose in Eq(5), SSR_1 is the sum of square of the residual in the auxiliary regression in Eq(8).

Test of No constant parameter: - we test against the null hypothesis of no constant parameter against smooth continuous change in parameter, assuming γ and C are constant. The null hypothesis of no constant parameter would be $\phi' = \theta = 0$

H_0 : No constant parameter

H_1 : There is continuous change in parameter

F-test approach is used to reject the null hypothesis

Graphical analysis of the error derived from Eq (5) which $\tilde{u}_t = y_t - \phi' z_t + \theta' z_t G(\gamma, c, s_t)$ on transition function, fitted series $\phi' z_t + \theta' z_t G(\tilde{\gamma}, \tilde{c}, s_t)$, and the original series, non-linear part $\theta' z_t G(\tilde{\gamma}, c', s_t)$ are critically examined to cross check errors in the residual. Once diagnosis checking has been considered and thoroughly check, we proceed to check for forecasting instability of the non- linear model estimated. This is the second objective of this research work, we need to check may be the model estimated which generate the large value of smooth parameter conforms or reflects on economic reality and more also how predictive, robust and accurate precision it is.

III. RESULTS AND DISCUSSION

From figure 1, 3and 4, it shows that the whole series was non- stationary since there is presence of upward trend, the mean is systematically moving with time in figure 1 but the case wasn't in figure 2 and 3 which reveals that the whole series is stationary after taken care of 1st and 2nd differences of the whole series. Since the application and estimation of the non-linear class time series model requires stationary series. Further test of stationarity was implored. Table 1 reports univariate ADF test on the whole series.

Difference type	variable	ADF (No Trend)	ADF (Trend)
1st Diff	Ex rate	-3.9683**	-4.1214**
2nd Diff	Ex rate	-7.6238**	-7.5305**

Table 1: ADF test on Exchange rate (whole series)

This test was based on ADF test and was conducted on the levels of exchange rate with respected to US dollar. The full sample period is from 1970-2013 yearly data. For the test, the lag length was chosen using the Schwarz Bayesian information criteria. ** indicate rejection of the null hypothesis at 1%, 5% and 10% level of significance respectively in the ADF test. ADF critical values taken from Fuller (1976) are -3.43, -2.86 and -2.57 while for regression including trend, these are -3.96, -3.41 and -3.13 respectively

Under two assumptions (trend and no trend), table 1 shows that at all levels of significance, non-stationarity were rejected and hence the whole series is being treated as stationary variable at 1st and 2nd difference. However, recent evidence suggests that exchange rate series are most likely to be stationary if one considers a large or enough sample periods Lothian and Taylor (1996). For this reason, we proceed for descriptive statistics of all the variables under study. Table 2 displays the descriptive statistics of all the series under study.

Series	No of Obs.	Mean	Median	Minimum	Maximum	Std. Dev.	Skewness	Kurtosis	C.V
PANEL A (Whole series) 1970 -2013									
Ex rate	42	51.998	19.5922	0.5464	158.8613	62.4256	0.6671	1.6261	1.2
Ex_rate (1)	42	3.765	0.0632	-8.4638	70.4568	12.0856	4.39774	23.847	3.2
Ex_rate (2)	42	7.4996	0.1481	-12.26	78.9156	17.4625	2.89577	11.441	2.32
Ex_rate log	42	2.3472	2.96823	-0.6044	5.0680	2.2730	-0.119807	1.3749	0.968
Ex_rate log(1)	42	0.1293	0.02331	-.06863	1.43966	0.2858	2.95612	12.462	2.21
Ex_rate log(2)	42	0.2577	0.05246	-0.1035	1.5273	0.43976	1.7456	5.0998	1.71
PANEL B (FEM series) 1994 - 2013									
FEM rate	18	114.1801	130.3613	21.866	158.8613	46.4115	-1.19924	3.1354	0.41
FEM_rate(1)	18	*7.6097*	0.838	-8.4638	70.4568	*17.900*	2.6546	9.7097	*2.35*
FEM _rate(2)	18	15.1458	5.57995	-12.26	78.9156	24.774	1.52950	4.4742	1.64
FEM rate log	18	4.57728	4.87022	3.0858	5.06803	0.70222	-1.6183	3.8779	0.15
FEM rate log(1)	18	0.11012	0.0055	-0.06806	1.43966	0.33867	3.6322	14.8071	3.07
FEM rate log(2)	18	0.21977	0.03609	-0.09714	1.52731	0.47002	2.2855	6.59618	2.17
PANEL C (SAP series) 1970 - 1994									
SAP rate	23	4.626	0.7241	0.5464	22.0511	6.8447	1.693	4.51989	1.48
SAP_ rate(1)	23	*0.9213*	0.0512	-0.165	7.3889	*1.8503*	2.3784	8.0769	*2.01*
SAP_ rate(2)	23	1.8490	0.1141	-0.0596	12.1416	3.1860	2.0724	6.6740	1.72
SAP rate log	23	0.56997	-0.3228	-0.6044	3.09336	1.36095	0.78474	1.9635	2.38
SAP rate log(1)	23	0.1499	0.07333	-0.1035	0.81588	0.24926	1.4868	4.09064	1.66
SAP rate log(2)	23	0.299	0.1714	-0.1035	1.50303	0.42842	1.205507	3.7323	1.43

