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Application of Markov Chain to stock trend: A study of PT HM Sampoerna, tbk.

A Fitriyanto[1] and T E Lestari[2]*

[1] Applied Mathematics, Faculty of Engineering and Technology, Sampoerna University, Jakarta, Indonesia.
[2] Faculty of Engineering and Technology, Sampoerna University, Jakarta. Indonesia.

*tika.lestari@sampoernauniversity.ac.id

Abstract. One of attractive area for investment is the stock market. Indonesia stock exchange being a stock market in a region that is considered investors will take the opportunity to make investment decisions based on the future expectations of the stock market. Knowing the behaviour of the stock price of a company really important for investor. Therefore, we conduct this research with aimed at knowing the stock market trend movement. In the prediction of stock market trends are widely applied some models; one of model is Markov Chain model. The objective of this research is to apply Markov Chain in PT HM Sampoerna stock price. The data that use in this research is the closing price of PT HM Sampoerna which was obtained from yahoo finance website over a period covering from 1st January 2017 to 31st December 2017. A Markov Chain model was determined based on probability transition matrix and initial state vector. In the long run, the model predicted that PT HM Sampoerna share prices with probability 0.09, 0.40, 0.46, and 0.05 respectively.

1. Introduction

The stock market is one of the best alternative to various companies for further expansion or set up a new business venture. Generally stocks are the shares of company or organization. Regarding to this activity, Indonesia has meeting place of both buyers and sellers of stock that we called it as the stock exchange which is a legal framework where an individual or group of individual can buy and sell such share in a systematic way and also referes to the wider domain of trading activities of stocks.

The development of Indonesia stock market is gradually moving toward maturity, this is seen on the increase on the total number of Single Investor Identification (SID) in 2017 is increasing 25.24% from 2016 [1] It is increasing from 894.116 SID each year to 1,118,913 SID1 that data provide based on Indonesia Central Security Depository. This is the first time for Indonesia to have SID more than one million. Thus, investor invest their money in stock, bond, government bonds, mutual funds, and others. It shown that people are now make choice to do investment to save and expand their money. It is big improvement for people in Indonesia, it means that people now realize that investment is important to build the economy of Indonesia and their economy itself. By doing investment, money will be growing up and it will increase the purchase power of the money.

Vasanthi mention that Investments are made in different markets, enabling investors to enjoy the benefit of diversification of market [2].

The history of development of foreign capital market has proven that the stock not only has provided significant long-term interests of investor in the past, but also will provide a good investment vector in the future. However, because of the vagaries of the stock market, investors not only have to seriously study the listed company's history, performance and development prospects of such fundamentals, but also be familiar with the variety of technical analysis in order to win a huge return on investment and become a successful investor. Stock trend analysis play an important role in practical stock trading [3]. One of Ideal condition is selecting stocks by fundamental analysis and confirming the timing of buying and selling stocks by technical analysis [4].

That is why is most essential to come up with statistical models and their analysis. There are various statistical methods to study such phenomena like; moving average, regression analysis, Markov Chain model and etc. In this paper we use Markov Chain model to analyze this problem [5]. Markov Chain model has been widely applied to predicting stock trend [6]. One of them is in stock trend. This similar research has done by Doubleday in 2011 and Agwuegbo in 2010. They use application of Markov Chain in stock trends using Dow Jones Industrial Average (DJIA) [7]. Their result indicated that the portfolio behaved similarly to the entire DJIA, both simple models and the partitioned model. In addition, Dimbinirina Ramarimbahoaka research is about Pricing Options in a Finite State Markov Chain Market [8].

2. Material and methods

Markov prediction model plays an important role in the modern statistics because it has Markov properties (no after-effect properties). Markov Chain was introduced by Andrei Andreevic Markov (1856 – 1922). One of the important property of Markov Chain model is that the occurrence of any event in the future depends on the present state.

The set of value taken by the Markov Process is known as state space. A Markov process having discrete state space is termed as Markov Chain1. The difference between Markov model and other statistics methods (such as regression analysis, time series, etc.) is no need to find mutual laws between the factors into the complex predictor. Markov Chain can predict change of the internal state by calculating the state transition probability then Markov model has broad applicability in predicition of the stock market. By using Markov Chain model it is easier to predict the possibility of state value in a certain period of time after knowing the initial probability distribution and transition probability matrix.

In this paper, we used stock data from PT. Hanjaya Mandala Sampoerna (data collected from Yahoo Finance). The data is the close price of the stock from 1 January 2017 until 31 December 2017.

