# STATE SPACE MODELLING AND KALMAN FILTERRING OF INTEREST RATE IN NIGERIA: IMPLICATIONS FOR INVESTMENT

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**Abstract**

*The volatile nature of interest rate in the Nigerian economy has informed various interest rate policies and regimes to ensure its stability with a view to enhancing investment in the country. Yet, it is not certain whether interest rate would be investment friendly to galvanize investment in the nearest future. This study has employed the state space modeling and the kalman filtering approaches to ascertain the likely behavior of interest rate in Nigeria up to 2020. Quarterly data on interest rate spanning from 1999Q1 to 2013Q4. The out-of-sample forecast of interest rate showed that from 2014Q1 to 2020Q4 interest rate in Nigeria will hover around an average of 18%. It was concluded that this level of interest rate is not investment friendly, and if efficient interest rate policies are not put in place, investment would be adversely affected especially that of small and medium scale enterprises. The paper recommended that the Central Bank should reduce lending rate to commercial banks and the government should provide infrastructure such as stable electricity supply so as to reduce the cost of doing business of commercial banks in the country.*

**KEYWORDS:** State Space, Kalman Filter, Monetary Policy Rate, Interest, Forecast

## Introduction

The veracity of the relationship between interest rates and investment in an economy is indisputable. Interest rates have a substantial influence on the rate and pattern of economic growth by influencing the volume and disposition of savings, as well as the volume and productivity of investment (Leahy, 1993). Changes in interest rates can significantly affect different types of investments. Changes in interest rates also influence the level of household consumption in a country. Consumption of durable goods is interest rate sensitive, since households will sometimes finance the purchase of "big ticket items" such as automobiles, household appliances, computers, televisions, and other goods through borrowing. Households will respond to higher interest rates by decreasing their consumption of these non-essential items since it becomes more costly to borrow when interest rates rise and consequently decreasing both the demand for the products and the incentive to produce. This is the indirect effect of interest rate on investment. Directly, high interest rate increases the cost of production and adversely affects profitability of investors.

In Nigeria, various interest rates regimes and policies have evolved with a view to making interest rates stable for enhanced investment. From 1987, direct controls on interest rate were relaxed, and this caused interest rate to increase till 1989. In 1992, there was partial deregulation of interest rate; however, this failed to achieve investment friendly objective. Thus, total deregulation of interest rates was adopted in 1996. Between 1999 and 2005 the Monetary Policy Committee (MPC) adjusted the Monetary Rediscount Rate (MRR) in line with the monetary conditions. The failure of the MRR to adequately signal the direction of monetary policy; then, the Monetary Policy Rate (MPR) was introduced in December, 2006. In line with market expectations, the CBN maintained its accommodative stance and kept its benchmark rate unchanged and the MPR was kept at 12 percent. In order to have investment friendly interest rates for the economy; especially for the small and medium enterprises, upon the assumption of office in June, 2014, the new CBN governor re-iterated the commitment of effective management of interest rates in Nigeria for enhanced investment. Thus, it becomes pertinent to model interest rate in Nigeria so as to make forecast ahead, and ascertain the possibility of the Nigerian economy achieving investment friendly interest rate.

Towards this end, this paper has employed the State Space modeling and the Kalman filtering approach to model and filter interest rate in Nigeria using the quarterly interest rate data from 1999 to 2013; and further forecast the likely behavior of interest rates in Nigeria up to 2020 and the implications for investment. The significance of this study is based on the current CBN policy of boosting investment using the instrument of interest rate adjustment. A forecast of the possible level of the interest rate up to year 2020 will significantly influence investment driving policies of the government.

**The Interest Rate Transmission Mechanism**

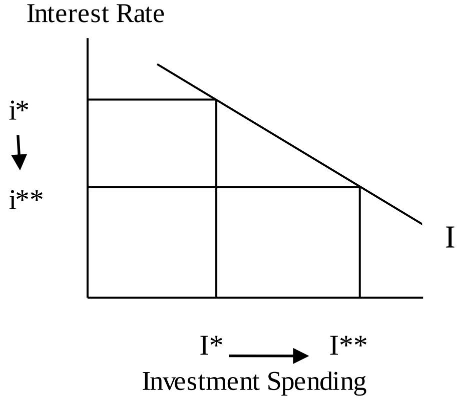
If interest rate is the cost of borrowing money, an increase in the interest rate reduces the overall investment because most of the businesses are partly or wholly financed with borrowed funds. An increase in the interest rate compels companies to put more resources to payoff this investment cost which obviously lowers investment stock. It therefore follows that, investment is a negative function of interest rate as expressed below;

$$I = f\left(\underline{R}\right) \text{------------------------------------------------------------------------------} (1)$$

where $I$ = investment and $R$ = interest rate.

Thus, for investors, interest rate has an inverse relationship with their investment decisions, since it influences the cost of capital for investment. Figures 2a and 2b depict degrees of responsiveness of investment to interest rate variability in an economy.

