Islamic Economic Studies
Vol. 26, No. 2, January 2019 (43-71) DOI: 10.12816/0052877

Co-Movement and Volatility Transmission between Islamic and Conventional Equity Index in Bangladesh

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Abstract

Though the issues of co-movement and volatility transmission between Islamic and conventional stock indices have been extensively studied worldwide, this is the first study in reference to Bangladesh to the best of our knowledge. The broad objective of this paper is to investigate whether Islamic stock index provides more diversification benefits than the conventional index from the perspective of cointegration and volatility spillover employing ARDL bounds testing cointegration procedure and GARCH family models. This study uses daily conventional (DS30) and Islamic (DSES) indices from the Dhaka Stock Exchange over the period from 20 January 2014 to 25 June 2018. Typically longer series of data are used in stock market research; however, this study is constrained to take only four and a half years of daily data as Islamic stock index in Bangladesh launched only just in January 2014. The results from ARDL bounds testing and error correction modeling show that both the markets are interlinked in the short-run and long-run. Since two markets move together in the long and short-run, one can predict its future price using any of the index prices. Univariate GARCH(1,1) model finds evidence of volatility clustering in both index returns which have a tendency to last a long time. The results of the EGARCH(1,1) model reveal that both markets are more sensitive to the bad news than with good news. Employing a bivariate GARCH-BEKK model, we find the existence of significant volatility transmission from conventional to Islamic stock market in Bangladesh. Results of GARCH-CCC framework show the evidence of strong direct interconnections between the markets. Finally, we test the presence of time-varying correlation between markets applying the GARCH-DCC model, and the results reveal that

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correlations are not only conditional but also significantly time-varying. The result also shows that the correlation process is mean reverting. Therefore, we conclude that conventional and Islamic stock markets in Bangladesh do not offer any diversification benefits to investors having both indices in their portfolios. Hence, faith-based investors and portfolio managers should add in other categories of assets in their portfolios to mitigate risk.

Keywords: Islamic and Conventional Equity Market, Cointegration, Volatility Spillover, GARCH-BEKK Model, GARCH-DCC Model

JEL Classifications: C32, C58, F36, G15
KAUJIE Classification: I73, I75, L32

1. Introduction

The investigation of co-movement and volatility spillover between stock markets in developed countries has been a dominant research agenda in financial economics over the few years. Though, the issues provide hints to investors about potential diversification opportunities, the empirical studies on this subject in Bangladesh perspective are still scarce. Jebran (2014) contends that investors will have no potential diversification opportunities if the stock markets are integrated. Harris and Pisedtasalasai (2006) argue that volatility spillover is an indicator of market efficiency. Efficient and the cointegrated stock market does not provide any opportunity for investors to diversify the risk. Thus, considering the importance for investors and policymakers, this study attempts to explore the cointegration and volatility dynamics between conventional and Islamic equity markets in Bangladesh. This study cares about cointegration and volatility dynamics between conventional and Islamic equity market as an Islamic equity market can be a fresh alternative investment value that can provide high diversification benefits to investors. It is generally believed that the risk-return trade-off of Islamic stocks may be different from conventional stocks as the included companies in Islamic indices meet the extra financial filter criteria, additional monitoring costs, and a smaller investment universe. For example, S&P Global 1200 Shariah index generates higher returns at 6.93% over the recent ten years from 2008 to 2018 compared to 5.67% returns generated by S&P Global 1200 (IFSB, 2018). According to Zamzamir et al. (2013), several studies reveal that Islamic indices are better and outperform the conventional indices. Saiti et al. (2014) present an indication that the Islamic equity index contributes a better diversification for the stock markets of Hong Kong, China, Korea, and Turkey. Besides, Sensoy (2016) claims that the level of the systematic risk in conventional markets is slightly higher than the risk in Islamic markets. In contrast, Majdoub et al. (2016) reveal that Islamic stock prices of France, Indonesia, the UK, and the US are strongly connected to its conventional counterpart. Many latest studies reveal that the stock markets appear to have co-movement. This co-movement might in the mode of stock markets integration along with in the mode of financial contagion (Dewandaru et al., 2014).

Commenced in 1970s and abiding by Islamic jurisprudence derived from the Holy Quran (the holy book of Islam), the Sunnah (the practices of the Prophet Muhammad s.a.w.) and ijtihad (the reasoning of qualified scholars), the Islamic Financial Services Industry (IFSI) has obtained a great interest as an efficient alternative class of financial intermediation. Islamic financial institutions are currently working in over 95 countries worldwide, and the industry has increased significantly over the few decades, reaching about USD 2 trillion marks, up from about USD 1 trillion in 2011 and US$5 billion in the late 1980s (IFSB, 2017 and 2018). The historical development of the Islamic capital market originated in July, 1987 after the fatwa on the Islamic equity fund; however, post 1990s, there has been considerable interest in terms of developing appropriate Shariah-compliant capital market products, such as Islamic securitized assets (Sukuks), Islamic equities, Islamic investment funds, etc. (IFSB, 2011). In general, investors stick to three Shariah screening procedures while investing in Islamic capital markets. First, the Islamic capital market requires investments to be free from riba (interest rates) and prohibited business activities, such as alcohol, gambling, pork-related products, pornography, conventional financial services, and conventional insurance. Second, Shariah-compliant companies must maintain few specific financial ratios, such as debt-to-equity ratio, cash and interest bearing securities-to-equity ratio, and cash-to-asset ratio. Finally, individual investors have to employ a dividend cleansing mechanism to purify investments if some part of the company’s income earned from interest-bearing accounts. Launched in February 1999, Dow Jones Islamic Market (DJIM) was the pioneer Shariah-compliant index in the world. The success of DJIM instigated a flow of Islamic indices over the past few years, such as the Standard & Poor Shariah Index (S&P), the Financial Times Islamic Index Series (FTSE), the Morgan Stanley Capital International Islamic Index Series (MSCI) and BSE 500 Shariah Index of Bombay Stock Exchange. Bangladesh is the first country in Southeast Asia where Islamic banking was introduced in 1983; however, the first Islamic stock index in Bangladesh named, Dhaka Stock Exchange (DSE) Shariah index (DSES) launched only just in January 2014. The DSES uses the Shariah screening methodology and processes employed by the S&P Shariah Family of Indices. The DSES Index is formed as a subset of the DSE Broad Index (DSEX) and comprises all stocks contained within the parent index that pass rules-based screening for Shariah compliance. Companies engaged in advertising and media (except news or sports channel and newspaper), conventional financial institutions, alcohol, cloning, tobacco, gambling, pork, pornography and trading of gold and silver are not included in the Shariah index (DSE, 2018). After removing companies with non-compliant business activities, the rest of the companies are examined for compliance in financial ratios and some 75 listed companies are chosen under the DSES Index. Islamic banking is proliferating in Bangladesh with a market share of about 30 percent (Moniruzzaman, 2018). The popularity of Islamic banking is growing at a rapid pace in Bangladesh, and it has achieved more than 20 percent annual growth over the years (Nabi et al., 2015). Therefore, it goes without saying that there is also a considerable potentiality and scope of Islamic capital market in Bangladesh having 145 million Muslim population. If this relatively fresh Islamic stock market enthuses from the phenomenal growth in the Islamic banking in Bangladesh, stakeholders will be positively concerned on the co-movement between the Islamic and conventional indices for their portfolio diversification.