Table 2: The group descriptive statistics for the exchange rate and other related series

Comparing the descriptive statistics in table 2, it reports that the mean of the 1st difference of SAP series is about or 8 times as low as the mean of the 1st difference of FEM series. In terms of spread values, the standard deviations of 1st difference of SAP series is around 9.7 times as low as volatile to the FEM series and its data are well spread than the FEM series. More also SAP series is more stable than FEM series since its coefficient of variation (2.01) is lower than the coefficient of FEM series (2.35). With this little information, we rather smooth both series instead of jumping from one regime to the other.

We proceed further to establish a chow test to determine any structural change. Table 3 reports the chow test using lag 1 as the maximum lag order and 1994, 1995 as the threshold dates.

Base year	Test -statistic	F - Value	P - value
1994	F-statistics	2.728	0.0777812
	Log-Likelihood	5.6306	0.059884
1995	F-statistics	3.461	0.041
	Log-Likelihood	7.02	0.098

Table 3: Chow test for structural change in whole exchange rate series (1970 – 2013)

From table 3 above, it shows that the null hypothesis of no structural change is not rejected at base year 1994 since the p- value to obtain a large value of F –value (2.728) is greater than the observed or exact p – value (0.05) but for base year 1995, the p-value obtained is less than exact p- value (0.05) indicating that there is presence of data break points since the null hypothesis of Eq (*) is rejected.

3.1 Linearity/Non-linearity test

Table 4 reports the suggested non-linear model and the choosing transition variable used to enter the non-linear estimation. The maximum delay parameter was d = 5 which means that the transition variable takes the form $s_t = y_{t-5}$, linearity was rejected and the suggested model was *logistic smooth transition autoregressive model* since the hypothesis of Eq (10) was rejected by the smallest p – value (0.15)

Transition variable	d	F	F_4	F_3	F_2	Suggested Model
$Rate\ d(2)_{t-1}$	1	0.85	0.81	0.71	0.8	linear
$Rate\ d(2)_{t-2}$	2	0.76	0.34	0.82	0.98	linear
$Rate\ d(2)_{t-3}$	3	0.89	0.69	0.9	0.76	linear
$Rate\ d(2)_{t-4}$	4	0.92	0.78	0.45	0.57	linear
$Rate\ d(2)_{t-5}$	5	2.1×10^{-7}	1.1×10^{-6}	0.15	0.24	LSTAR

Table 4: Results of Linearity tests where F is the minimum p – value over the delays d = 1, 2, …5, F_4, F_3, F_2 refers to the p – value of the test in Eq (8) in regards to selection of delay parameter "d".

An autoregressive model was modeled on the 2nd difference of the whole series and the best lag order was selected base on the Bayesian information criteria. The sample period was from 1977 to 2013 yearly data. The asterisk in table 4 indicates that $s_t = y_{t-5}$ is the best transition variable and LSTAR model was suggested.

3.2 Estimation

Determination of starting value of "c" and γ is essential, grid search method was implored to determine the starting value of "c" and γ in the non –linear least square estimation. Table 5 reports the corresponding value of "c" and γ using the residual sum of squares as the criteria to select the best values.

