

Determining the Dependency Pattern of Daily Change (increase or decrease) of Dhaka Stock Exchange Index (DSEX) in Bangladesh by Markov Chain and Logistic Regression Model

Sayedul Anam, Md. Ashik Abdulla, Md. Arif Hassan, Md. Kamruzzaman

Abstract: Bangladesh's capital market is South Asia's third largest market with two stock exchanges controlled by the Securities and Exchange Commission (SEC), namely Dhaka stock exchange (DSE) and Chittagong stock exchange (CSE). DSE introducing DSE broad index ("DSEX") and DSE 30 index ("DSE30") that effect from 2013. In this study, DSEX which reflect 97% of the total equity market capitalization is considered and focused the effect of change of index on market investment. The logistic regression (LR) model is performed in conjunction with the Markov chain (MC) of different order to represent the dependence of change (increase or decrease) of the current index upon the change of the previous two-time period. It was shown that the increased index day of the preceding two-time period relative to the decreased index day of the preceding two-time period affects the increased index day of the present time period. We observed a dependency of increase-decrease index of spell for the occurrence of index in the Dhaka stock exchange from the period of 28/01/2013 to 30/04/2019. The result shows that the frequency of index shift follows a second order Markov chain and logistic regression suggests that decrease index day of index followed by decreased and increase day of index followed by increased is more likely for the index of Dhaka stock exchange. This research helps to the individual investors in predicting the next day's stock price based on the prior two days index price. This study also contributes to researchers, corporate managers and other personnel to determine the dependency pattern of stock price.

Keywords: DSEX index, Markov chain, Logistic regression

I. INTRODUCTON

Dhaka Stock Exchange started formal trading of the Exchange in 1956 after obtaining the Certificate of Commencement of Business though it was incorporated in 1954. It is the largest capital market in the country. On June 06, 2017, DSE became a full member of the World Federation of Exchange Limited (WFE). DSE is also a primary member

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* Correspondence Author

Dr. Sayedul Anam*, department of General Educational Development, Daffodil International University, Dhaka, Bangladesh. Email: anam.ged@daffodilvarsity.edu.bd

Md. Ashik Abdulla, department of Business Administration, Daffodil International University, Dhaka, Bangladesh. Email: ashik.bba@diu.edu.bd

Md. Arif Hassan, department of Business Administration, Daffodil International University, Dhaka, Bangladesh. Email: hassan@daffodilvarsity.edu.bd

Md. Kamruzzaman, department of Business Administration, Daffodil International University, Dhaka, Bangladesh. Email: kamruzzaman.bba@diu.edu.bd

of South Asian Federation of Exchanges (SAFE). It has achieved the ISO 9001:2008 in 2016 and upgraded to ISO 9001:2015 for excellence in Quality Management System (QMS).

On January 28, 2013, the Exchange launched DSEX (DSE Broad Index) established by S&P Dow Jones Indices, a famous Index Service Provider. DSEX is the base index or benchmark index now for Dhaka Stock Exchange which has replaced the old DSE general Index (DGEN). The new index is built on the free-float system used by the main indexes of the world. A Free-float index is calculated on the readily available share on the market rather the full number of active and inactive shares available in the market. This method actually excludes the locked-in shares thus better represents the overall ongoing scenario of the market.

The DSE Broad Index on January 17, 2008 (reference date) has a base price of 2951.91 that was the indexed value of the DSE General Index. The stocks must hit a float-adjusted market capitalization above BDT 100 million in order to be eligible for the DSEX index. Nevertheless, if the stock index falls below BDT 100 million but not less than BDT 70 million with several other requirements met could stay in this list. DSEX demands that stocks will maintain an ADVT (average daily value traded) of 1 million BDT for minimum six-month as of the rebalancing reference date. In addition, for the three months prior to the rebalancing reference date, it is required that each of the qualifying stocks be exchanged for at least half of the regular trading days per month.