This study limits its investigation on the domestic diversification opportunities between the conventional and Islamic stock markets despite the recommendations of the financial theory about the additional gains of international diversification. It is often assumed that the best diversified investment is a stock index. Though domestically-oriented faith-based stock market investors in Bangladesh have no alternatives and seek to invest solely in stocks that are compliant with the Islamic laws, this endeavor should be interesting since it is important to know whether domestically-oriented conventional market investors will benefit from investing in Islamic stocks as well. Besides, Gorman and Jorgen (2002) assert that domestically-oriented investors are not irrational and the benefits of international investment are hard to attain. Abid et al. (2014) reveal that the domestic diversification strategy dominates the international diversification strategy at a lower risk level. Moreover, Chniguir et al. (2017) argue that institutional investors show strong preference for national assets. In the same way, French and Poterba (1991), Tesar and Werner (1995), and Oehler, Rummer, and Wendt (2008) suggest that investors tend to hold portfolios largely dominated by domestic assets. In practice, investors have a tendency to favor their domestic market. This home-bias investors of Bangladesh can enjoy the benefits of diversification investing in a mix of securities that differ in size, style, and sector. The benefits of diversification may also arise from different securities of Shariah index and conventional index.

By Inspiring from the above-stated realities, the current study tries to find the answer of the following questions: i) Do Islamic stock prices share the short-run and long-run relationships with the conventional stock prices in Bangladesh? ii) Do common stylized facts prevail in the conventional and Islamic stock markets? iii)

Who is the volatility transmitter between the conventional and Islamic stock indices in Bangladesh? iv) Are there any conditional correlations between the conventional and Islamic stock indices? v) Does the Islamic stock market offer diversification benefits for conventional investors? This study will contribute to the existing literature in several ways. First, to the best of our knowledge, this is the first study to explore the integration and volatility spillover between Islamic index and its conventional counterpart in reference to Bangladesh. Second, this study provides valuable information to domestic and international investors as we employ modern econometric techniques on data of Islamic index in Bangladesh from the time of formation. Therefore, the overall contributions of this study may give valuable knowledge to investors to allocate their portfolio efficiently and policy makers to regulate existing policies or implement new policies. The organization of this study is as follows: section 2 focuses a literature review; section 3 reports data and preliminary statistics, while section 4 justifies the methodology. Lastly, section 5 reports the empirical findings and section 6 concludes the study.

2. Literature Review

The bulk of the existing literature, such as King and Wadhwani (1990), Hamao, Masulis, and Ng (1990), Bekaert and Harvey (1997), Liu and Pan (1997), Bekaert and Wu (2000), Abbas et al. (2013), and Mohammadi and Tan (2015) focus on the co-movement and volatility spillover between international conventional stock markets. For instance, Mohammadi and Tan (2015) examine the dynamics of daily returns and volatility in stock markets of the U.S., Hong Kong, and mainland China over 2 January 2001 to 8 February 2013 employing VAR and MGARCH models. The results suggest the evidence of unidirectional return spillovers from the U.S. to the other three markets; but no spillover between Hong Kong and either of the two mainland China markets. The study also finds the evidence of unidirectional ARCH and GARCH effects from the U.S. to the other three markets. The patterns of dynamic conditional correlations from the DCC model suggest an increase in correlation between China and other stock markets since the most recent financial crisis of 2007.

In recent years, some empirical studies have been conducted on the return and volatility spillover between Islamic and conventional indexes. Rizvi and Arshad (2014) perform an empirical study on the volatilities and correlations of Islamic indices using four conventional global indices and five Islamic indices from the Dow Jones Indices family over the period from January 3, 2000 to December 30, 2011. Employing multivariate GARCH DCC method, they find a low moving correlation between the conventional and Islamic indices. Chiadmi and Ghaiti (2014) investigate the volatility behavior of the Standard and Poor's Sharīʻah index (S&P Sharīʻah), the Dow Jones Islamic Market (DJIM) index, the FTSE Islamic index, the MSCI Islamic World as well as their conventional counterparts, respectively, the S&P 500, the Dow Jones Industrial Average (DJIA), the FTSE All world, and the MSCI World Indexes. Results of the GARCH family models expose that the financial crisis significantly influenced Islamic stock indexes. However, the Islamic indices were less volatile than their conventional counterparts. Using the dataset over the period from 2000 to 2011 and covering three major regions: Europe, the USA, and the world, Jawadi, Jawadi, and Louhichi (2014) find that Islamic indices outperformed their conventional peers during the financial crisis period. They extend utilizing CAPM-GARCH to correct the bias while it captures volatility dynamics. Kim and Sohn (2016) investigate the volatility spillover effect between the conventional finance market and the Islamic finance market using a bivariate framework of the BEKK parameterization from January 2, 2002 to November 10, 2015. The results show a unidirectional volatility spillover from the U.S. conventional stock market to the Islamic stock indexes of Islamic countries, but not vice versa. They reject the decoupling hypothesis of the linkage between Islamic and the conventional markets. Mseddi and Benlagha (2017) investigate the spillover effects between the returns and volatilities of stocks related to Islamic and conventional banks in GCC countries using Diebold and Yilmaz's index measurement approach, DCC-GARCH model, and Zivot and Andrews test during the period 2005-2014. They find that there is a strong bidirectional returns spillover between conventional banks and a very weak spillover from Islamic banks to conventional banks. Zivot and Andrews test result reveals that the dependence between stock returns in an Islamic bank market structure is more strongly affected by the financial crisis than in a conventional bank market. Moreover, the volatility linkage is more highly affected by the crisis in an Islamic context than that in a conventional bank system. Finally, they find that the behavior of current variances is more affected by the magnitude of past variances than during past return innovations. In addition, for all the GCC countries except Bahrain, a high persistence in the time series of correlation indicates that a long-run average of the correlation can be pushed away by shocks for a very long period.

