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Modeling Volatility, Risk-Return Trade off and Leverage Effect using EGARCH (p,q)-M Model: Evidence from Bangladesh and India

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Abstract: Using the EGARCH (1,1)-M model, this study examines and compares the liaison between time-varying volatility and stock return as well as leverage impact on the Dhaka Stock Exchange (DSE) and the Bombay Stock Exchange (BSE). Daily return data from the DSEX and S&P BSE SENSEX indices are used to estimate the model. It is found that the risk-return relationship in DSE is negative which is not consistent with theory of finance, whereas the investors' of BSE demand higher return for bearing additional risk. In addition to this, the impacts of volatility clustering, volatility persistence are more prevalent in DSE than BSE though the importance and impact of old news is very significantly important in both markets. Beside we have also found significant leverage effect in both markets but investors' sensitivity towards negative shocks is higher in BSE than the DSE.

Keywords: DSE, BSE, volatility, EGARCH (1,1)-M.

JEL Classification: C22; G12; G15

1. Introduction

Stock market has been considered as the main engine of economic growth in both developed and emerging economies. Among other functions, it executes the vital role of channelizing savings into investment, i.e., the allocation of economic resources to the economy's productive activity. Proper pricing of securities traded in the market place aids allocation of scarce resources, which motivates investors to save and invest their worth in capital market (that is, return on investment is sufficient enough to compensate their risk). So, nexus between risk and return is considered as most vital subject matter in finance. The capital asset pricing model (CAPM) postulates the relationship between return and risk. This model demonstrates a positive linear relationship between systematic risk (â) and expected return (Sharpe (1964)). But the validity of this model is questionable because of some assumptions like- â coefficient is remain stable over time, market is efficient, error term is assumed to be normally distributed (iid) and homoskedastic. In real world, it is found that â is unstable over time and market is inefficient because of that CAPM has lost its applicability in practice. To surmount these limitations, Engle et Al. (1987) developed a new way of testing the risk-return relationship under GARCH-M framework where risk premium is conditional upon time and error term is heteroskedastic and non-linear. Volatility has three types: clustering, persistence and asymmetry. Modeling volatility has become a very interesting subject to economists because of its application in optimization of portfolio, management of risk and asset pricing (Ahmed and Suliman (2011)). Engle (1982) initiated the concept of conditional heteroscedasticity where, conditional variance is a function of past shocks. This model led to a breakthrough in financial econometrics. But, generalized autoregressive conditional heteroscedasticity (GARCH) model permits past conditional variances in the current conditional variance equation, Bollerslev (1986). This generalization has recognized as effective in forecasting conditional variance (Engle (2001)). Beside these another important phenomenon that is exhibited in stock price or return series is asymmetry also known as leverage effect, (Nelson (1991)). These type of observations in financial time series have led to the use of broad range of heteroskedastic models to estimate and forecast volatility of market return.

Merton (1973) used an intertemporal CAPM to measure risk-return relationship which shows a positive risk-return relationship in capital market. French et al. (1987) used GARCH-M model to examine the return volatility in US equity market and found both positive and negative relationship. Using UK and US stock exchange data Attanasio and Wadhwani (1989) to model risk and stock market return and found portfolio relationship using quarterly US stock return. Friedman and Kuttner (1992) found a positive time varying risk return relationship. Tsouma (2007) used AR(1) GARCH-M to test risk-return nexus in 20 developed and 20 emerging markets and found the volatility transmission from the leading markets to other markets. Chiang and Doong (2001) investigated behavior of stock return on seven Asian Stock market and found that the four out of seven Asian stock markets have a significant nexus between stock return and unexpected volatility. Besidesthere also a significant relationship existed between stock return and time varying volatility under TAR-GAECH (1,1)-M model. Poshakwale and Murinde (2001) have observedthat the volatility seems to be persistent; however, as measured by a GARCH-M model this does not seems to be priced in Hungary and Poland stock market. Chowdhury and Iqbal (2005) examined the nature of volatility and risk-return relationship in Dhaka Stock Exchange (DSE). Investors 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 was observed. Using GARCH-M (1,1), Basher et al. (2007) investigated the time varying risk and return relationship, and found both negative and positive results. Although a negative risk return coefficient is not consistent with portfolio theory, it is theoretically possible in emerging markets (Glosten et al. 1993).

