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Application of Markov Chain in Predicting Change in Opening Stock Price

Research Article

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Abstract: The objective of this present paper is to predict the prompt future change in opening stock price and to find steady state transition probability matrix. The opening stock price of National Stock Exchange NIFTY 50 of India from January to July 2017 was studied and opening price of Stock was scrutinized as following Markov chain. This method is widely applied in Stock Exchange and Business area.

Keywords: Markov Process, Transition Matrix, Steady State, Initial state probability distribution.

1. Introduction

The achievement or failure of the entity, company or organizations in the Stock market confide in the choice of decision made which in turn depend to a large extend on how much accurate information they have for prompt future. The Stock Exchange of a day is strongly depends on the opening Stock price of the day. So the prediction for prompt future change in opening Stock price is adored. But it is a complex task since the distribution of financial time series is changing over cycle of time. The Russian Mathematician A.A Markov defined and studied a random process to study the changes from one state to another by mathematical analysis method, known as Markov process during 1906−1912. It can be define in various dynamic systems like as business and natural phenomenon. This research analyzes the change in opening Stock price of a day from the previous day by considering them as distinct states and their pattern of change is calculated using discrete Markov process. Opening Stock price assumes to be cyclic for short period of time but for long period of time it seems to be secular trend. So change in opening stock from previous day to consider, for removing the secular trend. We focused on the concept of Markov Process and proposition of Markov Chain. The data of National Stock Exchange NIFTY 50 for first 7 months of 2017 was analyzed. Furthermore, the calculation of steady state transition matrix and prediction for the prompt future opening stock price are presented.

2. Methodology and Collective Data

Definition 2.1. *Consider a scheme consisting of a sequence of random trials (or experiments), each trial resulting in one of a given set of mutually exclusive and exhaustive events* $E_1,\ E_2, \ldots$.

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Definition 2.2. *The events $E_1,\ E_2,\ldots$ are called states of the system.*

Definition 2.3. *We shall use the symbol $E_j^{(n)}$ to denote that the system passes into state E_j (or equivalently, E_j occurs) at the n^{th} trial, $n = 0, 1, 2, \ldots$.*

Definition 2.4. *For any pair of natural number m and n, $m < n$, the conditional probability $P(E_j^{(n)} \left| E_i^{(m)}\right)$ is called transition probability of passing from state E_i to state E_j in $(n - m)$ steps.*

Definition 2.5. *We say that the scheme is a Markov chain if, for every i, j and n, the condition,*

$$P\left(E_j^{(n)} \left| E_i^{(n-1)}, E_{i_{n-2}}^{(n-2)}, \ldots, E_{i_0}^{(0)}\right.\right) = P\left(E_j^{(n)} \left| E_i^{(n-1)}\right.\right) \tag{1}$$

is satisfied for arbitrary $i_0, i_1, \ldots, i_{n-2}$.

Definition 2.6. *The square matrix $P = (p_{ij})$, which is either finite or infinite order is called transition matrix of the Markov chain,*

$$P^{(n)} = \begin{bmatrix} P_{11} & P_{12} & P_{13} & \cdots & P_{1n} \\ P_{21} & P_{22} & P_{23} & \cdots & P_{2n} \\ \cdots & \cdots & \cdots & \cdots & 1/83 \\ \cdots & \cdots & \cdots & \cdots & 0 \\ P_{n1} & P_{n2} & P_{n3} & \cdots & P_{nn} \end{bmatrix} \tag{2}$$

Since transition matrices are comprised of conditional probabilities, each entry of a transition matrix is non-negative and less than 1. Each row of a transition matrix must also sum to the value 1.

Definition 2.7. *The probabilities $p_j(n)$, defined by $p_j(n) = P(E_j^{(n)})$ = probability that the system passes into state E_j at the n^{th} trial are called absolute state probabilities at the n^{th} trial and $\sum_j p_j(n) = 1$ for all $n = 0, 1, 2, \ldots$.*

Definition 2.8. *Consider an N-state homogeneous Markov chain with transition matrix $P = (p_{ij})$ and initial absolute state distribution $p(0)' = (p_1(0), \ldots, p_N(0))$. If $P_{(n)} = (p_{ij}(n))$ denotes the matrix of n-step transition probabilities and if $p(n)' = (p_1\,(n)\,, \ldots, p_{(N)}(n))$ the absolute state distribution at the end of the nth trial, then*

$$P(n) = P^n \ \text{ and } \ p(n)' = p(0)'P^n \tag{3}$$

Definition 2.9. *Suppose T be a transition probability matrix. As n get larger and larger, T^n gets closer and closer to a unique matrix that's every row are equal. No matter what assumptions we make about the initial probability distribution, the probability distribution will remain unchanged. This probability distribution is called steady state probability distribution. If μ is steady state probability distribution then,*

$$\mu P = \mu \tag{4}$$

The data for opening Stock price is given below. The numbers are round up to nearest hundred by chopping method and the change in it from the previous day are calculate to convert the data into discrete and finite state data so that we can apply Markov chain.