Table 5 reports that the asterisk (*) in the cell (8, 12) indicates that the starting value of γ and "c" are 14.6 & -23.866 are used to compute the unknown parameters in Eq (5). Using the starting value above to enter the non-linear least estimations, table 6 reports the coefficients estimated in the linear and non-linear parts, and the estimated smooth parameter γ and "c".

γ / C	0.5 , 24	1 , 22	2 , 20	4 , 18	5 , 16	6 , 14	7 , 12	3 , 18	8 , 10	9 , 24	10 , 22	11 , 20
-10.99, 99.45	24,-10.99 (865.85)	22,-10.99 (1192.74)	20,-10.99 (1556.58)	18,-10.99 (1932.69)	16,-10.99 (2307.64)	14,-10.99 (2680.7)	12,-10.99 (3052.87)	18,-10.99 (1932)	10,-10.99 (3411.13)	24,-10.9 (859.63)	22,-10.99 (1192.41)	20,-10.9 (1556.5)
-20.99, 89.45	24,-13.38 (-611.65)	15,-20.9 (-27695)	13.4,-20. (-4187.7)	13.8,-20. (1384.56)	16,-17.2 (1996.2)	13.2,-20 (-23879)	12,-17.18 (3012.89)	16.9,-20 (-1393)	10,-20.99 (3350.96)	24,-13.38 (-611.65)	13.8,-20.9 (1169.97)	18,-17.2 (-3414)
-30.99, 79.45	12.3,-23.4 (-13174.4)	10,-27.2 (-2431.2)	20,-11.93 (1558.74)	8.7,-30.9 (278.67)	15.3,-19 (1972.78)	14,-19.57 (-10.679)	10.5,-27 (1720)	16.9,-19 (-4512.2)	8.4,-30.9 (2553.75)	9.9,-30.9 (-7401.5)	20.8,-15.7 (-780.38)	17.6,-15 (-1892)
-40.99, 69.45	24,-10.52 (883.08)	22,-10.5 (1196.3)	7.7,-37.1 (-6881.6)	9.6,-33.4 (-974.46)	9.5,-29.5 (-292028)	10.7,-25. (-28776)	9.4,-29.6 (-17495.)	10.3,-25 (-76475)	9.6,-27.8 (2843.2)	11.02,-25 (-1980.1)	11.1,-25.7 (710.05)	16.6,-18 (-1980.3)
-50.99, 59.45	18.4,-16.7 (770.54)	22,-12.9 (-350.22)	5.6,-47.1 (729.3)	9.1,-31.9 (-5511)	7.1,-35.7 (-5038.2)	10.2,-28 (-5715.8)	7.5,-35.7 (-6281.8)	5.2,-50.9 (-8339.1)	9.5,-31.9 (-14969)	14.9,-20 (-1634.8)	15,-20.5 (-1751.2)	11.7,-24 (-13759)
-60.99, 49.45	24,-11.5 (894.65)	4.4,-57.2 -232.55)	6.5,-41.9 (-3205.5)	7.1,-38.1 (-7302.9)	8.4,-34.3 (-6214.5)	6.9,-38.1 (-6934.7)	9.4,-30.5 (2307.9)	4.9,-53.4 (-8849)	9.2,-30.5 (2582.02)	17.1,-19 (-4716.2)	22,-11.48 (1180.53)	18.4,-19 (-2131.7)
-70.99, 39.45	24,-10.05 (879.038)	17.7,-17 (-1835.2)	7.1,-40.5 (441.92)	5.4,-51.9 (-4529.8)	11.2,-29. (-6518)	7.2,-36.7 (-8385.6)	8.4,-32.9 (-7254.3)	6.6,-40.5 (-2254)	8.2,-36.7 (45.9041)	18.9,-17 (-18768)	17.2,-17.6 (-981.98)	13.7,-25 (-17478)
-80.99, 29.45	18.4,-16.3 (-157.80)	22,-12.4 (959.89)	12.4,-54 (-1638.8)	11.8,-23 (-15160)	5.8,-46.7 (-29682.)	8.5,-39.1 (1580.4)	11.,-23.8 (-120.26)	16.9,-58 (-91343)	9.9,-27.7 (-52293.)	14.9,-20 (-6575)	11.4,-23.8 (-29646)	**14,-23.8 (-424664)***
-90.99, 19.45	24,-11.01 (886.00)	22,-11.01 (1197.33)	7.7,-41.4 (-3886.4)	9.6,-30 (767.11)	7.1,-37.7 (610.23)	12.1,-22 (1761.88)	9.1,-30.5 (1829.5)	6.3,-41.5 (877.68)	8.9,-30 (314.04)	14.9,-41 (-4441.7)	14.2,-18.6 (-1871.7)	17,-18.6 (-5069)
-100.99, 9.45	18.4,-17.2 (-5302)	6.8,-40.5 (177.29)	13.4,-20. (296.26)	15.4,-25 (-5613)	14.2,-21. (592.61)	12,-24.8 -(30209)	8.7,-32.4 (1431.5)	5.2,-51.4 (172.15)	8.4,-32.4 (-71225.)	10.7,-28 (-33785)	15.8,-17.2 (-11158)	15,-21.0 (-2838)
-110.99, 0.55	24,-10.99 (865.922)	4.9,-53.3 (-2198.5)	17,-18.68 (-15738)	4.67,-57 (-2643.2)	7.4,-37.9 (-3718)	14,-22.66 (-9655.1)	7,-37.97 -45286.4)	16.9,-18 (-2281.4)	8,-34.1 (-6632.1)	13.9,-22 (-1471.3)	20.3,-14.9 (997.61	14,-22 (-70397)