Bali et al. (2009) used the GARCH model and found that conditional betas and expected return have a strong positive, meaningful relationship. Ahmed and Suliman (2011) used the various GARCH models and discovered that the conditional variance mechanism is extremely persistent and provides proof of the presence of a positive risk premium in Khartoum Stock Exchange (KSE). Using GARCH-M, Hossain and Uddin (2011) examined efficiency and conditional volatility of DSE using DSEG, DSI and DSE20 indices and found positive risk return relationship for DSI and DSE20 but negative for DSEG. Bagchi (2012) have developed risk-weighted portfolios as per beta, market-to-book value, and market capitalization, and found a positive nexus between the India Volatility Index and portfolio returns. Cheng and Jahan-Parvar (2014) investigated fourteen Pacific basin markets using the GARCH Model and discovered an optimistic and meaningful risk-return relationship. Using Turkish Stock Exchange data, nexus between stock returns and beta portfolios was examined by Terregrossa and Eraslan (2016). They have found a systematic relationship between betas and portfolio returns and name them as a security market plan. Aslanidis et al. (2016) investigated risk-return nexus for thirteen European markets and obtained negative risk-return relationship. Sehgal and Pandey (2018) examined the risk-return relationship in developed, emerging and frontier markets in before and after global financial crisis using CAPM and found absence of risk-return relationship in before crisis, but significant negative relationship in after crisis. Using GARCH-in-mean models, Nageri et al. (2019), have examined risk-return relationship in Nigeria in before and after financial crisis and results expressed a negative relation in before and after meltdown.

The Bombay Stock Exchange (BSE), first to be recognized by the Indian government. The BSE Sensex was formed in 1986 which is the main index to give a way to measure the exchange's overall performance. In 2001 and 2002, the BSE's trading platform was expanded with the introduction of

Sensex options and equity derivatives, respectively. On July 25, 2001, BSE debuted Dollex-30, a dollar-linked equivalent of SENSEX. BSE is one of the world's largest stock exchanges, with over 6000 stocks listed. Total market capitalization was US$2179.78 billion, the overall market P/E ratio was 26.88 and market capitalization accounted for 75.98% of its nominal GDP as on June 30, 2019. BSE has a great role in the growing up of Indian corporate sector. It has also provided an equity trading platform for SME.

On the contrary, Dhaka Stock Exchange (DSE) is the main bourse in Bangladesh. It was started as East Pakistan Stock Exchange Association Limited on April 28, 1954 but renamed as DSE Ltd. on May 13, 1964. Market capitalization of DSE was US$48.18 billion, the overall market P/E ratio of DSE was 13.46 (*https://www.ceicdata.com/en/indicator/bangladesh/pe-ratio*), market capitalization to GDP was 13.5% as on June 30, 2019 (*https://www.ceicdata.com/en/indicator/bangladesh/market-capitalization—nominal-gdp*). In DSE, trading activities is conducted automated trading system.

As far of our knowledge no work have been done in comparing risk-return relationship and attitude of investors' toward risk of these two neighbor countries. So, prime aim is to explore and compare risk-return relationship and attitude of investors towards risk in DSE and BSE.

2. Data and Methodology

Data contains daily closing value of DSE broad index (DSEX) of DSE and S&P BSE SENSEX of BSE. Here, the study period covers from January 28, 2013 to January 30, 2020 from the data bank of the DSE and BSE located in the URL address: *http://www.dsebd.org/recent_market_information.php and https://www.bseindia.com/indices/IndexArchiveData.html* respectively.

Here, daily market returns are calculated as first difference in logarithm in daily closing prices of DSEX and S&P BSE SENSEX indices of successive days. That is,

$$r_t = \log P_t - \log P_{t-1}$$

Where r_t refers t period's market return, P_t refers price index at day t and P_{t-1} refers price index at day t-1.

Unit Root Tests

In this study, three unit root tests, Augmented Dicky-Fuller (ADF), DF-GLS and Phillips-Perron (PP) have been used.

The ADF tests (Dicky and Fuller 1979, 1981) are based on the following ordinary least squares regression equations:

$$\Delta y_t = \delta y_{t-1} + \sum_{i=1}^{m} \varphi_i \, \Delta y_{t-i} + \varepsilon_t$$

$$\Delta y_t = \alpha + \delta y_{t-1} + \sum_{i=1}^{m} \varphi_i \, \Delta y_{t-i} + \varepsilon_t$$

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

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.

The PP test differs from the ADF test mainly in how they deal with serial correlation and heteroscedasticity in the errors (Brooks (2008)). The test regression for the PP tests is

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

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

Under null hypothesis that $\pi = 0$, the PP Z_t and Z_π statistics have the same asymptotic distribution as the ADF t-statistic.

