Communications on Applied Nonlinear Analysis
ISSN: 1074-133X
Vol 31 No. 8s (2024)

Analyzing SBI Share Price Volatility: A Novel Mathematical Exploration with the Markovian Model

A. Manickam[1] , A. Benevatho Jaison [2], Dasunaidu Kuna[3*],Lakhlifa Sadek[4]
S. Indrakala[5] and Pranjal Mohan Pandey[6]

[1] School of Sciences, Division of Mathematics, SRM Institute of Science and Technology, Tiruchirappalli Campus, SRM Nagar, Trichy – Chennai Highway, Near Samayapuram, Tiruchirappalli –621105. Tamilnadu, India. manickammaths2011@gmail.com

[2] Mathematics Division, School of Advanced Sciences and Languages, VIT Bhopal University, Bhopal-Indore Highway, Kothrikalan, Sehore, Madhya Pradesh - 466114, India. benejaison@gmail.com

[3] Department of Basic Sciences &Humanities, Department of Mathematics GMR Institute of Technology, Rajam-532 127, Vizianagaram(Dt), Andhra Pradesh, India. * dasunaidu.k@gmrit.edu.in

[4] Department of Mathematics, Faculty of Sciences and Technology, BP 34. Ajdir 32003 AI- Hoceima,Abdelmalek Essaadi University,Tetouan,Morocco. lakhlifasadek @gmail.com

[5] Department of Mathematics, Kunthavai Nacchaiyar Government Arts College for Women(Autonomous), Thanjavur 613007, Tamil Nadu, India. s.indirakala@yahoo.com

[6] AI Division, School of Computing Sciences and Engineering, VIT Bhopal University, Bhopal-Indore Highway, Kothrikalan, Sehore, Madhya Pradesh - 466114, India. pranjal.mohan2020@vitbhopal.ac.in

Article History:

Received: *18-05-2024*

Revised: *01-07-2024*

Accepted: *20-07-2024*

Abstract

By transferring inactive cash from surplus to deficit units in the economy, the stock market plays a significant part in facilitating financial transactions in developing as well as developed nations. Stock market forecasting is observed as one of the most difficult undertakings in today's financial sector. As a result, much emphasis has been placed on scrutiny and prediction of future standards and performance of the financial time series. Business cycles, interest rates, monetary policy, general economic conditions, traders' expectations, political events, and so on influence the stock market. Academic studies show that market price fluctuations are not random, but rather follow a highly non-linear, dynamic pattern. The aim of this written paper is to use a Markov model to detect volatility in SBI share prices. Markov chains are commonly used to describe a wide range of real-world scenarios including randomness. They are used in a variety of sectors, ranging from search engine page ranking to the investigation of genetics in biology. They are frequently used throughout the finance and economics fields to describe unpredictability and anticipate the value of assets in addition to the changes in macroeconomic circumstances such as recession and expansion cycles.

Keywords: Markov process, Prediction, TPM, Steady state probability.

1.Introduction:

It is a complex task to predict financial markets as the distribution of economic time series varies over a certain extent of time. Financial conditions, investor expectations, and the relative performance of other stock markets or exchange rates could all contribute to these fluctuations. Investors have recently started to express interest in trading on stock market indices as it offers them opportunities to manage their market risk whilst providing a lucrative investment opportunity for speculators and arbitragers.

Depending on the trend which is prevailing in the stock market, investors employ distinct trading strategies. Due to this, predicting the future trajectory of the stock market becomes essential. This presents a possibility of a trend that the stock market as a whole might follow. This also helps assist investors choose an appropriate investment strategy.

Stock market prediction is an important aspect of finance. Despite this, information related to a certain stock is vague, uncertain and incomplete, which makes predicting future economic performance a task. Hence, accurate stock market predictions are important. One of the main reasons for it is, the need for investors, to avoid and manage potential market risks and the opportunities to make profits by trading indexes by arbitrators and speculators.

In the past, several researches have been conducted, relating to stock market prediction throughout the world in several stock exchanges from the 1990s. Usually, there are three methods of thoughts observed regarding such prediction. The first of this method of thoughts, believes that an investor cannot achieve beyond the average trading advantages seen due to historical and current information. The Random Walk and Efficient Market hypotheses are examples of major theories. If these predictions will come true it will make all prediction methods worthless. Lo and MacKinlay (1999) gave us engrossing evidence to disprove the random walk hypothesis and which motivates researchers to develop better market price model's prediction.