Some of the existing literature, such as Kasa (1992), Masih and Masih (2001), Saiti (2014), Saiti (2015), Singh and Kaur (2016), Majdoub, Mansour, and Jouini (2016), and Khan and Khan (2018) are focused on the stock market integration. They have employed the cointegration hypothesis to identify the integration of financial markets. For instances, Saiti (2014) uses close-to-close daily return data in USD for MSCI conventional and Islamic stock indices in Muslim (Malaysia, Indonesia, Turkey, GCC region ex-Saudi) and Far East countries (Japan, China, Korea, Hong

Kong, Taiwan), plus the MSCI conventional index of US as proxy for the US-based investor in order to examine whether they shared any degree of long-run relationship with the US. Engle-Granger, and Johansen and Juselius cointegration tests evidence a less cointegration between the stock indices of Islamic countries (compared to non-Islamic countries) and the US stock index. Singh and Kaur (2016) investigate the co-movement in the BRIC countries' stock markets in the long-run employing a Johansen cointegration technique. The results indicate no long-run co-movement among the BRIC countries as a whole. However, the pairwise and multivariate cointegration tests highlight the existence of a co-movement among the Brazilian, Russian and the Chinese markets, excluding Indian during the financial crisis and the period afterwards. Khan and Khan (2018) investigate the cointegration between Islamic and conventional stock markets in Asia Pacific region using the weekly stock prices from June 2009 to July 2017. Employing the Engle-Granger two-steps cointegration test, they find that Dow Jones Islamic Market Asia Pacific (DJIMAP) is cointegrated with BSE Sensex India, TWSE index of Taiwan, PSX Pakistan, and NZ-50 index of New Zealand. Majdoub, Mansour, and Jouini (2016) examine the market integration between conventional and Islamic stock prices for the US, the UK, France, and Indonesia from 8 September 2008 to 6 September 6 2013. They apply the cointegration procedures of Johansen, and Gregory and Hansen, and the multivariate Asymmetric Generalized Dynamic Conditional Correlation GARCH (AGDCC-GARCH) approach of Cappiello, Engle, and Sheppard. They find long-run relationships for all countries, except for the UK where there is no cointegration between conventional and Islamic stock prices. They comment that there is a high connection between the developed markets for both conventional and Islamic indexes. Finally, the results of their study reveal that the Islamic index is strongly linked with its conventional counterpart for each economy.

From the previous literature review, we can note that the results are much divergent and no consensus has been reached to date. Despite the diversity of previous empirical work emphases on the exploration of interdependencies between Islamic and conventional stock markets, the literature is limited on the international markets. In this context, this paper attempts to fill the gap in the literature as it attemps to explore the intra-country interdependencies between Islamic and conventional stock markets. Moreover, there is a lack of study regarding a combined investigation on the integration and volatility spillover dynamics between the Islamic and conventional Index as Jebran, Chen, and Tauni (2017) perform recently. Jebran, Chen, and Tauni (2017) investigate the Islamic and conventional Index integration and volatility spillover dynamics in Pakistan over the period from September 2008 to September 2015 employing Johansen and Juselius cointegration method, VECM model, GARCH, and EGARCH models. The results show a significant long-run and short-run association between Islamic and conventional index in Pakistan. The findings of their study also recommend that domestic investors possess low diversification opportunities by combining both Islamic and conventional index in their portfolios. Thus, the questions whether the Islamic and conventional markets in Bangladesh are integrated and whether the volatility spillover effect are existed, are tough to answer without inspecting this problem. Unfortunately, there is no prior research on this topics that covers Bangladesh. This study fills the gap in the existing literature as it provides useful information to the portfolio managers and investors who are looking for the opportunity of diversification.

3. Data and Preliminary Statistics

The empirical work in this study utilizes daily data of Dhaka Stock Exchange (DSE) Shariah index (DSES) from the Islamic stock market and DSE DS30 (DS30) from the conventional stock market over the period from 20 January 2014 to 25 June 2018. DSE introduced DSE Broad Index (DSEX) and DSE 30 Index (DS30) as per 'DSE Bangladesh Index Methodology' designed and developed by S&P Dow Jones Indices with effect from January 28, 2013. DSEX is the Benchmark Index which reflects around 97% of the total equity market capitalization, while DS30 constructed with 30 leading companies which can be said as investable Index of the Exchange (DSE, 2018). With effect from 20 January 2014, DSE Shariah index (DSES) comprised of about 75 companies which were selected on the basis of Shariah-compliant criteria. Additions and deletions to DSES are made once a month, and more than 100 companies are selected in a recently revised DSES. Both DSES and DS30 indices subsets of DSEX; however, only 7 common stocks consist on DSES and DS30 at present. Since only a few common stocks are consisted in these two indices, they might not all have similar returns over time. In order to find the long and short-run dynamic relationship between Islamic stock market and conventional stock market, we use daily log data of DSES and DS30. The volatility spillover dynamics are examined using daily return data of DSES and DS30 over the same period with a total of 1077 observations. The data are collected from the official website of the Dhaka Stock Exchange. The daily index data are used to calculate returns as follows:

$$\mathrm{R_{i,t}} = [\mathrm{Log}(\mathrm{P_{i,t}}) - \mathrm{Log}(\mathrm{P_{i,t-1}})] \times 100$$

where, R_i = Daily return, Log = Natural Logarithms, P_t= Price Index at time t, and P_{t-1}= Price Index at time t-1.

