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Share Price Prediction Using Markov Chain Modelling and Principal Component Analysis for Stock Market Capitalisation

***[1]Victor-Edema, U.A., & [2]Amadi, I.U.**
[1]Department of Statistics, Ignatius Ajuru University of Education, Rumuolumeni, Rivers State, Nigeria
[2]Department of Mathematics/Statistics, Captain Elechi Amadi Polytechnic, Rumuola Port Harcourt, Nigeria

***Corresponding author email**: uyodhu.victor-edema@iaue.edu.ng

Abstract
Investors in the financial market are frequently confronted with critical decisions regarding the allocation of funds for the purpose of optimal profit returns. This is largely due to its stochastic nature. This study is centred on analysing this stochastic behaviour for optimal investment decisions. The Markov chains and Principal Component Analysis (PCA) were applied to the closing share price data of two Nigerian banks - Access and Fidelity Banks. Their share prices were transformed into a 3-step transition probability matrix solution, spanning several years, to accurately predict future changes in share prices. The PCA results showed that the first and second PCA values are similar for both banks, suggesting that the factors that affect share price are similar for both banks. The small difference in the values indicates that some specific factors affect one bank more than the other, but overall, they are influenced by similar factors. This information is useful for investors deciding between the two banks, as it suggests that their risk and return profiles are similar. All numerical examples were generated using MATLAB.

Keywords: Stochastic analysis, Markov chain, Share price, Market Capitalization, Transition matrix, PCA

Introduction

Investors and corporate owners are confronted with pivotal decisions regarding the optimal allocation of funds across different facets of their business, particularly due to the unpredictable nature of stock market prices. Consequently, these constraints highlight the need for a resilient mathematical model to guide investors in their decision-making processes. Investment decisions stand as pivotal mechanisms that can either bolster or undermine investors' positions. Sound decisions contribute to the financial robustness of investments, whereas erroneous choices may lead businesses into a downward spiral.

Numerous researchers have extensively explored the application of Markov chains to model stock prices. For instance, the study by Agwuegbo et al. (2010) investigated stock market prices and their impact on the financial and economic landscape. The findings emphasized the random nature of stock prices, asserting that investors cannot manipulate the fairness or unfairness of a stock price based on expectations. Next, Lakshmi and Jyothi (2020) explored the Markov process associated with stock market performance and found that Oil India is more likely to remain stable without significant increases or decreases. In a parallel investigation, Davou et al. (2013) scrutinized a Markov chain model focusing on share price movements. Their findings revealed that shares of Guarantee Trust Bank (GTB) change hands more frequently compared to First Bank Nigeria (FBN). In the field of analyzing the stock market, Agbam and Udo (2020) investigated the prediction of stock prices in Nigeria using a Markov chain model relying on results derived from a probability transition matrix. Likewise, Amadi et al. (2022a), and Amadi and Victor-Edema (2025) delved into stochastic analyses involving Markov chains with finite states and asymptotic null controllability for share prices, respectively. Both studies utilized a 3-state transition probability matrix to define precise parameters for computing the expected mean rate of return for individual stocks. In a related study, Mettle et al. (2014) focused on the stochastic analysis of share prices, specifying conditions for determining the anticipated mean return time for stock prices, thus enhancing investment decisions based on optimal transition probabilities. Similarly, Amadi et al. (2022b) investigated stock market behaviour using a Markov chain, underscoring the consistent nature of steady-state probabilities for share prices across different iterations, regardless of a bank's current share price. Furthermore, Adeosun et al. (2015) introduced a Markov chain model for forecasting stock market trends, highlighting its superior effectiveness in analyzing and predicting market indices and closing stock prices. Regarding the long-term outlook on security prices in Nigeria, Davies et al. (2019) gathered data from randomly selected banks within the country's banking sector, suggesting potential stability in Nigerian bank price levels over time, regardless of prevailing circumstances. Similarly, Ofomata et al. (2017) analyzed the persistent behavior of closing prices for shares from eight Nigerian banks using a Markov chain model. By calculating the limiting distribution transition probability matrix for share prices, they expressed optimism for Nigerian bank stocks despite existing market conditions. The study concluded that the findings would provide valuable insights for investors. Further exploration in this field can be found in subsequent studies such as Ugbebor et al. (2001), Bairagi and Kakaty (2015), Zhang and Zhang (2009), Eseoghene (2011), and Christian and Timothy (2014), among others.