2.1. Definition of Markov Chain

Let {X_n,n=0,1,2,…,} be a stochastic process that take on a finite of possible values. If X_n=i, then the process said to be in state i at time n. Suppose that

$$P\{X_{n+1} = j | X_n = i, X_{n-1} = i_{n-1}, \dots, X_0 = i_0\} = P_{ij} \quad (1)$$

Whenever the process in state i, there is a fixed probability P_{ij} that will next be in state j. The equation above means that the conditional distribution of any future state X_{n+1}, given the past states $X_0, X_1, \dots, X_{n-1}$ and the present state X_n, is independent of the past states and depends only on the present state.

2.2. Transition probability, transition probability matrix and state probability matrix

The transition probability as defined by the Markov Chain is called transition or jump probability from state i to state j, then since probabilities are nonnegative and since the process must make a transition into some state, we will have

$$P_{ij} \geq 0, ij \geq 0; \sum_{j=0}^{\infty} P_{ij} = 1, i = 0,1, \dots \quad (2)$$

Let P denote the matrix of one-step transition probabilities P_{ij} so that

$$P = [P_{ij}] = \begin{bmatrix} P_{11} & P_{12} & \dots & P_{1m} \\ P_{21} & P_{22} & \dots & P_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ P_{m1} & P_{m2} & \cdots & P_{mm} \end{bmatrix} \quad (3)$$

From this transition matrices, we need to construct matrices that result from the state vector. We let the initial state vector as $B(1)$, then to find the next state vector we use formula below:

$$B(n) = B(n-1) \times P \quad (4)$$

From the state vector, we will construct new matrix, which is:

$$Q = \begin{bmatrix} B(1) \\ B(2) \\ B(3) \\ B(4) \end{bmatrix} \quad (5)$$

A Markov Chain said to have a steady state distribution if matrices transition P have an equation:

$$\pi Q = \pi \quad (6)$$

A vector of steady state P from a column in random walk state m could be defined as:

$$\lim_{n\to\infty} Q^n = \begin{bmatrix} \pi 1 & \pi 2 & \dots & \pi m \\ \pi 1 & \pi 2 & \dots & \pi m \\ \vdots & \vdots & \ddots & \vdots \\ \pi 1 & \pi 2 & \dots & \pi m \end{bmatrix} \quad (7)$$

2.3. Stationary distribution of a Markov Chain

Let Q is the matrices of transition probability with m state from a homogeneous Markov Chain. If $\ni \pi = \pi Q \; and \; \sum_{j=0}^{m} \pi_j = 1$ then $\pi = [\pi_0, \pi_1, \pi_2, \dots, \pi_m]$ is the stationary distribution for homogeneous Markov Chain. If a Markov Chain is irreducible, positive recurrent, and aperiodic (Ergodik Markov Chain) then it has a limit of probability, thus

$$\lim_{n\to\infty} {Q_{ij}}^n = \pi_j > 0 \; (i, j = 0,1,2, \dots) \quad (8)$$

that free from initial condition i, with $\{\pi_j, j = 0,1,2, \dots\}$ singular and it's a positive solution from $\pi_j = \sum_{i=0}^{\infty} \pi_i Q_{ij}$ and $\sum_{j=0}^{\infty} \pi_j = 1, \; j = 0,1,2, \dots$ its called Stationary Distribution of Markov Chain.

3. Result

3.1. Data Source

The stock price is very important indicator for investor in order to analyze and forecast stock market. It measure the changes in financial market and represents a portfolio of securities trading on a particular market.

As mentioned in materials and methods, in this paper we used stock data from PT. Hanjaya Mandala Sampoerna. The data is the close price of the stock from 1 January 2017 until 31 December 2017. The stock price is shown in figure1. The data will be classified into 4 state. State means the characteristics or category that given to any data in given time. This state is classify from the difference of previous stock price with the current price.

The 4 state is classify into:

- State 1: Going Up High,
- State 2: Going Up Low,
- State 3: Going Down Low,
- State 4 : Going Down High

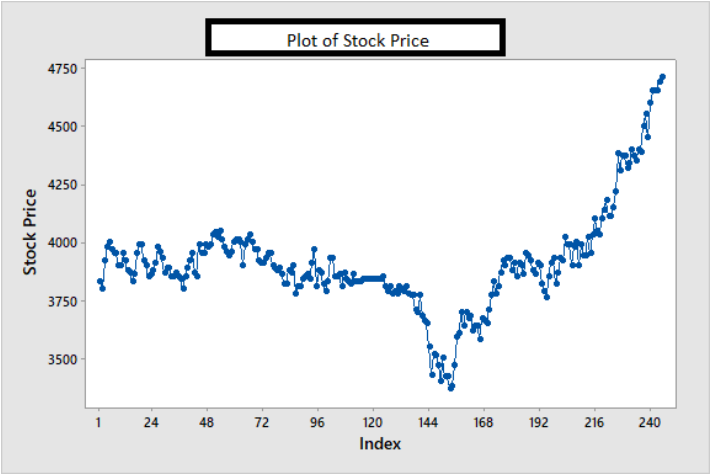

Figure 1. Plot of stock price.