Date	Opening Price	Round up to 100	Change from Previous day	Date	Opening Price	Round up to 100	Change from Previous day
30-Dec-16	8119.65	81		23-Mar-17	9048.75	89	1
-Jan-17	8210.1	82	1	24-Mar-17	9104	89	0
03-Jan-17	8196.05	81	-1	27-Mar-17	9093.45	88	-1
04-Jan-17	8202.65	82	1	28-Mar-17	9081.5	89	1
05-Jan-17	8226.65	82	0	29-Mar-17	9128.7	89	0
06-Jan-17	8281.85	82	0	30-Mar-17	9142.6	89	0
09-Jan-17	8259.35	82	0	31-Mar-17	9158.9	89	0
10-Jan-17	8262.7	82	0	03-Apr-17	9220.6	89	0
11-Jan-17	8327.8	83	1	05-Apr-17	9264.4	90	1
12-Jan-17	8391.05	83	0	06-Apr-17	9245.8	90	0
13-Jan-17	8457.65	84	1	07-Apr-17	9223.7	91	1
16-Jan-17	8390.95	83	-1	10-Apr-17	9225.6	92	1
17-Jan-17	8415.05	84	1	11-Apr-17	9184.55	91	-1
18-Jan-17	8403.85	84	0	12-Apr-17	9242.5	91	0
19-Jan-17	8418.4	84	0	13-Apr-17	9202.5	90	-1
20-Jan-17	8404.35	84	0	17-Apr-17	9144.75	90	0
23-Jan-17	8329.6	83	-1	18-Apr-17	9163	91	1
24-Jan-17	8407.05	84	1	19-Apr-17	9112.2	90	-1
25-Jan-17	8499.45	84	0	20-Apr-17	9108.1	91	0
27-Jan-17	8610.5	86	2	21-Apr-17	9179.1	91	0
30-Jan-17	8635.55	86	0	24-Apr-17	9135.35	91	0
31-Jan-17	8629.45	86	0	25-Apr-17	9273.05	92	1
01-Feb-17	8570.35	85	-1	26-Apr-17	9336.2	93	1
02-Feb-17	8724.75	87	2	27-Apr-17	9359.15	93	0
03-Feb-17	8735.15	87	0	28-Apr-17	9340.95	93	0
06-Feb-17	8785.45	87	0	02-May-17	9339.85	93	0
07-Feb-17	8805.7	88	1	03-May-17	9344.7	93	0
08-Feb-17	8774.55	87	-1	04-May-17	9360.95	93	0
09-Feb-17	8795.55	87	0	05-May-17	9374.55	93	0
10-Feb-17	8812.35	88	1	08-May-17	9311.45	93	0
13-Feb-17	8819.8	88	0	09-May-17	9337.35	93	0
14-Feb-17	8819.9	88	0	10-May-17	9339.65	93	0
15-Feb-17	8778.95	87	-1	11-May-17	9448.6	94	1
16-Feb-17	8739	87	0	12-May-17	9436.65	94	0
17-Feb-17	8883.7	88	1	15-May-17	9433.55	94	0
20-Feb-17	8818.55	88	0	16-May-17	9461	94	0
21-Feb-17	8890.75	86	0	17-May-17	9517.6	95	1
22-Feb-17	8931.6	85	-1	18-May-17	9453.2	94	-1
23-Feb-17	8956.4	87	2	19-May-17	9469.9	94	0
27-Feb-17	8943.7	87	0	22-May-17	9480.25	94	0
28-Feb-17	8898.95	87	0	23-May-17	9445.05	94	0
01-Mar-17	8904.4	88	1	24-May-17	9410.9	94	0
02-Mar-17	8982.85	87	-1	25-May-17	9384.05	93	-1
03-Mar-17	8883.5	87	0	26-May-17	9507.75	95	2
06-Mar-17	8915.1	88	1	29-May-17	9560.05	95	0
07-Mar-17	8977.75	88	0	30-May-17	9590.65	95	0
08-Mar-17	8950.7	88	0	31-May-17	9636.55	96	1
09-Mar-17	8914.5	87	-1	01-Jun-17	9603.55	96	0
10-Mar-17	8953.7	87	0	02-Jun-17	9657.15	96	0
14-Mar-17	9091.65	88	1	05-Jun-17	9656.3	96	0
15-Mar-17	9086.85	88	0	06-Jun-17	9704.25	97	1
16-Mar-17	9129.65	88	0	07-Jun-17	9663.95	96	-1
17-Mar-17	9207.8	89	1	08-Jun-17	9682.4	96	0
20-Mar-17	9166.95	89	0	09-Jun-17	9638.55	96	0
21-Mar-17	9133.95	89	0	12-Jun-17	9646.7	96	0
22-Mar-17	9047.2	88	0	13-Jun-17	9615.55	96	0