Figure-1
Islamic and Conventional Index

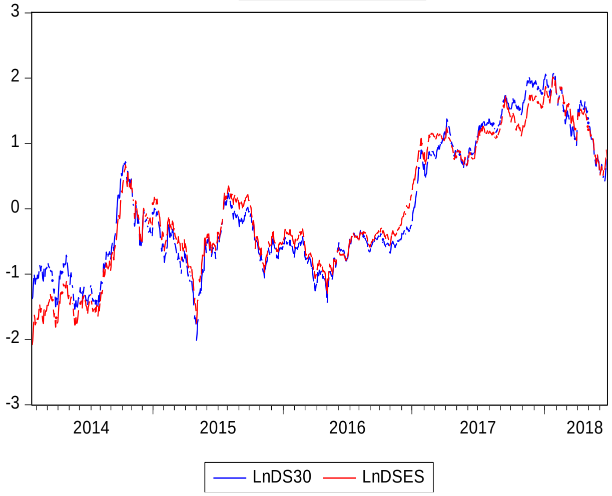
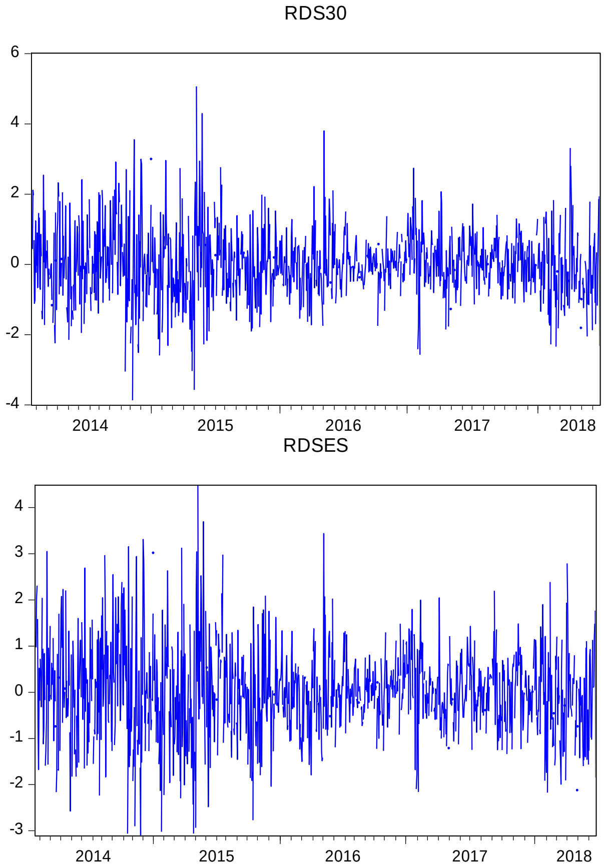


Figure 1 shows the time plots of the DS30 and DSES index series. The visual inspection on index series characterizes that both indices are chasing similar upward and downward trends indicating co-movement between the two series. Figure 2 shows the time plot of the return series of the Islamic and conventional index. Daily returns of Islamic index (RDSES) and conventional index (RDS30) fluctuate around zero and are characterized by volatility clustering. The figure also represents that both returns demonstrate higher volatility in 2014–2015.

Figure-2
Returns of the Islamic Index (RDSES) and Conventional Index (RDS30)



Descriptive statistics of the variables are shown in Table 1. It is evident from the table that average daily log index and returns are positive across the Islamic and conventional markets. The daily returns of Islamic stock market are larger than the daily returns of conventional markets. RDS30 is the more volatile series, though the two markets exhibit almost similar degrees of volatility as reflected in their standard deviations. The positive skewness in RDS30 and RDSES implies that large positive changes in returns occur more often than negative changes. The excess kurtosis of RDS30 and RDSES indicate that stock market returns of Islamic and conventional exhibit leptokurtosis that is a well-known stylized fact in the finance literature. The large Jarque-Bera statistics reject the null hypothesis of normal distribution for both series. Therefore, the rejection of the normality test based on the Jarque-Bera test gives evidence for the existence of GARCH effects.

Table-1
Basic Statistics

	Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	P-Value	Obs.
LnDS30	7.53	7.74	7.32	0.10	0.50	1.99	89.85	0.00	1078
LnDSES	7.06	7.27	6.85	0.10	0.19	1.96	55.23	0.00	1078
RDS30	0.02	3.72	-2.80	0.73	0.35	4.59	136.67	0.00	1077
RDSES	0.03	3.03	-2.05	0.67	0.30	4.09	69.51	0.00	1077

The results of Augmented Dickey-Fuller (ADF) and Phillips-Peron (PP) unit root tests in Table 2 reveal that the null hypothesis of unit root is strongly accepted for the LnDS30 and LnDSES in level. Thus, the LnDS30 and LnDSES are nonstationary in levels. Results also reveal that the series become stationary in first differences with 1% significance level. Since none of the variables are integrated of order two, i.e., I (2), we can proceed our study applying the ARDL bound testing method. Results also confirm that both the return series (RDS30 and RDSES) are stationary, that is, they do not follow a random walk. Since, both the return series are stationary, we can follow GARCH processes.

Table-2
ADF and PP Unit Root Test Results of the Variables

Variables	ADF			PP		
	Intercept	Trend & Intercept	None	Intercept	Trend & Intercept	None
LnDS30	-1.66 (0.45)	-2.11 (0.54)	-0.66 (0.86)	-1.72 (0.42)	-2.28 (0.45)	-0.66 (0.86)
ΔLnDS30 (RDS30)	-27.02* (0.00)	-27.02* (0.00)	-27.02* (0.00)	-27.28* (0.00)	-27.27* (0.00)	-27.28* (0.00)
LnDSES	-1.97 (0.30)	-2.33 (0.42)	-1.03 (0.92)	-2.04 (0.27)	-2.47 (0.34)	-1.04 (0.92)
ΔLnDSES (RDSES)	-26.98* (0.00)	-26.99* (0.00)	-26.96* (0.00)	-27.18* (0.00)	-27.18* (0.00)	-27.17* (0.00)

Note: First bracket shows P-values. * indicates stationary at 1% significant level using MacKinnon (1996) critical and P -values.

