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Modeling and Predicting Stock Market Returns: A Case Study on Dhaka Stock Exchange of Bangladesh

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Abstract

The available information pertaining to stocks should be entirely reflected in an efficient capital market with a view to aiding policy makers and investors in designing investment strategy. Hence, this paper investigates the time-series behavior of market returns of Dhaka Stock Exchange (DSE) of Bangladesh. This study also aims to find out the parsimonious model for forecasting monthly market returns of DSE more accurately. The monthly data of general index were collected from DSE for the period January 2002 to July 2013. Using Relative Difference method, monthly market returns were calculated. Autoregressive Integrated Moving Average (ARIMA) models were taken into account to model the behavior of stock market returns. Subsequently, based on Akaike Information Criterion and forecast errors, the findings of the study vouchsafe that ARIMA (2, 0, 2) can be employed to model and forecast market returns behavior of DSE efficiently. Finally, the monthly market returns were forecasted using the parsimonious model for the next 24 months and the predicted values fitted the observed values reasonably well.

Keywords: Stock market, DSE, Forecasting, Market return, ARIMA.

I. Introduction

A considerable amount of research has been devoted to the investigation of the sensitivity of stock market returns of different markets all over the world. Stock returns have been investigated through applying time series models based on the accumulated historical evidences. The examination of time-series patterns includes detecting the predictable pattern associated with stock-return series. Different studies vouchsafe that all the time series of stock returns don't follow a random-walk process (Fama and French[1], Poterba and Summers[2]. Ding *et al.*[3]). Employing regression and variance ratios, Fama and French[4] found that stocks contain mean reversion.

Capital market efficiency has been a matter of great interest for policy makers and investors in designing investment strategy since the last couple of decades. Fama[5,6] explained few principles as a portion of the hypothesis involving capital market efficiency. Following his work, many capital market researchers sought to demonstrate the efficiency of capital markets but found market inefficient by identifying systematic and permanent variations in stock market returns. If efficient market hypothesis (EMH) holds true, it will prevent the investors from realizing extra return by utilizing the inherent information of stocks. Realizing extra returns will be feasible only by incorporating the extra risky stocks in investors' portfolios. In Bangladesh, the stock markets became the cynosure after the liberalization of financial systems in the stock market. The prodigious opportunities of investment and low risk in South Asian stock markets have attracted the domestic and foreign institutional investors gradually.

A substantial amount of empirical research has been conducted to investigate the stock-market behavior of the major developed stock markets against a few one devoted to investigation of stock markets in Asian countries. Few studies emphasized on the investigation of time series components of equity returns and the predictability of these returns. Investigation on a sample of 15 disclosed that both permanent and temporary systematic components are found in individual time series of stock market returns of firms over a long period (Ray[7]). Jarrett and Kyper[8] reported that patterns in monthly stock prices follow predictable patterns. Jarrett and Kyper[8] also examined the predictability of daily returns for more than 50 firms listed on American Stock Exchanges and inferred that daily variation exists and is predictable. Hamori and Takihisa[9] investigated non-seasonal unit roots to achieve stationarity in stock price indexes of G7 nations. In addendum, different studies examined the Monday effect (and other daily effects) in daily stock returns and indexes for these stock exchanges (Cho *et al.*[10], Mehidian and Perry[11]; Pettengill[12]. Steeley[13]). Most of these studies discovered strong evidence of Monday and other calendar effects in the index of stock returns in the exchanges studied. Shum and Tang[14] epitomized additional factors such as contemporaneous market excess returns in different stock markets of Asia.

Most of the Asian stock markets except few have experienced a rapid growth in gross national product through contributing to a significant rise in savings and, hence, in the supply of lendable funds (Chiang and Doong[15]). An increase in demand for international financial assets has been emerged due to the development of these stock markets. In Bangladeshi stock markets, stock prices and capital movements are sensitive to rumors, news, return differentials, changes in business conditions, and political conditions. The volatile behavior of stock markets does not only turn into a regular phenomenon in Asia but also become an integral part of global risk analysis.

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A couple of studies have been found to deal with prediction of stock prices in several countries including Bangladesh (Sohail et al.[16], Kumar[17]; Al-Zeaud[18]). But no such study has been performed yet to investigate the market returns of stock markets in Bangladesh. Hence, our research interest is motivated to explore the market returns of Dhaka Stock Exchange (DSE), a renowned stock exchange of Bangladesh. The major objective of this study is to investigate the market return behavior of DSE with a view to providing more accurate information to portfolio managers for determining their investment strategy. This study also endeavors to give a more definite basis to policy-makers for formulating apposite risk-management strategy. This paper is organized into following sections. Section II provides a brief description of Bangladesh stock market. Data and methods are outlined in section III. Section IV presents the results and discussions and section V contains concluding remarks.