Table 5: Grid search values of "c" and γ . The interval starting values are between (0.5, 24), (-10.99, 99.45) for γ and "c" respectively. In each cell, the value in parenthesis is the residual sum of squares and the first two values are the initial starting value of γ and "c" respectively. Check appendix for the graphical representation of the initial starting of grid values.

Variable	Starting value	Estimate	Std	T- statistics	P - value
Linear part					
Constant	-216756.392	-26544.609	1200.059	-0.056	0.0495
$Rate\ d(2)_{t-1}$	-4915939	-288563.970	1118.4576	-0.044	0.2218
$Rate\ d(2)_{t-2}$	-1837675	-304429.515	1110.476	-0.034	0.1495
$Rate\ d(2)_{t-3}$	13875016	-173609.967	1011.478	-0.0258	0.3462
$Rate\ d(2)_{t-4}$	6185430	-156961.993	1781.18	-0.0881	0.9306
$Rate\ d(2)_{t-5}$	6115570	276748.476	12014	0.005	0.16
Non-linear Part					
Constant	2167555	205543.39	1010.478	128.48	0.0495
$Rate\ d(2)_{t-1}$	4915932	288563.7767	1004.469	130.478	0.0395
$Rate\ d(2)_{t-2}$	1837676.25	304429.94	963.48	126.78	0.00145
$Rate\ d(2)_{t-3}$	-138754.25	173609.0507	924.683	110.483	0.0365
$Rate\ d(2)_{t-4}$	-6185427.781	156961.738	897.89	108.43	0.0245
$Rate\ d(2)_{t-5}$	-611556.1875	-27674.6799	850.431	102.438	0.014
γ	14.68	**43.463**	24.45753	1.7771	0.0424
c	-23.86678	-12.45752	3.1116	-4.0036	0.0006

Table 6: Reports of the coefficients in linear and non-linear parts including the estimated smooth parameter and location parameter

The coefficients were obtained from the non-linear least square estimation using Newton Raphson algorithm, and the data series used was 2nd difference of the whole series using sample period 1977 to 2013 of yearly data with total observations of 37. Producing AIC, BIC, HQ, an adjusted R^2 and $R^2$with values 7.63, 8.244, 7.84, 0.813 and 0.74.

Table 6 reports that the substituted starting value of smooth parameter and location parameter yielded a very tangible value of the estimated smooth parameter (43.463). This value is large enough and which means it allows for continuous of regimes and strong, smooth adjustment of the series from SAP regime to FEM regime rather than jumping.

The γ value (43.46341) is correctly signed and significant different from zero since its p- value (0.0424) is less than 5% level of significance. While Sarantis (1999) points to the difficulty in estimating γ, Sarrno (200b) argues that the statistical inference of γ is in a sense not questionable because linearity is been rejected in the earlier test. And this high value of γ still also means that small deviations of the switching variable from the threshold value or location parameter are more likely to place the real exchange rate almost entirely in one regime or other.