Forecasting potential states of share prices is challenging due to their inherently unpredictable nature, marked by fluctuations that can unsettle stakeholders. Hence, the share price data from Access and Fidelity Banks were utilized to gain insights into their price movements. To comprehensively track these volatile movements, stochastic analysis of Markov chains was employed. Furthermore, Principal Component Analysis (PCA) was applied to the transition matrices of the two banks to elucidate the underlying dynamics and patterns of share prices, facilitating informed trading decisions and maximizing profits. The structure of this document is organized as follows: Section 2 provides details on the materials and methods employed, while Section 3 encompasses the presentation of results and discussions. The paper is wrapped up with a conclusion in Section 4.

Methodology

The initial step in this exploration of Markov chains is the establishment of the concept of a stochastic process. A stochastic process is a statistical phenomenon that evolves according to probabilistic principles over time. Mathematically, it is represented as a sequence of random variables arranged chronologically, and defined at various time intervals, which can be continuous or discrete. As a stochastic process involves a collection of random variables, its requirements mirror those of random vectors.

Definition 1: A stochastic process X qualifies as a Markov chain when it adheres to the Markov property.

$$P\left(X_{n+1} = j / X_0, X_1, \cdots, X_n\right) = P\left(X_{n+1} = j / X_n\right) \tag{1}$$

For all $n \geq 0$ and $i, j \in S$ (state space).

Understanding that the Markov property specified in equation (1) is comparable to any one of the following conditions for each $j \in S$ is satisfactory.

$$P\left(X_{n+1} = j / X_{n1}, X_{n2}, \cdots, X_{nk}\right) = P\left(X_{n+1} = j / X_{nk}\right) \tag{2}$$

$\left(\text{for any } n_1 < n_2 <, \cdots, n_k \leq n\right)$

Assuming $X_n = i$ implies that the chain is in the ith state at the nth step. It can also be said that the chain has the value 'i' or ' being in state i.'. The concept underlying the chain is elucidated through its transition probabilities.

$$P\left(X_{n+1} = j / X_n = i\right) \tag{3}$$

They are dependent on i, j and n.

Definition 2: The chain X is said to be homogeneous if the following are stated below

$$P\left(X_{n+1} = j / X_n = i\right) = P\left(X_1 = j / X_0 = i\right) \tag{4}$$

For all n, i, j.

The transition matrix $\mathrm{P} = \left(P_{ij}\right)$ is $n \times n$ matrix of transition probabilities.

$$P_{ij} = P\left(X_{n+1} = j / X_n = i\right) \tag{5}$$

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Therefore, in a homogeneous Markov chain, the transition probabilities consistently remain fixed at a specific point.
Theorem 3: Consider P as a stochastic matrix, signifying the following:
i) P has non-negative entries or $\mathrm{P}_{ij} \geq 0$ (ii) $\sum_j P_{ij} = \sum_j P\left(X_{n+1} = j / X_n = i\right) = \sum_j P\left(X_1 = j / X_0 = i\right)$ which is stationarity or point of convergence.

Proof: (i) each associated entry P is a transition probability P_{ij} and a probability $P_{ij} \geq 0$.
(ii) $\sum_j P_{ij} = \sum_j P\left(X_{n+1} = j / X_n = i\right) = \sum_j P\left(X_1 = j / X_0 = i\right)$
Which is stationarity.
$P\left(X_i \in S / X_0 = i\right) = 1.$
Theorem 4: (Chapman-Kolmogorov Equations)
$P_{ij(m+n)} = \sum_{r=i}^{n} P_{ir(m)} P_{rj(n)}$ Since $\mathrm{P}_{m+n} = \mathrm{P}_m \mathrm{P}_n$ and so on $\mathrm{P}_n = \mathrm{P}^n$ the nth power of P .

$$P_{ij(m+n)} = P\left(X_{m+n} = j / X_0 = i\right)$$
$$\sum_r P\left(X_{m+n} = j, X_m = r / X_0 = i\right)$$
$$\sum_r P\left(X_{m+n} = j / X_m = i / X_0 = i\right) P\left(X_m = r / X_0 = i\right)$$

Proof:
Using the following probability rule:
$P\left(A \cap B / C\right) = P\left(A / B \cap C\right) P\left(B / C\right)$ and setting
$A = \left\{X_{m+n} = j\right\}, \mathrm{B} = \left\{X_m = r\right\}, \text{and } \mathrm{C} = \left\{X_0 = i\right\}$
Using Markov property yields

$$P_{ij(m+n)} = \sum_r P\left(X_{m+n} = j / \mathrm{X}_m = r\right) P\left(X_m = r / \mathrm{X}_0 = i\right)$$
$$\sum_r P_{rj(n)} P_{ir(\mathrm{m})}$$
$$\sum_r P_{1r(\mathrm{m})} P_{r1(\mathrm{n})}$$

Hence $\mathrm{P}_{m+n} = \mathrm{P}_m \mathrm{P}_n$ and so $\mathrm{P}_n = \mathrm{P}^n$, the power of P.