The alternative procedure proposed by Elliott et al. (1996) the DF-GLS test and running the ADF tests.

$$\Delta Y_t^d = \pi Y_{t-1}^d + \sum_{j=1}^{p} \emptyset_j \, \Delta Y_{t-1}^d + \varepsilon_t$$

ΔY_t^d is the detrended time series data.

Normal Distribution

The density function of normal distribution is:

$$f_X(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(x-\mu)^2/2\sigma^2}$$

where μ is the mean and σ^2 is the variance of *X*, thus $X \sim N(\mu, \sigma^2)$. In the EGARCH model, when X_t is assumed to be normally distributed, the expectation in the $g(Z_t)$ function is:

$$E[|Z_t|] = \sqrt{\frac{2}{\pi}}.$$

Student-t Distribution

The density function of Student-t distribution is:

$$f_X(x, \vartheta) = \frac{\Gamma[(\vartheta+1)/2]}{\sqrt{\vartheta\pi}\,\Gamma\left[\frac{\vartheta}{2}\right](1+\frac{x^2}{\vartheta})^{(\vartheta+1)/2}}$$

where ϑ is the degree of freedom ($\vartheta > 2$).

In EGARCH model, when X_t is assumed to be Student-t () distributed, the expectation in the $g(Z_t)$ function is:

$$E[|Z_t|] = \frac{\Gamma[(\vartheta+1)/2]2\sqrt{\vartheta-2}}{\sqrt{\pi}(\vartheta-2)\Gamma[\vartheta/2]}$$

Asset price fluctuation is termed as volatility. Higher volatility indicates higher risk which affects investors' wealth as well as confidence. At the time of increased volatility, either investors' tend to exit from market or will demand higher return for additional risk. Here, we examine the positive correlation hypothesis between volatility and the expected stock returns using EGARCH-M model.

Before using GARCH models, it first to examine the residuals of return series for getting evidence of the presence or absence of heteroscedasticity. If there is no evidence of heteroscedasticity in return series, then there is no question of using GARCH models. In our study, we have applied ARCH-LM test (Engle (1982)) for testing ARCH effect in the residuals of both series. The null hypothesis of this test is, "there is no ARCH effect in residuals".

To perform the test, we must go through a procedure for collecting the residuals. We can get residuals value OLS regression of the conditional mean equation which might be autoregressive process (AR), moving average process (MA) or a combination of both (ARMA). The ARMA(1,1) process, the conditional mean equation is:

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

After getting the residuals, e_t, then regress the squared residuals on a constant and q lags as:

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

where, v_t is the white noise error term. Here the null hypothesis is:

$H_0 : \alpha_1 = \alpha_2 = ... = \alpha_q = 0$ (i.e. there is no ARCH effect)

Against the alternative hypothesis

$$H_1 : \alpha_i > 0$$

For at least one case, where $i = 1,2,3, \dots, q$

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.

Engle et al. (1987) provide an extension to the GARCH model, where the conditional mean is a explicit function of the conditional variance, is known as the GARCH-in-Mean (GARCH-M) model. EGARCH model was first proposed by Nelson in 1991 where he described the asymmetrical response of the return under the positive and negative shocks. Here, conditional variance depends on both the size and sign of error terms (ε_t), EGARCH(1,1) specification is:

Mean Equation:

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

Variance Equation:

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

The EGARCH model confirms the conditional variance is always positive without imposing non-negativity constraints because of its logarithmic specification. 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).

3. Results and Discussion

The Daily Market Returns of DSE and BSE are presented in Figures 1 and 2.

Figures 1 and 2 show the movement of daily market returns for DSE and BSE. Variations of returns were high in DSE in 2013 to 2015. But return movement was tranquil and almost hovering around zero line in 2016 and

