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Application of Markov chain to share price movement in Nigeria (1985–2019)

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Abstract

The study evaluates the movement of share prices in the Nigerian stock market. Markov chain approach provides a successful analysis and prediction of time-series data (1985–2019) which reflects Markov dependency. The probability α and β was estimated, and the expectation of the monthly increase (E(I)) and decrease (E(D)) of the share price index was obtained as 5 months and 3 months, respectively. The steady-state probabilities π_1 and π_2 were obtained as 0.335 and 0.665, respectively, independent of the initial conditions. The results observed that as the years rolled, the monthly share prices continued to increase due to increased activity in the stock market. In addition, further investigation shows that share price movement and stock market performance influence economic performance. Based on the findings, the Nigerian government and the market authorities should initiate policies that reduce arbitragers' ability to forecast and beat the markets to forestall investors' confidence. Hence, investor property rights protection, discouragement of insider trading, and ensuring that local or domestic investors are enlightened about the stock market and the inherent benefits in Nigeria will enhance stock market efficiency and growth.

Keywords: Markov chain, Share price, GDP growth rate

JEL Classification: C53, G10, O40

Introduction

The ongoing debate encompassing the movement of share prices of listed companies in the case of Nigeria has formed a significant motivation for this study and insight into the market performance [29, 37, 39, 40]. Conceptually, appreciation of share prices indicates how valuable and viable the firms that form part of the private sector are. Furthermore, when share prices rise, it translates to an increase in market capitalisation, which measures the market performance and the financial market development. However, some increase in share prices is not market-driven but caused by speculators whose aim lies in beating the market to make an abnormal profit. In this situation, the investors' confidence is deterred, reducing the level of investment and economic activities in the country irrespective of the relationship between financial performance and stock market share values of listed corporations (Uwalomwa et al. [48]).

The increasing speculation of share prices may be perceived as a tradition, especially in emerging economies like Nigeria, but its consequences on investors' confidence, investment level and general market performance should not be neglected (Uwalomwa et al. [48]; [29]. As such, to promote investors' confidence and market performance, equitable information dissemination is relevant to mitigate the predictability of share price movement in the Nigerian market. The information symmetric could deter the belief of the fundamental school of thought and the technical/chartist. The former is of the view that current share prices can be predicted using the information on financial instruments such as bonuses issues, and dividends among others, while the latter emphasises predictive power using past information on

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share prices only [6]. Reiterating the proposition of fundamentalists and the technicalists, Fama [18] argued that it can only be possible when the market is inefficient and thus suggest that if the market prices of financial instruments like stocks, shares, bonds, futures and options contracts reflect all publicly available information, it will be difficult, if not impossible to predict the market using current or past information on any of the financial instruments. Also, Milan and Ladislav [34] opined that as long as the distribution of financial time series changes over time, forecasting of the stock market is difficult, especially in an efficient market—the ability of the market prices to reflect all available and relevant information. This entails that the interaction of demand and supply determines the share prices, and any attempt by investors to manipulate the system will yield zero abnormal revenue (Fama [18]).

Other than the fundamentalists and the technicalists attitude on share prices forecasting, the inherent macroeconomic instability in Nigeria also constrained the stability of share prices of many listed firms with the Nigerian Stock Exchange (NSE), especially the second-tier market (i.e. the market where the securities of smaller firms which are unable to meet the requirements for main market or first-tier market of the exchange are listed), and this has affected the performance indices such market capitalisation, total share traded and volume of shares traded [29]. Hence, the current instability in the exchange rate and the high rate of inflation affects the level of investment and market growth. Consequently, an increase/decrease in the exchange rate could result in a proportional increase/decrease in share prices, and the rising inflation causes a significant reduction in consumer spending and thus, make stocks to be more volatile [43]. Therefore, to incentivise increasing volume of trade and avoid volatile share prices capable of hindering investors' trust and cross-listing of stocks, the Nigerian stock market must be efficient in reflecting all the relevant and available information to share prices. This will promote investors' confidence and also facilitate improvement in the market indices.

In the effort to ensure a robust and efficient stock market that can incorporate publicly available and relevant information instantaneously and promote financial development in general, the Nigerian government through the Central Bank of Nigeria (CBN) initiated and implemented several policy reforms to reposition the macroeconomic and institutional environment needed to instil confidence and ensure property rights protection of the investors, poised to create a viable competitive business environment for the facilitate economic activities in Nigeria. Among these reforms include the bank consolidation in 2005 through mergers and acquisitions, which helped to improve the Bank's capital base from N2 billion to a minimum of N25 billion. With the aid of this reform, 89 banks in Nigeria were reduced to 25 in 2005, which was further reduced to 24 banks [28, 43]. Hence, this reform was considered important because of the increasing collapse of the Nigerian banking system and financial difficulty which led to the revocation of 35 financial institutions' licenses between 1994 and 2000 and the liquidation of their assets by NDIC as directed by the Federal High Court of Nigeria. Other important reforms include the Alpha project initiative in 2004 which addressed the inherent weaknesses in the financial system in general and the banking sector in particular [43]. Thus, in 2010, the Asset Management Corporation of Nigeria (AMCON) was established for the purpose of addressing the increasing non-performing loans in the banking industry [28]. Also, zero tolerance in the regulatory framework and strict enforcement of corporate governance principles in banking were initiated to instil investors' confidence in the market [43]. In addition, the effort to guarantee a less corrupt system and safeguard customers in the banking system gave birth to the introduction of the consumer and financial protection division, the revision and initiation of relevant laws that could effectively promote corporate governance, transparency and accountability in the application of banking laws and regulations in Nigeria. Subsequently, the Nigerian market has experienced an economic boost due to improvements in information disclosure and transparency in the financial position of listed firms on the stock exchange [23, 29].

Against this background, the understanding of the stochastic process of share price movement is imperative in the Nigerian stock market. Amidst this, the knowledge of the present state of the stock market may assist in the gainful control of all the necessary information that could influence the future developmental process of the share price movement in Nigeria. Hence, the adoption of the Markov chain in the analysis of share price movement in Nigeria would help to determine if there exists a steady-state distribution or equilibrium in the stock market. This could enhance the financial system and the Nigerian economy in various ways, (i) enabled investors to build huge wealth through investment in financial instruments, (ii) offers an excellent opportunity to turn one's savings into wealth, (iii) promotes bank liquidity, (iv) enhances the stability of the stock market, (v) deepens and broadens financial intermediation, (vi) promotes investors' confidence and business activities and (vii) stock market efficiency [13, 30, 33, 45]. Therefore, this paper contributed to knowledge in the following ways, (i) examining the stochastic process of the share price movement by investigating the random walk and rational expectation hypotheses by Kendall [24] and Muth [35], respectively, (ii) determining if there exists a steady-state distribution or equilibrium in the second tier of the Nigeria stock market which had been ignored by several past studies such as Davou et al. [14] and Afolabi and Dada [2] and (iii) investigating the extent and magnitude of the effect of share price movement on the Nigerian economic performance using generalised multiple regression techniques. The emphasis in Nigeria arises from the fact that the Nigerian stock exchange is one of the most sort exchanges in West African, and the knowledge on the share price movement of second-tier market is vital to enhance the understanding and the role of the market in promoting growth.