We analyze data information by using Markov Chain by (1) Constructing the state process and determining the state probability. (2) Determine state transition probability matrix. (3) Calculating state probability. (4) Analysis, decision making in a stable condition.

The transition matrices we get for those state are:

$$P = \begin{bmatrix} 0.06 & 0.41 & 0.53 & 0 \\ 0.07 & 0.42 & 0.47 & 0.04 \\ 0.08 & 0.40 & 0.47 & 0.06 \\ 0.40 & 0.40 & 0.10 & 0.10 \end{bmatrix}$$

From this transition matrices, we get the stationary distribution. Before

$$Let\ initial\ state\ vector = B(1)$$

$$B(1) = [0.09 \quad 0.39 \quad 0.46 \quad 0.05]$$

From the initial state vector, we need to find the next vector. As we use 4 state, we need to find the state vector from 1 to 4$(B(1), B(2), B(3), B(4))$.

$$B(2) = [0.09 \quad 0.41 \quad 0.45 \quad 0.05]$$

$$B(3) = [0.09 \quad 0.41 \quad 0.46 \quad 0.05]$$

$$B(4) = [0.09 \quad 0.41 \quad 0.46 \quad 0.05]$$

Stationary Distribution will be construct from the state vector:

$$Q = \begin{bmatrix} 0.09 & 0.39 & 0.46 & 0.05 \\ 0.09 & 0.41 & 0.45 & 0.05 \\ 0.09 & 0.41 & 0.46 & 0.05 \\ 0.09 & 0.41 & 0.46 & 0.05 \end{bmatrix}$$

As the matrix column still not at steady. We need to make it into steady state which is done for this data in Q^2

$$Q^2 = \begin{bmatrix} 0.09 & 0.40 & 0.46 & 0.05 \\ 0.09 & 0.40 & 0.46 & 0.05 \\ 0.09 & 0.40 & 0.46 & 0.05 \\ 0.09 & 0.40 & 0.46 & 0.05 \end{bmatrix}$$

From the result above, the steady state vector is found in the matrices multiplication. It is become steady state vector in Q^2. From the result we could get:

$\boldsymbol{\pi 0}$	$\boldsymbol{\pi 1}$	$\boldsymbol{\pi 2}$	$\boldsymbol{\pi 3}$
0.09	0.40	0.46	0.05

The result is interpreted as:

- Probability for Going Up High= 9%
- Probability for Going Up Low= 40%
- Probability for Going Down Low= 46%
- Probability for Going Down High= 5%

4. Conclusion

As we mentioned before, the objective of this paper is we use markov chain model to analyze a stock trend problem, regarding to stock the movement of stock index to the various states in a particular trading day is independent with the index of initial days but depends only on the index of the most recent day. In this study the Markov Chain model is applied to analyze the behaviour of PT HM Sampoerna stocks. The initial state vector and the transition probability matrices are used to estimate probability of PT HM Sampoerna stock being in different states in the upcoming days. The steady state probabilities are obtained from the nth step transition probability matrices shows that the chance of PT HM Sampoerna index will increase is 0.09 and 0.4. The probability that the index will decrease is 0.46 and 0.05. The result can be interpreted as 9 % and 40% increase and 46% and 5% decrease, in this paper we classified increase with going up high and low and decrease with going down low and high respectively. So, this probability can be used as consideration of investor to use this stocks in market activity.

This Markov Chain prediction method is purely a probability forecasting method as predicted results is simply expressed probability of certain state of stock or shares price in the absolute state. This study shows how the markov model fits the data and is able to predict trend due to random walk capability, in that each state can be reached directly by every other state in the transition matrix, consequently giving good results. Markov Chain prediction method is no exception and therefore, a combination of results from using Markov Chain to predict with other factors can be more useful as a basis for decision making. The current study was a case in one company PT HM Sampoerna. Furthermore, the study was conducted based on first order Markov Chain assuming only four possible state. This study therefore suggest that further studies could be conducted on several companies listed in Indonesia, using higher order Markov Chains to gain better insight into behaviour of the stock market.

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