Note

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Stylized Facts of the Statistical Properties of Risk and Return of the Dhaka Stock Exchange: 1991-2015

KAZI IQBAL[*]
SIBAN SHAHANA[**]

While the role of financial market, particularly the stock market, in promoting economic growth through efficient allocation of capital is well recognised, the investors of the developing economies have little knowledge about the return and risk of the markets they operate in. To this end, we compile a security level historical data for the period 1991-2015 for Dhaka Stock Exchange and identify some important stylized facts about the return and risk. Descriptive statistics of disaggregated stock data suggest that while the daily rate of returns swing up and down over decades, the volatility tends to increase over time. Manufacturing stocks outperform other sectors both in return and volatility. Similarly, older stocks earn better return with lesser risks than the newer stocks. Several standard tests confirm that the distribution of daily returns is not normal; it does not follow random walk and the market is not efficient. Overall, there is a risk return trade-off and this trade-off varies significantly with sectors, age and quality of the stocks.

Keywords: Stock Market, Daily Return, Risk-return Tradeoff, Dhaka Stock Exchange

JEL Classification: G10, G12

I. INTRODUCTION

It has been a long tradition to document the "stylized facts" of the statistical properties of the stock market return such as distributional properties, tail properties and extreme fluctuations, linear and nonlinear dependence of returns, etc. in order to identify a common set of empirical regularities in the market irrespective of the instruments and time periods. Following Cont (2001) that identified eleven such statistical properties common to stock and currency

[*]Bangladesh Institute of Development Studies (BIDS), Dhaka, Bangladesh.
[**]Bangladesh Institute of Development Studies (BIDS), Dhaka, Bangladesh.

markets,[1] a large volume of country case studies has emerged aiming to fix the broad narrative on the stock market return and the related issues. This paper contributes to this discussion by summing up a few broad trends of the return and risk of the securities traded in the Dhaka Stock Exchange (DSE) for the period 1991-2015.

The economy of Bangladesh has been growing at around 6.5 per cent per year over the last one decade and has entered the bracket of lower middle-income country in 2016. The 7thFive Year Plan envisions that the economy will achieve growth rate of 8 percent in 2020 and it will accelerate further beyond the Plan period to reach the double-digit mark. In this backdrop, a key question is: how this growth will be financed when the share of private investment is more or less stagnant. While we know that the major share of financing will come from the private sector, we have very little understanding of the method of financing. That is: what would be the distribution of equity (i.e., stock) and non-equity (i.e., bond and bank) financing along the desired growth path of Bangladesh economy?

The role of equity finance as a source of corporate finance increases with the level of economic development (Shaw and Gurley 1955). At the initial stage of development financial intermediaries such as banks and non-bank financial institutions provide the necessary capital for the corporate sector. As the economy grows and so do the size of firms, the demand for equity finance increases (Levin and Zervos 1998, Arestis *et al.* 2001). With efficient institutions such as quality legal and tax systems, effective contract enforcement, and transparent and standardized accounting practices, equity financing is more likely to grow (Goldsmith 1969).

The economy of Bangladesh is likely to experience greater share of equity capital as it moves along its higher growth trajectory. However, the understanding of the capital market of Bangladesh and its potential is very limited. The role of the security market is mostly absent in the development discourse of Bangladesh and has not yet received due attention in policy domain largely because there is hardly any robust analysis on it. The current literature is mostly outdated and fails to ask the most fundamental first order questions such as what is the rate of return of the capital market? What is the extent of equity premium? What is the extent of trade-off between return and risk? Therefore, constructing a set of stylized facts of the capital market of Bangladesh with regard to return and risk is essential for

[1]These properties include absence of autocorrelation, heavy tails, gain/loss asymmetry, aggregational gaussianity, intermittency, volatility clustering, conditional heavy tails, slow decay of autocorrelation in absolute returns, leverage effect, volume/volatility correlation, and asymmetry in time scales.

providing feedbacks into the broader discussion on the nexus between method of finance and economic growth in Bangladesh.

Having a general understanding of the stylized facts[2] of the return and risk of the market is also important for the small investors who are susceptible to market manipulation. The latest stock market crash in 2009-10 is a glaring example of how poor understanding of the capital market may contribute to forming irrational exuberance. The participants may have failed to assess the return against the high risk of securities because they do not know the trade-offs. Poor knowledge about the market of small investors is argued to make it easier for large players to manipulate the market. Share Market Inquiry Report, 2011 by Khondkar Ibrahim Khaled also held the ignorance of these small investors responsible for the market crash.

As discussed above, we ask very basic questions regarding stock return and its volatility. First, we study the behaviour of stock return and next we focus on the volatility issues. The specific questions under each broad theme are given below:

<u>Understanding the behaviour of stock return</u>

i. What is the historical average of the rate of return of the stock market (1991-2015)? How this return has changed over time?
ii. How does return vary with sector, age, and quality of firms?
iii. What type of stochastic process the stock return follows? That is, how predictable is the stock market return?

<u>Understanding the behaviour of volatility of stock return</u>

i. What is the historical average of the volatility of the stock market return (1990-2015)? How this volatility has changed over time?
ii. How does volatility vary with sector, age, quality of the firms?
iii. What is the trade-off between risk and return and how it has changed over time?

We have identified twelve stylized facts on daily return and its volatility for the period 1991-2015 of the stocks listed in DSE. The first six stylized facts generalize how the returns and their volatility have changed over time, both at aggregated and disaggregated level (i.e., sector, age, quality), based on simple descriptive statistics. The following three stylized facts deal with statistical

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[2]The term "stylized facts" was first introduced by Nicholas Kaldor (1957) in the context of economic growth. He argued that "facts as recorded by statisticians are always subject to numerous snags and qualifications, and for that reason are incapable of being summarized" and hence he suggested to "concentrate on broad tendencies, ignoring individual detail."

properties of the stocks such as normality of distribution, random walk and efficient market hypothesis. We have conducted a battery of tests to confirm these statistical properties. The last two stylized facts are on risk-return trade-offs using standard GARCH-m and Fixed Effect models.

We have found that the 2000s was the decade of high positive return and this decade of high return was preceded and followed by negative returns in the 1990s and 2010s. Comparison of returns across sectors reveals that the rate of return of manufacturing companies outperforms other sectors on average. In the case of age of stock, older stocks yield higher returns than the newer ones. The rate of return is higher and volatility is lower for Category "A" than other categories, justifying the categorisation. The monthly volatility of daily return has increased over time. Disaggregated data show that volatility across sectors are very similar and there is significant heterogeneity in volatility among stocks of different quality and age.

The statistical properties of the distribution of daily stock returns of DSE are very similar to that of other developing countries. We have found that the distribution of daily stock return is not normal. Daily returns do not follow random walk and the market is not "efficient." There is also volatility clustering. GARCH-m model suggests that there is a risk return trade-off; a one percentage point increase in return is associated with 1.6 percentage points of risk. Fixed Effect models indicates that there is substantial heterogeneity in risk-return tradeoffs among stocks of different sectors, quality, and age.

The rest of the paper is organised as follows. Section II reviews the relevant literature; section III describes the data and the variables; section IV documents 12 stylized facts about returns and volatility using both un-weighted daily stock price data and DSE index, and section V draws conclusion.