3.3 Specification, diagnostic and evaluation stage

Table 7 and table 8 reports the test of no – error autocorrelation and test of no – constant parameter. Table 6 report that the null hypothesis of no – error autocorrelation was not rejected since the p –value of (0.0648) was greater than 0.01 and 0.05 observed p – values, also the null hypothesis of no – constant parameter was rejected since the p – values of the alternative transition functions are less than observed p – values at 1%

and 5%. Hence, concluding that there is continuous smooth change in parameters. The two tests of specification errors indicate that the non-linear LSTAR model derived is good enough and can represent a nonlinear class time series model to fit a series that exhibit cyclical behaviors or non-linearity structures.

lag	F- value	Df_1	Df_2	P -value	$F_{critical}$
3	3.4689	4	10	0.0648	3.478

Table 7: Report of test of no error autocorrelation

Transition function	F- value	Df_1	Df_2	P-value	$F_{critical}$
H_1	6.8432	2	5	0.002646	5.78614
H_2	7.3214	3	5	0.01345	5.409
H_3	6.4312	4	5	0.000187	5.19217

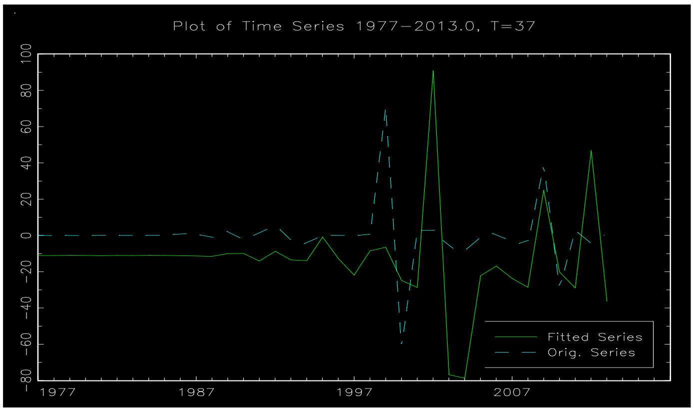

Figure 2: Plot of Fitted series with Original series (1970-2013)

Figure 2 display the graph of fitted series with inline with the original series. Both graphs together were observed after taken the account of the 2nd difference of the whole series. The fitted series is almost closely to the original series and while little errors were observed indicating that the LSTAR model estimated conforms to economic reality. It can be seen from year 2013 the estimated exchange rate was 158.03486 after taken account of differencing, applying backshift operators and necessary re-parameterizing and obtaining each forecasted values.

IV. Conclusion

This research focuses on the forecasting of exchange rate in regime switching using a non-linear class time series model using annual data from sample period from 1970 – 2013. Nigeria have experienced two dynamic regimes so far ever since 1970 till date. The regime of structural adjustment program (SAP) and foreign exchange market regime (FEM). Under the descriptive statistics, it was revealed that the SAP regime was stable and has a low volatility compared to FEM regime. Both regime exhibit some cyclical behaviors and, and also taken both regime series together a cyclical behavior also exist. In modeling a series that exhibit a cyclical behavior, state dependency and regime switching, a typical test of linearity needs to be critically examined. It was found out that taken account of the whole series, at 2nd difference, linearity test was rejected i.e. (jumping from one regime to another was rejected) and alternative (smoothing the series from SAP regime to FEM regime or allowing for continuous of regimes) was accepted. A test of data break points or any presence of structural changes were examined and it was indicated that indeed a data break point exist for the year 1995 where Central Bank of Nigeria established another regime for evaluating the Nigeria currency.

To determine the shape of distribution of the function examined, it is ideal to know the transition variable which aid in estimating smooth parameter, transition function and it was revealed that the transition variable takes the form of lagged five periods of the whole series and a logistic function was generated. Taken both in concerns, the estimated smooth parameter was 43.463 revealing that the large value is properly signed and significantly different from zero and is unquestionable since the aim of this research is to have a large value of smooth parameter. This large value turns to be great for allowing a "continuous of regime" and also smoothen of both series rather than jumping. The model which provides the estimated smooth parameter was found to pass the specification test: no – error autocorrelation, but allowing for change in parameter. The second aim of this research was found eligible since the forecasted value for the year 2013 was 158.03486 which conform to economic reality; hence indicating that the non-linear logistic model derived is a very good and has predictive power in forecasting exchange rate which exhibit non-linearity structures.