Business Investment



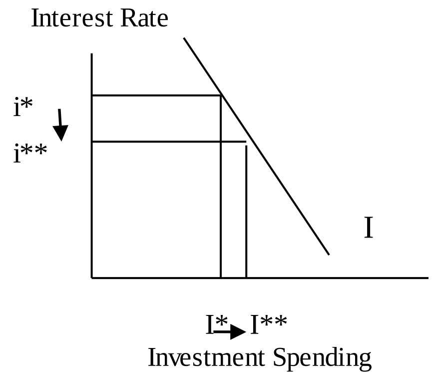
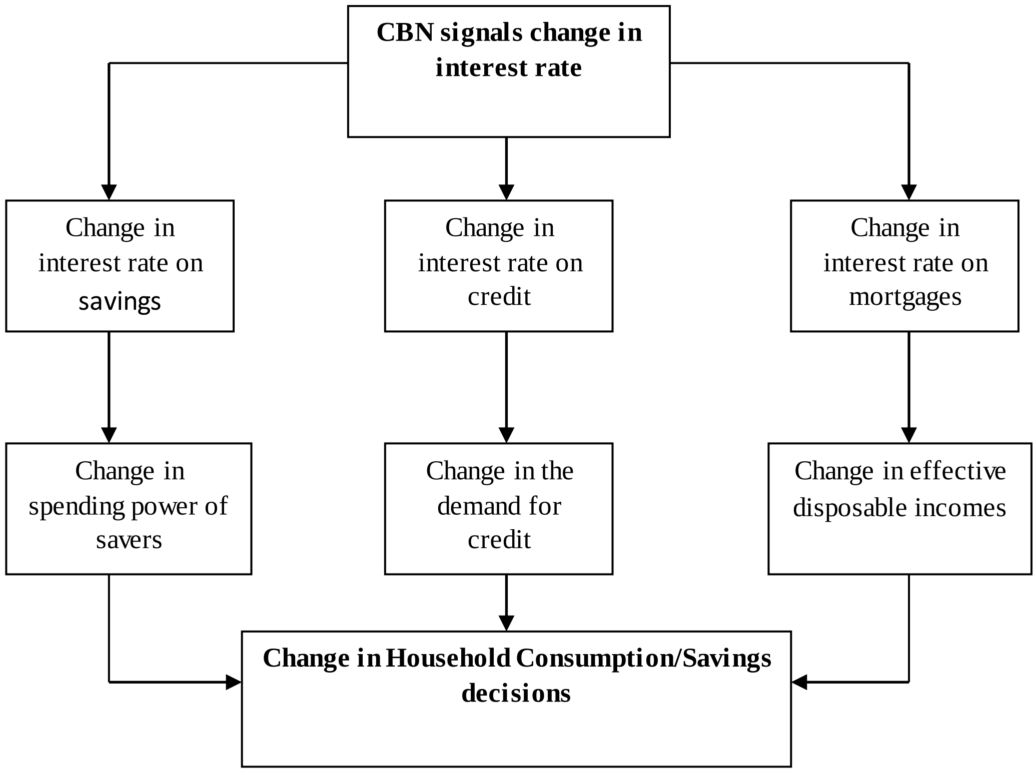




**Figure 2a** **Figure 2b**

**Source: Authors' Construction**

Firms take interest rates into account when deciding whether or not they go ahead with new or existing capital investment spending. A fall in interest rates (from i* to i**) will proportionately increase business confidence and raise the level of investment spending (from I* to I**) as shown in figure 2a. The same is for Figure 2b except that, a fall in interest rate (from i* to i**) will lead to a negligible rise in the level of investment spending (from I* to I**). The figure 2b scenario is more likely to occur according to the Keynes absolute income hypothesis. Also, Keynes is of the view that interest rate changes is not the only factor influencing investment, factors such as returns on investment, government policies will also affect investment.

Household Consumption/Savings




**Source: Authors' Construction**

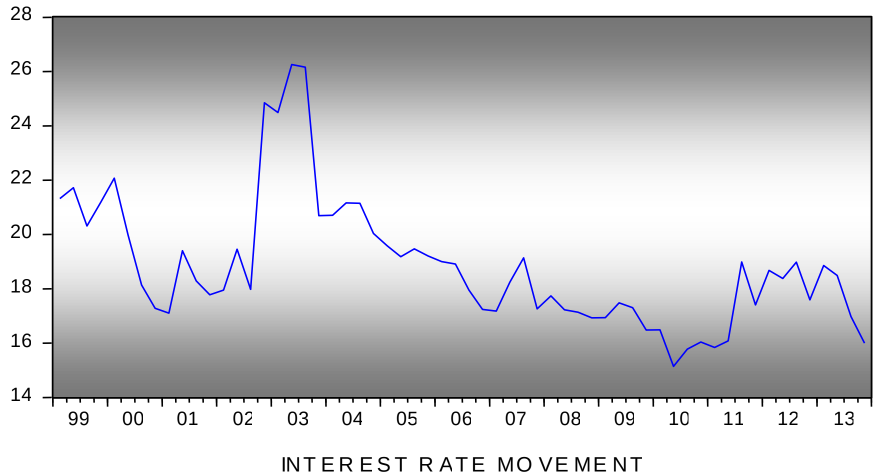
A change in interest rate on savings, credit and mortgages occasioned by change in the interest rate by the Central Bank of Nigeria (CBN) is capable of transmitting a unique change in the spending power of savers, demand for credit and effective disposable incomes respectively. High interest rate on savings induces savings and lowers the spending power of savers while high interest rate on credit discourages borrowing and lowers the demand for credit. Similarly, high interest rates on mortgages increase the cost of mortgages and reduce the demand for most types of housing and vice versa. Conversely, when interest rates on savings fall, there is a re-distribution of income away from lenders (who receive less) towards those with variable rate loans. People with positive net savings also stand to lose out from big cuts in interest rates. Also, lower interest rate on credit encourages people to spend using various forms of credit and boosts demand for "big ticket" consumer durables and high street spending generally. Similarly, if interest rates on mortgages fall, the effective disposable income of home-owners who have variable-rate mortgages with their building society or bank will increase- leading to a rise in their purchasing power. Lower mortgage rate stimulates an increase in new mortgages approvals and generally cause an expansion in housing market activity.

