PREDICTING STOCKS PRICE MOVEMENT IN NIGERIA: A MARKOVIAN ANALYSIS

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Abstract

Stock market is an important platform in an economy that supports several key sectors of the economy as the movement of stock prices in the financial market provides a fundamental indicator in determining the strength and altitude of development in an economy.This study examined the use of Markov chain model to predict stock price movement of banks' stocks with a focus on a deposit money bank (DMB) stock.which is one of highly traded shares in the Nigerian stocks market. The study use daily closing stock prices of deposit money bank between 2010 to 2015. The daily closing stock prices were converted to weekly prices which were used to derive a three- state of increase (Inc), reduction (Redc) and stable(S) states for the application of markovian analysis with the aid of MATLAB software. The model was used to predict the short-run and long-run stock prices of the DMB. The study concluded that the markov chain analysis can be used to determine the steady state of the DMB shares for the period under the three different states. The findings shows that Markov chain technique can be used to estimate stocks' prices movement which will assist investors, stock brokers and other stakeholders in the capital market in taking optimal decisions which will give confidence to the market and thereby attract more participants; which will lead to further growth of Nigerian stocks market.

Keyword: Markov Chain, Transition Matrix, Steady State, Stocks Price Movement, Bank Shares.

1. INTRODUCTION

The stock market is an important platform in an economy that supports several key sectors of the economy (Okonta & Madu, 2017). The movement of stock prices in the financial market according to Choji, Edumo and Kassem (2013) serves as a vital indicator in determining the strength and level of development in an economy. It is therefore, pertinent for the regulatory authorities, investors, traders and key players in the financial market to monitor and understand the movement of various indices, particularly, stock market prices (Okonta & Madu, 2017; Idolor, 2011). This becomes expedient as any fluctuation in stock market prices influences both personal and coporate financial lives, as well as the economic health of a country (see Raheem & Ezepue, 2016; Hamadu & Adeleke, 2018). It should be noted that scholars agreed that fluctuations of stocks' prices are random and most difficult to predict because of influence of various factors on it, such as political atmosphere, general economic conditions, globalisations among others (Onwukwe, Elendu & Samson, 2014).

Notwithstanding, there is a need for investors and other participants to be able to have access to adequate information and methods of analysing such in order to take informed decision regarding movement in stocks' prices. In relation to this, there is need to develop appropriate models or methods to help resolve these problems of predicting stock price movement correctly. Some of these method includes moving averages, regression analysis, markov chain, Hickenmarkov processes, weighted markov chain, neutral network, autoregressive integrated moving averages (ARIMA) models, data minning, among others (Bhusal, 2017; Otieno,Otumba & Nyabwanga, 2015). Markov Chain has been recognized as one of the most appropriate statistical model used in predicting stock market price movement. (Sariyer, Acar & Durak, 2018; Bhusal, 2017, Okonta & Madu, 2017; Raheem & Ezepue, 2016; Samson, 2014; Onukwe& Samson, 2014; Choji *et al*, 2013; Idolor, 2011).This study therefore considered the effectiveness of Markov chain in predicting stock price movement of banks in Nigerian stock market.

2. LITERATURE REVIEW

Mesike, Adeleke and Ojikutu (2018) defined a Markov chain as a stochastic process in which the future developments depends only on the present state and not the history of the process. Markov process was introduced between the year 1906 and 1912 by the Russian mathematician Andre Markov in his study of understanding the behaviour of random process where he developed the theory of Markov chain as a way of modelling such Processes (Zhou, 2015). According to Bhusal (2017), a major property of Markov chain is that the occurrence of any state or situation in the future depends on the present state. Choji *et al.* (2013) expressed that movement in prices of stocks in the Nigerian stock exchange market witnessed three situations which are rise in price, decrease in price and static price over a period of time. However, these changes were caused by a number of factors which includes information (whether negative or positive), business situations, sectors participations, government policy, economic situation among others. Markov chain is a widely used probability model because of its simplicity and can be used to model different types of phenomena (Hao & shijin, 2015; Damjam, 2009). Bairagi and Kakaty (2017) concluded that application of markov chain to predict prices is highly reliable when predicting market prices of potatoes in Nagaon district of Assam. Mesike *et al*.(2018) used the framework of a discrete-time Markov process with a finite state space to examined the desirability of a differentiated pricing system.