II. LITERATURE REVIEW

While there is an extensive literature on the statistical properties of risk and return in developed countries, the literature on stylized facts of the movement of stock return and volatility is very thin for developing countries. In this section, we limit our discussion only to Bangladesh economy, as well as to a number of developing countries with which Bangladesh economy fares well.

The literature on stock market of Bangladesh is outdated and deals with a short span of time. As a result, the findings can be very period-specific without offering much to generalize. Chowdhury (1994) is the first study to document the statistical properties of the stock market using DSE index for the period 1988-1994. It documents that the daily return for this period was 0.016 per cent with standard deviation of 0.029 per cent. This study finds negative first order autocorrelation, suggesting that stock market returns may be predictable to some extent. Hence, it argues that the efficient market or random walk hypothesis does not strictly hold in this period. The findings also indicate that changes in DSE price index are conditional heteroskedastic and some long-term dependency is prevalent in the series of return.

Basher et al. (2007), using slightly larger sample (1986-2002), find that the daily return was about -0.031 percent with a standard deviation of 1.55 percent. This study finds similar figures for return and volatility when it excludes the short period of 1996 when the bubble built up and busted. It also separates out the post-financial liberalisation period (1991 to 2002) of their sample and finds that the stock returns are also negative. The post liberalisation period is found to have slightly higher volatility than the whole period.

The studies on stock market in developing countries largely center on the issue of volatility of stock return. This strand of literature examines the impact of changes in policies and regulations (monetary policy, stock market regulations, liberalisation of financial market), political event (e.g., Brexit), and stock market event (e.g., boom and crash) on volatility. Basher, Hassan and Islam (2007) examine the time-varying risk-return relationship and the impact of change in regulations such as circuit breaker on volatility for Dhaka Stock Exchange (DSE) using daily and weekly stock returns. The results show a significant relationship between conditional volatility and stock returns, but the risk-return parameter is found to be sensitive to choice of samples and frequencies of data.

There is an argument that market liberalisation increases the volatility after opening up the market as investment flows from developed market are very sensitive of changing economic condition in developing countries. However, evidence from the developed and emerging markets suggests the non-existence of systematic effect of market liberalisation on stock return volatility (Santis and Imrohoroglu 1994). Choudhry (1996) studies stock market volatility for six emerging stock markets (Argentina, Greece, India, Mexico, Thailand, and Zimbabwe) before and after the 1987 stock market crash using monthly data for the period 1976 to 1994. Results indicate persistence of volatility both before and after the 1987 crash. However, the changes are not uniform and depend on the individual markets. The impact of political event such as political strike in Bangladesh is found to have a negative impact on volatility (Haque *et al. 2018).* Political strikes reduce the frequency and volume of trade and it shrinks the extent of volatility in the period 2005-2015.

Construction of stylized facts on the statistical properties of DSE requires some comparison with a few comparable countries such as India and Pakistan. While the literature is replete with studies examining the behaviour of stock return and its volatility for these two countries, it lacks long term and disaggregated analysis. The monthly stock return in India for the period 1979-2003 was about 0.011 percent with standard deviation of about 0.07 percent (Batra 2004). Volatility is found to increase in post-recession period (recession year is 2007) from the pre-recession period in India (Mandal and Bhattacharjee 2012). Mukherjee, Sen and Sarker (2011), using BSE SENSEX index of India for the period of 1997-2009, found that the daily return was non-normal with fat tails and it showed significant volatility persistence and volatility clustering, conforming to the broad stylized facts observed in financial time series.

On the other hand, in Pakistan, monthly return was 0.016 percent with 0.043 percent standard deviation in the period 1981-92 (Khilji 1993). Though dated, literature shows that the distribution of returns of Karachi Stock Exchange (KSE) is positively skewed, leptokertic and shows volatility clustering (Khilji 1993, Hussain 1997, Uppal 1993). Interestingly, Hussain and Uppal (1997) observed a significant decline in volatility during the month of Ramadan with no significant change in the average return.

The earlier studies on Bangladesh (Chowdhury 1994, Basher, Hassan and Islam 2007) examining the statistical properties of the stock market did not address the basic issues such as historical average of stock return and its volatility, how they are related and how they have changed over time. This is largely due to the fact that these studies worked with small sample period. As a result, the current discourse on financing of growth in Bangladesh cannot properly assess the potential of the stock market when pit against the traditional mode of financing such as banks. Further, these earlier studies focused only on the aggregate indices, ignoring the presence of high degree of heterogeneity among firms listed in stock exchanges. While the understanding of aggregates are important, these studies did not take into account the fact that stock market return and its volatility vary substantially with sectors, age, and quality of firms. In this study, we compile daily firm level stock market data for the years 1991-2015 which contain a few million observations, 1,071,312 to be exact. The richness of our data allows us to address the issue of heterogeneity across firms in return and volatility.

III. DATA AND VARIABLES

We compile daily stock market data for all listed securities from Dhaka Stock Exchange (DSE) on the following variables: closing price of the day, total number of shares issued by the firm, bonus share, right share, and cash dividend for the period 1991-2015. Note that the closing price is the unadjusted price; that is it does not consider stock split, right share, cash, and stock dividend. Therefore, we collected these information to construct the "adjusted price" which are used to calculate the return of each security.

Construction of adjusted price and return

The first challenge is to calculate the "adjusted closing price" by incorporating stock split, cash, and stock dividend. In the case of cash dividend, the amount is subtracted from price before calculating the rate of return. In the case of stock dividend, the price is deflated by "gross" dividend rate. That is, if the price of a stock is Taka 11 and the company announces 10 percent stock dividend, the adjusted price will be 11/1.1 = Taka 10. Similarly, we adjust for the ratio of right share and stock split to calculate adjusted price. We use continuously compounded rate of return:

Rate of return = 100*[log (closing price (t)) – log (closing price (t-1])]

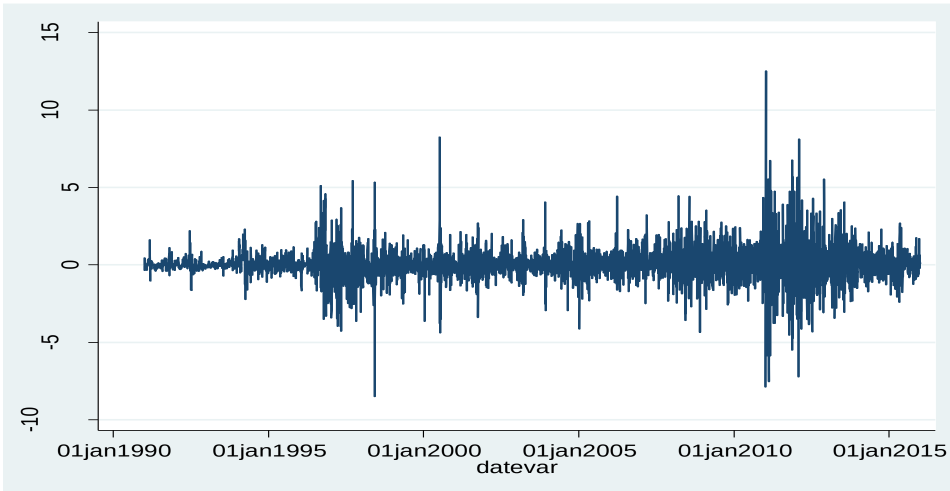
We calculate standard deviation (SD) of stock return using deviation from historical mean.