**Interest Rate Policies in Nigeria**

Interest rate policies in Nigeria have undergone series of reforms to enhance interest rate management in order to encourage investment. In August 1987, all controls on interest rates were removed, while the CBN adopted the policy of fixing only its minimum rediscount rate to indicate the desired direction of interest rates changes. Throughout this period interest rate rose up to 1989. This was modified in 1989, when CBN issued further directive on the required spreads between deposit and lending rates. Subsequent to the deregulation of interest rate in the post-SAP era, the spread between deposit and lending rates begin to widen and thus, interest rates increased remarkably. The high interest rate implies that cost of borrowing have gone up in the organized financial market, thereby increasing the cost of operations. The spread rose from -0.25 percent in 1985 to 13.7 in 1992 and a height of 20.7 percent in 2002 (Olawale and Adegoke, 2010).

In 1991, the government prescribed a maximum margin between each bank's average cost of funds and its maximum lending rates. Later, the CBN prescribed savings-deposit rate and a maximum lending rate. Partial deregulation was however restored in 1992 when financial institutions were only required to maintain a specific spread between their average cost of funds and their maximum lending rates. The removal of maximum lending rate ceiling in 1993 saw interest rates rising to unprecedented levels with its attendant negative impact on the real sector investment in 1994, direct interest rate controls were restored. As these and other controls introduced in 1994 and 1995 had negative economic effects, total deregulation of interest rates was adopted in October, 1996. Between 1999 and 2005 the bank through its Monetary Policy Committee (MPC) adjusted the Monetary Rediscount Rate (MRR) in line with monetary conditions. However, due to its inefficiency to effectively signal the direction of monetary policy; a new framework for implementing monetary policy was introduced in December 2006; that is the Monetary Policy Rate (MPR) (CBN, 2010).

In 2011, the MPR was raised by 275 basis points from 9.25 percent to 12.0 percent in order to curb inflationary pressures and encourage borrowing for enhanced investment. The average interbank rate witnessed some volatility in the second quarter of 2012. Volatility was higher on shorter term tenors due to aggressive mop up activities by the CBN. For instance, rates on the call and 7 Days tenors hit as high as 15.46 percent, and 15.79 percent, respectively. In 2013, the monetary policy committee (MPC) refused to raise further the MPR and maintained it at 12.0 percent (Abubakar, 2013). The volatile movement of interest rates in Nigeria is given in Figure 3




**Source: CBN Bulletin, 2013**

**Figure 3 : Trend Analysis of quarterly interest rate in Nigeria (1999Q1-2013Q4)**

The figure shows an erratic movement of interest rates over time in Nigeria. Between 2002 and 2004, interest rate rose and hovered around 27 percent; this was due to the inefficiency of the MRR to effectively signal the direction of monetary policy in Nigeria that necessitated its replacement with the MPR by the MPC. MPR as a monetary instrument depended on adaptive expectation model where monetary authorities used paste information to make future forecast. Thus the inability of adaptive model informed the choice of MPR which uses rational expectations assumptions where both the past and present information are used in making forecast. With the implementation of the MPR, interest rate declined and hovered around 15 percent in 2010; but rose again averaging 17 percent between 2011 and 2013.

**Empirical Literature**

Lot of researches on the relationship between interest rate and investment have concluded that, increase in real interest rate tend to raise the real cost of borrowing and consequently, decrease in the level of investment. For instance, Udonsah (2012) investigated the impact of interest rate on investment decision in Nigeria between 1981 and 2010. Using the technique of Ordinary Least Squares, found that interest rate has negative impact on investment decision in Nigeria.

Joshua and Delano (1990) in a study on “determinants of private investment in Less Developing Countries (LDCs)” on 23 less developing countries for the period of 1975 to 1985 using multiple regression analysis found that, interest rate is inversely related to investment in the countries investigated.