Onwuke and Samson (2014) worked on predicting the long run behaviour of Nigerian bank's stocks prices using Markov chain approach and discovered that fifty percent (50%) of the stocks shows higher tendency of increase in price, twenty-five percent (25%) shows a higher tendency of being stable while the remainder of the bank stocks are likely to witness a fall in the long run. Dallah and Adeleke (2018) investigated the Markovian characteristic of the Nigeria stock market using closing weekly data on Nigerian stock market All Share Index (ASI) market, 30- Index and five sub-sectors of Nigerian stock exchange.The study found that compounded returns of the indices for the sectors and the market are highly volatile with rapid tendency for deterioration, and the long-run distribution forecasts established that the market converged to stationarity after six weeks. Rundo, Trenta, Di Stallo and Battiato (2019) employed an advanced Markov-based machine framework for making adaptive trading system in predicting stock prices and its trend more accurately. The study used banks data listed on the Milano stock exchange in Italy and discovered that the method predicts stock prices more accurately.

Okonta, Elem-Uche and Madu (2017) carried out a markovian analysis of the Nigerian stock market weekly index and concluded that weekly returns from Nigerian stock market follows a leptokurtic non-Gaussian distribution, with no trend exhibited and goes into a steady state condition after eight weeks. Idolor (2011) opined that the result from Markov analysis in predicting and analysing stock indices should be refined with the use of other techniques in order to have a robust interpretation, given that the stock market returns are determined by forecastable movements in equity prices.

3. DATA AND METHODS

Data

Daily closing price of a Deposit Money Bank's (DMB) shares was obtained from the Nigerian Stock Exchange Daily Official List(SEDOL), over a five-year period from 2010 to 2015. The daily market closing price of the bank was converted to weekly price by obtaining the average of daily official price from Monday to Friday of each week.The bank was selected due to the dispersion nature of workable data, and the basis of selection emanated from adequacy and availability of data suitable for analysis in addressing the study objective. The transition from one state to another was observed from the data collected and compiled. The share price movement is expected to assume three states which are increase in share price (Inc), decrease (Redc) and stability (Stable) in stocks price movements under different states were and presented in Table 1 below:

Table 1: The share price movement

	Inc	Redc	Stable	

Inc	78	75	8	161
Redc	69	72	6	147
Stable	3	1	0	4
TOTAL	150	148	14	312

Method

Markov Chain Model

A Markov chain is a sequence of experiments that consists of a finite number of states with some known probabilities $P_{ij}$where $P_{ij}$is the probability of moving from state i to state j or simply put as a stochastic process which depends on immediate outcome and not on history. It may be regarded as a series of transmission between different states, such that the possibilities associated with each transition depends only on the immediate proceeding state and not how the process arrived at the state. The probabilities associated with the transition between the states are constant with time. The output from the markov analysis enables a complete description of the system to be obtained in terms of its reliability, availability and resource utilization. Results produced by a markov analysis can then be used within a cost-benefit analysis to help identify the optimal design choice. Markov analysis is a valuable tool for making predictions, as ithas the advantage of being an analytical method. Simple model, such as those used for markov analysis, are often better at making predictions than more complicated models. (see Egerton, 2016; Zhou, 2015; Lawal, Abubakar, Danladi & Andrew, 2016; Silver & Silva, 2021). The Markov chain model can be said to be a sequence of consecutive trials such that

