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Market Efficiency and Volatility in Stock Market of Bangladesh

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PhD Thesis

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Dedicated to my parents

Md. Abdul Mazid

and

Mrs. Mahmuda Khatun

for their endless love, inspiration, sacrifice and guidance.

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Md. Masud Karim

Declaration

The dissertation entitled MARKET EFFICIENCY AND VOLATILITY IN STOCK MARKET OF BANGLADESH submitted to the University of Rajshahi for the Degree of Doctor of Philosophy in Finance and Banking is exclusively my own and original work.

Except where reference is made, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis or report presented by me for another degree or diploma. No other person's work has been used without due acknowledgement in the main text of the report.

This thesis has not been submitted for the award of any other degree or diploma in any other tertiary institution.

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Certificate

I have the pleasure to certify that the dissertation entitled MARKET EFFICIENCY AND VOLATILITY IN STOCK MARKET OF BANGLADESH is an original work which has been carried out by Md. Masud Karim under my guidance and supervision. To the best of my knowledge, no part of the dissertation, in any form, has been submitted to any other institute or university for a degree or diploma, or any other similar purposes.

I also certify that I have gone through the drafts and final version of the dissertation and found it satisfactory for submission to the University of Rajshahi for the Degree of Doctor of Philosophy in Finance and Banking.

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Acronyms

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
AR	Autoregressive
ARCH	Autoregressive Conditional Heteroscedasticity
ARCH-LM	Autoregressive Conditional Heteroscedasticity-Lagrange Multiplier
ARMA	Autoregressive moving average
ARIMA	Autoregressive Integrated moving average
AR1-OLS	First Order Autoregressive-Ordinary Least Square
BB	Bangladesh Bank
BDS	
BHHH	Brendt, Hall, Hall and Hausman
CDBL	Central Depository Bangladesh Limited
CSE	Chittagong Stock Exchange
DDGE	Dynamic General Equilibrium
DF	Dickey-Fuller
DF-GLS	Dickey-Fuller Generalized Least Square
DGEN	Dhaka Stock Exchange General Index
DS20	Dhaka Stock Exchange 20 Index
DSE	Dhaka Stock Exchange
DSI	Dhaka Stock Exchange All shares Index
DVP	Delivery versus Payment
EGARCH	Exponential Generalized Autoregressive Conditional Heteroscedasticity
EMH	Efficient Market Hypothesis
ERS	Elliot-Rothenber-Stock
EWMA	Exponential Weighted Moving Average
FOK	Full fill or Kill
GARCH	Generalized Autoregressive Conditional Heteroscedasticity

GARCH-M	Generalized Autoregressive Conditional Heteroscedasticity in Mean
GDP	Gross Domestic Product
GJR-GARCH	Glosten-Jagannathan-Runkel Generalized Autoregressive Conditional Heteroscedasticity
IPO	Initial Public Offering
KPSS	Kwiatkowsk-Phillips-Schmidt-Shin
K-S	Kolmogrov-Smirnov
LM	Lagrange Multiplier
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MDH	Mixture of Distribution Hypothesis
ME	Mean Error
MSE	Mean Square Error
OLS	Ordinary Least Square
PF	Partial Fill
PFAK	Partial Fill and Kill
PP	Phillips-Perron
Q-Q	Quantile – Quantile
RW	Random Walk
RWH	Random Walk Hypothesis
RMSE	Root Mean Square Error
SEC	Securities and Exchange Commission
SOEs	State Owned Enterprises
TGARCH	Threshold Generalized Autoregressive Conditional Heteroscedasticity
VAR	Vector Autoregression
VR	Variance Ratio

Abstract

This thesis attempts firstly to seek evidence of the weak form efficiency of Dhaka Stock Exchange (DSE) by hypothesizing random walk assumption. In this case, both parametric tests (unit root test, variance ratio test, autocorrelation test and ARIMA model) and non-parametric test (run test) have been employed. Secondly, this study examines the volatility pattern of daily return, volatility-return relationship and contemporaneous trading volume-volatility relationship. Volatility models like GARCH (1,1), GARCH (1,1)-M, EGARCH (1,1) and GJR-GARCH (1,1) have been used to capture volatility dynamics in return series. In addition, the causal relationship between contemporaneous trading volume and volatility has been studied under VAR modeling framework.

Now a day, forecasting stock price and return volatility have been considered as prime issues in finance. Theoretical basis of weak form efficient market hypothesis is that the successive stock price/return is independently and identically distributed and past prices/returns have no predictive content to forecast future trend. On the other hand, volatility clustering, leptokurtosis and asymmetric impact of news (leverage effect) are very peculiar characteristics of stock return. To examine and capture such types of phenomenon, this study uses daily closing value of two main indices (DGEN and DS20) of DSE for the period of 2001 to 2012.

The both return series of DSE show positive skewness, excess kurtosis and deviation from normality. Results of unit root tests, run test, autocorrelation test and variance ratio test provide evidence that the return series do not follow random walk model. In addition, the coefficients of ARIMA are significant at various lags of autoregressive and moving average terms and using best fitted ARIMA (3,0,1) model for DGEN return series and ARIMA (2,0,2) model for DS20 return series, future return can be predicted lucratively. On the other hand, ARCH-LM test shows significance presence of heteroscedasticity in return series and GARCH family models capture the phenomenon effectively. Results of volatility models exhibit the presence of volatility clustering (i.e., large change follow a large change and small change follow a small change) in return series. In DSE, impacts of shocks to volatility are highly persistent and old news is as much important as new news. Findings of GARCH-M model indicate the relationship between volatility (time-varying risk) and return is positive and significant. GJR-GARCH model ensures the existence of leverage effect i.e., the bad news have more impact on volatility than the good news of equal magnitude. Here, we also measure the impact of trading volume on volatility using best fitted GJR-GARCH model and found that there is significant and positive relationship between trading volume and volatility. The asymmetric impact of news on volatility becomes higher when contemporaneous trading volume is added as an additional explanatory variable in volatility model but it reduces volatility persistence. VAR and Granger causality test indicate that trading volume influences volatility at earlier and later both lags but volatility influence volume after 6 lags.

Overall, the findings indicate that the Dhaka Stock Exchange is not efficient in weak form and highly volatile which is one of the main barriers to investing in this market. Findings obtained in this study have significant implications to the investors, security analysts, policy makers and regulatory authorities and these findings can be used as important guiding rules to enhance the investors' confidence and efficiency level in stock market of Bangladesh.

Chapter-One

Introduction

1.1 Background

Stock market has been considered as the major vehicle of economic growth in both emerging and developed economies. Among many other functions, it performs the vital role of channelizing savings into investment. Thus, capital market plays a pivotal role in the allocation of economic resources into the productive activities of economy. This allocation takes place through the appropriate pricing of securities traded in the market. The investors can be motivated to save and invest in the capital market of a country only if the securities are appropriately priced in the market.

Market efficiency and return volatility are two very important characteristics of stock market. A stock market in which stock prices fully reflect all the available information is called efficient. In fact, the information and its dissemination determine the efficiency of a capital market. That is, how promptly and properly the security prices reflect these information show the degree of efficiency of the capital market. Weak-form efficiency or currently known as predictability efficiency (Fama, 1992) implies that current prices fully reflect all past market information. This type of market efficiency is also termed as informational efficiency (Dimson and mussavian, 1998). Nevertheless, the markets are also economic institutions and play an important role in allocating resources to the most desirable and profitable sectors in cost effective ways. This type of market efficiency is termed as allocative efficiency. Capital market can also be defined from the view point of operational efficiency. The concept of operational efficiency refers to a market's ability to deliver liquidity, rapid execution of order and low trading costs (Sharpe et al., 1999). In this study, we are concerned only about the informational efficiency of capital market. Without informational efficiency, it would not be possible to achieve others efficiencies. We do care about stock market efficiency because it is a necessary condition to channeling fund to the highest-valued projects. In an efficient market, it is easier for the firms to raise capital as the market performs price discovery process, that is, the market determines the price at which investors are willing to exchange claim with the firm's future cash flows (Hameed and Ashraf, 2006).

So, conception of market efficiency is used to explain the degree to which stock price reflect information instantly. Impact of information on security prices is also considered as the basis of efficient market hypothesis (EMH). Alternatively, the EMH postulates that the market prices incorporate all information rationally and instantaneously. Stock market efficiency has three forms: the weak form, the semi-strong form and the strong form (Fama, 1970). The weak form version of EMH asserts that the prices of financial assets reflect all information contained in past prices. In this case, no one can earn abnormal profit using chart analysis or any analysis based on past prices. Secondly, semi-strong version of EMH proclaims that the prices of securities reflect all information that are publicly available. Under semi-strong market one cannot make abnormal profit using publicly known information. Finally, strong form version states that prices of financial assets reflect all information, that is, not only the information contained in past prices and publicly available but also the inside information (Fama, 1970 and 1991). If the weak-form of EMH can be rejected, then the other form, that is, semi-strong form and strong form of EMH can also be rejected.

In recent past, a large number of empirical researches have been conducted for testing the validity of the random walk hypothesis or weak-form EMH in connection with stock markets in both developed and emerging countries. The study on examining the weak-form efficiency has produced diversified results. From the earlier research works, it has been found that the weak and semi-strong forms of the efficient market hypothesis prevailed in developed capital markets (see, e.g., Osborne, 1962; Granger and Morgenstern, 1963; Fama 1965; Ball and Brown, 1968). Recently, it has been found that returns of stock market are predictable (Worthington and Higgs, 2006; Fama and French, 1988; Lo and MacKinlay, 1988; Poterba and Summers, 1986). Mixed empirical evidence is also found in case of the developing countries. Studies on the markets of developing countries can be separated into two groups depending on their results. A number of researches shows the evidence in favor of the weak-form efficiency (Mahmood et al., 2011; Liu, 2010; Aga and Kocaman, 2008; Asiri, 2008; Akinkugbe, 2005; Abrosimova et al., 2005; Moustafa, 2004; Chang and Ting, 2000; Ojah and Karemera, 1999; Urrutia, 1995;). On the contrary, numerous researchers show the evidence of rejection of the random walk hypothesis i.e., predictability of stock returns in emerging markets (Patel et al., 2012; Chiwira and Muyambiri, 2012; Al-Jafari, 2011; Alam et al., 2011; Gupta and Yang, 2011; Nwosa and Oseni, 2011; Vitali and mullah, 2010; Hamid et al., 2010; Uddin and Khoda, 2009; Mishra and Pradhan, 2009; Mobarek et al., 2008; Gupta and Basu, 2007; Hoque, Kim and Pyun, 2007; Islam and Khaled, 2005; Gilmore and McManus, 2003; Mobarek and Keasey, 2000; Poshakwale, 1996; Huang, 1995; Laurence, 1986).

Taking into consideration the theoretical and practical significance, the contradictory experiential evidence of the random walk hypothesis motivates us to have a fresh look at this issue of weak-form efficiency in the context of an emerging market, namely

Dhaka Stock Exchange. This study is potentially interesting case study for a developing capital market, which shares most of the characteristics of a typical emerging market.

On the other hand, fluctuation is a natural phenomenon in financial markets. A variation of prices or returns goes under the name of volatility, i.e., how much prices or returns are changing over a given period. In simple words, volatility means "conditional variance of underlying assets returns" (Tsay, 2010). Most of the investors and financial analysts are concerned about the uncertainty of the returns on their investment, caused by speculative market prices and instability of business performance (Alexander, 1999). Due to the development of financial econometrics some quantitative models have come forward that are able to explain the attitude of investors not only towards expected returns but towards volatility as well. Conventional econometric models, like Ordinary Least Squares (OLS) are built on the assumption of homoscedasticity or constant variance. Primarily, the basic model for estimating volatility in stock return using OLS is the naive random walk. Secondly, AR1-OLS could be expected for measuring volatility. But it is seen that the financial time series does not behave in a random manner rather it exhibits a set of peculiar characteristics. A lot of researchers have documented evidence that the stock prices (returns) show phenomenon of volatility clustering or pooling, leptokurtosis and asymmetry. Volatility clustering occurs when large changes in stock prices (returns) are followed by large changes and small changes in prices (returns) are followed by a small changes of either signs (Mandelbrot, 1963). It is also supported by Baille et. al. (1996) and Chou (1988). The repercussion of such volatility clustering is that volatility shocks today will influence the expectation of volatility many periods in future. Another phenomenon that often attracts the minds of stock market researchers is leptokurtosis, which means that the distribution of stock returns is not normal but demonstrative of a fat-tail and excess peakedness at the mean relative to normal distribution. In other words, leptokurtosis signifies high probability of extreme value than the normal law predict in a series (Fama, 1965). Beside these another important phenomenon that is exhibited in stock price or return series is asymmetry also known as leverage effect, which means that stock return volatility tends to rise more following a large fall in price (bad news) than increase in price (good news) for the same magnitude (Black, 1976; Nelson, 1991; Engle and Ng, 1993). These type of observations in financial time series have led to the use of a broad range of heteroskedastic models to estimate and forecast volatility of stock market.

Modeling financial time series is not a simple job because they have some special characteristics, like, volatility clustering, leptokurtosis, leverage effect. In order to capture the first two characteristics of the financial time series, Engle (1982) suggests to model time-varying conditional variance with the Auto-Regressive Conditional Heteroscedasticity (ARCH) processes that allows past error terms to vary over time, in exchange of the assumption of constant variance of a time series. Early empirical evidence shows that high ARCH order has to be selected in order to grasp the dynamic of the conditional variance but higher order ARCH process have some limitations. The Generalized ARCH (GARCH) model of Bollerslev (1986) is an answer to this issue by allowing for a lag structure for the variance and it reduces the number of estimated parameters from ∞ to only 2. The GARCH model allows the conditional variance to be a function of lagged squared errors as well as of its past conditional variances. The GARCH model has been found to be valuable in modeling the time series behavior of stock return (Koutmos et al. 1993; Baillie and DeGennaro, 1990; Akgiray, 1989; French et al. 1987). One of the primary restrictions of both models (ARCH and GARCH) is that they can capture the symmetric response volatility to positive and negative shocks i.e., first two features of time series and therefore fail to model the third stylized fact, namely the "leverage effect". To solve this problem, many nonlinear extensions of the GARCH model have been proposed. Among the models most widely spread models are the Exponential GARCH (EGARCH) model of Nelson (1991), the so-called GJR model of Glosten, Jagannathan, and Runkle (1993), the Threshold ARCH (TARCH) model of Zakoian (1994). In developing an ARCH type model, one will have to provide three distinct specifications- one for the conditional mean equation, one for the conditional variance, and one for the conditional error distribution. In this study, an attempt has been made to find out an appropriate asymmetric GARCH model for the stylized fact of Dhaka Stock Exchange of Bangladesh.

In finance, higher risk is the cause of higher expected return. The GARCH approach allows for an empirical assessment of the relationship between time-varying risk and return. Engle et al. (1987) provides an extension to the GARCH model, where the conditional mean is an explicit function of the conditional variance which is known as the GARCH in Mean (GARCH-M) model. According to Chou (1988), the GARCH-M model provides a more flexible framework to capture volatility phenomenon in time series of stock return and provides a way to directly study the explicit tradeoff between risk and expected return. Choudhury (1996) uses GARCH-M model to study volatility, risk premium and persistence of volatility in six emerging countries before and after the 1987 stock market crash.

Volatility is unavoidable in the financial market due to changes in fundamentals, information, and market expectations. Interestingly, these three elements are strongly connected and interact with each other. Stock prices should reflect changes in various aspects of our society such as economic, political, financial, and like others. Specifically, profitability of corporations, quality of product, business strategy, political stability, interest rates, etc., should have a vital influence on price fluctuations. In fact, the process can be viewed as a “game” where the sequence becomes one of changes in fundamentals, information arrival, and new expectations, which in turn results in a continuous cycle where these incidents embrace each other in a series of lagged responses.

Volatility is a natural consequence of trading, which occurs through the news arrival and following response of traders. The chain reaction of market participants will force equity prices to reach post information equilibrium level and from this view point information, liquidity, and volatility are related with each other.

The relation among information, volume (liquidity), and volatility is consistent with four competing propositions: the mixture of distributions hypothesis (MDH) (Clark, 1973; Epps and Epps, 1976; Harris, 1986, 1987), the sequential information hypothesis (Copeland, 1976; Morse, 1980; Jennings et al., 1981; and Jennings and Barry, 1983), the dispersion of beliefs approach (Harris and Raviv, 1993; Shalen, 1993), and the information trading volume model of Blume et al. (1994).

The motivation behind the MDH is drawn by the apparent leptokurtosis exhibited in daily price changes attributed to the random events of importance to the pricing of stocks. The MDH postulates that volume and volatility are contemporaneously and positively correlated, while jointly driven by a stochastic variable defined as the information flow. Information flow into the market is not clearly visible, for this reason the trading volume of stock market is considered as a proxy of information arrival because ups and downs in the trading volume seem to be caused by the arrival of new information. To capture the impact of trading volume on volatility, the daily contemporaneous volume is added to the conditional variance equation (GARCH equation) as an added variable. The causal (dynamic) relationship between trading volumes and return volatility can be tested employing a bi-variate vector autoregressive (VAR) model which helps us to show the linear simultaneous correlation between the variables. To support the findings of GARCH family models in testing the hypotheses related to the volume and volatility relation, we further check the Granger causality within the VAR approach. In our study, it has been found that the contemporaneous trading volumes significantly explain volatility and is consistent with the mixture of distribution hypothesis (MDH) and it is also observed that the causal and feedback relationship existed between volume and volatility.

In recent years, emerging stock markets are growing at a faster rate due to the adoption of market-friendly policies, liberal and attractive policies for foreign investors, reformation of the corporate sector, establishment of private ownership for state-owned enterprises, continuous support from government, etc. However, the markets of emerging countries like Bangladesh are informationally inefficient and highly volatile which act as a great hurdle for investment in stock market. Beside these, poor corporate governance and fabricated auditing reports, lack of proper and timely disclosure, controversial behavior of institutional investors, lack of adequate supervision, high transaction costs, lack of awareness regarding stock market, etc are also responsible for market inefficiency. In an inefficient market, technical traders and portfolio managers can earn abnormal profit through constructing technical trading strategies.

Empirical studies for return-volatility behavior in developed markets are bountiful but they have been started in the emerging market in recent years. After globalization and integration of the world economics interest of investors and researchers has grown regarding emerging stock markets because these markets are offering vast opportunities for domestic and foreign investors to diversify portfolios across the globe. An enormous number of studies (such as, Choi et al., 2012; Ahmed and Suliman, 2011; Emenike, 2010; Ashley and Patterson, 2010; Mahajan and Singh, 2009; Floros, 2008; Alberg et al., 2008; Srivastava, 2008; Medeiros and Doornik, 2008; Liau et al., 2008; Mala and Raddy, 2007; Leon, 2007; Magnus and Fosu, 2006; Kumar, 2006; Poshakwale and Murinde, 2001; Franses and paap, 2000; Choudhury,T, 2000; Henry, O., 1998; Lamoureux and Lastrapes, 1990; French, et al., 1997; etc.) examines the return-volatility behavior in developed and emerging markets.

Though study on stock return volatility on developed market is huge but unfortunately such type of research on capital market of Bangladesh is very limited. In most cases, findings of these studies are not note-worthy and consistent with theory of finance. Choudhury and Iqbal (2005) indicate that there is no significant relationship between risk and return and also indicate that positive and negative shocks (good news and bad news) have same impact on volatility. Basher et al., (2007) show that there is a negative and significant risk-return relationship is in DSE which is inconsistent with the portfolio theory and a similar result is given by Hossain and Uddin (2011) for DSI and DGEN index return series. Till today, nobody has examined the volume-volatility relationship in Bangladesh stock market. That is why, this study endeavors to examine various issues relating to the efficiency of market, return-volatility relationship, impact of good news and bad news on volatility and volume-volatility relationship. Examination of these relationships in a dynamic and causal framework is supposed to provide more insight into various aspects of Bangladesh capital market.

1.2 Motivation

The economy of Bangladesh has great potential and is considered as an emerging tiger in South-east Asia. With view to becoming a middle income country, a huge amount of investment is required within shortest period of time. To support our investment needs, we can mobilize fund in two ways- through banking system, -through capital market. Banking system, by its very nature, cannot supply fund for longer periods of time, whereas long term investment is inevitable for economic emancipation and development. In that case, capital market can bridge the gap and supply fund in productive sectors for long period of time. Thus, an effective, vibrant and efficient capital market is utterly needed in Bangladesh for growth and development.

The research on market efficiency and volatility has been extensive for developed as well as developing countries. In addition, a significant number of studies conclude that fair price of instruments can only be determined in an efficient market, and also that market efficiency is a necessary condition to channeling fund to highest-valued projects. Besides these, volatility in stock market is a cause of additional risk and investors demand extra risk premium for excess volatility. It is well established that market inefficiency and volatility increase the cost of capital which acts as a big hurdle on the path of economic development (please see Chapter 3 for detail). However, the available research on both these grounds: market efficiency and return volatility in stock market are very limited with respect to Bangladesh.

Forsooth, the effectiveness of the market in economic development is determined by volatility and market efficiency. In an inefficient market, investors face a lot of trouble in selecting the optimal investment as information regarding the company performance is slow or less available. Not only that, inefficiency is a cause of illiquidity of financial instruments, slow execution of order and higher transaction cost. As a result, investors can be influenced by uncertainty either to withdraw fund form market until resolving the problems or to show their reluctance to invest fund for long periods of time.

The motivation of this research comes from the practical limitations of the capital market in Bangladesh as discussed above. In order to address the intensity of the limitations of capital market and how these limitations can be systematically handled, this study aims to construct two econometric analytical frameworks. One of these frameworks is aimed at finding out the level of efficiency of the capital market, while the other one is constructed for the assessment of nature of volatility and volatility-return relationship. Therefore, the capital market being a vital institution that facilitates economic development, the efficiency of capital market is a matter of interest to many parties. In recent years, especially in the aftermath of the global financial meltdown, the study of the weak form capital market efficiency and volatility has attracted the attention of researchers, economists, and financial analysts. It is considered that more efficient and better functioning capital markets could provide greater momentum to domestic economic growth.

1.3 Objectives of the Study

Broadly, the objective of the study, therefore, is to cover both theoretical and empirical works about the market efficiency and return volatility condition of Dhaka Stock Exchange. The study also measures and tests the significance of weak form efficiency, the nature of return volatility and volatility-return relationship by applying different econometric models. The specific objectives of this study are as follows:

a) To investigate whether the DSE follows the random walk or not under full sample period as well as the three sub-periods based on different political regime.

b) To build up a dynamic time series model (ARIMA) for assessing efficiency and forecasting returns of DSE.

c) To examine the volatility pattern of returns of DSE under GARCH modeling framework.

d) To explore the relationship between volatility and trading volume using GARCH family models.

1.4 Limitations of the Study

This study focuses on market efficiency and return volatility on stock market, however the existing market efficiency literature has become extremely extensive, so that even a careful survey of it is undoubtedly beyond the scope of this thesis. Consequently, only a short discussion of central findings in the market efficiency literature regarding random walk hypothesis or weak-form efficiency has been offered here in order to provide a general picture of this study.

The most noticeable limitation of this study is that the empirical part of this study restricts exclusively the weak-form efficient market hypothesis or return predictability using time series analysis of stock return behavior. Accordingly, the statistical tests are only employed for testing market efficiency, thereby technical trading rules or adjusting transactions costs such as bid-ask spread and time lag of settlement procedures are excluded in this study.

It is also important to take into consideration the reasons and effect of thin trading in analyzing weak form efficiency, which is also a widely recognized typical feature in most emerging stock markets, that can produce serious bias in empirical work. This study, however, only uses daily data, even though this might lead to possible bias in empirical work. A longer time-period, that may reduce this problem and increase the power of random walk test (Lo and MacKinlay, 1988).

1.5 Layout of the Thesis

General discussion on testing weak form efficiency and modeling volatility of Dhaka stock market of Bangladesh as well as the objective of this study is included in Chapter 1. In Chapter 2, the nature of stock markets of Bangladesh is discussed, which gives the basic ideas on Dhaka Stock Market and Chittagong stock market. Major functions and different terms of DSE are also discussed here. In chapter 3, Literature review on testing weak form efficiency and volatility of stock market are included i.e., the previous empirical evidences on weak-form efficiency and stock market volatility in developed, emerging countries and Bangladesh stock markets as well. Chapter 4 describes the data, hypotheses and methodologies of the empirical research which are used in this study. This chapter also contains different kinds of time series models. Several types of unit root tests are also discussed in this chapter. Chapter 5 focuses on testing the weak form efficiency of DSE and ARIMA forecast for general and DS20 index return. Chapter 6 presents the empirical results on nature of stock market volatility, volatility-return relationship and volatility-volume relationship. Finally, Chapter 7 summarizes the results of this study and draws conclusion as well as provides suggestions for future research.

Chapter-Two

Capital Market of Bangladesh: An Overview

2.1 Introduction

The stock market plays a vital role in development of economy and acting as an intermediary between savers and companies seeking supplementary funds for business expansion. A lively capital market is always support to a healthy economic progress. While lending by banking sector provides valuable preliminary support for corporate growth, a well-functioning stock-market is a significant precondition for moving into a more mature growth phase with more sophisticated conglomerates.

Without existence of stock market firms' are dependent on internal sources of fund and loan from banking sector for their investment. All over the world the stock exchanges are considered as the unparallel institution for mobilization of savings and also a very responsive indicator of business activities. In Bangladesh, this institution is performing a very important role for achieving economic emancipation. The capital market can be reliable place for investing funds in industrial sector of a country and the investors can become a partner in the development process of the country by investing in capital market. Capital market can support governmental efforts to mobilize private capital and help government policy to inspire private venture a success. That is why, capital market are to be treated as the heart of the economic activity.

Through capital market, fund is collected from different savers and formed a huge size of capital which is eventually invested in various industrial sectors. Firstly, for collecting funds financial instrument are issued in the primary market through IPO and this instruments are traded in a place that is termed as stock exchange. In a capital market all buyers and sellers of securities can take part to transact their securities. In the corporate world, stock exchange plays a significant role as a financial intermediary between savers and users of money. Investors are interested to invest in stock markets all around the world in order to earn the economic benefits.

Bangladesh economy is an emerging one; there is plenty scope of growth of capital market. Market capitalization to GDP in our country is very negligible in comparison with other regional markets. With the help of upcoming issues of stock it seems that the market capitalization will reach a higher level within a short span of time. The major reason for the existence of the stock market is to provide liquidity of shares and diversified instruments which helps to increase market capitalization. It also helps investors to gain more confidence and create positive impact on Gross Domestic Product (GDP) of Bangladesh. Neighboring countries such as India and Pakistan have market capitalization of more than 75% of their GDP. Comparatively, the Bangladesh capital market accounts for a far lower contribution of its GDP indicating ample scope for future escalation in this sector. Large companies often need substantial amount of capital to finance their operation that may be beyond their capacity to generate from internal sources within reasonable time period. The stock market can permit these corporations to raise the amount of capital through issuing of securities in primary market.

The main purpose of this chapter is to give a brief history of Bangladesh stock market, Common approaches to stock market strategy and different functions of Bangladesh stock market.

2.2 Overview of Capital Market of Bangladesh

Without formal stock exchange it is not possible for investors to exchange their financial instrument when required. If there is a formal and organized stock exchange available then financial assets get liquidity formally. For this perspective stock exchange is the most essential part of overall economic development. Bangladesh has two stock exchange, Dhaka stock Exchange (DSE), established in 1974 and Chittagong Stock exchange (CSE), established in 1995. In both stock markets trading activities is conducted by Automated Trading System. Both exchanges are self-regulated and as private sector entities they have own operating rules which is approved by the SEC. Brief discussions about both the stock exchanges are furnished below:

2.2.1 Dhaka stock Exchange (DSE)

Dhaka Stock Exchange (DSE) is a very momentous and reputed organization in the financial sector as well as main bourse in Bangladesh. As a part of emerging capital market, the DSE is very volatile in nature. It has a very growth prospect and due to that, investors have been attracted to the potential for high returns along with diversification facilities. After liberation, trading in DSE resumed in 1976 with changes in the economic policy of the then Government. Since then, the stock exchange has been continuing its journey and contributing to the development of the nation.

The DSE has been growing at a slow but steady rate up to now. Nonetheless, the market was very turmoil in 1990, 1996 and 2010. About 25% of market capitalization had been lost in 1990 due to political unrest but regained and come back to the position in 1991 and again continued with a steady growth up to 1995. The most remarkable year for DSE is 1996 because; in this year the DSE gained about 196% while it depreciated about 68% in just next year. After that it continuously lost its index value and market capitalization up to 2002. After 2002, we witnessed a very steady growth in DSE up to 2009. But, in 2010, we again faced a bitter experience. On the first trading day of 2010 (3rd January), the benchmark DSE General Index was 4568.40 but it touched a record at 8918.51 on December 05, 2010. It can be noticed that the market has gained almost double in terms of index value and market capitalization. On the other hand, the daily turnover (Tk) of DSE has increased almost three times during the same period, i.e. on January 03, 2010 it was Tk. 1095 cores and it reached at Tk. 3250 cores on December 05, 2010. Following the year 2010, people connected with stock market in any ways have experienced a very awful situation. Within the first quarter of 2011, the DSE General Index come down to below 6000 and most of the investors who used margin loan have not only lost their entire equity but also their equity become negative. We have witnessed an extreme volatility in the price of the securities in the Bangladesh capital market during the last year 2011. The value of General Index has gone down at below 4000 by the end of 2011.

2.2.2 Historical Background of Dhaka Stock Exchange Limited

In early 1952, five years after the independence of Pakistan, the Calcutta Stock Exchange prohibited transactions in Pakistani stocks. This necessitated the formation of a stock exchange in East Pakistan. The provincial industrial advisory council soon thereafter set up an organizing committee for the formation of a stock exchange in East Pakistan. A Decisive step was taken in the second meeting of the organizing committee held on the 13th March, 1953. In the cabinet room, Eden Building, under the chairmanship of Mr. A. Khaleeli, secretary Government of East Bengal, Commerce, Labor And Industries Department at which various aspects of the issue were discussed in detail. It was suggested that Dhaka Narayanganj chamber of commerce & industry should approach its members for purchase of membership cards at RS.2000 each for the proposed stock exchange. The chamber informed its members and members of its affiliated associations of the proceedings of the above meeting, requesting them to intimate whether they, chamber of about 100 persons, interested in the formation of the exchange on 07.07.1953. The meeting invited 8 gentlemen to become promoters of the exchange with Mr. M Mehdi Ispahani as the convener and authorized them to draw up the memorandum and article of association of the exchange and proceed to obtain Register under the companies Act.1913. The other 7 promoters of the exchange were Mr. J M Addision-Scott, Mr. Mhodammed Hanif, Mr. A C Jain, Mr. A K Khan, Mr M Shabbir Ahmed and Mr. Sakhawat Hossin.

At last the East Pakistan Stock Exchange Association Ltd. was incorporated on 28 April 1954. It changed its name to East Pakistan Stock Exchange Ltd on 23 June 1962 and finally to Dhaka Stock Exchange (DSE) on 14 May, 1964. Although incorporated in 1954, Formal trading started in 1956 in Narayanganj. In 1958, the stock exchange was shifted to Narayanganj Chamber Building. DSE purchased its own land, and moved to its own premises at 9/F Motijheel C/A in 1959. Prior to independence in 1971, the number of listed companies in DSE was 196 with a total paid up capital of Tk 4 billion. The daily average transaction during that period was about 20,000 shares.

At the time of incorporation the authorized capital of the exchange was Rs. 300000 divided into 150 shares of Rs. 2000 each and by an extra ordinary general meeting adopted at the extra ordinary general meeting held on 22.02.1964 the authorized capital of the exchange was increased to Tk. 500000 divided into 250 shares of Tk. 2000 each. The paid up capital of the exchange now stood at Tk.460000 dividend into 230 shares of Tk. 2000 each. However 35 shares out of 230 shares were issued at TK. 80,00,000 only per share of TK. 2000 with a premium of TK. 79,98,000.

After the Independence, the government of Bangladesh took charge of the abandoned industrial units and pursued a policy, under which large industrial units were nationalized. The trading activities of DSE remained suspended till 1975 and following change in the economic policy of the government, DSE resumed its activities in 1976 with only 9 listed companies, having a total paid up capital of Tk 137.52 million. The actual growth of the stock exchange in Bangladesh (the DSE) started since 1983, when the market capitalization was Tk 812 million. The year 1987 experienced a relatively steep rise in the market with 92 listed companies. With the liberalization of policies in the 1990's the stock market gradually started to prosper. The Table 2.1 shows major events of DSE since its inception.

Table 2.1: Major Events of DSE at a Glance since Its Inception

Year	Events
1954	The East Pakistan Stock Exchange Association Ltd. was incorporated on 28 April 1954
1956	Formally, first trading started at Narayanganj
1958	Stock exchange shifted to Dhaka from Narayanganj
1959	Shifted to its own building at Motijheel
1962	Renamed as East Pakistan Stock Exchange
1964	Renamed as Dhaka Stock Exchange Limited
1971	Suspended trading activities
1976	Restarted trading activities with 9 companies
1993	SEC was established on June 08,1993
1998	Automated trading started
2004	Central Depository Bangladesh Limited (CDBL)
2004	On line trading started
2011	Denomination of face value of all shares at Tk. 10

2.2.3 Objectives of DSE

Dhaka Stock Exchange has been established with the following objectives:

- Providing new sources of finance for private domestic investment.
- Improving the efficiency of investment by allocating finance to more efficient investors.
- Ensuring the liquidity for the investors who invest in stocks and bonds.
- Improving the level of savings and create opportunities for institutional savers.
- To attract foreign portfolio investors and enhance inflow of foreign currency.
- Encourage privatization.

2.2.4 Services rendering by DSE

The following services have been providing by Dhaka Stock Exchange:

- Listing of Companies. (As per Listing Regulations).
- Providing the screen based automated trading of listed Securities.
- Settlement of trading.(As per Settlement of Transaction Regulations).
- Gifting of share / granting approval to the transaction/transfer of share outside the trading system of the exchange (As per Listing Regulations 42).
- Market Administration & Control.
- Market Surveillance.
- Publication of Monthly Review.
- Monitoring the activities of listed companies. (As per Listing Regulations).
- Investors' grievance Cell (Disposal of complaint by laws 1997).
- Investors Protection Fund (As per investor protection fund Regulations 1999.
- Announcement of Price sensitive or other information about listed companies through online.

2.2.5 Growth and Development of DSE

In recent, Dhaka Stock Exchange Limited, a growth engine of the national economy, has passed through a very volatile situation with many others new experiences. Emerging as the cheap and long-term source of finance for the expansion of business and industrial sector and keeping the legacy of success of country's capital market is entering into the New Year 2013. In the recent days, Capital Market is not merely a place of securities trading rather it has emerged as time-bound role, in a catalyst from, player in the overall economy. The growth & development of Dhaka Stock Exchange limited during last six years (From 2007 to 2012) are presented in Table-2.2:

Table 2.2: Major Market Indicators at a Glance from 2006-07 to 2011-12.

Market Indicators at a Glance from 2006-07 to 2011-12 (Amount in billion taka)						
Indicators	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Market Capitalization	475.86	931.03	1241.34	2700.74	2853.89	2491.61
Market Cap. to GDP (%)	10.18	17.18	20.19	43.92	41.10	31.64
Contribution to National Exchequer	0.0494	0.1630	0.2681	1.2817	4.4728	2.7169
Issued capital	164.28	284.38	457.94	607.26	809.37	933.63
Turnover Value	164.67	543.29	893.79	2563.50	3259.15	1171.64
Daily Average Turnover	0.7037	2.2732	3.7397	10.5061	13.5798	4.9228
Foreign Trade Turnover	0.9895	1.9224	1.1839	1.8698	2.8872	2.3917
Turnover Volume	1.9830	3.7611	5.7579	10.1284	19.6952	18.5880
General Index (points)	2149.32	3000.50	3010.26	6153.68	6117.23	4572.88
No of Mutual Funds (Nos)	14	14	17	26	35	41
No of Companies (Nos)	259	271	285	243	232	238
No of tradable Securities(Nos)	273	286	300	271	270	282
Market P/E (Points)	17.28	22.80	18.44	24.08	16.55	12.53
Market Yield (%)	2.85	1.94	2.17	1.70	3.02	4.35

Note: It is to be noted here that 79 companies was de-listed from main market and sent to OTC market in 2009.

Dhaka Stock Exchange limited witnessed tremendous growth in almost all of its market indicators. Market capitalization is an indicator of the size of a capital market. In comparison to developed capital markets, our market is very small. But, it is growing day by day. On June 30, 2012, the market capitalization of our exchange stood at Tk.2491.61 billion against Tk.475.86 billion on June 30, 2007, registering 84.72% average annual growth during the last six years. In the developed country, capital market significantly contributes to national economy. In Bangladesh, our exchange's contribution to GDP was just 10.18% on June 30, 2007 in terms of Market Capitalization which increased to 31.64% on June 30, 2012. The annual contribution to National Exchequer was Tk.0.0494 billion on June, 2007 which increased to Tk.4.4728 billion on June 30, 2011 and Tk.2.7169 billion on June 2012. The issued capital of all securities in DSE was Tk.164.28 billion on June 30, 2007 which rose to Tk.933.63 billion on June 30, 2012.

The daily average turnover was Tk.0.7037 billion on June 30, 2007 which increased remarkably at the apex Tk.13.5798 billion on June 30, 2011, but due to debacle of 2011, it has drastically fallen to Tk.4.9228 billion. The foreign investors are also getting interested about our capital market day by day. On June 30, 2007, the annual foreign turnover was TK 0.9895 billion which is increased to Tk.2.3917 billion on June 30, 2012, records 28.33% annual growth. The general index was 2149.32 points on June 30, 2007 which touched at its record on 8918.51 points on December 05, 2010. Nonetheless, after than it started falling and now the DGEN is only 4572.88 points on June 30, 2012.

Mutual funds are very important product or instrument in any exchange. Generally, Mutual funds increases liquidity, smoothness & strength in the market; on the other hand it reduces market risk. On June 30, 2007 the number of Mutual funds in DSE is 14 which are increased to 41 on June 30, 2007.

We observed that the number of investors or participants in the exchange increased remarkably during the last few years. On June 30, 2007, the number of BO accounts was 1,303,020 where on June 30, 2012; it has been increased to 2,380,406. People in Bangladesh are getting interested about the capital market day by day.

While in 2000 the market capitalization was only around 2.24% of the country's GDP, at the end of June, 2011 it stood around 41.22%. The trading network has expanded to the six divisions of the country transcending the periphery of Dhaka and Chittagong. The network is also expanding to district towns and other important places gradually.

Bangladesh capital market is still now a small market comparing to other developed markets, but it is growing day by day. It is not possible to make the Bangladesh capital market developed over night. Government, regulatory parties and all other concerned peoples should come together to work for the betterment of our exchange.

2.2.6 Procedure of Listing through IPO

The unlisted companies are required to complete certain procedures to get listing at DSE (Exchange).The present procedure of listing, in brief, may describe as follows:

a) Every company intending to enlist its securities to DSE by issuing its securities through IPO is required to appoint Issue Manager to proceed with the listing process of the company in the Exchange;
b) The Issue Manager prepares the draft prospectus of the company as per Public Issue Rules of SEC and submit the same to the SEC and the Exchange(s) for necessary approval;

c) The Issuer is also required to make agreement with the Underwriter(s) and Bankers to the Issue for IPO purpose;
d) After receiving the draft prospectus, the Exchange examine and evaluate overall performance as well as financial features of the company which may have short term and long term impact on the market;
e) The Exchange send its opinion to SEC within 15 days of receipt of draft prospectus for SEC's consideration;
f) After proper scrutiny, SEC gives it consent for floating IPO as per Public Issue Rule;
g) Having consent from SEC, the Issuer is required to file application to the Exchange for listing its securities within 5 days of issuance of its prospectus;
h) On successful subscription, the company is required to complete distribution of allotment/refund warrants within 42 days of closing of subscription;
i) After 100% distribution of shares/refund warrants and compliance of other requirements, the application for listing of the Issuer is placed to the Exchange's meeting for necessary decision of the Board of DSE;
j) The Board of DSE takes the decision regarding listing/non-listing of the company which must be completed within 75 days from the closure of the subscription.

Companies, who want to enlist its name with DSE, must apply for listing according to the manner of listing regulations.

2.2.7 De-Listing and Suspension

De-listing refers to the removal of a stock from trading on an exchange. Delisting occurs when a publicly-traded company violates the exchange's rules, or, more commonly, when the company ceases to meet listing requirements. For example, when a company's market capitalization falls below a certain level, it is in danger of delisting.

Suspension means a halt in trading in a share on the Stock Exchange. A company might ask for a temporary suspension of dealings - if a take-over bid is under discussion, for example, sometimes a suspension means bad news is on the way. Dhaka stock Exchange has the following de-listing & Suspension Regulations. A listed company may be de-listed or suspended for any of the following reasons:

a) If its securities are quoted below 50 percent of face value for a continuous period of three calendar years provided that if the shares of the company quoted at 50 percent or above of their face value then such a rate is maintained for a continuous period of thirty working days.
b) If it has failed to declare dividend or bonus:
    i) For five years from the date of declaration of last dividend or bonus; or
    ii) In the case of manufacturing companies, for five years from the date of commencement of commercial production; and
    iii) For five years from the date of commencement of business in all other cases.
c) If it has failed to hold its annual general meeting for a continuous period of three years;
d) If it has gone in to liquidation either voluntarily or under court order;
e) If it has failed to pay the annual listing fees as prescribed in these regulations payable to the Exchange for a period of 2 years or penalty imposed under these regulation or any other dues payable to the Exchange for a period of two years;
f) If it has failed to comply with the requirements of any of these Regulations;
g) No company which has been de-listed or suspended shall be restored and its shares re-quoted until it removes the causes of de-listing/suspension and receives the assent of the Council or Exchange for the restoration.

Where no trading has taken place on the Exchange in the Securities of a listed company for a continuous period of 180 days, the Exchange, if it is satisfied that the prices quoted are not in accordance with the market realities, the Exchange may declare it as not traded or as an inactive stock, until such time as a subsequent trade takes place and a price is ascertained.

2.3 The Chittagong Stock Exchange (CSE)

The Chittagong Stock Exchange Ltd (CSE), the second stock exchange, was established in1995. The board of directors consisting of 24 members directs the activities of CSE. Out of them, 12 directors are elected by direct votes of CSE members and other 12 directors are nominated by the elected members from non-CSE members upon approval of the Commission. Now there are 135 members in CSE of which 120 members are registered by the Commission for conducting securities business. As on June 30, 2011 total number of securities in CSE was 215 against which issued capital was Tk. 20677.39 crore and market capitalization was Tk. 225978.00 crore**.**

2.4 Types of Markets

There are the following four markets in the system, namely:

a) **Public Market**- Matching in this market is automatic based on the touchline prices which follow normal settlement procedure.

b) **Spot Market** - Matching in this market is also automatic, settlement of which follows procedure for spot transactions. The Management Team may put an instrument on compulsory spot to curb volatility in prices of the instrument.

c) **Block Market**- This is the market for bulk selling and buying on automatic matching with equal quantity and best price (all or none condition) basis. Orders entered in this market are immediately flashed on all trading workstations. The minimum amount for a bid of bulk lot for a certain security shall be Tk. 0.5 (point five) million at market price unless otherwise fixed by the Council from time to time with the approval of the SEC.

d) **Odd lot Market**- Odd lot shares are traded in this market on automatic matching with equal quantity and best price (all or none condition) basis.

2.5 Types of Transactions

Orders may be grouped or categorized based on the price, volume and validity which are discussed in the followings:

Based on price, orders will be of the following categories:

- **Limit order**- Limit order must have a price limit which ensures that the order shall be traded at the price equal to or better than the limit price.
- **Market order**- Market order is the order to be executed at the touchline price. A market order is matched immediately on arrival in to the trading engine at the touchline price. If there is no touchline price then the market order shall be rejected.

Based on volume, orders will be of the following categories:

- **Partial fill** - A partial fill (PF) order signifies that as much possible of the order quantity shall be executed as soon as the order is submitted to the trading engine. If the order is not fully executed the remaining order quantity shall be stored which shall be visible to the market.
- **Partial fill and kill**- A partial fill and kill (PFAK) order signifies that as much as possible of the order quantity shall be executed as soon as the order is submitted

and the remaining order quantity shall be returned to the trader who entered the order.

- **Full fill or kill**- A full-fill or kill (FOK) order signifies that either all of the orders quantity shall be executed as soon as the order is submitted to the trading engine or the entire order shall be rejected and returned to the trader.

Based on validity, orders will be of the following categories:

- **Good till day**- By default, all orders shall be valid till the end of the current trading day.
- **Good till date**- The trader can specify the date till which the order should remain active in the market. The order validity date can be a date which is up to a maximum of thirty days from the current trading day.