Obamuyi (2009) Studied the relationship between interest rate and economic growth in Nigeria. The study employed cointegration and error correction modeling techniques and revealed that lending rate has significant effect on economic growth. The study then postulated that investment friendly interest rate policies necessary for promoting economic growth needs to be formulated and properly implemented.

Sulaiman et al (2013) examined the rate of interest and its impact on investment to the extent of Pakistan from 1964 to 2014 using Vector Error Correction Model. Their findings conformed to the economic theory and a number of other studies that investment has significant inverse association with real interest rate in Pakistan. Similarly, Larsen (2004) in a study on “the impact of loan rates on direct real estate investment holding period return” in the United State found that real estate investment is inversely related to interest rate. This means that changes in interest rates tend to affect investment decisions of investors.

**Theoretical Framework and Models**

This section explains the modeling procedures involved in the State Space and Kalman Filtering approaches.

**State Space Modelling of Interest Rate**

State state models are models that use state variables to describe a system by a set of first–order difference and differential equations. It is a class of probabilistic graphical model (Koller and Friedman, 2009) that describes the probabilistic dependence between the latent or unobserved variable and the observed measurement. Fitting a model into state space framework produces powerful statistical properties for optimal forecast usually through the process of Kalman Filtering. The state space model structure is a good choice for this study because it requires specifying only one input (interest rate) for quick estimation

Many time-series models used in economics and econometrics are special cases of the class of linear state space models developed by engineers to describe physical systems. The linear state-space model postulates that an observed time series is a linear function of a (generally unobserved) state vector and the law of motion for the state vector is first-order vector autoregression (Rothenberg and Elliot, 1996). A state space approach also called dynamic linear modeling approach applied to univariate models makes it possible to use mathematical framework in the model development.

A state space model consists of a signal (measurement) and a state (transition) equation. The signal equation is responsible for relating the observable data and the unobservable state variables and it can be represented by the following system:

$$y_t = Z_t\alpha_t + C_t x_t + u_t ------------------------2$$
$$\alpha_t = T_t\alpha_{t-1} + D_t x_t + R_t\eta_t ----------------------3$$

where equations 2 and 3 are the signal and state equations respectively. The vector $y_t$ represent the signal and $x_t$ is the vector of the exogenous observed variable. $\alpha_t$ is a vector of the unobserved state variable, so that $y_t$ and $x_t$ are used to make inferences about $\alpha_t$. Collectively, ($C,D,T,Z$) are referred to as the system matrices. In particular, $T$ is a matrix that describes the transition between the states (state transition matrix), $D$ and $C$ are the input matrices, $Z$ is the output matrix and $R_t$ is the system noise matrix.

By assuming that the state space model above is time invariant, the general Autoregressive Moving Average of oder $p$ and $q$ (*ARMA (p,q))* model is specified as

$$y_t = \phi y_{t-1} + ... + \phi_p y_{t-p} + \eta_t + \theta_1\eta_{t-1} ... + \theta_q\eta_{t-q} ------------------------------ 4$$

Where $p$ is the order term of the Autoregressive (*AR*) and $q$ is the order term of the moving average *(MA)*. According to Mehmet (2007), by letting $m = \max(p, q+1)$, then $p = m$ *and* $q = m-1$. Hence the state form of the *ARMA (p,q)* is specified as

$$y_t = \phi y_{t-1} + ... + \phi_p y_{t-m} + \eta_t + \theta_1\eta_{t-1} ... + \theta_{m-1}\eta_{t-m+1} -----------5$$

When $y_t = (1 \ \ 0'_{m-1})\alpha_t$ then, the state equation

$$\alpha_t = \begin{pmatrix} \phi_1 & \phi_2 & \cdots & \phi_{m-1} & \phi_m \\ 1 & 0 & \cdots & 0 & 0 \\ 0 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & & \vdots \\ 0 & 0 & \cdots & 1 & 0 \end{pmatrix} \alpha_{t-1} + \begin{pmatrix} 1 \\ \theta_1 \\ \vdots \\ \theta_{m-2} \\ \theta_{m-1} \end{pmatrix} \eta_t$$

**Kalman Filter**

The kalman filter is a recursive algorithm for producing optimal linear forecasts of $\alpha_{t+1}$ and $y_{t+1}$ from the past history of $y_t$. Assuming that $Z$ and $T$ in equation 2 and 3 are known,

$$\alpha_t = \mathrm{E}(\alpha_t | y_{t-1}) \text{ and } \eta_t = \mathrm{var}(\alpha_t | y_{t-1}).$$

It is a recursive procedure for computing the conditional mean $x_{t|t-1}$ and covariance matrix ($P_t$) of the state vector $x_t$ given $Y_{t-1}$. It is used to estimate the likelihood function of a state space system (Kalman, 1960). After selecting the initial state $x_{1|0}$ and $P_1$, the Kalman filter is often considered to iterate between two steps: time update or prediction and measurement update. The prediction step uses the current state estimate at time $t$, i.e $x_{t|t}$, to produce an estimate of the state at $t+1$ using the state equation:

$$\alpha_{t+1|t} = \mathrm{T}\alpha_{t|t} \text{ ---------------------------------------------------------- } 6$$

Similarly, if $\mu_t$ and $\eta_t$ in equation 2and 3 are normally distributed, the minimum MSE forecast of $y_{t+1}$ at time $t$ is $\mathrm{Z}\alpha_{t+1}$. (Rothenberg and Elliot, 1996). Apart from operating recursively, the Kalman Filter has the advantage of keeping track of the estimated state of the system and the variance or uncertainty of the estimate (Kalman, 1960).