Fundamental analysis is the second viewpoint. Numerous macroeconomic variables are well studied by analysts and considering the potential link between stock price fluctuations, we observe financial conditions and the results of the industry concerned to a level of correlation that exists with variations in the stock prices. Elleuch (2009) observed whether based on historical accounting information and use of a simple fundamental analysis strategy there can be prediction of stock returns. According to the fundamental accounting and price information of stocks trading on the Australian Stock Exchange, Fan & Palaniswami (2001) used support Vector Machines (SVM) to identify stocks that will outperform the market. Qi & Maddala (1999) showed that the ability of stock returns by means of linear regression can be improved by a neural network. Singh et al., (2011) examined the casual relationship between index returns and certain crucial macroeconomic variable namely employment rate, exchange rate, GDP, inflation and money supply for Taiwan.The third viewpoint on market pricing is provided by technical experts by prediction. Experts believe that the market exhibits identification and prediction of reiterating tendencies and performance. The procedure consisted of numerous statistical parameters such as technical indicators and charting patterns depending on historical data. Due to a high dependency on human expertise and justification, these techniques often yield contradictory results. In addition to the technical analysis techniques, financial researchers have created a number of well-known numeric forecasting models, including the autoregressive conditional heteroscedasticity (ARCH) model by Engle (1982), the generalized ARCH (GARCH) model by Bollerslev (1986), the autoregressive moving average (ARMA) model by Box & Jenkins (1976), and the autoregressive integrated moving average model (ARIMA). Mehrara et al., (2010) used moving average crossover inputs based on technical analysis rules for forecasting stock price index in Tehran Stock Exchange. The fourth vision is dynamic systems and chaotic behavior of stock price. Statistical models and soft-computing models can be used to categorize these models. All of these strategies have very distinct underlying models, so the results they produce are typically quite erratic. Moreover, these

analytical techniques heavily rely on human judgment and knowledge in areas such as the location of reversal (or continuation) patterns, market patterns, and trend predictions.Due to the above mentioned factors, researchers signify the necessity of creating models on the basis of statistical and soft computing techniques to provide accurate predictions.The ARIMA-methods are among the most well-known statistical techniques. Fuzzy logic (Hiemstra 1994), genetic algorithms (Lin, Cao, Wang & Zhang 2004), Markov models (Hassan & Nath 2005), and hidden markov models (Gupta A 2012) are further methods used to forecast stock markets. Typically, a predicate model is created using a training set made up of various kinds of historical data and then applied to future prediction. The four perspectives mentioned above described the type of analysis used in stock market analysis.

According to the analysis of data given above, we see that the amount of success of all these strategies not only varies from study to study but also depends on the data used and the way these methods are applied each time. None of them, however, has been demonstrated to be the reliable forecasting tool that the investor would like to have. The goal of the current study is to investigate a Markov model that outperforms earlier models for daily stock market predictions in terms of its ability to predict changes in SBI share values.

2.Mathematical Model:

Named after Andrey Markov, Markov chains are a type of stochastic model that shows a series of potential outcomes, with each state's probability or prediction dependent only on the previous event's state and not on any previous states. For determining the probability of n+1th steps being x, only the nth steps matter, not the entire series of actions before n. This characteristic is often referred to as memory lessness or the Markov property. Let's examine our Markov chain using a diagram,

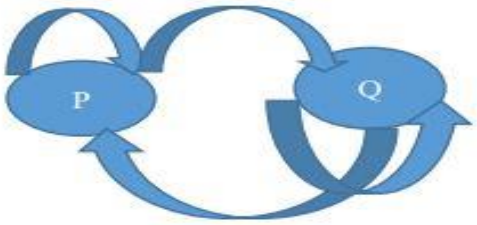

Figure 1: Markov two-state process

A diagram showing a two-state (in this case, P and Q) Markov process. The likelihood of the Markov process shifting from one state to another is indicated by the number connected with the arrows, which started from the present state and pointed to the future state in this example.

When the Markov process is in state P, for example, the likelihood that it will transition to state Q is 0.7, whereas the probability that it will stay in state P is 0.3. The likelihood of any process in state Q changing to state P is 0.4, while the probability of it staying in the same state is 0.6.

If a series of events exists mathematically, then $\{Y_t , t \geq 0\}$ is a sequence of events, then $P [Y_{t+1} = j | Y_t = i, Y_{t-1} = i - 1, \ldots \ldots , Y_1 = 1, Y_0 = 0]$

$= P [Y_{t+1} = j | Y_t = i] = a_{ij} \geq 0$, where $\sum_{j=1}^{n} a_{ij} = 1$. Such type of the random process is termed as a discrete time MC according to Medhi in [8], where

X_0 , X_1 , X_2 , … … . , X_t, X_{t+1} are the states of the Markov chain in the state space S and the probability aij is called transition or MC probability.