2.6 The participants in Bangladesh Capital Market

The main participants in Bangladesh capital market are as follows:

Participants	➢ Bank ➢ Insurance company ➢ Government ➢ Mutual fund agency ➢ Stock market Broker and Dealer ➢ Merchant Bank ➢ Leasing company ➢ Individual etc.

2.7 Role and Importance of Capital Market in the Economy of Bangladesh

Economy of Bangladesh is a developing and capital market has great significance in our economy. Importance of capital market in Bangladesh is followings:

a) Provides an important alternative source of long-term finance for long-term productive investments. This helps in diffusing stresses on the banking system by matching long-term investments with long-term capital.
b) Provides equity capital and infrastructure development capital that has strong socio-economic benefits - roads, water and sewer systems, housing, energy, telecommunications, public transport, etc. - ideal for financing through capital markets via long dated bonds and asset backed securities.
c) Provides avenues for investment opportunities that encourage a thrift culture critical in increasing domestic savings and investment ratios that are essential for rapid industrialization. The Savings and investment ratios are too low, below 10% of GDP.
d) Encourages broader ownership of productive assets by small savers to enable them benefit from Bangladesh's economic growth and wealth distribution. Equitable distribution of wealth is a key indicator of poverty reduction.
e) Promotes public-private sector partnerships to encourage participation of private sector in productive investments. Pursuit of economic efficiency shifting driving force of economic development from public to private sector to enhance economic productivity has become inevitable as resources continue to diminish.
f) Assists the Government to close resource gap, and complement its effort in financing essential socio-economic development, through raising long-term project based capital.

g) Improves the efficiency of capital allocation through competitive pricing mechanism for better utilization of scarce resources for increased economic growth.

h) Provides a gateway to Bangladesh for global and foreign portfolio investors, which is critical in supplementing the low domestic saving ratio.

2.8 Regulatory Framework of Bangladesh Capital Market

Capital market is an integral part of any country's financial system. The general objective of regulations of capital markets is to attain the goal of financial policy. Apart from this other three goals are, firstly, to improve the efficiency of securities markets, secondly, to improve the stability and soundness of the financial system, thirdly, to maintain an adequate level of investors protection. To accomplish these goals, the capital market of Bangladesh is governed by certain rules and regulations. Major regulatory authorities of Bangladesh capital market consists Registrar of Joint Stock Companies (Rjsc), Securities and Exchange Commission (SEC), Dhaka Stock Exchange (DSE), Chittagong Stock Exchange (CSE), Controller of Capital Issues (CCI), Bangladesh Bank and Controller of Insurance.

Regulatory structure of Bangladesh capital market (only security segment) is shown in the Figure 2.1.

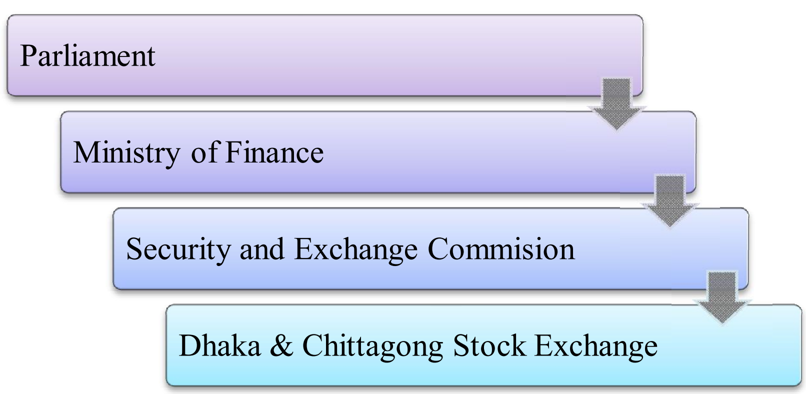


Figure 2.1: Regulatory Structure of Bangladesh Capital Market

The capital Market is registered as a Public Limited Company and its activities are regulated by its Articles of Association rules & regulations and bye-laws along with the Securities and Exchange Ordinance, 1969, Companies Act 1994 & Securities & Exchange Commission Act, 1993.

A Government body under the ministry of finance established to regulate the securities market in Bangladesh. It was established on June 9, 1993 under the Securities and Exchange Commission Act 1993. Prior to its establishment, the securities market was regulated under Capital Issues Act 1947. The need of establishing an independent and statutory agency for monitoring and supervising the functions of the security market both the primary level and secondary level was felt. To fulfill this need CCI has been abolished and SEC was formed to supervise the security market of Bangladesh. The main office of SEC is at Dilkusha Commercial Area, Dhaka.

It mandates SEC to perform a dual function: investor protection through regulation of the securities market and fostering the development of this market. SEC has been vested most of the functions and powers under the Securities and Exchange Commission Act, 1993, which brought stock exchanges, their members, as well as contracts in securities which could be traded under the regulations of the Ministry of Finance. In addition to registering and regulating intermediaries, service providers, mutual funds, collective investment schemes, venture capital funds and takeovers, SEC is also vested with the power to issue directives to any person(s) related to the securities market or to companies in areas of issue of capital, transfer of securities and disclosures. It also has powers to inspect books and records, suspend registered entities and cancel registration.

Securities and Exchange Commission Regulatory Framework

- Capital Issues (Continuance of Control) Act 1947
- Securities and Exchange Ordinance 1969
- Securities and Exchange Commission Act 1993
- Securities and Exchange Commission (Stock Broker, Stock Dealer and
- Authorized Representative) Regulation 1994.
- Securities and Exchange Commission (Merchant Banker and Portfolio Manager) Regulation 1996
- Securities and Exchange Commission (Mutual Fund) Regulation 1997
- Credit Rating Rules 1996
- Securities and Exchange Commission (Control of Insider Trading) Regulation 1995
- Securities and Exchange Rules 1987
- Public Issue Rules 1998
- Right Issue Rules 1998

Bangladesh Bank (BB) has regulatory involvement in the capital market, but this has been limited to debt management through primary dealers, foreign exchange control and liquidity support to market participants. BB regulates as primary dealers in the Government securities market. Recently, BB has included stock dealers & stock brokers, portfolio manager & Merchant bankers, security custodian in money laundering prevention Act. 2009.

The Dhaka Stock Exchange (DSE) is registered as a Public Limited Company and its activities are regulated by its Articles of Association rules & regulations and bye-laws along with the Securities and Exchange Ordinance, 1969, Companies Act 1994 & Securities & Exchange Commission Act, 1993.

As legal entity CSE is a not-for-profit public limited company. All of its 129 members are corporate bodies. It has a separate secretariat independent of policymaking Board. The Board comprises of brokers and non-brokers directors with equal proportion to ensure the transparency.

The Board constituted Committees to delegate such functions and authority as it may deem fit. There is an independent secretariat headed by a full time Chief Executive Officer. CSE activities are regulated by it's own regulations and bye laws along with the rules, orders and notification of the SEC.

2.9 Market Control Parameters

The Council from time to time as it thinks fit, shall regulate the market control parameters, such as tick size (smallest increment of the currency for specifying the price for an order), market lot (smallest tradable unit for security except in the odd lot market), minimum block size (minimum quantity allowed for block orders expressed in lots), maximum block size (maximum quantity allowed for block orders expressed in lots), minimum order size (minimum quantity for a public order or a spot order expressed in lots), closing price minutes (closing price will be calculated taking into account the trades which occurred during this time before the closing time), closing price trades (the number of trades which shall be taken into account for calculating the closing price), circuit breaker (the maximum permissible deviation of the price from the circuit breaker base price for that security), circuit filter (the maximum permissible deviation of the price of an aggressor order from the last trade price), market protection percentage (a fixed percentage of the touchline price to avoid the possibility of market orders being matched, during continuous trading, at ridiculous rates), index calculating frequency (interval at which index shall be calculated), etc. under immediate intimation to SEC. Provided that the system shall automatically enforce the price limit regulations/orders which shall reject any order beyond the price limit set under the price limit regulations/orders.

2.9.1 Exposure Limit

DSE shall regulate the net limit for a member. If a member exceeds the limit at any point of time such member shall be automatically suspended by the system under immediate intimation to SEC. DSE shall, from time to time, determine the size of every security as limits for a single buy or sell order under immediate intimation to SEC. Any order breaching these limits shall be automatically rejected by the system.

2.9.2 Settlement

The settlement of all trading shall be made in accordance with the provisions of the rules or regulations made in this behalf by DSE for the time being in force.

2.9.3 Removal of Difficulties

If any difficulty arises in giving effect to the provisions of these regulations, the CEO may, with the prior approval of the Council, by order, take appropriate measures necessary for the purpose or removing the difficulty under immediate intimation in writing to SEC.

2.9.4 Matters not Covered

In matters not covered by these regulations the decision of the Council in the concerned matter shall be applicable: Provided that notwithstanding anything contained in these regulations the trading in the DSE shall not follow any system which contradicts to any other securities law, rules or regulations made in this behalf for the time being in force.

2.10 Clearing and Settlement

A trade executed through exchanges is settled amongst the brokers through the clearing house of the exchanges.

- **Clearing:** Clearing is all about participant trade reporting, affirmation, billing and assigning settlement instructions.

- **Settlement:** Settlement is the process of overseeing that delivery of all instruments to the buyer and payment of all moneys to the seller has occurred before removing the trade from the settlement pool.

In settlement of trade, except Z category securities, the buying and selling brokers deposit cheque and securities respectively to the clearing house on 2nd day of the trade (T+1) and the clearing house deliver securities and give cheque to the buying and selling broker respectively on 4th day of the trade (T+3). For settlement of the trades of the securities under Z-category the aforesaid periods is T+1 and T+9 respectively. A description of the whole clearing and settlement system of DSE is as under:

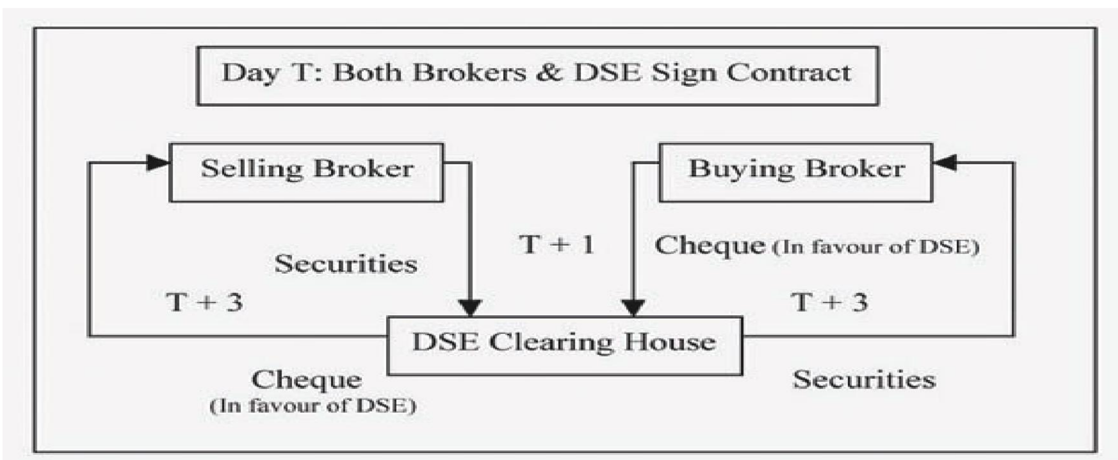
Table 2.3: The Whole Clearing & Settlement System of DSE for A, B, G and N Categories Shares

	T+0	T+1	T+2	T+3
Buy	**Buy confirmed**	**Settle funds**		**Receive shares**
Sell	Sell confirmed & sold share paid-in for ear marking (*to comply member's margin requirement*)	Shares Settled		Receive funds
Foreign Buy (Public Mkt.)	Buy Confirmed	Settle funds (by Broker)		Brokers Receive share on behalf of Foreign Clients
Foreign Sell (Public Mkt.)	Sell confirmed	Sold shares paid-in for ear marking		Brokers Receive funds on behalf of Foreign Clients

Note: Only Brokers will be responsible for any kinds of settlement failure with DSE. It is also to be noted here that foreign clients can also trade in DVP mode.

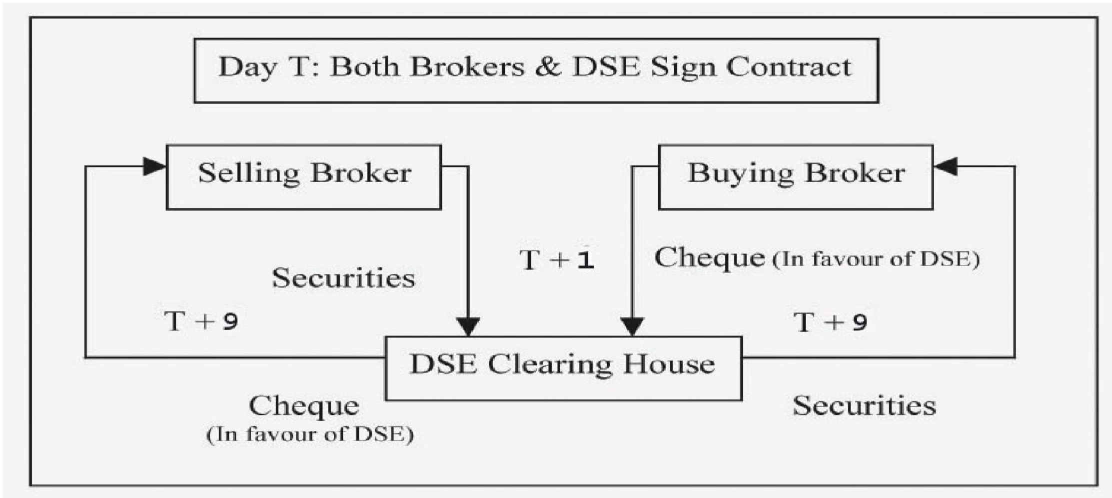
Under DVP Mode, Members shall be allowed to carry out transaction of foreign buyer and/or seller involving a custodian bank to be settled directly between the member through the custodian bank within the fifth day subsequent to the trading day, i.e. T+5, in respect of the transactions carried out on each trading day with intimation to the clearing house. For ‘Z’ Group it will be T+1 and T+9 respectively. For Spot Market, both Shares & Funds are settled on T+0 and Cleared on T+1.

However, here is a complete picture of the settlement system for all of our Instruments in Five (5) groups in the Four (4) markets are presented in the Figures 2.2, 2.3, 2.4 and 2.5.



Figures 2.2: Settlement System for A, B, G & N Category Instruments

The cycle presented in Figure 2.2 is valid for A, B, G & N category instruments traded in Public, Block & Odd-lot market.



Figures 2.3: Settlement System for Z Category Instruments

The cycle presented in Figure 2.3 is valid only for Z group instruments traded in Public, Block & Odd-lot market.

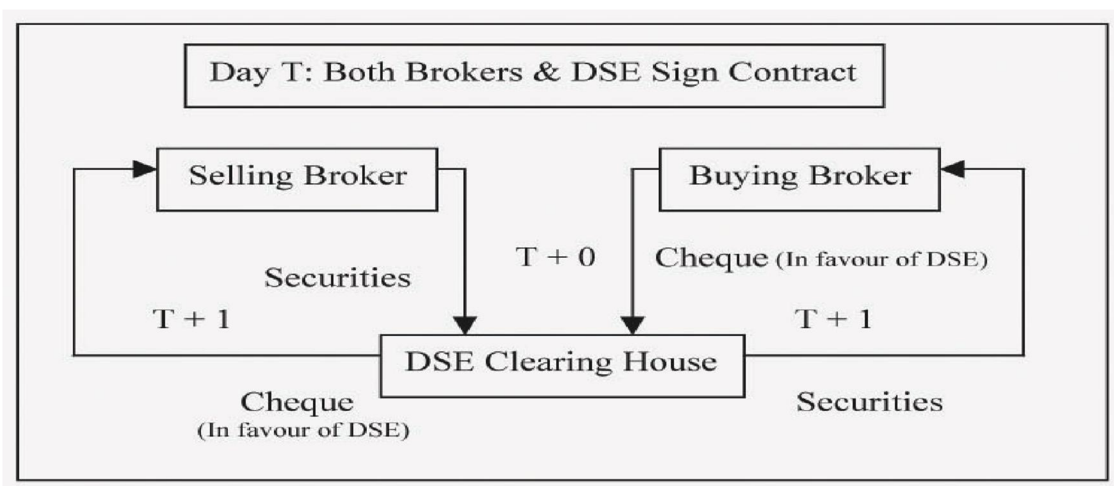


Figure 2.4: Instruments of All Groups Traded in Spot Market

The cycle presented in Figure 2.4 is valid for A, B, G, N& Z category instruments traded in spot market.

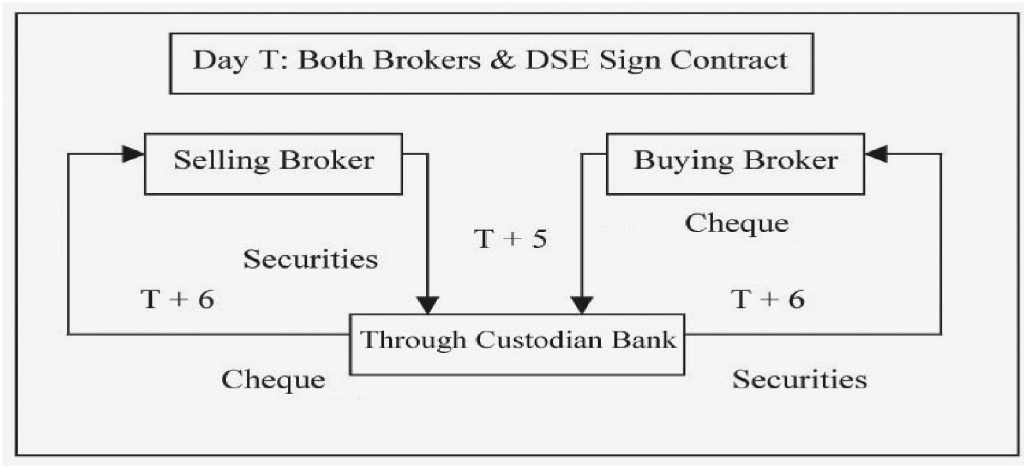


Figure 2.5: Instruments of Foreign Trades (DVP) of All Groups

Figure 2.5 shows the cycle for A, B, G, N& Z category instruments of foreign trade.

Remarks

- If any instrument declared as Compulsory Spot then Trades of Block and Odd-lot market of that Instrument will be settled like Spot Market.
- Howla Charge, Laga Charge & Tax are always payable to DSE at Pay-In date for both Buyer and Seller traded in Public, Block & Odd-lot Market.
- Howla Charge, Laga Charge & Tax are always payable to DSE at T+1 day for both Buyer and Seller traded in Spot Market.
- Outside-Of-Netted settlement for "A" Group instrument has been withdrawn from 10th Dec 2006.
- DVP Trades are Off-Market Settlement (Broker to Broker).

2.11 Different Methods of Listing

In our capital market, there are three types of listing methods. They are as follows:

- Listing through IPO
- Direct listing
- Listing through Book Building

2.11.1 Initial Public Offering

An initial public offering (IPO) is a type of public offering where shares of stock in a company are sold to the general public, on a securities exchange, for the first time. Through this process, a private company transforms into a public company. Initial public offerings are used by companies to raise expansion capital, to possibly monetize the investments of early private investors, and to become publicly traded enterprises

They are often issued by smaller, younger companies seeking capital to expand, but can also be done by large privately owned companies looking to become publicly traded. Nonetheless, In Dhaka Stock Exchange Limited, a total of 16 companies floated IPOs worth TK 8526.53 million on the last fiscal year 2011-12 against in 2007-08 only 13 companies floated IPOs worth TK 3981.55 million witnessing a substantial growth in IPO floating during the last five years.

Table 2.4: Numbers of IPOs floated at DSE from 2007-08 to 2011-12

IPO Statistics of DSE		
Year	**No. of IPOs Issued**	**Public Offers/IPO (TK in Million)**
2007-08	13	3,981.55
2008-09	15	2,630.41
2009-10	21	8,370.33
1010-11	17	8,555.00
2011-12	16	8,526.53

2.11.2 Direct Listing

Direct listing means listing of a company by directly offering the securities to the public through a stock exchange. In case of direct listing, the shares are traded on the secondary market from the beginning and there is no primary market of the securities. Direct Listing Method helps owners to divest their shares to the general public for making their issue listed in the bourse to obtain its genuine market value. This window is most suitable for Government to off load their shares to general public as well to find strategic partner for sharing management for better efficacy, transparency, and accountability.

In exercise of power conferred by section 34(1) of the Securities and Exchange Ordinance, 1969 (XVII of 1969), Dhaka Stock Exchange, with the prior approval of the Securities and Exchange Commission, makes this Regulation named “Dhaka Stock Exchange (Direct Listing) Regulations, 2006.” After this regulation, Dhaka Electric Supply Company is the first company who gets direct listing with DSE in 2006. After that, four more Government and five private companies get direct listing with DSE. Now only public company is allowed to offload its share under direct listing. In recent, some private companies use this listing method with ill-motive to make more money from the market for which the general investors had to get loser. And this was criticized by different concerned peoples which force SEC to announce that no more direct listing for private companies. Under this method, total 10 companies raised fund from the market by TK 4025.31 crore which is presented in Table 2.5.

Table 2.5: Total Fund Raised from Market under Direct Listing up to 2012

Fund Raised from market under direct listing method		
S.L.	**Particulars**	**Capital Raised in Tk. Crore**
	Direct Listing by Govt. Company	
1.	Dhaka Electric Supply Co (FV Tk.100, Premium Tk.157.11)	64.72
2.	Power Grid Co. of BD Ltd.(FV Tk.100, Premium Tk.79.86)	155.64
3.	Jamuna Oil Co. Ltd. (FV Tk.10, Premium Tk.318.64)	443.66
4.	Meghna Petrolium Ltd. (FV Tk.10, Premium Tk.314.96)	389.95
5.	Titas Gas (FV Tk.10, Premium Tk.355.01)	974.82
	Total	**2028.80**
	Direct Listing by Private Company	
1.	ACI Formulation (FV Tk.10, Premium Tk.155.21)	148.47
2.	Shinepukur Ceramics (FV Tk.10, Premium Tk.71.72)	286.12
3.	Navana CNG Ltd. (FV Tk.10, Premium Tk.197.52)	376.65
4.	Ocean Container Ltd. (FV Tk.10, Premium Tk.135)	172.55
5.	Khulna Power Co. Ltd. (FV Tk.10, Premium Tk.184.20)	1012.72
	Total	**1996.51**
	Grand Total	**4025.31**

2.11.3 Listing through Book Building Method

Book building refers to the process of generating, capturing, and recording investor demand for shares during an IPO (or other securities during their issuance process) in order to support efficient price discovery. In other words, Book Building Method is the process by which an underwriter attempts to determine at what price to offer an IPO based on demand from institutional investor. Book building is a common practice in developed countries and has recently been making inroads into emerging markets as well. Recently, in Bangladesh capital market this method for IPO pricing was introduced. Under this method, three (03) companies name: RAK Ceramics, MJL Bangladesh Limited and M.I. Cement mills Limited, were listed with DSE. But, this method was badly criticized for its shortcomings in the process of price discovery. Later, SEC was forced to repeal the method in 2011.

2.12 Recent Performance of Bangladesh Stock Market

Since last few years, Bangladesh capital market has been suffering from various problems, crisis and lack of investors' confidence. All the concerned bodies, including the Finance Ministry, Securities and Exchange Commission, Bangladesh Bank, National Board of Revenue and Dhaka Stock Exchange limited realized the matter and now are trying to work together for the development of stock market. But it is too late. Lack of co-ordination among the regulatory bodies gets the situation into more deteriorated. All that things destroyed the confidence of general investors. Sometimes, Government and regulatory bodies' initiatives lifted the market up and bought some hope for investors, but lack of combination and irresponsible activities and words of Government people and regulatory bodies bought down the market into the same situation immediately. Nonetheless, amid the debacle, our capital market has been gaining momentum. Even in the backdrop of Global Financial Crisis 2008, when stock markets in almost all the developed and developing countries crashed and Governments of those countries spent thousands of dollars to rescue the markets. Both depth and dimension in Bangladesh capital market has been becoming gradually strong and securities market registered significant growth at the initial stage and later market fell a little bit. But lack of supply of fundamentally sound shares has been causing overheating situation and circumstance like overpricing has been a common phenomenon here in recent times. Because of the slower pace of investment activities, reduced interest on deposit and saving certificate and increasing enthusiasm among all the quarters towards capital market the securities market in Bangladesh has been flooded with huge liquidity. But market regulators and other relevant stakeholders have not been succeeded in making the supply side recipe to the extent demand has been created. Consequently, the capital market has become boom and boom and as a rule, the market started falling sharply and the bearish resulted. At the beginning of 2009, the general index was 2807.61 points and on December 05, 2010 it witnessed record at 8918.51 points, but after than it started falling and on February 06, 2012 it reached at 3616.24 points.

2.13 Market Capitalization at DSE

Market Capitalization is sum of the market value of all listed securities' outstanding shares. It is an indicator of the size of a capital market. In comparison to developed capital markets, the market Capitalization of our market is very small. But, our capital market is growing day by day. Figure 2.6 and 2.7 represent Market capitalization and market capitalization to GDP.

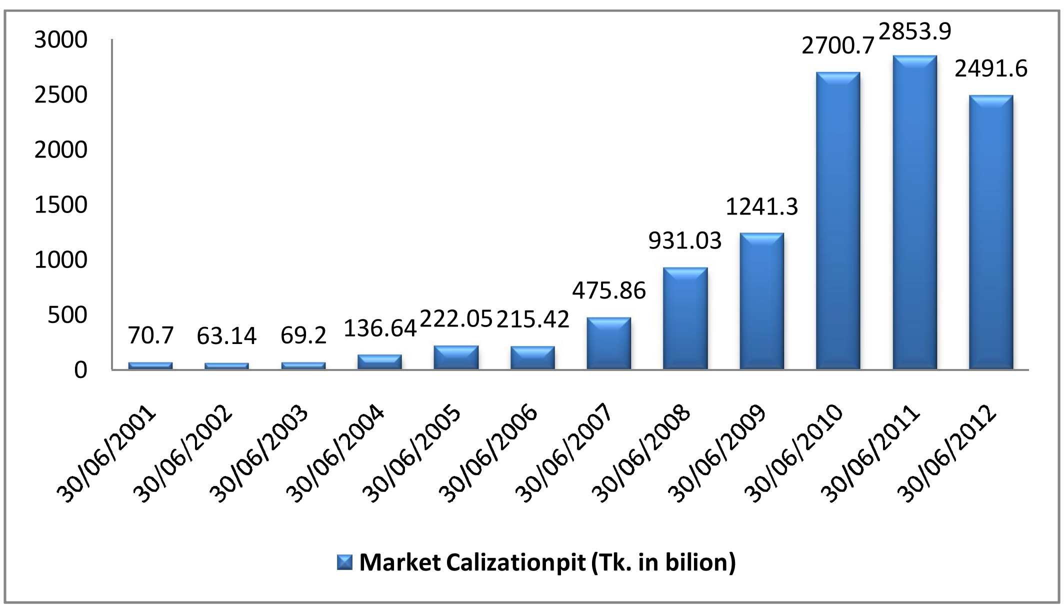


Figure 2.6: Graphical Presentation of Market Capitalization from June 2000 to June 2012.

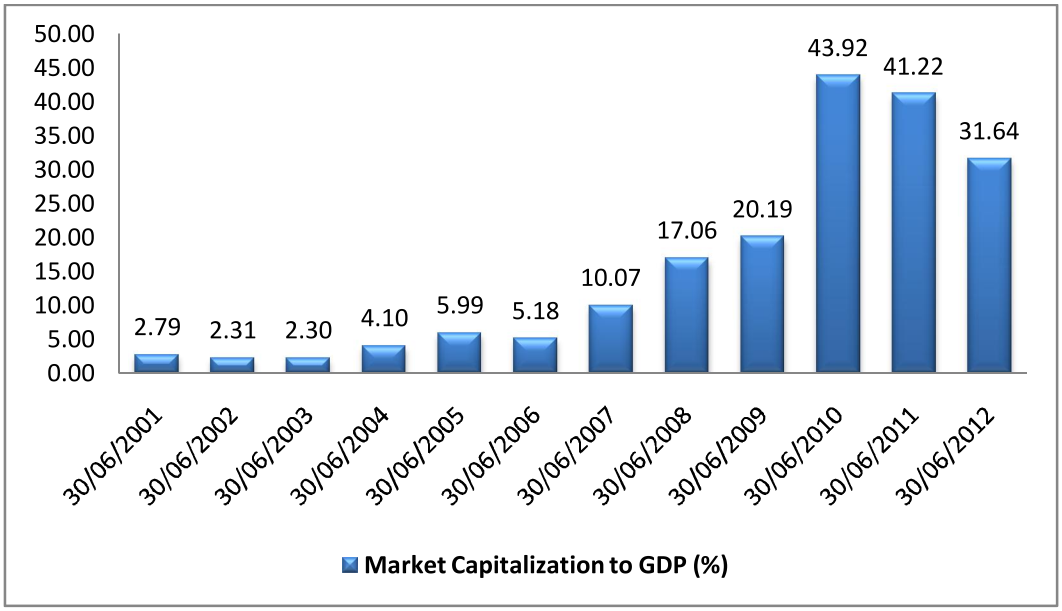


Figure 2.7: Graphical Presentation of Market Capitalization to GDP from June 2000 to June 2012

Market capitalization is gradually increasing in DSE up to 30 June, 2011. As on 30 June, 2012 our Market Capitalization stood at Tk. 2491.61 billion against Tk. 2853.44 billion of 30 June, 2011 reflecting 12.68% fall.

Capital market is a heart of any developed country. It significantly contributes to the national GDP of the country. However, our present capital market (in terms of Market Capitalization) is contributing 31.64% to Bangladesh's total GDP as on 28 June, 2012.

2.14 Turnover at DSE

Turnover is heart of any stock exchange as it supplies liquidity in the capital market. Compare to 1'st half of 2011, in 2012 DSE begins slowly, but, in the months of March and April it showed new hope for investors which has been wiped out at the end of this

June 30, 2012 due to various reasons like rumors, negligence from regulatory bodies & Govt., lack of coordination between various market participating bodies, destroying of confidence among investors etc.

However, in DSE a total of 18588.02 million shares & debentures worth Tk. 1171638.97 million were traded in 2012 against 19695.16 million shares and debentures valued at Tk 3259152.58 million in 2011. The following picture shows the daily turnover movement along with the movement of DSE General Index (DGEN):

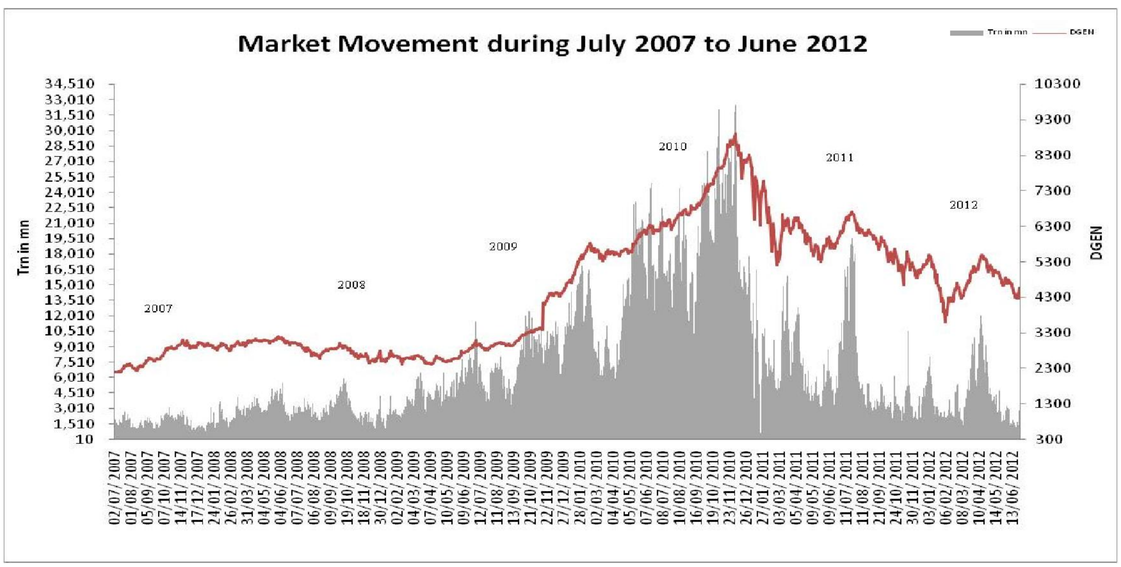


Figure 2.8: Graphical Presentation of the Movement of Turnover along with DGEN index from July 2007 to June 2012.

Figure 2.8 indicates that both turnover and DGEN have been increased up to December 2010. The trading volume hits a high of Tk.32495.76 million on December 05, 2010. After 2010, a sharp plunging of trading volume and index value has been noticed in DSE. On June 28, 2012, trading volume at DSE was Tk.2999.98 million which is almost 11 times lower than the highest trading volume.

2.15 Overall Price Movement Pattern at DSE

An index represents the performance of the stock market of a given nation reflecting investors' sentiment on the state of its economy. In the last financial year, 2012, DSE has witnessed an extreme volatility in the price of securities in the capital market.

The DSE General Index (DGEN) closed at 4572.88 on June 28, 2012 whereas it begins at 5351.75 on January 01, 2012. The DGEN hits a high of 5502.30 on 17 April, 2012 and a low of 3616.24 on 06 February, 2012 during the first six months of 2012. The DSE 20 Index that encompasses the blue-chip shares clocked at its highest point at 4025.13 on 17 April, 2012 and the lowest was recorded at 2997.04 on 06 February, 2012.

DSE All Share Price Index (DSI) closed at 3877.64 on 28 June, 2012 while it begins in this current year at 4459.00 on 01 January, 2012. The DSI hits a high of 4612.78 on 17 April, 2012 and a low of 3045.31 on 06 February, 2012 during the first six months of 2012.The movements of three indices are presented in Figure 2.9.

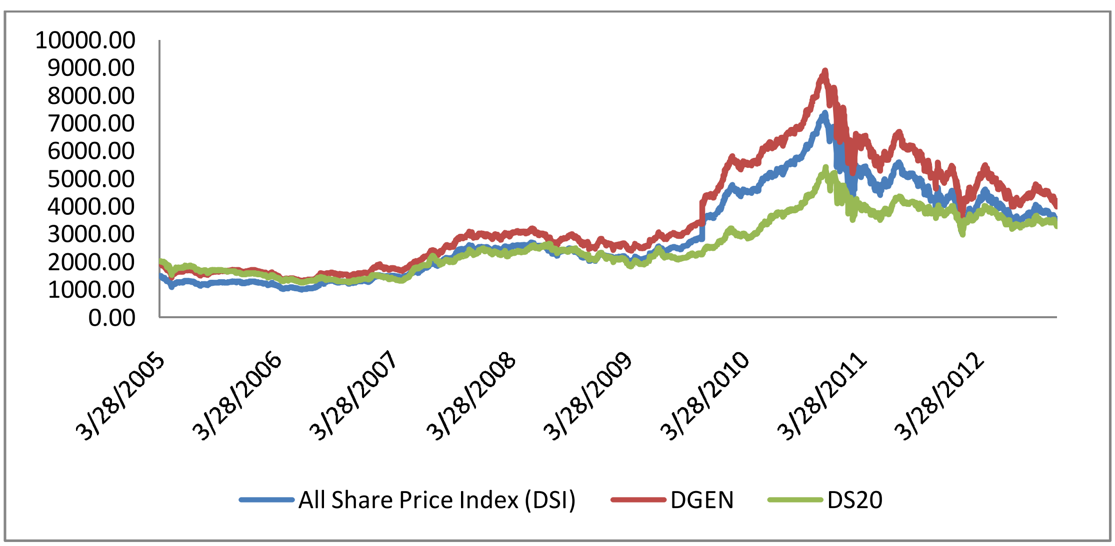


Figure2.9: Movement of Three Price Indices from 2002 to 2012

2.16 Recent Listing Scenario at DSE

Generally, Listing refers to admission of securities of the issuer to buying and selling rights (dealings) on a stock exchange by way of a formal agreement. The main aim of admission to dealings on the exchange is to give liquidity and also marketability to securities, as also to give a mechanism for efficient control and supervision of trading. Nonetheless, in the financial year 2011-12, a total of 15 companies with paid-up capital TK 1795.14 Crore have been listed with the Dhaka Stock Exchange Limited against 19 companies with paid-up capital of TK 2666.42 Crore in 2010-11. A comparative picture between IPO and listing in DSE are presented in Figure 2.10:

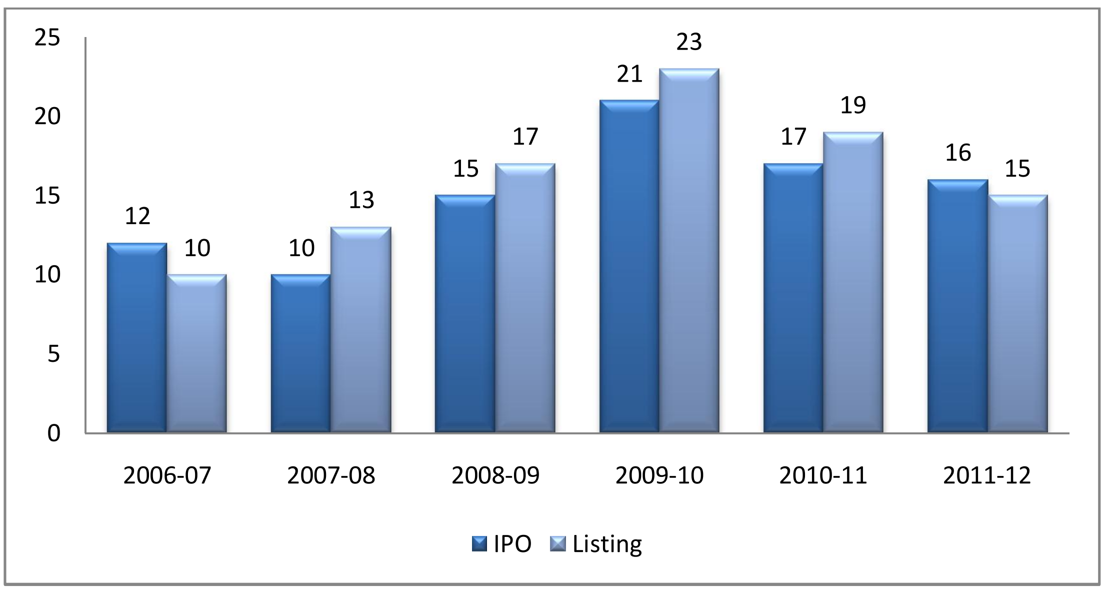


Figure 2.10:Comparative Position of IPO and Listing in DSE from 2007-08 to 2011-12

In financial year 2009-10, a total number of 23 companies have been listed at DSE which is the ever highest number of listing at DSE in any financial year.

2.17 Dividend Declaration and Percent of Dividend

Generally, investors invest their money in the capital market with a hope that it will generate more money into their funds. Usually, they do it in the forms of capital gain, dividend, and Bonus or Right shares from the capital market. These are the most fundamentals to all investors. Many companies pay out dividend regularly to shareholders from their earnings and send a clear, powerful message about their future prospects and performance. A company's willingness and ability to pay steady dividends over time - and its power to increase them - provide good clues about its fundamentals.

In the year 2011 a total of 253 companies and mutual funds out of total listed 272 companies and mutual funds declared dividend against 239 companies (out of 251 companies and mutual funds) declaring dividends in 2010. In the year 2011 the percentage of dividend declared by the listed companies and mutual funds ranged from 3 percent to 675 percent which was 5 percent to 750 percent in the year 2010.

Table 2.6: Picture of Dividend Declaration and Percentage of Dividend in DSE from 2007 to June 2012

Statistics of Dividend in Dhaka Stock Exchange Limited						
Particulars	**2007**	**2008**	**2009**	**2010**	**2011**	**2012 (Upto June)**
Dividend						
No. of Co. declared cash dividend	141	128	124	95	92	69
No. of Co. declared stock dividend	65	82	107	144	161	109
No. of Co. declared no dividend	68	58	34	13	15	5
Limit of Dividend						
Above 100%	5	3	5	7	9	7
Above 50% up to 100%	7	7	3	4	2	2
Above 30% up to 50%	6	4	10	10	11	9
Above 20% up to 30%	22	21	17	16	14	7
Above 10% up to 20%	76	58	64	46	40	34
Below 10%	25	35	25	12	16	10

2.18 Flow of Financial Information

Dhaka Stock Exchange (DSE) makes sure for disseminating financial information about their listed securities and other concerned. All companies are responsible to provide their financial information timely. They submit quarterly, half-yearly and annual reports on regular basis. The companies are responsible to inform the market about any price sensitive information as soon as it is available. To ensure transparency of the flow of financial information, DSE always monitors and inspects the companies. If they find any malfunction in the market, they make query in the respective company. Once, the price of any company rises suddenly, DSE instantly make query in the respective company.

Any financial information disclosed by the company is published in the renowned daily Newspaper as well as in the DSE website. DSE also publishes it in their Monthly and Fortnightly Publications. Thus the flow of financial information is very prompt and transparent. In some cases, some inside information disrupts the market. However, if the regulatory institutions and DSE take more initiatives and increase their monitoring activities, the flow of financial information will be more transparent and easy.

2.19 Transaction Costs

In economics and related disciplines, a transaction cost is a cost incurred in making an economic exchange (the cost of participating in a market). For example, most people, when buying or selling a stock must pay a commission to their broker; that commission is a transaction cost of doing the stock deal. In the same way DSE has its transaction costs. DSE charges various fees and commission on its Transactions and collects it from the participants (Members) of the transactions. In the following various transactions costs and its rates in DSE are given:

- Laga Charge = 0.02% on Members' total turnover which is recoverable from both buyer and seller.
- Howla Charge = TK 2 for each Howla from both buyer & Seller. That is TK 4 for each Howla.
- Depository Participant (DP) Charge: DP charge @ TK 0.037% collected from members on daily transactions (both buyer and Seller).

2.20 Some Arithmetic of DSE

2.20.1 About Indices

Dhaka Stock Exchange has three indices. Those are

a) **DSE All Shares Index (DSI):** DSI index launched on November 1, 1993 with base index 350 points. DSI is determined on the basis of price movement of individual stocks of all categories DSI index comprises all companies. But it didn't include Mutual Funds & Bonds. The DSE reintroduced All Share Price Index (DSI) on March 28, 2005.

b) **DSE General Index (DGEN):** The index 'DGEN' is now considered the benchmark price barometer for DSE.DGEN index launched on November 24, 2001 with base index 817.63704 points. DSE General Index is an index comprising of A, B, G & N categories of Securities. But it didn't include Mutual Funds & Bonds.

c) **DS20:** The DSE 20 index was introduced on January 01, 2001. The DSE-20 index has the basis of 1000 base-index. The criteria taken into account in formulating the index were market capitalization, free float shares in public hands, minimum payment of 10 percent dividend for the last three consecutive years and 95 percent trading day's liquidity in terms of trading during the last six months. Subjective criteria such as good corporate governance, regular holding of Annual General Meeting and sectoral representation also considered. DS20 index included some selected 20 companies.

Algorithm of DSE Indices

Index Calculation Algorithm (according to IOSCO Index Methodology):

$$\text{Current Index} = \frac{\text{Yesterday's Closing Index} * \text{Current market capitalization}}{\text{Opening Market Capitalization}}$$

$$\text{Closing Index} = \frac{\text{Yesterday's Closing Index} * \text{Closing market capitalization}}{\text{Opening Market Capitalization}}$$

Current M.Cap = $\sum$ (LTP × Total no. of indexed shares)

Closing M.Cap = $\sum$ (CP × Total no. of indexed shares)

Notes:

M.Cap - Market Capitalization

DSE - Dhaka Stock Exchange

IOSCO - International Organization of Securities Exchange Commissions

LTP - Last Traded Price

CP - Closing Price

2.20.2 Algorithm of Market Capitalization

Market Capitalization is a measurement of size of a business enterprise (corporation) equal to the share price times the number of share outstanding (shares that have been authorized, issued, and purchased by investors) of a publicly traded company. As owning stock represents ownership of the company, including all its equity, capitalization could represent the public opinion of a company's net worth and is a determining factor in stock valuation. The equation is very simple as follows:

Market Capitalization = Market Price per share × No. of Shares Outstanding

Market capitalization represents the public consensus on the value of a company's equity. An entirely public corporation, including all of its assets, may be freely bought and sold through purchases and sales of stock, which will determine the price of the company's shares. As on 30 June, 2012 the Market Capitalization in DSE stood at Tk. 2491.61 billion.