In the last five years of operation, DGEN was the most widely talked issue among individual investors. Data that were used to calculate the index were not as per international standard. However, the fault got assurance with the jump of 764 points in one day after the Grameen phone had been enlisted on DSE. Instantly the BSEC demand eliminates these inconsistencies under the surveillance of internationally reputed firm Standard & Poor's. Hence, the new benchmark index DSEX comes. Initially the index starts with 97% of the total equity market capitalization and to maintain the standard it periodically reviews the enlisted company in the early January 2019 the index has included 15 new companies and excluded other 17 old ones that ends up with having 283 companies for the index.



The index is based on DSE Bangladesh Index Methodology which is supervised by a DSE panel to ensure the satisfactory performance of the index. Moreover, a number of precautionary steps has been taken to protect the investors interest -Firm rules for guidelines, international standard surveillance, circuit breakers for trade and disclosure requirements for both listed scripts and IPOs etc. [21].

A major challenge of stock market for sustainable development is the volatility of price index and its investors decisions are primarily affected with these changes. Nevertheless, market volatility is also correlated with business governance inefficiency [19]. Moreover, the speculative behavior of many investors works against the development of trust and a sense of fairness in capital markets. The pressure of market manipulation, insider trading and simple scams and the speculativeness of the market constitute a fetal obstacle for the development of capital and the successful operation of capital markets [22].

II. LITERATURE REVIEW

Shleifer [20] assumes that the index is information free and thus shows a clear test of demand curve slopes. He found stocks that are newly added to index earn significant positive abnormal returns that do not evaporate after ten days. As new stocks are not perfect substitutes, the opening price pressure created by index is not overturned. It is also observed new firms that are added to the index causes significant price increases in the run-up window [1]. Moreover, trading volume effects in the run up and also post change windows enhanced liquidity are not reversed in the post change period. Lynch [15] found the day the change was in place, the day after the announcement and the day before the day of the shift, found a positive cumulative unusual return of 3,807 million.

Huffman [13] notes exogenous shock when portfolio decisions in one period affect transactions in the next period, which are subsequently associated in transactions. Reasonable circumstances are consistent with autocorrelations in trading volume even without having a well-developed theory for multi period trade volumes. Ajinkya and Jain [2] showed experimental distributions of daily trading volume prediction errors for individual firms and for portfolios by using volume measures and expectation models. The predicted errors for raw volume measurements are significantly skewed positively, with thin left tails and fat right tails. On the other hand, the volume measurements observed to be nearly normally distributed by natural log transformations. Nevertheless, for more than one day of forecasting intervals, auto-correlation in the daily volume of trading found it useful to recognize unusual trading.

Past evidence shows that stocks used in (excluded from) an index show a significant positive (negative) unusual return on the day of the announcement and that the volume of trading is influenced by the occurrence. Bildik and Gulay [5] have analyzed the price and volume impact of two ISE indexes, where the index funds and index derivatives do not appear, on stocks correlated with changes in the value-weighted index structure. The findings are consistent with prior evidence that stocks included in (excluded from) the index tend for positive (negative) unusual returns in ISE. In this respect, volatility

and quantity are dramatically affected.

Harris and Gurel [11] stated in his price pressure hypothesis that due to the excess demand of fund managers the stock prices increase before the change date and then reverse when unreceptive sellers are paying attention by the price rises that drive the amounts above equilibrium. Thus, this theory forecast that a newly added (deleted) stock causes a temporary increase (decrease) in the price. To figure out the recent volatility with the corresponding standard errors used as the indicator variable, For the period from 1946 to 1985, LeBaron [14] applied R_t for the weekly returns of the Standard and Poor 500 Index. It demonstrated that a substantially higher average return for the small portfolios than for the largest. In fact, the highest E/P portfolio found better than the lower.