In addition, this study departs from the past studies in two ways, a) the adoption of nonparametric and parametric techniques of analysis and b) the emphasis on the second-tier market which is the market reserved for smaller firms that cannot meet the requirements listing on the more stringent first-tier market of the Nigerian exchange. Over the past years, studies on share price movement in Nigeria focused more on the first-tier market without preference for the second-tier market (see [2, 14] etc.), and out of these studies, many adopted parametric analysis using linear unit root technique in investigating the predictability of share price movement in Nigeria (see Manasseh et al. [30]). This technique does not possess the ability to account for steady-state distribution of the share price moment in Nigeria. In addition, this study used the all-share index (ASI), which included price indices for all companies listed on the Nigeria stock exchange, as opposed to the closing price, which was used in previous research. The rest of the paper is structured as follows. Section two presents a short discussion on the review of related literature—theoretical and empirical review, while section three presents the data source and method. Section four went further to present the results, while section five discussed the findings. Hence, section seven presents the policy recommendations.

Theory and empirical review of related literature

Since the interest of this study focused on the application of the Markov chain and share price movement in Nigeria, two theories that closely deal with the possible indicators or events that could trigger share price movement was reviewed, and they include (a) efficient market theory by Fama [18] and (b) rational expectation theory stipulated by Muth [35]. The discussion of Fama [18] and Muth [35] perceptions on what may likely cause share price movement is followed by the review of related empirical literature. Hence, the theoretical underpinning for this study is entrenched in efficient market theory which linked share price dynamics to a random walk. Several theoretical and empirical contexts have merged ever since the hypothesis, to test whether the stock market is actually described as a random walk or mean-reverting process.

Efficient market theory

This theory was postulated by Fama [18], which is of the view that share prices cannot be forecasted either using past or current share prices and other related financial information. Fama [18] further argued that neither technical nor fundamental analysts possess the skill to predict future prices of shares with the aid of this information to generate abnormal returns as long as the stock market is efficient enough to incorporate all the relevant, publicly available information about the individual stocks. This theory is related to the perception of a random walk which portrays a price sequence where all successive price variations signify random departures from past prices. Numerous studies have been carried out to inquire if the stock market is described as a "random walk" or mean-reversing, but there was no harmony in the findings of these studies. However, studies such as Mlambo and Biekpe [36] supported Eugene Fama's claim, while other studies such as Tuyon and Ahmad [46] and Urquhart and McGroarty [47] contradict Fama's postulate and as such believed that stock markets are mean-reverting.

Rational expectation theory

The theory of rational expectation suggests that investors forecast the future price of shares prices using all available information. This implies that share price movement is based on the expectations of market participants or investors, and as such, this may not be correct always. Thus, according to Muth [35], investors or market participants form their expectations based on three primary factors, (a) rationality, (b) available information and (c) past experience. However, expectations must not be correct to be rational, because as soon as new information about financial instruments is made public, investors usually inform their expectations immediately. Amid, investors do this to mitigate the negative influence of movement in share prices on their wealth. Hence, this has an important influence on the way people invest in shares expecting high returns. Studies such as Aliyu [5], Lucas [26] and Kuttner [25] lend support to rational expectation theory, while Ash et al. [8] contradicted Muth [35]. For example, Aliyu [5] inquiry on the interactive effect of stock prices on the exchange rate in Nigeria: evidence from rational expectation theory, shows that the unexpected part of policy inventions on M2 and MPR negatively affected the stock returns, whereas the expected part does not. Similarly, while Lucas [26] argued that unexpected monetary risks affect economic activities and have no effect on output and employment, Kuttner [25] found that unexpected variations in the US policy rate affect key indicators of the financial system, and as such, further evidence on the expected monetary shocks have no effect on key indicators of the financial system. But on the contrary, Ash et al. [8] studied the worth of the Hodrick–Prescott filter (HP) as a measure of rational expectation and concluded that HP is not fully rational in the sense of Muth [35].

Empirical review of related literature

On the empirical front of stock markets, many studies have applied the aforementioned theories using the Markov chain in evaluating stock market behaviour. Some of these studies include Otieno et al. [41, 42] and Doubleday and Esunge [16]. They studied the application of the Markov chain to stock trends or to predict the immediate future prices for Google, Dow Jones Industrial Average (DJIA) and Safaricom shares. Obtaining secondary quantitative data, they concluded that the steady-state probability was virtually the same at 0.3, 0.1 and 0.2 and all three levels of an interval. Each company has a high percentage of share price appreciation. Only Doubleday and Esunge [16] concluded that a portfolio of this nature would yield slow, steady growth as there are likely to be more days of gain than days of loss. Similarly, Zhou [52]. investigated the share price in China's sports industry using a weighted Markov chain. The study found that the closing price in the 71st week was consistent with the prediction block. Also, Mettle et al. [31, 32] analyse share price movement with the aid of the Markov chain for selected stock of five companies listed on the Ghana stock exchange, which shows that the equity with the highest state transition probability and least mean return time remains the best choice for an investor. In like manner, Akpan and Macaulay [3] examined the market capitalisation effects on share prices with Guarantee Trust Bank of Nigeria and First Bank of Nigeria using the Markov chain. The findings show that the probability of each of the two banks appreciating is increasing, with GT bank taking the lead.