In this study, we have taken into account five different Markov chain states. Here are descriptions of the five MC states:

Ma.A : When $(y_n - y_{n-1}) > +25$, the procedure is at the stage where is Maximum Achievement.

Mi.A : When $+1 < (y_n - y_{n-1}) < +25$, the process is in the state of Minimum Achievement.

St : When $-1 < (y_n - y_{n-1}) < +1$, the process is in the state of Stable.

Mi.D : When $-25 < (y_n - y_{n-1}) < -1$, the process is in the state of Minimum Decline.

Ma.D : When $(y_n - y_{n-1}) < -25$, the process is in the state of Maximum Decline,

where x_n is current and y_{n-1} is the previous closing share prices of SBI. The Markov chain model is denoted by $\Lambda = (Q, Y, \alpha^{(0)})$, where Q is the set of states' Q = $\{Ma.A, Mi.A, St, Mi.D, Ma.D\}$, X and $\alpha^{(0)}$ are the model's parameters, also referred to as TPM and IPV. The TPM, according to the Markov chain, is the likelihood that a particle will transfer from one state to the next. IPV contain five elements α_1, α_2 , α_3, α_4, α_5. The elements of IVP are the likelihoods of the states Ma.A, Mi.A, St, Mi.D, Ma.D such that $\sum_{i=1}^{n} \alpha_i = 1$.

3.Application of Proposed Model:

The information used in this study was taken from www.investing.com and relates to the open share prices of State Bank of India (SBI). From January 1st, 2016, through December 23rd, 2022, this data covers 1725 trading days and includes SBI's daily opening price change for those days. Figure 2 illustrates the stock market trend for SBI from January 1, 2016, to December 23, 2022.

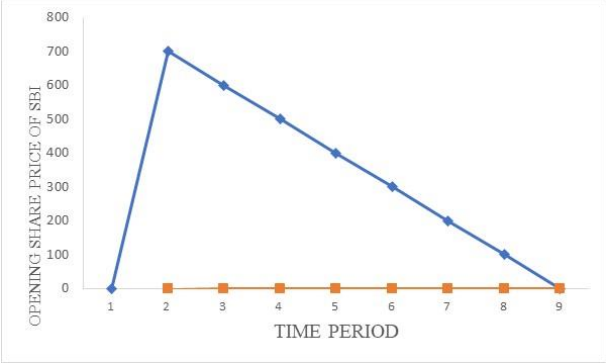

Figure 2: SBI's Opening Share Price Trend

According to the opening share price data for SBI, the price on the next day will either be in the state of Ma.A, Mi.A, St, Mi.D, or Ma.D. The frequency of the states is listed in the following table. Ma.A, Mi.A, St, Mi.D, and Ma.D.

Table 1: Frequencies of the States

Positions	**Ma.A**	**Mi.A**	**St**	**Mi.D**	**Ma.D**	**Total**
Occurrence	12	709	265	737	1	1724

Thus, the following steps are taken to obtain the necessary initial probability vector: P(Ma.A) = 0.00696056, P(Mi.A) = 0.4112529, P(St) = 0.1537123, P(Mi.D) = 0.42401392, and P(Ma.D) = 0.00058005 for the following parameters.

The following table lists the transition frequencies:

Table 2: Transition Frequency Table

	Ma.A	**Mi.A**	**St**	**Mi.D**	**Ma.D**	**Total**
Ma.A	1	5	2	3	1	12
Mi.A	5	265	105	333	0	708
St	1	108	54	102	0	265
Mi.D	5	331	104	297	0	737
Ma.D	0	0	0	1	0	1

As a result, using Table 2, the necessary TPM is discovered in the matrix shown below.

$$Y = \begin{bmatrix} 0.083\ 0.416\ 0.166\ 0.007\ 0.374\ 0.148\ 0.003\ 0.408\ 0.203 \\ 0.250\ 0.083\ 0.470\ 0\ 0.385\ 0\ \ 0.006\ 0.449\ 0.141\ 0\ 0\ 0\quad 0.402\ 0\ 0\ 0 \end{bmatrix}$$

The higher-order SBIs that attain the stationary probability distribution of SBI are identified in order to determine the long-run behaviour of SBI. Below is given the stationary probability distribution:

$$Y^6 = \begin{bmatrix} 0.006\ 0.411\ 0.153\ 0.006\ 0.411\ 0.153\ 0.006\ 0.411\ 0.153 \\ 0.427\ 0\ 0.427\ 0\ 0.427\ 0\ \ 0.006\ 0.411\ 0.153\ 0\ 0\ 0\quad 0.427\ 0\ 0\ 0 \end{bmatrix}$$

$$= Y^7 = Y^8 = Y^9 = \cdots \ldots = Y^n.$$

The stationary condition is reached at step 6, demonstrating that the TPM of a Markov chain reaches equilibrium after the sixth trading day that won't change for the following consecutive trading days. The SBI share price share states' state probability distribution for the 1725th day will be (1) = (0)Y = [0.0069647 0.41147001 0.1537983 0.4271870 0.0005800] since $\alpha^{(n+1)} = \alpha^{(0)}$ Y.