II. Bangladesh Stock Market

Bangladesh possesses a liberal market economy where banks and stock market both play major role in maintaining the monetary system of the country. The number of banks including all categories now stands at 56 (Source: Bangladesh Bank Website) in Bangladesh. The country has two Stock Exchanges, *Dhaka Stock Exchange* (DSE) and *Chittagong Stock Exchange* (CSE). These exchanges are self-controlled and private sector bodies that follow their functioning policies approved by the Stock Exchange Commission (SEC). DSE, the major stock exchange of Bangladesh, is established at Motijheel in 1954 where buying and selling are carried out by Computerized Automated Trading System.

Bangladesh encountered the first stock market crash in 1996. In 2009, it faced another major crash. The stock market was in turbulence throughout 2009 when the long bullish trend started to turn grim. The entrance of Grameen phone into the capital market heavily aided the market, when the index rose by 22% over a single day on 16 November 2009 (Chowdhury and Ahmed[19]). Share prices continued to fluctuate reaching the annual high in mid-2009 before plummeting by the end of 2009, with retail investors' threatening of a hunger strike (The Daily Star[20]). The market continued to be turbulent throughout 2010 in the DSE with the largest fall in a single day. All this happened within a month.

III. Data and Methods

Initially, the data of monthly general index of DSE were collected during the period January 2002 to July 2013 from Dhaka Stock Exchange library. Monthly market returns (MMR) were calculated subsequently using *Relative Difference* method as follows:

$$MMR = 2 * (i(t) - i(t-1))/(i(t) + i(t-1))$$

where $i(t)$ is the closing general index value of the market at month t. *Relative Difference* has several advantages over other formulas for return, like LogRatio or Ratio (See Ultsch[21] for a detailed discussion). It is to be noted that stock indexes are measured by the last trading day of each month with respect to monthly data.

The acronym ARIMA stands for *Autoregressive Integrated Moving Average* and is sometimes referred to *Box-Jenkins models.* An autoregressive model of order p is conventionally classified as AR (p) whereas a moving average model with q terms is classified as MA (q). A combined model that contains p autoregressive terms and q moving average terms is called ARMA (p,q) (Gujarati[22]). If the object series is differenced d times to achieve stationarity, the model is classified as ARIMA (p, d, q). Here, the symbol 'd' signifies 'integrated'. A time series Y_t is said to follow an ARIMA model if

$$\varphi(B)(1-B)^d Y_t = \theta(B)e_t$$

where B is the backshift operator (i.e., $BY_t = Y_{t-1}$), $\varphi(B) = (1 - \varphi_1 B - \varphi_2 B^2 - \cdots - \varphi_p B^p)$ is the autoregressive operator, $\theta(B) = (1 - \theta_1 B - \theta_2 B^2 - \cdots - \theta_q B^q)$ is the moving average operator and e_t is the random error term.

Box and Jenkins[23] proposed a methodology that consists of three phases viz. i) Model identification; ii) Estimation of model parameters; and iii) Diagnostic checking for the appropriateness of identified model. Again, identification comprises four steps, namely, stability in variance, checking the stationarity, obtaining stationarity, and model selection and parameter estimation.

Finally, Akaike Information Criterion (AIC) has been used for selecting best model among different possible models. The model having minimum AIC value is deemed as the parsimonious model. Maximum likelihood method was used to estimate the parameters of the best model. The data were analyzed using R and SAS software.

IV. Results and Discussions

Fig. 1 shows the time series plot of market returns of DSE. From the time plot, it was observed that market returns were stationary over the time period according to the mean and variance.

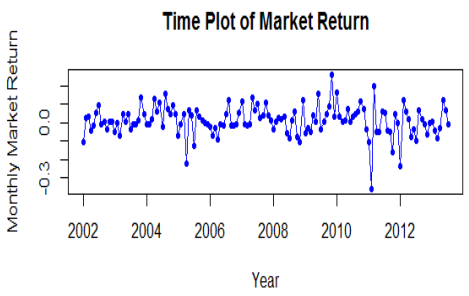

Fig. 1. Time series plot of monthly market return of DSE

Again, Augmented Dickey-Fuller (ADF) test, one of the famous unit root tests, was used to check stationarity of market return data. In this test, the existence of unit root is used as the null hypothesis and the result is shown in Table 1. The p-value was found smaller than 5% level of significance which implies that observed data set is stationary. Autocorrelation function (ACF) and partial autocorrelation function (PACF) plots are the major tools for time series, specially, ARIMA modelling.