To predict the tendency of stock price Sulin Pang [18] applied Logistic Regression model. Whereas, Zheng Mei and Miao Jia [16] used Logit model to forecast the stock trend of Shanghai stock market and made contrast with ARMA model. After that Gong and Sun [9] applied Logistic Regression to predict next month's stock price trend just through considering current month financial data instead of analyzing and collecting long term financial data. Based on the 30 years (1956-1985) average precipitation information in 14 South Korean stations, Moon, Ryoo and Kwon [17] used Markov chain model on daily rainfall occurrence; it is found the daily precipitation is mostly dependent on the previous day. Similarly Hossain [12] used Markov Chain to find the change influence previous two day state on today state about rainfall of Dhaka station. Anam [3], [4] applied Markov chain to identify the flood occurrence. However, there is no such research found using Markov model in determining the dependency of daily changes of stock price. Therefore in this paper authors try to identify the influence of previous days index change on today index change and their dependency pattern to make decision for the investors using both Markov and Logistic regression model.

III. METHODOLOGY

A. Discrete Markov Chain Model

The probability model has been shown by P. Billingsley in 1961 [7] to be based on the assumption that the state of any day depends on the condition only of the previous day. The relationship of dependency is known as the first order dependence in which the outcome of one experiment depends on the outcome of the previous experiment so that these transition probabilities are constant. Therefore, the statistical model for investigating the effect of dependency on this traditional method is therefore a two-state discrete time period for Markov Chain. We have found some attempts to model such dependence by m order Markov chains in recent years.

A Markov order chain m is a series of outcomes of trials if every result only depends on this. The markov chain order m, if assigned a fixed m, shall be composed of all possible variables values $\{ X_n \}$ in accordance with the random sequence X_n ($n = 0, 1, 2, \dots$) it is true that

$$P[X_n = j / X_0 = i_0, X_1 = i_1, \dots, X_{n-m} = i_{n-m}] = P[X_n = j / X_{n-m} = i_{n-m}] \quad (1)$$

B. Multiple Logistic Regression Model

Consider a set of p-independent variables that the vector will denote $X=(X_1, X_2, X_3, \dots, X_p)$. We're going to assume for the time that each of these variables is at least scaled at intervals. Below is the unique form of the logistic regression model:

$$P(X) = \frac{e^{\beta_0 + \sum_{i=1}^p \beta_i x_i}}{1 + e^{\beta_0 + \sum_{i=1}^p \beta_i x_i}}; i = 1, 2, \dots, p \quad (2)$$

Then the design of multiple logistic regression is as below:

$$f(X) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_p x_p \quad (3)$$

$$\text{in which case } P(X) = \frac{e^{f(x)}}{1 + e^{f(x)}}$$

C. Data Collection

Secondary data have been used for the research. The data is collected from Dhaka Stock Exchange website (<https://www.dsebd.org/>) [8]. We have collected daily change index from January 2013 to May 2019. We have collected from 2013 because from this year DSEX indexing was introduced which is more significant to measure the change of index.

IV. ANALYSIS AND DISCUSSION

A. Markov Chain

The explanatory variables were calculated, but classified in dichotomous form because of the behavior of these weather factors in Bangladesh in past years [5]. Here dependent variable (Y) is in dichotomous scale. If the index increases, it would take value 1 with probability P and if the index decrease, it would takes the value 0 with probability 1-P. The independent variables are:

X_1 = Yesterday's index
= 0 if index decrease
= 1 if index increase

X_2 = Day before yesterday's index
= 0 if index decrease
= 1 if index increase

In view of the today's and yesterday's DSE index, the transitions counts for the first order Markov model in which the index has been taken as an indicator of increase and decrease index. The following table 1 displays the first order changes in frequencies in light of the present day (today's) increase and decrease index and also the increase and decrease index in the previous day (Yesterday's).

Table- I: Counts of Frequency for first order transition

Yesterday's state of Index	Today's state of index		Total
	Decrease (0)	Increase (1)	
Decrease (0)	420	308	728
Increase (1)	307	470	777

Total	727	778	1505
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The table shows that the maximum proportion (0.605) fits to transition from increase index day to increase index day and lowermost proportion (0.395) belongs to transition from increase day to decrease day. Table-2 provides total probability estimates for the first order Markov chain obtained directly through the use of a formula for the transition count:

$$P_{ij} = \frac{n_{ij}}{n_i}, n_i = \sum_j n_{ij} \text{ and } P_{ij} = P[X_t = j / X_{t-1} = i] \quad (4)$$

Table- II: Name of the Table that justify the values

Transition Probabilities	P ₀₀	P ₀₁	P ₁₀	P ₁₁
Maximum Likelihood estimates	0.500014	0.499986	0.46689	0.53311

Here in this table, we find that the day was increase at the previous time point is high (0.53311) if it is being in increase index state and in decrease state is the lowermost (0.46689).