To obtain an estimate of the transition probability as follows

$$P_{ij} = P\left(X_t = j / X_{t-1} = i\right), \; for \; j = 0, 1, 2, 3, \cdots, N$$

$$P_{ij} = \begin{cases} P \text{ if } \; j = 1 + j \\ q = 1 - P \text{ if } \; j = i - j \\ 0 \; \text{otherwise} \end{cases}$$

Where $k+1$ is the number of states.

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$$\left.\begin{aligned} n_{ij} &= \sum_{i=1}^{n} P_{ij} \text{ for i j=0,2,3} \\ &\frac{n_{ij}}{n_i} \text{ for } i\ j = 0,1,\cdots k \end{aligned}\right\} \tag{6}$$

However, for $k = 3$ is an estimate of the transition matrix.

$$\hat{P}ij(\text{FIDELITY})_{2016-2022} = \begin{pmatrix} \hat{P}_{00} & \hat{P}_{01} & \hat{P}_{03} \\ \hat{P}_{10} & \hat{P}_{11} & \hat{P}_{12} \\ \hat{P}_{20} & \hat{P}_{21} & \hat{P}_{22} \end{pmatrix} \tag{7}$$

$$\hat{P}ij(\text{ACCESS})_{2016-2022} = \begin{pmatrix} \hat{P}_{00} & \hat{P}_{01} & \hat{P}_{03} \\ \hat{P}_{10} & \hat{P}_{11} & \hat{P}_{12} \\ \hat{P}_{20} & \hat{P}_{21} & \hat{P}_{22} \end{pmatrix} \tag{8}$$

Setting $i\ j = 0,1,2 \text{ for } k = 3$

Developing a Markov chain model of Access and Fidelity Banks share prices

To improve the accuracy of the Markov chain model in predicting upcoming events, it is crucial to tailor it specifically for forecasting share price movements. The initial share prices need to be classified into three clear and distinct finite states as detailed below:

R signifies the likelihood of a decrease in share prices, I indicates the likelihood of an increase, and N represents the probability of share prices remaining unchanged.

However, the probability presented in the transition matrix offers a thorough depiction of the Markov chain, where each element in the matrix conveys precise information. To define the three states of the Markov process, the subsequent table is indispensable.

Table 1: Transition Probability Matrix

State	1	2	3	Total of Row
1	P_{11}	P_{12}	P_{13}	T_1
2	P_{21}	P_{22}	P_{23}	T_2
3	P_{31}	P_{32}	P_{33}	T_3

In every entry, P_{ij} represents the frequency of transitions from state i to state j. The transition matrix is calculated by dividing each element in a row by the total of that respective row. However, this study focused on analyzing the Fidelity share price data from Osu et al. (2019).

Principal Component Analysis (PCA) of the Share Price Variables

Definition 3: Suppose $\underline{X}$ has a joint distribution that has a variance matrix $\sum$ with eigenvalues $\lambda_1, \geq \lambda_2 \geq ... \geq \lambda_p \geq 0.$ Consider the random variables $y_1 ... y_p$ that are a linear combination of the $X_1's$ (Udom, 2015), i.e.:

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$$\left.\begin{aligned} y_1 &= \underline{l}_1'\underline{X} = l_{11}X_1 + \ldots + l_{p_1}\lambda_p \\ &\vdots \\ y_p &= \underline{l}_1'\underline{X} = l_1 pX_1 + \ldots + l_{p_1}\lambda_p \end{aligned}\right\} \quad (9)$$

The y_i's will be PC if they are uncorrelated and the variances of y_1, y_2 are as large as possible. Recall that if $y_i = l_i'X$. To assess the information content within y_i, we can examine the proportion of the overall population variance attributed to y_i.

$$\frac{\lambda_i}{\lambda_1 + \lambda_2 + \cdots + \lambda_p}, i = 1, \ldots, p \quad (10)$$

Hopefully, the proportion is large for e.g., 1, 2, and 3.