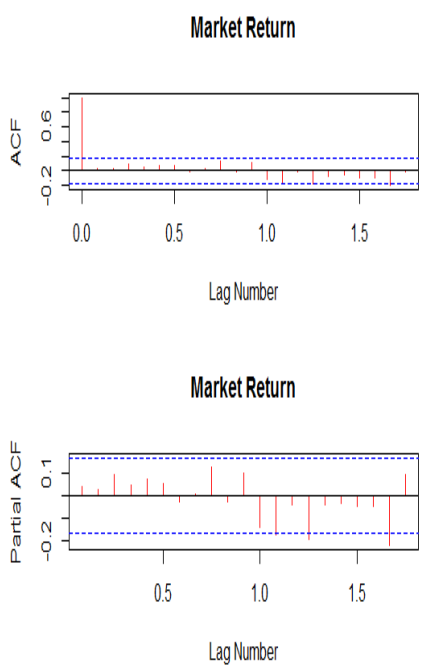

Fig. 2. ACF and PACF plots of market return

Table 1. Results of ADF test

Unit root test	Test Statistic value	P-value
ADF	-3.7583	0.02313

ACF and PACF plots do not show any wavy cyclical pattern with seasonal frequency which refers to the non-seasonality of the dataset (Figure 2). From the ACF and PACF plots, we can also conclude that the series is stationary. Therefore, an ARIMA (p, 0, q) model is initially identified for the dataset.

The Akaike information Criterion (AIC) was employed to determine the best model for predicting market return. The values of AIC for different plausible models are shown in Table 2. As per AIC values, ARIMA (2, 0, 2) model shows minimum AIC. Hence, ARIMA (2, 0, 2) is chosen as the best model for modeling and forecasting market return behavior of DSE. Estimates of parameters and corresponding p-values of the best model are reported in Table 3. The p-values of all the estimated coefficients are found smaller than 0.05 which refers to the significance of parameters at 5% level. Therefore, the model selection is seemingly correct.

Table 2. AIC values of ARIMA (p, 0, q) model

	p = 0	p = 1	p = 2	p = 3
q = 0	-304.52	-302.73	-300.81	-299.93
q = 1	-302.72	-301.95	-300.18	-298.9
q = 2	-300.77	-300.23	-306.92	-305.15
q = 3	-299.71	-299.01	-305.15	-305.88
Best model		ARIMA (2, 0, 2)		

After estimating parameters of the obtained ARIMA model, white noise property test for residuals was examined. Residuals of the best model are assumed to follow white noise process. Ljung-Box test was performed for checking white noise property. The null hypothesis of this test assumes that errors are independent and identically distributed random variables, i.e., white noise.

Table 3. Estimation of parameters and Ljung–Box test results for ARIMA (2, 0, 2) model

Parameter	Estimated value	Standard error	P-value
Intercept	0.0115	0.0091	0.0512
φ_1	1.7733	0.0662	0.000
φ_2	-0.8577	0.0640	0.000
θ_1	-1.8569	0.0511	0.000
θ_2	0.9768	0.0558	0.000
Ljung–Box test			
χ^2-value	P-value	Decision	
0.1747	0.6759	do not reject	

The results presented in Table 3 show that the p-value of Ljung–Box test is greater than 0.05, which leads to failure of rejecting null hypothesis. Therefore, residuals of ARIMA (2, 0, 2) model follow white noise process and the model has no autocorrelation between its residuals. In practice, if all sample ACFs are close to zero, the series is said to be a white noise series. In Fig 3, ACFs of all the residuals of the aforementioned model are found around zero indicating that the residuals follow white noise process. Thus, ARIMA (2, 0, 2) model is deemed the parsimonious model for forecasting market returns.

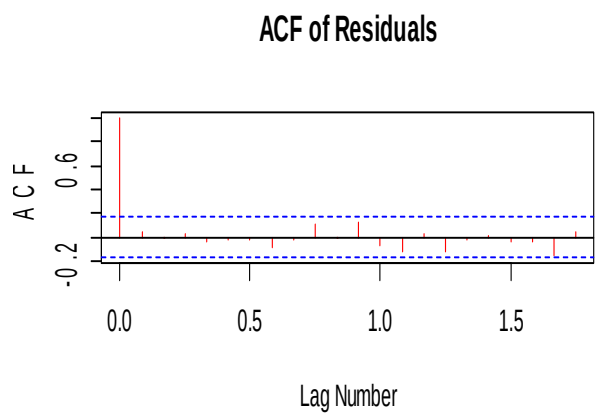

Fig. 3. ACF of residuals

In this paper, ARIMA (2, 0, 2) model has been chosen to forecast the behavior of market returns of DSE. The efficiency of this forecasting model is checked through the different measures of error. The forecast error is obtained by subtracting the forecasting value from the observed value. Three forecast error measures, namely, mean error (ME), mean square error (MSE), and mean percentage error (MPE) were examined for our model that are reported in Table 4.