Studies such as Kallah-Dagadu [22], Otieno et al. [41, 42], Choji et al. [11], Gourène and Mendy [20] and Mettle et al. [31, 32] have at one time applied Markov at different time periods to analyse financial stocks listed on the Ghana Exchange, trends of Safaricom share in Nairobi Exchange, the states in Guarantee Trust Bank and First Bank of Nigeria, co-movement between OPEC oil prices and the African stock markets, and share price changes on the Ghana Exchange, respectively. Estimating the transition matrix, long-run probabilities and mean recurrent times for stock price movements for the period January 2017 to December 2020 using weekly stock prices, Kallah-Dagadu [22] found the following, (a) long-run distribution of the stock prices with evidence of the highest probabilities when compared loss and gain point states, (b) that the mean recurrent time to the point gain state varies from 3 to 35 weeks, (c) Standard Chartered Bank, GCB, Ecobank and Cal Bank are the top best-performing stocks when meaning recurrent times and steady-state distribution were taken into consideration. In the quest to predict Safaricom share prices movement for the period 1 April 2008 to 30 April 2012, Otieno et al. [41, 42] indicated that the Markov chain under the auspice of memoryless property and random walk capability forecast Safaricom share movement accurately, suggesting that Safaricom share prices can be easily predicted. In like manner, Choji et al. [11] study on the possibility of predicting the states of Guarantee Trust Bank and First Bank of Nigeria for 2005 to 2010, found that the share prices of these banks can be forecasted in the long run. Gourène and Mendy [20] study on the co-movement of OPEC oil prices and the African stock markets revealed that the two market's prices move together in the long run but at a slow rate. Further investigation shows that South Africa and Egypt were an exception, while other stock markets in African experience high movement of share prices during and after the US financial crisis. Also, in a study on the analysis of share price changes for five selected equities on the Ghana Exchange, Mettle et al. [31, 32] concluded that Markov chain techniques in equity price studies improve portfolio decisions.

Bhusal [10] studied the long-run behaviour of the Nepal Stock Exchange (NEPSE) with respect to 2741 trading days which covers 15 August 2007 to 18 June 2017. The findings of the study show that share prices (proxy, NEPSE index) experienced 0.39 and 0.44 probability increase and decrease, respectively, while a 0.17 increase in share prices remain constant. Further evidence suggests that the exchange share prices maintain an increasing state three days after. Thus, the study concludes that the stock index movement from one state to another on a trading day is not predicted by past trade, but depends on the most current trading day. In addition, Zhang and Zhang [51] study in forecasting the stock market trend in China using closing stock prices revealed that the Markov chain is effective in predicting the stock market index and has no after-effect under the market mechanism.

Evidence of stock market and economic growth nexus

Other Studies like Ezeoha et al. [17], Atje and Jovanovic [7], Ndubuisi and Okere [37] Demirguc-Kunt and Levine [15] explored the relationship between the Nigerian stock market and economic growth. These authors argue that GDP growth rate turnover ratios are positively correlated. Further research shows the stock market boosts economic growth. Nyong [38] found that capital market development hurts the economy, likewise, Flood and Marion [19] in the case of G-7 countries investigated monetary policy reaction to stock prices. Insight from the results indicates that stock prices do not exert a significant impact on economic activity. Manasseh et al. [28, 29] found financial sector reform increases economic growth in Nigeria. The analysis indicates a unidirectional association between the financial sector and stock market growth and bidirectional causality between the stock market and economic growth. Christian and Timothy [12] study on long-term security pricing in Nigeria found a disparity and rising share prices. Uwalomwa et al. [48] found that a firm's financial performance, dividend payouts, and financial leverages determine share prices.

In a recent study, Wen et al. [49] assessed the impact of commodity futures data on industrial production growth using weekly data from 1991 to 2019 and found that extreme price has a positive implication for IP growth. Another insight from the results domiciled in Sharma and Shrivastava [44] indicates a positive relationship between GDP and stock prices in the case of the Indian economy using the causality test. Using the autoregressive distributed lag (ARDL) model for data from 1994 to 2019, Bhattarai et al. [9] found a unidirectional causality running from stock market development to economic growth. In a study of 12 members of OECD countries, Yilanci, et al. [50] used data spanning from 1981:1 to 2018:3 to quantify the causal relationship in a frequency domain in the panel setting and found that stock prices predict long-term economic activity. Furthermore, Alexeev and Chih, [4] examined the impact of price shocks on economic growth using the annual data for 50 US states from 1975 to 2018. Insight from the results revealed the effects of the positive and negative price shocks on the state of the economy.

Data source and method

The study is designed to assess the behaviour of share prices of the second-tier markets on the Nigerian stock exchange. Daily closing prices of shares of the Nigerian Stock Exchange price Index (NSEI) obtained from the Nigerian Stock Exchange (NSE) for the period 1985–2019 were used for the estimation. The scope of the data set (1985–2019) is determined by its availability and as such limits our ability to explore this study on a microlevel, by investigating the stochastic process of share price movement of individual firms listed on the second-tier market of the Nigerian exchange. Thus, we suggest future studies in this direction to promote the understanding of the second-tier market and its relevance to the Nigerian Stock Exchange development.

Model formulation

Markov chain is a random process with state space transitions. A Markov chain is a set of random variables (X_t), where t represents time intervals; such a process is called the Markov property. Again, it is a succession of random variables with serial dependency solely between consecutive periods. It can describe systems that follow a series of linked events, where what happens next depends on the system's state. Stochastic events are based on probabilities, not certainties. In stochastic events, the current state of a variable or system is independent of all past states save the present state. Thus, current share price prices are independent of all historical share prices except the present price. However, this follows the Random walks hypothesis. Hence, a sequence of random variables, X_1, X_2, $X_{3,...}$ X_n, with the Markov property, can be illustrated below.

$$\begin{aligned}&\Pr\left(X_{n+1}=x/X_1=x_1,X_2=x_2,X_3=x_3,\ldots,X_n=x_n\right)\\&\quad=\Pr\left(X_{n+1}=x/X_n=x_n\right)\end{aligned} \tag{1}$$

$$P\left(X_{t-n}=j/X_t=i\right)\ =P\left(X_n=j/X_0=i\right);\ \text{for all t}\ =\ 0,1 \tag{2}$$

There is no correlation between the current state, future state or past state, according to Eqs. (1) and (2). X_i possible values form countable sets, which in this context is referred to as the chain's state space. In the transition matrix, the same information is displayed from time n to time $n+1$. Assuming that Markov chains are time homogeneous in this example, the graph and matrix are not given as sequences because they are independent of n [21]. The choice of the Markov chain technique arises from its advantage and simplicity when compared with other techniques like autoregressive conditional heteroscedasticity, autoregressive integrated moving average, autoregressive moving average, generalised autoregressive conditional heteroscedasticity and exponential generalised autoregressive conditional heteroskedastic. Markov chain is a stochastic system which possesses the capacity to estimate conditional probabilities based on the current state unlike the aforementioned. The suitability of the Markov chain as an effective and efficient model for forecasting stock market behaviour has been confirmed by Mettle et al. [31, 32] and Zhang and Zhang [51] who argued that Markov chain is effective in forecasting share price behaviour in their respective studies.