3. Results/Findings

The data utilized in this study is derived from the research conducted by Osu et al. (2019). It aims to illustrate the closing performance of market share prices for two merged banks categorized into finite states. The share price data covered the period 2016 to 2022 and is sourced from the Nigerian Stock Exchange.

Table 1: Share Price of Fidelity Bank, PLC from 2016-2022

Share price movements	Reducing (R) its share Price	Increasing (I) its share price	No(N) change in price	Row totals
R	415	62	138	615
I	61	121	81	263
N	139	80	384	603

Table 2: Share Price of Access Bank, PLC from 2016-2022

Share price movements	Reducing(R) its share Price	Increasing(I) its share price	No(N) change in price	Row totals
R	410	80	126	616
I	79	98	92	269
N	127	91	378	596

Probability Transition Matrix For Access Bank Share Price

$$ACCESS_{BANK}\,(\text{pij}) = \begin{pmatrix} 0.6656 & 0.1299 & 0.2045 \\ 0.2937 & 0.3643 & 0.3420 \\ 0.2131 & 0.1527 & 0.6342 \end{pmatrix}$$

Access Bank (2016-2022): Suggests a 67% chance of a forthcoming price decline, a 13% likelihood of an increase, and a 20% probability of price stability. Similarly, under comparable conditions, there is a 29% probability of a decline, a 36% chance of an increase, and a 34% likelihood of no change. To sum up the scenarios, there is a 21% probability of a decline, a 15% chance of an increase, and a 63% likelihood of no change. The above valuations provide an eye opener to the management of Access Bank, PLC that will enhance investment decisions.

Probability Transition Matrix for Fidelity Bank Share Price

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$$\text{FIDELITY}_{BANK}(\text{Pij}) = \begin{pmatrix} 0.6748 & 0.1008 & 0.2244 \\ 0.2319 & 0.4601 & 0.3080 \\ 0.2305 & 0.1327 & 0.6368 \end{pmatrix}$$

Fidelity (2016-2022): Expresses a 67% likelihood of a price reduction in the near future, a 10% probability of a price increase, and a 22% chance of price stability. Furthermore, in similar conditions, there is a 23% probability of a price drop, a 46% likelihood of a price increase, and a 31% chance of no change. Ultimately, a 23% chance of a price decrease, a 13% probability of a price increase, and a 64% chance of no change. The stochastic analysis of Fidelity share prices offers insights into future price movements, aiding informed investment decisions in the long run.

Principal Component Analysis (PCA) of Two Share Price Variations

For Access Bank: Solving the transition matrix as characteristics equation gives the following:

with eigen values $\lambda_1 = 0.2195$, $\lambda_2 = 0.4446$ and $\lambda_3 = 1$

Any vector of the form say:

$$K_1 = \begin{pmatrix} 0.5599 \\ -3.4973 \\ 1.0000 \end{pmatrix} = \begin{pmatrix} 0.5599C \\ -3.4973C \\ 1.0000C \end{pmatrix}; \text{ say is an eigenvector corresponding to } \lambda_1 = -0.2195$$

Any vector of the form say:

$$K_2 = \begin{pmatrix} -1.08855 \\ 0.2776 \\ 1.0000 \end{pmatrix} = \begin{pmatrix} -1.08855C \\ 0.2776C \\ 1.0000C \end{pmatrix}; \text{ say is an eigenvector corresponding to } \lambda_2 = 0.4446$$

Any vector of the form say:

$$K_3 = \begin{pmatrix} 1.0000 \\ 1.0000 \\ 1.0000 \end{pmatrix} = \begin{pmatrix} 1.0000C \\ 1.0000C \\ 1.0000C \end{pmatrix}; \text{ say is an eigenvector corresponding to } \lambda_2 = 1.0000$$