IV. STYLIZED FACTS OF THE STATISTICAL PROPERTIES OF DSE: 1991-2015

The security level disaggregated data allows us to study the statistical properties of the daily returns and their volatilities by sectors, quality (A, B and Z), and age of the firms. We analyse the un-weighted return and volatility of the stock. At the individual level, small investors hardly hold market portfolio and therefore, the market indices do not necessarily reflect the performance of their portfolio. Moreover, a large fraction of the stocks are held by institutions which are not traded in the market. Hence, a number of stylized facts rely on the un-weighted measures, particularly when disaggregated information is used.

Stylized fact 1: *2000s is the decade of high positive return, preceded and followed by negative decadal returns.*

FIGURE 1: **Average daily log returns of share prices of all companies (1991–2015)**



While the average daily rate of return was about 0.0034, which is equivalent to about 1.10 percent per annum for the period 1991-2015, it fluctuated significantly over the entire period of our study (Table I). The mean return varied over time, fluctuating from almost small negative (-0.005 percent in the 1990s) to high positive (about 0.05 percent in 2001-2010) and then fell to high negative return in the following decade (-0.06 percent after 2010). While the daily returns fluctuated over time, variations of daily returns across shares remain more or less stable, measured by standard deviation of stock prices. Note that the daily rate of return was found to be 0.02 percent (equivalent to 7.3 percent annually) for the period of 1988-1994 in Chowdhury (1994) and - 0.035 percent for the period of 1986 to 2002 (Basher, Hassan and Islam 2007).

TABLE I

DECADE WISE DAILY STOCK RETURN (%)

Year	Mean daily return	SD
1991-2015	0.003	2.34
1991-2001	-0.005	2.30
2001-2010	0.047	2.35
2011-2015	-0.06	2.39

It is important to note that during the period of study, the market went through two booms and bursts. The first surge occurred in 1996 and the second one took place in 2010. During the period of the first boom, the daily average un-weighted return was about 0.17 percent, followed by a crash that saw the daily return declined to about -0.21 percent in 1997. In 2010, the market earned a daily rate of return of 0.12 percent and then nose-dived to -0.15 percent in the following year.

Stylized fact 2: *The rate of return of manufacturing companies outperforms other sectors on average.*

TABLE II

SECURITIES BY SECTORS

Financial (6)	Manufacturing (10)	Service (5)
Bank	Tannery	Telecom
Life insurance	Ceramic	IT
General insurance	Pharmaceuticals	Service and real estate
NBFI	Food	Paper and printing
Mutual Fund	Jute	Travel and leisure
Bond	Textile	
	Engineering	
	Cement	
	Fuel and Energy	
	Miscellaneous	

DSE defines 21 categories of securities and in order to make them tractable we create three broad sectors – financial, manufacturing, and services. Table II shows how 21 categories are grouped into these three sectors. While the average daily return was 0.003 percent for all stocks during 1991-2015, the rate of return for manufacturing sector was 0.007 percent (Table III). The daily return for service and financial sectors for the entire study period was the same (-0.002 percent). In the period of high return (2001-2010), however, financial sector outperforms the manufacturing sector. The manufacturing and financial sectors saw the un-weighted average daily returns of 0.039 percent and 0.068 percent respectively during 2001-2010. On average, when the market is down, the daily returns of manufacturing fell less than other two sectors, pushing its average return upward for the whole period. Unfortunately, there is no study for DSE linking firm level fundamentals and stock market returns. The anecdotal evidence suggests that the fundamentals such as return on asset, return on equity and earning per share are very sound for the manufacturing sector. More than half of the firms in manufacturing sector belong to the "A" category share.

TABLE III

SECTOR WISE DAILY RETURN AND SD (%)

Year	Manufacturing	SD	Service	SD	Financial	SD
1991-2015	0.007	2.35	-0.002	2.31	-0.002	2.34
1991-2001	-0.006	2.43	-0.025	2.26	0.008	1.81
2001-2010	0.039	2.26	0.029	2.28	0.068	2.54
2011-2015	-0.045	2.44	-0.045	2.42	-0.083	2.33

Stylized fact 3: *Old is gold.*

We categorised the firms by the time they were enlisted in DSE. Firms which started transaction before 2000 are referred to as "Old" firm and firms which started transaction after 2000 are the "New" firms. According to this classification, the old firms outperformed the new ones (Table IV). The daily average return of old firms was 0.011 percent since 1991 and return for new firms was -0.01 percent.

TABLE IV

FIRM'S AGE-WISE DAILY RETURN (%)

Age of firms	Mean daily return	SD
Old firms (before 2000)	0.011	2.37
New firms (after 2000)	-0.010	2.51

Stylized fact 4: *Categorisation based on quality truly reflects the relative return.*

We have calculated mean daily return for different categories based on quality. As we know, "A" category companies are the ones that regularly hold the Annual General Meetings (AGMs) and have declared dividend at the rate of 10 percent or more in a calendar year. "B" category companies are regular in holding the AGM but have failed to declare dividend at least at the rate of 10 percent in a calendar year. "Z' category companies fail to hold the AGM or fail to declare any dividend or they are not in operation continuously for more than six months. Table V shows that the daily average returns for A, B and Z were 0.007, 0.000 and -0.003 respectively, suggesting that the categorisation of quality truly reflects the relative return.

TABLE V

FIRM QUALITY AND DAILY RETURN (%)

Category	Mean daily return	SD
A	0.007	2.35
B	0.000	2.52
Z	-0.003	2.60

Stylized fact 5: *Monthly volatility of daily return has increased over time.*

We estimate volatility based on the moving average of 21 days. Monthly volatility of daily return for the entire period was 1.71 percent. During the period of 1991-2001, the monthly volatility of the daily return was 1.37 percent, which increased to 1.69 percent in the following decade and then further accelerated to 2.00 percent during 2011-15 (Table VI).

TABLE VI

DECADE WISE MONTHLY VOLATILITY OF DAILY RETURN

Year	Volatility (%)
1991-2015	1.71
1991-2001	1.37
2001-2010	1.69
2011-2015	2.00

It is argued that financial liberalisation, macroeconomic volatility and foreign institutional investment may cause higher volatility in the return of the stock market. The stock market volatility and financial liberalisation in developing countries are found to move together (Grabel 1995). There are also evidence of positive correlation between the macroeconomic fundamentals and stock market volatilities, with volatile fundamentals translating into volatile stock markets (Diebold and Yilmaz 2008). There are also evidence of foreign institutional investment contributing to the volatility of the stock market (Chen *et al.* 2013, Pal 2005).