Then, the volatility clustering nature of RDS30 and RDSES is confirmed by the autocorrelation test that is reported in Table 3. The Ljung -Box Q and Q^2 statistics show that serial correlations exist in both stock market returns. This may be seen as evidence for the presence of volatility clustering in both the return series. The effect of Autoregressive Conditional Heteroscedasticity (ARCH) is also observed in both indices from the results of ARCH-LM test. Thus, a GARCH process is a likable candidate for modeling their time series behavior.

Table-3
Tests for Serial Correlation and ARCH Heteroskedasticity in RDS30 and RDSES

Lags	RDS30			RDSES		
	Q-stat	Q^2-stat	ARCH-LM (F-stat)	Q-stat	Q^2-stat	ARCH-LM (F-stat)
5	47.76 (0.00)	186.60 (0.00)	12.97 (0.00)	53.09 (0.00)	194.19 (0.00)	12.94 (0.00)
10	51.72 (0.00)	190.05 (0.00)	7.43 (0.00)	53.74 (0.00)	199.11 (0.00)	7.69 (0.00)
20	65.52 (0.00)	201.33 (0.00)	6.04 (0.00)	62.22 (0.00)	212.77 (0.00)	5.78 (0.00)
30	77.93 (0.00)	239.39 (0.00)	4.27 (0.00)	71.05 (0.00)	241.59 (0.00)	4.28 (0.00)

Note: First bracket shows P-values.

4. Models

In this study, Autoregressive Distributed Lag (ARDL) bounds testing cointegration procedure is employed to observe the long-run relationships between Islamic and conventional stock prices in Bangladesh, while we use ARDL-Error Correction Model (ARDL-ECM) to examine the short-run association. Moreover, the volatility dynamics between two equity returns is examined employing GARCH family models (GARCH, EGARCH, MGARCH-BEKK, MGARCH-CCC, and MGARCH-DCC). We use Eviews software for determination of descriptive statistics and cointegration model. Moreover, RATS statistical software is used to estimate the GARH-BEKK GARCH-CCC and MGARCH-DCC models.

4.1 Cointegration and Error Correction Model

This study uses Autoregressive Distributed Lag (ARDL) bounds testing cointegration procedure of Pesaran, Shin and Smith (2001) as it has several advantages in comparison to the conventional cointegration procedures: First, ARDL model can be applied on a time series data irrespective of whether the variables are I(0) or I(1) but not the I(2) (Pesaran and Pesaran, 1997). Second, the ARDL procedure permits that the variables may have different optimal lags, while it is impossible with conventional cointegration procedures. Third, the ARDL procedure is very efficient with small sample sizes. Fourth, the ECM can be derived simultaneously without losing long-run information. Fifth, the ARDL model corrects the omitted lagged variables bias. Finally, the ARDL procedure makes use of only a single reduced form equation, while the conventional cointegration procedures estimate the long-run relationships within the context of a system of equations.

The ARDL long-run model of Islamic and conventional stock prices in Bangladesh can be expressed mathematically as:

$$\mathrm{LnDS30}_t = \alpha_1 + \beta_1 \mathrm{LnDSES}_t + \varepsilon_{1t} \qquad (1)$$
$$\mathrm{LnDSES}_t = \alpha_2 + \beta_2 \mathrm{LnDS30}_t + \varepsilon_{2t} \qquad (2)$$

where, α, β, and ε represent constants, coefficients, and error terms respectively. Equations (1) and (2) can be re-expressed in the following conditional error correction model (ECM) version of the ARDL to implement the bounds testing procedure:

$$\Delta \mathrm{LnDS30}_t = c_1 + \pi_1 \mathrm{LnDS30}_{t-1} + \pi_2 \mathrm{LnDSES}_{t-1} + \sum_{i=1}^{\rho} \theta_i \, \Delta \mathrm{LnDS30}_{t-i} + \sum_{i=1}^{\rho} \emptyset_i \, \Delta \mathrm{DSES}_{t-i} + u_{1t} \qquad (3)$$

$$\Delta \mathrm{LnDSES}_t = c_2 + \pi_1 \mathrm{LnDSES}_{t-1} + \pi_2 \mathrm{LnDS30}_{t-1} + \sum_{i=1}^{\rho} \theta_i \, \Delta \mathrm{LnDS30}_{t-i} + \sum_{i=1}^{\rho} \emptyset_i \, \Delta \mathrm{DSES}_{t-i} + u_{2t} \qquad (4)$$

The first part of the above equations represents the long-run dynamics of the model and the second part show the short-run relationship in which Δ signifies the first difference operator. C_i (i = 1, 2) shows constant, π_i (i = 1,2) denotes coefficients on the lagged levels, θi and ϕ_i (i =1…ρ) denote coefficients on the lagged variables, and finally u_i(i = 1,2) stands for error terms. ρ signifies the maximum lag length, which is decided by the Akaike Information Criterion (AIC) as it has a lower prediction error than that of the SBC based model.

After selecting the optimal lag lengths of the models using AIC, we check the robustness and stability of the models. The diagnostic tests, including the serial correlation, normality, and heteroskedasticity associated with the models are performed. In addition, the stability tests are conducted by operating the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ). Then, we estimate the equations (3) and (4) in order to test the long-run relationship by conducting F-test for the joint significance of the coefficients of the lagged levels of the variables. Pesaran, Shin, and Smith (2001) argue that two sets of critical values for a given significance level can be determined. The first level is calculated on the assumption that all variables incorporated in the ARDL model are I(0), while the second one is calculated on the assumption that the variables are I(1). If the calculated F-statistics exceeds the upper bound of the critical values, then the null hypothesis of 'no cointegration' is rejected. The null hypothesis is accepted if the calculated F-statistic is below the lower bounds value, while the cointegration test becomes inconclusive if calculated F-statistic falls between the two levels of the bounds.