To obtain a normalized eigenvector for the share price of FIDELITY bank:

$$K_1'K_1 = 1, \begin{pmatrix} 0.5599C & -3.4973C & 1.0000C \end{pmatrix} \begin{pmatrix} 0.5599C \\ -3.4973C \\ 1.0000C \end{pmatrix}, \quad \text{C} = \frac{1}{\sqrt{13.5445953}}, \; e_1 = \begin{pmatrix} \frac{0.5599}{\sqrt{13.5445953}} \\ \frac{-3.4973}{\sqrt{13.5445953}} \\ \frac{1.0000}{\sqrt{13.5445953}} \end{pmatrix}$$

$$= 0.1521, -0.9503 \text{ and } 0.2717$$

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$$K_2'K_2 = 1, \begin{pmatrix} -1.08855C & 0.2776C & 1.0000C \end{pmatrix} \begin{pmatrix} -1.08855C \\ 0.2776C \\ 1.0000C \end{pmatrix}, \mathrm{C} = \frac{1}{\sqrt{2.262002863}}, \ e_2 = \begin{pmatrix} \frac{-1.08855}{\sqrt{2.262002863}} \\ \frac{0.2776}{\sqrt{2.262002863}} \\ \frac{1.0000}{\sqrt{2.262002863}} \end{pmatrix}$$

$$= -0.7238, \ 0.1838 \ \text{ and } 0.6649$$

$$K_3'K_3 = 1, \begin{pmatrix} 1.0000C & 1.0000C & 1.0000C \end{pmatrix} \begin{pmatrix} 1.0000C \\ 1.0000C \\ 1.0000C \end{pmatrix}, \mathrm{C} = \frac{1}{\sqrt{3}}, \ e_3 = \begin{pmatrix} \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \end{pmatrix} = 0.5774, \ 0.5774 \ \text{ and } 0.5774$$

$$Y_1 = e_1'K = 0.1521K_1 - 0.9503K_2 + 0.2717K_3$$
$$Y_2 = e_2'K = -0.7238K_1 + 0.1838K_2 + 0.6649K_3$$
$$Y_3 = e_2'K = 0.5774K_1 + 0.5774K_2 + 0.5774K_3$$

To calculate the principal component of Access Bank share price accounted for the first PC

$$\lambda_1 = 0.2195, \ \lambda_2 = 0.4446 \ , \lambda_3 = 1.0000 = \frac{\lambda_1}{\lambda_1 + \lambda_2} = 40\%$$

To calculate the principal component of Access Bank share price accounted for the 2nd PC

$$\lambda_1 = 0.2195, \ \lambda_2 = 0.4446 \ , \lambda_3 = 1.0000 = \frac{\lambda_1 + \lambda_2}{\lambda_1 + \lambda_2} = 42\%$$

For FIDELITY Bank: Solving the transition matrix as characteristics equation gives the following:

$$\text{with eigen values } \lambda_1 = 0.3278, \ \lambda_2 = 0.4439 \text{ and } \lambda_3 = 1.0000$$

Any vector of the form say:

$$V_1 = \begin{pmatrix} 0.06009 \\ -2.4331 \\ 1.0000 \end{pmatrix} = \begin{pmatrix} 0.06009C \\ -2.4331C \\ 1.0000C \end{pmatrix}; \text{ say is an eigenvector corresponding to } \lambda_1 = 0.3278$$

Any vector of the form say:

$$V_2 = \begin{pmatrix} -1.3959 \\ 0.9712 \\ 1.0000 \end{pmatrix} = \begin{pmatrix} -1.3959C \\ 0.9712C \\ 1.0000C \end{pmatrix}; \text{ say is an eigenvector corresponding to } \lambda_2 = 0.4439$$

Any vector of the form say:

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$$V_3 = \begin{pmatrix} 1.0000 \\ 1.0000 \\ 1.0000 \end{pmatrix} = \begin{pmatrix} 1.0000C \\ 1.0000C \\ 1.0000C \end{pmatrix}; \text{ say is an eigenvector corresponding to } \lambda_2 = 1.0000$$

To obtain a normalized eigenvector for the share price of FIDELITY Bank:

$$V_1'V_1 = 1, \begin{pmatrix} 0.06009C & -2.4331C & 1.0000C \end{pmatrix} \begin{pmatrix} 0.06009C \\ -2.4331C \\ 1.0000C \end{pmatrix}, \ \mathrm{C} = \frac{1}{\sqrt{6.923586418}}, \ e_1 = \begin{pmatrix} \frac{0.06009}{\sqrt{6.923586418}} \\ \frac{-2.4331}{\sqrt{6.923586418}} \\ \frac{1}{\sqrt{6.923586418}} \end{pmatrix}$$

$$= 0.02284, -0.9247 \text{ and } 0.38004$$

$$V_2'V_2 = 1, \begin{pmatrix} -1.3959C & 0.9712C & 1.0000C \end{pmatrix} \begin{pmatrix} -1.3959C \\ 0.9712C \\ 1.0000C \end{pmatrix}, \mathrm{C} = \frac{1}{\sqrt{2.89176625}}, \ e_2 = \begin{pmatrix} \frac{-1.3959}{\sqrt{2.89176625}} \\ \frac{0.9712}{\sqrt{2.89176625}} \\ \frac{1.0000}{\sqrt{2.89176625}} \end{pmatrix}$$