Estimation techniques

One-step transition probabilities

As long as the conditional probability of an event given any prior events and the current state is not reliant on the prior events, the one-step transition probabilities are said to be stable. This is because the odds of transition are stationary, they do not fluctuate over time. In this situation, a stochastic process X_t is considered to be Markovian if it has stationary (one-step) transition probabilities. This process is shown thus;

$$P\left(X_{t-1=}j/X_0 = k_0, X_{1=}k_1, \ldots, X_{t-1=}k_{t-1}, X_t = i\right)$$
$$= P\left(X_{t+1} = j/X_t = i\right);\ \text{for}\ \ \mathrm{i} = 0, 1 \ldots \text{and every.}$$

Sequence $i, j, k_0, k_1, \ldots, k_{t-1}$.

$$P\left(X_{t-n} = j/X_t = i\right) = P\left(X_n = j/X_0 = i\right); \quad \text{for all t} = 0, 1 \tag{3}$$

To simplify notation, assume that

$$P_{ij} = P\left(X_{t+1} = j/X_t = i\right) \tag{4}$$

$$P_{ij}^{(n)} = P\left(X_{t+n}j/X_t = i\right) \tag{5}$$

To describe the transition probability $p_{i,j}^{(n)}$ of an individual's progression from one step to another, the term "n-step" is used. Conditional probability $p_{i,j}^{(n)}$ is a probability that, given a random start time, the system will be in a particular state j after exactly n steps (time units). It is worth noting that the conditional probability must be non-negative because the process must change states, and it must meet the requirements.

$$P_{ij}^{n} \geq 0;\ \text{for all } i \text{ and } j. \quad n = 0,\ 1,\ 2, \tag{6}$$

$$\sum P_{ij}^{n} = 1; \text{for all } i. \quad n = 0,\ 1,\ 2, \tag{7}$$

A convenient way of showing all the n-step transition probabilities is the matrix form $0, 1, 2, \ldots M$. Equivalently, the n-step transition matrix

$$\begin{array}{c} \text{State} \\ 0 \\ 1 \\ \vdots \\ M \end{array} \begin{bmatrix} 0 & 1 & \cdots & M \\ P_{oo}^{(n)} & P_{o1}^{(n)} & \cdots & P_{oM}^{(n)} \\ P_{1O}^{(n)} & P_{11}^{(n)} & \cdots & P_{1M}^{(n)} \\ \cdots & \cdots & \cdots & \cdots \\ P_{Mo}^{(n)} & P_{M1}^{(n)} & \cdots & P_{MM}^{(n)} \end{bmatrix} \tag{8}$$

Note that the transition probability in a particular row and the column is for the transition from the row *state* to the column state. When $n = 1$, we drop the superscript n and simply refer to this as the transition matrix. *For* $n = 0, P_{i,j}^{(0)}$ *is just* $P(X_0 = j/X_0 = i)$ *and hence is 1 when* $i = j$ *and is 0 when* $i \neq j$. The Markov chains to be considered in this section have the following properties and form: (a) a finite number of states and (b) stationary transition probabilities.

The initial probabilities *P(Xo = i)* for all *1*, the (one-step) transition probabilities, i.e. the elements of the (one-step) transition matrix, are:

$$\begin{array}{c|cccc|} \text{State} & 0 & 1 & 2 & 3 \\ 0 & P_{\infty} & P_{01} & P_{02} & P_{03} \\ 1 & P_{10} & P_{11} & P_{12} & P_{13} \\ 2 & P_{20} & P_{21} & P_{22} & P_{23} \\ 3 & P_{30} & P_{31} & P_{32} & P_{33} \end{array} \tag{9}$$

Chapman-Kolmogorov equations

THE following Chapman–Kolmogorov equations provide a method for computing these n- step transition probabilities:

$$P_{i,j}^{(n)} = \sum_{k=0}^{m} P_{i,k}^{(m)} P_{k,j}^{(n-m)} \tag{10}$$

$$\text{For} i and j = 0, 1, \ldots, M, \text{ while } m1, 2, \ldots, n-1$$

$$n = m+1, m+2, \ldots$$

These equations point out that in going from state i to state j in n-steps, the process will be in some state k after exactly m (less than n) states. Thus, $P_{i,k}^{(m)} P_{k,j}^{(n-m)}$ is just the conditional probability that, given a starting point of state i, the process goes to state k after m steps and then to state j in *n-m steps*. Therefore, adding the conditional probabilities over all possible k must yield $P_{i,j}^{(n)}$. The special cases of $m = 1$ and $m = n$ -1 lead to the expressions;

$$P_{i,j}^{(n)} = \sum_{k=0}^{m} P_{i,k} P_{k,j}^{(n-1)} and P_{i,j}^{(n)} = \sum_{k=0}^{m} P_{i,k}^{(n-1)} P_{k,j} \tag{11}$$

where i and j represents all states. These expressions enable the n-step transition probabilities to be obtained from the one-step transition probabilities recursively. This recursive relationship is best explained in matrix notation. For $n = 2$, these expressions become;

$$P_{i,j}^{(2)} = \sum_{k=0}^{m} P_{i,k} P_{k,j}\ ,\ \text{for all states } i \text{ and } j, \tag{12}$$

These equations also hold in a trivial sense when $m = 0$ or $m = n$, but $m = 1$, 2..., n – 1 are the only interesting case where the $P_{i,j}^{(n)}$ is the elements of a matrix $P^{(2)}$. Also note that these elements are obtained by multiplying the matrix of one transition probabilities by itself. That is; $P^{(2)} = P.P = P^2$

In the same manner, the above expressions for $P_{i,j}^{(n)}$, when $m = n\text{-}1$ indicate that the matrix of *n-step* transition probabilities is;
$P^{(n)} = PP^{(n-1)} = P^{(n-1)}P$. Such that; $PP^{n-1} = P^{n-1}P = P^{n}$

Thus, the *n*-step transition probability matrix P^n can be obtained by computing the *n*th power of the one-step transition matrix *P***.**

Long-run properties of Markov Chains: steady-state probabilities

FOR any irreducible ergodic Markov chain.
$\underset{n\to\infty}{Lim} P_{i,j}^{(n)}$, exists and is independent of *i*. Furthermore, $\underset{n\to\infty}{Lim} P_{i,j}^{(n)} = \pi_j > 0$, where the π_j uniquely satisfy the following steady-state equation.

$$\pi_j = \sum_{i=0}^{m} \pi_i P_{i,j}, \text{ for } j = 0, 1, \ldots, M \text{ and } \sum_{j=0}^{m} \pi_i = 1 \tag{13}$$

Markov chain steady-state probabilities are π_j. Steady-state means the probability of finding the process in a specific state, say *j*, after a large number of transitions tends to π_j regardless of the probability distribution of the beginning state. It is vital to emphasise that steady-state probability does not mean the process settles down. The process continues to transition from one state to another, and for any step *n*, the transition probability from state *i* to state j is $P_{i,j}$. The π_j can be read as stationary probability (not stationary transition probability) in the following way. If the initial probability of being in state *j* is π_j ($P\{X_o = j\} = \pi_j$ for all j), then the probability of finding the process in state *j* at time *t*.