Stylized fact 6: *While volatility across sectors is very similar, there is significant heterogeneity in volatility among stocks of different quality and age.*

TABLE VII

VOLATILITY BY SECTOR, QUALITY AND AGE OF SECURITIES

Sector	Volatility (%)	Quality	Volatility (%)	Age	Volatility (%)
Manufacturing	1.70	A	1.75	Old	1.35
Service	1.70	B	2.02	New	1.74
Financial	1.75	Z	2.00		

Table VII presents the volatility of stocks for the period 1991-2015, with the breakdown of sectors, quality, and age of the stocks. Volatility is 1.70 percent for both manufacturing and service sectors and for financial sector it is slightly higher-1.75 percent. However, in the case of quality, category A had much less volatility compared to category B and Z, though the return of category A is higher. Moreover, the new stock has higher volatility (1.74 percent) than that of old stocks (1.35 percent).

Stylized fact 7: *Distribution of daily stock return is not normal.*

The distribution of daily returns (Figure 2) shows that the distribution is skewed and has asymmetric tails as the coefficients of skewness and kurtosis are statistically different from the normal distribution. The sample kurtosis is greater than +3 indicating the distribution of return is leptokurtic – a fat-tailed distribution.

We look at properties of the skewness and kurtosis of the raw data of daily stock return and in this case, we use the actual raw data for Skewness tests for normality. The output of the joint test for normality shows a higher chi-squared value (1482.2) and respective p-value (0.00) with a clearer rejection of null hypothesis of normality (Table VIII). The tests reveal that the daily stock returns are asymmetric (with right symmetry) and have excess kurtosis.

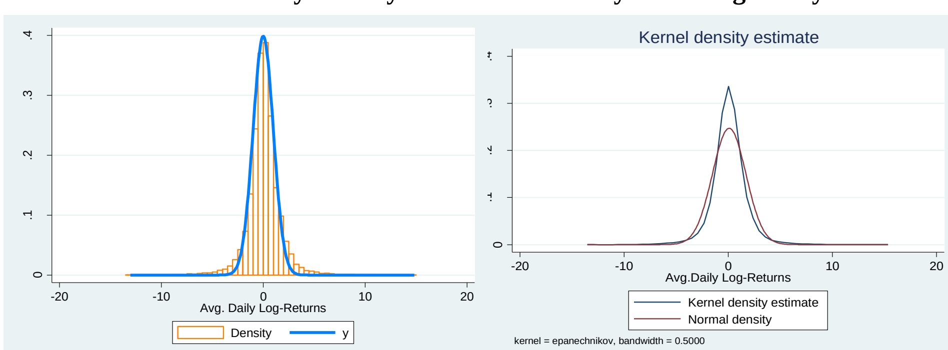
TABLE VIII

SKEWNESS/KURTOSIS TESTS FOR NORMALITY

Variable	No. of obs.	Prob. (Skewnesss)	Prob. (Kurtosis)	Chi2(2)	Prob>chi2
Average daily return	9,130	0.000	0.000	1482.2	0.000

We have also plot the probability density and kernel density of average daily return. The right panel of Figure 2 compares a kernel estimator of the density of the average log returns with a normal density. The peak around zero appears clearly, indicating a leptokurtic distribution, which implies a slimmer and fat-tailed distribution curve compared to a normal distribution. The fatter tails indicate relatively more weight in the tails and hence more extreme and less moderate values compared to a normal bell-shaped distribution.

FIGURE 2: **Probability Density and Kernel Density of Average Daily Return**



Moreover, we also plot the quintiles of the return (Figure A.1 in Appendix). The standardized returns are not normally distributed as the points in the Q-Q plots against normal distribution lie alongside a straight line. It shows that there are both large positive and negative shocks that drive the departure from normality.

Stylized fact 8: Daily returns don't follow random walk.

The issues regarding the stochastic process of stock return evolve around the question of random walk originally examined by Kendall (1953) or more generally the efficient market hypothesis (Fama 1965). The Random Walk Model (RWM) states that stock price fluctuations are independent of each other and have the same probability distribution. The idea behind the random-walk model is to suggest that all information present in the market is immediately reflected in the price; so today's news affects only today's prices and so on. Furthermore, price moves only with the advent of new information and this information is random and unpredictable. The news, by its definition, is unpredictable, thus making price changes unpredictable and random. Hence, the Random Walk Model assumes that the expected value of daily returns equals zero. So the broad implication of the random-walk hypothesis is that an uninformed investor purchasing a diversified portfolio will obtain, on average, a rate of return as high as achieved by an expert.

We run a battery of tests to investigate whether the stock returns follow a random-walk process since each test has its own strength and weaknesses. We perform autocorrelation test, and runs test and variance ratio test to triangulate our results.

<u>Autocorrelation</u>

We run a simple statistical correlation test to check if the stock-price changes over time are correlated. The correlation between the variable and itself lagged by 12 periods is reported in Appendix in Table A.1. The estimated values of the autocorrelations are significantly different from zero at 1 percent level, suggesting that stock return series are statistically dependent.

<u>Testing for random walk: Runs test</u>

In our case, a run is defined as a sequence of days in which the stock price changes in the same direction. The runs test is an approach to determine whether successive price changes are independent; the normality assumption of distribution is ignored by this test. The null hypothesis for the runs test is that the observed series is a random series. The non-parametric runs test is considered more appropriate than a parametric serial correlation test as the returns data does not conform to the normal distribution (non-normality assumption is analysed in previous section). The standard normal Z-statistic is used to test whether the actual number of runs is consistent with the independence hypothesis. According to Sharma and Kennedy (1977), at the 5% level of significance, if the Z value is greater than or equal to ±1.96, the null hypothesis of random walk is rejected. The Z statistics of the DSE daily market return is found to be -44.24, which much is greater than -2.64 in absolute terms (Table A.2 in Appendix). This means that the observed number of runs is significantly fewer than the expected number of runs at the even at 1% level of significance. The negative Z value indicates positive serial correlation in the return series. Therefore, the null hypothesis that the return series of the DSE stock return follow a random walk can be rejected.

Variance ratio test

Lo and MacKinlay (1988) suggested the variance ratio test to test the random walk hypothesis. To test that stock returns vary randomly around a constant mean, we consider the null hypothesis that the log return series is a random walk with drift. Under the random walk null hypothesis, the corresponding z statistics tells us whether the variance ratio has a value of 1. The Lo-MacKinlay variance ratio test statistic is large enough to reject the hypothesis at 1 percent level of significance (Table A.3 in Appendix). Lo-MacKinlay variance ratio test results suggest that log return series do not follow a random walk.

Stylized fact 9: *Market is not "efficient."*

The efficient-market hypothesis (EMH) states that asset prices fully reflect all available information; hence, it is impossible to "beat the market" consistently. According to Fama (1970), there are three forms of market efficiency subject to three different information sets. A market where future prices cannot be predicted using past historical price data exhibits weak-form market efficiency. Under the semi-strong form of market efficiency prices instantaneously adjust to relevant publicly available information. The strong form takes the theory of market efficiency to the ultimate extreme and suggests that, even if some investors have monopolistic access to any information relevant for price formation, it will not help them to predict future prices. The definition of the strong form of market efficiency is ambiguous and, in general it is not possible to empirically test this hypothesis. Hence, the existing literature primarily focuses on testing the weak and semi-strong forms of market efficiency using stock price indices.