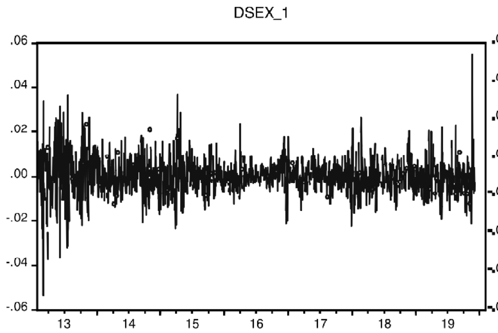

Figure 1: Return series of DSEX index

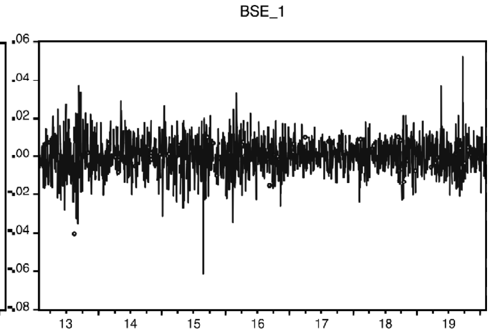

Figure 2: Return series of S&P BSE SENSE Index

2017 and thereafter ups and downs of return was increased slightly. On the other hand, the returns series in BSE are fluctuating within the range of 2% over the whole sample period except few outliers. From the above figures, we also observe that large positive change followed by a large negative change and small positive change followed by small negative change and vice-versa for both DSE and BSE. These patterns reveal that both return series have significant time varying variances and it is also a strong indication of volatility clustering.

Table 1: Descriptive statistics of DSEX and S&P BSE SENSEX return series

	Mean	*Maximum*	*Minimum*	*Std. Dev.*	*Skewness*	*Kurtosis*	*Jarque-Bera*	*Probability*	*Observations*
DSEX	5.25E-05	0.05445	-0.05358	0.00815	0.13125	6.94234	1099.275	0.0000	1690
S&P BSE SENSEX	0.000411	0.05185	-0.06119	0.00883	-0.18236	6.07320	690.3877	0.0000	1730

The Table 2 shows that the both markets have positive mean returns but the mean of BSE is higher than the DSE. Variability of returns of BSE is slightly higher than DSE because of its higher standard deviation. The returns of DSE are positively skewed which means that the large positive returns tend to be larger than the higher negative returns whereas the returns of BSE are negatively skewed. The level of kurtosis for both markets is higher than three which mean that the return series are leptokurtic. However, the skewed distribution of returns and high kurtosis of both markets indicate that the strong departure from normality. The Jarque-Bera test of normality rejects the hypothesis of a normal distribution of the returns for both markets at 1% significance level.

Table 2: The estimated results of ADF and PP tests for DSEX and S&P BSE SENSEX return series

	ADF test		*PP test*		*DF-GLS*
	Test Statistic	*p-value*	*Test Statistic*	*p-value*	*Test Statistic*
DSEX	-35.57292	0.0000	-36.01971	0.0000	-1.96133**
S&P BSE SENSEX	-38.35287	0.0000	-38.22821	0.0000	-3.99649**

The table 2 represents result of unit root (ADF, PP and DF-GLS) tests for both DSE and BSE. It is seen that the ADF, PP DF-GLS tests reject null hypothesis at 1% level of significance. So, the time series data are stationary and fit for econometric analysis.

Evidence of the presence of heteroscedasticity in residuals of both return series is inevitable for applying GARCH family models. The null hypothesis of this test is, Ho: there is no ARCH effect in residuals

Table 3: Results of ARCH-LM test on residuals of DSEX and S&P BSE SENSEX return series

	DSEX	*S&P BSE SENSEX*
ARCH-LM test statistic (TR^2)	34.96656	13.90186
p value	(0.0000)	(0.0010)

The table 3 represents the values of TR^2 and its probability for the residuals under two markets. It is observed that the values of TR^2 and its corresponding probability for DSEX return series is 34.96656 and 0.0000 and for S&P BSE SENSEX is 13.90186 and 0.0010. So, the values of TR^2 are significant at 1% level of significance. Therefore, the null hypothesis of no heteroscedasticity is rejected and indicates a strong evidence of the presence of ARCH effects in the residuals of return series in both cases. As because of presence of ARCH effect in residuals series, we can modeling of index return volatility by applying GARCH framework.

The EGARCH-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 EGARCH-M model for both markets are furnished in the table 4.