2.21 DSE Automation

Usually, an automated trading system (ATS) is a computer trading program that automatically submits trades to an exchange. They are designed to trade stocks based on a predefined set of rules which determine when to enter a trade, when to exit it and how much to invest in it.

Today, using information and trading platforms has become a de facto requirement for successful trading in the financial markets. Their advantages as compared to conventional trading schemes include, for example, an unprecedented speed of processing and delivery of information to end users, the level of integration with data providers, and a wide array of built-in technical analysis instruments. At the same time, an investor opening an account with a brokerage firm simply cannot simultaneously manage the real-time analysis and trade in more than 4-6 financial instruments in several markets 24 hours 7 days a week. This brings about the need to employ automatic trading systems in the form of runtime environment with client and server parts and the programs to control these systems.

Realizing the importance of automation, DSE started its Automated Trading System in 1998 on Mainframe Server platform. Considering market growth the Trading Server was upgraded time to time to enhance the trading capacity. System experienced highest trades of around 0.4 m on 5th December 2010. DSE is using HP Non Stop S7810 Server as a Trading System which is fault tolerant, highly available, scalable, hot swappable, upward compatible and easily maintainable.

2.22 Conclusion

In recent past, capital market of Bangladesh has gone through a very turmoil situation but still has a lot of potential of this market. However, Bangladesh capital market also showed signs of increasing maturity in terms of capital rising power through issuing and listing new shares of companies. A healthy and stable market is utterly needed for the sponsors and investors as well as economic development. The stability came through a variety of sources namely, educated retail investors, institutional investors, eligible and fair regulators, timely intervention of government etc.

Liquidity crisis and lack of good instruments (shares, bonds, options etc.) are the basic problems and top most challenges that we have right now. To make the market more attractive, the corporate tax bracket can be reduced for encouraging sponsors to list their companies in the exchanges. To create market depth, more profitable state-owned-enterprises (SOE) should be listed immediately. The supply of securities can be augmented if the SOEs are allowed to operate through the stock exchanges. Launching of SOE shares is likely to enlarge the size of capital market with in short period of time.

It is expected that the corporatization of SOEs will bring in accountability and transparency as well as confidence on the financial system of government.

Tax gap between listed and non-listed companies could be increased. Infrastructure projects should access capital market to raise financing through bonds and shares. Securitizations should be encouraged. We need to be proactive and take initiatives to promote new products in the market. In a more developed market, institutional investors such as merchant banks, commercial banks, insurance companies, are major traders of securities. We need enforceable and more effective laws and rules to attract foreign institutional investors.

Automation and introduction of Central Depository system helped capital market to grow considerably. The regulatory body, namely Securities and Exchange Commission, is continuously facilitating our capital market with its international standard surveillance and monitoring. The continuous endeavor of the SEC has resulted in capital market to be free from fraudulent and manipulative activities. Thus presence of the SEC has impacted significantly in the development of the market.

The Bangladesh capital market still has a long way to go. After crash of 2010 government has taken lot of measures to create positive impact on market. If more investor-friendly policy reforms were to be implemented, the capital market will certainly play a critical role in leading Bangladesh towards being the next Asian tiger with higher growth.

Chapter-Three

Theoretical Framework and Review of Literature

3.1 Introduction

Development of theory serves as the basis of research. But all theories are based on some assumptions and have some limitations. Such problems then stimulate further effort to develop new theories and new ways of empirically testing their implications. In this section, we have paid an endeavor to bring forward all theories that are works as the basis of the development efficient market hypothesis. Beside these existing literatures on weak form efficiency and modeling volatility of Dhaka stock exchange (DSE) of Bangladesh as well as all over the world and the evolutions of the test procedures for hypothesis have been reviewed in this chapter. Review of literatures is divided into two parts. First part highlights on reviews the literatures of the weak form of efficiency. Second part highlights on reviews the literatures on modeling return volatility.

3.2 Understanding about Market Efficiency

Capital market efficiency has been explained in various ways, but main theme is what information is available to market participants and how they handle that information. From this view point, an efficient market is one where stock prices respond instantly and accurately to relevant information. This type of market efficiency is termed as informational efficiency (Dimson and mussavian, 1998). Nevertheless, the markets are also economic institution and play role in allocating resources to most desirable and profitable sectors in cost effective ways. This type of market efficiency is termed as allocative efficiency. Capital market can also be defined from the view point of operational efficiency. The concept of operational efficiency refers to a market's ability to deliver liquidity, rapid execution of order and low trading costs (Sharpe et al., 1999). In this study, we are concerned only with the informational efficiency of capital market. Financial market efficiency represents the absence of predictability of price using information. If the market returns of financial assets are predictable, profit-seeking investors will exploit the opportunity until the predictability disappears. An efficient market can be described as the one which adjust securities prices rapidly to the arrival of new information. Therefore, the current prices of securities must reflect all possible information about the securities quickly and accurately. So, conception of market efficiency is used to explain the degree to which stock price reflect information instantly. Impact of information on security prices is also known as the basis of efficient market hypothesis (EMH). Alternatively, the EMH postulates that the market prices incorporate all information rationally and instantaneously. Stock market efficiency has three forms: the weak form, the semi-strong form and the strong form (Fama, 1970). The weak form version of EMH asserts that the prices of financial assets reflect all information contained in past prices. In this case, no one can get abnormal profit using chart analysis or any analysis based on past prices. Secondly, semi-strong version of EMH proclaims that the prices of securities reflect all information that are publicly available. Under semi-strong market one cannot make abnormal profit using publicly known information. Finally, strong form version states that prices of financial assets reflect all information, that is, not only the information contained in past prices and publicly available but also the inside information (Fama, 1970, 1991). If the weak-form of the EMH can be rejected, then the others form, that is, semi-strong form and strong form of the EMH can also be rejected.

3.3 Theoretical Background

Historically, it has been seen that the random walk model and EMH are very closely related. The EMH asserts that the financial markets are informationally efficient. Stock price follow a random manner which is the main assertion of weak form efficiency. Jules Regnault, a stock broker of France, in1863 first observed that stock prices follow a random nature. However, the idea of EMH derived at very early of 20th century in the theoretical contribution of Louis Bachelier at 1900 in his PhD thesis, " the Theory of Speculation". Although Bachelier projected the efficient market hypothesis and developed a model describing the pricing of options and distribution of price changes but his work was largely ignored over fifty years. However, some independent works corroborated Bachelier's works. Cowles (1933), in his empirical research, documented the inability of forty-five professional agencies to predict stock price changes. Another early statistical studies by Working (1934), Cowles and Jones (1937), Kendall (1953), Osborne (1959, 62), Coothner (1962), Granger and Morgenstern (1963), Fama (1965), among others, performed tests on the random walk hypothesis and found a supportive evidence of the random walk hypothesis that the successive price changes are independent (Ball, 1994).

Samuelson (1965) developed logic behind the efficient market hypothesis that unexpected price changes in a speculative market must behave as independent random manner if the market is competitive. Actually, that was the theoretical framework for the random walk developed by Samuelson. His argument was that unexpected price changes reflect new information, which cannot be deduced from previous information. Paul Samuelson had begun to circulate Bachelier's work among economists and the EMH emerged as a prominent theory in the mid-1960. In 1964 Bachelier's dissertation along with other empirical studies mentioned above were published in an anthology edited by Paul Cootner. In 1965 Eugene Fama published his dissertation arguing for the random walk hypothesis.

Fama (1970) published a review of both the theoretical and the empirical evidence for the efficient market hypothesis. Fama (1970) formalizes this hypothesis further and indicates that a market is called efficient if prices "fully reflect" all available information (Findlay and Williams 2000). Fama (1970) defines three necessary conditions for the presence of capital market efficiency. *Firstly*, he cited the absence of transactions costs. *Secondly*, he assumes all relevant information is available to all market participants without cost. *Thirdly*, on the implications of current information for the current price and distributions of future prices of each security, the current price of security should "fully reflect" all available information. These conditions ensure that investors possessing available information cannot earn above-competitive returns. A violation of any of the conditions does not necessarily indicate inefficiency. The market "may be efficient if sufficient numbers of investors have ready access to available information" (Fama 1970). The violations of these conditions, however, may suggest impeding efficient adjustment prices to information (Ball, 1994; Fama, 1970).

Evidence from existing theoretical and empirical works represents various phases of the improvement of the concept of EMH. There is two different approaches behind the development process of capital market efficiency into contemporary form. One is Fama's approach and another one is the information economics approach. Fama's approach is mentioned to as the "empirical" tradition of Chicago school, which developed earlier formal fundamentals of EMH. The "information" economics approach was followed in works of Rubinstein (1975), Beaver (1981), and Latham (1986), who introduced alternative definitions (Findlay and Williams 2000). Fama focused to describe how the market uses information or establishes prices, whereas "information economics" school attempted to formalize the EMH considering individual investors and their relation to prices. Beaver (1981) defines market to be efficient with respect to information signal if it generates security prices identical to those that would be generated in a market where each individual investor knows the signal, given preferences and endowments are identical in both markets. Latham (1986) states efficiency in relation to some information set that if exposed to all investors would not change prices and portfolios. Ball (1994) mentioned more formal definitions over Fama's model. The "identical world" where all investors assumed costlessly possess available information, however, in the real word it is impossible expected that all investors being costlessly and fully informed about all information. Therefore, any test of efficiency has to assume an equilibrium model, which was proposed by the "empirical school" (Ball 1994).

Leroy (1989) criticized Fama's definition that in an efficient market, prices "fully reflect" available information as void and redundant. He argues that it is unclear how the market correctly uses all relevant information in determining security prices, if investors have heterogeneous information. A paradox is observed in Fama's definition of full reflection of information in price. If all available information are fully reflected in price, there is no reason for an investor to search for information in his decision-making of buying and selling different stocks. Grossman and Stiglitz (1980) analyzed this inconsistency and offered the model where the prices partially reflect the information that arbitrageurs possess. Their theory was based on two types of investors, informed and uninformed. If the market is efficient, where information is associated with a cost, the informed individuals would not able to get any compensation from the uninformed individuals, since the information will be fully reflected in the stock prices. However, they also found certain noise in this model, which implied that stock prices could not reflect all information. If the market price were perfectly informative, there would be little incentives for investors to search and pay for additional information for their decision-making. (Grossman and Stiglitz 1980; Latham 1986). More recently, Malkiel (1992) extends Fama's definition by including two dimensions: in efficient markets, security prices would be unaffected by revealing that information to all participants. Second, it is impossible to make profit by trading on this set of information. Therefore, the market efficiency can be judged by measuring profits made by trading on the information. This view is a closely related definition of market efficiency provided by Jensen (1978) (Campbell et al. 1997; Timmermann and Granger 2004).

From above discussion, it can be said that though there are a lot of disagreements toward Fama's definition and redefinitions of the concept, but still his definition of efficient markets is the most frequently used standard and benchmark for determining market efficiency.

3.4 Literature on Weak-form of Efficiency

Weak-form efficiency of stock market shows that future prices of stock cannot be predicted from past prices data since the current prices are considered to reflect all information that is incorporated in historic data. In weak form efficient stock market securities prices should follow a random walk process, where the future price changes should be random and consequently unpredictable. The random walk hypothesis is compatible with the weak form of the efficient market hypothesis. As weak-form efficiency hypothesis asserts unpredictability of stock prices, random walk hypothesis indicates the randomness of price movements. Therefore, this section sheds the light on these studies of different financial markets that tested the weak-form efficiency of the capital market. Now a day, there exists huge number of literature on EMH. For better understanding, review works are categorized in to three different groups: (i) literature regarding developed markets (ii) literature regarding emerging markets (iii) literature on Bangladesh market.

3.4.1 Literature on Developed Market

In developed countries, huge numbers of empirical studies have been performed to test the hypothesis of weak form efficiency on stock market. Testing weak form efficiency was started on the developed market at very earlier generally agree with the support of weak-form efficiency of the market considering a low degree of serial correlation and transaction cost (Working, 1934; Kendall, 1943, 1953; Cootner, 1962; Osborne, 1962; Fama, 1965). All of the studies support the proposition that price changes are random and past changes have no effect in forecasting future price changes particularly after consideration of transaction costs. Nevertheless, there are some studies which found the predictability of share price changes (for example, Fama and French, 1988; Poterba and Summers, 1986) in developed markets but they did not reach to a conclusion about profitable trading rules. Enough literatures on weak form of efficiency are available based on the parametric and non-parametric approaches on develop markets. Some of them are highlighted as under:

Lo and MacKinlay (1988) examine 1216weekly observations derived from the Center for Research in Security Prices (CRSP) daily returns file for the period September 6, 1962 to December 26, 1985, using a simple specification test based on variance estimator. Their results reject the random walk hypothesis for the entire sample period (1216-week) and for all sub-periods (608-week) for returns indexes and size-sorted portfolios. In contrast to the negative serial correlation that Fama and French (1988) found for longer-horizon period, Lo and MacKinlay (1988) find significant positive serial correlation for weekly and monthly holding-period returns. Fama and French (1988) show that long holding-period returns are significantly negatively serially correlated, indicating that 25 and 40 percent of the variation of longer-horizon return is predictable from past returns. On the other hand, similar to Poterba and Summers (1986) and Fama and French(1988), Lo and MacKinlay (1988) find the evidence against the EMH in stock prices of small firms but not for large firms. Lo and MacKinlay (1988) also argue that the rejection of random walk hypothesis cannot be explained completely by infrequent trading or time varying volatilities, although the rejections are due largely to the behavior of small stocks. Contrary to results of Fama and French (1988), Lo and MacKinlay (1988) also assert that the rejection of random walk for weekly returns does not support a mean reverting model of asset prices.

Lee (1992) uses variance ratio test to study whether weekly stock returns of the United States and 10developed countries: Switzerland, Belgium, Canada, France, Italy, Australia, Japan, Netherlands, United Kingdom, and Germany follow a random walk process for the period 1967-1988. Findings of this study show that the random walk hypothesis (RWH) is not rejected concluding weak-form efficiency for these markets.

Choudhry (1994) investigates the random nature of individual stock indices in seven OECD countries: Japan, the United States, the United Kingdom, Canada, France, Germany, and Italy. The ADF and KPSS unit root tests, and Johansen's cointegration tests is used to examine monthly stock indices. Data period covers from 1953 to 1989 and log difference is applied to convert the index prices into return. The study reveals that stock markets are efficient in seven OECD countries during the sample period. The ADF and KPSS tests reveal that all indices in seven countries seem to contain a unit root and they are also non-stationary in levels. Johansen's cointegration test reveals no evidence for a stationary long-run relationship between the seven stock series. Therefore, absence of long-run multivariate relationships also provides evidence in favor of efficient markets.

A study is conducted by Huang (1995) to test weak form efficiency of nine Asian stock markets: Japan, Hong Kong, Korea, Philippines, Indonesia, Taiwan, Singapore, Thailand and Malaysia by using the variance ratio test under both assumptions homoscedastic and heteroskedastic. In his study, weekly stock returns of nine stock market indexes from the period 1988 to 1992 are taken in to account. The test results reveal that the random walk hypothesis for the six markets is rejected (not efficient in weak form), except the market in Indonesia, Japan and Taiwan,. It is seen that the value of variance ratio exceeds one in the markets of Hong Kong, Thailand, Korea, Malaysia, and Philippines, representing the existence of positive serial correlation.

Chan et al. (1997) test the weak-form and the cross-country market efficiency hypothesis of eighteen international stock markets. To conduct the study, Phillips-Peron (PP) unit root and Johansen's cointegration tests are used. The markets included are Australia, Belgium, Canada, Denmark, Finland, France, Germany, India, Italy, Japan, Netherlands, Norway, Pakistan, Spain, Sweden, Switzerland, the United Kingdom, and the United States. The data period covers from January 1962 to December 1992, with 384 monthly observations for each of the stock series. In their studies, these markets were analyzed both individually and collectively in regions to test for the weak form efficiency. They conclude that all stock markets are individually weak form efficient and only a small number of stock markets show evidence of cointegration with others.

Al-Loughani and Chappel (1997) study on UK stock market to test the validity of the weak-form of efficient market hypothesis. To conduct the work, Lagrange multiplier (LM) serial correlation, Dickey-Fuller (DF) unit root and BDS non-linear tests are used. They consider daily observations of FTSE 30-share index from the period June 30, 1983 to November 16, 1989.The Dickey Fuller tests show that series are non-stationary in levels and are stationary in first differences, which are consistent with random walk hypothesis. But the BDS and serial correlation tests reject the random walk hypothesis.

Consequently, as per their findings the FTSE 30-share index series does not follow a random walk during the sample period.

Groenewold (1997) conducts a study on the stock markets of Australia and New Zealand to examine both weak and semi-strong forms of the EMH. He considers daily observations of the Statex Actuaries' Price Index for Australia and the NZSE-40 Index for New Zealand. Sample period covers the full 1975 to1992. The Dickey –Fuller (DF) and Phillips-Peron (PP) unit root tests, variance ratio and autocorrelation tests are used to examine weak form efficiency. On the other hand, both cointegration and Granger causality tests are applied for identifying semi-strong efficiency. The non-stationary implications of the weak form efficiency are supported by the findings of both unit root test. On the contrary, the autocorrelations indicate different result, ie., one can forecast future return, although the stationarity results are consistent with the weak form of the EMH . Furthermore, the random walk hypotheses in both markets are not rejected by the results of variance ratio test. The indexes of two countries are found not to be cointegrated, which is consistent with market efficiency, but the Granger causality shows an evidence against the EMH. He concludes, considering all results, that past returns in both countries might help to explain the current return in each, but the proportion of variation explained is still small.

Worthington and Higgs (2004) examine the random walks hypothesis for sixteen developed markets: Germany, Spain, Austria, Denmark, Finland, Switzerland, France, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Belgium, Sweden, and the United Kingdom, and four emerging stock markets: Czech Republic, Hungary, Poland and Russian. They consider daily returns of market value weighted equity indices for this study. Sample period covers for sixteen developed markets from December 31, 1987 to May 28, 2003, and for four emerging stock markets from December 30, 1994 to

May 28, 2003. For analyzing data, they use serial correlation test, runs test, three types of unit root test Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and KPSS and multiple variance ratio tests. Results of their study express that the random walk hypothesis is not rejected in major European developed markets. They find that Germany and Netherlands are efficient in weak form under both serial correlation and runs tests, while Ireland, Portugal and the United Kingdom are efficient under one test or the other. Therefore, rests of the markets do not follow a random walk.

Lima and Tabak (2004) test the random walk hypothesis for Hong Kong and Singapore equity markets using variance ratio of Lo and MacKinlay and multiple variance ratio methods. They consider of the Hang Seng Index for Hong Kong and the Straits Time Index for Singapore. The daily returns data cover the period from June 1992 to December2000 for both markets. The random walk hypothesis for Hong Kong market is not rejected by variance ratio test but for the Singapore STI index is rejected. Another study conducted by Cheung and Coutts (2001) using variance ratio method also confirms that Hang Seng follows a random walk hypothesis.

Table 3.1: Summary of Selective Empirical Studies on Weak-Form Efficiency in Developed Markets

Researcher/s	Market/s	Sample period	Tools	Result
Lo&MacKinlay (1988)	US	1962 to 1985, Weekly return data	Variance ratio test	Not efficient in weak form
Lee (1992)	US and other ten industrialized countries	1967 to 1988, Weekly stock return data	Variance ratio test	Weak form efficient

(*Continued on next page*)

Researcher/s	Market/s	Sample period	Tools	Result
Choudhury (1994)	US, UK, Canada, Japan, France, Italy, Germany	1953 to 1989, monthly stock indices	ADF, KPSS and Johnsen's cointegratin tests	Weak form efficient and no long run relationship as per cointegration test
Chan et al., (1997)	18 international Stock markets	1962 to 1992 monthly observations	PP tests Johnsen's cointegratin tests	All markets are individually weak form efficient
Huang (1995)	Japan, Korea and other seven markets	1988 to 1992 weekly stock returns of market indices	Variance ratio test	Japan, Taiwan and Indonesia are weak form efficient others are not.
Al-Loughani and Chappel (1997)	UK	1983 to 1989 daily observations of FTSE-30 index	Serial correlation, DF unit root and BDS tests	Market does not follow random walk and not weak form efficient
Groenewold (1997)	Australia and New Zealand	1975 to 1992 Daily observation of Statex Actuaries price index and NZSE-40 index	DF test, PP test, Variance ratio, Auto correlation	Both markets are efficient in weak form
Worthington and Higgs (2004)	Sixteen developed markets	1987 to 2003 daily returns of the value weighted index	ADF, PP, KPSS,Serial correlation, run and multiple variance ratio tests	All markets are efficient in weak form
Lima and Tobak (2004)	Hong Kong and Singapore	1992 to 2000 daily return data for Hang seng and STI index	Variance ratio and multiple variance ratio	Hong Kokg market is efficient in weak form but Singapore STI is not.

3.4.2 Literature on Emerging Market

Now a day, both academics and investors have shown their keen interest about various aspects of emerging stock markets. One of the basic characteristics of emerging markets is existence of both higher risk and higher return than the developed equity market. In early nineties many emerging markets experienced a dramatic price swings and growths of emerging markets are significant. Developing countries have liberalized regulation and tried to entice investors from domestic and foreign sources. Due to the above, enormous numbers of researchers and investors have focused on predictability of return behavior of emerging markets as well as major of the studies test the acceptability of random walk hypothesis in the emerging stock markets. A few numbers of works are reviewed as under:

Laurence (1986) tests weak form efficiency of the Kuala Lumpur Stock Exchange (KLSE) and the Stock Exchange of Singapore (SES). The runs and autocorrelation test both are applied to conduct the study. The sample period covers from 1973 to 1978 for both KLSE and the SES and Price observations of the individual stock are taken under consideration in this regard. The findings under both tests recommend that both markets (KLSE and SES) are not efficient in weak form.

In the same year, Barnes (1986) conducts another study on Kuala Lumpur Stock Exchange (KLSE) finds KLSE to be weak form efficient. In this case, he also applies runs and autocorrelation test on 30 individual company's prices and six sector indexes for the period of 1974 to 1980. Findings of Barnes are contradictory with the findings of Laurence.

Using variance ratio and run tests Urrutia (1995) examines weak form efficiency of the four Latin American emerging markets. He considers index prices in local currency on monthly basis from the period December 1975 to March 1991 for Argentina, Brazil, Chile, and Mexico. Results under two techniques are contradictory. The random walk hypothesis is rejected by the findings of variance ratio test for all the four markets, whereas runs test does not reject the hypothesis. He concludes that the four Latin American emerging stock markets are weak form efficient as per findings of run test.

Chang et al. (1996) conduct a study on Taiwan stock exchange to examine the weak form efficiency. They consider monthly data for the period of 1967 to 1993. The Ljung-Box Q test, the runs test and the unit root tests are used for analyzing data. Their findings reveal that the Taiwan stock market is efficient in weak-form.

Weak form efficiency and day of the week effect are studied by Poshakwale (1996) on the Bombay Stock Exchange. He uses daily BSE national index data for the period January 1987 to October 1994. He finds that the frequency distribution of the prices in BSE does not follow a normal distribution. Besides, findings of runs and serial correlation tests also provide evidence on non-random behavior of stock prices in BSE. He also finds that the returns realized on Friday are considerably higher compared to rest of the days of the week. Consequently, he concludes that the Indian stock market is not weak-form efficient.

Ojah and Karemera (1999) investigate weak form efficiency for the four Latin American markets Argentina, Brazil, Chile, and Mexico as like Urrutia (1995). Single variance ratio initiated by Lo and MacKinlay (1988), multiple variance ratio initiated by Chow and Denning (1993), and runs tests are used to analyze the monthly national stock price indexes in U.S. dollar terms of four countries for the period December 1987 to May 1997. The single variance ratio test reveals that Brazil, Chile and Mexico do not follow a random walk whereas Argentina follows such. But the findings of multiple variance ratios specify that all the four markets follow a random walk. As per the runs tests, the random walk hypothesis for Chile is rejected, but not for Argentina, Brazil and Mexico. They conclude that four Latin American emerging markets are weak-form efficient and this finding is very much similar to Urrutia (1995).

Using single variance ratio, multiple variance ratio and run tests Karemera et al. (1999) study the random walk hypothesis for fifteen emerging stock markets. They consider monthly national stock price indexes expressed in both local currency and the U.S. dollars for the period 1986 to 1997. It is seen that local currency-based data and U.S. dollars based data produce contradictory results. As per the multiple variance ratios 10 out of the 15 emerging stock markets are consistent with the random walk hypothesis while considering U.S. dollar based data whereas 5 out of the 15 are consistent the random walk hypothesis under the single variance ratio. On the contrary, results of 10 out of the 15 markets follow a random walk under the multiple variance ratios, whereas 6 out of the 15 follow a random walk under the single variance ratio when local currency-based data are taken into account. But, findings on Argentina, Brazil, Hong Kong, Indonesia, Mexico, Philippines, Singapore, Taiwan, and Turkey equity returns are not consistent under two different currency-based data. Findings under runs test reveal that the hypothesis of independence cannot be rejected at 5% level of significance for 9 of the 15 markets. They conclude that, considering local currency-based data, 12 of the 15 emerging markets are weak form efficient except Argentina, Chile and Singapore.

Chang and Ting (2000) again examine the validity of weak form efficiency of the Taiwan stock market using the variance ratio test. Here, they use the weekly, monthly, quarterly and yearly returns of the value-weighted stock price index for the period of

1971 to 1996. They conclude that the Taiwan stock market is efficient in weak form and conform to the findings of Chang et al. (1996).

Abeysekera (2001) examines weak form efficiency of the Colombo Stock Exchange (CSE) in Sri Lanka using the serial correlation, runs and unit root tests. The daily, weekly and monthly returns of the Sensitive Share Index (based on market prices of 24 blue-chip companies listed on the CSE) and a 40-security value weighted index are considered for the period January 1991 to November 1996. From the findings it can be conclude that the CSE is efficient in weak form because of the three tests consistently reject the random walk hypothesis. He also studies a day-of-the-week and a month-of-the-year effect on the CSE, but neither effect found to be on the stock market in Sri Lanka.

The nature of the causal relationship between stock prices and macroeconomic variables is examined by Bhattacharya and Mukherjee (2002) in India. They use the techniques of unit root tests, cointegration and the long–run granger non–causality test proposed by Toda and Yamamoto (1995) for analyzing data. The study uses Bombay Stock Exchange Index and the five macroeconomic variables, viz., money supply, index of industrial production, national income, interest rate and rate of inflation using monthly data for the period 1993 to 2001. From the empirical results, it is seen that there is no causal relationship between stock prices and national income; stock prices and money supply and stock prices and interest rate but the index of industrial production influence the stock price. Another finding shows that there exists a two way causal relation between stock price and inflation rate. Therefore, they conclude that Indian stock market is approaching towards informational efficiency at least with respect to three macroeconomic variables, viz. money supply, national income and interest rate.

Appiah-Kusi and Menyah (2003) examine the weak-form efficiency of eleven African stock markets by considering thin trading in the calculation of returns, and permitting for nonlinearity and time-varying volatility in the return generation process. The weekly data of index prices in local currency is taken into consideration for all markets and the sample period covers from 1989 to 1995. They use Miller et al. (1994) model, a logistic map and EGARCH-M model to test efficiency of all the eleven markets. Findings of the study show that the markets in Egypt, Kenya, Mauritius, Morocco, and Zimbabwe are consistent with the concept of weak form efficiency but rest of the six markets are found not to be consistent with weak form efficiency. In addition, they find that the return generation process is nonlinear in all the eleven markets, and in five of the market, investors demand a time-varying risk premium for bearing additional the risk.

Gilmore and McManus (2003) study the weak form efficiency of the stock markets in Central European countries including Czech Republic, Hungary and Poland. To conduct the work, they use various tests including univariate techniques like unit root, variance ratio, and autocorrelation tests; multivariate techniques like Johansen and Granger causality tests; and model-comparison approach like Naive, ARIMA and GARCH models. They use weekly Investable and Comprehensive indexes from the International Financial Corporation (IFC) for the period July 1995 through September 2000. As per results the ADF and PP unit root tests show that all series are integrated of order I(1). The Q-statistics show that autocorrelations in returns are reducing over time for all three markets, indicating efficiency improvement in these markets. The variance ratios under the assumption of heteroscedasticity fail to reject random walk hypothesis for either index for any of the three markets. There is no cointegration relationship between these markets as per Johansen cointegration test, while Granger-causality is found between the markets. So, multivariate techniques produce contradictory results. The results of model comparison approach provides strong indication against the random walk hypothesis for these markets, that are completely different form the results of univariate method. At last, their conclusion is that these three markets are not yet weak-form efficient.

Using variance ratio tests Smith and Ryoo (2003) examine the random walk behavior in five European emerging markets. For this study, they use weekly data of index prices for the period April 1991 to August 1998. As per findings of the study the random walk hypothesis is rejected for four markets (Greece, Hungary, Poland and Portugal) because of existence of strong autocorrelation errors in return series. In Turkey, they show that the Istanbul stock market is follow a random walk and efficient in weak form. They claim that this might be deriving from the fact that the Istanbul stock market being larger and liquid compared with the other four markets. Conversely, variance ratio test suggests that relatively large size on its own is neither necessary nor sufficient for a market to follow a random walk. Small markets can follow a random walk.

The behavior of stock prices in the United Arab Emirates (UAE) stock market is examined by Moustafa (2004). The data comprises of the daily prices of 43 stocks included in the UAE market index for the period October 2, 2001 to September 1, 2003. He uses serial correlation and run tests as statistical tools to analyze the data. It is found that the returns of the 43 stocks do not follow normal distribution. Consequently nonparametric run test is only applied in this study to examine the randomness of stock prices. However, the findings of runs tests show that the returns of 40 stocks out of the 43 are random at 5% level of significance. So, as his findings the UAE stock market is efficient in weak-form.

Akinkugbe (2005) examine weak and semi-strong form efficiency of Botswana stock markets. His data comprises 738 weekly observations for the period June 1989 to

December 2003. He uses Autocorrelation test and unit root tests (ADF and Phillip-Perron) to study the weak form efficiency of Botswana stock exchange. As per findings of this study, autocorrelation test indicates no evidence of serial correlation and the both unit root tests indicate a stationary process for stock returns. Therefore, he concludes that the market is efficient in weak-form.

Jefferis and Smith (2005) conduct a study on seven African Stock markets, South Africa, Egypt, Morocco, Nigeria, Zimbabwe, Mauritius, and Kenya. The study period covers early January 1990 to 30 June 2001. The empirical results show that South Africa stock market is weak-form efficient during the entire period while Egypt, Morocco, and Nigeria became weak-form efficient towards the end of the period. Similar study conducted by Smith, Jefferis and Ryoo (2002) on eight African stock markets using multiple variance ratio tests. The results of the study reveal that except South Africa the random walk hypothesis is rejected for others seven markets; Botswana, Egypt, Kenya, Mauritius, Morocco, Nigeria and Zimbabwe. So, they conclude that the South Africa stock market is efficient in weak form.

Using unit root, autocorrelation and variance ratio tests Abrosimova et al. (2005) tested for weak-form efficiency in the Russian stock market. For this analysis daily, weekly, monthly Russian Trading System (RTS) index data are considered for the period September 1995 to May 2001. Result of the ADF and the PP unit root tests show that the RTS index series are found to be stationary difference. Results of both autocorrelation and variance ratio tests reject the null hypothesis of the random walk for the daily and weekly, but not for the monthly data. For monthly data, the variance ratio under the assumption of heteroscedasticity increments the null hypothesis of random walk cannot be rejected. Therefore, they study linear and non-linear dependence in the daily and weekly data using ARIMA and GARCH models. They find that none of the analyzed models outperformed others. They end up with evidence that support weak-form efficiency in the Russian stock market.

Hassan et al. (2006) conduct a test of efficiency in seven European emerging stock markets. They use International Finance Corporation's weekly stock index data for the period December 1988 through August 2002. Several methods used in their studies including Ljung-Box Q-statistic, runs, and variance ratio tests. According to their results Greece, Slovakia, and Turkey are not weak form efficient whereas markets in Czech Republic, Hungary, Poland and Russia are found to be efficient in weak form.

Using serial correlation, run and multiple variance ratio tests Worthington and Higgs (2006) examine the weak-form market efficiency for twenty-seven emerging stock markets. The serial correlation and runs tests conclude that most emerging markets are weak-form inefficient. However, when multiple variance ratio tests are utilized, results were in general consistent with the serial correlation and runs tests. Furthermore, Worthington and Higgs (2004), which is reviewed earlier, tested efficiency of twenty European countries and found that only five countries meet the most stringent criteria for random walk, while France, Finland, the Netherland, Norway, and Spain meet only some requirements for a random walk.

Many researchers conduct their studies on East Asian and South East Asian countries stock markets to examine the weak-form efficiency of the efficient market hypothesis. Hoque, Kim and Pyun (2006) investigate the authenticity of random walk for eight emerging equity markets in Asia including, Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand. Findings of their study reveal that stock prices of the eight Asian countries do not follow a random walk except Taiwan and Korea.

Kim and Shamsuddin (2006) examine the validity of random walk for a group of Asian stock markets again. The results of the study show that the Japanese and Taiwanese markets only follow random walk, and efficient in the weak form. But there is no sign of efficiency in case of the markets of Indonesia, Malaysia and Philippines. Nevertheless, after the Asian crisis, Singaporean and Thai markets have become efficient.

Cavusoglu (2007) examined the weak form of the efficient market hypothesis for the Athens Stock Exchange through approaches accounting for conditional heteroscedasticity. The study covered the period 1999 to 2007, using the daily FTSE/ASE-20 stock price index. The study also examined the influence of changes in economic conditions on stock returns and on conditional volatility. The findings from the study did not provide evidence on the weak form of the efficient market hypothesis.

Using unit root, auto-correlation, runs and variance ratio tests, Aga and Kocaman (2008) examined the efficiency market hypothesis in Istanbul stock exchange market. They consider return index-20 for the period spanning 1986 to 2005and also used a times series model to test the weak-form of the efficient market hypothesis. The empirical results show that there is evidence of a weak-form of efficient market hypothesis in Istanbul stock exchange market.

Enowbi et al. (2009) test the random walk hypothesis to examine market efficiency for four African markets, Egypt, Morocco, South Africa, and Tunisia. For conducting study, they use various parametric and non-parametric tests. The finding of the study show that only South Africa stock market exhibits a random walk but other markets are not.

Vitali and Mollah (2010) investigate the weak-form efficiency of major African markets. He considers daily price indices of Egypt, Kenya, Mauritius, Morocco, Nigeria, South Africa and Tunisia over the period 1999-2009. As per findings of the study, the RWH is rejected for all stock markets indices over the whole sample period with the exception of South Africa over the second sub-period (2007-2009). Therefore, they conclude that only South African market could be regarded as a weak-form efficient and rejection of the RWH in the African stock markets indicate that stock prices do not fully reflect all historical information.

Applying ADF, DF-GLS, PP and KPSS tests Mahmood et al (2011) examine weak form efficiency of Chinese stock market. They consider returns of both Shenzhen and Shanghai stock exchanges individually. The findings of the study shows that Chinese stock market is weak form efficient and information contained in past price series may not be very useful to earn excess returns. On the contrary, Liu (2010) investigates weak form efficiency of Chinese stock market and produces different result than Mahmood et al. (2011). He employs unit root test, autocorrelation function, BDSL, Engle-LM and AR (p)-EGARCH and AR (p)-TARCH to analyze data of Chinese stock market over the period 2001 to 2008. He concludes that the Chinese stock markets are not weak-form efficient.

Gupta and Yang (2011) investigate the weak form efficiency or random walk hypothesis of Indian stock market using various types of unit root tests (ADF, PP and KPSS). In this study, they compute daily, weekly, monthly and quarterly returns using index values for the Mumbai Stock Exchange (BSE) and National Stock Exchange (NSE) of India for the time period of both BSE and NSE from July 01, 1997 to March 04, 2011.Mixed results have been seen from this study. For daily and weekly data, all three test methods reject weak form efficiency during all sample periods. In case of quarterly data, all three methods ADF, PP and KPSS tests support the weak form efficiency for sub-period 2007 to 2011, but slight conflict for earlier sub-period1997 to 2007 as only PP test shows weak form inefficiency. When monthly data is used, all three test methods are consistent on the weak form efficiency for the sub-period 2007 to 2011 and inefficient for earlier sub-period 1997-2007.

Al-Jafari (2011a) examines the weak-form efficiency of Bahrain securities market by testing the random walk hypothesis (RWH). In this study, daily observations of Bahrain all share indexes is used for the period of February 01, 2003 to November 30, 2010. Using parametric (serial correlation and the ADF) and nonparametric (run and pp) tests, he studies the randomness and the behavior of Bahrain stock market. The findings of empirical analysis suggest that Bahrain securities market is not efficient at the weak- form. As a result, the prudent investor can earn abnormal returns by using historical information which lies in the sequences of stock prices and trading volumes. At the same year, Al-Jafari (2011b) conducts another study on Kuwait stock market using the same types of parametric and nonparametric tests. The study uses daily observation of Kuwait stock exchange (KSE) index from 17 June 2001 to 8 December 2010. The results suggest the KSE is informationally inefficient at the weak-form level indicating that prudent investors will realize abnormal returns by using historical data of stock prices and trading volume.

Nwosa and Oseni (2011) examine the weak-form efficiency of the Nigerian stock market, using serial correlation and regression method. In this study, he uses time series data, covering a time span of 1986 to 2010.The Augmented Dickey Fuller (ADF) and Philip Perron (PP) tests are used to examine the stationarity in data and it is observed that the variables are stationary at first differencing. The findings of the serial correlation and regression analysis both shown that the Nigeria stock market is not weak form efficient, that is, stock price does not follow random walk. They suggest that to enhance informational efficiency of the Nigerian stock exchange, there is the need to ensure strong and adequate supervision by the regulatory authorities and adopt appropriate policies.

Chiwira and Muyabiri (2012) examine weak form efficiency of Botswana stock exchange (BSE), specifically applying various parametric and nonparametric test to assess the random walk model. They use the Augmented Dickey Fuller tests, autocorrelation test, Kolmogorov-Smirnov Test, Runs Test and the Phillips Perron unit root test. All these tests are applied on weekly and monthly All Company Index (ACI) data for the period 2004 to 2008. Findings of all the tests show that the BSE is inefficient at the weak-form because of rejection of the random walk hypothesis. Therefore, they conclude that well-informed and skilled investors have an opportunity of outperforming the market and hence make higher than expected return through using historical data.

Table 3.2: Summary of Selective Empirical Studies on Weak-Form Efficiency in Emerging Markets

Researcher(s)	Market(s)	Sample	Tools	Result
Laurence (1986)	Kuala Lumpur and Singapore Stock Exchange	1973 to 1978 Monthly individual stock price	Run and Autocorrelation tests	Not efficient in weak form
Barnes (1986)	Kuala Lumpur stock exchange	1974 to 1980 six sectoral indices and 30 individual companies' prices	Run and autocorrelation tests	Weak form efficient

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Researcher(s)	Market(s)	Sample	Tools	Result
Urrutia (1995)	Argentina, Brazil, Chile and Mexico	1975 to 1991 monthly index prices in local currency	Variance ratio test and run test	Variance ratio test reject RWH whereas run test do not reject
Chang et al. (1996)	Taiwan stock exchange	1967 to 1993 monthly index value	Ljung-Box Q test, run test, unit root tests	Weak form efficient
Poshakwale (1996)	Bombay stock exchange	1987 to 1994 daily BSE national index value	Run test and serial correlation test	Not efficient in weak form
Ojha and Karemera (1999)	Argentina, Brazil, Chile and Mexico	1987 to 1997 monthly national stock price index at US$ term	Single variance ratio, multiple variance ratio and run tests	All markets are weak form efficient
Karemera et al. (1999)	Fifteen emerging stock market	1986 to 1997 monthly national stock price index in both local currency and US$ term	Single variance ratio, multiple variance ratio and run tests	They have found mixed (+ve and –ve) results under various tools
Chang and Ting (2000)	Taiwan stock exchange	1971 to 1996 weekly, monthly, quarterly, yearly return of value weighted stock price index	Variance ratio test	Weak form efficient
Abey sekera (2001)	Colombo stock exchange	1991 to 1996 daily, weekly and monthly returns of the sensitive share index and value weighted index	Serial correlation, run test and unit root test	Not efficient in weak form

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Researcher(s)	Market(s)	Sample	Tools	Result
Smith et al. (2002)	Eight African markets	1990 to 1998 stock price index	Multiple variance ratio	Except South Africa all other markets are not efficient in weak form
Appiah-Kusi and Menyah (2003)	Eleven African markets	1989 to 1995 weekly index prices at local currency	Logistic map and EGARCH-M model	Only 5 markets are efficient at weak form and others are not
Gilmore and McManus (2003)	Czech Republic, Hungary and poland	1995 to 2000 weekly Investable and Comprehensive indexes from the International Financial Corporation (IFC)	Unit root, variance ratio, autocorrelation, Johnsen and Granger causality tests, ARIMA and GARCH	Markets are not efficient at weak form
Smith and Ryoo (2003)	Five European emerging markets	1991 to 1998 Weekly index value	Variance ratio test	Except Turkey other markets are not efficient at weak form
Moustafa (2004)	UAE stock market	2001 to 2003 daily price of 43 stocks	Serial correlation and run tests	Returns of 40 out of 43 stocks are follow random walk
Akinkugbe (2005)	Botswana stock market	1989 to 2003 weekly return data	Autocorrelation, ADF, PP tests	Weak form efficient
Abrosimova et al. (2005)	Russian stock market	1995 to 2001 daily, weekly and monthly RTS index value	Unit root, auto correlation, variance ratio tests and ARIMA and GARCH model	Findings support weak form efficiency

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Researcher(s)	Market(s)	Sample	Tools	Result
Jefferis and Smith (2005)	Seven African markets	1990 to 2001 weekly stock price indices at local currency	GARCH and test of evolving efficiency (TEE)	Only South African market is efficient for entire period
Hassan et al. (2006)	Seven European emerging markets	1988 to 2002 weekly stock index value	LB Q-statistic, run test and variance ratio test	They've found mixed results (4 out of 7 markets are efficient in weak form)
Worthington and Higgs (2006)	Five emerging markets and five developed markets	End of all series is May28, 2003. Value weighted daily equity indices are used.	Serial correlation, run and multiple variance ratio tests	They've found mixed results and most of the markets are weak form inefficient
Hoque et al. (2007)	Eight emerging markets in Asia	Stock price index	Multiple variance ratio test	Except taiwan and Korea, other markets are not efficient
Gupta and Basu (2007) .	India	1991-2006 Daily index value	Phillips-Perron tests, augmented Dickey-Fuller (ADF) and KPSS	The results of these tests found that this market is not weak form efficient.
Aga and Kocaman (2008)	Istambul stock market	1986 to 2005 return index-20	Time series model	Weak form efficient
Asiri (2008)	Bahrain stock market	1990 to 2000 Time series data for 40 listed companies	ARIMA, Autocorrelation, Unit root test, Exponential smoothing model	The results suggest that current prices in the BSE reflect the true picture and follow random walk.