Here we test the stock market efficiency of DSE in its weak form. The tests of the weak-form of efficiency have their origins in random walk theory. According to the random-walk theory, price changes are unpredictable and since we cannot predict new information beforehand, even a small ability to forecast would contradict the random-walk theory. Thus, Efficient Market Hypothesis (EMH) is linked to RWM in the sense that investors cannot predict stock price as any price change is solely due to availability of new information and the new information arises randomly.

We have already showed that the return series of the DSE stock return does not follow a random walk. If some part of the daily stock return can be explained based on the available information, it will be a violation of the weak form of stock market efficiency. It is a standard practice to use autoregressive integrated moving average model (ARIMA) for testing weak form of the efficient market hypothesis. If the coefficients are significantly different from zero, we can reject the weak-form efficiency.

From the Dickey-Fuller test with drift, we found that the null hypothesis of unit root presence can be rejected at 1 percent in both level and first difference of daily average return (see Table A.6). Autocorrelation and partial autocorrelation also suggest that the series is stationary. So we can use original variable, the daily average stock return for testing the weak form of EMH. The results of AC and PAC give us a strong prediction about the series being a autoregressive moving average, ARIMA (p,q) process. From the partial autocorrelation graph (Figure A.2), we can use AR (1). Again, as the PACF displays a sharp cutoff while the ACF decays more slowly and the lag-1 autocorrelation is positive, the autocorrelation pattern can be explained more easily by adding AR terms than by adding MA terms. We observe that the first autocorrelation is relatively very large and outside the confidence bound (Figure A.2 in Appendix). This indicates that it is statistically different from zero. So we can start model with lag MA (1). As the daily log return series is stationary and integrated of order 0, i.e. I (0), we can use ARIMA (1, 0, 1) model to test the weak form of efficiency.

We have followed a "forward stepwise" approach, adding terms of one kind or the other as indicated by the appearance of the ACF and PACF plots. And we find parsimonious simplest model ARIMA (1, 0, 1) fits the data well. Both the AR and MA coefficients are statistically significant at 1 percent level. The value of log likelihood is -11330.43, which is smaller than any other ARIMA models at different AR and MA lags (Table A.4 in Appendix). This ARIMA model also consists of minimum value of BIC and second lowest in AIC. The sigma value (0.837) also represents the lowest volatility.

The Breusch-Godfrey LM test (up to lag 5) for autocorrelation test on ARIMA (1, 0, 1) model also shows that we cannot reject the null hypothesis that there is no serial correlation (Table A.5 in Appendix). The correlogram of residuals also shows that all lags stay within 95% confidence interval of standard error bound. The partial correlogram plot also shows the similar result. This means that we have not left any information and this model best fit the data.

In the ARMA model, the MA (1) term is statistically significant at 1 percent level, which suggests that past returns have an effect on the current market price. This is a violation of the weak form of the EMH. The estimated regression model can be written as: Return = 0.004674 + 0.595318 AR - 0.394025 MA (see Table A.7). The computed R^2 value of the model is 0.059, which means that only around 6% variability in daily stock returns is explained by the model. That is, this result of ARIMA (1, 0, 1) model can be considered a violation of informational efficiency.

Stylized fact 10: *There is "volatility clustering".*

Literature suggests that the leptokurtosis arises from a pattern of volatility in financial markets where large changes in price tend to cluster together, giving rise to the persistence of volatility. We see from the Figure A.3 in Appendix that periods of high volatility are followed by periods of high volatility and periods of low volatility tend to be followed by periods of low volatility. Again, we find that the squared returns (absolute returns) clearly exhibit strong autocorrelation, confirmed by the correlogram in Figure A.4 in Appendix. The squared return series present small significant serial correlation of squared returns decaying towards zero very slowly. This is an indication of volatility clustering. The plot of squared returns appears in persistence, which implies volatility clustering (Franses 1998: 155). This property is also compatible with the assumption of the white noise. These results suggest that residuals or error term is conditional heteroscedastic and can be represented by ARCH and GARCH.

Checking ARCH Effect

A test for ARCH effects in a linear regression has been conducted and the LM test indicates the presence of significant ARCH effects (Table IX).

TABLE IX

LM TEST FOR AUTOREGRESSIVE CONDITIONAL HETEROSKEDASTICITY (ARCH)

lags(p)	chi2	df	Prob > chi2
1	3571.498	1	0.00
	H0: no ARCH effects vs.	H1: ARCH(p) disturbance	

Stylized fact 11: *There is a risk return trade-off; one percentage point increase in return is associated with 1.6 percentage points of risk.*

We investigate the risk-return relationship for DSE index. We use very popular model from the GARCH (Generalised Autoregressive Conditional Heteroscedasticity) family, namely the GARCH-in-mean[3] model. This model allows us to study the relationship between risk and returns in a setting that is consistent with developing economies which are typically characterized by leptokurtosis and volatility clustering. This has the following specification:

$$R_t = \mu_t + \lambda\delta_t + e_t$$

$$\delta_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i\, e_{t-i}^2 + \sum_{i=1}^{q} \beta_i\, \delta_{t-j}^2$$

$$e_t = \delta_t . \epsilon_t$$

where:

- R_t is the stock return at time t.
- μ is the mean of GARCH model conditional on past information.
- λ is the volatility coefficient (risk premium) for the mean.
- δ^2 is the variance at time t and δ is the conditional standard deviation(i.e. volatility) at time t.
- e_t is the model's residual at time t.
- p is the order of the ARCH component
- $\alpha_1, \alpha_2, \alpha_3, \ldots, \alpha_p$ are the parameters of the the ARCH component model.
- q is the order of the GARCH component
- $\beta_1, \beta_2, \beta_3, \ldots, \beta_q$ are the parameters of the GARCH component model.
- Inequality restrictions $\alpha_0 > 0$, $\alpha_i > 0$, $\beta_j > 0$ are imposed to ensure that the conditional variance (δ^2) is positive.
- E are the standardized residuals:

  $[e_t]$~ i.i.d

  $E[e_t]=0$

  $Var[e_t]=1$

The influence of volatility on stock returns is captured by the coefficient of λ in Equation 1. A positive risk-premium (λ) indicates that return and volatility are positively linked. It is an explicit way to estimate the trade-off between risk and expected return. A significant and positive coefficient λ implies that investors are compensated with higher returns for bearing higher levels of risk. A significant

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[3]Engle, Lilien and Robins (1987) provide an extension to the GARCH model where the conditional mean is an explicit function of the conditional variance. Such a model is known as the GARCH in the mean or GARCH-M model.

negative coefficient indicates that investors are penalized for bearing risk. We run the model using the DSE index from the period 03 January 1993–31 December 2015 and the result is presented in Table X.

TABLE X

RISK-RETURN TRADEOFF USING DSE INDEX

VARIABLES	(1)	(2)	(3)
	Return	ARCHM	ARCH
L.arch			0.214***
			(-0.006)
L.garch			0.739***
			(-0.005)
Risk-return tradeoff		0.0162*	
		(-0.009)	
Constant	0.0160**		0.114***
	(-0.007)		(-0.003)
Observations	8,398	8,398	8,398

Note: Standard errors are in parentheses (*** $p<0.01$, ** $p<0.05$, * $p<0.1$).