Date	Opening Price	Round up to 100	Change from Previous day	Date	Opening Price	Round up to 100	Change from Previous day
14-Jun-17	9621.55	96	0	10-Jul-17	9719.3	97	1
15-Jun-17	9617.9	96	0	11-Jul-17	9797.45	97	0
16-Jun-17	9595.45	95	-1	12-Jul-17	9807.3	98	1
19-Jun-17	9626.4	96	1	13-Jul-17	9855.8	98	0
20-Jun-17	9670.5	96	0	14-Jul-17	9913.3	99	1
21-Jun-17	9648.1	96	0	17-Jul-17	9908.15	99	0
22-Jun-17	9642.65	96	0	18-Jul-17	9832.7	98	-1
23-Jun-17	9643.25	96	0	19-Jul-17	9855.95	98	0
27-Jun-17	9594.05	95	-1	20-Jul-17	9920.2	99	1
28-Jun-17	9520.2	95	0	21-Jul-17	9899.6	98	-1
29-Jun-17	9522.95	95	0	24-Jul-17	9936.8	99	1
30-Jun-17	9478.5	94	-1	25-Jul-17	10010.55	100	1
03-Jul-17	9587.95	95	1	26-Jul-17	9983.65	99	-1
04-Jul-17	9645.9	96	1	27-Jul-17	10063.25	100	1
05-Jul-17	9619.75	96	0	28-Jul-17	9996.55	99	-1
06-Jul-17	9653.6	96	0	31-Jul-17	10034.7	100	1
07-Jul-17	9670.35	96	0	01-Aug-17	10101.05	101	

Table 1. **Opening price of Stock Exchange from January to July 2017**

2.1. Analysis

Now we assume -1, 0, 1, and 2 as four states and change from one sate to another is tabulated as below,

	-1	0	1	2	Total
-1	0	10	10	2	22
0	12	49	21	1	83
1	10	22	4	0	36
2	0	3	0	0	3

The one step transition probability matrix is,

$$\begin{array}{c} \\ -1 \\ 0 \\ 1 \\ 2 \end{array} \begin{array}{c} \begin{array}{cccc} -1 & 0 & 1 & 2 \end{array} \\ \begin{bmatrix} 0 & \frac{10}{22} & \frac{10}{22} & \frac{2}{22} \\ \frac{12}{83} & \frac{49}{83} & \frac{21}{83} & \frac{1}{83} \\ \frac{10}{36} & \frac{22}{36} & \frac{4}{36} & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \end{array}$$

To find the steady state probability we apply equation (4). Suppose $\mu = (a, b, c, d)$ be the steady state probability of the four states then

$$(a,\ b,\ c,\ d) \begin{bmatrix} 0 & \frac{10}{22} & \frac{10}{22} & \frac{2}{22} \\ \frac{12}{83} & \frac{49}{83} & \frac{21}{83} & \frac{1}{83} \\ \frac{10}{36} & \frac{22}{36} & \frac{4}{36} & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} = (a,\ b,\ c,\ d)$$

After matrix multiplication we get

$$
\begin{aligned}
-a+\frac{12}{8}3b+\frac{10}{36}c&=0\\
\frac{10}{22}a-\frac{34}{83}b+\frac{22}{36}c+d&=0\\
\frac{10}{22}a+\frac{21}{83}b-\frac{32}{36}c&=0\\
\frac{2}{22}a-\frac{1}{83}b-d&=0
\end{aligned}
$$

We convert it into coefficient matrix and applied elementary matrix operation.

$$
\begin{bmatrix}
1 & \frac{-12}{83} & \frac{-5}{18} & 0\\
0 & 1 & \frac{-6059}{2826} & \frac{-913}{314}\\
0 & 0 & 1 & \frac{-2619}{224}\\
0 & 0 & \frac{112}{1413} & \frac{-291}{314}
\end{bmatrix}
$$

Setting $d = k$ and solving the equations corrected up to five decimal place, $c = \frac{2619}{224}d = 11.69196k$; $b = \frac{-6059}{2826}c + \frac{913}{314}d = 27.97544k$; $a = \frac{12}{83}b + \frac{5}{18}c = 7.29231k$. By virtue of (**??**), $a + b + c + d = 1$, so $k = \frac{1}{47.95971} = 0.02085$. Finally, the steady state probability μ is,

$$(a,\ b,\ c,\ d) = (0.15204,\ 0.58329,\ 0.24378,\ 0.02085)$$

3. Conclusion

The following results are derive: After a long run, the probability that the change in opening stock price of National Stock Exchange NIFTY 50 of India at a specific day from previous day follows as

(1). The probability that the opening stock price at a specific day will reduce by 100 form previous day is 0.15204

(2). The probability that the opening stock price at a specific day will remain unchanged from previous day is 0.58329

(3). The probability that the opening stock price at a specific day will increase by 100 form previous day is 0.24378

(4). The probability that the opening stock price at a specific day will increase by 200 form previous day is 0.2085

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