**Preliminary Analysis**

When modeling with ARMA, the time series need to be stationary which means, it should exhibit similar behavior over time inform of constant expected value of autocovariance and to avoid spurious estimates. (Montgomery, Jenkings and Kulahci, 2008). This study therefore identified the stationary properties of the time series (interest rate) and estimated an ARMA model for the quarterly interest rate in Nigeria from 1999Q1 to 2013Q4 which makes up to 60 observations. The choice of the sample size is based on the assumption that, periods of uninterrupted democratic regimes are more favourable to driving private sector investment.

A cursory examination of Figure 3 suggests that the series is non stationary (apparent trend, and moving averages). The observations seem to wander away from a fixed mean, and the variance seems to be non constant over time. This necessitated the application of the Augmented Dickey Fuller (ADF) test of unit root Dickey and Fuller (1979). The result of the ADF test is presented in table 1

**Table 1: Unit Root Test**

| Variable | ADF t-statistics @ Level | ADF t-statistics @ 1$^{st}$ Diff | Mackinno critical value @ 5% | Order of integration |
|---|---|---|---|---|
| Interest Rate | -2.5039 | -8.9289 | -2.9115 | I(1) |

**Source: Authors compilation using Eviews**

Table 1 has confirmed the non stationarity of the interest rate variable in level. However, the variable became stationary after first differencing; hence, the estimation process is based on the differenced data.

After the time series (interest rate) has been stationarized by differencing, we fit an ARMA model to find the value of the parameter that minimizes the error term mostly and as well to determine whether autoregressive (AR) or moving average (MA) terms are needed to correct any autocorrelation that remains in the differenced series. Using the Box and Jenkings (1976) suggestion of one – fourth of the number of observations in the examination of autocorrelation, the autocorrelation function (ACF) and the partial autocorrelation function (PACF) are determined using 15 lags (60/4). The result is presented in table 2

**Table 2: ACF and PACF Spikes and Values**

Date: 09/21/14 Time: 16:20
Sample: 1999Q1 2013Q4
Included observations: 60

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | 0.779 | 0.779 | 38.284 | 0.000 |
| | | 2 | 0.633 | 0.065 | 63.945 | 0.000 |
| | | 3 | 0.486 | -0.064 | 79.373 | 0.000 |
| | | 4 | 0.355 | -0.056 | 87.747 | 0.000 |
| | | 5 | 0.271 | 0.033 | 92.703 | 0.000 |
| | | 6 | 0.223 | 0.055 | 96.139 | 0.000 |
| | | 7 | 0.138 | -0.117 | 97.477 | 0.000 |
| | | 8 | 0.106 | 0.045 | 98.276 | 0.000 |
| | | 9 | 0.068 | -0.011 | 98.610 | 0.000 |
| | | 10 | 0.052 | 0.029 | 98.810 | 0.000 |
| | | 11 | 0.107 | 0.169 | 99.680 | 0.000 |
| | | 12 | 0.158 | 0.068 | 101.62 | 0.000 |
| | | 13 | 0.168 | -0.045 | 103.86 | 0.000 |
| | | 14 | 0.159 | -0.060 | 105.90 | 0.000 |
| | | 15 | 0.126 | -0.023 | 107.22 | 0.000 |

From the table, only the first five autocorrelations are significantly different from zero at 5% level. That is, only the first five autocorrelations extend beyond the 95% confidence intervals indicated by dashed lines. The autocorrelations decay to statistical insignificance rather quickly. We conclude that the mean of the series is probably stationary. An AR model seems appropriate because the ACF decays toward zero rather than cutting off sharply to zero. If the ACF cuts off to zero, it suggests a moving-average model (Mehmet, 2007). The PACF plot on the other hand has a significant spike only at lag 1, meaning that all the higher order autocorrelations are effectively explained by the lag 1 autocorrelation. Alternatively, we can obtain the ideal candidate of AR, MA or ARMA by estimating up to the 2nd lag and selecting the one with the lowest Schwarz information criteria (SC) as shown below upon estimation;

Table 3: AR and ARMA values

**Table 3: Autoregressive Moving Average (ARMA) test of Candidate Model**

| **ARMA(p,q)** | AR(1) | AR(2) | MA(1) | MA(2) | ARMA(1,1) | ARMA(1,2) | ARMA(2,1) | ARMA(2,2) |
|---|---|---|---|---|---|---|---|---|
| **SC** | 3.71 | 4.14 | 4.16 | 4.22 | 3.77 | 3.75 | 3.78 | 4.19 |

The minimum SC (3.71) value is obtained for the AR(1) model (Schwarz, 1978). Thus we consider this model as the ideal candidate.