4.2 Univariate Volatility Models

In order to get reliable results of volatility dynamics, researchers should initially examine the volatility characteristics of stock returns, such as heavy tails, volatility clustering, and leverage effects. Miron and Tudor (2010) argue that stock returns exhibit some patterns and that is crucial for correct model specification and estimation. In this line of thinking, we have already checked that the return series of DSES and DS30 show evidence of volatility clustering and leptokurtosis (Figure 2 and Table 3 in Section 3). The stationary properties of the return series have also been checked using ADF and PP unit root tests (Table 2 in Section 3). Further, we intend to explore the degree of persistence and long memory in the conditional variance in the return series using univariate GARCH model. Then, we also investigate whether these return series follow the asymmetry or leverage effect employing univariate EGARCH model.

4.2.1 GARCH(1,1) Model

This study uses an extended version of ARCH model named, Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model of Bollerslev (1986) as Alexander (2001) says that ARCH models are not often used in financial markets because the simple GARCH models perform so much better. The conditional variance of the GARCH(p,q) model can be written in the following form:

$$
\begin{aligned}
&\varepsilon_t \mid \Omega_{t-1} \sim N(0, h_t^2),\\
&h_t^2 = \omega + \sum_{i=1}^{p} \alpha_i\, \varepsilon_{t-1}^2 + \sum_{j=1}^{q} \beta_j\, h_{t-j}^2, \qquad (5)\\
&\omega > 0, \alpha_i, \beta_j \geq 0 \rightarrow h_t^2 \geq 0,\; i = 1, \dots p, \text{and } j = 1, \dots . q.
\end{aligned}
$$

where Ω_{t-1} is the set of all information available at time t-1, ω is the mean of yesterday's forecast, α_i is the coefficient of the ARCH term ε_{t-1}^2 and β_j is the coefficient of the GARCH term h_{t-j}^2.

A large positive value of β_j indicates that volatility is persistent, while α+β is less than one or very close to one is an indication of a covariance stationary model with a high degree of persistence and long memory in the conditional variance. In this study, we use a GARCH(1,1) model as Alexander (2001) argues that it is rarely necessary to use more than a GARCH(1,1) model.

4.2.2 EGARCH(1,1) Model

The symmetric GARCH model cannot capture the leverage or asymmetric effect (volatility is higher in a falling market than in a rising market). Nelson (1991) develops an asymmetric volatility model named, Exponential GARCH (EGARCH) model to address the leverage effect in the volatility. The conditional variance equation of EGARCH (1, 1) model can be written as:

$$\ln\sigma_t^2 = \omega + \alpha|z_{t-1}| + \gamma z_{t-1} + \beta\ln\sigma_{t-1}^2 \quad (6)$$

where the left-hand side is the logarithm of the conditional variance. It indicates that the leverage effect is exponential and that forecasts of the conditional variance have to be non-negative. z_{t-1} shows the asymmetric impact of positive and negative shocks. The asymmetry term $\gamma < 0$ implies that negative shocks have a greater impact on volatility rather than the positive shocks. The negative asymmetric term also suggests for leverage effect that negative shocks do obviously have a bigger impact on future volatility than positive shocks of the same magnitude.

4.3 Multivariate Volatility Models

Multivariate GARCH (MGARCH) models are valuable expansions from univariate GARCH models as the MGARCH models can predict the dependence in the co-movements of stock returns in a more reliable way. Different types of MGARCH models have been proposed in the literature, such as models of the conditional covariance matrix (VECH, BEKK), models of conditional variances and correlations (CCC and DCC). In this work, we try to investigate the stock returns volatility spillover effect between Islamic and conventional stock markets employing MGARCH-BEKK, while we utilize MGARCH-CCC and MGARCH-DCC framework to examine the conditional correlation.

4.3.1 MGARCH-BEKK

In order to capture the co-movement volatility between conventional and Islamic stock returns in Bangladesh, this study uses multivariate GARCH-BEKK (Baba-Engle-Kraft-Kroner) model. The MGARCH-BEKK model is an extended version of the GARCH model which can capture volatility transmission among different series as well as the persistence of volatility within each series. BEKK formulation enables us to reveal the existence of any transmission of volatility from one market to another (Engle and Kroner, 1995). The BEKK model of Engle and Kroner (1995) can be written as:

$$H_t = CC' + \sum_{i=1}^{k} A_i\, \varepsilon_{t-1}\varepsilon'_{t-i}A'_i + \sum_{i=1}^{k} B_i H_{t-i}\, B'_i \qquad (7)$$

where C, A_i, and B_i are N×N matrices, but C is triangular. This equation guarantees all positive definite diagonal representation.

To illustrate the BEKK model, consider the simple GARCH (1,1) model:

$$H_t = CC' + A_1\varepsilon_{t-1}\varepsilon'_{t-1}A'_1 + B_1 H_{t-1} B'_1 \qquad (8)$$

In the bivariate case as in this study, the BEKK becomes:

$$\begin{aligned} H_t &= CC' + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon^2_{1,t-1} & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon^2_{2,t-1} \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \\ &+ \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}' \end{aligned} \qquad (9)$$

where the symmetric matrixes A captures the ARCH effects, matrixes B focus on the GARCH effects. The diagonal parameters in matrixes A and B measure the effects of own past shocks and past volatility on its conditional variance. The off-diagonal parameters in matrixes A and B, a_{ij} and b_{ij} measure the cross-market effects of shock and volatility; also known as volatility spillover.

In the BEKK model, the ARCH component associated with the conditional variance of RDS30 can be written as:

$$h_{11,t} = C_1 + a^2_{11}\varepsilon^2_{1,t-1} + a^2_{21}\varepsilon^2_{2,t-1} + 2a_{11}a_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} \qquad (10)$$

where the ARCH volatility in the RDS30 depends on the squares as well as the cross products of the previous shocks associated with the RDS30 and RDSES. Here, a_{11} and a_{21} capture the effects of past squared shocks in each market on today's volatility in RDS30.

Similarly, The GARCH component of the RDS30 conditional variance can be written as:

$$h_{11,t} = b_{11}^2 h_{11,t-1} + b_{21}^2 h_{22,t-1} + 2b_{11}b_{21}h_{12,t-1} \qquad (11)$$

where the volatility of RDS30 depends on the past conditional variances and covariances associated with each of the two markets. Here, b_{11} and b_{21} capture the effects of past volatility in each of the two markets on today's volatility in RDS30.