$$P(X_n = J|X_{n-1})$$

$$P(X_n = J|X_{n-1} = i_{n-1}, \dots ., X_0 = i_0 \qquad \{3.1\}$$

$$P(X_n = J|X_{n-1} = i_{n-i})$$

$$P(X_n = j) = P_J^{(n)} = P(x_n = j|x_{n-1} = i)\ P_{ij}. \quad \{3.2\}$$

is absolute probability of outcome ($P_j, \ \ j = 1,2,3, \dots.$) the above is a system of events (actually set of outcomes at any trial) that are mutually exclusive. An important class of Markov chain model is that of which the transition probabilities are independent of n,

we have

$$p\{X_n = j / x_{n-1} = I = P_{ij}\} \qquad \{3.3\}$$

which is a homogenous Markov chain where order of the subscripts in P_{ij}corresponds to direction of transition $i.e, ij$. Hence we have

$$\sum_{i=1}^{n} P_{ij} = 1 \text{ and } P_{ij} \geq 0, \qquad \{3.4\}$$

since for any fixed, the transition probabilityP_{ij} will form a probability distribution. If the limiting distribution of x_n as $n \to \infty$ exist, the transition probabilities are most conveniently handled in matrix form as P = $P_{ij} \quad i.e,$

$$P = \begin{bmatrix} P_{11} P_{12} \dots\dots P_{1n} \\ P_{21} P_{22} \dots\dots. P_{2n} \\ \dots\dots\dots\dots\dots\dots\dots \\ \dots\dots\dots\dots\dots\dots\dots \\ . \\ P_{1n} P_{2n} \dots\dots P_{nn} \end{bmatrix} \qquad \{3.5\}$$

And this is referred to as the transition matrix, which depends on the number of states involved and may be finite or infinite (Hamilton, 1989; Micheal, 2005).

Fixed point Probability vectors

The definition of a regular chain states in terms of powers of P, has the following important consequences. For each j and for k sufficiently large, each of the transition probabilities $P_{1j}^{(k)} \dots. P_{2j}^{(k)} \dots p_{nj}^{(k)}$is close to the same number. That is each of the entries in the jth column of the $k - step$ transition matrix $P(k)$is close to W_1. Another way of saying these is that for large values of k, the $k - step$ transition matrix.

$$P(k) = \ldots\ldots \begin{bmatrix} P_{11}{}^{(k)} P_{12}{}^{(k)} \ldots\ldots P_{1n}{}^{(k)} \\ P_{21}{}^{(k)} P_{22}{}^{(k)} \ldots\ldots P_{2n}{}^{(k)} \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \end{bmatrix}. \qquad \{3.6\}$$

$$P_{n1}{}^{(k)} P_{n2}{}^{(k)} \ldots\ldots\ldots P_{nn}{}^{(k)} \qquad \{3.7\}$$

Is very close to the matrix H that has all row identical

$$\begin{bmatrix} W \\ W \\ \cdot \\ W \end{bmatrix} = \begin{bmatrix} W_1 W_2 \ldots\ldots W_n \\ W_1 W_2 \ldots\ldots W_n \\ \cdots \cdots \cdots \cdots \cdots .. \\ W_1 W_2 \ldots\ldots W_n \end{bmatrix} \qquad \{3.8\}$$

Where $W = (W_1 W_2 \ldots\ldots W_n)$

The vector W is called the fixed point or stationary vector and this observation is supported by calculating higher powers of P. That is the rows(W_1 W_2 . . . W_n)

The rows are supposed to add up to 1 but do not sometimes due to round- up errors.