Furthermore, the appropriateness of the AR(1) model is determined by matching the actual values of both ACF and PACF with their theoretical values as shown the figure below;

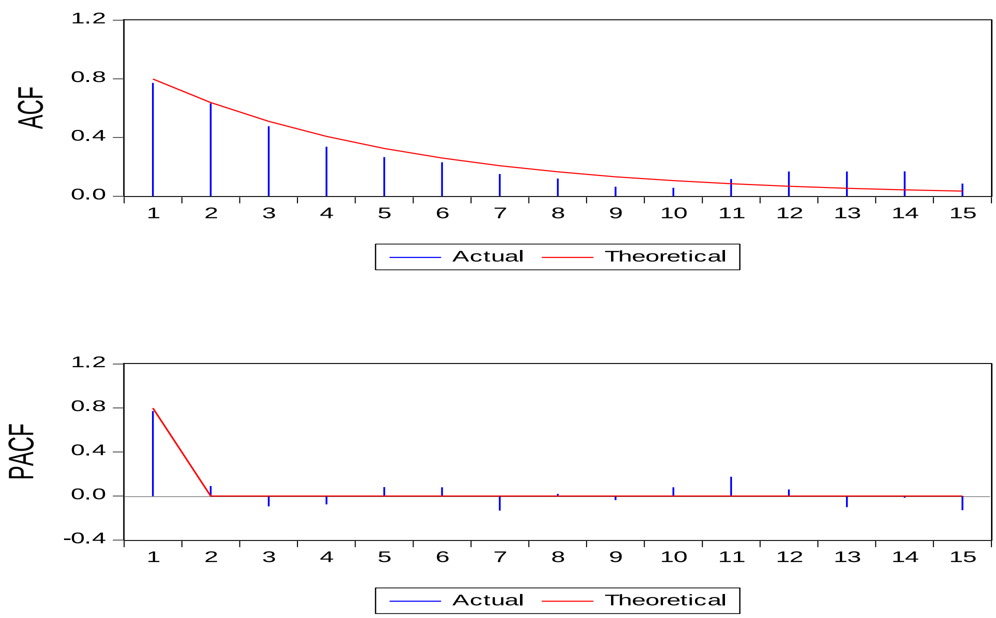



**Figure 4: ACF and PACF Test of Autocorrelation**

Clearly, the theoretical ACF and PACF match all the significant sample ACF and PACF estimates (actual). The AR(1) model produced quite similar autocorrelation function with a merging of sampling error (Mehmet, 2007). Therefore, AR(1) model is appropriate for the quarterly movement in interest rate.

**Data Analysis**

Having identified and specified the appropriateness of the ARMA model, the unknown parameters for the variances and the unobserved component can be estimated using the maximum likelihood (Marquardt) method of estimation. The log likelihood function (a modification of the Gauss–Newton algorithm) used in this paper corresponds to the one given by Durbin and Koopman (2001) and is referred to by Harvey as the prediction error decomposition (Harvey1989). The table below showed the state space estimation of the AR(1).

**State Space Estimation and the Kalman Filtering of AR(1)**

**Table 4: Result of the State Space Estimation of AR(1) Model**

Sspace: AR(1)
Method: Maximum likelihood (Marquardt)
Date: 09/21/14 Time: 22:54
Sample: 1999Q1 2013Q4
Included observations: 60
Convergence achieved after 15 iteration

| | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C(1) | 0.719380 | 0.103528 | 6.948644 | 0.0000 |
| C(2) | 0.836467 | 0.070178 | 11.91916 | 0.0000 |
| | Final State | Root MSE | z-Statistic | Prob. |
| SV1 | 18.34352 | 1.140723 | 16.08061 | 0.0000 |
| SV2 | -1.960278 | 1.721515 | -1.138694 | 0.2548 |
| Log likelihood | -120.7601 | Akaike info criterion | | 4.092003 |
| Parameters | 2 | Schwarz criterion | | 4.161814 |
| Diffuse priors | 2 | Hannan-Quinn criter. | | 4.119310 |

**Source: Eviews7 Output**

Table 4 showed that the model has been fitted on 60 observations using the Marquardt optimization algorithm taking 15 iterations to achieve convergence solution. At convergence, the maximum of the log likelihood is found to be -120.7601. The coefficients C(1) = 0.719380 and (C2) = 0.836467 are the logs of the variances of the error terms for the measurement and state equations respectively. (i.e $\sigma^2{}_{\mu} = 2.0532$ and $\sigma^2{}_{\eta} = 2.3082$ ). The final state of the unobserved component for one-step and 2-step ahead predicted values are 18.34352 and -1.960278 respectively.