Table 4 summarizes the estimated coefficients of the EGARCH-M(1,1) model to compare time varying risk-return relationship, the degree of persistence of volatility, leverage effect in both markets. The estimated coefficients of standard deviation in mean equation are negative (-0.040129 under normal distribution and -0.041556 under student's t distribution)

Table 4: Estimated results of the EGARCH-M (1,1) model

	DSEX		*S&P BSE SENSEX*	
Co-efficients	*Normal Distribution*	*Student's t distribution*	*Normal Distribution*	*Student's t distribution*
δ (coefficient of SD in mean equation)	-0.040129 (0.5292)	-0.041556 (0.5234)	0.070499 (0.4966)	0.106233 (0.2919)
ω (constant)	-0.514734 (0.0000)	-0.535064 (0.0000)	-0.427751 (0.0000)	-0.457884 (0.0000)
α (ARCH Effect)	0.298620 (0.0000)	0.299503 (0.0000)	0.101213 (0.0000)	0.090737 (0.0001)
γ (Leverage effect)	-0.058734 (0.0000)	-0.060075 (0.0000)	-0.108140 (0.0000)	-0.110847 (0.0000)
β (GARCH Effect)	0.971696 (0.0000)	0.969711 (0.0000)	0.963359 (0.0000)	0.959533 (0.0000)
$\alpha + \beta$	1.270316	1.2679214	1.064572	1.050570
AIC	-7.080514	-7.080160	-6.738738	-6.769550
Test statistic ARCH-LM				
test statistic	0.320124	0.324697	0.392295	0.219423
p value	0.5715	0.5688	0.5311	0.6395

and insignificant for DSEX return series. 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)). Since, the risk-return relationship for DSE broad index (DSEX) negative and insignificant indicating that the investors as a whole in Bangladesh are not well aware of risk and not claiming logical additional return for bearing added risk and investors' behaviour is not consistent theory of risk-return relationship. This is a strong symbol of rumour based inefficient market because investors investing their worth based on gossip and rumour without considering logical ground. On the other hand, positive but insignificant (0.070499 under normal distribution and 0.106233 under student's t distribution) risk-return relationship are found for S&P BSE SENSEX return series. The results indicate that the mean returns not only depend on the past sequence of return but also depend on the past conditional variance of residuals (time-varying risk). These results (positive relationship between risk and return) are consistent with the theory of risk-return relationship in finance which postulates that the higher return expected for assets with higher level of risk in Bombay Stock Exchange. So, attitude of investors towards risk in BSE is more rationale than the DSE. Beside this, the ARCH(α) and GARCH(β) coefficients under two different distributions in both markets are significant at 1% level indicating lagged error and lagged conditional variance have a significant impact on current volatility. The ARCH(α) parameters indicate that the presence of volatility clustering (i.e., large positive change tend to be followed by large negative change and small positive change tend to be followed by small negative change and vice versa) in both markets. The value of α in DSE (0.298620 and 0.299503) is almost 3 times higher than the BSE (0.101213 and 0.090737) indicating volatility clustering effect in DSE is more prevalent than the BSE. The β coefficients are all most same and very high in both markets which indicate the impact of old news is very important in DSE and BSE to predict future movements of market. Volatility persistence is measured by the sum of α *and* β. It is found that the sums are very high and more than 1 in both markets (DSE: 1.270316 and 1.2679214 and BSE: 1.064572 and 1.050570) which indicate that the shocks to the conditional variance are highly persistent and conditional variance process is explosive (Floors (2008)). Since, the value of sum in DSE is higher than BSE, so persistence rate is also higher at DSE.

It is also seen that the leverage effect (γ) is significant at 1% level of significance for both markets return series indicating that negative news/ shocks have a larger effect on volatility of return than the positive shocks of the same magnitude. The absolute value of γ for DSE return series is smaller than the BSE return series, so asymmetric impact, that is, the negative news/shocks have a larger effect on volatility of return than the positive shocks of the same magnitude in BSE than DSE. So, sensitivity of investors towards negative news in BSE is higher than DSE.

4. Conclusions

In this study, volatility, risk-return trade-off and leverage effect have been analyzed for two major South Asian stock markets: DSE and BSE under EGARCH-M (1,1) model. It is found that negative risk-return relationship is existed in DSE which indicate that the risky investors are not rewarded by higher return and this result is not consistent with theory of finance. Besides, the investors are getting additional return for relatively higher risk in BSE which is supported by theory of finance. The α and β coefficients are very significant which reveal volatility clustering effect and effect of old news are very prominent in both markets. Though, the impact of old news is almost same in DSE and BSE to predict future movements of market over a very long horizon but clustering impact is more prevalent in DSE than BSE. The persistence of conditional variance process, which we measure by sum of α and β, is very large and more than one in both markets indicating the process is explosive. Finally, leverage factor β is significant indicating asymmetric impact of news on volatility i.e., bad news have greater impact on volatility than the same magnitude of good news. This asymmetric effect is higher in BSE tan DSE. Considering all these above factors, return behavior in BSE is more rationale and compatible with theory of finance than the return behavior of DSE.

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