$n = 1, 2, \ldots$ is also given by $P\{X_n = j\} = \pi_j$.

Steady-state equations consist of $M+2$ equations in $M+1$ unknowns and have a unique solution. A redundant equation can be eliminated. It can't be $\sum_{j=0}^{m} \pi = 1$ since $\pi_j = 0$ for all *j* and satisfies $M+1$. The other $M+1$ steady-state equations have unique solutions up to a multiplicative constant, but the last equation necessitates a probability distribution. So, steady-state equations are:

$$\pi_1 = \pi_1 P_{0,0} + \pi_2 P_{0,1}$$

$$\pi_2 = \pi_1 P_{1,0} + \pi_2 P_{1,1}$$

$$1 = \pi_1 + \pi_2$$

The Markov property is a process whose future probability behaviour is uniquely determined by the current state of the system. X_n is Markov.
$P\{X_{t-1} = j / X_0 = k_0, X_1 = k_1, \ldots, X_{t-1} = k_{t-1}, X_t = i\}$, this gives

$$P\{X_{t+1} = j / X_t = i\}, for i = 0, 1, \tag{14}$$

Generalised linear regression model (GLM)

This versatile expansion of linear regression includes response variables with non-normal error distributions. GLM generalises linear regression related to the response variable through link function and by allowing each measurement's variance to be a function of its predicted value. This model analyses the simultaneous impacts of many variables, including categorical and continuous mixes. Model structure describes relationships and associations. Parameters measure association strength. Model parameters are estimated. The goal is to model *Y's* predicted value as a linear function of *X* such that; $E(Y_t) = \beta_0 + \beta_1 X_i$. The structural form of the model takes the following form;

$$Y_i = \beta_0 + \beta_1 X_i + e_t \tag{15}$$

where Y_i is independent and normally distributed. Errors are normally distributed, $e_i \sim N\ (0, \sigma^2)$, and *X* is fixed, while σ^2 is the constant variance. Therefore, Y_t is the vectors of economic growth measures and X_t is the vectors of stock market measures. To integrate these measures into the model, and to enable us establish the impact of share price movement on economic growth, Eq. (15) is therefore transformed into Eq. (16) as indicated below:

$$\text{EGR}_t = \beta_0 + \beta_1 \text{SPM}_t + \beta_2 \text{CV}_t + \varepsilon_t \tag{16}$$

where EGR_t *and* SPM_t in the model are vectors of economic growth measures and share price movement, respectively, while CV_t *are* the measures of other control variables in the study. EGR_t is measured with gross domestic product growth rate ($\text{GDP}gr_t$). While SPM_t is proxied with all-share indexes, CV_t controls for other variables such as market capitalisation (MC_t) as percentage of GDP, budget deficit ratio (BDR_t) and exchange rate (EXR_t). β_0 and ε_t are the intercept and the error term, respectively, while β_1 and β_2 are the parameters that measures the coefficients of share price movement, market capitalisation of second-tier market of the Nigerian exchange. The data on $\text{GDP}gr_t$ and control variables were source from national bureau of statistic (NBS).

Results presentation

In line with the assumptions of ordinary least squares, numerous diagnostic tests were performed on the data (OLS) such as augmented Dickey–Fuller. This root test is used to determine whether the data sets are stationary. It incorporates lags as regressors into the test equation. In this case, however, the outcomes of the estimation tests before and after are shown below.

Table 1 Tests for stationarity. Source: Authors computation with data generated from NSE and NBS

Variables	ADF	5% Critical level		Remarks
		At Levels	First–Order	
GDP_{gr}	−4.085	−3.000	–	*I ~ 1(0)*
ASI	−21.026	−3.000	–	*I ~ 1(0)*
MC	−5.421	–	−3.000	*I ~ 1(1)*
BDR	−7.936	–	−3.000	*I ~ 1(1)*
EXR	−4.549	–	−3.750	*I ~ 1(1)*

Table 2 Cointegration tests results. Source: Authors computation

H_0: The series does not have a unit root				
`	Test Statistics	1%	5%	10%
Z(t)	−3.963	−3.750	−3.000	−2.630
MacKinnon approximate *p*-value for Z(t) = 0.0016				

The stationarity results presented in Table 1 show that all the variables are integrated of order zero (*I ~ 1(0)*) and one (*I ~ 1(1)*), and thus, the null hypothesis which claim that there is unit root, suggesting that the variables are not stationary is rejected. As a result, we hypothesized that the endogenous variable (GDPgr) would change in tandem with the explanatory variables throughout time. In order to verify this assertion, we ran a unit root test on the residuals generated from Eq. 16 above.

We do not find evidence in support of the cointegration of the S&P 500 with the U.S. money stock and bond yield (Tables 2, 3).

Testing for cointegration

The fact that the endogenous variable (GDP_{gr}) is integrated of the same order with either one or all of the exogenous variables in the model (see Table 1), we suspect that the variables may drift together in the long run. In this case, it appears that the variables are interconnected, and in order to determine the true influence of the individual variables on the endogenous variable, the Engle–Granger test which considers the null hypothesis that there is no cointegration was carried out. Therefore, since the test statistics of -3.963 in absolute term is larger than the critical values at the 1%, 5% and 10% levels, we cannot reject the null hypothesis of no cointegration. Hence, we do not find evidence in support of the cointegration of the endogenous variable with exogenous variables. Thus, there is no existence of long-term relationship between different trend processes, which means that we cannot model the long term and there is no solid basis for inference based on the standard distributions.

In addition, post-estimation tests such as heteroscedasticity, multi-collinearity, specification autocorrelation and normality were also performed to ensure that the basic assumptions of ordinary least square (OLS) are met before assessing the impact of share price movement on economic growth. This can invalidate statistical tests of significance that presume that modelling mistakes are uncorrelated and uniform if heteroscedasticity is present. Since the true variance and covariance are underestimated, the ordinary least square estimator is unbiased but inefficient when heteroscedasticity is present. As a result, the researchers used Cameron and Trivedi's decomposition of White's test to determine whether the variables are homoscedastic. Although the aggregate *p*-value (0.0343) is less than 5% critical, we reject the null hypothesis of constant variance and accept the alternative. Regressing with robust standard error or Newey–West HAC standard error fixes the problem of not having constant variance in the model. Autocorrelation in the residual (prediction errors) from a regression analysis utilising Durbin–Watson (DW) tests is also examined in this paper. There was no evidence of autocorrelation in the data (DW = 2.039179).