**Table 5: Result of the Kalman Filtering of AR(1)**

Sspace: AR(1)
Method: Kalman filter
Date: 09/21/14 Time: 22:35
Sample: 1999Q1 2013Q4
Included observations: 60

| | Final State | Root MSE | z-Statistic | Prob. |
|---|---|---|---|---|
| SV1 | 18.34357 | 1.140629 | 16.08197 | 0.0000 |
| SV2 | -1.960285 | 1.721468 | -1.138728 | 0.2548 |

| | | | |
|---|---|---|---|
| Log likelihood | -120.7601 | Akaike info criterion | 4.025336 |
| Parameters | 0 | Schwarz criterion | 4.025336 |
| Diffuse priors | 2 | Hannan-Quinn criter. | 4.025336 |

**Source: Eviews Output**

The Root Mean Square Error (RMSE) which is the metric of comparison for the forecasting ability of the model is smaller in the Kalman Filter for the SV1 (1.140723) indicating robustness in the one-step ahead forecast than two-steps ahead (SV2). Hence, our forecasts are based on one-step ahead method.

**Interest Rate Forecasts**

In order to forecast the behavior of interest rate, two sets of forecasts were used, namely, the with-in-sample forecast and the out- of-sample forecast. The with-in-sample forecast covers the period of 1999Q1 to 2013Q4. The forecast result is shown in Figure 5.

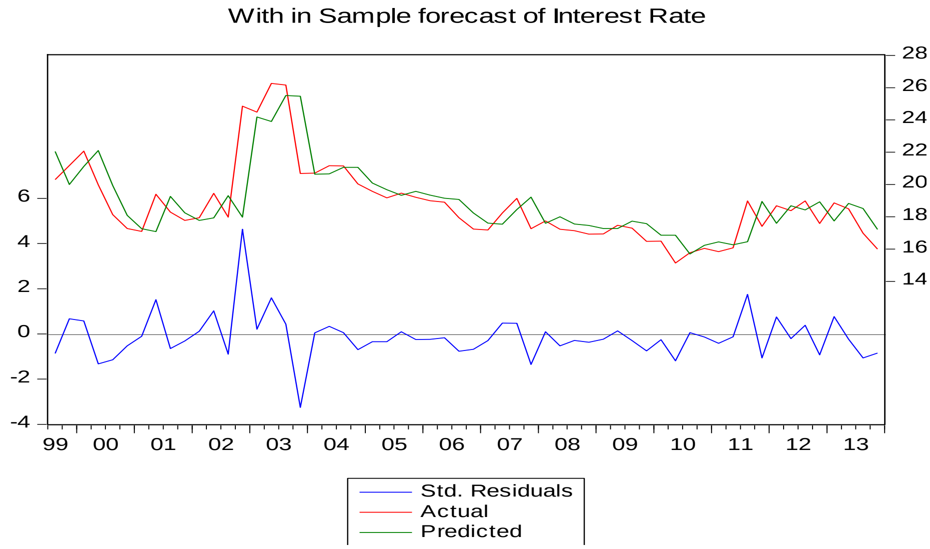



**Figure 5: Actual and Predicted Interest Rate from 1999Q1 to 2013Q4 Forecast**

The figure shows the actual and predicted interest rates forecast in Nigeria from 1999Q1 to 2013Q4. A close examination reveals that the predicted interest rates mimic the actual interest rate movement in the forecasted period. This shows that both the state space and the Kalman Filter models are adequate and suitable for forecasting interest rate behavior in Nigeria. Based on the suitability of the models, it is assumed that, the out-of-sample forecast is likely to yield optimal results. Thus, we proceeded to forecast ahead using a sample range of 2014Q1 to 2020Q4 in order to ascertain the likely behavior of the interest rate in Nigeria and the implications it holds for investment. The out-of-sample forecast on the other hand covers the period from 2014Q1 to 2020Q4 as shown in Figure 6.