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Researcher(s)	Market(s)	Sample	Tools	Result
Kim and Shamsuddin (2006)	A group of Asian countries	Stock price indices	Multiple variance ratio	Mixed result have shown, only Japanies and Taiwan markets follow random walk
Mishra and Pradhan (2009)	Indian stock market	2001-2009 Stock index value	Unit Root Test, Phillips-Perron tests augmented Dickey-Fuller(ADF)	The study provides the evidence of weak form inefficiency of Indian capital market.
Enowbi et al. (2009)	Four African Markets	2000 to 2009 daily index value in local currency	ADFtest, PPtest, Autocorrelation, KPSS, Variance ratio, EGARCH	South African market only follow the random walk
Vitali and Mollah (2010)	Major African markets	1999 to 2009 daily stock price indices	Unit root, auto correlation, run and variance ratio tests	All markets are not efficient except South Africa
Liu (2010)	Chinese stock market	2001 to 2008	Unit root, aoto correlation, BDSL, Engle-LM, AR(p)-GARCH AR(p)-TARCH	Not weak form efficient
Hamid et al. (2010)	14 Asia-Pacific countries	2004-2009 monthly closing value of stock indices	Auto-correlation, Runs Test, Unit Root Test and Variance Ratio.	no one market is completely follows random walk hence these markets are inefficient

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Researcher(s)	Market(s)	Sample	Tools	Result
Al-Jafari (2011a)	Bahrain stock market	2003 to 2010 daily observation of all share index	Serial correlation, run, ADF, and PP tests	Not efficient at weak form
Al-Jafari (2011b)	Kuwait stock market	2001 to 2010 daily observation of KSE index value	Serial correlation, run, ADF, and PP tests	Not efficient at weak form
Nwosa and Oseni (2011)	Nigerian stock market	1986 to 2010 time series stock price data	Serial correlation, regression, ADF and PP tests	Not efficient at weak form
Mahmood et al. (2011)	Chinese stock market	Returns of Shen Zhen and Shanghai stock exchange	ADF, DF-GLS, PP, KPSS tests	Weak form efficient
Gupta and Yang (2011)	Indian stock market	1997 to 2011 daily, weekly, monthly and quarterly returns of index value	ADF, PP and KPSS tests	Mixed results have been seen under various tools
Chiwira and Muyambiri (2012)	Botswana stock exchange (BSE)	2004 to 2008 weekly and monthly all company index data	ADF, auto correlation, K-S, run and PP tests	Not efficient in weak form
Patel et al. (2012)	India, Hong Kong, Japan and China	2000 to2011 daily closing prices of selected indices	K-S test, run test, unit root test, autocorrelation, Variance ratio test	Study shows evidence of weak form inefficiency

3.4.3 Literature on Bangladesh Stock Market Efficiency

Now a day, market efficiency is very interesting phenomenon in finance literature because it influences investors' investment strategies. In an efficient market investors can not earn abnormal return whereas earning excess return is quite possible through developing trading strategies in case of inefficient market. Thus, stock market efficiency is well studied matter in all over the world. Likewise, a number of studies were conducted on Dhaka Stock Exchange in recent years and most of them are connected with market efficiency. A brief review of findings of some of earlier research works is presented as under:

Alam, Hasan and Kadapakkam (1999) investigate the weak form efficiency of five Asian countries: Bangladesh, Hong Kong, Malaysia, Sri Lanka and Taiwan. Variance ratio test has been applied on monthly stock price index series for the period 1986 to 1995. Findings of their study reveal that the markets in the Bangladesh, Hong Kong, Malaysia and Taiwan follow the random walk but Sri Lanka does not. They conclude that the stock market of Bangladesh is efficient in weak form.

Using the runs and autocorrelation tests Mobarek and Keasey (2000) examine the validity of weak-form efficiency for the Dhaka stock exchange. Sample size of this study contains 2638 daily observations of the daily price indices from the period 1988 to1997. The daily share price indices comprise of all the listed companies stock. As per findings of the runs and the autocorrelation tests, he concludes that returns of Dhaka stock exchange do not follow random walks and not efficient in weak form.

Ahmed (2002) has discovered that the movement of stock prices cannot be explained as observing the random walk theory rather they follow some dependencies. LJung-Box statistic is used for analyzing data. The sample period covers from January 1990 to April 2001 and entire sample period divided into two sub-periods. The first sub-period is characterized with positive autocorrelation in contrast to the second sub-period and full period where dominance of negative autocorrelation is observed. The results also suggest that it may take close to one month for new information to be completely incorporated into stock prices on DSE.

Islam and Khaled (2005) investigate weak form efficiency of the Dhaka stock exchange and observe conflicting evidence from the use of monthly versus daily data. In this study, the daily, weekly and monthly market prices and returns of DSE have been used for the period 1990 to 2001. Unit root and variance ratio tests have been used to test for the random walk hypothesis in their studies. They also study the structural changes by applying the variance ratio test separately for the pre-boom and post-crash period and with and without heteroscedasticity adjustment. According to them, the hypothesis of market efficiency could not be rejected in the case of monthly data. For weekly data and daily data, however, market efficiency is rejected for the pre-boom period, not for the post-crash. In addition, they argue that by using heteroscedasticity of variance ratio test they find evidence in favor of short-term predictability of share prices in the Dhaka stock market before the 1996 boom, but not during the crash.

Cooray and Wickremasinghe (2005) conduct a study to test weak form efficiency in the stock markets of India, Sri Lanka, Pakistan and Bangladesh. They use the Augmented Dicky Fuller (ADF), the Phillip-Perron (PP), the Dicky-Fuller Generalized Least Square (DF-GLS) and Elliot-Rothenber-Stock (ERS) tests for analyzing data. As per findings of the study, they conclude that Stock markets of India, Sri Lanka and Pakistan were weak-form efficient under all tests, while weak-form efficiency of Bangladesh stock market was supported by ADF and PP tests only but not supported by the DF-GLS and ERS tests.

Kader and Rahman (2005) investigate weak form efficiency of DSE by using technical trading rule (basically k% filter rule). Their findings reveal that abnormal profit is possible on regular basis by trading at a specific pattern, which violates the random walk hypothesis and DSE is not efficient in weak form.

Uddin and Alam (2007) search evidence supporting the existence of market efficiency on DSE. They conduct the study using daily general price index for the period 1994 to2005 and also show the empirical relationship between stock index and interest rate based on monthly data from May 1992 to June 2004. ADF test and OLS regression are used for analyzing data. The ADF test shows that the DSE index does not follow the random walk model. Further, the linear relationship between share price and interest rate, share price and growth of interest rate, growth of share price and interest rate, and growth of share price and growth of interest rate were determined through ordinary least square (OLS) regression. For all of the cases, they found that Interest Rate has significant negative relationship with Share Price and Growth of Interest Rate has significant negative relationship with Growth of Share Price in Dhaka Stock Market. So, DSE is not weak form efficient**.** Alam et al. (2007) also examine the randomness of market return, market risk-return relationships and the frequency of the market depth or liquidity. From their findings, it is clear that the DSE returns does not follow random walk and not efficient in weak form.

Hussain et al. (2008) examine the efficiency of Dhaka Stock Exchange using dynamic regression analysis for parametric test and 50days, 100days and 200days Moving Average Rule for technical analysis. The sample includes 5815 daily observations of DSE General Indices (DSE-GEN) for the period September 16, 1986 to June 30, 2008.Their study results indicate that the DSE is not efficient even in weak form but the inefficiency of DSE is diminishing after the market crash of 1996. They have given some suggestion that can improve the efficiency of the market. These suggestions are ensuring symmetric information among all investors, proper implication of rules of regulatory commission and introducing sophisticated means of investment and tools.

Uddin and Yasmin (2008) investigate market efficiency of the Dhaka stock exchange (DSE) using unit root tests. They consider the daily price indices of all securities listed on the DSE for the period from January 01, 1994 to March 22, 2007. Further, daily closing prices of 18 companies operating in the Banks and Financial Institutions (BFI) sector has been analyzed as a proxy of the prices of the movement of individual stock. This industry is chosen as this sector is rapidly growing in Bangladesh stock markets. The results of the ADF test suggest that the DSE price indices and also individual stock prices of the Dhaka stock exchange (DSE) does not follow the random walk model and is not efficient even in weak form.

Mobarek et al. (2008) examine whether the return series on Dhaka Stock Exchange (DSE) is independent and follows the random walk model or not. In this study, they use both non-parametric (Kolmogrov-Smirnov: normality test and run test) and parametric test (Auto-correlation test, Auto-regressive model and ARIMA model) for analyzing data. They consider the DSE daily general price index for the period 1988 to 2000. The results of all tests reveal that the security returns do not follow random walk model and the significant auto-correlation coefficient at different lags reject the null hypothesis of weak-form efficiency. This finding is very similar with findings of Mobarek and Keasey (2000). He examined weak-form efficiency using the daily price indices of all listed securities on the DSE for the period of 1988 to 1997. The results provide evidence that the share return series do not follow random walk model and the significant autocorrelation co-efficient at different lags reject the null hypothesis of weak-form efficiency.

Using unit root (ADF) test Uddin and Khoda (2009) investigate the authentication of random walk hypothesis for Dhaka stock exchange. They have examined the behavior of daily return of Dhaka Stock Market indices. The sample comprises the DSE general index which contains all securities prices listed in DSE, DSE top 20 index, and daily closing prices of 23 companies operating in the Pharmaceutical sector as a proxy of the of the movement of individual stock prices. The findings of the unit root (ADF) test on DSE general price index, DSE top 20 index and individual stock prices of the proxy companies indicate that the Dhaka stock exchange is not efficient even in weak form and DSE does not follow the random walk model.

Using K-S, run, autocorrelation and auto regression tests Alam et al. (2011) try to examine the impact of continuous policy reforms on the market efficiency of the Dhaka Stock Exchange. All the policies of the market are grouped into eleven categories based on their similarities and timing. They consider the 3209 daily observations of DSE Daily General Price Index for the period 1994 to2005.The overall findings tell that the frequency distribution of the stock prices in DSE does not follow a normal or uniform distribution as per K-S test. The results of run and autocorrelation tests reveal that the nonrandom nature of the return series. Beside, auto regression test confirms that one can predict future price based on the past values in the series. At last, they conclude that all of the existing policy of DSE cannot ensure market efficiency, not even in weak form and continuous and frequent policy changes have no impact on market efficiency in DSE.

Using Q-Q probability chart and Kolmogrov-Smirnov Goodness of Fit test and ARIMA model Chaity and Sharmin (2012) investigate level of market efficiency of DSE for explaining the relationship between information and share price in capital market and whether or not returns in a market follow a random walk process over a longer period of time. The study uses All Share Price Indices and DSE General Indices for the period January 1, 1993 to June 30, 2011 and January 2002 to June 30, 2011 respectively. The findings of the study reveal that the return series of both indices of DSE do not follow the normal distribution and this finding is further confirmed by K-S test, which is against the random walk model. The result of serial correlation and auto correlation test also indicates the nonrandom nature of return series for both indices. Finally, ARIMA forecasting strengthens the non-random nature of return series of Dhaka stock Exchange. The Result of the study indicates that the DSE is not 'Weak form of Efficient' and not follow 'Random Walk model'.

Table 3.3: Summary of Literature Review on Bangladesh Markets

Researcher/s	Market/s	Sample period	Tools	Result
Alam et al. (1999)	Bangladesh, Hong Kong, Malaysia, Sri Lanka, Taiwan	1986 to 1995 monthly stock price index	Variance ratio test	Except Sri Lanka, Bangladesh and other three markets are efficient in weak form
Mobarek and Keasey (2000)	Dhaka stock exchange	1988 to 1997 daily price index	Run test and Auto correlation test	Not efficient in weak form
Ahmed (2002)	Dhaka stock exchange	1990 to 2001	Ljng-Box statistic and Auto correlation	Take time to incorporate information in stock price and not efficient
Islam and Khaled (2005)	Dhaka stock exchange	1990 to 2001 daily, weekly and monthly stock price index and return	Unit root test and variance ratio test	Produced mixed result. RWH is rejected in case of daily and weekly data whereas not rejected in case of monthly data
Cooray and Wickremasinghe (2005)	Bangladesh, Sri Lanka, Pakistan and India	1996 to2005 Stock return data	ADF, PP, DF-GLS and ERS tests	Weak form efficiency of DSE only supported by ADF and PP tests but not supported by DF-GLS and ERS tests

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Researcher/s	Market/s	Sample period	Tools	Result
Uddin and Alam (2007)	Dhaka stock exchange	1994 to 2005 daily general price index	ADF test and OLS regression	Not efficient in weak form
Hussain et al. (2008)	Dhaka stock exchange	1986 to 2008 daily observation of DSE general index	Dynamic regression analysis and moving average rule	Not weak form efficient but inefficiency is diminishing
Mobarek et al. (2008)	Dhaka stock exchange	1988 to 2000 daily general price index	K-S, run,auto correlation, auto regression and ARIMA	Not weak form efficient
Uddin and Yesmin (2008)	Dhaka stock exchange	1994 to 2007 daily all share price index and daily closing price 18 banking companies	Unit root test	DSE price index and individual stock price do not follow random walk
Uddin and Khoda (2009)	Dhaka stock exchange	2002 to 2008 daily observation of DGEN index and closing price of 23 companies	ADF tests	Not efficient in weak form
Alam et al. (2011)	Dhaka stock exchange	1994 to 2005 daily general price index	K-S test, run test, auto correlation and auto regression	DSE is not efficient and policy impact has no impact on efficiency
Chaity and Sharmin (2012)	Dhaka stock exchange	1993 to 2011 all share price index	K-S test, Q-Q probability chart and ARIMA	DSE not efficient in weak form

From the above discussion, it is seen that a wide range of studies regarding efficient market hypothesis of all over the world have been taken under consideration. The entire discussions are divided into three heads, namely, developed markets, emerging markets and our own markets. It is well established that the developed markets are efficient in weak form. But, controversy is raised in case of emerging markets because of two types of findings. Some studies reveal that the emerging markets are weak form efficient whereas others show their empirical evidence against of weak form efficiency. In Bangladesh, previous studies relating to the EMH of DSE show mixed evidence. The studies such as, Mobarek and Keasey (2000); Uddin and Khoda (2009); Hussain, Chakraborty and Kabir (2008), Mobarek et al. (2008); Alam et al. (2011); Kader and Rahman (2005); Uddin and Alam (2007); Alam et al. (2007); Uddin and Yasmin (2008); Hossain (2004); Basher et al. (2007); Chaity and Sharmin (2012) and others show evidence against weak form efficiency. However, there are very few studies like Alam et al. (1999); Hassan and Chowdhury (2008) show evidence in favour of weak form efficiency of DSE. Further, Islam and Khaled (2005) do not reject the hypothesis of market efficiency of DSE for monthly data. In addition, they find the evidence of short term predictability of share prices in DSE before 1996 boom not for the post-crash period. Cooray and Wickremasinghe (2005) have seen mixed result for Bangladesh, the classical unit root tests (ADF and PP) support weak form efficiency whereas DF-GLS and ERS do not support.

Therefore, a strong disagreement is existed among the researchers regarding the weak form efficiency of Bangladesh stock market. The previous empirical evidences evocated some questions: Is DSE weak form efficient or not? Thus, can we predict future returns using any predictive model? The above mentioned questions and disagreements among the researchers induced us to conduct a further study regarding the market efficiency of DSE.

3.5 Literature Review on Volatility of Stock Market

Volatility means "the conditional variance of underlying asset returns" (Tsay, R. 2010). The conditional variance is allowed to change over time as a function of past error, while the unconditional variance is remain constant. Volatility exhibits three typical patterns in most financial time series, namely, clustering, persistence and asymmetry. Last two decades, modeling and forecasting volatility of financial time series has become a very interesting subject to financial economists because of its application in portfolio optimization, risk management and asset pricing (Ahmed and Suliman, 2011). To estimate the conditional variance (volatility) of financial assets a number of models have been developed, known as, conditional heteroscedastic models. Among the models, ARCH proposed by Engel, 1982, and GARCH proposed by Bollerslev, 1986, have become very popular and enable the researchers to estimate time-varying conditional second order moment (variance) of time series by using past unpredictable changes in the returns of that series.

Robert F. Engle (1982) was the first to initiate the concept of conditional heteroscedasticity. He projected a model where the conditional time series is a function of past shocks. This model led to a breakthrough in financial econometrics. The impact this model has had on the research around time-varying volatility gave him the Nobel Prize in Economic Sciences in 2003. Although the initial ARCH model was designed to capture persistence in inflation, the model fits to a number of other financial time series. The model has had a vast influence on theoretical and applied econometrics and was influential in the establishment of Financial Econometrics as a discipline (Franses and McAleer, 2002).

In the ARCH model, the conditional variance is allowed to change over time as a function of past errors, while the unconditional variance is left constant (Bollerslev, 1986). A generalization of the ARCH model was proposed by Bollerslev (1986). His generalized autoregressive conditional heteroscedasticity (GARCH) model allows for past conditional variances in the current conditional variance equation. This generalization leads to models that are parsimonious and easy to estimate. Even in its simplest form it has proven successful in predicting conditional variance (Engle, 2001).

3.5.1 Literature on Developed and Emerging Market Volatility

A lot of empirical studies have been conducted on modeling and forecasting stock market volatility by using ARCH and GARCH specifications and their extensions. It is seen that the most of the studies focus on developed markets and to the best of my knowledge, there are very few studies focus on DSE. Findings of the studies are furnished as under:

French et al. (1987) investigate the effect of stock market volatility on stock return. The daily values of S&P composite portfolio are used to estimate the monthly standard deviation of stock market returns for the period of January 1928 through Dec 1984. At first, daily return are used to estimate monthly volatility and using ARIMA models they decompose these estimates into predictable and unpredictable components. The GARCH-M is also used to estimate the ex-ante relationship between risk premium and volatility. It is found that the predictable level of volatility and expected risk premium are positively related but a strong negative relation is existed between the unpredictable component of volatility and excess holding period returns.

Lamoureux and Lastrapes (1990) examine the relationship between volume and volatility of US stock market. The data set contains daily return and volume of 20 actively traded stocks. ARCH and GARCH(1,1) models are used to conduct the analysis and contemporaneous trading volume is incorporated as a explanatory variable in the variance equation. It is found that the daily trading volume has a significant explanatory power regarding the variance of daily return. Furthermore, the inclusion of volume in variance equation reduces the persistence of volatility very significantly and the ARCH effect tend to be disappeared.

Henry (1998) tries to explain the nature of stock market volatility. He uses daily data from Hong Kong stock market for the period of January 1, 1990 to June 12, 1995, which consists of 1415 observations of closing value of Hang Seng index. He applies the news impact curve of Engle and Ng for the specification of models of the conditional volatility of stock return. Beside this, GARCH, EGARCH, GGARCH, GJR-GARCH and GQARCH are used. The study shows that a negative shock to stock prices will generate more volatility than a positive shock of equal magnitude. (1) The standard GARCH (1,1) model is shown to produce biased estimates of conditional variance when stock price movements are large and negative (et-1<0). The estimated news impact curve for the GARCH (1,1) suggests that conditional variance is underestimated for large negative shocks and overestimated for large positive shocks. (2) A Wald test for integration in variance suggests that shocks to volatility are infinitely persistent, in the sense that the optimal k-step-ahead linear forecast of the conditional variance continues to depend on the initial conditions for all forecast horizons. Using the regression based methodology suggested by Psaradakis & Tzavalis(1995) the null of infinite persistence in variance is not satisfied. (3) Examinations of various news impact curves suggest that the EGARCH(1,1) model is highly sensitive to very large positive and negative shocks. (4) The conditional variance equation of the GJR model contains two parameters β and δ are marginally significant. (5) GQARCH model passes all tests and appears relatively congruent with the asymmetry inherent in the data appears to be the most adequate characterization of underlying data generating process.

McMillan et al. (2000) provide a comparative assessment of the efficiency of various statistical and econometric models to forecast the volatility of the UK stock market. To conduct the study, closing price of FTA All Share index and FTSE100 stock index are taken into consideration as daily, weekly and monthly basis. The sample period covers from January 02, 1984 to July 31, 1996 for FTSE100 index and January 01 1969 to July 31, 1996 for FTA all shares index. They have used historical mean, moving average, random walk, exponential smoothing, exponentially weighted moving average (EWMA), simple regression, GARCH, TGARCH, EGARCH, CGARCH and recursively estimated models. Under symmetric loss, results suggest that the random walk model provides vastly superior monthly volatility forecasts, while random walk, moving average, and recursive smoothing models provide moderately superior weekly volatility forecasts, and GARCH, moving average and exponential smoothing models provide marginally superior daily volatility forecasts. If concentration is restricted to one forecasting method for all frequencies, the most consistent forecasting performance is provided by moving average and GARCH models.

Leon et al., (2000) examine the responsiveness of sectoral sub index returns to changes in the domestic market portfolio and compares prediction of nonsystematic risk using GARCH and EGARCH specification of the error variance. They use composite stock price index, the indices of sub sectors of commercial banks, conglomerates, manufacturing 1, manufacturing 2, trading and property for the period of 1983 to 1995 of Trinidad and Tobago Stock Exchange. The results suggest that the returns for the portfolios of commercial banks and conglomerates respond more than proportionately to the changes in market portfolio. The portfolio of trading and property are found to be less responsive to movement in the market index. It is also seen that the volatility appears to have been greater during the period of macroeconomic instability and political unrest.

Choudhry (2000) examines the day of the week effect on seven emerging Asian Stock Market returns and conditional variance. To conduct the study the daily a specific stock index of India, Indonesia, Malaysia, Philippines, South Korea, Taiwan and Thailand are considered. The sample period covers from January, 1990 to June, 1995 and return is calculated as the log differences of stock price index. The GARCH(p,q) model, serial correlation test of white noise, spill over test, GARCH-t and battery of standard specification test have been used to analyze the data. The empirical results divulge that the significant presence of day of the week effect and weekend effect (Monday effect). The results also prove that the stock market anomalies are not just characteristic of developed market but also of the emerging market. It is found that the "day of the week" effect and "weekend" effect both influence conditional variance (volatility). The noteworthy day of the week effect on return found in this study cannot be explained based on the settlement procedure but outcomes show some evidence of a possible spill-over form Japanese market.

Franses and Paap (2000) examine the day-of-the-week effect in the returns as well as volatility of return. In this study, the S&P-500 composite index is used from January 01, 1980 to September 28, 1994. They have applied periodic autoregressive with periodically integrated GARCH [PAR-PIGARCH] model to conduct the work. With this statistically adequate PAR-PIGARCH model, positive autocorrelation is found in the returns on Monday and negative autocorrelation is found on Tuesday. It is also found that the model detects day-of-the-week variation in the persistence of volatility.

The time series behavior of stock return are investigated by Chiang and Doong (2001) based on seven Asian Stock market indexes. The daily stock price indexes of seven Asian stock markets from January, 1988 through June, 1998 are used for this study. To test the relationship between stock return and unexpected volatility, they follow the methodology proposed by French et al. (1987). Where, they provide a direct test of relationship between excess return and volatility. Again to study the relationship between stock return and time varying volatility, they employ Threshold Autoregressive GARCH (1,1)- M (i.e., TAR-GARCH(1,1)-M) models. In first case, it is found that the four out of seven Asian stock markets have a significant relationship between stock return and unexpected volatility. In second case, it is also found that there is a significant relationship existed between stock return and time varying volatility under TAR-GAECH(1,1)-M model for all countries because the GARCH parameters are highly significant. In case of weekly return, the significance level of the GARCH effect become smaller and it becomes very little in case of monthly data. So the strong asymmetric effect is prevailing in case of high frequency data (daily data) and it disappears in case of low frequency data.

Poshakwale and Murinde (2001) have examined the volatility of the East European emerging stock markets. The research work is conducted on two countries, Hungary and Poland. They use the daily closing prices of the BUX(comprising 17 Hungarian stocks) for the period of January 1, 1994 to June 30, 1996 and the Warsaw General Index of 20(WIG-20) for the period of April 16,1994 to June30,1996. They also use exchange rate data for Polish Zloty and Hungarian Forint, each against the German Mark and British Pound for the same period. They have used BDSL statistics, LM-test, GARCH procedure, ARIMA models, ARMA(0,1), ARCH model, GARCH-M model. Findings of this study are:(i) The BDSL statistics indicate the presence of non-linearity in the both indexes, at the same time the presences of conditional heteroscedasticity is detected through LM-tests.(ii) Then, the GARCH process is used for modeling conditional heteroscedasticity. The GARCH models outperform the conventional OLS models and show significant first order auto regression, where as ARMA(0,1) model fails to capture nonlinear dependencies.(iii) The well known day of the week effect, reflected in significantly positive Friday and negative Monday commonly found in most of the market, do not appear to be present in the two markets. (iv)This paper also suggested that martingale hypothesis, that the future changes of the daily stock prices in the Hungarian and Polish stock market are orthogonal, can be significantly rejected. (v) Volatility seems to be of a persistent nature, however, as measured by a GARCH-M model this does not seems to be priced in both market. But persistency declines after 1995 for Poland due to improved market integration with the UK and German stock market.

Balaban et al., (2002) evaluate the out-of-sample forecasting accuracy of eleven models for weekly and monthly volatility in fourteen stock markets. Volatility is defined as within-week and within-month standard deviation of continuously compounded daily returns on the stock market index of each country. The sample period covers from December 1987 to December 1997. In this study the first half of the sample is taken for the estimation of parameters whereas the second half is for the forecast period. The random walk model, historical mean model, moving average models, weighted moving average models, exponentially weighted moving average models, exponential smoothing model, regression model, ARCH model, GARCH model, GJR-GARCH model, and EGARCH model are employed in this case. They use the standard loss functions to estimate the performance of the various competing models that are the mean error (ME), the mean absolute error (MAE), the root mean squared error (RMSE), and the mean absolute percentage error (MAPE). As per all of these standard loss functions, the exponential smoothing model delivers superior forecasts of volatility. On the contrary, ARCH-type models usually demonstrate to be the worst forecasting models. They also consider the asymmetric loss functions to penalize under or over prediction. As soon as under-predictions are penalized more heavily ARCH-type models generate the best forecasts while the random walk is worst. Conversely, when over-predictions of volatility are penalized more heavily the exponential smoothing model performs best while the ARCH-type models are now commonly found to be substandard predictors.

Batra (2004) examines the time varying volatility in Indian stock market and whether the process of financial liberalization in India has any impact on increase in volatility persistence in the Indian stock market or not. It is also examined the shift in stock price volatility and the nature of events that apparently cause the shifts in volatility. They also attempt to characterize the evolution of stock market cycles over time in India. Two major indices in Bombay Sensex and the International Finance Corporation published Global (IFCG) indexes are used for the period of April 1979 to March 2003 and January 1988 to December 2001 respectively. To analyze the monthly stock return, the asymmetric GARCH (E-GARCH) is used for time variation in volatility, augmented E-GARCH with dummy variable is used for structural change in stock return volatility and the Pagon and Sussoumov (2003) methodology is adopted for characterizing the stock market cycles. From this study it has been seen that the period around BOP crisis and the subsequent initiation of the economic reforms the stock market was most volatile. The shifts in stock return volatility are probably a result of major policy changes. In India, volatility in stock market vitally influenced by domestic political and economical events rather than the global events. The stock market cycle over the study period reveals that the bull phases are longer, the amplitude and volatility of bull phases are higher.

Kumar (2006) examines the ability of ten different statistical and econometric volatility models. Symmetric and asymmetric error statistics are used to evaluate these competing models. In this article Nifty index is considered as proxy for stock market and closing index values are collected for the period of June 3, 1990 to December 31, 2005. The

exchange rate data (RS./$) is also collected for January 3, 1994 to December 31, 2005. Out of sample, first 126 monthly observations of NIFTY and first 85 monthly observation of exchange rate are used for estimated model and remaining observations are used for forecasting. Competing models are Random walk, Historical Mean, Moving Average, Simple regression, Exponential Weighted Moving Average (EWMA) and simple and higher order GARCH models. It is found that the based on out of sample forecasts GARCH(4,1) and EWMA methods will provide better forecasting in Indian stock market and GARCH (5,1) will lead to better format in the FOREX market.
Magnus and Fosu (2006) conduct this study is to model and measure the conditional variance (volatility) in the returns of Ghanaian stock market. The daily closing values of Databank Stock Index (DSI) of Ghana stock exchange are used over the periods from June 15, 1994 to April 28, 2004.The random walk (RW), GARCH(1,1), EGARCH(1,1) and TGARCH(1,1) models are used for this purpose. Later they use minimum Akaike Information Criteria (AIC) and maximum Log-likelihood (LL) values as a combination of information criteria and a set of model diagnostic tests, like ARCH-LM, Q-Statistics and BDS tests to choose the best volatility model for DSI. It is found that there is a volatility clustering, leptokurtosis and asymmetry effects associated DSI returns. It is also found that the high degree of volatility persistent is exhibited here. The random walk hypothesis is rejected for DSI. For modeling and forecasting conditional variance of DSI the GARCH (1,1) model is outperformed than the other competing models.

Leon (2007) investigates the relationship between stock return volatility and trading volume in the regional stock exchange of the West African Economic and Monetary Union called the *Bourse Régionale desValeursMobilières* (BRVM) using daily data on stock prices and trading volume over the period 2 January 2002 to 29 July 2005. The study tests for Granger causality between stock returns volatility and trading volume within a VAR framework. It is seen that a one-way causality running from trading volume to stock returns volatility regardless of the measures of volatility used. The result of this test shows that volume has predictive power for stock returns volatility. The finding also suggests a degree of market inefficiency in the BRVM. This finding is useful for regulators, practitioners, and market participants for their success depend on their ability to forecast stock price movements.

Mala and Raddy (2007) have tried to measure the level of volatility presence in stock market of Fiji. In the study the risk and return behavior is characterized of the listed firm on the south specific stock exchange (SPSE). The regime- switching ARCH model and the GARCH models are used to estimate the conditional variance of daily stock return of Fiji. Time series data of sixteen firms of Fiji stock market for the period of January 2001 to December 2005 is used in this analysis. LM test applies to show the conditional heteroscedasticity and there is a strong evidence of conditional heteroscedasticity for seven stocks out of 16. They also observe that the GRACH coefficients of these stocks that have conditional heteroscedasticity are statistically significant because their individual P value are zero (0). Later, the stock return volatility is regressed against interest rate and it has been seen that the changes of interest have measurable and significant effect on volatility of stock market.

Chancharat et al., (2007) investigate the impact of international stock market and domestic macroeconomic variables on Thai stock market price return, in the pre and post 1997 Asian crisis period. They use monthly stock price Index of Thailand as well as another 15 countries stock index for the period of January 1998 to December 2004 except Russia. In addition the microeconomic variables for Thailand comprise the Customer Price Index (CPI), the exchange rate (Ex),the Interest rate (MR),the money supply (M2) and oil price(OP) and in all cases monthly observation are used for the period of January 1988 to December 2004. For pre 1997 period the correlogram shows significant ARCH effect and to capture the ARCH and GARCH effect, they select GARCH in mean model for this study. It is found that the Singapore stock market significantly influenced the Thai stock market in both before and after 1997 crisis. Before 1997 the Indonesian and Malaysian stock market were related to Thai stock market but after 1997 Korea and Philippines influenced the return of Thai stock market.

Medeiros and Doornik (2008) examine the empirical relationship between stock returns, return volatility and trading volume. The Brazilian stock market (Bovespa) data has been used and sample contains stock return and trading volume data from 01/03/2000 through 12/29/2005. The cross-correlation analysis, unit-root tests, bivariate simultaneous equations regression analysis, GARCH modeling, VAR modeling, and Granger causality tests are used to conduct the study. It is seen that there is a significant contemporaneous relationship between return volatility and trading volume, which is detected in the cross-correlation analysis. However, a simultaneous equation analysis show that stock returns depend on trading volume, but that does not apply the other way round. It is also found that higher trading volume is associated with an increase in return volatility and this relationship is asymmetrical. The GARCH(1,1) estimation of stock returns and volatility confirm the ARCH effects and high hysteresis in conditional volatility. The hysteresis of variance over time partly declines if one includes trading volume as a proxy for information arrivals in the equation of conditional volatility. The GARCH estimation provide an almost negligible support for the MDH (Mixed of Distribution Hypothesis), since the inclusion of trading volume in the variance equation produces a weakly significant coefficient and it does not relieve the strong ARCH effects observed in the restricted variance equation. When it comes to Granger-causality, our results show no signs of causality between trading volume and stock returns. However, Granger causality between trading volume and return volatility is strongly evident in both directions, which indicates that information might flow simultaneously rather than sequentially into the market.

Liau et al., (2008) measure the effect of trading volume on both the short-run and long-run volatility. Closing the prices of index and trading of Taiwan stock market are used in this case. The sample period covered from January 3, 2000 to April 7, 2008. Logarithmic differences of closing price of index are taken to compute the daily return and trading volume also transformed through logarithm. The components GRACH (C-GRACH) model is used to capture the characteristics of volatility of Taiwan stock market. They add the daily contemporaneous volume to the variance equation to show the impact of trading volume on short-run and long-term volatility. Volatility is decomposed in to two components transitory and permanent and examines the trading volume return volatility relationship. The empirical results reveal a positive correlation between trading volume and transitory volatility and short term phenomenon. It is also seen that the GRACH effect tend to disappear when volume is added to the transitory variance equation. From empirical result it is seen that non synchronous trading apparently exists in Taiwan stock market. The measure of volatility persistence, ie, the value of $\alpha + \beta$ is less than one, which indicates the shocks are transitory. The speed of the mean reversion of permanent volatility is verified by P and the larger P indicates the slower mean reversion for the permanent volatility.

Srivastava (2008) examines and explains the daily return volatility of Indian stock markets. Two main indices in Indian stock market, i.e, Indices of Bombay Stock Exchange (SENSEX) and National Stock Exchange (NIFTY) are considered in this study. The sample period covered from April, 2000 to March, 2008 and daily closing price of two indices are considered. Logarithmic differences of price of two successive periods are used to determine the rate of return. The autoregressive conditional heteroscedasticity-(ARCH) and TARCH models have been used to search the presence of volatility on the stock markets of India. The main objective of this study is to capture the volatility clustering and persistence of shock of stock. From this study it has been seen that both stock exchanges have significant ARCH effect and ARCH and GARCH model are appropriate to estimate the volatility. Both EGARCH (1,1) and EGARCH(1,1)-M fit the process very weakly, and indicate that markets will fluctuate radically with new shocks. This study also reviles that there are leverage effect in both markets. It is also found that the stock market's volatility in India expressed some features, which are very similar to those found earlier in many stock market in the world, i.e, there autocorrelation and negative asymmetry in daily return.

Using various form of GARCH model Alberg et al., (2008) have conducted a comprehensive empirical analysis of the mean and conditional variance of Tel Aviv Stock Exchange (TASE) indexes. Two types of indexes i,e TA25 & TA100 are considered. The sample contents 3058 daily observation of the TA25 index from the period of October 20, 1992 to May 31, 2005 and 1911 daily observation of the TA100 index from the period of July 2, 1997 to May 31, 2005. They have used GARCH model, though both ARCH and normal GARCH models capture volatility and leptokurtosis, but their distribution is symmetric and failed to capture the leverage effect. To detect the problem, they propose some non liner extensions of GARCH, i,e, Exponential GARCH (EGARCH), GJR-GARCH and Asymmetric Power ARCH (APARCH). Forecasting performance of different GARCH models are compared under different distribution for two indexes. It is found that the EGARCH under a skewed student-t model is the most successful for explaining the dynamic behavior of return and forecasting two indices over the GRACH, GJR and APARCH models.

Floros (2008) examines risk and volatility of financial market. 1987 daily observations of Egyptian stock market (CMA General Index) and 2003 daily observations of Israel stock market (TASE-100 index) are used for these purposes. First ARMA (p,q) model is used to filter conditional mean structure in data then various GARCH type models like simple GARCH, EGARCH, CGARCH,TGARCH,GARCH-M,POWER-GARCH and AGARCH (asymmetric component GARCH-an extension of CGARCH) are employed to capture volatility of these two markets. It is found that, the daily returns can be characterized by the GARCH models and the sum of the coefficient of these models is close to 1(one) that indicates persistence of conditional volatility. They report that the existence of leverage effect and bad news increases volatility for TASE 100 indices in both markets. Volatility is examined as a measure of the total risk and found that the increased volatility (in risk) will not necessarily lead to rise in the returns. It is also found that the CMA index of Egyptian stock market is more volatile because of uncertainty in prices and economy over the study period.

Mahajan and Singh (2009) investigate the empirical relationship between return volume and volatility dynamics of stock market. The stock return's series is computed from daily closing price of Bombay Sensex index for the period of 29th October 1996 to 31st March 2006. This study examines the heteroscedasticity in stock return that can be explained by incorporating volume as mixing variable. To test, whether the positive contemporaneous relationship between trading volume and returns exist, the GARCH(1,1) model is estimated where volume is included in mean equation. To examine, whether trading volume explains the GARCH effects for returns, volume parameter is incorporated in GARCH (1,1) variance equation. To examine the asymmetric shocks to volatility, they use EGARCH (1,1) model. Further to examine dynamic relationship between variables, the linear Granger causality test is applied. To test for Granger causality, they use a bivariate VAR model. The empirical analysis shows that there is a positive and significant correlation exists between volume and return volatility which indicates both mixture of distribution and sequential arrival hypothesis of information flow. It implies that the informed traders trade only when they receive private information, and that there trading carries information and affects prices. The GARCH (1,1) model express the small declines in persistent of variance over time if one includes trading volume as a proxy for information arrivals in the equation of conditional variance and α and β (ARCH & GARCH) effects remain significant, which indicates the inefficiency in the market. The EGARCH(1,1) indicates that the presence of leverage effect and positive impact of volume on volatility. The differential cost of taking long and short positions is main reason for information asymmetry or leverage effect. Finally, they found a significant relationship of causality flowing from volatility to trading volume, which inconsistent with the mixture of distribution hypothesis but support the sequential information arrival hypothesis. It implies that the strong form of market efficiency does not hold since some private information exists that is not reflected in stock price.

Liu et al. (2009) examine how the performance of volatility is influenced by the specification of return distribution. For this study daily closing sport price of Shanghai and Shenzhen composite indices are used. The sample period covers from January 04, 2000 to December 29, 2006 and the total number of observations is 1683. GARCH-N and GARCH-SGED are applied for analyzing data and forecasting stock market volatility to Shanghai and Shenzhen composite stock indices over various forecasting horizon. They mention China stock market has been growing at faster rate, that is why, it has attracted foreign investors. Rapid growth and risk are very closely related due to that volatility forecasts are a vital issue. A relative window scheme is adopted to implement and compare the relative ability to predict out of sample volatility for the GARCH-SGED and GARCH-N model. It has been seen that the MSE and MAE are lower for the GARCH-SGED models than the GARCH-N model for both markets across all forecast horizons. Under another statistical test, the DM statistics insure that the GARCH-SGED model forecasts volatility more accurately than GARCH-N model in everywhere. This study also mention that the incorporation of SGED returns into the GARCH(1,1) model produces better volatility forecast for all markets in china, indicating the significance of both skewness and tail thickness in the conditional distribution of return.

Ashley and Patterson (2010) sincerely examine the ability of ARCH/GARCH family of models to find out the nonlinear dependence of stock market returns. The daily returns of the CRSP equally weighted index, which includes all NYSE and AMEX and major NASDAQ stocks, is used for this study. The sample period covered January 06, 2006 to December 31, 2007 and total number of observation is 500. They have found that the GARCH(1,1) model is the only viable model from the ARCH/GARCH family and cannot be rejected as an effective model for the process generating these daily stock return data. In the case of reproducing the kind of nonlinear serial dependence mentioned by the battery of nonlinearity test the GARCH(1,1) model appears to be reasonably adequate.

Tripathy (2010) examines the empirical relationship between stock returns and trading volume volatility in Indian stock Market for the period of January 2005 to January 2010.This paper has used the GARCH (1, 1) model, asymmetric TARCH, EGARCH, PGARCH and Component ARCH model to empirically examine the persistence of shocks to volatility and to determine the asymmetry in the pattern of volatility. The analysis shows that the recent news of trading volume can be used to improve the prediction of stock price volatility but the past news coefficient is statistically insignificant and suggests that old news is not having influencing the trading volume volatility. This study also finds the evidence of leverage and asymmetric effect of trading volume in stock market and indicates that bad news generate more impact on the volatility of the stock price in the market. Further the study concludes that asymmetric GARCH models provide better fit than the symmetric GARCH model.

Emenike (2010) examines the nature of conditional variance of stock return of Nigerian stock exchange (NSE). Monthly All Share Index (ASI) of NSE is used or considered for this study. The study covers the periods from January 1985 to December 2008 total number of observation is only 288.The GARCH (1,1) and the GJR–GARCH(1,1) models are used to capture stock return volatility clustering, leptokurtosis & leverage effect of the NSE return series. The Generalized Error Distribution (GED) is also used to capture the non normal density function of the NSE return series because the GED is a powerful alternative in cases where the assumption of conditional normality cannot be maintained. It is found that volatility of stock return is highly persistent and which is clearly indicated by the unity of α_1& β_1 ($\alpha_1+\beta_1$). The GJR–GARCH (1,1) exhibits the existence of leverage effect in the stock return. The shape parameter estimated from GED shows evidence of leptokurtosis in return distribution of the NSE.

Ahmed and Suliman (2011) attempt to measure conditional variance, i.e., volatility in the daily returns of Khartoum Stock Exchange (KSE), Sudan. To compute daily returns the first differences in the logarithm of closing price have been taken. The data periods cover January 02, 2006 to November 30, 2010 and total number of observation equal to 1326. In this paper univariate GARCH models, like- GARCH(1,1),GARCH-M(1,1), EGARCH(1,1), TGARCH(1,1) and PGARCH(1,1) are used for modeling stock return volatility. First they examine the residuals for heteroscedasticity and ARCH-LM test provides strong evidence of presence of ARCH effects in the residual series. It is found that the volatility is very persistent in nature and positive relationship is existed between volatility and expected stock return which indicates that there is a risk premium for additional risk. They also found that the asymmetric models provide better fit than the symmetric model due to the presence of leverage effect.

Choi et al. (2012) examine the relationship between return volatility and trading volume as a proxy for information arrival to market. The sample consists of a daily stock index and its trading volume on the Korea exchange (KRX) from January 4, 2000 to December 30, 2010. Daily index returns and trading volume are calculated in terms of percentage logarithmic change. Mixture of distribution hypothesis (MDH) is used to examine the relationship between stock returns and trading volume in the context of information arrival. The MDH provides an explanation of volatility and volume by linking changes in price volume and the rate of information flow. To capture the volatility dynamics of financial time series, GARCH family models are used as most popular tools. But normal GARCH has some limitations, i.e, it captures a symmetric response of volatility to both positive and negative market shocks because conditional variance is regarded as a function of the magnitude of lagged residuals, not whether they are positive or negative. But it has been argued that a negative shock may lead to more volatility than a positive shock of the same magnitude. For this reasons, in this study EGARCH and GJR-GARCH models are used to assess asymmetric volatility and effect of new information arrival to the market. It is found that 1) Korea stock market index shows strong volatility persistence and asymmetry. 2) After incorporation of contemporaneous trading volume in the GJR-GARCH and EGARCH models, a positive relationship between trading volume and volatility have been found. 3) It is also found that the contemporaneous trading volume is positively correlated with volatility but lagged trading volume is not correlated with volatility. Thus, the trading volume affects the flow of information, supporting the validity of MDH. 4) The asymmetric effect of bad news on volatility is higher when contemporaneous trading volume is included.

Although, market shocks whether positive or negative have similar effect on conditional volatility. So trading volume is a useful tool for predicting volatility.

Ravichandran and Bose (2012) investigate the empirical relationship between trading volume and volatility of stock return in U.S stock market. Sample period covers from May 2005 to May 2011. To conduct the analysis, ARCH, GARCH, EGARCH, TARCH, PGARCH and component ARCH models are used. It is found that the recent news has an impact on the volatility of trading volume but past news is statistically insignificant and having no influence on trading volume volatility. So it is evident from the study that systematic variations in the trading volume are assumed to be caused only by the arrival of new information and the recent news of trading volume can be used to improve the prediction of stock price volatility. It is also observed that the existence of leverage and asymmetric impact of trading volume of stock market and concluded that the bad news generate more impact on volatility of stock price and trading volume because investors have a risk aversion mentality and react faster to bad news. Moreover, random walk model dominated the forecasting performance and it is considered the best model followed by the TGARCH model.

Table 3.4: Summary of Empirical Studies on Return Volatility in Developed and Emerging Markets

Researcher/s	Market/s	Sample period	Tools	Results
French et al. (1987)	US	1928 to 1984	GARCH-M	It is found that the predictable level of volatility and expected risk premium are positively related

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Researcher/s	Market/s	Sample period	Tools	Results
Lamoureux and Lastrapes (1990)	US stock market	Daily return for 20 stocks for different period: 1980-1984	ARCH and GARCH (1,1)	-the daily trading volume has a significant explanatory power regarding the variance of daily return -the inclusion of volume in variance equation estimates the persistence of volatility i.e, the ARCH effect tend to be disappeared.
Henry (1998)	Hong Kong stock market	1990 to 1995	GARCH, EGARCH, GGARCH, GJR-GARCH and GQARCH	study shows that a negative shock to stock prices will generate more volatility than a positive shock of equal magnitude. GQARCH model passes all tests and appears relatively congruent with the asymmetry inherent in the data
Leon et. al. (2000)	Trinidad and Tobago	1983 to 1995	J-B test, GARCH, EGARCH	-returns of commercial banks and conglomerates respond more than market index. -return of trading and property are found to be less responsive to movement in the market index. -the volatility appears to have been greater during the period of macroeconomic instability and political unrest.
Chiang and Doong (2001)	seven Asian Stock market	1988 to 1998	TAR-GARCH(1,1)-M	four markets have a significant relationship between stock return and volatility the strong asymmetric effect is prevailing in case of high frequency data (daily data) and it disappears in case of low frequency data.
Poshakwale and Murinde (2001)	Hungary and Poland	1994 to 1996	BDSL-stat, ARCH-LM, ARIMA GARCH-M	Volatility seems to be of a persistent nature. as measured by a GARCH-M model this does not seems to be priced in both market.