The parameters of GARCH model for returns is positive and significant at 1 percent level and thus reject the null hypothesis of non-existence of volatility clustering. There is an ARCH effect in the index return, indicating that there is a direct effect between news that enters the market and the level of volatility. Overall, the coefficient of the risk-return parameter is positive (0.016) and statistically significant, suggesting that the investors are compensated with high return in times of high volatility.

Stylized fact 12: *There is a substantial heterogeneity in risk-return tradeoffs among stocks of different sectors, quality, and age.*

In order to compare the risk-return trade-offs across sectors, quality, and age, we rely on panel data estimation and run a host of fixed effects. In particular, we estimate the following regression model.

$$\sigma_{it} = \alpha + \beta r_{it} + \gamma_i + \delta_t + u_{it} \tag{II}$$

In this case, σ_{it} is the weekly standard deviation of daily return of security *i* in week *t*. r_{it} is the weekly return of security *i* in week *t*. γ_i captures the security fixed effect and δ_t is the time fixed effect. We use week, month and year fixed effects for all models. We run regression specification (II) for full sample as well as for different sectors (manufacturing, services and finance), quality (A, B and Z) and age (new and old) of securities. The standard errors are clustered around security. The results are presented in Table XI.

Overall, a one percentage point increase in return is coupled with 3.7 percentage points of risk (SD). Sector wise disaggregated analysis reveals that the risk-return tradeoffs are very similar for manufacturing and service sectors, 4.2 and

4.1 percentage points respectively. The tradeoff is the lowest for the financial sector for which one percentage point increase in return is associated with 2.1 percentage points increase of risk.

In the case of quality of stock, "A" category stands out. This category earns higher return and risk-return tradeoff is also the lowest (3 percentage points). There is not much difference between category "B" and "Z" one percentage point increase in return comes at the cost of 4 and 4.1 percentage points increase in risk respectively. The risk-return tradeoff is much higher for older stocks (3.8) compared with the new ones (3.1).

TABLE XI

FE RESULTS OF RISK-RETURN TRADE-OFF

	Full sample	Sector			Quality			Age	
		Manufacturing	Service	Finance	A	B	Z	New	Old
Weekly return	0.037***	0.042***	0.041***	0.021***	0.030***	0.040***	0.041***	0.031***	0.038***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.003)	(0.003)	(0.001)	(0.001)
Security FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weekly FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Monthly FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yearly FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.052	0.222***	0.046	0.109*	-0.019	0.423**	0.151	1.091***	0.100**
	(0.043)	(0.052)	(0.200)	(0.055)	(0.039)	(0.168)	(0.122)	(0.150)	(0.045)
R^2	0.204	0.210	0.253	0.191	0.172	0.218	0.189	0.175	0.203
Observation	295,206	179,810	15,591	92,701	165,332	10,086	32,251	57,741	227,568

Note: Standard errors are in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

V. CONCLUSION

In this paper we have documented twelve stylized facts on daily return and its volatility for the period 1991-2015 of the stocks listed in DSE. We use disaggregated security level data and this allows us to uncover some interesting trends of stocks of different sectors, age, and quality. While we mostly rely on descriptive statistics to identify general trends of risk and return, both at aggregated and disaggregated levels, we run a series of tests to check normality, random walk and efficiency of the market. We use standard GARCH-m and Fixed Effect models to identify the risk-return trade-offs.

We documented that there were large swings in returns across decades, but the volatility has increased monotonically over time. Category "A", old and manufacturing stocks earned higher returns with lesser risk. We found that the stock return does not follow random walk, its distribution is not normal and the market is not efficient. GARCH-m and Fixed Effect models suggest that there is substantial tradeoff between risk and return of the stocks and this tradeoff is very heterogeneous across sectors, quality, and age.

Documentation of general trends of a sector or a market lays the foundation for rigorous works in future. Understanding of the broader tendencies captured by stylized facts also helps theorize some interesting aspect of the issues. While there are some sporadic works on the behaviour of the stock market in Bangladesh, there is no systematic volume of works to address the relevant issues of the stock market, largely because there is no documentation of broader trends to begin with. We believe our work fills this gap to some extent.

The stylized facts identified in this paper will also inform investors to take educated decision. As discussed in the introduction, small investors in developing countries are mostly financially illiterate. In order to address this issue, the relevant regulatory bodies are conducting various short-term courses on stock market for the current and potential investors. For example, Security and Exchange Commission (SEC) and DSE Training Academy routinely conduct training on stock market. But anecdotal evidence suggests that the training materials of these short courses are very weak and lack broader understanding of the market. We believe our work will be a useful material for such courses.

REFERENCES

Arestis, Philip, Panicos O. Demetriades, and Kul B. Luintel. 2001. "Financial Development and Economic Growth: The Role of Stock Markets." *Journal of Money, Credit and Banking*, Blackwell Publishing, 33(1): 16-41.

Basher, Syed, Kabir Hassan and Anisul Islam. 2007. "Time-varying Volatility and Equity Returns in Bangladesh Stock Market," *Applied Financial Economics,* 17(7).

Batra, A. 2004. "Stock Return Volatility Patterns in India". Indian Council for Research on International Economic Relations, New Delhi.

Chen, Hian, Jinmin Du, Donghui Li, and Rui Ouyang. 2013. "Does Foreign Institutional Ownership Increase Return Volatility? Evidence from China." *Journal of Banking & Finance*, 37(2): 660-669.

Choudhry, T. 1996. "Stock Market Volatility and the Crash of 1987: Evidence from Six Emerging Markets." *Journal of International Money and Finance*, 15(6): 969-981.

Chowdhury, A. R. 1994. "Statistical Properties of Daily Returns from Dhaka Stock Exchange." *The Bangladesh Development Studies*, 26(4): 61-76.

Cont, R. 2001. "Empirical Properties of Asset Returns: Stylized Facts and Statistical Issues." *Quantitative Finance*, 1: 223–236.

Diebold, Francis and Kamil Yilmaz. 2008. "Macroeconomic Volatility and Stock Market Volatility, Worldwide." National Bureau of Economic Research, Working Paper 14269.

Engle, R. F., D. Lilien, and R. Robins. 1987. "Estimating Time Varying Risk Premia in the Term Structure: The ARCH-M Model." *Econometrica*, 5.5: 391-408.

Fama, Eugene F. 1970. "Efficient Capital Markets: A Review of Theory and Empirical Work." *The Journal of Finance*, 25(2): 383-417.

_______1965. "The Behavior of Stock-market Prices." *The Journal of Business*, 38(1): 34-105.

Franses, Philip H.1998. *Time Series Models for Business and Economic Forecasting*. Cambridge University Press

Grabel, Ilene. 1995, "Assessing the Impact of Financial Liberalization on Stock Market Volatility in Selected Developing Countries." *Journal of Development Studies,* 31 (6): 903-917.

Goldsmith, R. W. 1969. *Financial Structure and Development*. New Haven: Yale University Press.

Hoque, Mainul, Kazi Iqbal, Kenmei Tsubota and Abu Shonchoy. 2018. "Political Instability and Stock Market Returns: Evidence from Firm-level Panel Data of Securities in Bangladesh." *IDE Discussion Papers*: No.712, Japan

Hussain, F. 1997. "The Distribution of Stock Returns in an Emerging Market: The Pakistan Market." Unpublished.