The condition of the list must be taken into account on the three following days in order to count the number of transitions for the second order chain. That is to say, in view of the index condition of the last two days, whether today's value increase or decrease. Table-3 shows the second order chain transition counts

Table- III Frequency counts for second order transition

State of index in the Immediate past two days	Today's of index state		Total
	Decrease (0)	Increase (1)	
0-0	288	172	460
0-1	115	190	305
1-0	173	135	308
1-1	191	278	469
Total	767	775	1542

It is mentioned in the above table that 62.6 percent of the 1542 days remain in the decrease index for three consecutive days, while 59.3 percent of the day remain in the index day state. At least once in the next three days, the rest of the states changed their index standings. In all consecutive day the highest ratio (0.626) belongs to decrease index transition and day before yesterday decrease to yesterday's decrease to today increase index day shows the lowest ratio (0.374). The highest probability estimates of the second order Markov chain transition probabilities obtained through the equation:

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$$P_{ijk} = \frac{n_{ijk}}{n_{ij}}, n_{ij} = \sum_k n_{ijk} \text{ and} \quad (5)$$

$$P_{ijk} = P[X_t = k / X_{t-1} = j, X_{t-2} = i]$$

The estimates are shown in Table-IV.

Table- IV Second order model of maximum likelihood estimates

Probability of Transition	P ₀₀₀	P ₀₀₁	P ₀₁₀	P ₀₁₁	P ₁₀₀	P ₁₀₁	P ₁₁₀	P ₁₁₁
Maximum Likelihood estimates	0.60	0.398	0.43	0.60	0.597	0.40	0.45	0.64

We can find from the table that if the index was in increase index state at the previous time point is high then the probability (0.64) is in increase index state and that of being in the increase state given the past two states were decrease is lowermost (0.398).

- *Significance test of the order of Markov Chain:*
Significance test of hypothesis for first order, i.e.,

H₀ : Zero order Markov chain ($P_{ij} = P_j$)

H₁ : First order Markov chain ($P_{ij} \neq P_j$)

The chi-squared test statistics is

$$\chi^2 = 2 \sum_{i=0}^1 \sum_{j=0}^1 n_{ij} [\log_e \frac{n_{ij}}{n_i} - \log_e \frac{n_j}{n..}] \quad (6)$$

Where $S1-1(S-1)2 = 1$ (degrees of freedom). The calculated result of the above test is 52.844 that are higher than $\chi^2_{0.05,2}$ (5.99). Hence we can conclude that alternative hypothesis is accepted that means first order Markov chain is significant for that case.

Again significance test of hypothesis for second order, i.e.,

H₀ : First order Markov chain ($P_{ijk} = P_{jk}$)

H₁ : Second order Markov chain ($P_{ijk} \neq P_{jk}$)

The chi-squared test statistics is:

$$\chi^2 = 2 \sum_{i=0}^1 \sum_{j=0}^1 \sum_{k=0}^1 n_{ijk} [\log_e \frac{n_{ijk}}{n_{ij}} - \log_e \frac{n_{jk}}{n_j}] \quad (7)$$

Where, $S2-1(S-1)^2 = 2$ (degrees of freedom). Here the calculated result of the above test is 8.156 that are higher than $\chi^2_{0.05,2}$ (5.99). Hence we can conclude that alternative hypothesis is accepted that means second order Markov chain is significant for that case [10].

B. Logistic Regression Parameters' Significance Test and Identify the Dependency of Index Change

Logistic regression analysis of daily index changes is shown in table-V. The total number of observation is 1510. Observation 0 means that the index decrease and the

observation 1 means that the index increase. Out of total 1510 observation, 779 observations are the index increase and 731 observations are index decrease. The proportion of index increase is 51.6%. The standard log likelihood is used to determine how well the model adapts to the data. The log likelihood here are 1021.1216, showing that the model fits the data correctly.