Thus,Suppose P is a transition matrix of a regular Markov chain then

i. P^n approaches a stochastic matrix H as $n \to \infty$
ii. Each row of H is the same probability vector W =(W_1 W_2 . . . W_n).
iii. The components of W are all positive. (choji *et al.*,2013)

Derivation of Three State Transition Matrix

The transition matrix we would require involves three states only as the stock assumes basically three states. The states are the chance that a stock decreases, that it remains the same (stable) and that it increases. We state the three state as follows:

Inc= Bank share price increases

Redc = Bank share price decreases

Stable = Bank share price remains the same

Matrix of transition probabilities provides a precise description of the behavior of Markov chain. Each element in the matrix represents the probability of the transition from a particular state to the next state. The transition probabilities are usually determined empirically, that is based solely on experiment and observation rather than theory. In other word, relying or based on practical experience with reference to scientific principles. Historical data collected can be translated to probability that constitute the Markov matrix of probabilities.

To compare the probability matrix for Markov process with three (3) states, one can complete a table as shown in the table below.

Table 2: Transition Matrix

$State$	1	2	3	$Sum\ of row$
1	P_{11}	P_{12}	P_{13}	T_1
2	P_{21}	P_{22}	P_{23}	T_2
3	P_{21}	P_{32}	P_{33}	T_3

Each entry P_{ij} in the table refers to the number of times a transition has occurred from state i to state j, the probability transition matrix is formed by dividing each element in every row by the sum of each row.

Result and Discussion

The transition from one state to another from the share price movement were used to obtain the transition probability matrix.

Table 3:Transitional Probabilities

	Inc	Redc	Stable	
Inc	0.4845	0.4658	0.0497	1
Redc	0.4694	0.4898	0.0408	1
Stable	0.7500	0.2500	0	1

Source: Researcher's computation, 2022

The information was used to obtain the transition probability matrix as presented below.

$$P_{DMB} = \begin{bmatrix} 0.4845 & 0.4658 & 0.0497 \\ 0.4694 & 0.4898 & 0.0408 \\ 0.7500 & 0.2500 & 0.000 \end{bmatrix}$$

This is represented in the diagram below.

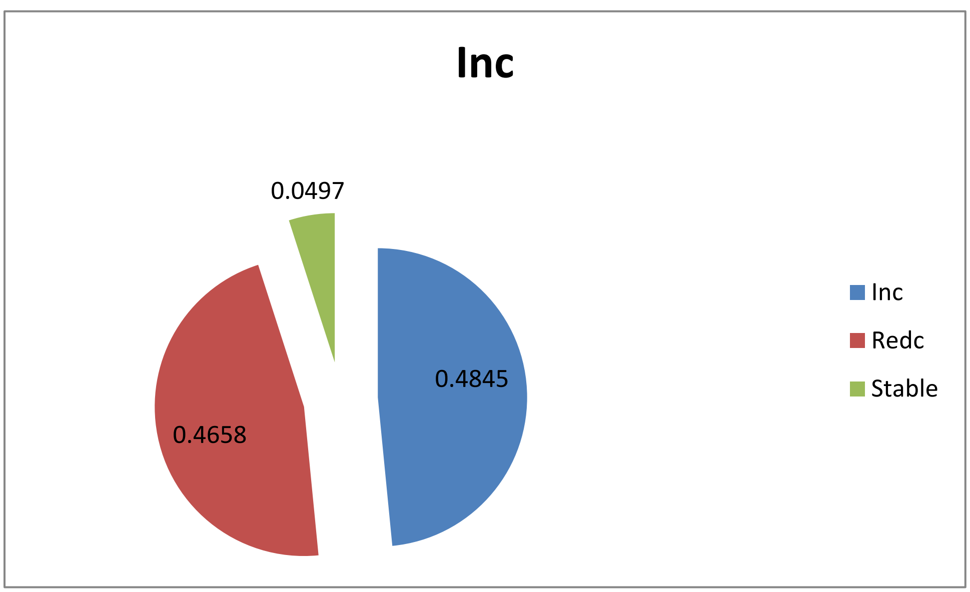

Figure 1;

Increase in share price of the DMB.

The diagram explained that if a deposit money bank shares starts with an increase, there is a probability of 0.4845 of a further increase whereas the probability of a reduction of the share price of the bank after starting with an increase is 0.4658, and a probability of 0.0497 of the banks' shares that increases initially will remain the same stable.