The possible recommendation of this research is that researchers, business forecasters decision makers, academicians and research students under study interested in modeling exchange rate should first take account of any presence of regime switching, cyclical behaviors of some macroeconomic variables.

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APPENDIX

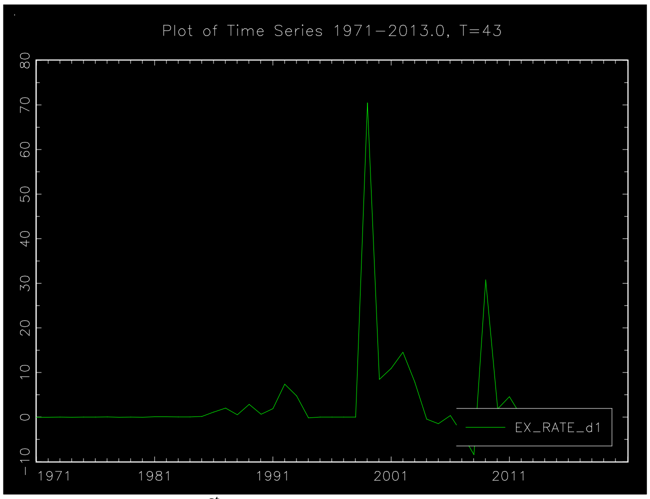

Figure 3: Graph of the 1st diff. of the whole series (1971 – 2013), T=43

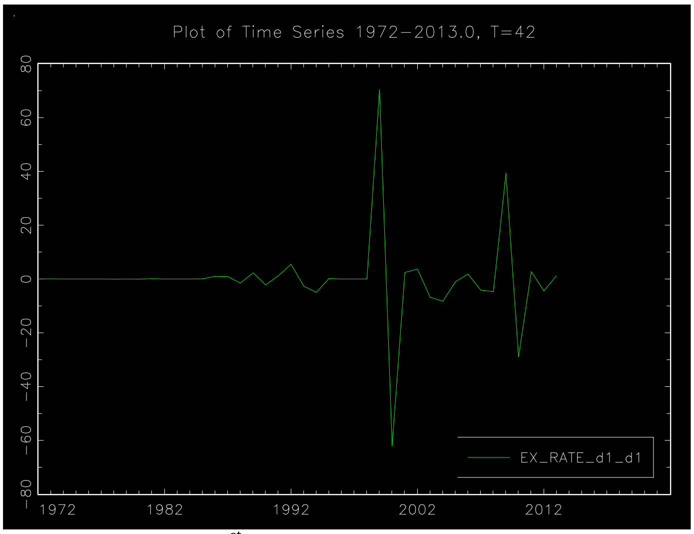

Figure 4: Graph of the 2nd diff. of the whole series (1972 – 2013), T=42

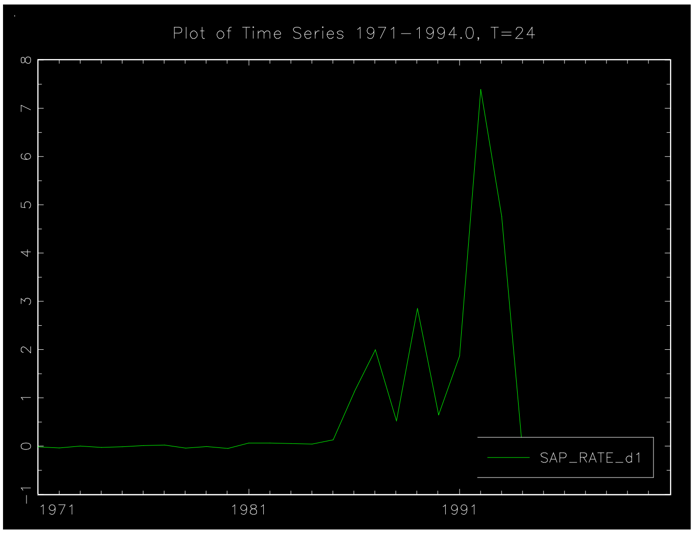