4.3.2 MGARCH-CCC

Constant Conditional Correlation (CCC) model is developed by Bollerslev (1990). This model assumes that correlations between each pair of returns are constant and thus the volatility model consists only of the equations for the variances. CCC model has been very popular among empirical studies because it reduces the conditional correlation matrix to constant correlation coefficients between variables, so the number of parameters to be estimated is small in comparison with other models. The conditional covariance matrix is defined as:

$$H_t = S_t R S_t \qquad (12)$$

where S_t is an (N×N) diagonal matrix of time-varying standard deviations and R is an (N×N) matrix of constant correlations.

In the bivariate case as in this study, the CCC becomes as follows:

$$H_t = \begin{bmatrix} \sqrt{h_{11,t}} & 0 \\ 0 & \sqrt{h_{22,t}} \end{bmatrix} \begin{bmatrix} 1 & \rho_{12} \\ \rho_{21} & 1 \end{bmatrix} \begin{bmatrix} \sqrt{h_{11,t}} & 0 \\ 0 & \sqrt{h_{22,t}} \end{bmatrix} \qquad (13)$$

In this case, H_t is assumed to be positive definite if certain restrictions on the parameters are correctly satisfied. Variance terms $h_{11,t}$ and $h_{22,t}$ are univariate GARCH processes with p=q=1.

4.3.3 MGARCH-DCC

The Dynamic Conditional Correlation (DCC) model is proposed by Engle (2002) in which the conditional correlation matrix is time-dependent, and all conditional correlations follow the same dynamic structure. DCC model is more recent and has been successful over the CCC model as contemporary works of literature reveal that stock market integration has been varied over time. The form of Engle's (2002) DCC model is as follows:

$$H_t = D_t R_t D_t \qquad (14)$$

where D_t is a (N×N) diagonal matrix of time-varying standard deviations from univariate GARCH models. R_t is the time varying conditional correlation matrix and can be expressed as follows:

$$R_t = \mathrm{diag}(q_{11,t}^{-\frac{1}{2}} \dots q_{22,t}^{-\frac{1}{2}}) Q_t \mathrm{diag}(q_{11,t}^{-\frac{1}{2}} \dots q_{22,t}^{-\frac{1}{2}})$$

where $Q_t=(q_{ij,t})$ is the 2×2 symmetric positive definite matrix and is given by

$$Q_t = (1 - \alpha - \beta)\,\overline{Q} + \alpha\epsilon_{t-1}\varepsilon'_{t-1} + \beta\, Q_{t-1}$$

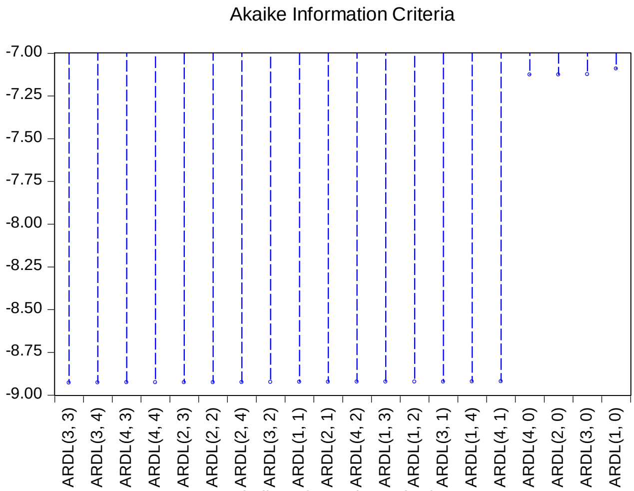
where α and β are non-negative scalar parameters with the restriction that $\alpha + \beta < 1$.

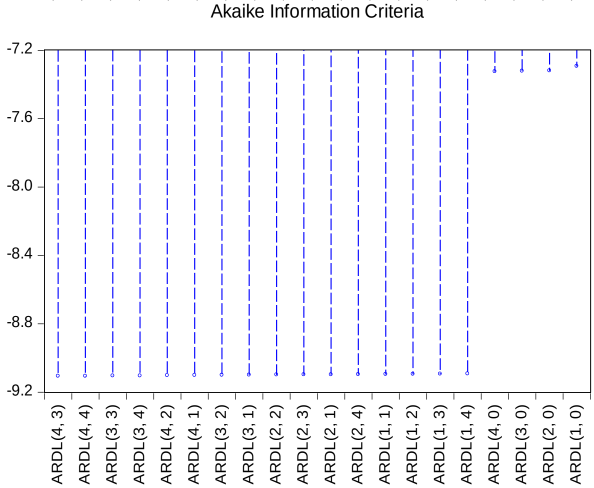
5. Results and Discussion

5.1 Results of ARDL Cointegration and ECM

After checking the order of integration in section 3 that none of the variables are I(2), we move to estimate the presence of cointegration between the variables of equation (3) and (4). The AIC selects an optimal ARDL (3, 3) for the variables included in the conventional stock model (The left portion of Figure 3), while optimal ARDL (4, 3) for the Islamic stock model (The right portion of Figure 3).

Figure-3
Selection of Optimal Model using AIC





Then we move to check the cointegrating relationship between the variables of both models using the bounds test after getting assured about the robustness and stability of the models. The calculated F- statistics in Table 4 for the conventional stock market model is 4.34 that is higher than the upper bound critical value of 4.16 at 5% level of significance. The computed F- statistics for Islamic stock market model is 4.74 that is also higher than the upper bound critical value at 5% level of significance. Thus, we reject the null hypothesis of no cointegration among the variables, and therefore we can comment that the long-run relationships exist between the variables.

Table-4

Results of ARDL Bounds Cointegration Test

Model	F-Statistic	5% Critical Bounds I(0)	I(1)	Cointegration
LnDS30=f(LnDSES)	4.34*	3.62	4.16	Present
LnDSES=f(LnDS30)	4.74*	3.62	4.16	Present

Note: * denotes rejection of the null hypothesis at the 5% level.