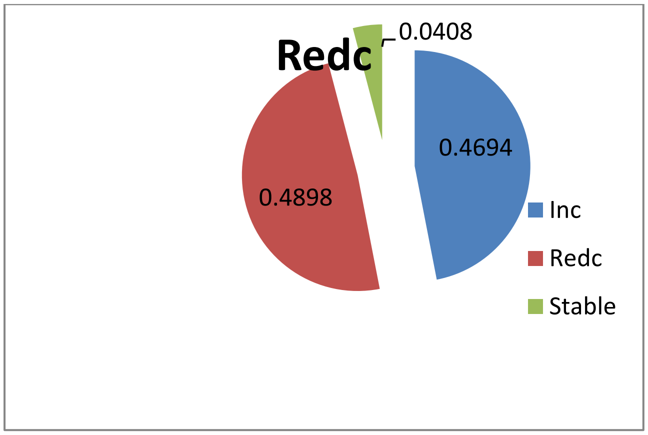

Figure 2: Reduction in share price of A (DMB)

This shows that there is a probability of 0.4694 that the DMB shares that reduces initially will increase, while there is a probability of 0.4898 of the DMB that reduces will further reduce and that after initial reduction in price of the DMB the probability of it being unchanged or remain stable is 0.0408.

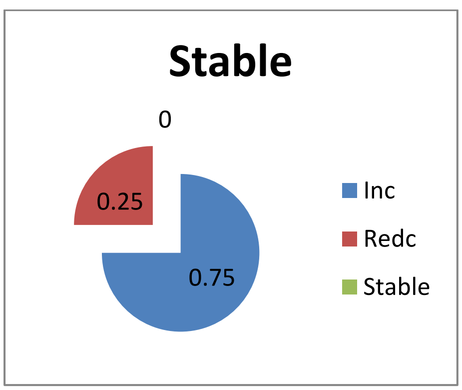

Figure 3: Stable states in share price of A (DMB)

With an initial stable state, a (DMB) shares has a probability of 0.7500 of an increase and a probability of 0.2500 reduction from an initial stable state. However, the probability that it will still be stable after starting from a stable state is 0.000.

Determination of initial state vector

The three states, i.e. movement of stock price of the DMB are increase (I) reduction (R) and stable state (S). The initial state vector $n_0 = (n_1 + n_2 + n_3 = 1)$ where $n_1$is the Probability of an increase, n_2 is the Probability of a reduction and n_3 is the Probability of a stable state. The initial state vector n_0 is the probability of the stock price of a deposit money bank increasing, reducing or remaining stable. The probability can be calculated thus:

$$n_1 = 161/312 \; ; \; n_2 = 147/312\underline{:} \text{ while } n_3 = 4/312 = 0.5160 \quad 0.4712 \quad 0.0128$$

Therefore, the initial vector can be constructed as presented below:

$$n(0) = (0.5160 \quad 0.4712 \quad 0.0128)$$

Derivation of states probabilities for forecasting movements of a (DMB)'s shares

With the above use of market analysis, the state probabilities for various periods can be obtained by multiplying transition probability matrix with initial state vector i.e. $N(1) = n(0)\,P$. Where$n(0)$ is the state vector for P^{th} state. P is the transition probability movement of the end of 312th week for the deposit money bank.

$$N(1) = n(0)\,P = \begin{pmatrix} 0.4845 & 0.4658 & 0.0497 \\ 0.5160, & 0.4712 & 0.0128 \\ 0.7500 & 0.2500 & 0.0000 \end{pmatrix}$$

$$= (0.4804, \quad 0.4740, \quad 0.0456)$$

The above indicates that there is a very high probability that the share price of the DMB will increase with a probability 0.4804 in 313^{th}week, reduces with a probability of 0.4740 and be stable with a probability of 0.0456 in the 313^{th} week