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Researcher/s	Market/s	Sample period	Tools	Results
Magnus and Fosu (2006)	Ghanaian stock market	1994 to 2004	RW, GARCH(1,1), EGARCH(1,1) and TGARCH(1,1)	-found that there is a volatility clustering, leptokurtosis and asymmetry effects existed DSI returns. -also found that the high degree of volatility persistent is exhibited here. -random walk hypothesis is rejected for DSI. -modeling and forecasting conditional variance of DSI the GARCH (1,1) model is outperformed than the other competing models.
Mala and Raddy (2007)	Fiji	2001 to 2005	ARCH-LM Test, regime-switching ARCH and GARCH	-the GRACH coefficients are statistically significant . - changes of interest rate have significant effect on volatility of stock market.
Alberg et al. (2008)	Tel Aviv Stock Exchange	TA25-1992 to 2005 and TA100-1997 to 2005	GARCH, EGARCH,GJR-GARCH and APARCH	Forecasting performance of different GARCH models are compared and found that the EGARCH under a skewed student-t model is the most successful for explaining the dynamic behavior of return
Liau et al. (2008)	Taiwan stock market	2000 to 2008	components GRACH	The value of α +β is less than one, which indicates the shocks are transitory. GARCH effect tends to disappear when volume is added to variance equation. Non synchronous trading apparently exists in Taiwan stock market.

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Researcher/s	Market/s	Sample period	Tools	Results
Medeiros and Doornik (2008)	Brazilian stock market	2000 to 2005	GARCH modeling, VAR modeling, and Granger causality tests	seen that there is a significant contemporaneous relationship between return volatility and trading volume GARCH(1,1) estimation confirm the ARCH effects and high hysteresis in conditional volatility. The hysteresis of variance over time partly declines if one includes trading volume as a proxy for information in variance equation. Granger causality between trading volume and return volatility is strongly evident in both directions
Floros (2008)	Egyptian stock market and Israel stock market	1997 to 2007	GARCH, EGARCH, CGARCH, TGARCH, GARCH-M, PGARCH and AGARCH	-the sum of the coefficients of these models is close to one, that indicates persistence of conditional volatility - They report that, the existence of leverage effect and bad news increases volatility -found that the increased volatility (in risk) will not necessarily lead to rise in the returns.
Liu et al. (2009)	Shanghai and Shenzhen composite indices	2000 to 2006	GARCH-N and GARCH-SGED	the MSE and MAE are lower for the GARCH-SGED model than the GARCH-N model for both markets across all forecast horizons The GARCH-SGED model forecasts volatility more accurately than GARCH-N model in everywhere.

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Researcher/s	Market/s	Sample period	Tools	Results
Mahajan, and Singh (2009)	Bombay Sensex index	1996 to 2006	GARCH (1,1), EGARCH (1,1) m, Granger causality test, bivariate VAR	- a positive and significant correlation exists between volume and return volatility -GARCH (1,1) model express the small declines in persistent of variance over time. - trading volume is included in conditional variance equation then α and β effects remain significant and indicate inefficiency -the EGARCH(1,1) indicates that the presence of leverage effect and positive impact of volume on volatility - they found a significant relationship of causality flowing from volatility to trading volume
Tripathy (2010)	Indian stock Market	2005 to 2010	GARCH (1, 1), TARCH, EGARCH, PGARCH and Component ARCH	shows that the recent news of trading volume can be used to improve the prediction of stock price volatility but the past news coefficient is statistically insignificant. -also finds the evidence of leverage and bad news generate more impact on the volatility of the stock price. -the study concludes that asymmetric GARCH models provide better fit than the symmetric GARCH model.
Emenike (2010)	Nigerian stock exchange	1985 to 2008	GARCH (1,1) and the GJR–GARCH(1,1)	- found that volatility of stock return is highly persistent, which is indicated by the unity of α_1& β_1. -the GJR–GARCH (1,1) exhibits the existence of leverage effect in the stock return.
Ahmed and Suliman (2011)	Khartoum Stock Exchange (KSE)	2006 to 2010	GARCH(1,1), GARCH-M(1,1), EGARCH(1,1) TGARCH(1,1) and PGARCH(1,1)	-the volatility is very persistent in nature -positive relationship is existed between volatility and expected stock return -the asymmetric models provide better fit than the symmetric model due to the presence of leverage effect.

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Researcher/s	Market/s	Sample period	Tools	Results
Choi et al. (2012)	Korea exchange (KRX)	2000 to 2010	GARCH, GJR-GARCH EGARCH	-shows strong volatility persistence and asymmetry -a positive relationship between trading volume and volatility have been found -the asymmetric effect of bad news on volatility is higher when contemporaneous trading volume is included
Ravichandra and Bose(2012)	U.S stock market	2005 to 2011	ARCH, GARCH, EGARCH, TARCH, PGARCH and component ARCH	-found that the recent news has an impact on the volatility of trading volume but past news is statistically insignificant and having no influence on trading volume volatility -also observed that there is the existence of leverage and the bad news generate more impact on volatility of stock price and trading volume. -the random walk model dominated the forecasting performance and it is considered the best model followed by the TGARCH model

3.5.2 Literature on Bangladesh Stock Market Volatility

In the case of Bangladesh, a few studies have appeared in the literature focusing on volatility of the Dhaka Stock Exchange (DSE) of Bangladesh.

Imam and Amin (2004) find that the volatility of the stock return of Bangladesh capital market follows a GARCH (1,1) process and there is persistence in volatility and the conditional volatility after the crash of 1996 is mean reverting. This finding suggests that current information has no effect on the long run forecasts, rather volatility shocks (random errors) to the volatility estimated at earlier period influence more in estimating volatility.

Chowdhury and Iqbal (2005) examine that nature of volatility in weekly returns of Dhaka Stock Exchange (DSE). They also search that factors which influence the risk-return relationship like volatility persistence, influence of return by asymmetric impact of volatility, additional premium for risk and its impact on expected return. The sample period covered from January 1989 to November 2001. Data are divided into two groups. Primarily they consider data for entire period. But from June 1996 to 1st half of 1997 was the most turbulent period in the history of Bangladesh stock market. For this reason, they drop data for the period of June 06, 1996 to September 25, 1997 and developed 2nd set of data. First AR(P) model is used to trace autocorrelation function in DSE returns. Then they use ARCH, ARCH-M, GARCH and TGARCH models for capturing the volatility. The empirical analysis shows that the returns of DSE is highly volatility persistence and tend to go away from mean infinitely. But when they use 2nd set of data, then it is seen that the volatility persistence reduce and mean-reverting tendency is observed. It is also seen that the investors of DSE remain indifferent between positive and negative shocks to volatility and they do not demand any risk premium for additional risk since insignificant risk-return relationship is observed. GARCH model captures the heteroscedasticity nature of return. They have also seen that variance is predictable from the information of past variance but it has no use to investors because risk-return relationship is not present in DSE.

Basher et al. (2007) investigate the time varying risk and return relationship in this study. They also study the impact of circuit breaker and lock-ins on the volatility of DSE. They examined the distribution of return and stochastic processes of such distributions of return. Daily closing prices of DSE are used for the period of September 01, 1986 to January 30, 2002. They use 5-day average data to construct weekly data. The return is calculated as the log difference of DSE stock price index. Sample period divided into two sub period: period before and after the market was open for international investors. In this study, the employ GARCH approach, because it allows for an empirical assessment of the relationship between risk and return that is the consistent with the nature of leptokurtosis and volatility clustering. First they employ simple autoregressive specification of the error and Box-Jenkins method and sensitivity tests suggest AR(1) is a reasonable and parsimonious for DSE daily index. Then, they examine residual from AR(1) specification for the for presence of GARCH effects. AR(1)-GARCH(p,q)-M model jointly employed by the BHHH algorithm. Then after Box-Jenkin and Breusch- Godfrey likelihood ration tests are use to check the specification of GARCH-M (1,1) model. They employ GARCH(1,1) model to examine the impact of circuit breaker and lock-ins on the volatility. From the above study it has been seen that there is a negative skewness, excess kurtosis and deviation from normality in DSE return. In addition, there is a significant serial correlation in DSE return indicating stock market inefficiency. It has been seen that the relationship between conditional volatility and DSE return is very significant. But the risk return parameter found to be both negative and positive. While the negative sign of risk return coefficient is not consistent in portfolio theory, it is theoretically possible in emerging markets as investors may not demand higher risk premium if they are better able to bear risk at times of particular volatility(Glosten et al., 1993). It is also found that the lock-in provisions do not have any overall impact on stock market volatility but the imposition of circuit breakers seems to have significant influence over the volatility of realized return. Beside this information asymmetry may play a circuit crucial part in infusing the distribution of return among the investors.

Mollah (2009) investigates the time varying risk return relationship and persistence of shocks to volatility in Bangladesh stock market. The daily all share price index of DSE is used for the period of 1986 to 2007. In this study GARCH type models like- GARCH (1,1), GARCH (2,1) and GARCH (2,2) are used for conducting the research work. The positive skewness and excess kurtosis reveal the non normality of the DSE return series. It is found that a very positive and significant autocorrelation is existed in DSE equity return which is symbols of weak form market inefficiency. The findings of GARCH models suggest that there is a significant relationship between conditional volatility and stock returns. The sum of the volatility persistence parameter ($\alpha+\beta$) is greater than one which indicates the tendency of volatility response to shocks to display a long memory in Bangladesh stock market and this nature is consistent with the nature of other emerging stock market.

Hossain and Uddin (2011) examine efficiency and conditional volatility of DSE using three price indices DSEG, DSI and DSE20. They use autocorrelation function for measuring the dependency of successive terms in stock return of DSE and ADF and Phillips and Perron (PP) tests for testing the hypothesis of weak form efficiency(random walk of stock return). They also use the ARIMA(p,d,q) model so that they can decompose information variables into their anticipated and unanticipated components. The authors consider another conflicting view point that the market may be influenced by volatility then result of efficiency test may be significantly different. For this reason GARCH-M model has been employed to capture volatility clustering in financial data. The result of auto correlation function, ADF and PP test and also result of ARIMA models do not support the hypothesis of weak form market efficiency of DSE. The GARCH(p,q)-M models indicate significant departure from the hypothesis of weak form efficiency. In case of volatility testing, the empirical analysis supports the significant relationship conditional volatility and stock return of DSE. The sample estimates indicate that the risk return relationship is positive for DSI and DSE20 but negative for DSEG. They said positive risk-return relationship is consistent with portfolio theory but when it is negative then this not consistent. They have seen that look-in provision and circuit breaker system have significant negative effects on volatility but caretaker government influences stock market volatility positively because of huge fund inflow in stock market during the period.

Table 3.5: Summary of Empirical Studies on Volatility in Dhaka Stock Exchange

Researcher/s	Market/s	Sample period	Tools	Results
Imam and Amin (2004)	Bangladesh capital market		GARCH (1,1)	There is persistence in volatility and the conditional volatility after the crash of 1996 is mean reverting. Current information has no effect on the long run forecasts, rather old news influence more in estimating volatility.
Chowdhury and Iqbal (2005)	Dhaka Stock Exchange	1989 to 2001	ARCH, ARCH-M, GARCH and TGARCH	The returns of DSE is highly volatility persistence and tend to go away from mean infinitely the investors of DSE remain indifferent between positive and negative shocks to volatility and they do not demand any risk premium for additional risk since insignificant risk-return relationship is observed. variance is predictable from the information of past variance but it has no use to investors because risk-return relationship is not present in DSE.
Basher et al. (2007)	DSE	1986 to 2002	AR(1)-GARCH (1,1)-M	$\alpha+\beta$ is greater than one which indicates volatility persistence response to shocks to display a long memory. δ is negative and significant indicate inconsistent with portfolio theory.

(*Continued on next page*)

Researcher/s	Market/s	Sample period	Tools	Results
Mollah (2009)	Bangladesh stock market	1986 to 2007	GARCH (1,1), GARCH (2,1) and GARCH (2,2)	The sum of the volatility persistence parameter (α+β) is greater than one which indicates the tendency of volatility response to shocks to display a long memory in Bangladesh stock market and this nature is consistent with the nature of other emerging stock market.
Hossain and Uddin (2011)	DSE	1993 to2010 for DSI and 2001 to2010 DGEN and DS20	ADF,PP ARIMA, ARCH-LM, GARCH-M	ARCH and GARCH parameters are significant and indicate volatility clustering. -Volatility persistence is seen for DSI but shock dry out for DGEN and DS20. Risk return relationship is found for DS20 not otherwise

In this section, we have gone through a huge research works regarding stock market volatility on developed and emerging markets. Using various econometric models, especially GARCH type models, they have tried to capture volatility clustering. Persistence, leptokurtosis and leverage impact. Sometimes variables like trading volume, interest rate, exchange rate etc. are added as an exogenous variable in GARCH modeling framework to show the impact of such variable on stock market volatility. Beside these, comparisons have been taken place among the models from the view point of efficiency of these models in capturing and forecasting volatility phenomenon in return series. But in our country, there are very few works on stock market volatility. Some bodies have studied the relationship between return and volatility using GARCH-M model and found that the relationship is negative and insignificant in most cases which is not consistent with the theory of finance. Beside this, Chowdhury and Iqbal (2005) used TGARCH model to capture information asymmetry (leverage impact) on return volatility and conclude that the investors remain indifferent between positive and negative shocks, indicating no leverage impact in our market. Still, as far my knowledge, no body has studied the relationship between trading volume and volatility on DSE. So, the return volatility relationship, information asymmetry on volatility should be studied further to know the present scenario of our market as well as trading volume and volatility relationship should be examined. In our study, we will pay an endeavor to go through thorough the above mention matters.

3.6 Conclusion

In this chapter, Literatures concerned with weak form efficiency and the relevance of this hypothesis in different stock markets are discussed. Literatures relating to different types of GARCH models which capture the various aspects of volatility in stock markets returns are also discussed here. We have got a vast idea about stock market efficiency and volatility in this chapter as well as determined the research gap in this field where we can put our efforts.

Chapter-Four

Data and Empirical Methodology

4.1 Introduction

The ultimate objective of this study is to measuring market efficiency and modeling volatility of stock returns in Dhaka Stock Exchange (DSE). In case of efficiency analysis, we have considered only weak form version of efficient market hypothesis, i.e., current price of stocks reflect all information contained in sequence of past price. To achieve this goal, we must go through a massive empirical analysis like, autocorrelation test, run test, unit root test, variance ratio test and ARIMA modeling. On the other hand, estimating return volatility is very vital issue of our study. A common and ready measure of volatility (conditional variance) is standard deviation, which is considered as standard tool applied in financial markets. This tool estimates sample standard deviation of the returns over a sample period. But there are some problems in its applications as well as choosing the sample period. If we consider a very long period sample, then it may be very irrelevant for today and if it covers very short period of time, it may be very noisy. Most of the investors and financial analysts are concerned about the uncertainty of the returns on their investment, caused by the speculative market prices (and market risk) and instability of business performance (Alexander, 1999). With the development of financial econometrics, some quantitative models have come forward that are able to explain the attitude of investors not only towards expected returns but also towards volatility as well. Conventional econometric models, like OLS, are built on the assumption of homoscedasticity or constant variance. Primarily, the basic model for estimating volatility in stock return using OLS is the naïve random walk. Secondly, AR1-OLS could be estimated for measuring volatility. But it is seen that the financial time series do not behave in a random manner rather exhibit a set of peculiar characteristics. A lot of researchers have documented evidence that the stock returns show phenomenon of volatility clustering or pooling, leptokurtosis and asymmetry. These type observations in financial time series have led to the use of a broad range heteroskedastic models to estimate and forecast volatility of stock market. In this chapter, the recent developments in modeling of market efficiency and modeling of the volatility of stock returns are chalked out.

4.2 Data

In this study, our main objectives are to examine the weak form efficiency and modeling volatility of Dhaka Stock Exchange (DSE) which is the prime stock exchange of Bangladesh. To conduct the empirical analysis, the study uses the daily closing stock price indices of DSE. Two main indices, namely, DSE General Price Index (DGEN) and DS20 indices are taken into consideration. Sample period covers for DGEN index from November 27, 2001 to November 29, 2012 and total number of observation is 2766. On the other hand, sample period covers for DS20 index from January 01, 2001 to November 29, 2012 and total number of observation is 3012. The DGEN index only comprises A, B, G and N categories shares. The companies which are called AGM regularly and declared dividend 10% and more, included in category A. The companies which are called AGM regularly and declared dividend less than 10%, included in category B. Newly listed companies are included in N categories and G comprises Greenfield companies. The DGEN is the well accepted and popular index to all shareholders because it provides a complete representative picture of DSE. The DS20 index has been taken under consideration as a proxy of the movement of A categories shares. In addition, we also consider trading volume to study the contemporaneous relationship between trading volume and volatility.

Share market is very much vulnerable to change in governments and their policies. We would like to test whether the different political regime affect the stock market efficiency and volatility or not. Based on the tenure of last three governments, we divide the entire data into three groups. October 02, 2001 to October 15, 2006 is considered as first regime; October 16, 2006 to December 30, 2008 is considered as second regime and January 01, 2009 to November 29, 2012 is considered as third regime.

All data have been collected from DSE data stream and different publication of DSE. Software Eviews 7 has been applied for conducting empirical analysis.

4.3 Appropriate Model for the Study

This study primarily deals with estimating the level of efficiency, then after, we will examine and estimate the nature of volatility of stock market of Bangladesh. To do such, we must go through the quantitative analysis. We will mention the different models that are applicable and appropriate to attain the objectives are as follows:

4.3.1 Stock Market Efficiency Modeling Technique

Stock market efficiency generally expressed as a lack of predictability of returns in excess of normal returns. If the market is efficient, then the current stock prices are fully and instantaneously reflected by all kinds of information. Under the hypothesis of weak form efficiency, the prices of securities must follow a random walk process or stochastic process and the current prices of stocks cannot be predicted by analyzing past trend in prices of that stock (Fama, 1970).

So, as per pure random walk model price will depend on:

$$InP_t = \alpha + InP_{t-1} + \epsilon_t \qquad (4.1)$$

This procedure is known as random walk or unit root process, where P*t* is the price of asset at time *t, α* is the drift term, P*t-1* is the price of asset at previous period and *εt* is the error term which is identically and independently distributed (iid) with zero mean and constant variance.

The daily market returns are used instead of closing prices of index. Daily returns are calculated as first difference in logarithm of daily closing prices of the DSE indices of successive days. That is,

$$r_t = \log p_t - \log p_{t-1} \qquad (4.2)$$

Where, r_t stand for return of day t, p_t stand for closing market index of DSE at day t and p_{t-1} stand for closing market index of DSE at day $t-1$.Justification of taking logarithm in both side are proven by theoretically and empirically. Logarithmic returns are tractable when linking returns over a longer interval. Empirically, logarithmic returns are more likely to be normally distributed, which is a prior condition of standard statistical techniques (Strong, 1992).

4.3.2 Basic Statistics for Data

To specify the distributional properties of the daily stock market prices (p_t) and DSE return series (r_t) during the period of this study, we must calculate and report various basic statistics and pay special attention on the followings:

Skewness- is the standardized 3rd central moment of a distribution. Positive skewness indicates that the distribution has a long right tail; negative skewness indicates a long left tail and both cases the indications confirm a non symmetric return. Zero skewness indicates symmetry around the mean.

Kurtosis(K)- is the standardized 4th central moment of a distribution. Kurtosis of normal distribution is 3. $K>3$ indicates that the distribution is leptokurtic that is fat tail and $K<3$ indicates a peakedness.

Jarque-Bera: is a test for normality. It confirms the null hypothesis of normality of the daily returns of DSE should be rejected at a certain significant level or not.

Hypothesis

The objective of this study is to examine the weak-form of efficiency for Dhaka Stock Exchange (DSE) using rigorous parametric and nonparametric tests. The null and alternative hypotheses are:

H_0: The DSE follows a random walk (it is weak-form efficient) for the period of study.

H_1: The DSE does not follow a random walk (it is not weak-form efficient) for the period of study.

4.3.3 Autocorrelation Test

This test is often used in order to measure the relationship between the stock return at the current period and its value in the previous period. An autocorrelation test is the most commonly used first tool for randomness. Autocorrelation test measures the correlation coefficient between a series of returns and lagged returns in the same series, whether the correlation coefficients are significantly different from zero. The autocorrelation in returns of Dhaka Stock Exchange are tested whether returns can be characterized by serial dependence.

Given a covariance-stationary time series r_t and the k^{th} order autocorrelation coefficient denoted as $(\rho)k$, the model of serial correlation coefficient is:

$$\rho(k) = \frac{Cov(r_t, r_{t-k})}{\sqrt{Var(r_t)}\sqrt{Var(r_{t-k})}} = \frac{Cov(r_t, r_{t-k})}{Var(r_t)} \quad (4.3)$$

where $(\rho)k$ is the autocorrelation coefficient of time series r_t; r_t is the return on a security at time t, k is the lag of the period. $Cov(r_t, r_{t-k})$ Denotes the covariance between the return of an index over time period t and its lagged return t-k periods earlier, and $Var(r_t)$ denotes the variance on the return of a security over time period t.

The Q-statistic is used to test whether the all autocorrelations is significantly different from zero. Box and Pierce (1970) formed the Q-statistic as follows:

$$Q_k = n \sum_{k-1}^{m} \rho^2 (k) \quad (4.4)$$

Under null hypothesis all values of $\rho(k) = 0$, Q_k is asymptotically Chi-Squared (χ^2) distributed with m degrees of freedom, m is the maximum lag length and n is the sample size. The perception behind the use of the statistic is that high sample autocorrelations lead to large values of Q. If the calculated value of Q exceeds the appropriate value in a χ^2 table, we can reject the null hypothesis of no significant autocorrelation at the appropriate significance level. Rejecting the null hypothesis means accepting an alternative that at least one autocorrelation is not zero. (Enders, 2004) Under the same hypothesis, Ljung and Box (1978) provide the finite-sample correction that yields a better fit to the χ^2 distribution for small sample sizes:

$$Q_{LB} = n(n+2)\sum_{k=1}^{m}\frac{\rho^2(k)}{(n-k)}, \quad \sim\chi^2 \tag{4.5}$$

where $\rho(k)$ is the estimated autocorrelation coefficients, k is a given lag; k takes the values of 1 to 12 lags and n is the sample size. If the calculated value of Q_{LB} exceeds the critical value of χ^2 with m degrees of freedom, then at least one value of $\rho(k)$ is statistically different from zero at the specified significance level.

4.3.4 Run Test

A runs test is another common approach to test for statistical independencies but it does not require normally distributed data. The runs test is a non-parametric test that is designed to examine whether successive price changes are independent. We can define a run as an uninterrupted sequence of one symbol or attribute. The number of runs is computed as a sequence of the price changes of the same sign (such as; + + or – –). In other words, length of a run is the number of elements in it. The test is based on the principle that if a series of a data is random, the observed number of runs in the series should be close to the expected number of runs. The non-parametric runs test is applicable here as a test of randomness for the sequence of return. Accordingly, it tests whether returns in DSE are predictable.

The null hypothesis of randomness is tested by observing the number of runs or the sequence of successive price changes with the same sign, positive, zero or negative. To assign equal weight to each change and to identify direction of consecutive changes, each change in return is classified according to its position with respect to the mean return. Hereby it is a positive change when return is greater than the mean, a negative change when the return is less than the mean and zero when the return equals to the mean. (Campbell et al. 1997) The runs can be carried out by comparing the actual runs (R) to the expected number of runs (m) using following equation:

$$m = \frac{2n_1 n_2}{n_1 + n_2} + 1$$

where n_1 denotes the number of positive observations, n_2 is the number of negative observations and m is the expected number of runs. For a larger number of observations ($N > 30$), the expected number of runs m is approximately normally distributed with a standard deviation σ_m of runs as specified in the following formula:

$$\sigma_m = \sqrt{\frac{2n_1 n_2(2n_1 n_2 - n_1 - n_2)}{(n_1+n_2)^2(n_1+n_2-1)}}$$

Then the standard normal Z-statistic used to conduct a run test is obtained by:

$$Z = \frac{R - m \pm (1/2)}{\sigma_m}, \qquad Z \sim N(0,1) \tag{4.6}$$

Where R is the actual number of runs, and 1/2 denotes the correction factor for continuity adjustment (Ma and Barnes 2001), in which the sign continuity adjustment is positive if $R \leq m$, and negative if $R \geq m$. A negative Z value indicates a positive serial correlation, whereas a positive Z value indicates a negative serial correlation. The positive serial correlation implies that there is a positive dependence of stock prices, therefore indicating a violation of random walks. Since the distribution Z is N(0,1), the critical value of Z at the five percent significance level is ±1.96.

4.3.5 Variance Ratio Test

The Variance Ratio approach has gained popularity and has become standard tool in random walk testing. Variance Ratio test first introduced by Lo and MacKinlay (1988), examines the predictability of time series data by comparing variances of differences of the data (returns) calculated over different intervals. If we assume the data follow a random walk, the variance of a q-period difference should be q times the variance of the one-period difference. Evaluating the empirical evidence for or against this restriction is the basis of the variance ratio test. The variance ratio examines the uncorrelated residuals in series, under the assumption of both homoscedastic and heteroscedastic random walk. The variance ratio (VR_q) is calculated as follows:

$$VR_{(q)} = \frac{\sigma^2(q)}{\sigma^2(1)} \qquad (4.7)$$

Where $\sigma^2(q)$is the unbiased estimator of $1/q$ of the variance of q^{th} difference and $\sigma^2(1)$ is the variance of first difference.

Under the hypothesis of homoscedasticity, the first test statistic $z(q)$ is expressed as follows:

$$z(q) = (VR(q) - 1)/\sqrt{(v(q))} \;\sim N(0,1)$$

Where, $$v(q) = \frac{[2(2q-1)(q-1)]}{3q(nq)}$$

The second test statistic $z^*(q)$ is developed under the hypothesis of heteroscedasticity and expressed as follows:

$$z^*(q) = \frac{VR(q)-1}{\sqrt{v*(q)}} \;\sim N(0,1)$$

Where, $$v*(q) = \sum_{k=1}^{q-1} \left[\frac{2(q-k)}{q}\right]^2 \emptyset(k)$$

Both the *z(q)* and *z*(q)* statistics test the null hypothesis that *VR(q)* =1 or the selected return series follows a random walk. When the random walk hypothesis is rejected and *VR(q)* > 1, returns are positively serially correlated. As pointed out by Urrita (1995), for emerging stock markets positive serial correlation in returns could simply describe market growth. When the random walk hypothesis is rejected and *VR(q)*<1, returns are negatively serially correlated. The situation is often described as a mean-reverting process and consistent. This has been interpreted as a signal of bubble in emerging financial markets.

4.3.6 Unit Root Tests

Unit root means the time series is integrated of order one. The unit root tests are used directly to investigate the random walk hypothesis. A series with unit root is said to be non-stationary indicating random walk. If the Dhaka stock Exchange is inefficient in the weak form, then it implies that market prices do not follow a random walk. Random walk requires that the time series must contain a unit root. Unfortunately, it is well known that unit-root tests have low power and that results can vary with the types of test used and on the number of lags included in the test equations. For this reason, it becomes a strategy among the researchers to examine the results of several test procedures in order to draw conclusions regarding variable integration. With this in mind, four unit root tests procedures are performed: (i) most widely used Augmented Dicky-Fuller (ADF) test of Dicky and Fuller (1979, 1981) (ii) the asymptotically most powerful DF-GLS test of Elliott *et al.* (1996), (iii) the nonparametric Phillips-Perron (PP) test and (iv) the Kwiatkowski *et al*. (1992) LM test (KPSS).

4.3.6.1 The Augmented Dickey-Fuller (ADF) Test

A weakness of the original Dickey-Fuller test is that it does not take account of possible autocorrelation in the error process ε_t. If ε_t is autocorrelated (that is, it is not white noise) then the ordinary least squares estimates of the equation and its variances are not efficient. A simple solution is to use lagged left-hand side variables as additional explanatory variables to approximate the autocorrelation. This test, called the Augmented Dickey-Fuller (ADF) test, is widely regarded as being the most efficient test from among the simple tests for integration and is at present the most widely used in practice. The Augmented Dickey-Fuller (ADF) tests for an autoregressive unit root are based on the following ordinary least squares regression equations:

$$\Delta y_t = \delta y_{t-1} + \sum_{i=1}^{m} \phi_i \Delta y_{t-i} + \varepsilon_t \tag{4.8}$$

$$\Delta y_t = \alpha + \delta y_{t-1} + \sum_{i=1}^{m} \phi_i \Delta y_{t-i} + \varepsilon_t \tag{4.9}$$

$$\Delta y_t = \alpha + \gamma t + \delta y_{t-1} + \sum_{i=1}^{m} \phi_i \Delta y_{t-i} + \varepsilon_t \tag{4.10}$$

The difference between the three regressions in equations (4.8) to (4.10) concerns the presence of the deterministic elements α and γ. The first regression equation in (4.8) is a pure random walk model, the second regression equation (4.9) adds an intercept or drift term, and the third in equation (4.10) includes both a drift and linear time trend. In all cases the null hypothesis is that the tested time series variable contains a unit root, that is, $\delta = 0$. The test statistic is the conventional least squares regression t statistics usually computed for testing the appropriate null hypotheses and rejection of this hypothesis means that the time series does not contain a unit root and is stationary.

4.3.6.2 Phillips-Perron Unit Root Tests

Phillips and Perron (1988) developed a number of unit root test that has become popular in the analysis of financial time series. The Phillips-Perron (PP) unit root tests differ from the ADF tests mainly in how they deal with serial correlation and heteroscedasticity in the errors. In particular, where the ADF tests use a parametric autoregression to approximate the ARMA structure of the errors in the test regression, the PP tests ignore any serial correlation in the test regression. The PP tests incorporate an automatic correction to the DF procedure to allow for autocorrelation residuals (Brooks, 2008). The test regression for the PP tests is

$$\Delta y_t = \beta' D_t + \pi y_{t-1} + u_t \tag{4.11}$$

Where u_t is $I(0)$ and may be heteroscedastic and D_t is the deterministic component.

Under the null hypothesis that $\pi = 0$, the PP Z_t and Z_π statistics have the same asymptotic distribution as the ADF t-statistic. The PP tests correct for any serial correlation and heteroscedasticity in the errors u_t of the test regression by directly modifying the test statistics. One advantage of the PP tests over the ADF tests is that the PP tests are robust to general forms of heteroscedasticity in the error term u_t. Another advantage is that the user does not have to specify a lag length for the test regression.

4.3.6.3 Dickey-Fuller Test with GLS Detrending (DF-GLS Test)

As discussed earlier, we may include a constant, or a constant and a linear time trend in our ADF test regression. We are concerned about the appropriate form to use a constant and/or trend term since we do not know the actual data-generating process. To overcome this problem, we use the alternative procedure proposed by Elliott *et al.*

(1996): the DF-GLS test. It is a modification of the ADF test. The basic idea of DF-GLS test is to detrend data before applying ADF unit root tests. Since the data is already detrended, the constant or time trend variables will be taken out prior to running the ADF tests.

$$\Delta Y_t^d = \pi Y_{t-1}^d + \sum_{j=1}^{p} \emptyset_j \, \Delta Y_{t-1}^d + \epsilon_t \qquad (4.12)$$

ΔY_t^d is the detrended time series data. The equation is like as ADF test regression which omits the deterministic terms and compute t statistic for testing null hypothesis, Ho: π=0.

4.3.6.4 Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Test

One potential problem with all the unit root tests so far described is that they take a unit root as the null hypothesis. Kwiatkowski et al. (1992) provide an alternative test (which has come to be known as the KPSS test) for testing the null of stationarity against the alternative of a unit root. This method considers models with constant terms, and either with or without a deterministic trend term. Thus, the KPSS test tests the null of a level or trend-stationary process against the alternative of a unit root. Formally, the KPSS test statistic, LM, is equal to:

$$LM = \frac{\sum_{t=1}^{T} S_t^2}{T^2 f_0} \qquad (4.13)$$

Where, f_0 is an estimator of the residual spectrum at frequency zero and where S_t is a cumulative residual function:

$$S_t = \sum_{i=1}^{t} \hat{\varepsilon}_i \qquad (4.14)$$

The critical values for the LM test statistic are based upon the asymptotic results presented in Kwiatkowski *et al*. (1992).

4.3.7 Autoregressive Integrated Moving Average, ARIMA (p,d,q)

Autoregressive Integrated Moving Average (ARIMA) model is introduced by Box and Jenkins (1984). In addition to above statistical technique, a dynamic time series model, ARIMA, is employed in this study to examine the weak form efficiency of DSE. Current stock prices or returns depends not only its past value but also past and current disturbance terms. Theoretically the weak form efficiency of a market persists when we cannot predict the share prices from its historical price information. When the share return can be predicted on the basis of past returns and on forecasted error together, this gives rise to ARMA model. Cuthbertson (1996) stated that if the weak form efficiency does not hold then the actual return might not only depend upon past returns but could also depend on past forecast errors. The ARMA model decomposes the variable information and indicates whether the stock price is a function of its past value and/or the current and past values of the disturbance term. Here, we do use ARIMA model in exchange of ARMA because it includes the integrated process. It is known that , as per Random Walk (RW) or weak form efficiency share price cannot be predicted by using past information. So, the random walk model needs to fit the model ARIMA (0,1,0) because future share prices will not be influenced by the lagged value share prices or on the lagged value of the error terms. If the coefficients of the model become statistically significant and different from zero then it will indicate that there is a influence of past prices or error terms or both on future prices or returns, which violates the assumption of random walk model and weak form efficiency.

ARIMA (p,d,q) model includes three types of parameter, that is, the autoregressive parameters (p), the number of differencing (d) and moving average parameter (q). For a given time series process Y_t, ARIMA (p,0,0) indicates a *Pth* order autoregressive AR(p), that is –

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \ldots + \alpha_p Y_{t-p} + \mu_t \qquad (4.15)$$

And ARIMA (0,0,q) model indicates a qth order moving average process. MA(q) can be written as follows:

$$Y_t = \alpha_0 + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \ldots + \beta_q \varepsilon_{t-q} + \mu_t \qquad (4.16)$$

The above two equations indicate AR(p) and MA(q). ARIMA is a combination of both the equations. The ARIMA (p,0,q) and ARIMA (p,1,q) in the following way:

The ARIMA (p,0,q)

$$Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j} + \varepsilon_t \qquad (4.17)$$

The ARIMA (p,1,q)

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j} + \varepsilon_t \qquad (4.18)$$

Where Δ stand for the first difference of the series (index value), Yt stand for stock index value at time *t* and *p* and *q* are the number of autoregressive and moving average terms respectively.

4.3.8 Box–Jenkins Methodology

In time series analysis, the Box–Jenkins (1984) methodology, named after the statisticians George Box and Gwilym Jenkins, applies autoregressive moving average ARMA or ARIMA models to find the best fit of a time series to past values of this time series, in order to make forecasts. The Box-Jenkins methodology are described by the following procedure:

i. A class of models is considered assuming a certain hypothesis.
ii. To identify a model the appropriate values of p, d and q have to be searched.
iii. Having identified values of p, d and q next step is to estimate the parameter of AR and MA terms included in the model.
iv. If the model is validated using statistical hypothesis testing, then go to step(v); otherwise return to step (ii) to refine the model. Thus, the Box-Jenkins methodology is an iterative process.
v. The model parameters are defined and out-of-sample forecasting can be initiated.

We can easily show the process in Figure 4.1.

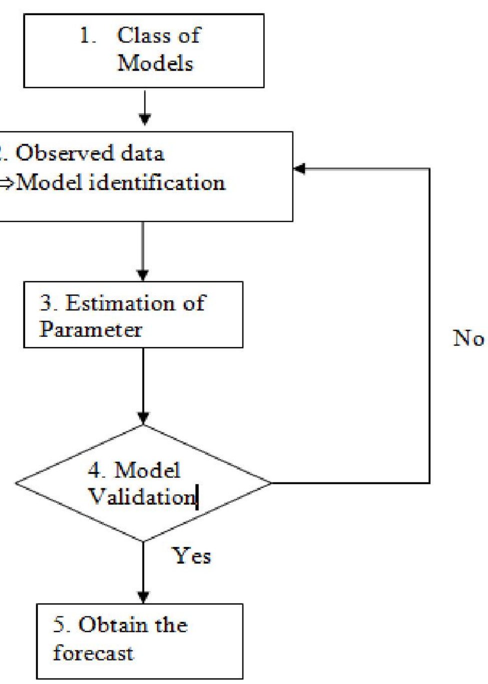

Figure 4.1: Flowchart of Box–Jenkins Methodology

4.3.9 Akaike Information Criterion

The Akaike information criterion (AIC) is a measure of the goodness of fit of a statistical model. It was developed by Hirotsugu Akaike, under the name of "an information criterion", and was first published by Akaike in 1974. It is grounded in the concept of information entropy, in effect offering a relative measure of the information lost when a given model is used to describe reality. It can be said to describe the tradeoff between bias and variance in model construction, or loosely speaking that of accuracy and complexity of the model.

The AIC is not a test of the model in the sense of hypothesis testing; rather, it provides a means for comparison among models—a tool for model selection. Given a data set, several candidate models may be ranked according to their AIC, with the model having the minimum AIC being the best. From the AIC values one may also infer that e.g. the top two models are roughly in a tie and the rest are far worse.

In the general case, the AIC is

$$AIC = 2k - 2\ln(L)$$

where k is the number of parameters in the statistical model, and L is the maximized value of the likelihood function for the estimated model.

4.4 Volatility Modeling Technique

A lot of research works have been conducted on modeling and forecasting stock market volatility by applying of ARCH model and its generalized form GARCH specifications and their large extensions. We have seen most the studies focus on developed markets, and to best of our knowledge there are very few empirical studies on the DSE of Bangladesh that are mentioned in literature review. One of the objectives of this study is to model of DSE returns volatility. In that case, we will apply various univariate specifications of GARCH type models for daily observations of the DSE index series. Descriptions of the models are followings:

4.4.1 Testing of Heteroscedasticity

This is most important event before using Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model is to first examine the residuals evidence of heteroscedasticity. To test the presence of heteroscedasticity in residuals of DSE index return series, the Lagrange Multiplier (LM) test for ARCH effects proposed by Engle (1982) is applied. To perform the test, we must go through a procedure for collecting the residuals (e_t). We can get residuals value ordinary least squares regression of the conditional mean equation which might be autoregressive process (AR), moving average process (MV) or a combination of AR and MV process (ARMA).For an example, in ARMA(1,1) process the conditional mean equation will be as

$$r_t = \alpha r_{t-1} + \beta \varepsilon_{t-1} + e_t \tag{4.19}$$

After getting the residuals, e_t, the next step is regressing the squared residuals on a constant and q lags as in the following equations:

$$e_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 e_{t-2}^2 + \cdots + \alpha_q e_{t-q}^2 + v_t \tag{4.20}$$

Where v_t is the white noise error term. Here the null hypothesis is that there is no ARCH effect up to order q can be formulated as follows:

$$H_0: \alpha_1 = \alpha_2 = \cdots = \alpha_q = 0$$

Against the alternative hypothesis

$$H_1 : \alpha_i > 0$$

For at least one case, where i= 1,2,3,…q

The test statistics from the joint significance of the q- lagged squared residuals is defined as TR^2, the number of observations multiplied by the coefficient of multiple correlations, from the regression. The TR^2 is evaluated against $\chi^2_{(q)}$ distribution.

We first run ARMA (1,1) model for conditional mean in the return series as an initial regression. Then we test null hypothesis to detect whether there are any ARCH effect in the residual series for any lag. If ARCH-LM test rejects null hypothesis for any lag included in the model, then it shows a strong evidence of the presence of ARCH effect in the residual series and therefore the variance of the return series is non-constant (heteroscedastic) for all specified periods.

Autoregressive Conditional Heteroscedasticity (ARCH) and its generalization (GARCH) models represent the main techniques that have been applied in modeling and forecasting stock market volatility (Shamiri and Isa, 2009). Discussion about various symmetry and asymmetry specifications of GARCH in the followings:

4.4.2 Symmetric GARCH

GARCH specification deals with error terms of a regression. Under symmetric GARCH models, it is assumed that the positive and negative error terms have the same effect on conditional variance. In other words, good news and bad news have the same effect on volatility. The basic GARCH model has many appealing features that have secured its popularity and usefulness. For example, it can parsimoniously capture leptokurtosis, volatility clustering, nontrading periods, forecastable events, and the relationship between macroeconomic uncertainty and stock market volatility (Carroll and Kearney, 2009). The main symmetric models are discussed below:

4.4.2.1 GARCH(p,q) Model: Bollerslev (1986) proposed a generalized autoregressive conditional heteroscedasticity (GARCH) model which specially generalizes Engel's orginal ARCH model by developing a technique that allows the conditional variance to be an ARMA process. A simple GARCH model is parsimonious and gives significant results (Floros, 2007; Bera and Higgins, 1993; Bollerslev et al., 1992; Connolly, 1989 and Baillie and DeGennaro, 1990). GARCH allows the conditional variance of a stock index to be dependent upon previous own lags (Floros, 2008). In this model, the conditional variance is represented as a linear function of its own lags (Ahmed and Suliman, 2011). The simplest specification of GARCH(1,1) model can be represented for stock return(r_t) and stock return volatility(σ_t^2) as follows:

Mean Equation:

$$r_t = \mu + \varepsilon_t \tag{4.21}$$

Variance Equation:

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \tag{4.22}$$

Where, ω>0, α_1>=0, and β_1>=0

And r_t =return of the assets at time t

μ =average return

ε_t=residual returns, decomposed as $\varepsilon_t = \sigma_t z_t$

where, z_t is standardized residual returns which is iid (independently and identically distributed) with zero mean and variance 1 and σ_t^2 is the conditional variance.

For GARCH(1,1) model the nonnegativity constraints (i,e; ω>0, α_1>=0, and β_1>=0) are needed to ensure that the variance (σ_t^2) is strictly positive (Poon, 2005).

In this model, the mean equation is written as a function constant (μ) with an error term (ε_t). Since σ_t^2 is the one period ahead forecast variance based on past information that is why it is called conditional variance. The conditional variance equation specified as a weighted average function of three terms:

The constant term: ω, which represent long run variance or average variance.

The ARCH term: ε_{t-1}^2, news about the volatility from previous period, measured as the lag of the squared residuals from the mean equation.

The GARCH term: σ_{t-1}^2, last period forecast variance.

The equation of conditional variance, i.e., GARCH models capture the time-varying nature of volatility of the residuals derived from mean equation. This specification is often explained in a financial context, where a stock trader or broker predicts this period's variance by forming a weighted average of a long term average measured by the constant term, the information about volatility observed in previous period (ARCH term), and the forecast variance of last period (GARCH term). Also, the estimate of β shows the persistence of volatility to a shock, alternatively, the impact of old news on the volatility (Floros, 2008). If the assets return was unexpectedly large in either the upward or the downward direction, then the trader will increase the estimation of the variance for next period (Ahmed and Suliman, 2011).

The general specification of GARCH model is, GARCH(p,q) is as under:

$$\sigma_t^2 = \omega + \sum_{i-1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta j \sigma_{t-j}^2 \qquad (4.23)$$

Where, q is the number of lagged of error terms and p is the number of lagged of variance terms.

4.4.2.2 The GARCH in Mean (GARCH-M) Model: The return of securities may vary with varying its volatility. Financial theories suggest that an increase in variance result in a higher expected return. An investor can use the GARCH-M model to modeling such type of phenomenon. Engle et al. (1987) provide an extension to the GARCH model, where the conditional mean is a explicit function of the conditional variance. Such model is known as the GARCH in Mean (GARCH-M) model. The stock return can be represented by GARCH (p,q)-M model as follows:

Mean Equation:

$$r_t = \mu + \delta\sigma_t + \varepsilon_t, \quad \varepsilon_t \sim N(0,\sigma^2) \qquad (4.24)$$

Variance Equation:

$$\sigma_t^2 = \omega + \sum_{i-1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta j \sigma_{t-j}^2 \qquad (4.25)$$

Where, r_t is the stock return, μ is the mean of r_t conditional on past information, the inequality restrictions ω>0, α_1>=0, and β_1>=0 are imposed to ensure that the conditional variance (σ_t^2) is positive. The parameter δ is called the risk premium parameter. The presence of σ_t in mean equation provides a way to directly study the explicit tradeoff between risk and expected return. The significance influence of volatility on stock returns is captured by the coefficient of $\sigma_{t,}$, that is, δ. The coefficient δ represents the index of relative risk aversion (i.e., time-varying risk premium). A positive and statistically significant coefficient, δ, represents that the trader trading stock were compensated by higher returns for carrying higher degree of risk for the same period. If the coefficient, δ, is negative and statistically significant indicates that the investors were penalized for bearing risk (Basher et al., 2007). The GARCH-M model provides a natural tool to investigate the linear relationship between return and variance of market portfolio provided by Merton's(1973, 1980) intertemporal CAPM (Bollerslev et al. 1992).