Table-V: Logistic Regression output

Logistic regression		Number of obs = 1510	
		LR chi2(2) = 49.54	
		Prob > chi2 = 0.0000	
Log likelihood = -1021.1216		Pseudo R2 = 0.0237	

TodayState	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
YesterdayState	.7293907	.1064736	6.85	0.000	.5207063	.938075
DaybeforeYesterday	.0092372	.1064953	0.09	0.931	-.1994897	.2179641
_cons	-.3155703	.0873828	-3.61	0.000	-.4868375	-.1443031

From the above table-V we found that the value of z-statistics is 0.0000 that indicate the model is very much significant. Here one independent variable yesterday state is very significant with today state rather the day before yesterday state. The probability shows that today's decrease index is about 0.7293 times as if yesterday is decrease index comparing to that day is increase index. The probability that today's decrease index is about 0.0092372 times as likely if day before yesterday decrease index compare to that day is increase index.

V. CONCLUSION

This research focuses mainly on two main statistical procedures. One is to determine the Markov Chain model, the day-to-day increase and decrease index, and the other is the logistic regression procedure, describing the dependence of one binary-dependent variable on the other. The Markov chain showed that the decline in the previous two days index in contrast to the rise in the last two days index has a positive effect on today's decrease in the index. Meanwhile, the reduction of the today's index is determined by the reduction in the index of the past two days under logistical regression model. This research contributes to the researchers, corporate managers and other personnel to determine the dependency pattern of stock price.

The future study in this field to empirically examine the dependency of other countries stock exchanges as on DSE and CSE is considered in this paper. This paper only used DSE and CSE as sample. Future study should be made using large sample size with multiple countries stock exchange. Here, only Markov chain and Logistic regression model is used. So, future study might use other statistical model to determine the dependency pattern of changes in stock markets.

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model, regression analysis, time series analysis. He has about 15 published research articles in national and international refereed journals on mathematics and statistics issues and has presented in at least 2 international conferences since 2010 to date.



Ashik Abdullah completed his Master of Business Administration (MBA) from Jahangirnagar University, Bangladesh. He also did his Bachelor from the same University. He is now working as a contractual lecturer at Daffodil International University. He teaches courses in undergraduate level including Principles of Accounting, Economics, Principles of Marketing and Brand Management. He has research interest on Business, Marketing and economics.



Md. Arif Hassan is an assistant professor of Accounting at Daffodil International University, Bangladesh. He is currently doing PhD at University Sains Islam Malaysia. He completed his Master of Business Administration major in Accounting from University of Dhaka, Bangladesh. He published several articles in peer reviewed journal. He got best paper award in an international conference- The 19th IAGBT-KIRTI Biannual Conference and Research in 2018. He teaches courses in undergraduate and graduate program of that University including, financial accounting, cost accounting and management accounting, accounting information system, advanced financial accounting, etc. His current research interests include financial reporting, Islamic Finance, accounting, stock market and International trade.



Md. Kamruzzaman has been working as a Senior Lecturer of Finance at Daffodil International University since 2017. He passed his Master of Business Administration major in Finance from University of Dhaka, Bangladesh. He teaches courses in undergraduate level. Having flair of finance his special focus on corporate finance, capital markets, behavioral finance and financial analysis. He also associated with social business and social entrepreneurship initiative since 2015. He has published research papers in the renowned journals including SCOPUS Indexed and presented papers in national and international academic conferences and got best paper award in Bangkok Annual Business and Social Science Research Conference.

AUTHORS PROFILE



Dr. Sayedul Anam completed his PhD from Jahangirnagar University, Bangladesh. He is now working as an assistant professor at the Department of General Educational Development, Daffodil International University. He teaches courses in undergraduate and graduate level including Basic Mathematics, Business

Mathematics, Business Statistics, Applied Statistics, Production and Operations Management, and Business Research Methodology. His research interests focus on the stochastic regression, stochastic linear programming