Table 4. Measures of forecast error

Forecast Errors	Estimates
ME	0.00062
MSE	0.0058
MPE	-135.83

Small values of all the error criteria bolster that the model is well fitted. ARIMA (2, 0, 2) model was further used to predict future stock returns. Table 5 shows the point and interval forecasts (Lower Limit=LL and Upper limit=UL) with 95% confidence level for August 2013 to July 2015. The forecasted values are pretty consistent with the observed values. There is an indication of slightly upward return in the imminent future.

Table 5. Forecasts of stock market returns

Year	Forecast Value	95% Confidence Interval	
		LL	UL
Aug 2013	-0.0008902153	-0.1503969	0.1486165
Sep 2013	0.0071486392	-0.1428605	0.1571578
Oct 2013	0.0144143160	-0.1356505	0.1644792
Nov 2013	0.0204040456	-0.1296903	0.1704984
Dec 2013	0.0247942224	-0.1255744	0.1751629
Jan 2014	0.0274422019	-0.1235292	0.1784136
Feb 2014	0.0283725790	-0.1234554	0.1802006
Mar 2014	0.0277513139	-0.1250250	0.1805277
Apr 2014	0.0258516177	-0.1277945	0.1794978
May 2014	0.0230156459	-0.1313011	0.1773324
Jun 2014	0.0196158294	-0.1351275	0.1743591
Jul 2014	0.0160191548	-0.1389324	0.1709707
Aug 2014	0.0125569862	-0.1424566	0.1675706
Sep 2014	0.0095021876	-0.1455136	0.1645180
Oct 2014	0.0070544335	-0.1479758	0.1620847
Nov 2014	0.0053337839	-0.1497644	0.1604320
Dec 2014	0.0043818879	-0.1508446	0.1596084
Jan 2015	0.0041696298	-0.1512261	0.1595654
Feb 2015	0.0046096547	-0.1509643	0.1601836
Mar 2015	0.0055720245	-0.1501585	0.1613026
Apr 2015	0.0069012372	-0.1489447	0.1627471
May 2015	0.0084329795	-0.1474820	0.1643480
Jun 2015	0.0100092401	-0.1459364	0.1659549
Jul 2015	0.0114907390	-0.1444620	0.1674435

Furthermore, the graphical visualization also indicates a good fit of the model (Fig 4). In Fig 4, red line indicates original value and blue line indicates the forecasted value.

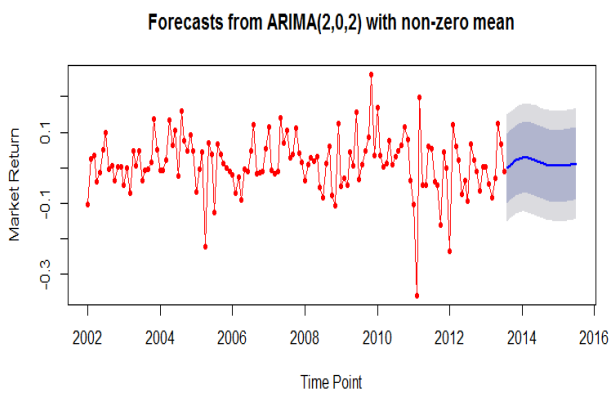

Fig. 4. Performance of ARIMA (2, 0, 2) model

The shaded areas represent the interval forecasts of market return of DSE with 95% confidence level.

V. Conclusions

This study has used Box-Jenkins methodology to analyze stock market returns of DSE in Bangladesh. Based on the appropriate model selection criteria, the ARIMA (2, 0, 2) model appears superior to the rest of the time series models in dealing with market return volatility. This model will be helpful to the investors and policy makers in predicting overall stock market behavior and designing efficacious strategy. No such model has been developed yet that can be employed for predicting market returns of DSE. Hence, this study is assumed to be pretty utilitarian for exploring the nature of market returns and the model developed in this study will be a key tool for forecasters to forecast the returns. Nevertheless, prior to using this model one must verify the validation of the model in different time periods because a forecasting model may loss its validity and suitability with the change in time. The scope of the study may be expanded by including the impact of economic and non-economic explanatory variables on the integration of the South Asian markets. It would also provide a better understanding of dynamics of linkages over a period of time.

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