Given the high correlation between predictor variables, it is no surprise that multi-collinearity might lead to a variable that's linearly predicted by its covariates. Multivariate coefficient estimates may behave wildly when subjected to small model modifications in this scenario. The model's predictive power and reliability are unaffected by the presence of several covariates. Because of this, the VIF values used to gauge the degree of multicollinearity are fewer than ten, according to the rule of thumb (VIF10). This shows that the variables are not connected in a linear way. Jarque–Bera skewness/kurtosis and Shapiro–Wilk W tests are used to see if the residual is normally distributed or not in this study. Jarque–Bera skewness/kurtosis results show that the residual is typically skewed at 0.2695, while kurtosis and probability are both at 0.3075. As long as the probability is more than

Table 3 Number of monthly share price movement of the second-tier market of NSE. Source: Authors computation with data generated from NSE

	Decrease in share price (D)	Increase in share price (I)	
Share price (D)	68	47	115
share price (I)	48	185	233
Grand total	116	232	348

Table 4 Expectation of a decrease and increase in the all-share index. Source: Authors computation with data generated from NSE

1	α	$1/\alpha$	E(D)	Duration
	0.409	1/0.409	2.44499	3 months (aprox.)
1	β	$1/\beta$	**E(I)**	
	0.206	1/0.206	4.85437	5 months (aprox)

Table 5 Decrease and increase instant in all-share indexes. Source: Authors computation with data generated from NSE

α	β	$\alpha+\beta$	$\beta/(\alpha+\beta)$	d
0.409	0.206	0.615	0.334959	0.335
α	β	$\alpha+\beta$	$\alpha/(\alpha+\beta)$	**I**
0.409	0.206	0.615	0.665041	0.665

5%, the residual must be regularly distributed. The results of the Shapiro–Wilk test show that the probability value (0.16845) is larger than 5%, indicating that the residual is normal.

Discussions

In the stochastic analysis literature of share prices, Mettle et al. [31, 32] explained Markov chains with finite states as condition that generates increase or decrease of share prices in the stock market. In this study, the researcher defines a decrease in all-share index as state 0 and an increase as state 1. In this study, we hypothesised that decrease in the all-share index is a failure and that an increase is a success. Therefore, we consider this as a Bernoulli distribution or Bernoulli trials of which the probability of a success or failure at each trial depends on the outcome of the precious trials. When the outcome at the n^{th} trial is a failure, then the probability of a failure at the $(n+1)^{\text{th}}$ trial is $1-\alpha$ and the probability of success at the $(n+1)$ trial is α. Similarly, when the outcome of the n^{th} trial is a success, then the probability of a success at the $(n+1)^{\text{th}}$ trial is $1-\beta$ and the probability of a failure at the $(n+1)^{\text{th}}$ trial is β. This can be represented in a matrix form as follows;

$$P = \begin{vmatrix} 1-\alpha & \alpha \\ \beta & 1-\beta \end{vmatrix}, 0<\alpha,\beta<1$$

Build on the two-state Markov process, $X=0$ if $d_t \leq 0$, implies insignificant rise in stock price from $t-1$ to t. $X=1$ if $d_t > 0$, implies that significant rise in stock price from $t-1$ to t.

Therefore, 2×2 matrixes are obtained as;

$$\begin{array}{c|cc} \text{State} & 0 & 1 \\ 0 & P_{\infty} & p_{01} \\ 1 & P_{10} & p_{11} \end{array}$$

$$p = \begin{vmatrix} 0.591 & 0.409 \\ 0.206 & 0.794 \end{vmatrix}$$

From the above, one-step (p) probability matrix, the researcher estimates the probability of increase in a month given that there was a decrease in all-share indexes for twenty-nine years at 0.409. Further, the probability of a decrease given that there was an increase was also estimated to be 0.206. The probability of a decrease followed by a decrease is 0.591 and the probability of an increase followed by an increase is 0.794. The model assumes exponential distribution. The length of decrease is given as $\alpha e^{-\alpha\ t}$ and the length of an increase is given as $\beta e^{-\beta t}$. Considering the monthly all-share index as the unit of time, the mean length of a decrease in all-share index is $1/\alpha$ and the mean length of an increase in all-share index is 1/β. We denote the mean length or the expectation of a decrease and increase in the all-share index as E (D) and E (I), respectively. Therefore;

$E(D) = {}^{1}\!/_{\alpha}$ while $E(I) = {}^{1}\!/_{\beta}$. Representing E(D) and E(I) in a Table 4, we have the following results.

We define a decrease instant in all-share indexes as a month that starts with a decrease and an increase instant as a month that starts with an increase. A decrease instant can be represented by "a", while "a" which is an increase instant is represented by I (see Table 5).

Considering the above results, the probability that a month starts with a decrease is 0.335 and the probability

Table 6 Probability of all the monthly share prices. Source: Authors computation with data generated from NSE

Month	Number	P^1(I)	P^1(D)	P^1(I/D)	P^1(I/I)	P^1(D/D)	P^1(D/I)
Jan	29	N = 25 P = 0.862	N = 4 P = 0.138	N = 3 P = 0.104	N = 21 P = 0.724	N = 1 P = 0.035	N = 3 P = 0.104
Feb	29	N = 23 P = 0.793	N = 6 P = 0.207	N = 4 P = 0.138	N = 18 P = 0.621	N = 2 P = 0.069	N = 3 P = 0.104
Mar	29	N = 23 P = 0.793	N = 6 P = 0.207	N = 3 P = 0.104	N = 18 P = 0.621	N = 2 P = 0.069	N = 4 P = 0.138
April	29	N = 23 P = 0.793	N = 6 P = 0.207	N = 4 P = 0.138	N = 17 P = 0.586	N = 2 P = 0.069	N = 4 P = 0.138
May	29	N = 22 P = 0.759	N = 7 P = 0.241	N = 3 P = 0.104	N = 18 P = 0.621	N = 4 0.138	N = 3 P = 0.104
June	29	N = 23 P = 0.793	N = 6 P = 0.2–7	N = 3 P = 0.104	N = 19 P = 0.655	N = 3 P = 0.104	N = 3 P = 0.104
July	29	N = 23 P = 0.793	N = 6 P = 0.207	N = 4 P = 0.138	N = 18 P = 0.621	N = 2 P = 0.069	N = 4 P = 0.138
Aug	29	N = 23 P = 0.793	N = 6 P = 0.207	N = 4 P = 0.138	N = 17 P = 0.586	N = 3 P = 0.104	N = 4 P = 0.138
Sept	29	N = 24 P = 0.828	N = 5 P = 0.172	N = 3 P = 0.104	N = 19 P = 0.655	N = 0.07	N = 3 P = 0.104
Oct	29	N = 23 P = 0.793	N = 6 P = 0.207	N = 3 P = 0.104	N = 19 P = 0.655	N = 3 P = 0.104	N = 3 P = 0.104
Nov	29	N = 23 P = 0.793	N = 6 P = 0.207	N = 3 P = 0.104	N = 19 P = 0.655	N = 3 P = 0.104	N = 3 P = 0.104
Dec	29	N = 23 P = 0.793	N = 6 P = 0.207	N = 3 P = 0.104	N = 19 P = 0.655	N = 3 P = 0.104	N = 3 P = 0.104