Hussain, F. and J. Uppal. 1997. "Portfolio Return Behavior in the Month of Fasting: The Ramadan Effect." Unpublished.

Kendal, M. G. 1953. "The Analysis of Economic Time Series." *Journal of the Royal Statistical Society,* 96: 11-25.

Khaled K. I. 2011. *Investigation Report of Probe Committee, Bangladesh*.

Khilji, M. Nasir. 1993. "The Behaviour of Stock Returns in an Emerging Market: A Case Study of Pakistan." *The Pakistan Development Review*, 32(4): 593-604.

Levine, R. and Zervos, S. 1998. "Stock Markets, Banks, and Economic Growth." *American Economic Review,* 88: 537-558.

Mandal, A. and P. Bhattacharjee. 2012. "The Indian Stock Market and the Great Recession." *Theoretical and Applied Economics*, XIX (3):568: 59-76.

Mukherjee, I., C. Sen, and A. Sarkar. 2011. "Study of Stylized Facts in Indian Financial Markets." *International Journal of Applied Economics and Finance*, 5(2): 127–137.

Pal, Parthapratim. 2005. “Volatility in the Stock Market in India and Foreign Institutional Investors: A Study of the Post-Election Crash.” *Economic and Political Weekly*, 40(8): 765-772.

Shaw, E. S. and J. G. Gurley. 1955. “Financial Aspect of the Economic Development.” *The American Economic Review*, 45: 515-538.

Taufiq, Choudhry. 1996. “Stock Market Volatility and the Crash of 1987: Evidence from Six Emerging Markets.” *Journal of International Money and Finance*, 15(6): 969-981.

Uppal, J. 1993. “The Internationalization of the Pakistani Stock Market: An Empirical Investigation.” *The Pakistan Development Review*, 32(4): 605-618

Appendix

Table A.1: **Autocorrelation and Partial autocorrelation between return and its lags**

LAG	AC	PAC	Q	Prob>Q
1	0.2281	0.2281	475.18	0
2	0.1224	0.0743	612.11	0
3	0.0765	0.0358	665.64	0
4	0.0596	0.029	698.07	0
5	0.0419	0.0153	714.13	0
6	0.0552	0.036	742	0
7	0.0044	-0.0237	742.18	0
8	0.0099	0.0027	743.07	0
9	0.0151	0.0094	745.14	0
10	0.0111	0.0029	746.27	0
11	0.014	0.0084	748.05	0
12	0.0309	0.0243	756.8	0

Table A.2: **Run Test**

N(r <= -0.0196)	4565
N(r > -0.01957)	4566
obs = 9131 N(runs) = 2453 z = -44.24 Prob>z = 0	

Table A.3: **Lo-MacKinlay Modified Overlapping Variance Statistic for Average Daily Stock Log Returns (01Jan1991 – 31Dec2015)**

q	N	VR	R_s	p>z
2	9115	0.569	-41.1824	0
4	9115	0.305	-35.4682	0
8	9115	0.161	-27.0867	0
16	9115	0.08	-19.944	0

Table A.4: **Akaike's information criterion and Bayesian information criterion**

Obs ll(null)	ll(model)	df.	AIC	BIC
9,131	. -11330.43	4	22668.86	22697.34

Table A.5: **Breusch-Godfrey LM Test for Autocorrelation**

H0: no serial correlation			
lags(p)	chi2	df	Prob > chi2
1	0.289	1	0.5909
2	2.197	2	0.3334
3	2.512	3	0.4732
5	3.595	5	0.6091

Table A.6: **Dickey-Fuller Test for Unit Root**

No of observations = 9130)						
		Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	P-value of Z(t)
Drift	Z(t)	-75.746	-2.327	-1.645	-1.282	0.00
Trend	Z(t)	-75.744	-3.96	-3.41	-3.12	0.00
Difference	Z(t)	-151.612	-2.327	-1.645	-1.282	0.00

Table A.7: **ARIMA (1, 0, 1) model for testing weak form of EMH**

Sample: 01jan1991 – 31dec2015				Number of obs = 9131		
Log likelihood = -11330.43				Wald chi2(2) = 7126.39		
sigma = 0.8368838				Prob > chi2 = 0		
ARIMA	Coef.	Std.	Err.	z	P>z	[95%Conf.Interval]
AR L1.	0.595	0.014	41.32	0.00	0.567	0.623
MA L1.	-0.394	0.017	-23.77	0.00	-0.426	-0.361
Constant	0.006	0.013	0.35	0.729	-0.021	0.031
sigma	0.837	0.0021	407.91	0.000	0.832	0.840

Figure A.1: **Q-Q plots for normality**

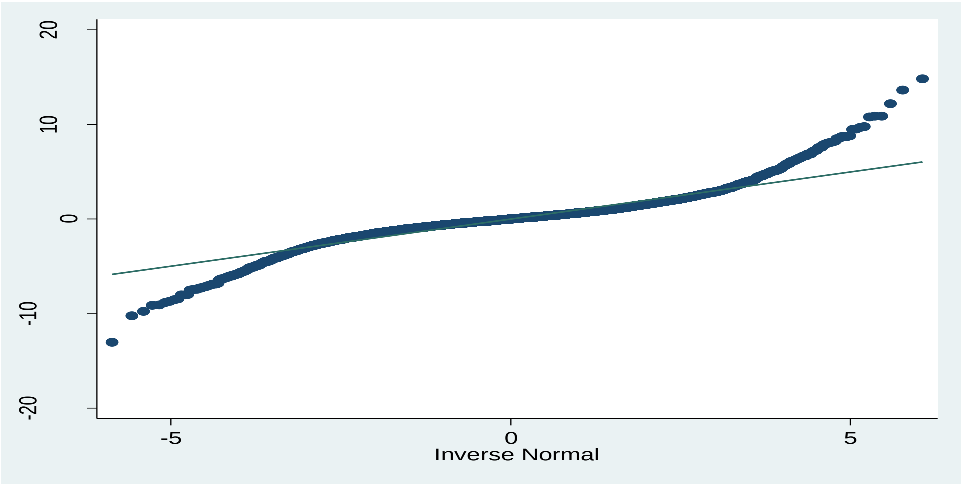

Figure A.2: **Autocorrelation (AC) and Partial Autocorrelation (PAC) of Daily Average Return**