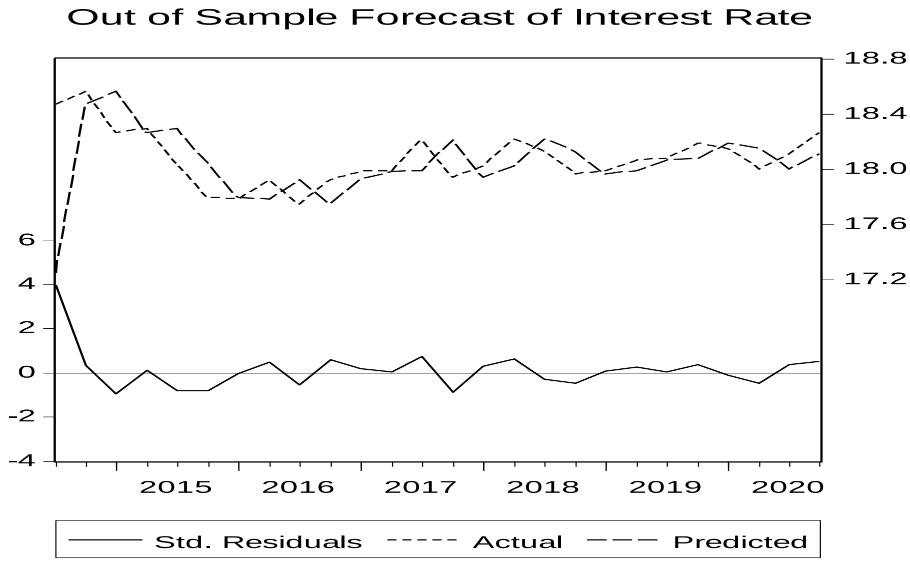



**Figure 6: Actual and Predicted Interest Rate from 2014Q1 to 202Q4 Forecast**

The figure shows that the predicted out-of-sample interest rate in 2014 was approximately 17.2 percent; while the actual interest in the same period was above 18 percent. Furthermore, both the predicted and the actual interest rates averaged 18 percent throughout the out-of-sample period. This suggest that, interest rate would hover around 18 percent from 2015 to 2020; which is slightly above the with-in-sample period prediction (i.e below 18%) in Figure 5.

The implication for investment is that, if the evolving interest rate policies are not efficient to effectively lower interest rate in the country, there would be a likelihood of decline in investment especially that of the small and medium scale enterprises; since the cost of capital would be higher relative to the current cost of borrowing. This is because, high cost of credit does not only affect private sector investment through increased cost of operation but also affects production performance and this has negative effect on liquidity and profitability of the enterprises (Sender, 2000). Similarly, if the forecasted interest rate is allowed to hold, borrowing will be discouraged and investors (small and medium scale enterprises) in Nigeria will suffer from capital constraints which will lower their resilience to risk and prevent them from attaining economies of scale or even folding up in the shortest possible time.

High interest rate charges is a major factor that limits SMEs access to finance, and the limited access to finance is a key obstacle to enterprise growth and entrepreneurship, particularly for young people in Nigeria. According to the World Bank, it is only 6.7 percent of Nigerian firms reported having a loan or active line credit in 2014, and that SMEs' lending is made up only 5 percent of the total commercial bank lending in Nigeria. This basically is because of high interest rate charged by commercial banks that grossly affects the profitability of investors in Nigeria. A situation that has seriously encouraged patronage of informal financial institutions for investment funds which is not healthy for the regulation of the economy.

In order to validate our forecasted results, evaluation statistics were used for both with-in-sample and out-of-sample forecasts; the results are shown in Table 6.

**Table 6: Evaluation of the Forecasts**

| Statistic | With-in-Sample Forecast | Out-of-Sample Forecast |
|---|---|---|
| Root Mean Squared Error | 0.747981 | 0.659584 |
| Theil's Inequality Coeff. | 0.035183 | 0.041885 |
| Bias Proportion | 0.567771 | 0.000000 |
| Variance Proportion | 0.152212 | 0.128692 |
| Covariance Proportion | 0.984124 | 0.761308 |

**Source: Computed from Model Forecasting**

The validatory statistics in Table 6 are the Root Mean Squared Error, the Theil's ineqality coefficient, decomposed into Bias proportion, Variance proportion and the Covariance proportion. The RMSE for both the with-in-sample and out-of- sample periods are low as expected. The Theil's ineqality coefficients for both the with-in-sample and out-of- sample forecasts are also low as expected. The results show that the causes of discrepancies between the actual and the predicted innterest rate is not caused by mean of interest rate. The variance proportions are low as expected, implying that the discrepancies between the actual and the predicted is not caused by the variance of interest rate. The covariances are generally high indicating that the actual and the predicted values are correlated with each other. The synergy of these statistics shows the high predictory power of the model; implying that our findings are valid and suitable for interest rate policies in the Nigerian economy.

**Conclusion, Recommendations and Policy Implications**

It is concluded in this paper that if effective interest rate policies are not formulated and implemented in the country, it will be difficult for the Central Bank of Nigeria (CBN) to achieve its accommodative interest rate target in country which is aimed at financial inclusion. This is because, if apropriate measures are not taken from now till 2020, interest rate can not be below 18 percent. The implication is that, the SMEs which are expected to benefit from investment friendly interest rate regime will be deterred by the 18 percent interest rate, since their profitability will be adversely affected. This high interest rate will affect employment, income, and economic growth of real sector of the economy.

For the economy to achieve an accommodative interest rate regime, the paper makes the following recommendations;

i. The CBN as the lender of last resort to commercial banks must reduce the cost of funds to commercial banks. Since commercial banks charge interest rates based on the cost they obtain funds from the apex bank. This means 12 percent of the MPR plus other cash handling charges of the commercial banks. Thus, to reduce interest rate, the MPR which is the major signal of the direction of monetary policies should be reduced.

ii. The CBN should evolve policies to reduce the cost of doing business of the commercial banks in the country. This is because, commercial banks charge higher interest rates to enable them cover their operating costs such as electricity bills, and other charges. Towards this end, government should ensure stable and uniterrupted power supply in the country. Also, the cash handling charges can be reduced through the cashless policy of the CBN.

iii. The CBN should enforce the N65 Automated Teller Machine (ATM) charges to cushion the maintance cost of managing ATMs in the country, as this would immensely help banks adequately maintain the manegement of the ATM.

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