In some empirical application, the conditional variance term, σ_t^2, appears directly in the conditional mean equation rather than conditional standard deviation form (σ_t). In some cases, lagged form of variance is used rather than contemporaneous variance (σ_t^2). Under the above circumstances the form of mean equation are as follows:

$$r_t = \mu + \delta\sigma_t^2 + \varepsilon_t, \qquad \text{where, } \varepsilon_t \sim N(0,\sigma^2)$$

$$r_t = \mu + \delta\sigma_{t-1}^2 + \varepsilon_t, \qquad \text{where, } \varepsilon_t \sim N(0,\sigma^2)$$

4.4.3 Asymmetry GARCH

A common and interesting phenomenon of stock price is that the bad news has a more prominent impact on stock price volatility than the good news of the same magnitude. An inverse relationship is existed between current return and the future volatility. The tendency of volatility to decline when return rise and to rise when return fall is often called leverage effect (Enders, 2004). The basic limitation of symmetric GARCH models is that they cannot capture the leverage effect because the conditional variance depends on the magnitude of lagged residuals but not their signs. Another important limitation is that the basic GARCH is restricted by nonnegativity constraint. To overcome the limitations many extensions of basic GARCH model have been developed that are known as asymmetric GARCH models. The main models of this class are discussed below.

4.4.3.1 Exponential GARCH (EGARCH) Model: EGARCH model was first presented by Nelson in 1991. The main purpose of EGARCH model is to describe the asymmetrical response of the stock market under the positive and negative shocks. In the EGARCH model the natural logarithm of the conditional variance is allowed to vary over time as a function of the lagged error terms and its own lagged rather than the lagged square errors. Here, conditional variance depends on both the size and sign of error terms (ε_t) EGARCH(1,1) specification can be written as:

$$ln\sigma_1^2 = \omega + \beta_1 ln\sigma_{t-1}^2 + \alpha_1 \left[\left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| - \sqrt{\frac{2}{\pi}} \right] + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \quad (4.26)$$

The logarithmic specification of the EGARCH model ensures the conditional variance is always positive without imposing nonnegativity constraints. For an EGARCH(1,1) model the log variance will thus be a constant, ω, plus three terms. The term β_1 captures the effect of prior variance terms on the current conditional variance and the γ term captures the sign of lagged error terms. When, $\gamma \neq 0$ the effects of the information are asymmetric. The presence of leverage effect can be tested by the hypothesis of $\gamma<0$, that is, when $\gamma<0$, there is a significant leverage effect. If there is a negative relation between returns and volatility, γ must be negative. The absolute value of standardized error terms, $\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$, have an expected value $\sqrt{\frac{2}{\pi}}$ assuming the standardized errors are distributed as a N(0,1). If the absolute standardized errors are greater (less) than expected value, the conditional variance will rise (fall). Hence, the third term in the model captures the magnitude of the lagged error terms. If we compare the above equation with the basic GARCH model, we can see that there are no constraints for the parameters (α,β,ω). This is one of the biggest advantages of EGARCH model compared to basic GARCH model.

4.4.3.2 GJR-GARCH Model: This model first proposed by Glosten, Jagannathan, and Runkel (1993). To model the asymmetry in stock return data this model is used widely. It is assumed that the impact of the square error terms on the conditional variance is different when the error term is positive and when it is negative. GJR therefore introduces an indicator function that takes value 0 (zero) when conditional variance is positive and 1 (one) the variance is negative. The leverage term usually arises when the unconditional returns are skewed. The specification of conditional variance under GJR-GARCH (1,1) model can be written as follows:

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \gamma d_{t-1} \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \tag{4.27}$$

Where, d_{t-1} is a dummy variable, indicates

$d_{t-1}=1$, if $\varepsilon_{t-1}<0$ and implies bad news

$d_{t-1}=0$, if $\varepsilon_{t-1} >=0$ and implies good news

In this model, good news ($\varepsilon_{t-1}>=0$) and bad news ($\varepsilon_{t-1}<0$) have different effect on conditional variance. The γ coefficient is known as the asymmetry or leverage term. When γ =0, the model automatically converted to the standard GARCH form. Therefore, when shock is positive (good news), its impact on conditional variance (volatility) can be determine by α. But negative shock (bad news) has an impact on volatility of $\alpha+\gamma$.

If γ>0, then the leverage effect exists and bad news (ε_{t-1}<0) increases the volatility than the good news ($\alpha + \gamma > \alpha$). Hence, if the γ is positive and statistically significant, negative shocks have a larger effect on conditional variance (σ_t^2) than positive shocks.

General specification of GJR model is

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} (\alpha_i + \gamma_i d_{t-i})\varepsilon_{t-1}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \qquad (4.28)$$

Where, α_i, γ_i and β_j are non-negative parameters satisfying conditions similar to those of GARCH model.

4.4.3.3 The Threshold GARCH (TGARCH) Model: The TGARCH model proposed by Zakoian(1994) is similar in structure to GJR-GARCH model, it models the conditional standard deviation instead of the conditional variance. Specification of conditional standard deviation under TGARCH model is as follows:

$$\sigma_t = \omega + \alpha_1 |\varepsilon_{t-1}| + \gamma d_{t-1} |\varepsilon_{t-1}| + \beta_1 \sigma_{t-1} \qquad (4.29)$$

Where, $d_{t-1}=1$ if $\varepsilon_{t-1}<0$ and $d_{t-1}=0$ if $\varepsilon_{t-1}>0$.

4.5 Modeling the Effect of Trading Volume on Volatility

Studying the relationship between volatility and trading volume, we use volume as a proxy for arrival of information to the market. Examine the relationship between stock returns and trading volume using the Mixture of Distribution Hypothesis (MDH) in the context of information arrival. The MDH gives an explanation for volatility and volume by linking changes in prices, volume and the rate of information flow. We use daily stock index and contemporaneous trading volume of DSE to conduct the study applying

GARCH family models. The GARCH specification allows the current variance to be a function of past conditional variance, allowing volatility shocks to persist over time (Ahmed et al. 2005). It is supported by various research works that there is a relationship between contemporaneous trading volume and squared returns which raises the question of whether trading activity can be identified as one potential source of the observed serial dependence in the return volatility (Clark, 1973; Epps &Epps, 1976; Lamoureux & Lastrapes, 1990; Andersen, 1996). MDH states that stock returns are generated by a mixture of distributions in which the number of information arrivals into the market represents a stochastic mixing variable. Return data can be observed as a stochastic process with a changing second order moment reflecting the intensity of information arrivals. Flow of information into the market is not broadly noticeable, that is why trading volume of stock market is used as a proxy. Methodical ups and downs in trading volume are seemed to be caused by the arrival of new information.

To measure the effect of trading volume on volatility, the daily contemporaneous volume must be added to the conditional variance equation and various GARCH models can be defined as follows:

4.5.1 GARCH (1,1) model with Volume Parameter: The GARCH (1,1) specification with volume parameter is as under:

Mean Equation:

$$r_t = \mu + \varepsilon_t, \quad \varepsilon_t \sim \mathrm{N}(0,\sigma^2) \tag{4.29}$$

Variance Equation:

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \phi V_t \tag{4.30}$$

Where, r_t represents realized return of DSE indices, μ is the mean of the returns, and V_t is the trading volume, which is used as a proxy for information arrival to the market. In this case, the coefficient of V_t, i.e., the ϕ measures the impact of volume on volatility. The degree of persistence in the volatility is measured by the sum of the coefficients α (ARCH effect) and β (GARCH effect). According to the MDH, the GARCH effect in the data can be explained if ϕ is significantly positive and (α + β) should be considerably smaller than the magnitude of persistence in the restricted version of the conditional volatility, which does not include volume.

However, one the basic limitations of GARCH model is that it only captures symmetric response of volatility for both positive and negative market shocks, because conditional variance is regarded as a function of the magnitude of lagged residuals, not their signs. But it has been argued that a negative shock may lead to more volatility than a positive shock of the same magnitude and it is also called asymmetric response. At the moment of studying the relationship between trading volume and volatility, capture the asymmetric response, it would be more logical to use the following asymmetric GARCH models:

4.5.2 Exponential GARCH (EGARCH) with Volume Parameter: To study the relationship between the trading volume and conditional volatility by considering the asymmetric effects**,** EGARCH (1,1) specification with volume parameter can be written as follows:

$$ln\sigma_1^2 = \omega + \beta_1 ln\sigma_{t-1}^2 + \alpha_1 \left[\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right| - \sqrt{\frac{2}{\pi}}\right] + \gamma\frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \emptyset V_t \qquad (4.31)$$

In the above equation, V_t represents the trading volume and served as a proxy of information arrival to the market and ϕ measures the effect of trading volume on conditional variance.

4.5.3. GJR-GARCH Model with Volume Parameter: Specification of GJR-GARCH model with volume parameter can be expressed as under:

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \gamma d_{t-1} \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \phi V_t \tag{4.32}$$

Here also *Vt* is the trading volume and ϕ measures the effect of trading volume on conditional variance.

When ϕ =0 in both EGARCH and GJR-GARCH model, the effect of volume on conditional variance is disregarded. In that case the persistence of volatility is measured by $\alpha + \beta$, where a larger value of the sum of α and β indicates greater persistence of market shock. But if the trading volume is incorporated as a of information arrival, then it is expected that the value of ϕ would be greater than zero (ϕ>0). Furthermore, in the presence of volume with ϕ>0, α and β will be small and statistically insignificant if daily volume is serially correlated. In particular, the persistence of variance as measured by α and β should become negligible if accounting for the uneven flow of information explains the presence of GARCH in the data (Lamoureux &Lastrapes, 1990). All parameters in the variance equations can be estimated using the Brendt, Hall, Hall Hausman (BHHH) algorithm, assuming a student's *t*-distribution.

4.6 Test for Causality between Trading Volume and Volatility

Further we examine the causal (dynamic) relationship between trading volumes and return volatility. To test for Granger causality, we employ a bi-variate vector autoregressive (VAR) model. This technique helps us to examine the linear simultaneous correlation between the variables and further tests whether trading volume precedes volatility or vice-versa. To support the findings of GARCH, EGARCH and

GJR-GARCH models in testing the hypotheses related to the volume and volatility relation, we further check the Granger causality within the VAR approach. The bivariate VAR model can be written as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \sigma_{t-i}^2 + \sum_{i=1}^{p} \phi_i V_{t-i} + \varepsilon_t \tag{4.33}$$

$$V_t = \beta_0 + \sum_{i=1}^{p} \beta_i V_{t-i} + \sum_{i=1}^{p} \gamma_i \sigma_{t-i}^2 + \varepsilon_t \tag{4.34}$$

Where, σ_t^2 represents conditional variance (volatility) and *Vt* represents trading volume. The conditional variance (volatility) time series data is generated by applying the restricted GARCH family model without volume regressor. The null hypothesis of conditional variance (volatility) not to granger cause volume if the coefficient ϕ_i (i=1,2…,p) are all equal to 0 (zero) and volume not to granger cause volatility if the γ_i (i=1,2,..,p) are all equal to 0 (zero). If the coefficient ϕ and γ are significantly different from zero, there is a bivariate feedback interaction between trading volume and volatility. To test the null hypotheses corresponding to examine Granger causality among variables, a standard F-statistic is used in the study.

4.7 Post Estimation Analysis

The true variance process could be different from the one specified by the conditional volatility models. Many diagnostic tests are available in order to test this. The simplest test is to construct the series of residuals, ε_t. This series is supposed to have constant mean and variance if the model is specified correctly. Tests for autocorrelation in the squares are also able to detect model failures. A Ljung and Box (1978) portmanteau test with 15 lagged autocorrelations for ε^2 is often used (Engle, 2001). In the Ljung-Box Q statistic tests, the null hypothesis is that the autocorrelations are all together equal to zero. The alternative is that at least one is non-zero.

4.7.1 Remaining ARCH effects

If a GARCH model captures volatility clustering, the residuals standardized by their conditional volatility $(\varepsilon_t/\sqrt{h_t})$ should have no significant ARCH effects left. Standardized returns are then nearly normally distributed (Alexander, 2001). To test whether there are remaining ARCH effects, Engle's ARCH test is therefore applied to the standardized residuals.

4.7.2 Remaining Autocorrelation

Just as in the pre-estimation analysis, the autocorrelation function is useful in the post estimation analysis. The standardized squared residuals should have no remaining autocorrelation if the GARCH model is well specified (Alexander, 2001). When applying different ARCH class models on the same time-series, and more than one show no autocorrelation in squared standardized returns, a simple procedure is to choose the model giving the highest maximum likelihood for the sample, implying that this model is more likely under the density generated by the volatility forecasts (Alexander, 2001).

4.7.3 Evaluation of Volatility Forecasts

The objective of applied econometrics is often to find the superior forecasting model. Traditionally this is done by direct comparison of the mean squared error (MSE) of the forecasts, while more popular tests in recent literature evaluate the statistical significance of differences in MSE and compare the informational content of forecasts (Harris and Sollis, 2003).

According to Gonzales-Rivera et al. (2004), the task of comparing the relative performance of different volatility models is built on either a statistical loss function or an economic loss function. Statistical loss functions are based on moments of forecast errors, and include statistics such as the mean error (ME), the root mean square error (RMSE), the mean absolute error (MAE) and the mean absolute percent error (MAPE):

$$\text{Mean Error (ME)} = \frac{1}{N}\sum_{t=1}^{N}\varepsilon_t = \frac{1}{N}\sum_{t=1}^{N}\left(\hat{\sigma}_t - \sigma_t\right) \quad (4.35)$$

$$\text{Mean Square Error (MSE)} = \frac{1}{N}\sum_{t=1}^{N}\varepsilon_t^2 = \frac{1}{N}\sum_{t=1}^{N}\left(\hat{\sigma}_t - \sigma_t\right)^2 \quad (4.36)$$

$$\text{Root Mean Square Error (RMSE)} = \sqrt{\frac{1}{N}\sum_{t=1}^{N}\varepsilon_t^2} = \sqrt{\frac{1}{N}\sum_{t=1}^{N}\left(\hat{\sigma}_t - \sigma_t\right)^2} \quad (4.37)$$

$$\text{Mean Absolute Error (MAE)} = \frac{1}{N}\sum_{t=1}^{N}\left|\varepsilon_t\right| = \frac{1}{N}\sum_{t=1}^{N}\left|\hat{\sigma}_t - \sigma_t\right| \quad (4.38)$$

$$\text{Mean Absolute Parcent Error (MAPE)} = \frac{1}{N}\sum_{t=1}^{N}\frac{\left|\varepsilon_t\right|}{\sigma_t} = \frac{1}{N}\sum_{t=1}^{N}\frac{\left|\hat{\sigma}_t - \sigma_t\right|}{\sigma_t} \quad (4.39)$$

The best model would be the one that minimizes such a function of the forecast errors.

4.8 Conclusions

In earlier sections, we have discussed different econometric concepts, tools and models that would be used for conducting entire works to achieving the objective of this study. Section 4.2 contains in details about data. Section 4.3 contains various econometric techniques which deal with estimating the level of efficiency of stock market. Section 4.4 provides a detail out line of different econometric model which are relevant with modeling and forecasting stock return volatility. Section 4.5 and 4.6 describe the models which are relevant with estimating the impact of trading volume on volatility and establishing the causal relationship between volume and volatility. Section 4.7 contains various econometric tools that will be applied to test the validity and efficiency of models.

Chapter-Five

Empirical Results: Market Efficiency

5.1 Introduction

Market efficiency is an important and debatable issue from the very beginning of its inception. In most cases, it has been seen that the developed markets are efficient in weak form but under developed and emerging markets are not efficient in weak form. The purpose of this chapter is to seek evidence of weak form efficiency of Dhaka Stock Exchange. This chapter will be divided into two major categories; one is testing the random walk hypothesis of return series of DSE, which is widely used in examining weak form efficiency of stock markets and another is ARIMA model building and forecasting of future returns i.e., past market returns and its errors are relevant or not in determining in future returns in DSE. For conducting investigation regarding weak form efficiency Unit root test, Run test, Variance ratio test, Autocorrelation test and ARIMA model will be applied on market return data.

5.2 Line Chart of Indices and Returns

Weak form efficiency test is concerned with random walk of return series. It is known that the concept of normality and randomness of a time series is complementary. Normal distribution of price or return series indicates that the series follow random walk. For getting presumption before applying formal tests line chart of the daily closing value of DGEN and DS 20 price series are presented in figures 5.1 and 5.2:

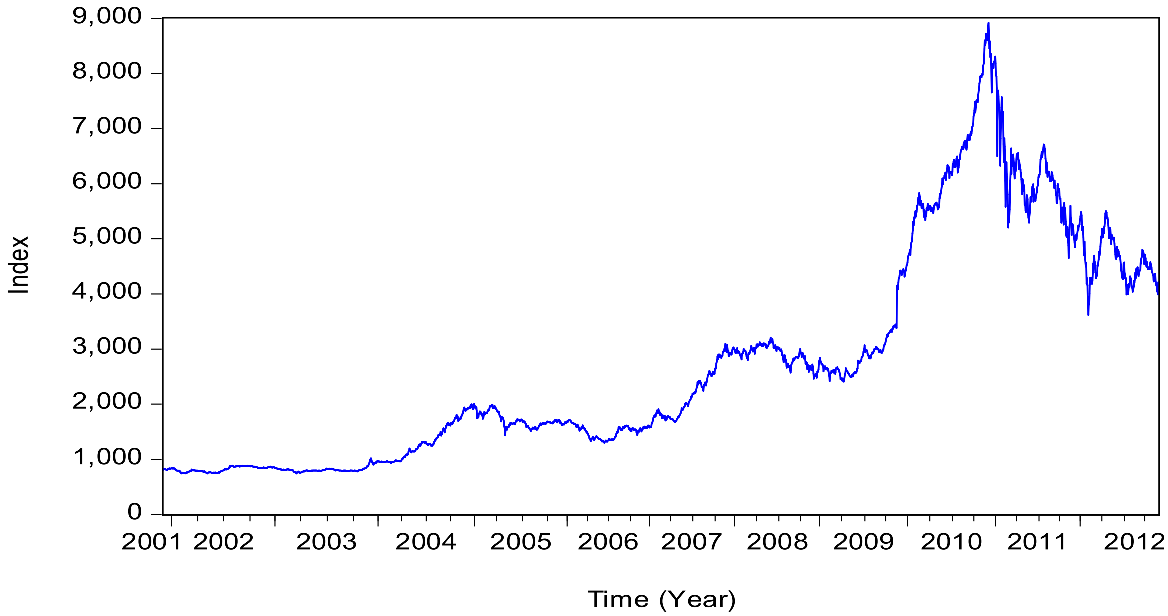

Figure 5.1: Graphical Representation of DGEN Index

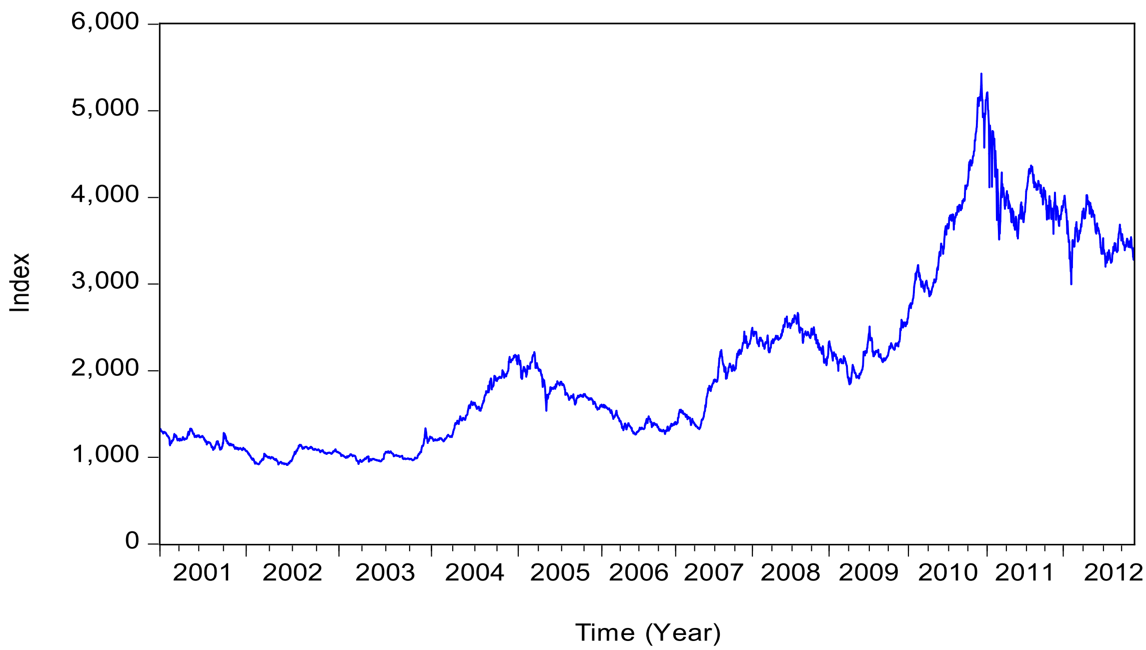

Figure 5.2: Graphical Representation of DS20 Index

The Figures 5.1 and 5.2 show that the movement of two price indexes (DGEN and DS20) of DSE for the full sample period. We can get a general idea how the price indices evolve overtime. Both figures depicted above indicate that up to 2009 market was very steady and slightly up showing but after 2009 market become more volatile. At the end of 2010 both indices become almost three times higher than the beginning indices value of that year. We notice sharp plunging of stock price after 2010 to November 29, 2012.

To test market efficiency, the return series have been used instead of index value as expected returns are more commonly used in asset pricing literature. Market returns are calculated from daily price indices without adjustment of dividend, bonus and right issues because many researchers confirm that their conclusions remain unchanged whether they adjust their data for dividend or not (for example, Lakonishok and Smidt, 1988; Fishe, Gosnell and Lasser, 1993). Here, daily market returns are calculated as first difference in logarithm in daily closing prices of DGEN and DS 20 indices of successive days. That is,

$$R_{mt} = logp_t \;\; - logp_{t-1}$$

Where R_{mt} refers the market return in period t, P_t refers price index at day t and P_{t-1} refers price index at day $t-1$. Justification of using logarithm is that the log normal returns are more likely to be normally distributed which is the prior condition of applying statistical techniques (strong 1992).

The Daily Market Returns of DGEN Index and DS20 Index series are presented in Figures 5.3 and 5.4:

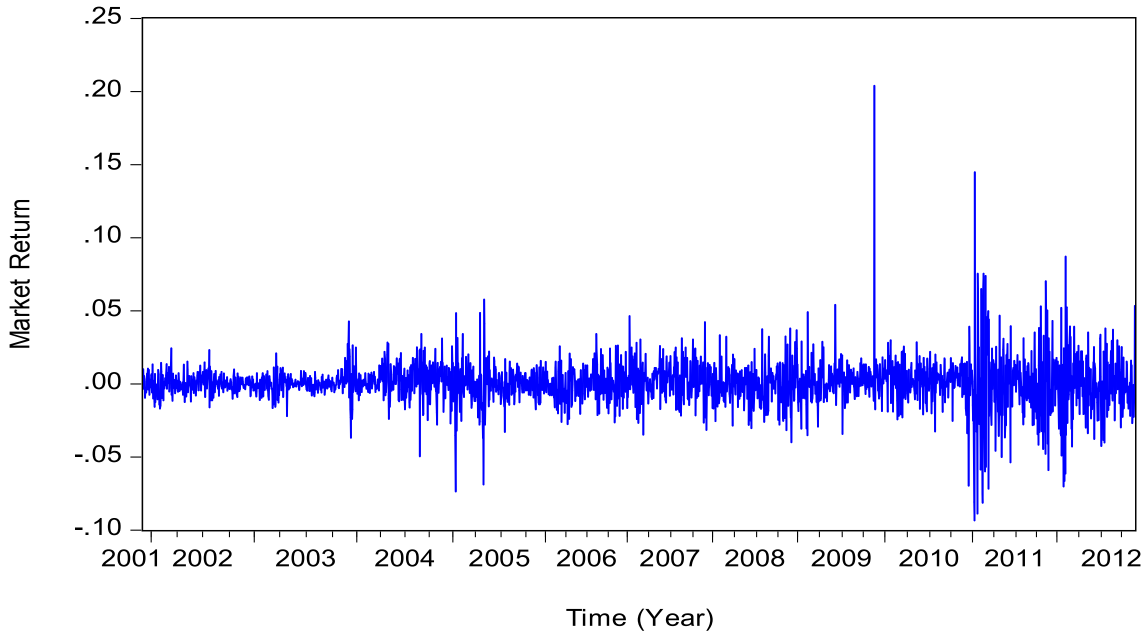

Figure 5.3: Graphical Representation of DGEN Return

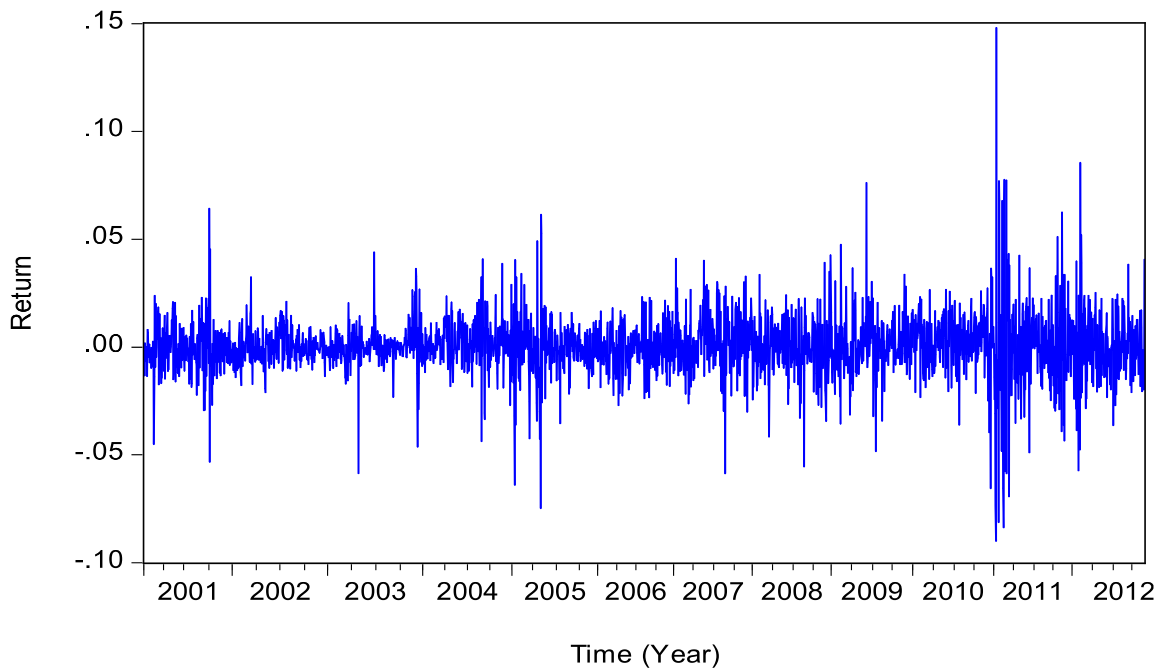

Figure 5.4: Graphical Representation of DS20 Return

Figures 5.3 and 5.4 show that the returns of both market indices and both return series seem to tranquil at earlier period along with large increase and decrease at later period. It seems that the returns of DS20 index have higher variations compared with the returns of DGEN index. The both returns series are fluctuating within the range of ± 4%. Up to 2010 the returns seem to be tranquil and moving around zero line except few outliers. However, after 2010 volatility of market returns increases tremendously.

5.3 Descriptive Statistics of Return Series

To measure the distributional properties of market return series, we report various descriptive statistics in table 5.1:

Table 5.1: Description Statistic for Daily Return Series of DGEN and DS20 Indices

Descriptive Statistics	DGEN	DS 20
Mean	0.000701	0.000314
Median	0.000510	0.000000
Maximum	0.292146	0.147951
Minimum	-0.093300	-0.089924
Std. Dev	0.016084	0.013765
Skewness	2.870859	0.295151
Kurtosis	56.39089	13.48285
JarqueBera Probability	332329.6 0.00000	13825.77 0.000000
Sum	1.940253	0.945043
Sum Sq. Dev.	0.715334	0.570123
Observations	2766	3010

The Table 5.1 shows that the both indices have positive mean returns but mean and median of DGEN are higher than the DS 20. Variability of returns of both indices is not similar rather the return of DGEN is more volatile than the return of DS 20 because of higher standard deviation. For both indices, the returns are positively skewed which means that the large positive returns tend to be larger than the higher negative returns. The level of kurtosis for both indices is higher than three which mean that the return series are leptokurtic. However, the positive skewness and high kurtosis of both return series indicate that the strong departure from normality. The Jarque-Bera test of normality rejects the hypothesis of a normal distribution of the return for both indices at 1% significant level.

From the above discussion it is clear that the return series of DSE is not normally distributed. Thus, one of the major objectives of this study is to examine the weak form efficiency of Dhaka Stock Exchange. For attaining the objective, at earlier in methodology (chapter-4) we set up a null hypothesis (Ho: the DSE return series follow a random mark) and mentioned some techniques to test the hypothesis. Findings of the tests are represented with detailed discussions as under.

5.4 Unit Root Test

A series contains unit root is non stationary and strong evidence of random walk. It is well-known that if the price/return series follow random walk then it cannot be predicted using past information contained in that series. So existence of unit root confirms that the series follow random walk and that is the proof of market efficiency. Here, we do use four types of unit root test, namely, ADF, PP, DF-GLS and KPSS. Hypothesis of these unit root tests are given bellow:

For ADF, PP and DF-GLS,

Ho: the return series contains unit root

H_1: the return series does not contain unit root

For KPSS,

Ho: the return series does not contain unit root

H1: the return series contains unit root

The result of ADF, PP, DF-GLS and KPSS for unit root of DGEN and DS 20 return series are presented in table 5.2:

Table 5.2: Result of Unit Root Test for Whole Period (Full Sample)

Test index	**ADF** (H_0: has unit root)		**PP** (H_0: has unit root)		**DF-GLS** (H_0: has unit root)		**KPSS** (H_0: has no unit root)	
	t-stat	p value	t stat	p value	t stat	Critical value	LM-stat	Critical value
DGEN	-53.6395	0.0001	-53.7042	0.0001	-3.9104	-3.480*** -2.890** -2.570*	0.1972	0.739*** 0.463** 0.347*
DS20	-52.0905	0.0001	-52.0926	0.0001	-8.6275		0.1373	

Note: *, ** and *** indicate critical value at 10%, 5% and 1% levels respectively.

From the Table 5.2, we observe that the ADF, PP, and DF-GLS tests reject null hypothesis (Ho: series contains unit root) for both indices return series at all conventional level of significance. Here, reason behind the rejection of null hypothesis is that the *p* value is less than 1% as well as critical value of *t*-statistics is higher than the estimated *t*-statistics for all cases of first three tests. On the other hand, KPSS test does not reject the null hypothesis (Ho: series does not contain unit root) at all level of significance for both return series. From the above results, we can conclude that the both return series are stationary and thus do not follow the random walk under all unit root tests. So, as per results of unit root tests it would be possible to predict future prices in DSE. Therefore, the market is not efficient in weak form and one can earn excess return using information contained in past price.

Table 5.3: Period wise Results of ADF, PP, DF-GLS and KPSS Tests

Sample Period : Oct. 02, 2001 to 15th October 2006

Index	ADF (H_0: has unit root)		PP (H_0: has unit root)		DF-GLS (H_0: has unit root)		KPSS (H_0: has no unit root)	
	t-stat	p-value	t-stat	p-value	t-stat	Critical value	LM-stat	Critical value
DGEN	-30.7780	0.000	-30.8822	0.000	-3.0653	-2.567*** -1.941** -1.616*	0.2163	0.739*** 0.463** 0.347*
DS 20	-31.6223	0.000	-31.6813	0.000	-0.9679		0.3109	

Sample Period: 16th October 2006 to 30st December 2008

Index	ADF (H_0: has unit root)		PP (H_0: has unit root)		DF-GLS (H_0: has unit root)		KPSS (H_0: has no unit root)	
	t-stat	p-value	t-stat	p-value	t-stat	Critical value	LM-stat	Critical value
DGEN	-21.1613	0.000	-21.1444	0.000	-20.2425	-2.567*** -1.941** -1.616*	0.4368	0.739*** 0.463** 0.347*
DS 20	-20.1135	0.000	-20.2844	0.000	-20.1037		0.2676	

Sample Period: 1st January 2009 to 29th November 2012

Index	ADF (H_0: has unit root)		PP (H_0: has unit root)		DF-GLS (H_0: has unit root)		KPSS (H_0: has no unit root)	
	t-stat	p-value	t-stat	p-value	t-stat	Critical value	LM-stat	Critical value
DGEN	-30.5018	0.000	-30.5073	0.000	-4.0147	-2.567*** -1.941** -1.616*	0.2683	0.739*** 0.463** 0.347*
DS 20	-31.5515	0.000	-31.5436	0.000	-5.1581		0.2230	

Note: *, ** and *** indicate significant at 10%, 5% and 1% levels respectively.

The Table 5.3 represents the results of various unit tests for three different intervals (e,g., Sample: October 02, 2001 to 15th October, 2006; Sample: 16th October, 2006 to 30st December 2008 and Sample: January 01, 2009 to November 29, 2012). It is seen that the ADF and PP tests reject the null hypothesis (Ho: return series contains unit root) at all conventional level of significance (P value is zero) for three different periods. The DF-GLS test, which de-trend data before testing unit root, cannot reject null hypothesis for DS20 return data at any conventional level for the first sub-period but rejects null hypothesis under both DGEN and DS20 data for all sub periods at 1% level of significance (absolute *t*-statistic is greater than the critical value). On the other hand, KPSS unit root test, where null hypothesis is just opposite of other unit root tests, is used to check the previous unit root tests results. It is clearly seen that the KPSS test does not reject the null hypothesis for return series of both indices under all sub period at 10%, 5% and 1% level of significance because the LM- stat is lower than its critical value.

From the above discussion, we can conclude that though DF-GLS test does not reject null hypothesis in case of first period data but in all other cases under all tests it is clearly seen that the return series do not contain unit root. Therefore, the both return series are stationary and do not follow random walk for the whole study period as well as any of the sub period. So, the DSE was not efficient in weak form within our study period.

5.5 Run Test

Run test is a non-parametric test that is used to measure statistical dependencies or randomness of successive price changes. This test is considered as the most powerful test because it does not depend on distributional properties of data. The null hypothesis of this test is as under:

Ho: the return series follow random walk (successive price changes are independent)

Table 5.4: Result of Run Test for Whole Period (Full Sample)

Index	Observation	Actual Run	Expected Run	Z-Statistics
DGEN	2766	1144	1377.57	-8.9206***
DS20	3010	1237	1502.50	-9.6915***

Note: *, ** and *** indicate critical value at 10%, 5% and 1% levels respectively.

The run test is carried out by comparing the actual runs and expected number of runs. When the actual number of runs exceed (fall below) the expected runs, a positive (negative) *Z* value is obtained. A negative *Z* value indicates a positive serial correlation and positive *Z* value indicates a negative serial correlation. The positive serial correlation implies that there is a positive dependence of stock prices (Guidi et al., 2010). From the table 5.6, it is seen that the actual number of runs is significantly lower than the expected number of runs, for this reasons the *Z* values for both return series are negative. The absolute estimated *Z* value for both return series (-8.9206) and (-9.6915) are greater than the critical Z value of ±1.96 (at 5% significance level), and indicate that the null hypothesis for both series are rejected. Thus, the findings of run test indicate that the both return series do not follow random walk. Therefore, we can conclude that the successive price changes are not independent and market is not efficient in weak form.

Table 5.5: Results of Run Test for Both Return Series (Period wise)

Sample Period : 2nd October 2001 to 15th October 2006

Index	Observation	Actual Run	Expected Run	Z-Statistics
DGEN	1305	533	651.62	-6.5862
DS20	1353	521	675.47	-8.4178

Sample Period: 16th October 2006 to 31st December 2008

Index	Observation	Actual Run	Expected Run	Z-Statistics
DGEN	517	200	257.18	-5.0799
DS20	517	231	258.57	-2.4362

Sample Period: 1st January 2009 to 29th November 2012

Index	Observation	Actual Run	Expected Run	Z-Statistics
DGEN	944	410	470.34	-3.9477
DS20	944	400	470.64	-4.6141

Note: *, ** and *** indicate critical value at 10%, 5% and 1% levels respectively.

The Table 5.5 represents the results of run tests for three different periods. From the results of first sub period, it is clearly observe that the number actual runs is lower than the expected runs and absolute value of estimated Z statistics is greater than the critical Z value of ± 1.96 for both return series. Therefore, the null hypothesis is rejected and return series under both indices do not follow random walk during the study period.

The results of sub period October, 2006 to December, 2008 for both indices indicate that the actual run is lower than the expected run. We also observe that the absolute estimated Z statistic again greater than the ± 1.96. So, null hypothesis is again rejected and market was not efficient under the study period.

From the results of the sub period January 2009 to November 2012, we observe that the actual run further again lower than the expected run and absolute estimated Z statistics are higher than the critical Z statistic, ± 1.96. Consequently, we can reject null hypothesis and the market was inefficient in weak form during the period.

Consolidated findings of run test is that the null hypothesis is rejected for all cases, i.e., for full sample period as well as three sub periods. The results indicate that the return series of both indices of DSE do not follow random walk and one can earn excess return using the information lies on past price trend, that means the market is inefficient in weak form. The findings are very similar to the findings of Mobarek and Keasey (2000) on Bangladesh market; Patel et al. (2012) on four selected Asian markets; Hamid, K. et al. (2010) on fourteen Asia-Pacific markets.

5.6 Variance Ratio Test

Variance ratio test is used to investigate the randomness of time series data and relevant with weak form efficiency test of stock market. The null hypothesis under the test is as follow:

Ho: variance ratio should be approximately equal to one

Table 5.6: Results of Variance Ratio Test at Return Series (Full Sample Period)

Index	Period=j	2	4	8	16
DGEN	VR(j)	0.542649	0.256628	0.128678	0.065111
	Z(j)	-8.400230	-8.386234	-7,434209	-5.941367
	P-value	0.0000	0.0000	0.0000	0.0000
DS 20	VR(j)	0.542066	0.256981	0.132704	0.065906
	Z(j)	-8.936610	-8.610382	-7.375062	-5.665928
	p-value	0.0000	0.0000	0.0000	0.0000

Table 5.6 represents the estimated variance ratio (*VRj*), test statistic (*Zj*) and *P*-value of two return series (DGEN and DS20) for full sample period. The variance ratio is reported for multiples of 2, 4, 8 and 16 days with the one day return used as base (Appendix A.1 exhibits variance ratio for 2 to 16 days with *Zj* and *P*-value). From the Table 5.6, it is clearly seen that the all variance ratios are significantly different from one. Here, we also found that the estimated *Zj* statistics are significantly lower than the critical *Zj* statistic at all conventional level of significance and P values are zero in all cases. Therefore, the null hypothesis (H_0: approximately equal to one) under the variance ratio test can be rejected for both return series and that indicates the series do not follow the random walk. As a result, we can conclude the DSE is not efficient in weak form.

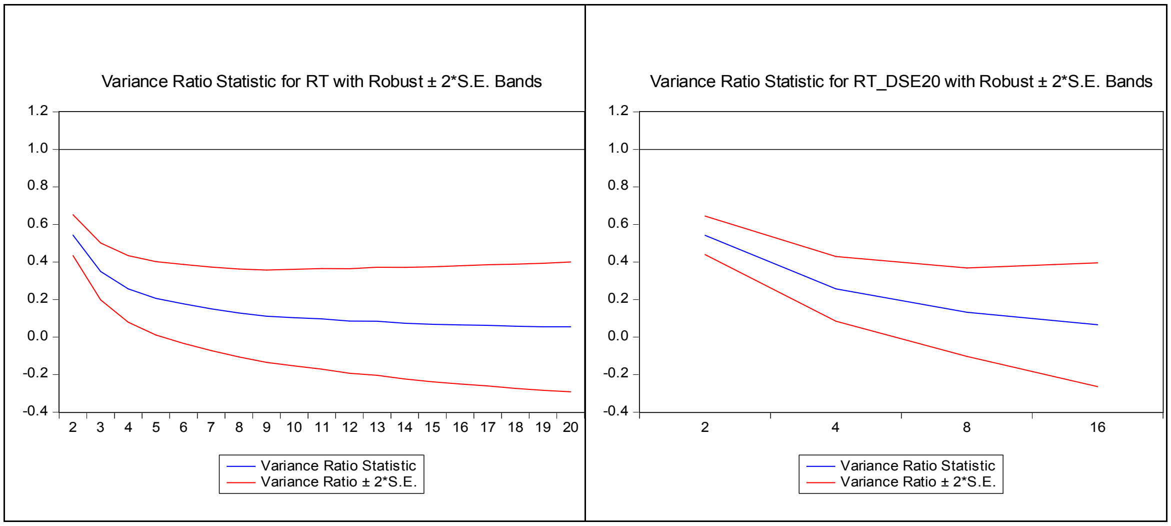

Figure 5.5: Graphical presentation of variance ratio for both DGEN and DS20 return series (Full sample)

From Figure 5.5, it is clear that the both variance ratio lines lie below the unit line with declining trend. So, the both series do not follow random walk.

Table 5.7: Results of Variance Ratio Test at Return Series (period wise)

Sample Period : 2nd October, 2001 to 15th October 2006					
Index	**Period=J**	**2**	**4**	**8**	**16**
DGEN	VR(J)	0.613850	0.283218	0.149371	0.072904
	Z(J)	-5.888158	-6.445549	-5.517107	-4.583994
	P-value	0.0000	0.0000	0.0000	0.0000
DS 20	VR(J)	0.590140	0.279659	0.148040	0.070544
	Z(J)	-5.679781	-5.970219	-5.261475	-4.502460
	p-value	0.0000	0.0000	0.0000	0.0000

(Continued on next page)

Sample Period: 16th October 2006 to 31st December 2008

Index	Period=J	2	4	8	16
DGEN	VR(J)	0.555901	0.264399	0.137653	0.071512
	Z(J)	-7.459152	-7.163551	-5,639003	-4.274946
	P-value	0.0000	0.0000	0.0000	0.0000
DS 20	VR(J)	0.549552	0.274967	0.148043	0.077369
	Z(J)	-6.841173	-6.531744	-5.322629	-4.202892
	p-value	0.0000	0.0000	0.0000	0.0000

Sample Period: 1st January 2009 to 29th November 2012

Index	Period=J	2	4	8	16
DGEN	VR(J)	0.521405	0.248392	0.121734	0.062889
	Z(J)	-5.863599	-5.673442	-5.040466	-4.007331
	P-value	0.0000	0.0000	0.0000	0.0000
DS 20	VR(J)	0.506524	0.240381	0.121705	0.061074
	Z(J)	-6.132800	-5.632541	-4.801832	-3.616562
	p-value	0.0000	0.0000	0.0000	0.0003

Table 5.7 represents the results of variance ratio test for daily returns of DGEN and DS20 for three sub period. In first sub period (November, 2001 to October 2006), the standardized variance ratios are significantly different from one. It is found that the estimated *Z* statistics (*Zj*) are significant at any number of *j* and *P* values are zero in all cases. Thus, this means that the return series do not follow the random walk and shows

predictability. Rejection of random walk indicates that the market was inefficient during the study period.

In second sub period (October, 2006 to December, 2008), null hypothesis can be rejected at 1% level of significance because the absolute *Zj* are significantly greater than critical *Z* value and *P*-value are zero in all cases. Thus, the return series did not follow random walk and market was inefficient during the second sub period. In third sub period (January, 2009 to November, 2012), it is also found that the null hypothesis is again rejected in all aspect as like, first sub period and second sub period .Therefore, the market was not efficient during the period.

Therefore, according to the variance ratio test it is inferred that, considering full sample as well as three sub periods, the null hypothesis is out rightly rejected and market was not efficient. The findings of this study are very similar to the findings of Smith, Jafferis and Ryoo (2002) on eight African markets, Jafferis and Smith (2005) on seven African markets, Smith (2008), Enowbi et al. (2009) on four African markets, and Al-Jafari and altaee (2011) on Egyptian equity market.

5.7 Autocorrelation Test

Autocorrelation test is used to examine the weak form efficiency of stock market as because it tests of either dependence or independence of random variable in a series. The coefficient of autocorrelation measures the relationship between the values of a random variable at time *t* and its value in the previous period. The auto-correlation coefficients have been computed for the different lags of the market return series and shown whether the correlation coefficients are significantly different from zero. Here, we apply Ljung-Box *Q* statistic to test whether the auto-correlation coefficients are statistically significant. The power transformation has been applied on both return series and squared return series have been used to examine the autocorrelation at different lags (Hossain and Uddin, 2011). Positive autocorrelation indicates predictability of returns in short period whereas negative autocorrelation indicates mean reversion in returns. The presence of non-zero auto-correlation coefficients in the lag of return series clearly suggests that there are serial dependence between the values and evidence against weak form efficiency of market.