Table 7 Expected total number of monthly increase and decrease in share prices. Source: Authors computation with data generated from NSE

n	α	β	$\alpha + \beta$	$\alpha/\alpha + \beta$	$n \times {}^{\alpha}/_{\alpha+\beta}$	$E(I_n)$
348	0.409	0.206	0.615	0.665041	231.434268	231.434
n	$E(I_n)$	n – $E(I_n)$				$E(D_n)$
348	231.434268	116.565732				116.566

that a month starts as an increase is 0.665. We also found the difference probabilities and conditional probabilities of increase (*I*) and decrease (*D*) of share prices. *P (I)* and *P (D)* are the probabilities for increase and decrease, respectively. *P (I/D), P (I/I), P (D/D)* and *P (D/I)* are the conditional probabilities (see Table 6).

Therefore, the expectation of an increase in the all-share index can be expressed as shown in Table 7 given that;

$$\alpha = 0.409,$$

$$\beta = 0.206,$$

$$n = \text{total number of months}(348),$$

$$I_n = \text{total number of monthly increases},$$

$$D_n = \text{total number of monthly decreases},$$

$$P_1(I) = \text{probability of increase}(0.665),$$

$$P_2(D) = \text{probability of decrease}(0.335)$$

Therefore, the expected total number of monthly increase $(E(I_n))$ and decrease $(E(D_n))$ could be evaluated using

$$E(I_n) = n \times {}^{\alpha}/_{\alpha+\beta}; \text{ and } E(D_n) = n - E(I_n)$$

To find the standard deviation of increase, we find the variance and then take the square root of the variance.

$$\begin{aligned}\mathrm{Var}(I_n) &= n\alpha(\beta)(1+(1-\beta)-\alpha)/(1-(1-\beta)+\alpha)^3\\ &= 348\times 0.409\times 0.206\,(1+0.385)/(1-(0.794)+0.409)^3\\ &= 40.60874292/0.232608375\\ &= 174.579883119\\ \mathrm{Std.Dev} &= \sqrt{174.579883119}\\ &= 13.2129\end{aligned}$$

Moreso, we also found the difference probabilities and conditional probabilities of increase and decrease of share prices. *P (I)* and *P (D)* are the probabilities for increase and decrease, respectively. *P (I/D), P (I/I), P (D/D)* and *P (D/I)* are the conditional probabilities.

Steady-state transition probabilities

For the steady-state probabilities, $\pi_j = \sum_{i=0}^{m}\pi_i P_{i,j}, for j = 0, 1, \ldots, M and \sum_{j=0}^{m}\pi_i = 1$

$$[\pi_1, \pi_2]\begin{bmatrix}0.591 & 0.409\\ 0.206 & 0.794\end{bmatrix}; \text{and}$$

$$\pi_1 = \pi_1(0.591) + \pi_2(0.206)$$

$$\pi_2 = \pi_1(0.409) + \pi_2(0.794)$$

$$\pi_1 + \pi_2 = 1$$

Evaluating these set of equations, we obtain the steady-state probabilities.

$$(\pi_1 = 0.335, \pi_2 = 0.665)$$

We assume that row vector $P^{(n)} = P_0^{(n)}, P_1^{(n)}$ given that the probability state is 0 or 1 at time n. accordingly, if the first probabilities in the two states are given as thus, $P_0 = P_0^{(0)}, P_0^{(0)}$, then it is considered as state 0 at time *n*. Even if it is also be in two mutually exclusive ways, (i.) that is, state 0 was occupied at time n − 1, (ii.) no transition out of state 0 at time n, which can be seen when the probability is in $P_0^{(n-1)}(1-\alpha)$. In another form, state 1 can occur at time *n − 1* and there is transition from state 1 to state 0 at time n. Again, this happens with $P_1^{(n-1)}\beta$. These considerations culminate to the following recurrent relations.

$$P_0^{(n-1)} = P_0^{(n-1)}(1-\alpha) + P_1^{(n-1)}\beta$$

$$P_1^{(n)} = P_0^{(n-1)}\alpha + P_1^{(n-1)}(1-\beta)$$

To obtain the matrix form of the above equation, we have

$$P^{(n)} = P_1^{(n-1)}P$$

To solve the iteration, we have

$$P^{(n)} = P^{(n-2)}P^2 = P^{(n-3)}P^3 = \ldots. = P^{(n-j)}P^j = \ldots. = P^{(0)}P^n$$

Consequently, having known the initial probabilities and the transition probability matrix, the state transition probabilities at any time *n* can be deduced. The transition probability matrix is given as;

$$P = \begin{bmatrix}0.591 & 0.409\\ 0.206 & 0.794\end{bmatrix};\ PP = \begin{bmatrix}0.591 & 0.409\\ 0.206 & 0.794\end{bmatrix} \times \begin{bmatrix}0.591 & 0.409\\ 0.206 & 0.794\end{bmatrix}$$

$$P^2 = \begin{bmatrix}0.436 & 0.566\\ 0.286 & 0.715\end{bmatrix};\ P^2P^2 = \begin{bmatrix}0.436 & 0.566\\ 0.286 & 0.715\end{bmatrix} \times \begin{bmatrix}0.436 & 0.566\\ 0.286 & 0.715\end{bmatrix}$$

$$P^4 = \begin{bmatrix}0.350 & 0.650\\ 0.327 & 0.673\end{bmatrix};\ P^4P^4 = \begin{bmatrix}0.350 & 0.650\\ 0.327 & 0.673\end{bmatrix} \times \begin{bmatrix}0.350 & 0.650\\ 0.327 & 0.673\end{bmatrix}$$

$$P^8 = \begin{bmatrix}0.335 & 0.665\\ 0.335 & 0.665\end{bmatrix};\ P^8P^8 = \begin{bmatrix}0.335 & 0.665\\ 0.335 & 0.665\end{bmatrix} \times \begin{bmatrix}0.335 & 0.665\\ 0.335 & 0.665\end{bmatrix}$$

$$P^{16} = \begin{bmatrix}0.335 & 0.665\\ 0.335 & 0.665\end{bmatrix}$$

From the transition probability matrix, assuming that January 1985 had an increase in the share price, then the probability that January 2019 will have an increase is 0.665. Furthermore, if we consider January 1985 having a decrease in the share price, then the probability that the share price of January 2019 will decrease is 0.335. Put differently, one can assert that there will 67 per cent and 33 per cent assurance that there will be an increase and a decrease in the share prices, respectively. Also, we observed that in the long run, the state transition probabilities converge to a system of statistical equilibrium in which the state transition probabilities become independent of the initial conditions.