According to this probability distribution, the share prices of SBI have a 0.41 chance of achieving Minimum Achievement (Mi.A) compared to before opening share price on the 1725th day in the future. The state probabilities for the days 1726, 1727, 1728, and 1729 are also calculated and provided in the following table.

Table 3. Day-by-day probabilities for the future

α(2)	0.006	0.411	0.153	0.427	0
α(3)	0.006	0.411	0.153	0.427	0
α(4)	0.006	0.411	0.153	0.427	0
α(5)	0.006	0.411	0.153	0.427	0

The anticipated amount of trips to state j is $\sigma_{jj} = \sum^{n-1} Y^k$ and the anticipated duration to go back to state j from state j is $\sigma_{jj} = 1/\ \alpha_j$ where j = 1, 2, 3, or 4. The number of visits to a particular state in five trading days for SBI is therefore as follows:

$$\sigma_{ij(5)} = \begin{bmatrix} 0.116\ 2.022\ 0.771\ 0.034\ 2.023\ 0.762\ 0.031\ 2.052\ 0.822 \\ 1.997\ 0\ 2.176\ 0\ 2.092\ 0\ \ 0.003\ 2.093\ 0.755\ 0\ 1.681\ 0.6\quad 2.114\ 0\ 2.686\ 0 \end{bmatrix}$$

The initial row of the matrix shows that if the SBI share price starts at Ma.A on each of the five trading days, the average number of visits the chain makes to Ma.A, Mi.A, St, Mi.D, and Ma.D are 0.1, 2.01, 0.76, 1.98, and 0.08, respectively. now we have

$\sigma_{(Mi.A,Mi.A)}$ = 1/0.411 = 2.4from the stationary probability matrix.

The chain for SBI stock prices visits the state of Mi.A on average every 2 days or so, according to the anticipated first reaching time to the state of Mi.A from the state of Mi.A. The anticipated return time to each state can also be discovered.

4.Results and Conclusion:

Because stock market investors often do not trade every day, it is more crucial to know when to buy and sell stocks versus predicting daily price fluctuation. Investors who trade their stocks daily are hit with astronomical trading costs. The goal of market timing as an investment technique is to generate an extra return. In the past, excess return has been attained by alternating between asset classes ahead of significant stock market turning periods. Furthermore, even though there are an endless number of trading rules that might be used, it appears that only a small number of them would have resulted in a profit.

In order to analyse and assess the predicting accuracy of the MC model in the setting of the Indian stock market, we applied a first order discrete time MC model to the historical stock prices of a State Bank of India. The movement and behaviour of the share price trend in probability measurements is explained by the Markov Chain model. The explanation of IPV and TPM shows likelihood of the state Ma.D. as extremely low, illustrating market instability. The consequences regardless of SBI's initial share price, the stationary probability matrix demonstrates that, over a long period of time, we can envisage that the share price for it would increase. would reach its highest achievement with a probability of 0.006, its minimum achievement with a chance of 0.411, remain steady with a probability of 0.153, and experience the least amount of loss. maximum decline has a probability of 0.00058, minimum decline has a probability of 0.427, and stability has a probability of 0.153.

According to the aforementioned findings, SBI's share prices are less likely to experience a maximum decline than are the share prices of all other states that are still in existence, and they are also more likely to experience a minimum decline than all other states that are still in existence. Consequently, we may say that investing in SBI shares is not a terrible choice for investors because there is a strong likelihood that the minimal accomplishment will occur, If the chain is in the minimal achievement state, it will reach the minimum achievement state after two days it is initially in the state of maximum decline, it will take it approximately 1724 days to reach that state. The creation of trading systems using historical data has been hotly contested. We all agree that the future won't exactly resemble the past, but a popular investment strategy is to use strategies that appear to have a good chance of succeeding in the future and would have likely worked well in the past.

Acknowledgement:

The authors are grateful to the anonymous editor and Reviewers for taking the time and effort to review the manuscript. We sincerely appreciate all valuable comments and suggestions which helped

us improve the manuscript's quality. The first author dedicates this research article to his beloved son **"M.Midhush"**.

Funding information: This research received no specific grant from any funding agency, commercial or non-profit sectors.

Conflict of interest: The authors have no conflicts of interest to disclose.

Ethical approval: This research did not require ethical approval.

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