Estimation of long run movement of the (DMB) share

In order to estimate the long-run behaviour of share price movement of the (DMB) shares, the higher order transition probability motion of the bank share movement was computed and the result presented below:

$$p = \begin{pmatrix} 0.4845 & 0.4658 & 0.0497 \\ 0.4694 & 0.4898 & 0.0408 \\ 0.7500 & 0.2500 & 0.0000 \end{pmatrix}$$

$$P^2 = \begin{pmatrix} 0.4907 & 0.4663 & 0.0431 \\ 0.4879 & 0.4688 & 0.0433 \\ 0.4807 & 0.4718 & 0.0475 \end{pmatrix}$$

$$P^5 = \begin{pmatrix} 0.4890 & 0.4677 & 0.0434 \\ 0.4694 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \end{pmatrix}$$

$$P^{10} = \begin{pmatrix} 0.4890 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \end{pmatrix}$$

$$P^{15} = \begin{pmatrix} 0.4890 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \end{pmatrix}$$

$$P^{20} = \begin{pmatrix} 0.4890 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \end{pmatrix}$$

$$P^{25} = \begin{pmatrix} 0.4890 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \end{pmatrix}$$

$$P^{30} = \begin{pmatrix} 0.4890 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \\ 0.4890 & 0.4677 & 0.0434 \end{pmatrix}$$

From the probability matrices presented above, there is an indication that equilibrium will be attained after the 5^{th} year i.e. P^5. This means that, the share price movement of the DMB will be in steady state after five years (P^5). This means that there is high probability that the deposit money bank share price will increase upon reaching the steady state, notwithstanding the fact that whether it has increase, or remain stable or there is an initial reduction at 0.4890. There is a probability of 0.4677 that the DMB share price will reduce irrespective of its initial state i.e. increases, reduces, or stable.Whereas the probability of share price of the deposit money bank remaining unchanged or stable is 0.0434 after the 5th year, irrespective of its initial state.

Predicting long-run probability of the DMB shares movement as a steady state

If the share price of the deposit money bank is in a given state, with initial state vector $n(0) =$ (0.5160, 0.4712, 0.0128), probability that the share price will increase reduce or remain stable in a steady state condition is given below:

$$[0.5160 \quad 0.4712 \quad 0.01280]\begin{bmatrix} 0.4889 & 0.4677 & 0.0434 \\ 0.4889 & 0.4677 & 0.0434 \\ 0.4889 & 0.4677 & 0.0434 \end{bmatrix}$$

$$[0.4889 \quad 0.4677 \quad 0.0434]$$

This shows that even if we do not know where the share price movement starts, we should be able to predict the different states in the long run. After five years i.e. on reaching steady state the probability of the bank's shares increasing is 0.4890, reducing is 0.4672 while the probability of share price of the DMB unchanged on the long run is 0.0434.

4. CONCLUSION AND IMPLICATION OF THE STUDY

The major aim of the study was to predict stock price movement of a deposit money bank in Nigeria as the movement of stock prices in the financial market, serves as a very important indicator in determining the strength and level of development in an economy.The findings of this sudy show that Markov chain technique can be used to make prediction of movements in share prices of banks with a focus on the deposit money banks' stock. The DMB shares are expected to reach a steady state in the fifth year on the long run. It also makes the prediction of share price movement predictable on the Short and long-run. The result shows that the probability of increase in share price of the deposit money bank is higher than reduction in share price of the bank and that of probability of the bank's share price being unchanged on the long run. It should be noted that the prediction should be taken in cognizance of other factors that affect share price movements such as government policies, political environment, and economic conditions among others.

In view of the aforementioned, it is suggested that investors and stock market experts ,particularly, in the area of equity stock should explore the use of the markov chain in their portfolio selection which will help instill confidence in them and further attract potential investors into the market as it aid the prediction of stock prices and determination of state of equilibrium or steady state

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