Figure 5: Graph of the SAP series (1971 – 1994), T=24

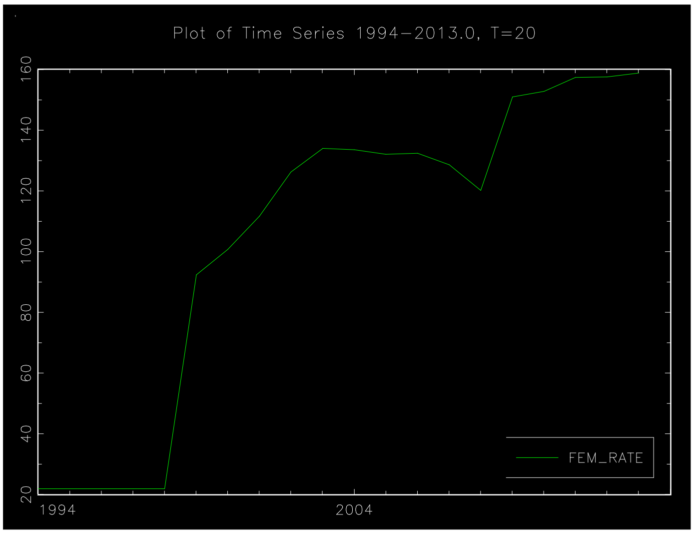

Figure 6: Graph of the FEM series (1994 – 2013), T=20

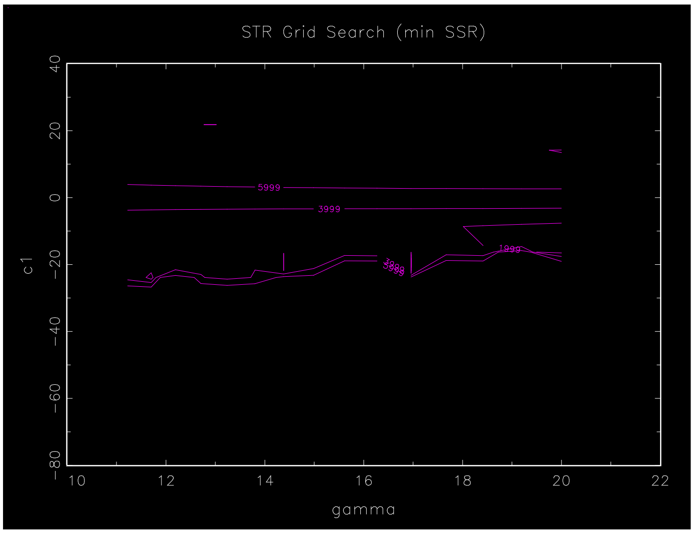

Figure 7: Graph of the limiting starting value of the Grid Search (γ and C) of the minimum residual sum of squares

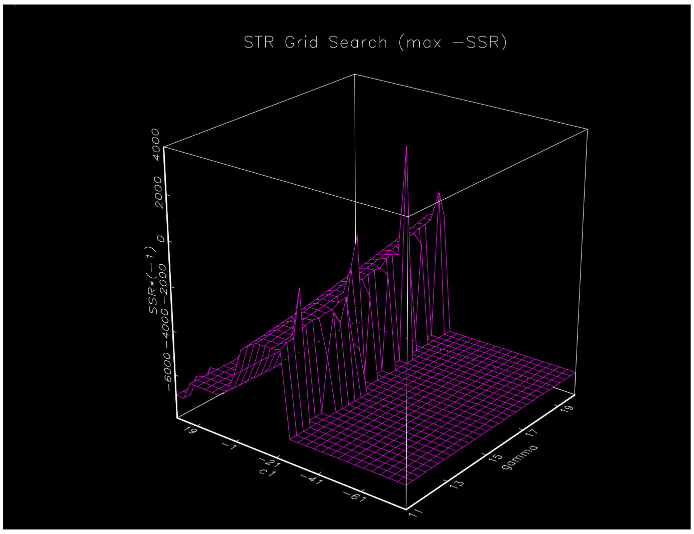

Figure 8: Graph of the limiting starting value of the Grid Search (γ and C) of the maximum residual sum of squares.

ONASANYA, OLANREWAJU. K, et. al. "Forecasting Of Exchange Rate In Regime Switcing: Evidence From Non –Linear Time Series Model." *The International Journal of Engineering and Science (IJES)*, 10(09), (2021): pp. 01-12.