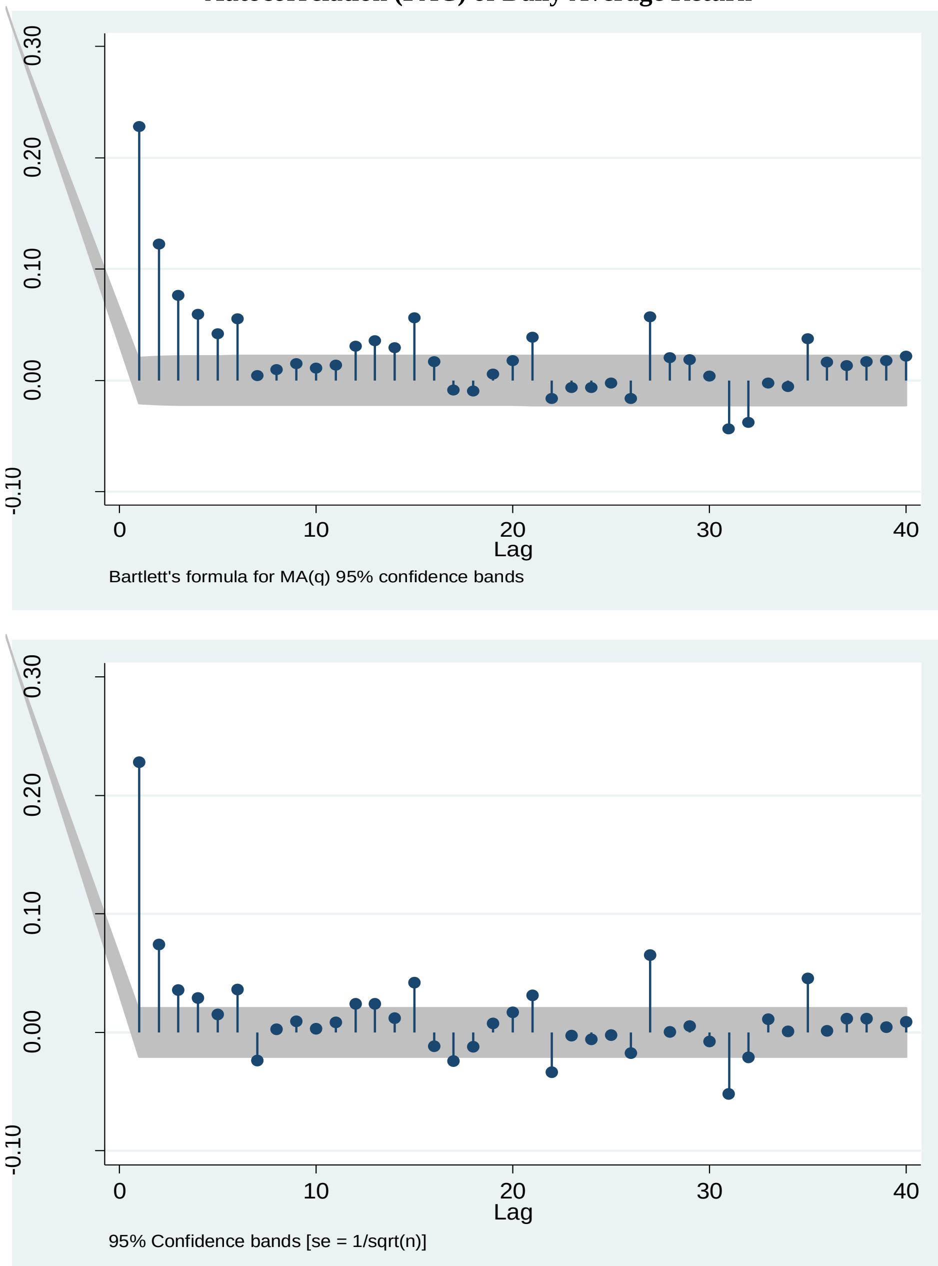

Figure A.3: **Daily average return and first difference in daily average return**

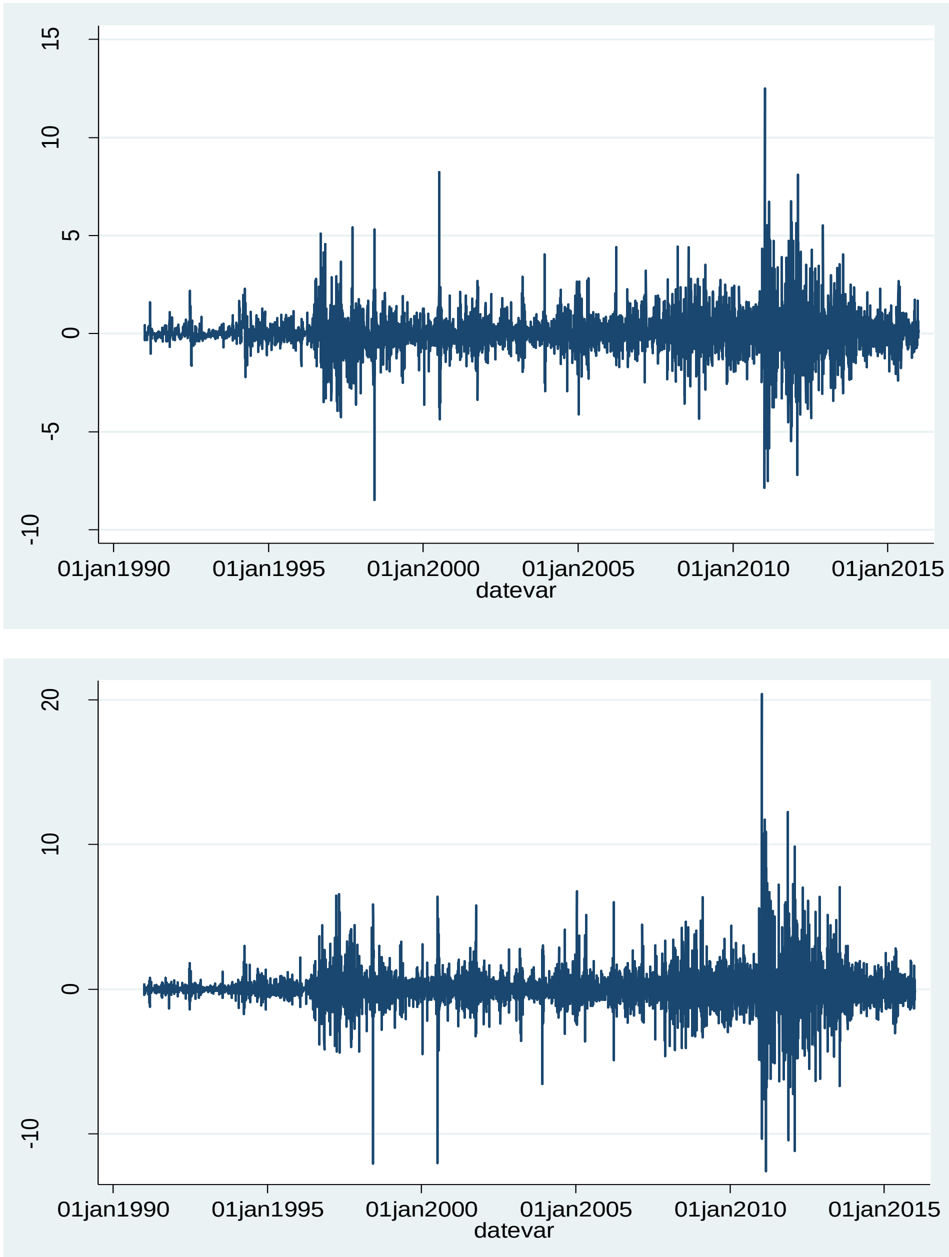

Figure A.4: **Autocorrelation (AC) and Partial Autocorrelation (PAC) of Daily Average Square Returns**