$$= -0.8209, 0.5711 \text{ and } 0.5881$$

$$V_3'V_3 = 1, \begin{pmatrix} 1.0000C & 1.0000C & 1.0000C \end{pmatrix} \begin{pmatrix} 1.0000C \\ 1.0000C \\ 1.0000C \end{pmatrix}, \mathrm{C} = \frac{1}{\sqrt{3}}, \ e_3 = \begin{pmatrix} \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \end{pmatrix} = 0.5774, 0.5774 \text{ and } 0.5774$$

$$Y_1 = e_1'V = 0.02284V_1 - 0.9247V_2 + 0.38004V_3$$
$$Y_2 = e_2'V = -0.8209V_1 + 0.5711V_2 + 0.5881V_3$$
$$Y_3 = e_2'V = 0.5774V_1 + 0.5774V_2 + 0.5774V_3$$

To calculate the principal component of the Access Bank share price accounted for the first PC

$$\lambda_1 = 0.3278, \ \lambda_2 = 0.4439 \ , \lambda_3 = 1.0000 = \frac{\lambda_1}{\lambda_1 + \lambda_2} = 42\%$$

To calculate the principal component of the Access Bank share price accounted for the 2nd PC

$$\lambda_1 = 0.3278, \ \lambda_2 = 0.4439 \ , \lambda_3 = 1.0000 = \frac{\lambda_1 + \lambda_2}{\lambda_1 + \lambda_2} = 44\%$$

Discussion

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In the Access Bank share price, the first and second PCA values of 40% and 42% are the percentages of the total variance in share prices that are explained by the first and second principal components, respectively. This means that 40% of the total variation in share prices can be explained by the first principal component (PC), and an additional 42% can be explained by the second PC. The remaining 18% of the variation is explained by the remaining Principal Components (PCs). This information is useful for understanding the behavior of financial markets. This situation helps Access Bank to identify trends and patterns in share prices, which can be used for predictions.

Similarly, the Fidelity Bank share price, the first and second PCA values of 42% and 44%, is the percentage of the total variance in share prices that is explained by the first and second principal components in that order. This implies that 42% of the total variation in share prices can be explained by the first principal component (PC), and an extra 44% can be explained by the second PC. The outstanding 14% of the variation is explained by the outstanding principal components (PCs). This basic information is useful for understanding the behavior of financial markets. This circumstance benefits Fidelity Bank by identifying trends and patterns in share prices and being used for predictions in order to maximize good profit margins.

However, the inferences of the two banks as drawn from this work are as follows: The fact that the first and second PCA values are similar for both banks suggests that the factors that affect share price are similar for both banks. The small differences in the values indicate that some specific factors affect one bank more than the other, but overall, they are influenced by similar factors. This is useful information for investors trying to decide between these two banks, as it suggests that the risk and return profiles of the two banks may be similar. Additionally, it is crucial to remember that PCA values are only one factor to take into account when making investment decisions.

Conclusion

The financial markets widely recognize the stock market's performance and operations as a viable investment sector. This research tackles the challenge of predicting share prices for Access and Fidelity Banks, utilizing Markov chain and principal component analysis methodologies. Initially, 3-step transition probability matrices were established. An analysis of these matrices revealed that Access Bank, PLC exhibits the highest probability of a future price increase at 12%, along with the highest likelihood of a decrease at 21%, and the most favorable chance of no change at 20% in the near future. This data serves as a valuable guide for informed decision-making in the bank's daily operations. Similarly, Fidelity Bank, PLC demonstrates the highest probability of a future price increase at 10%, along with the highest probability of a decrease at 23%, and the optimal likelihood of no change at 22% in the near future, providing essential insights for effective day-to-day management decisions.

Again, the fact that the first and second PCA values are similar for both banks, suggests that the factors that affect share price are similar for both banks. The small difference in the values indicates that there are some specific factors that affect one bank more than the other, but overall they are influenced by similar factors, which is useful information for investors who are trying to decide between these two banks, as it suggests that the risk and return profile of the two banks is similar.

Finally, this study explores the three-state scenario of a transition matrix through PCA. The suggestion of a stochastic differential equation problem presents an exciting direction for future research.

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