Share prices movement and economic growth

Numerous economic theories argue that share price fluctuations could have a substantial impact on economic growth in a variety of ways [27]. Table 8 displays the estimated regression findings, which reveal a connection between share price movement and economic growth in Nigeria.

In Table 8, R^2 (0.4024) displays the percentage of the endogenous variable's variance that can be explained by the exogenous variables. Explanatory variables account for approximately 40% of the variation in GDP growth rate. F (5, 17) = 2.75 and Prob > F = 0.0435 show that the regression model is statistically meaningful. This demonstrates the model's ability to accurately forecast Nigeria's GDP growth rate in the long term. The root MSE (5.977) represents the standard deviation of the residual in our model, suggesting that the model is perfectly matched to the data. Also, the above results show that share price

Table 8 Estimated results on share price fluctuations impact on economic growth. Source: Authors computation with data generated from NSE and NBS

Dependent Variable: Gross Domestic Product Growth Rate—GDPgr						
Variable	**Coef**	**Robust Std. Error**	**t-Stat**	**P >|t|**	**[95% Conf. Interval]**	
ASI	**.544475**	**.0948564**	**5.74**	**0.012**	**−.1298676**	**.2703916**
MC	.5539639	.1225584	4.52	0.014	−.0727725	.4443788
BDR	−.0012527	.0010986	−1.14	0.270	−.0035705	.001065
EXR	−.0871632	.0488911	−1.78	0.092	−.015988	.1903144
L1.resid	−.3291654	.3409294	−0.97	0.348	−.3901327	1.048464
_Cons	−4.748378	4.041796	−1.17	0.256	−13.27582	3.779067
F (5, 17)		2.75		Prob > F		0.0435
R-squared		0.4024		Root MSE		5.977

movement is positive and significantly related to GDP growth rate (GDPgr), suggesting that an increase in share price movement could result to increase in growth in Nigeria. This finding is consistent with the works of Nurudum (2009), Adjasi and Biekpe [1] but contradict studies by Nyong [38]. Furthermore, we observed stock market performance, proxied with market capitalisation (MC) to be significant and positively related to GDPgr. However, it implies that second-tier market growth and development may promote Nigerian economic growth. The study further revealed an insignificant negative relationship between BDR, EXR and GDPgr. The error correction (ECM = L1.resid) result evidences that about 32% of disequilibrium is corrected in the short run.

Summary and conclusion

This study contributes to repositories of knowledge by investigating the application of Markov chain to share price movement in Nigeria using daily closing share price for the period 1985–2019. The study explores the efficacy of Markov process as reliable technique to estimate (a) the stochastic process of the share price movement, (b) the existence of a steady-state distribution or equilibrium in the second-tier markets and (c) the extent and magnitude of the effect of share price movement on the Nigerian economic performance. First, the stochastic process determined by examining the random works and the rational expectation hypothesis. Hence, using a stochastic process X_t which is considered to be Markovian if it has stationary (one-step) transition probabilities, we found that the state transition probabilities converge to equilibrium. This means that the initial market conditions are independent of current state, implying that information on past share prices of second-tier market cannot be used to forecast the current share prices of the market. Therefore, we can also infer that expectation of future share price increase by the market actors is affected the state transition probabilities which converge to equilibrium. Second, to determine if there exist a steady-state distribution or equilibrium in the second-tier market of the Nigerian exchange, we estimated the expectation of the monthly increase of the share price index $E(I)$ and monthly decrease in the all-share index $E(D)$. From the results, the $E(I)$ was obtained as 5 months and the $E(D)$ was obtained as 3 months. Considering the monthly all-share index as the unit of time, the mean length of a decrease in all-share index and the mean length of an increase in all-share index denoted as $E(D)$ and $E(I)$, respectively, were calculated. The results show that the steady-state probabilities π_1 and π_2 indicates that a month starts with a decrease is 0.335, while the probabilities that a month starts as an increase is 0.665. A such, this evidence shows that in the long run, the state transition probabilities converge to a system of statistical equilibrium in which the state transition probabilities become independent of the initial conditions. Thus, as the years roll, the monthly share prices continue to increase as a result of an increase in the activities at the stock market. It was also observed that there is no stability in the share prices, and this could be as a result of the volatile nature of the market.

In addition, exploring the extent and magnitude of the effect of share price movement on the Nigerian economic performance and generalising linear regression techniques was adopted. The evidence from the findings shows that all-share index is positive and significantly affects economic performance in Nigeria with a magnitude effect of 0.545 due to a unit increase in share price movement. This relationship contradicts the apriori expectation, which may be as a result of the performance of the market as at the time of this study. Further evidence also revealed that market capitalisation which measures the worth of the firms listed and the market's perceptions of its future prospects exert a significant and positive impact of economic performance. This reflects the ability of what investors are willing to pay for a stock. Other control variables such as exert negative and significance influence on economic performance except budget deficit ratio (BDR). Hence, from it is evidenced that second-tier market of the Nigerian exchange plays significant role in promoting the Nigerian economic performance and as such should be promoted. Given the outcome of the above findings, to ensure that the second-tier market and the entire Nigerian exchange sustain the steady state as revealed, we recommend the following: first, the initiation of cohesive polices that could maintain stable exchange rate environment. Thus, the instability in international markets and volatile exchange rates affect share prices and the domestic market's returns. Amid, persistent increase in exchange rate could causes share price volatility, and as such, this may like cause disequilibrium in the market, particularly in the long run. Second, considering the findings on the stochastic process determined by the random works and the rational expectation hypothesis, we encourage the market authorities—Security and Exchange Commission (SEC), to initiate policies that will ensure that information on firms' revenue, dividend, bonuses, and changes in board of directors (if any) are made public in every quarter of the year, as well as strengthen domestic law and order to enhance the protection of local and foreign investors. This will promote transparency and investors' confidence, as well as limit the rate of insider trading activities inherent in emerging markets across the globe, and subsequently translate to increase in trading activities in the market. Third, since market capitalisation of second-tier market exert positive and significant impact on economic performance in Nigeria, fiscal policies that can encourage tax holiday or exemption on smaller firms listed in the market should be initiated to afford the market the opportunity to compete with the larger firms listed in the first-tier market of the Nigerian exchange. However, further research in the area of stochastic process and share price movement of individual firms listed on second-tier market is important to promote the understanding of second-tier market and its relevance to the Nigerian Stock Exchange development.

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