Table 5.8: Results of Auto-correlation Test for Both Return series (Full Sample)

Lag	DGEN (Full Sample)			DS20 (Full Sample)		
	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value
1	.205	116.82	0.000	.423	538.62	0.000
2	.145	175.23	0.000	.274	764.86	0.000
3	.096	200.66	0.000	.160	842.13	0.000
4	.063	211.58	0.000	.110	878.70	0.000
5	.078	228.47	0.000	.129	928.95	0.000
6	.094	252.80	0.000	.154	1000.4	0.000
7	.123	294.46	0.000	.226	1155.2	0.000
8	.137	346.74	0.000	.260	1358.8	0.000
9	.126	390.72	0.000	.243	1537.4	0.000
10	.079	408.26	0.000	.153	1608.3	0.000
11	.070	421.93	0.000	.114	1647.4	0.000
12	.059	431.61	0.000	.113	1686.1	0.000
13	.071	445.51	0.000	.120	1729.8	0.000
14	.082	463.99	0.000	.151	1799.0	0.000
15	.090	486.40	0.000	.160	1876.8	0.000
16	.103	515.85	0.000	.196	2992.8	0.000

The Table 5.8 exhibits autocorrelation coefficients, *Q*-statistics and *P*-value of both return series. The autocorrelation coefficients of both return series are very significant for all lags. It is found that the *P* values of the Ljung-Box *Q*-statistics are equal to zero in all cases for both return series indicate that the null hypothesis of entire autocorrelation coefficients together equal to zero is rejected at 1% level of significance. Significant dependence of returns at all lags clearly suggests that the both series do not follow the random walk model and market is not efficient in weak form.

Table 5.9: Results of Auto-correlation Test for Both Return series (Period Wise)

Lag	DGEN (Nov,01-Oct,06)			DGEN (Oct,06-Dec,08)			DGEN (Jan,09-Dec,12)		
	ACF	Q-stat	P-value	ACF	Q-stat	P-value	ACF	Q-stat	P-value
1	.484	306.89	0.000	.032	0.5335	.465	.178	29.973	0.000
2	.269	401.40	0.000	.061	2.4641	.292	.122	43.953	0.000
3	.198	452.92	0.000	.032	2.9852	.394	.072	48.797	0.000
4	.158	485.84	0.000	.118	10.295	.036	.036	50.053	0.000
5	.131	508.38	0.000	.046	11.386	.044	.055	52.905	0.000
6	.085	517.77	0.000	.039	12.173	.058	.078	58.058	0.000
7	.060	522.51	0.000	-.004	12.183	.095	.106	68.774	0.000
8	.076	530.09	0.000	.037	12.885	.116	.121	82.687	0.000
9	.082	538.96	0.000	-.042	13.816	.129	.109	94.076	0.000
10	.161	573.10	0.000	.031	14.310	.159	.055	97.004	0.000
11	.165	608.92	0.000	.042	15.223	.172	.045	98.948	0.000
12	.125	629.66	0.000	-.037	15.967	.193	.036	100.17	0.000
13	.075	637.05	0.000	.003	15.973	.251	.049	102.48	0.000
14	.118	655.51	0.000	.142	26.744	.021	.058	105.65	0.000
15	.071	662.15	0.000	-.020	26.961	.029	.071	110.44	0.000
16	.054	666.08	0.000	.028	27.369	.038	.085	117.36	0.000

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Lag	DS20 ((Nov,01-Oct,06))			DS20 (Oct,06-Dec,08)			DS20 (Jan,09-Dec,12)		
	ACF	Q-stat	P-value	ACF	Q-stat	P-value	ACF	Q-stat	P-value
1	.436	257.32	0.000	.049	1.2402	.265	.429	173.93	0.000
2	.255	345.42	0.000	.007	1.2645	.531	.265	240.12	0.000
3	.170	384.79	0.000	.081	4.7006	.195	.136	257.67	0.000
4	.163	421.08	0.000	.108	10.793	.029	.082	264.04	0.000
5	.102	435.32	0.000	.039	11.582	.041	.116	276.77	0.000
6	.067	441.48	0.000	-.006	11.601	.071	.155	299.60	0.000
7	.063	446.93	0.000	-.039	12.390	.088	.248	357.94	0.000
8	.061	451.97	0.000	-.015	12.507	.130	.286	435.95	0.000
9	.053	455.81	0.000	-.017	12.657	.179	.266	503.44	0.000
10	.142	483.38	0.000	.060	14.569	.149	.140	522.20	0.000
11	.143	511.13	0.000	-.025	14.907	.187	.095	530.74	0.000
12	.133	535.34	0.000	.028	15.311	.225	.093	538.95	0.000
13	.075	542.97	0.000	-.009	15.353	.286	.108	550.08	0.000
14	.062	548.22	0.000	.047	16.533	.282	.147	570.91	0.000
15	.032	549.60	0.000	-.006	16.551	.346	.167	597.66	0.000
16	.028	550.70	0.000	-.026	16.900	.392	.209	639.71	0.000

The Table 5.9 represents sample autocorrelation coefficients, *Q*-statistics and *P*-values of return series of two indices for three sub periods. In the period October 02, 2001 to October, 2006, the returns under two indices are serially correlated for all lags. As per *Q*-statistics null hypothesis of no autocorrelation is rejected at 1% level of significance (*P*-values are zero) for all lags. The results also reveal that the dependence of returns are higher at lag 1 to 5, 10 to 12 and 14 for DGEN return series and at lag 1 to 5 and 10 to 12 for DS20 return series and suggest the market was inefficient during the period.

In the period October 16, 2006 to December 29, 2008, the results reveal that the intensity of autocorrelation is lower than the previous period. The DGEN return series shows significant autocorrelation at lag 4, 5 and 14 to 16 at 5% level of significance and lag 6 and 7 at 10% level of significance. On the other hand, the DS20 return series are autocorrelated at lag 4 and 5 at5% level of significance and at lag 6 and 7 at 10% level of significance. Thus, the findings of this period clearly suggest that the return series do not follow the random walk during the period.

For January 01, 2009 to November 29, 2012, it is found that the autocorrelation coefficients of the both return series are highly significant for all lags, 1 to 16, at 1% level of significance. Statistically non-zero autocorrelation reveals that the return series are not independent rather there are serial dependence between the values of return series. Thus, one can predict the future return which is strong violation of weak form efficiency.

From the results of three sub periods, it is clearly seen that the findings of first period and third period are approximately same and market was inefficient. But the results of second sub period show the stronger position of market and less inefficient than the other two sub period. Our results of autocorrelation test are consistent with the findings of Patel et al., (2012) on four Asian markets; Hamid et al., (2010) on fourteen Asia-Pacific markets; Mobarek and Keasey (2000) on Bangladesh market and Poshakwale (1996) on Indian market. We have found significant autocorrelation in both earlier lags and higher lags for both indices returns. It reveals that the historical information embedded in the longer period of lags would be as influential in determining the future price as that of information embedded in shorter lag lengths.

5.8 ARIMA (Auto-Regressive Integrated Moving Average) Model Building

So far, we have examined the efficiency of DSE through testing whether the return series follow random walk or not. Weak form efficiency of a market prevails when return cannot be predicted using information lies on past price trend. However, stock returns not only depend on its past values of return series but also past and current error terms. When the stock market return can be predicted based on the past return along with past and current errors together, this gives raise the issue of ARMA model (Cuthbertson, 1996). However, in this study ARIMA (p,d,q) model has been used instead of ARMA (p,q) model because it includes integration process. In our study, several unit root tests have been performed at earlier of this chapter and found that the both return series have no unit root. As a result, the series are stationary and the order of integration *d* is set as zero.

It is well known that under a random walk model ARIMA (0,1,0) is to be fitted in the time series data. A well-fitted ARIMA (0,1,0) model postulates that the return cannot be predicted using lag values of returns and on its error terms. If the coefficient of the ARIMA (0,1,0) statistically insignificant, then it indicates the dependency of series at any other lag of auto-regressive and/ or moving average term. Under the circumstances we may conclude that the series do not follow random walk and market is not efficient in weak form. Results of the model ARIMA (0,1,0) are presented in table 5.10:

Table 5.10: Results of ARIMA (0,1,0) for DGEN and DS20 Return Series

Series	Parameter	coefficient	Standard error	t-statistic	P-Value
DGEN	constant	1.57E-05	0.000397	0.039591	0.9684
DS20	Constant	1.42E-05	0.000346	0.040954	0.9673

The Table 5.10 represents the results of ARIMA (0,1,0) model for both DGEN and DS20 return series. The coefficient of ARIMA (0,1,0) of DGEN return series is 0.0000157 with a t-statistic of 0.039591 and probability of 0.9684 highly insignificant, indicates rejection of the assumption of the random walk model. The diagnostic checking of residuals of ARIMA (0,1,0) model for DGEN return series exhibits significant autocorrelation at 1, 2, 5. 6, 7, 8, 10, 11, 12, 13, 15, 16, 17, 18 and 19 lags at 5% level of significance (see Appendix A.2) confirm the rejection of the model. Similarly, the coefficient of ARIMA (0,1,0) for DS20 return series is 0.0000142 with t-statistic of 0.040954 and probability of 0.9673 also indicates insignificance of coefficient and the series is far away from the assumption of random walk. In diagnostic checking, the correlogram of residual squared shows that there is a significant autocorrelation at 1, 2 and 4 to 20 lags at 5% level of significance (see Appendix A.2).

Therefore, the findings suggest that the both return series (DGEN and DS20) do not follow the random walk model. The results are consistent with the results of unit root test, run test, variance ratio test and autocorrelation test. So, we can conclude again that the market is not efficient in weak form.

Since, The ARIMA (0,1,0) is not a fitted model for both return series, thus one can predict the future returns at other lags of AR (p) and MA (q). The choice of the order of auto-regressive (p) and moving average (q) are very important in ARIMA model. In our study, order of p and q are indentified using Box-Jenkins methodology (see, chapter-4). Under this methodology, we have estimated ARIMA (1,0,0), ARIMA (2,0,0), ARIMA (1,0,1), ARIMA (2,0,1), ARIMA (2,0,2), ARIMA (3,0,1), ARIMA (3,0,2), and ARIMA (3,0,3) models for the stock returns of both DGEN and DS20 series. Results of the models are furnished in table 5.11.

Table 5.11: Results of ARIMA (p,d,q) Models for DGEN Return Series (Full Sample)

Models	Parameters	coefficients	SE	t-stat	P-value
ARIMA(1,0,0)	Constant	0.000592**	0.000299	1.979255	0.0479
	AR(1)	0.041116**	0.017876	2.300021	0.0215
ARIMA(2,0,0)	Constant	0.000597**	0.000289	2.065528	0.0390
	AR(1)	0.044088**	0.019059	2.313209	0.0208
	AR(2)	-0.037013**	0.017888	-2.069136	0.0386
ARIMA(1,0,1)	Constant	0.000595**	0.000300	1.981110	0.0477
	AR(1)	0.019308	0.051458	0.375225	0.7075
	MA(1)	0.025868	0.054824	0.471834	0.6371
ARIMA(2,0,1)	Constant	0.000597**	0.000289	2.062513	0.0393
	AR(1)	0.013491	0.480369	0.028086	0.9776
	AR(2)	-0.035746	0.027019	-1.322998	0.1859
	MA(1)	0.030732	0.480693	0.063933	0.9490
ARIMA(2,0,2)	Constant	0.000595**	0.000288	2.068412	0.0387
	AR(1)	-0.011941	0.292467	-0.040828	0.9674
	AR(2)	-0.543300**	0.223226	-2.433853	0.0150
	MA(1)	0.050658	0.298119	0.169926	0.8651
	MA(2)	0.508471**	0.233591	2.176759	0.0296
ARIMA(3,0,1)	Constant	0.000625	0.000471	1.328261	0.1842
	AR(1)	1.024593***	0.024169	42.39326	0.0000
	AR(2)	-0.083402***	0.027249	-3.060694	0.0022
	AR(3)	0.047819**	0.019206	2.489850	0.0128
	MA(1)	-0.982326***	0.015010	-65.44456	0.0000
ARIMA(3,0,2)	Constant	0.000594**	0.000297	2.000839	0.0455
	AR(1)	0.518502***	0.043589	11.89519	0.0000
	AR(2)	-0.974877***	0.033158	-29.40092	0.0000
	AR(3)	0.045792**	0.020017	2.287610	0.0222
	MA(1)	-0.476233***	0.039578	-12.03276	0.0000
	MA(2)	0.935435***	0.037369	25.03214	0.0000

Note: *, ** and *** indicate critical value at 10%, 5% and 1% levels respectively

The Table 5.11 exhibits the results of ARIMA models for DGEN return series. In case of ARIMA(1,0,0) , the coefficient of AR(1) is significant at 5% level of significance. The coefficients of AR(1) and AR(2) of ARIMA (2,0,0) are significant at 5% level of significance. For ARIMA (1,0,1) and ARIMA(2,0,1) all coefficients are insignificant at any level of significance. For ARIMA (2,0,2), AR(1) and MA(1) are insignificant but AR(2) and MA(2) are significant at 5% level. For ARIMA (3,0,1) and ARIMA (3,0,2) all coefficients of AR and MA terms are significant at 1% and 5% level of significance. Under Box-Jenkins methodology, we have got four ARIMA models of DGEN return series which coefficients are significant and using these models we can predict approximate future returns.

Table 5.12: Results of ARIMA (p,d,q) Models for DS20 Return Series (Full Sample)

Models	Parameters	coefficients	SE	t-stat	P-value
ARIMA(1,0,0)	Constant	0.000316	0.000264	1.195656	0.2319
	AR(1)	0.049906***	0.018239	2.736170	0.0063
ARIMA(2,0,0)	Constant	0.000320	0.000256	1.250596	0.2112
	AR(1)	0.051475***	0.018256	2.819552	0.0048
	AR(2)	-0.032252*	0.018257	-1.766552	0.0774
ARIMA(1,0,1)	Constant	0.000315	0.000260	1.210392	0.2262
	AR(1)	-0.441891*	0.232088	-1.903980	0.0570
	MA(1)	0.496043**	0.224644	2.208131	0.0273
ARIMA(2,0,1)	Constant	0.000319	0.000257	1.238979	0.2155
	AR(1)	-0.252464	0.413894	-0.609974	0.5419
	AR(2)	-0.018918	0.031244	-0.605497	0.5449
	MA(1)	0.304526	0.413926	0.735700	0.4620
ARIMA(2,0,2)	Constant	0.000319	0.000250	1.275640	0.2022
	AR(1)	-1.016133***	0.019681	-51.62956	0.0000
	AR(2)	-0.959385***	0.019044	-50.37707	0.0000
	MA(1)	1.027997***	0.022297	46.10404	0.0000
	MA(2)	0.947793***	0.021717	43.64269	0.0000

(Continued on next page)

Models	Parameters	coefficients	SE	t-stat	P-value
ARIMA(3,0,1)	Constant	0.000324	0.000273	1.185528	0.2359
	AR(1)	0.685000**	0.334048	2.050605	0.0404
	AR(2)	-0.066159**	0.027748	-2.384270	0.0172
	AR(3)	0.044810**	0.018393	2.436252	0.0149
	MA(1)	-0.633457*	0.334133	-1.895825	0.0581
ARIMA(3,0,2)	Constant	0.000322	0.000271	1.187685	0.2351
	AR(1)	0.682110*	0.408406	1.670178	0.0950
	AR(2)	-0.167929	0.386621	-0.434349	0.6641
	AR(3)	0.049734**	0.025096	1.981711	0.0476
	MA(1)	-0.630589	0.408886	-1.542212	0.1231
	MA(2)	0.102107	0.378440	0.269810	0.7873

Note: *, ** and *** indicate critical value at 10%, 5% and 1% levels respectively.

Table 5.12 represents the findings of ARIMA models of DS20 return series. The coefficient of AR(1) of ARIMA (1,0,0) is significant at 1% level. For ARIMA (2,0,0), the coefficient of AR(1) is significant at 1% level and AR(2) is significant at 10% level but all coefficients of ARIMA (2,0,1) are insignificant at any level of significance. In case of model ARIMA (2,0,2) all coefficients are significant at 1% level of significance. For ARIMA (3,0,1), all auto-regressive terms are significant at 5% level and MA(1) is significant at 10% level. In case of ARIMA (3,0,2), AR(1) and AR(2) are only significant at 10% and 5% level of significance but other coefficients of this model are insignificant.

From above discussion, it is found that all the coefficients of ARIMA (1,0,0), ARIMA (2,0,0), ARIMA (3,0,1) and ARIMA (3,0,2) are significant at different conventional level of significance for DGEN return series. On the other hand, all coefficients of ARIMA (1,0,0), ARIMA (2,0,0), ARIMA (1,0,1), ARIMA (2,0,2), and ARIMA (3,0,1) are significant at different conventional level of significance for DS20 return series. However, the models that have significant coefficients are not always best fitted.

Validity of a model not only depends on significant parameters but also forecasting ability and white noise residuals. Forecasting ability is measured by mean square error (MSE) and having lowest MSE indicates the best forecasting ability. On the other hand, goodness of fit of a statistical model is measured by Akaike Information Criterion (AIC). The AIC is a relative measure of information lost when a given model is used to describe reality. To make a comparison among the models, several models may be ranked according to their AIC and the model having minimum AIC is the best. The values of AIC and MSE for several ARIMA models are displayed in table 5.13:

Table 5.13 AIC and MSE of ARIMA (p,0,q) for Different Values of p and q for Both Return Series

DGEN Return Series		
Models	**AIC**	**MSE**
ARIMA (1,0,0)	-5.548844	0.0002276
ARIMA (2,0,0)	-5.549320	0.0002273
ARIMA (3,0,1)	**-5.549429**	**0.0002269**
ARIMA (3,0,2)	-5.549404	0.0002270
DS20 Return Series		
Models	**AIC**	**MSE**
ARIMA (1,0,0)	-5.734556	0.00018900
ARIMA (2,0,0)	-5.734908	0.00018880
ARIMA (1,0,1)	-5.735127	0.00018887
ARIMA (2,0,2)	**-5.737679**	**0.00018804**
ARIMA (3,0,1)	-5.734300	0.00018867

From Table 5.13 it clearly seen that AIC value (-5.549729) and MSE (0.0002269) of ARIMA (3,0,1) for DGEN return series are lower than the other models. So, ARIMA (3,0,1) is the best fitted model for daily return series of DGEN as per model selection criterion. On the other hand, ARIMA (2,0,2) is the best fitted model for DS20 return series because the AIC (-5.737679) and MSE (0.00018804) are lower than the other models.

Findings of the ARIMA models for DGEN and DS20 return series suggest that ARIMA (3,0,1) and ARIMA (2,0,2) are found as the best fitted model with all coefficients significant at 1% level of significance except AR(3) for ARIMA (3,0,1) that is significant at 5% level of significance. The fitting of the models, ARIMA (3,0,1) for DGEN return series and ARIMA (2,0,2) for DS20 return series, indicating both the series do not follow the random walk process. Therefore, we can conclude that DSE is not efficient in weak form. Our findings are similar with the findings of Mobarek and Keasey (2000) on Bangladesh market, Poshakwale (1996) on Indian market, Moustafa (2004) on Bangladesh stock Exchange, Abrosimova et al. (2005) on Russian stock market.

5.9 ARIMA Forecasting of Returns

In case of time series data, forecasting is the most important issue for every researcher. For building up a forecasting model, the daily market return series of DGEN and DS20 are divided into two sub-periods. For DGEN return series, November 27, 2001 to June 28, 2012 (total number of observation 2671) is considered as historical period and July 01, 2012 to November 29, 2012 (total number of observation 95) is considered as validation period. For DS20 return series, January 01. 2001 to June 28, 2012 is considered as historical period and July 01, 2012 to November 29, 2012 (total number of observation 95) is considered as validation period. The ARIMA (3,0,1) for DGEN return series and ARIMA (2,0,2) for DS20 return series are also the best fitted model for the historical period as per the result of AIC, MSE and ACF for residuals. By these fitted models, we can forecast the value of return series for validation period to examine how far the fitted values deviate from the actual values.

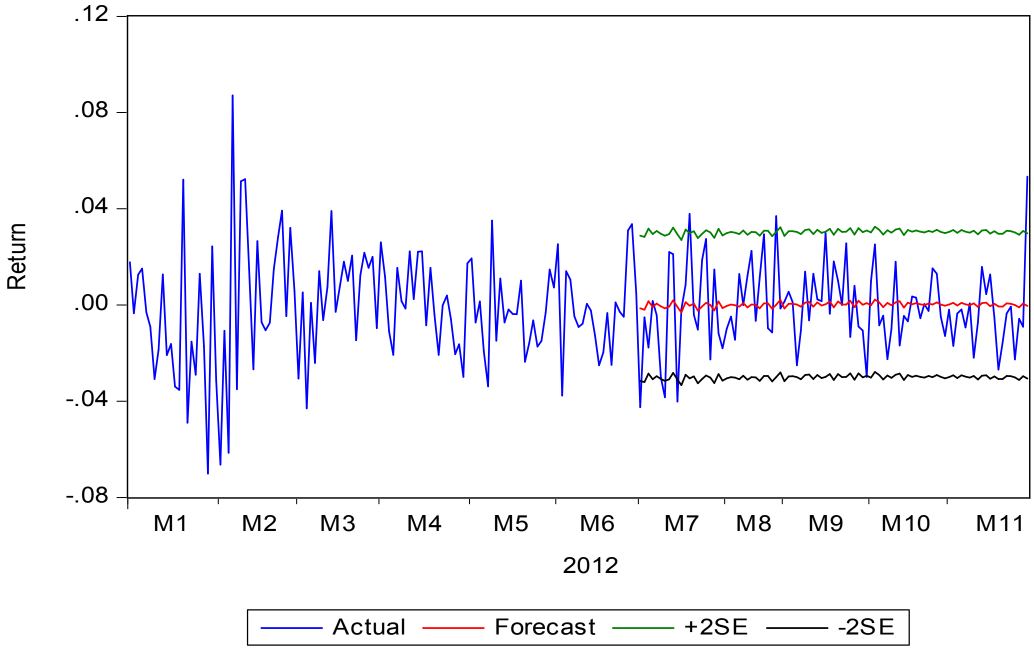

Figure 5.6: Forecasting of DGEN return for the validation period of July-Nov' 2012

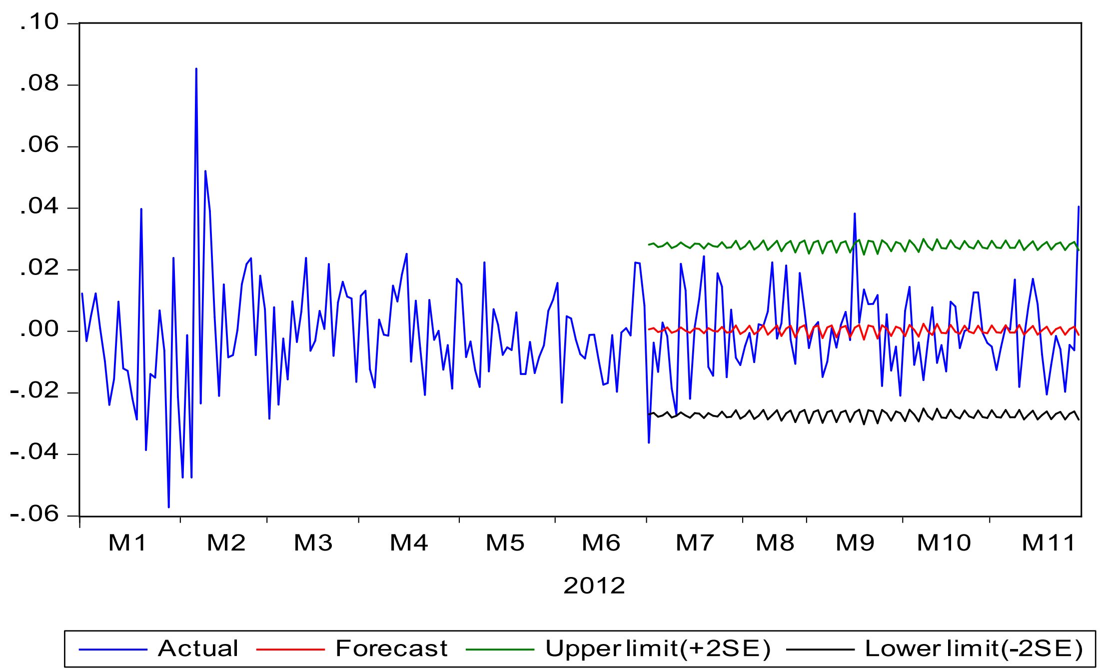

Figure 5.7: Forecasting of DS20 return for the validation of July-Nov' 2012

NOTE: for Figure 5.6 and 5.7: While the full series is graphed, then the forecasted area is rarely visible. For that reason, we only show January – November 2012 to make the forecasted area more visible.

Figures 5.6 and 5.7 represent forecasted return, actual return and upper and lower limit of ±2SE (i.e., 95% confidence interval) of both DGEN and DS20 return series respectively. In both cases, it is clearly seen that the actual returns are lying within 95% confidence interval (±2SE limit) of the forecasted returns over the validation period except few outliers. So, the forecasted return derived from the model and actual returns are approximately well fitted. Our results are similar with the findings of Mobarek and Keasey (2000) on Bangladesh market, Poshakwale (1996) on Indian market, Abrosimova et al. (2005) on Russian stock market, Irfan et al. (2010) on Pakistani market. At last, it can be concluded that the validation period is the reflection of the historical period. So, the past price as well as past and current disturbance terms can be used to determine the future price. Therefore, the findings of ARIMA models for both series confirm the findings under earlier parametric and non parametric tests applied in our study and proclaim the inefficiency of Dhaka Stock Exchange.

5.10 Concluding Remarks

We have gone through a massive empirical investigation and findings suggest the DSE is not efficient in weak form under the study period. The market returns of DSE show positive skewness, excess Kurtosis and departure from normality. The results of unit root tests indicate that the return series are stationary for full as well as three sub periods. As per results of run test null hypothesis is rejected under all circumstances, indicating return series do not follow random walk. The results of variance ratio test reveals that the both the DGEN and DS20 return series do not follow random walk because under all circumstances variance ratios are significantly lower than one. The autocorrelation test indicates that the return series are significantly autocorrelated under all periods though the intensity of autocorrelation for second sub-period is lower than the other periods. In addition, the coefficients of ARIMA models are significant at different lags of autoregressive and moving average terms under both returns series which indicate that future return can be predicted by applying such type of models. Therefore, as per findings of different statistical techniques it can be said that the both return series of DSE do not follow the random walk and indicating the inefficiency of Dhaka Stock Exchange.

Chapter-Six

Empirical Analysis: Stock Market Volatility

6.1 Introduction

The financial time series do not behave in a random manner rather display a set of peculiar characteristics and that are the very important phenomenon of stock market. A lot of researchers have been documented evidence that the stock prices (returns) show phenomenon of volatility clustering or pooling, leptokurtosis and asymmetry (leverage effect). In this chapter, an attempt has been made to modeling the volatility of Dhaka Stock Exchange general index (DGEN) and DS20. Volatility modeling and forecasting are the most important tasks in empirical finance. The Generalized Autoregressive Conditional Heteroscedastic (GARCH) models have been used to estimate volatility (conditional variance) in the daily returns of the principal stock exchange of Bangladesh namely, Dhaka Stock Exchange (DSE) for the period January 2001 to November 2012. This study considers both symmetric and asymmetric models that capture the most stylized facts about market return such as volatility clustering and leverage effect. Volatility is defined as tendency of the assets price to fluctuate either up or down. Increased volatility is perceived as indicating a rise in financial risk which can adversely affect investor assets and wealth. It is observed that when stock market exhibit increased volatility there is a tendency on part of the investors to lose confidence in the market and they tend to exit the market. On the other hand, investors who will be in market at the time of higher volatility should demand higher risk premium. Here, we also examine the positive correlation hypothesis between volatility and the expected stock returns using GARCH-M model. Beside these, relationship between volatility and information flow to the market have also been examined under GARCH family modeling and causality will be tested using bi-variate VAR model. In our study, trading volume is used as a proxy of information flow to the market.

It is found that the researchers are careless about mean equation in estimating GARCH models because it does not significantly affect the values of the coefficients of variance equation of GARCH model. In our study, we have considered two types of mean model: one is only based on constant plus error term and another one is the best fitted ARIMA model to examine whether it has any impact on the coefficient of GARCH model or not.

6.2 Examining ARCH Effect in Residuals

Before applying GARCH family models, we must test the presence of heteroscedasticity in the residuals of mean models for both return series. In our study, we have applied ARCH-LM test proposed by Engle (1982) for testing ARCH effect (see- chapter 4 for details) in the residuals of both series under two different mean models. The null hypothesis of this test is-

Ho: there is no ARCH effect in residuals

H_1: there is ARCH effect in residuals

Table 6.1: Estimated Results of ARCH-LM Test on the Residuals of DGEN and DS20 Return Series

Test statistic	DGEN series		DS20 series	
	Constant	ARIMA(301)	Constant	ARIMA(202)
Obs×R^2 (TR^2)	120.049	122.227	543.481	548.662
P-value	0.0000	0.0000	0.0000	0.0000

Table 6.1 represents the values of TR^2 and its probability for the residuals under two types of mean models for both DGEN and DS20 series. It is observed that the values of TR^2 are very high and their probabilities are zero in all cases. So, the values of TR^2 are significant at 1% level. Therefore, the null hypothesis of no heteroscedasticity is rejected and indicates a strong evidence of the presence of ARCH effects in the residuals series under all cases. Due to the presence of ARCH effect in residuals series, now we can proceed for the modeling of index return volatility by using GARCH family models.

6.3 Result Estimation Under GARCH (1,1) Model

We have found very extensive literature on GARCH modeling of stock market volatility. In most of the cases the researchers have used low order for the lag lengths p and q of GARCH (p, q) model. It has been found that the GARCH (1,1) model is the most appropriate for modeling and forecasting stock return volatility (Corhay and Rad, 1994). The lag order (1,1) of a GARCH model is sufficient enough to capture all about volatility clustering in a financial time series (Brook and Burke, 2003). Engle (2004) describes the GARCH (1,1) model as the workhorse for financial applications and claims it can describe the volatility dynamics of the stock returns on most developed and emerging markets. The estimated results of GARCH (1,1) model are presented in Table 6.2.

Table 6.2: Estimated Results of the GARCH (1,1) Model

Coefficients	DGEN		DS20	
	Constant	ARIMA(301)	Constant	ARIMA(202)
ω (constant) P-value	1.67E-06 0.0000	1.86E-06 0.0000	5.27E-06 0.0000	5.21E-06 0.0000
α (ARCH Effect) P-value	0.2078 0.0000	0.2221 0.0000	0.2318 0.0000	0.2419 0.0000
β (GARCH Effect) P-value	0.8139 0.0000	0.8036 0.0000	0.7687 0.0000	0.7621 0.0000
$\alpha + \beta$	1.0217	1.0257	1.0005	1.0040

Table 6.2 represents the estimated values of the coefficients of variance equation of the GARCH (1,1) model with their probabilities. It is observed that the sign of the all coefficients are positive (ω, α and $\beta > 0$) which is consistent with the nonnegativity constraints of this model. The three coefficients of the variance equation are highly significant at 1% level of significance under both types of mean model for DGEN and DS20 series because their probabilities are zero under all circumstances. The significant α and β indicate that the lagged squared error and lagged conditional variance have a significant impact on the conditional variance. The sum of the ARCH (α) and GARCH (β) parameters are greater than one ($\alpha + \beta$>1) in all cases indicate that shocks to the conditional variance are highly persistent and conditional variance process is explosive. This situation implies that the large changes in return tend to be followed by large changes and small changes tend to be followed by small changes. The large sum of α and β implies that the large positive and negative change in return will lead the future forecast of variance. The above results confirm that the existence of volatility clustering in both return series of DSE.

It is also seen that the values of the variance intercept are very small and ARCH parameters are around 0.20 to 0.24 while the coefficients of the lagged conditional variance are significantly high i.e., around 0.76 to 0.81 indicating the impact of old news are very important. We can conclude that the strong GARCH effect is appeared in our stock market for all cases. It also indicates that the tendency for a volatility response to shocks to display a long memory. The results confirm the time varying risk in stock returns in Bangladesh. Our findings are consistent with the findings of Basher et al., (2007) on Dhaka Stock Exchange, Chowdhury and Iqbal (2005) on Dhaka Stock Exchange, Mollah (2009) on Dhaka Stock Exchange, Ahmed and Suliman (2011) on Khartoum Stock Exchange (KSE).

6.3.1 Diagnostic Checking for GARCH (1,1) model

To examine whether the GARCH (1,1) model is well specified and well fitted or not, we conduct ARCH-LM test and auto correlation test on the residuals of this model.

6.3.1.1 ARCH LM test

If the GARCH(1,1) model is well specified and captures volatility clustering, then the residuals standardized by their conditional volatility should not have any significant ARCH effects. In that case, standardized residuals are then nearly normally distributed (Alexander, 2001). To test whether there are any remaining ARCH effects in the standardized residuals or not, Engle's ARCH-LM test is therefore applied .The hypothesis of ARCH LM Test is

H_0: There is no ARCH effect

H_1: There is ARCH effect

The results of the ARCH LM test for the residuals of GARCH(1,1) model are presented in Table 6.3.

Table 6.3: The estimated results of ARCH-LM test on the residuals of GARCH(1,1) model

Test statistic	DGEN series		DS20 series	
	Constant	ARIMA(301)	Constant	ARIMA(202)
Obs* R^2 (TR^2)	0.0208	0.0179	0.1255	0.1445
P-value	0.8854	0.8933	0.7231	0.7031

From the Table 6.3, it is seen that the values of TR^2 are very low and probabilities of the coefficients of LM test are very high indicating insignificance of the coefficients. So, the null hypothesis (H_0: There is no ARCH effect) cannot be rejected at any level of significance. Therefore, ARCH-LM test indicates that there are no additional ARCH effects and the model GARCH (1,1) is well fitted and well specified.

6.3.1.2 Test of Autocorrelation of Squared Residual

If the GARCH(1,1) model is well fitted, well specified and captured volatility clustering, then the autocorrelation of the squared residuals of this model become statistically zero and insignificant. The results of the autocorrelation test for the squared residuals of GARCH (1,1) model are presented in table 6.4:

Table 6.4 the estimated results of autocorrelation of squared residuals

Lag	DGEN Series					
	Constant			ARIMA(3,0,1)		
	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value
1	-0.003	0.0208	0.885	-0.003	0.0180	
2	0.002	0.0307	0.985	0.001	0.0223	
3	-0.001	0.0335	0.998	0.000	0.0224	
4	-0.002	0.0496	1.000	-0.003	0.0443	
5	-0.002	0.0642	1.000	-0.003	0.0637	0.801
6	-0.003	0.0976	1.000	-0.003	0.0949	0.954
7	-0.003	0.1193	1.000	-0.003	0.1182	0.990
8	-0.003	0.1417	1.000	-0.003	0.1396	0.998
9	-0.003	0.1696	1.000	-0.003	0.1679	0.999
10	-0.003	0.1898	1.000	-0.003	0.1926	1.000
Lag	**DS20 Series**					
	Constant			ARIMA(2,0,2)		
	ACF	**Q-Stat**	**P-Value**	**ACF**	**Q-Stat**	**P-Value**
1	-0.006	0.1251	0.724	-0.007	0.1436	
2	-0.017	0.9890	0.610	-0.011	0.4913	
3	-0.014	1.6125	0.657	-0.017	1.3279	
4	-0.018	2.5690	0.632	-0.018	2.3579	
5	-0.026	4.6641	0.458	-0.028	4.7422	0.129
6	-0.011	5.0421	0.538	-0.013	5.2188	0.074
7	-0.022	6.4390	0.490	-0.018	6.1454	0.105
8	-0.010	6.7400	0.565	-0.008	6.3343	0.176
9	-0.023	8.4072	0.494	-0.026	8.3243	0.139
10	-0.018	9.4314	0.492	-0.017	9.1964	0.163

Table 6.4 represents autocorrelation function (ACF) of squared residuals, Q-statistics and probability of Q- statistics. It is found that the Q-statistics are insignificant because the probabilities of Q-statistics are very high and indicating the standardized residual series follows a white noise process. Thus, the above mentioned model captures all ARCH effect and well specified.

6.4 Estimated Result under GARCH-M(1,1) Model

As per financial theories, risk (standard deviation) and expected return (mean) are very closely related and an increase in variance result in a higher expected return. The GARCH-M model can be used to modeling such type of phenomenon. The GARCH-M model is estimated by allowing the mean equation of the return series to depend on the function of conditional standard deviation. The estimated results of GARCH-M model are presented in Table 6.5.

Table 6.5: Estimated Results of the GARCH-M (1,1) Model

Coefficients	DGEN		DS20	
	Constant	ARIMA(301)	Constant	ARIMA(202)
δ (coefficient of SD in mean equation) *P*- value	0.1058 0.0052	0.0778 0.0477	0.1463 0.0017	0.1036 0.0415
ω (constant) *P*- value	1.60E-06 0.0006	1.82E-06 0.0002	5.42E-06 0.0000	5.37E-06 0.0000
α (ARCH Effect) *P*-value	0.2133 0.0000	0.2257 0.0000	0.2475 0.0000	0.2526 0.0000
β (GARCH Effect) *P*-value	0.8109 0.0000	0.8014 0.0000	0.7566 0.0000	0.7533 0.0000
$\alpha + \beta$	1.0242	1.0271	1.0041	1.0059

The Table 6.5 represents the estimated value of the coefficient (δ) of conditional standard deviation in the various mean equations as well as constant (ω), ARCH parameter, GARCH parameter and the sum of ARCH and GARCH parameter in variance equations along with their probabilities. The estimated coefficient (δ) of conditional standard deviation in mean equation is positive in all cases and significant at 1% level of significance when the mean equation follow a simple constant plus error process and at 5% level of significance when mean equation follow a ARIMA process.

This indicates that the mean return not only depend on the past sequence of return and its error terms but also depends on past conditional standard deviation of residuals (σ) (time-varying risk). The presence of σ_t in mean equation shows a trade-off between time-varying risk and expected return. The results indicate that as volatility increases, the return correspondingly increases by the factor of 0.1058 when mean equation simply follow a constant plus error process and of 0.0778 when mean equation follow a ARIMA (3,0,1) process for DGEN return series. On the other hand, return increases by the factor of 0.2049 when mean equation follow a simple constant plus error process and of 0.1036 when mean equation follow a ARIMA (2,0,2) process. These results are consistent with the theory of risk-return relationship in finance which state that the higher return are expected for assets with higher level of risk.

In variance equation, the ARCH (α) and GARCH (β) parameters are significant at 1% level of significance for all cases. The sum of the α and β are greater than one under all circumstances indicate that the shocks to the conditional variance are highly persistent and conditional variance process is explosive.

Empirical findings have represented mixed results regarding the sign and statistical significance of the risk-return parameter all over the world. Elyasiani and Mansurs (1998) have found a negative and significant relationship on US data. Thomas (1995) finds a positive but insignificant risk-return parameter for the Bombay Stock Exchange, Mecagni and Sourial (1999) find a positive and significant risk-return parameter for Egyptian stock market, Ahmed and Suliman (2011) have found a positive and significant risk return relationship on Sudan market, Hossain and Uddin (2011) have seen that the risk return relationship is positive for DSI and DS20 indices but negative for DGEN series and only coefficient of DS20 is statistically significant on in DSE, Chowdhury and Iqbal (2005) examine risk return relationship ARCH-M framework and conclude that there is no strong relationship between risk and return.

6.4.1 Diagnostic Checking for GARCH-M(1,1) Model

To examine validity of the GARCH-M (1,1) model we conduct ARCH-LM test and auto correlation test on the residuals of this model.

6.4.1.1 ARCH- LM test

In case of well specified model there shall not be any additional ARCH affects left in the residuals of conditional variance model. To test whether there are any remaining ARCH effects in the standardized residuals or not, Engle's ARCH-LM test is therefore applied .The hypothesis of ARCH LM Test is

H_0: There is no ARCH effect

H_1: There is ARCH effect

The results of the ARCH LM test for the residuals of GARCH-M(1,1) model are presented in table 6.6:

Table 6.6: Estimated Results of ARCH-LM test on the Residuals of GARCH-M (1,1) Model

Test statistic	DGEN series		DS20 series	
	Constant	ARIMA(301)	Constant	ARIMA(202)
Obs* R^2 (TR^2)	0.0209	0.0183	0.2651	0.2643
P-value	0.8850	0.8924	0.6066	0.6072

From Table 6.6, it is seen that the null hypothesis (H_0: There is no ARCH effect) cannot be rejected at any level of significance. Therefore, ARCH-LM test indicates that there are no additional ARCH effects and the model GARCH-M (1,1) is well fitted and well specified.

6.4.1.2 Test of Autocorrelation of Squared Residual

If the GARCH-M(1,1) model is well fitted then the autocorrelation of the squared residuals of this model should become statistically zero and insignificant. The results of the autocorrelation test for the squared residuals of GARCH-M(1,1) model are presented in table 6.7:

Table 6.7: Estimated Results of Autocorrelation of Squared Residuals of GARCH-M (1,1) Model

Lag	DGEN Series					
	Constant			ARIMA (3,0,1)		
	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value
1	-0.003	0.0209	0.885	-0.003	0.0183	
2	0.002	0.0298	0.985	0.001	0.0239	
3	-0.001	0.0337	0.998	0.000	0.0240	
4	-0.002	0.0485	1.000	-0.003	0.0470	
5	-0.002	0.0621	1.000	-0.003	0.0675	0.795
6	-0.003	0.0959	1.000	-0.003	0.1003	0.951
7	-0.003	0.1167	1.000	-0.003	0.1237	0.989
8	-0.003	0.1390	1.000	-0.003	0.1453	0.997
9	-0.003	0.1665	1.000	-0.003	0.1735	0.999
10	-0.003	0.1857	1.000	-0.003	0.1996	1.000
Lag	**DS20Series**					
	Constant			**ARIMA (2,0,2)**		
	ACF	**Q-Stat**	**P-Value**	**ACF**	**Q-Stat**	**P-Value**
1	-0.009	0.2643	0.607	-0.009	0.2631	
2	-0.018	1.2109	0.546	-0.010	0.5829	
3	-0.016	1.9402	0.585	-0.018	1.5492	
4	-0.019	3.0192	0.555	-0.019	2.6470	
5	-0.027	5.2511	0.386	-0.028	4.9923	0.125
6	-0.013	5.7286	0.454	-0.014	5.5615	0.062
7	-0.020	6.8893	0.440	-0.016	6.2866	0.098
8	-0.010	7.1949	0.516	-0.008	6.5023	0.165
9	-0.023	8.8014	0.456	-0.025	8.3268	0.139
10	-0.019	9.8828	0.451	-0.017	9.1907	0.163

The Table 6.7 represents ACF of squared residuals, *Q*-statistics and probability of *Q*-statistics. It is found that the *Q*-statistics are insignificant. So, the squared residuals of GARCH-M (1,1) model are not autocorrelated under all circumstances, indicating the standardized residual series follows a white noise process. Thus, the above mentioned model captures all ARCH effect and well specified.

However, symmetric GARCH models cannot differentiate between the impact of good news and bad news rather consider they both have same impact on volatility when their magnitudes are equal. This is one of the prime limitations of symmetric model.

6.5 Result Estimation under EGARCH (1,1) Model

To overcome the limitations of basic GARCH model, which cannot capture leverage effect, Nelson (1991) developed EGARCH model. To investigate the presence of leverage effect in the return series of Dhaka Stock Exchange during the sample period EGARCH (1,1) model is deployed. The estimated results of EGARCH (1,1) model are furnished in Table 6.8.

Table 6.8: Estimated Results of the EGARCH (1,1) Model

Coefficients	DGEN		DS20	
	Constant	ARIMA(301)	Constant	ARIMA(202)
ω (constant) *P*-value	-0.5090 0.0000	-0.5153 0.0000	-0.7013 0.0000	-0.7331 0.0000
α (ARCH Effect) *P*-value	0.3047 0.0000	0.3129 0.0000	0.3639 0.0000	0.3729 0.0009
β (GARCH Effect) *P*-value	0.9687 0.0000	0.9685 0.0000	0.9518 0.0000	0.9491 0.0000
γ (Leverage Effect) *P*-value	-0.0578 0.0000	-0.0802 0.0000	-0.0038 0.7964	-0.0188 0.2658
$\alpha + \beta$	1.2754	1.2814	1.3157	1.3220

Table 6.8 represents the various coefficients of variance equation i.e., constant (ω), ARCH effect (α), GARCH effect (β) and leverage effect (γ) along with their probabilities. It is found that the ARCH and GARCH coefficients of both return series under two different mean models are significant at 1% level of significance. It is also seen that the sum of ARCH effect (α) and GARCH effect (β) is higher than one in all cases, indicate the shocks to the conditional variance are highly persistent and the conditional variance process is explosive.

EGARCH (1,1) model has been applied to capture asymmetric effect i.e., leverage effect incorporating γ coefficient in variance equation. It is seen that the γ coefficient is negative and significant under both mean equation for DGEN series. The findings indicate that the negative shocks have a larger effect on conditional variance than the positive shocks of the same magnitude. Therefore, we can conclude that the existence of leverage effect is observed in DGEN return series during the study period.

But in case of DS20 return series, it is found that the $\boldsymbol{\gamma}$ coefficients of EGARCH (1,1) model under both mean equation negative, indicating leverage effect i.e., bad news create a larger effect on conditional variance than the good news but their impact are not significant. Findings of this study are consistent with the findings of floros (2008) on Egypt and Israel markets, Ahmed and Suliman (2011) on Khartoum Stock Exchange (KSE).

6.5.1 Diagnostic Checking for EGARCH (1,1) model

We apply ARCH-LM test and autocorrelation test on the residuals of EGARCH (1,1) model to examine whether the model is well fitted and well specified or not.

6.5.1.1 ARCH- LM test

ARCH effect will not be significant if the EGARCH (1,1) model is well specified and well fitted. The null hypothesis under the test is-

H_0: There is no ARCH effect.

H_1: There is ARCH effect

Table 6.9: Estimated results of ARCH-LM test on the residuals of EGARCH (1,1) model

Test statistic	DGEN series		DS20 series	
	Constant	ARIMA(301)	Constant	ARIMA(202)
Obs* R^2 (TR^2)	0.0136	0.0114	0.2470	0.0841
P-value	0.9071	0.9148	0.6192	0.7718

The ARCH-LM test statistics (TR^2) have very high probabilities indicating insignificant under all cases. So, the null hypothesis that there is no ARCH effect cannot be rejected. Therefore, we can conclude that variance equations are well specified.

6.5.1.2 Test of Autocorrelation of Squared Residual

The results of the autocorrelation test of squared residuals are presented in Table 6.10.

Table 6.10 Estimated Results of Autocorrelation of Squared Residuals of EGARCH (1,1) Model

Lag	DGEN Series					
	Constant			ARIMA (3,0,1)		
	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value
1	-0.002	0.0136	0.907	-0.002	0.0114	
2	0.002	0.0201	0.990	0.001	0.0137	
3	-0.001	0.0232	0.999	-0.000	0.0140	
4	-0.003	0.0407	1.000	-0.003	0.0407	
5	-0.002	0.0540	1.000	-0.003	0.0645	0.800
6	-0.004	0.0954	1.000	-0.004	0.1161	0.944
7	-0.003	0.1166	1.000	-0.003	0.1408	0.987
8	-0.003	0.1369	1.000	-0.003	0.1618	0.997
9	-0.003	0.1654	1.000	-0.003	0.1940	0.999
10	-0.003	0.1873	1.000	-0.003	0.2279	1.000
Lag	**DS20 Series**					
	Constant			**ARIMA (2,0,2)**		
	ACF	**Q-Stat**	**P-Value**	**ACF**	**Q-Stat**	**P-Value**
1	0.009	0.2463	0.620	0.005	0.0837	
2	-0.009	0.4995	0.779	-0.003	0.1150	
3	-0.010	0.8214	0.844	-0.013	0.6354	
4	-0.015	1.4840	0.829	-0.016	1.3869	
5	-0.023	3.0901	0.686	-0.025	3.2473	0.072
6	-0.008	3.2903	0.772	-0.008	3.4643	0.177
7	-0.018	4.3206	0.742	-0.014	4.0590	0.255
8	-0.006	4.4345	0.816	-0.003	4.0873	0.394
9	-0.018	5.4187	0.796	-0.020	5.2662	0.384
10	-0.015	6.0872	0.808	-0.013	5.7702	0.449

The all autocorrelation functions are to be found within the range of 95% confidence interval. The Q-statistics are insignificant in all cases. So, there is no significant autocorrelation in the residuals series of EGARCH (1,1) model which indicate the model is well specified and well fitted.

6.6 Estimated Result under GJR-GARCH (1,1) Model

To capture the asymmetry in the return volatility of DSE, GJR-GARCH model has been used. In this case, an indicator function is incorporated in conditional variance equation to measure the impact of squared error terms on volatility. The indicator function takes value 1 (one) when news is bad ($\varepsilon_t < 0$) and 0 (zero) when news is good ($\varepsilon_t > 0$). Therefore, the impact of positive shocks on conditional variance is only determined by α whereas negative shocks (bad news) has an impact on conditional variance of $\alpha + \gamma$. The estimated results of GJR-GARCH model are furnished in table 6.11:

Table 6.11: Estimated Results of the GJR-GARCH (1,1) Model

Coefficients	DGEN		DS20	
	Constant	ARIMA(301)	Constant	ARIMA(202)
ω (constant) P-value	1.76E-06 0.0004	1.99E-06 0.0002	5.35E-06 0.0000	8.64E-06 0.0000
α (ARCH Effect) P-value	0.1735 0.0000	0.1692 0.0000	0.2277 0.0000	0.1753 0.0000
β (GARCH Effect) P-value	0.8123 0.0000	0.8040 0.0000	0.7667 0.0000	0.7673 0.0000
γ (Leverage Effect) P-value	0.0739 0.0086	0.1046 0.0013	0.0127 0.6957	0.0351 0.0309
$\alpha + \beta$	0.9858	0.9732	0.9944	0.9426

Table 6.11 represents the estimated values of the coefficients of the GJR-GARCH (1,1) model. It is found that the coefficient of lagged squared residual (ARCH term, α) and lagged conditional variance (GARCH term, β) are significant at 1% level of significance. A significant α indicate that the existence of volatility clustering (ARCH process) in return series i.e., large changes follow large changes and small changes follow small changes (Basher et al. 2007). The economic interpretation of the ARCH effect (volatility clustering) in stock market has been provided with in both micro and

macro framework. The ARCH effect in the stock return could be due to clustering of trade volume, nominal interest rate, dividend yield, money supply etc. (Bollerslev et al., 1992).

The significant β indicates that the impact of old news on volatility. The very high value of β coefficients under different situations (0.76 to 0.81) express that the impact of old information are more important than new information in our market.

The sum of α and β less than unity but very close to one, indicate shocks to the conditional variance (volatility) are highly persistent. Since, the sum is less than one that is why there is a tendency to go back to long run mean of the volatility series. The sum of the α and β coefficients lies between the range of 0.9426 to 0.9949, are also an estimation of rate at which the response function of shocks decay on daily basis. The very high values of the sum of α and β indicate that the shocks will dry out very slowly and also an indication of long memory, i.e., if there is a new shock, it will have an implication on returns for a longer period.

The coefficients of leverage effect (γ) are significant and positive for all cases except constant leaded GJR-GARCH (1,1) for DS20 return series, indicating the presence of leverage effect. The existence of leverage effects confirms that the negative shocks (bad news) have a larger effect on conditional variance than the positive shocks (good news), i.e., $\alpha + \gamma > \alpha$. It is also found that the γ coefficients for DS20 return series are very smaller than the DGEN series, indicate that the investors' of blue chips categories shares are less bothered about good and bad news than the market as a whole.

The findings of GJR-GARCH model are consistent with the findings of Ahmed and Suliman (2011) on Sudan; Floros (2008) on Israel market only for TASE-100 index but not consistent with the findings of Chowdhury and Iqbal (2005) on Bangladesh market.

6.6.1 Diagnostic checking for GJR-GARCH (1,1) Model

We apply ARCH-LM test and autocorrelation test on the residuals of GJR-GARCH (p,q) model to examine whether the model is well fitted and well specified or not.

6.6.1.1 ARCH- LM test

ARCH effect will not be significant if the GJR-GARCH (p,q) model is well specified and well fitted. The null hypothesis under this test is-

H_0: There is no ARCH effect

H_1: There is ARCH effect

Table 6.12: Estimated Results of ARCH-LM Test on the Residuals of GJR-GARCH (1,1) Model

Test statistic	DGEN series		DS20 series	
	Constant	ARIMA(301)	Constant	ARIMA(202)
Obs* R^2 (TR^2)	0.0249	0.0215	0.1480	0.7047
P-value	0.8746	0.8836	0.7005	0.4012

From Table 6.12, it is observed that the values of TR^2 are very small with higher probabilities, indicating the null hypothesis cannot be rejected at any conventional level of significance. So, there is no additional ARCH effect in both return series and the GJR-GARCH (1,1) model is well specified.

6.6.1.2 Test of Autocorrelation of Squared Residual

The results of the autocorrelation test of squared residuals are presented in table 6.13:

Table 6.13: Estimated Results of Autocorrelation on Squared Residuals of GJR-GARCH (1,1) Model

Lag	DGEN Series					
	Constant			ARIMA (3,0,1)		
	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value
1	-0.003	0.0250	0.874	-0.003	0.0215	
2	0.002	0.0353	0.983	0.001	0.0243	
3	-0.001	0.0376	0.998	0.000	0.0245	
4	-0.002	0.0540	1.000	-0.003	0.0500	
5	-0.002	0.0678	1.000	-0.003	0.0721	0.788
6	-0.004	0.1083	1.000	-0.004	0.1153	0.944
7	-0.003	0.1311	1.000	-0.003	0.1422	0.986
8	-0.003	0.1545	1.000	-0.003	0.1660	0.997
9	-0.003	0.1856	1.000	-0.004	0.2001	0.999
10	-0.003	0.2082	1.000	-0.003	0.2322	1.000
Lag	**DS20 Series**					
	Constant			ARIMA (2,0,2)		
	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value
1	-0.007	0.1475	0.701	0.003	0.0288	
2	-0.017	1.0287	0.598	-0.003	0.0505	
3	-0.014	1.6465	0.649	-0.010	0.3549	
4	-0.018	2.5887	0.629	-0.013	0.8651	
5	-0.026	4.6378	0.462	-0.023	2.5235	0.112
6	-0.011	4.9911	0.545	-0.009	2.7813	0.249
7	-0.021	6.3379	0.501	-0.016	3.5559	0.314
8	-0.010	6.6371	0.576	-0.005	3.6186	0.460
9	-0.023	8.2626	0.508	-0.021	5.0046	0.415
10	-0.018	9.2897	0.505	-0.012	5.4058	0.493

Table 6.13 exhibits autocorrelation function, *Q*-statistics and *p*-value of *Q*-statistics. It is found that the *P*-values of the Ljung-Box *Q*-statistics are higher in all cases for both

return series indicate that the null hypothesis of entire autocorrelation coefficients together equal to zero is not rejected at 10% level of significance. So, there is no significant autocorrelation in the residuals series of GJR-GARCH (1,1) model which indicate the model is well specified and well fitted.

6.7 Comparison of Estimation Capacity of the Models

In our study, we have used different types of symmetric and asymmetric GARCH model to examine the nature of volatility in Dhaka Stock Exchange. Validity of the model relies on the significance of parameters, white noise residual and best forecasting ability. The mean squared error (MSE), mean absolute error (MAE) and AIC have been taken under consideration to choose the best model for prediction. Under two different return series (DGEN and DS20), the value of MSE, MAE and AIC of different models are furnished in table 6.14 (a) and 6.14(b):

Table 6.14 (a): Best Fitted GARCH Model for DGEN Return Reries

Model	MSE	MAE	AIC
Constant- GARCH(1,1)	0.000228	0.009735	-6.177675
ARIMA(3,0,1)-GARCH(1,1)	0.000230	0.009640	-6.201964
Constant- GARCH-M (1,1)	0.000229	0.009752	-6.180304
ARIMA(3,0,1)- GARCH-M (1,1)	0.000230	0.009665	-6.202774
Constant -EGARCH (1,1)	0.000228	0.009737	-6.177186
ARIMA(3,0,1)- EGARCH (1,1)	0.000231	0.009640	-6.203773
Constant- GJR-GARCH(1,1)	0.000228	0.009736	-6.179902
ARIMA(3,0,1)- GJR-GARCH(1,1)	**0.000203**	**0.009636**	**-6.205550**

Table 6.14 (b): Best Fitted GARCH Model for DS20 Return Series:

Model	MSE	MAE	AIC
Constant- GARCH(1,1)	0.000189	0.009172	-6.198295
ARIMA(2,02)- GARCH(1,1)	0.000192	0.009117	-6.231595
Constant- GARCH-M (1,1)	0.000190	0.009194	-6.201353
ARIMA(2,02)- GARCH-M (1,1)	0.000192	0.009131	-6.232377
Constant- EGARCH (1,1)	0.000190	0.009173	-6.201165
ARIMA(2,02)- EGARCH (1,1)	0.000192	0.009119	-6.233355
Constant- GJR-GARCH(1,1)	0.000189	0.009172	-6.197675
ARIMA(2,02)- GJR-GARCH(1,1)	0.000191	**0.009113**	**-6.252950**

Table 6.14 (a) and (b) contain MSE, MAE and AIC value of various GARCH models under both series. It is found that the MSE (0.000203), MAE (0.009636) and AIC value (-6.205550) of ARIMA (3,0,1)-GJR-GARCH (1,1) model are lower than the other models for DGEN return series. So, ARIMA (3,0,1)-GJR-GARCH (1,1) model is the best fitted variance model for DGEN return series as per model selection criterion. On the other hand, based on the MAE (0.009113) and AIC value (-6.252950) the ARIMA (2,0,2)- GJR-GARCH (1,1) model for DS20 return series is the best fitted variance model though it's MSE value (0.000191) is slightly higher.

It is found that all the coefficients of the best fitted models are significant at 1% level of significance; only the γ coefficient of DS20 return series is significant at 5% level (see. Table: 6.11). So, the significant coefficients of these models indicate that the variance of stock returns is time-varying. The significant coefficients of these models also indicate the existence of the volatility clustering, volatility persistence and leverage effects in the return series of Dhaka Stock Exchange of Bangladesh.

6.8 Volume and Volatility Relationship

We investigate the effect of trading volume on asymmetric volatility in the Dhaka Stock Exchange, by studying the relationship between volatility and trading volume as a proxy for information arrival to the market. Using the mixture of distribution hypothesis (MDH), the relationship between stock return and trading volume have been examined. According to MDH, the interaction among the volatility and trading volume is critically dependent upon the rate of information flow to the market. The MDH implies a positive relationship between trading volume and volatility.

In this case, we have used the best fitted ARIMA (3,0,1)- GJR-GARCH (1,1) for DGEN series to study the relationship between trading volume and volatility. The estimated results of the model are presented in table 6.15:

Table 6.15: The Estimated Results of the ARIMA(301)- GJR-GARCH (1,1) Model with and without Contemporaneous Trading Volume

Coefficient	ARIMA(301)-GJR-GARCH(1,1) (Restricted)	ARIMA(301)-GJR-GARCH(1,1) (Unrestricted)
ω (constant) p-value	1.99E-06 0.0002	4.27E-05 0.0000
α (ARCH Effect) p-value	0.1692 0.0000	0.1622 0.0000
β (GARCH Effect) p-value	0.8040 0.0000	0.7447 0.0000
γ (Leverage Effect) p-value	0.1046 0.0013	0.1485 0.0001
ϕ (volume effect) p-value	……….	3.18E-06 0.0000
$\alpha+\beta$	0.9732	0.9069

Table 6.15 summarizes the estimated coefficients of restricted (without trading volume) and unrestricted (with trading volume) versions of the ARIMA(3,0,1)-GJR-GARCH(1,1) model to compare the degree of persistence and leverage effect on volatility. It is found that the all estimated coefficients are statistically significant for restricted and unrestricted version of ARIMA(301)-GJR-GARCH(1,1) model. According to joint observations, always $\beta > \alpha$ and $\alpha+\beta < 1$, indicating the process can be classified as stationary (Bollerslev, 1987). It is also observed that the α and β are highly significant and $\beta > \alpha$ under both specifications, implying that the past volatility information have more importance to predict current volatility. The volatility persistency ($\alpha+\beta$) is considerably high (0.9732) and very close to unity for restricted model, but the degree of persistence diminishes (0.9069) after including contemporaneous trading volume to variance equation in the unrestricted model. Alternatively, volume data seems to absorb some GARCH effects in volatility but not as much as stated by Lamourerux and Lastrapes (1990).

The γ coefficients are significant for restricted and unrestricted ARIMA(301)-GJR-GARCH(1,1) models, indicating leverage effect (asymmetric impact) on volatility i.e., bad news have greater impact on volatility than good news. In addition, the absolute magnitude of asymmetry coefficient (γ) increases from 0.1046 to 0.1485 after inclusion of trading volume variable to the variance equation. It indicates the trading volume leads to more asymmetric volatility on the market. These findings consistent with Okan et al. (2009) on Turkey market, Choi et al., (2011) on Korea market.

It is also found that the coefficient of trading volume (ϕ) is positive and significant at 1% level, indicates the contemporaneous trading volume significantly explained volatility. So, the results of this model support the MDH.

6.8.1 Diagnostic Checking for ARIMA (3,0,1)- GJR-GARCH (1,1) model with and without contemporaneous trading volume

ARCH-LM test and autocorrelation test have been applied on the residuals of ARIMA(3,0,1)-GJR-GARCH (1,1) model to examine whether the model is well fitted or not.

6.8.1.1 ARCH- LM Test

ARCH effect will not be significant if the GJR-GARCH (p,q) model is well specified and well fitted. Here, the null hypothesis is no ARCH effect in residual series.

Table 6.16: Estimated results of ARCH-LM test on the residuals of GJR-GARCH (1,1) model

Test Statistic	ARIMA(301)-GJR-GARCH(1,1) (Restricted)	ARIMA(301)-GJR-GARCH(1,1) (Unrestricted)
Obs* R^2 (TR^2)	0.0215	0.0423
P-value	0.8836	0.8371

From table 6.16, it is observed that the values of TR^2 are very small with higher probabilities, indicating the null hypothesis cannot be rejected at any conventional level of significance under both restricted and unrestricted situations. So, there is no additional ARCH effect in the residuals of both models and the ARIMA(301)-GJR-GARCH(1,1) (Restricted and unrestricted) models are well specified.

6.8.1.2 Autocorrelation Test

The results of the autocorrelation test of squared residuals (see Appendix B.1) indicate that the null hypothesis of entire autocorrelation coefficients together equal to zero is not rejected at any conventional level of significance under both the restricted and unrestricted conditions. So, there is no significant autocorrelation in the residuals series of ARIMA(301)-GJR-GARCH(1,1) models under both restricted and unrestricted situation indicating the models are well specified and well fitted.

6.8.2 Bi-variate VAR model and Granger Causality Tests

The contemporary relationship between the conditional variance (volatility) and trading volume is checked under VAR structure (see, chapter-4). In this section, first we have estimated ARIMA(3,0,1)-GJR-GARCH(1,1) restricted model to gather volatility (conditional variance) series. As per AIC, we have used 9-lags for the estimation process of the VAR model. The findings of VAR model (see Appendix B.2 for detail VAR results) indicate that the volatility is significantly influenced by itself up to 3 lags as well at 7^{th} and 9^{th} lags. Volatility also influenced by trading volume instantly because the volume coefficients are highly significant up to 3 lags. On the other hand, the trading volume is significantly influenced by its own lags instantly but by volatility after 6^{th} lags. Therefore, it can be suggested that there is a feedback relationship between the volatility and volume variables.

Table 6.17: Estimated results of the Granger Causality tests

Null Hypothesis	Results for 3-lags		Results for 9-lags	
	F-stat	P-value	F-stat	P-value
Volume does not Granger cause volatility	11.0802	0.0000	3.4198	0.0003
Volatility does not Granger cause volume	1.2222	0.3000	2.9832	0.0015

The Table 6.17 shows the Granger causality tests results under the null hypothesis of volume does not Granger cause volatility and vice versa. The results indicate that volume significantly Granger cause volatility at both earlier and later lags because the null hypothesis (H_0: Volume does not Granger cause volatility) is rejected at 1% level of significance. But volatility significantly Granger cause volume at later lags not at earlier lags because the null hypothesis (H_0: Volatility does not Granger cause volume) under 3-lags cannot be rejected but under 9-lags null hypothesis can be rejected.

6.9 Concluding Remarks

By applying different types of GARCH models, we have examined volatility clustering, persistence, leverage impact, return-volatility relationship and trading volume-volatility relationship. It has been seen that DSE return series exhibits strong volatility persistence and asymmetry. As per results of GARCH-M model significant positive relationship is existed between return and volatility. It is also seen that the contemporaneous trading volume significantly explain volatility and supporting the validity of MDH. The bi-variate VAR model establishes causal and feedback relationship between trading volume and volatility.

Chapter-Seven

Conclusions

7.1 Overview

This study explores two individual but related issues regarding the capital market, more specifically Dhaka Stock Exchange (DSE) which is the prime bourse in Bangladesh. We have tried to investigate the informational efficiency within the structure of weak form efficient market hypothesis and to model the nature of volatility of DSE. Firstly, by applying Unit root tests, Run test, Variance ratio test, Autocorrelation test and ARIMA model we examine how the successive stock prices or returns are independent and past prices have any predictive content to forecast future stock prices. Secondly, using GARCH family models we investigate nature of time-varying risk (volatility) of market returns of DSE as well as study the contemporaneous relationship between trading volume and volatility under VAR model.

7.2 Findings: Weak Form Efficiency

This study highlights the different forms of efficient market hypothesis and its theoretical basis. Theoretical and empirical studies on weak form efficient market hypothesis on developed and emerging markets have been intensively done with findings of mixed evidences i.e., some studies show empirical results which reject the null hypothesis of weak form efficiency while other studies do not reject. This study examines the random walk hypothesis and tests weak form efficiency of DSE using several econometric tools. Summary of the findings of this study related with weak form efficiency are described below:

- Descriptive statistics indicate that the returns of DSE exhibit positive skewness, very high kurtosis and as such strong deviation from normal distribution.
- Findings of Unit root tests (ADF, PP, DF-GLS and KPSS) indicate that the both return series do not contain unit root, indicating stationarity under full as well as three sub-periods. Stationarity is just opposite of random walk.
- Results of non parametric run test indicates the actual runs are significantly lower than the expected number of runs and *Z*-statistics are highly significant under all circumstances, indicating successive price changes are not independent and thus, both return series do not follow random walk.
- For full sample period as well as three sub-periods, findings of variance ratio test indicate that the variance ratios are significantly lower than 1 (one), and showing strong evidence of non-random walk pattern in return series of DSE.
- The results obtained from autocorrelation test show strong evidence of serial dependence at various lags of return series under full as well as three sub-periods. Presence of autocorrelation is an indication of inefficiency of capital market.
- In addition to the above techniques, the ARIMA model is used to test the weak form efficiency and forecasting future return of DSE. Under a random walk condition ARIMA (0,1,0) must be fitted because return cannot be predicted at different lags of AR and/or MA terms. It is found that the coefficients of ARIMA (0,1,0) are insignificant under both return series, indicating return DSE does not follow random walk. Further, selecting appropriate model for forecasting return, Box-Jenkins methodology is used. As per AIC and MSE, the

order of ARIMA (3,0,1) for DGEN return series and ARIMA (2,0,2) for DS20 return series and fitting of these models clearly indicating non-randomness of both return series. Therefore, the best fitted models are used to forecast future returns and exhibited that the actual returns are laid between the limit of ±2 SD except few outliers. Forecasting future returns using predictive models is gross violation of the concept of EMH.

The above findings from empirical analysis reveal that the return series of DSE do not follow random walk. So, future return can be predicted using information contained in past price trends and DSE is not efficient in the weak form. The results are almost similar to the findings of earlier works, e.g., Mobarek and Keasy (2000) on Bangladesh market, Poshakwale (1996) on Indian market, Shadiqui and Gupta (2010) on Indian market, Irfan, M. et al., (2010) on Pakistani market, and Patel et. al., (2012) on India, Hong Kong, Japan and China market.

7.3 Findings: Volatility

The second empirical part of this study is to depict the picture of volatility clustering, volatility persistence, volatility-return relationship, asymmetric impact of news on return volatility (leverage effect), and trading volume-volatility relationship. Summary of the findings of this part are as follows:

- Under all GARCH type models, the ARCH(α) parameters are highly significant and a strong indication of volatility clustering effect i.e., large changes in return series follow large changes and small changes follow small changes in Dhaka Stock Exchange.

- Under all GARCH type models, it is found that the GARCH(β) parameters are highly significant and higher than ARCH term, indicating the impact of old news are very much important than the latest news in Dhaka Stock Exchange.
- Volatility persistence indicators i.e., the sum of α and β indicate that the shocks to the volatility are highly persistent under all models. As per best fitted GJR-GARCH (1,1) model the sum of α and β is less than but very close to 1(one), indicating shocks will dry out very slowly and an indication of long memory.
- The relationship between time-varying risk (volatility) and return is studied under GARCH-M framework and found a positive and significant relationship has been found between volatility and return. This relationship indicates that the investors are demanding higher return at the time of higher volatility in Dhaka Stock Exchange and this finding is consistent with the theory of risk-return relationship in finance.
- Leverage effect is found in Dhaka Stock Exchange i,e., negative shocks (bad news) have a greater impact on conditional variance (volatility) than the positive shocks (good news) of equal magnitude. It is also found that the blue chips shareholders are less concerned about good and bad news than the market as a whole.
- The relationship between trading volume and return volatility is also examined and it is found that there is significant interaction between trading volume and return volatility when volume parameter is taken as a proxy of daily information flow. Incorporation of trading volume in best fitted GARCH model increases asymmetric impact on volatility and reduces volatility persistence. It is also found that trading volume cause volatility at earlier and later lags but volatility causes volume only at later lags.

The above findings indicate that shocks to volatility are highly persistent, bad news creates more volatility than the good news of same magnitude, old news are more important and shocks dry out very slowly which is the indicator of long memory. Trading volume can explain the part of the entire volatility and there is a feedback relationship between trading volume and volatility. These findings are very much similar with the nature of other inefficient underdeveloped capital markets.

7.4 Contributions Made by the Thesis

This thesis makes the following contributions:

- To the best of our knowledge, this study is the first ever effort where the weak form efficiency of DSE has been studied under recent past three political governments. It is found that under the tenure of all governments the market is inefficient in weak form but some analytical tools and indicators show improved conditions during the period of October 16, 2006 to December 30, 2008.
- To the best of our knowledge, this study first ever establishes the asymmetric impact (leverage effect) of news on volatility i.e., bad news have more impact on volatility than the good news of equal magnitude. But earlier studies (Chowdhury and Iqbal, 2005) have failed to capture the leverage impact rather they have said that positive shocks (good news) and negative shocks (bad news) have same impact on volatility. This is a very unique contribution of this study.
- This study is the first ever effort to examine the trading volume–volatility relationship (causal and dynamic) on Dhaka Stock Exchange. It provides an empirical support to the idea that the ARCH effect in the daily stock return data reflects time dependence in the process generating information flow to the market. Daily trading volume, used as a proxy for information arrival time, is

found to have significant explanatory power regarding the time-varying variance (volatility) of daily returns.

- This study clearly establishes that the absorption of news (good and bad) or any other price sensitive information takes time to make effect on stock price. So, there is a scope to earn abnormal profit using past information.

- Bangladesh is a developing country where capital market has a significant contribution behind the growth and development of this country. The outcomes of this study would increase the understanding and awareness of investors, dealers, brokers and regulators about stock market efficiency and some peculiar features of volatility. These understanding will help them to develop proper trading policies and to formulate exact rules and regulations for handling capital market issues.

7.5 Recommendations

The findings of the thesis have significant implications for investors, regulators and policy makers. As we know, market efficiency is the prior condition of allocating scarce resources to the most desirable and highest-valued project in cost effective way, so it should get highest priority. On the other hand, volatility directly related with risk of investors in capital markets. The greater the volatility the higher the risk, that will increase the cost of fund. To launch the market on the path of efficiency and maintaining stability of stock prices and returns of Dhaka Stock Exchange the following steps should be taken:

- Timely effective disclosure and dissemination of that disclosed price sensitive information are inevitable for efficient and vibrant capital market. There is a long memory problem and old information is more important than new information and investors can predict market using the old information which is a clear indication of effective and proper dissemination of information. So, government and regulatory agencies should take necessary actions in these regard.

- Poor corporate governance and fabricated auditing reports are some of the prime reasons of inefficiency and excess volatility of market. It is seen that management and auditing firms have no accountability for putting willful wrong information and manipulating reports. So, regulatory authorities should take necessary steps for ensuring accountabilities of all concerned parties.
- Institutional investors and official market makers can play a very important role in stabilizing market and putting the market in the path of efficiency. Because of having professional and efficient man power, they can analyze the entire condition of the market and take logical steps just in time. Therefore, more institutional investors should be attracted and more mutual funds should be approved immediately to make the market efficient and to reduce excess volatility.
- Shares of well established and reputed firms should be floated in stock market for the development of stock market in Bangladesh. Such types of shares ensure liquidity of market as well as entice investors and enhance the confidence of investors. This is the duty of regulatory agencies to force them to float their shares in stock market otherwise they have to pay taxes at higher rate or become deprived from various facilities provided by government. Enlistment of reputed firms will attract institutional investors and foreign investors which will increase the depth of the market.
- Supervision and regulatory actions should be strengthened to make the market efficient and stable. It is observed that there are two vital scams (1996, 2010) in

our market. But regulatory agencies and governments have substantially failed to take any action against the culprits who are responsible for creating bubble and excess volatility in market. Close monitoring and supervision will provide an early signal about various malpractices and will help to take instant corrective measures. In addition, a special tribunal can be established to take rapid action against them who are engaged with scandalous activities of stock market. Sometimes stock price moves unexpectedly, in this case strong supervision and early warning system help authority to detect the reasons behind the movement and help them to take necessary steps immediately.

- Transaction costs are very high in our market which is one the reasons of low trading volume. The size of trading volume provides signal on market depth, breadth and liquidity. So, transaction costs should be reduced for the development of market.
- Education and awareness regarding stock market are very much vital for the development of market. In most cases, investors do not have sufficient knowledge for making rational judgment about various disclosures and issues of stock market rather they conduct their operations based on rumor. So, government and regulatory authorities should take some program like, workshop, seminar etc. for enhancing knowledge and awareness of general investors.

Along with above measures, co-ordination among Securities and Exchange Commission (SEC), Dhaka Stock Exchange (DSE), Chittagong Stock Exchange (CSE) and Government is very much important. They must be pro-active and more vigilant for implementing rules relating to capital market and ensuring justice and transparency in all issues. These recommendations would also be helpful for all the supervisory authorities, and very much essential for the soundness and stability of the capital market as well as the financial system of Bangladesh.

7.6 Limitations of the Study and Future Research

The scope of the study is confined to test random walk of return series and nature of volatility of Dhaka Stock Exchange only. The study does not cover the efficiency of individual stock, volatility forecasting and impact of macroeconomic variables on return volatility of Dhaka Stock Exchange. Besides these, the aspect of profit making strategy was not investigated in detail using any technical trading rule or adjusting transaction cost (such as brokerage fee, time lag of settlement procedure, bid-ask spread).

The study is reliant on secondary data sources obtained from DSE data stream and different reports published by the DSE and SEC and only daily returns, calculated based on DGEN and DS20 indices, are taken into consideration as a single time series variable. Further research can be conducted to examine whether the DSE is weak form efficient weekly, monthly or tick data and different indices.

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Appendix A

Appendix to Chapter 5

A.1 Detailed Variance Ratio Results

In Section 5.6 of Chapter 5, the summarized results of Variance Ratio are presented. Here, Table A.1 and A.2 show the detailed results of the Variance Ratio.

Table A.1: Detailed Results of Variance Ratio of DGEN Return

Null Hypothesis: DGEN Return is a martingale
Included observations: 2764
Heteroscedasticity robust standard error estimates
Lags specified as grid: min=2, max=16, step=1

Joint Tests	Value	df	Probability
Max |z| (at period 3)*	8.077131	2764	0.0000

Individual Tests

Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.542649	0.057892	-8.400230	0.0000
3	0.349524	0.080533	-8.277131	0.0000
4	0.256628	0.094274	-8.386234	0.0000
5	0.205842	0.103986	-7.637174	0.0000
6	0.175841	0.111753	-7.374799	0.0000
7	0.149505	0.118481	-7.178294	0.0000
8	0.128678	0.124690	-7.434209	0.0000
9	0.110196	0.130793	-6.803148	0.0000
10	0.103115	0.136786	-6.556866	0.0000
11	0.096869	0.142528	-6.336527	0.0000
12	0.085560	0.148002	-6.178560	0.0000
13	0.084725	0.153214	-5.973822	0.0000
14	0.073487	0.158181	-5.857301	0.0000
15	0.067468	0.162914	-5.724078	0.0000
16	0.065111	0.167437	-5.941367	0.0000

*Probability approximation using studentized maximum modulus with parameter value 15 and infinite degrees of freedom.

Table A.2: Detailed Results of Variance Ratio of DS20 Return

Null Hypothesis: DS20 Return is a martingale
Sample: 1 3011
Included observations: 3009
Heteroscedasticity robust standard error estimates
Lags specified as grid: min=2, max=16, step=1

Joint Tests	Value	df	Probability
Max |z| (at period 3)*	9.021677	3009	0.0000

Individual Tests

Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.542066	0.051300	-8.926610	0.0000
3	0.344104	0.072702	-9.021677	0.0000
4	0.256981	0.086293	-8.610382	0.0000
5	0.209074	0.096095	-8.230624	0.0000
6	0.175275	0.104052	-7.926089	0.0000
7	0.152600	0.111028	-7.632314	0.0000
8	0.132704	0.117598	-7.375062	0.0000
9	0.112395	0.124211	-7.145963	0.0000
10	0.104779	0.130807	-6.843809	0.0000
11	0.100172	0.137184	-6.559275	0.0000
12	0.085193	0.143286	-6.384500	0.0000
13	0.085531	0.149090	-6.133649	0.0000
14	0.075668	0.154609	-5.978507	0.0000
15	0.067657	0.159856	-5.832406	0.0000
16	0.065906	0.164862	-5.665928	0.0000

*Probability approximation using studentized maximum modulus with parameter value 15 and infinite degrees of freedom.

A.2 Detailed Autocorrelation Results of ARIMA(0,1,0)

In Section 5.8 of Chapter 5, the results of ARIMA (0,1,0) are presented. Here, Table A.3 and A.4 show the autocorrelation results of residual squired of ARIMA (0,1,0) model.

Table A.3: Detailed Results of Autocorrelation of Residual Squired of ARIMA (0,1,0) Model for DGEN Return

Sample: 3 2766
Included observations: 2764

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.363	0.363	364.04	0.000
		2	0.100	-0.036	391.80	0.000
		3	0.034	0.011	394.99	0.000
		4	0.043	0.035	400.11	0.000
		5	0.077	0.058	416.70	0.000
		6	0.073	0.027	431.34	0.000
		7	0.141	0.119	486.74	0.000
		8	0.210	0.138	609.28	0.000
		9	0.047	-0.097	615.33	0.000
		10	0.073	0.091	629.99	0.000
		11	0.072	0.021	644.48	0.000
		12	0.065	0.011	656.29	0.000
		13	0.069	0.023	669.41	0.000
		14	0.044	-0.002	674.78	0.000
		15	0.085	0.039	694.76	0.000
		16	0.101	0.034	723.05	0.000
		17	0.094	0.056	747.70	0.000
		18	0.105	0.026	778.43	0.000
		19	0.061	-0.003	788.71	0.000
		20	0.049	0.011	795.29	0.000

Table A.4: Detailed Results of Autocorrelation of Residual Squired of ARIMA (0,1,0) Model for DS20 Return

Sample: 3 3011
Included observations: 3009

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.323	0.323	315.18	0.000
		2	0.145	0.046	378.92	0.000
		3	0.043	-0.019	384.49	0.000
		4	0.061	0.052	395.68	0.000
		5	0.094	0.069	422.18	0.000
		6	0.100	0.049	452.42	0.000
		7	0.208	0.170	582.94	0.000
		8	0.289	0.196	834.69	0.000
		9	0.082	-0.100	854.78	0.000
		10	0.106	0.080	888.43	0.000
		11	0.098	0.058	917.57	0.000
		12	0.077	-0.016	935.42	0.000
		13	0.102	0.047	966.75	0.000
		14	0.059	-0.022	977.17	0.000
		15	0.132	0.042	1030.3	0.000
		16	0.124	0.025	1076.7	0.000
		17	0.135	0.087	1131.9	0.000
		18	0.119	0.003	1175.1	0.000
		19	0.079	-0.003	1194.0	0.000
		20	0.058	0.005	1204.3	0.000

Appendix B

Appendix to Chapter 6

B.1 Detailed Autocorrelation Results of ARIMA(3,0,1) - GJR-GARCH(1,1) model

In Section 6.8.1.2 of Chapter 6, the autocorrelation results of residual squired of ARIMA(3,0,1)-GJR-GARCH(1,1) model with and without trading volume (unrestricted and restricted) are discussed. Here, Table B.1 and B.2 show the detailed correlogram of residual squired of ARIMA(3,0,1)-GJR-GARCH(1,1) model with and without trading volume.

Table B.1: Detailed Autocorrelation Results of Residual Squired of ARIMA(3,0,1)-GJR-GARCH(1,1) Model (Restricted) for DGEN Return

Date: 07/24/13 Time: 15:15
Sample: 5 2766
Included observations: 2762
Q-statistic probabilities adjusted for 4 ARMA term(s)

	AC	PAC	Q-Stat	Prob
1	-0.003	-0.003	0.0215	
2	0.001	0.001	0.0243	
3	0.000	0.000	0.0245	
4	-0.003	-0.003	0.0500	
5	-0.003	-0.003	0.0721	0.788
6	-0.004	-0.004	0.1153	0.944
7	-0.003	-0.003	0.1422	0.986
8	-0.003	-0.003	0.1660	0.997
9	-0.004	-0.004	0.2001	0.999
10	-0.003	-0.003	0.2322	1.000
11	-0.002	-0.002	0.2447	1.000
12	-0.003	-0.003	0.2772	1.000
13	-0.000	-0.000	0.2776	1.000
14	-0.001	-0.001	0.2800	1.000
15	-0.002	-0.002	0.2877	1.000
16	0.000	0.000	0.2882	1.000
17	-0.003	-0.003	0.3179	1.000
18	-0.002	-0.002	0.3266	1.000
19	-0.001	-0.001	0.3320	1.000
20	-0.002	-0.002	0.3420	1.000
21	0.001	0.001	0.3447	1.000
22	-0.003	-0.003	0.3721	1.000
23	-0.002	-0.002	0.3822	1.000
24	0.000	-0.000	0.3822	1.000
25	-0.002	-0.002	0.3965	1.000
26	-0.002	-0.003	0.4129	1.000
27	0.001	0.001	0.4141	1.000
28	-0.003	-0.003	0.4428	1.000
29	-0.003	-0.003	0.4644	1.000
30	0.004	0.004	0.5085	1.000
31	-0.003	-0.003	0.5330	1.000
32	-0.000	-0.000	0.5330	1.000
33	-0.002	-0.002	0.5482	1.000
34	-0.003	-0.003	0.5746	1.000
35	-0.003	-0.003	0.6044	1.000
36	-0.002	-0.002	0.6108	1.000

Table B.2: Detailed Autocorrelation Results of Residual Squired of ARIMA(3,0,1)-GJR-GARCH(1,1) Model (Unrestricted) for DGEN Return

Date: 03/22/13 Time: 00:21
Sample: 5 2766
Included observations: 2762
Q-statistic probabilities adjusted for 4 ARMA term(s)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.004	-0.004	0.0423	
		2	-0.002	-0.002	0.0503	
		3	-0.003	-0.003	0.0685	
		4	-0.005	-0.005	0.1361	
		5	-0.005	-0.005	0.2054	0.650
		6	-0.006	-0.006	0.3185	0.853
		7	-0.004	-0.004	0.3696	0.946
		8	-0.003	-0.004	0.4027	0.982
		9	-0.005	-0.005	0.4675	0.993
		10	-0.005	-0.005	0.5380	0.997
		11	-0.003	-0.003	0.5640	0.999
		12	-0.005	-0.005	0.6204	1.000
		13	-0.000	-0.001	0.6210	1.000
		14	-0.001	-0.001	0.6256	1.000
		15	-0.002	-0.002	0.6387	1.000
		16	-0.002	-0.002	0.6466	1.000
		17	-0.004	-0.005	0.7007	1.000
		18	-0.002	-0.002	0.7100	1.000
		19	0.000	-0.000	0.7100	1.000
		20	-0.002	-0.002	0.7248	1.000
		21	0.003	0.003	0.7529	1.000
		22	-0.004	-0.005	0.8083	1.000
		23	-0.002	-0.003	0.8232	1.000
		24	-0.001	-0.001	0.8243	1.000
		25	-0.004	-0.004	0.8692	1.000
		26	-0.003	-0.004	0.9013	1.000
		27	0.000	-0.000	0.9014	1.000
		28	-0.004	-0.004	0.9520	1.000
		29	-0.004	-0.004	0.9983	1.000
		30	0.006	0.006	1.1029	1.000
		31	-0.004	-0.004	1.1524	1.000
		32	-0.002	-0.002	1.1656	1.000
		33	-0.002	-0.003	1.1813	1.000
		34	-0.004	-0.005	1.2357	1.000
		35	-0.005	-0.005	1.3118	1.000
		36	-0.003	-0.003	1.3393	1.000

B.2 Detailed VAR Results

In Section 6.8.2 of Chapter 6, the results of VAR are discussed. Here, Table B.3 shows the detailed results of the VAR estimation between conditional variance (volatility) ARIMA(3,0,1)-GJR-GARCH(1,1) Model and trading volume.

Table B.3: Detailed VAR Results between conditional variance (volatility) ARIMA(3,0,1)-GJR-GARCH(1,1) Model and volume for DGEN Return

Vector Autoregression Estimates
Included observations: 2753 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	Volatility	Volume
Volatility (-1)	1.018843	-10.14257
	(0.01911)	(26.4100)
	[53.3071]	[-0.38404]
Volatility (-2)	-0.097375	39.39665
	(0.02729)	(37.7114)
	[-3.56795]	[1.04469]
Volatility (-3)	-0.048713	-40.06510
	(0.02733)	(37.7591)
	[-1.78266]	[-1.06107]
Volatility (-4)	-0.025169	-10.27423
	(0.02734)	(37.7814)
	[-0.92052]	[-0.27194]
Volatility (-5)	0.038196	10.56576
	(0.02733)	(37.7634)
	[1.39763]	[0.27979]
Volatility (-6)	-0.009686	-79.70818
	(0.02733)	(37.7683)
	[-0.35438]	[-2.11045]
Volatility (-7)	0.072092	47.76298
	(0.02732)	(37.7481)
	[2.63898]	[1.26531]

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	Volatility	Volume
Volatility (-8)	0.017789	10.57132
	(0.02722)	(37.6153)
	[0.65347]	[0.28104]
Volatility (-9)	-0.037821	46.60778
	(0.01912)	(26.4162)
	[-1.97838]	[1.76436]
Volume (-1)	2.35E-05	0.644559
	(1.4E-05)	(0.01909)
	[1.69866]	[33.7725]
Volume (-2)	-6.42E-05	0.069813
	(1.6E-05)	(0.02273)
	[-3.90180]	[3.07128]
Volume (-3)	3.97E-05	0.161320
	(1.7E-05)	(0.02282)
	[2.40674]	[7.06999]
Volume (-4)	6.28E-06	0.018240
	(1.7E-05)	(0.02303)
	[0.37654]	[0.79200]
Volume (-5)	-1.93E-05	0.018726
	(1.7E-05)	(0.02301)
	[-1.15611]	[0.81368]
Volume (-6)	2.09E-05	0.019006
	(1.7E-05)	(0.02300)
	[1.25817]	[0.82635]
Volume (-7)	1.28E-06	0.002898
	(1.7E-05)	(0.02281)
	[0.07730]	[0.12707]
Volume (-8)	5.97E-06	-0.009167
	(1.6E-05)	(0.02277)
	[0.36252]	[-0.40265]
Volume (-9)	-5.43E-06	0.065631
	(1.4E-05)	(0.01908)
	[-0.39300]	[3.43953]
C	-0.000123	0.143297
	(4.3E-05)	(0.05892)
	[-2.88141]	[2.43196]

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R-squared	0.871065	0.968309
Adj. R-squared	0.870216	0.968100
Sum sq. resids	9.88E-05	188.6654
S.E. equation	0.000190	0.262692
F-statistic	1026.140	4640.905
Log likelihood	19690.66	-216.6687
Akaike AIC	-14.29107	0.171209
Schwarz SC	-14.25021	0.212069
Mean dependent	0.000264	16.13009
S.D. dependent	0.000528	1.470799