Table 5 shows the long-run coefficients of both models. The long-run coefficients are significant at 1% level of significance implying that Islamic stock prices have a long-run impact on conventional stock prices in Bangladesh and vice versa. The result implies that a 1% increase in Islamic stock prices contributes to a 1.03% increase in conventional stock prices. Further, a 1% increase in conventional stock prices contributes to 0.93% increase in Islamic stock prices in the long-run in Bangladesh.

Table-5
Long-Run Coefficients

Model	Variable	Coefficient	P-value	Long-run Cointegration Equation
LnDS30	LnDSES	1.03*	0.00	LnDS30 = 0.24 + 1.03 LnDSES
LnDSES	LnDS30	0.93*	0.00	LnDSES = 0.05 + 0.93 LnDS30

Note: * denotes significant at 1% level.

Table-6
Error Correction Estimates

Model: LnDS30=f(LnDSES)			Model: LnDSES=f(LnDS30)		
Variable	Coefficient	P-Value	Variable	Coefficient	P-Value
D[LnDS30(-1)]	0.08*	0.00	D[LnDSES(-1)]	0.09*	0.00
D[LnDS30(-2)]	-0.06**	0.04	D[LnDSES(-2)]	-0.10*	0.00
D[LnDSES]	1.01*	0.00	D[LnDSES(-3)]	0.02**	0.05
D[LnDSES(-1)]	-0.08**	0.02	D[LnDS30]	0.84*	0.00
D[LnDSES(-2)]	0.08**	0.01	D[LnDS30(-1)]	-0.06**	0.04
ECT(-1)	-0.01*	0.00	D[LnDS30(-2)]	0.07**	0.02
			ECT(-1)	-0.01*	0.00

Note: * and ** denote significant at 1% and 5% levels respectively.

Results of short-run dynamics are presented in Table 6. The results reveal that the coefficients of error correction terms of both models are negative and statistically significant at the 1% level of significance. It suggests that there is bidirectional long-run causality running between conventional stock prices and Islamic stock prices in Bangladesh. The error correction terms of both models imply that 1% of the last days' disequilibrium is corrected today. The short-run results are perfectly consistent with that of long-run coefficients. The short-run relationship between Islamic and conventional stock prices is also positive and significant at 1% level. Therefore, we can comment that conventional and Islamic stock markets in Bangladesh do not offer any diversification benefits to investors having both indices in their portfolios.

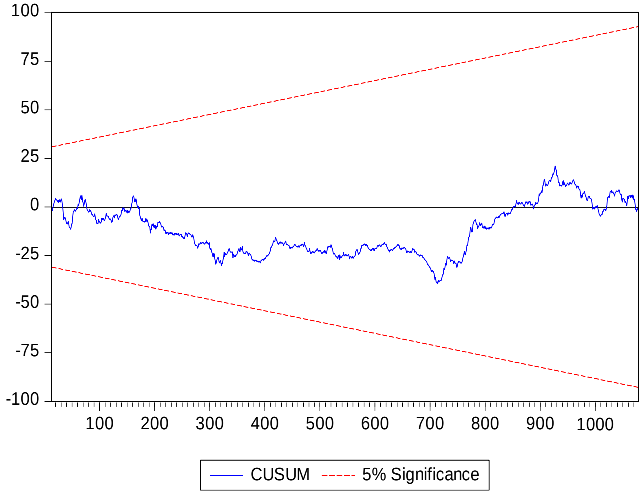
Table-7
Results of Diagnostic Tests

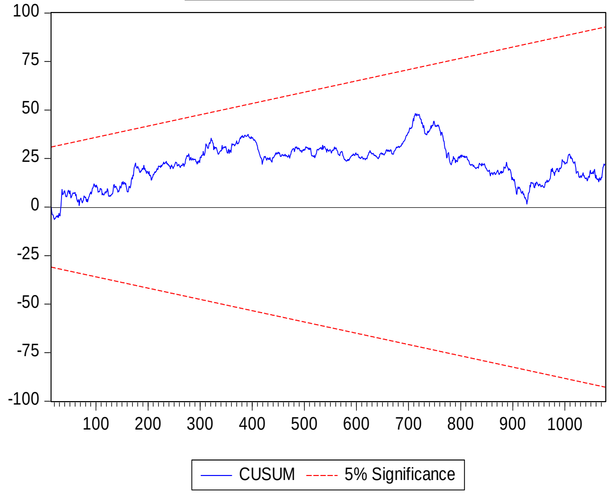
Residual Diagnostic	Conventional	Islamic
Serial Correlation LM	1.05 (0.37)	1.89 (0.11)
ARCH Heteroskedasticity	8.84 (0.00)	4.94 (0.00)

Note: P-values are in brackets.

Diagnostic checking of the models is conducted using multivariate residual-based tests for serial correlation and ARCH heteroskedasticity test owing to validate the robustness of the models (Table 7). Lagrange Multiplier (LM) tests at 3 lags for the conventional model and 4 lags for the Islamic model indicate the absence of autocorrelation at the 1% level of significance, while ARCH Chi-square test for heteroskedasticity indicates the presence of heteroskedasticity. Then, the cumulative sum of recursive residuals (CUSUM) test is employed in order to check the stability of the models (Figure 4). The left portion of Figure 4 plots the CUSUM statistics for the conventional model, while right portion plots for the Islamic model. The plotted points for the CUSUM statistics stay within the critical bounds of a 5% level of significance meaning that both the models are stable.

Figure-4
Plots of CUSUM Stability Test





5.2 Results of Univariate GARCH Models

Table 8 reports the results of the variance equations of the estimated GARCH and EGARCH models. A visual look at Table 8 clears that all the estimates of GARCH and EGARCH models are statistically significant and the GARCH effect is very close to one for both series indicating the volatility is clustering. The sum of the ARCH and GARCH coefficients in GARCH(1,1) models is 0.98 for both indices meaning that volatility is persistent in Islamic and conventional stock markets in Bangladesh. The estimated EGARCH(1,1) models show that the asymmetry term γ for both indices is negative and highly significant suggesting that bad news has more effect than the good news in both markets. In terms of diagnostic fit presented in Table 8, the estimated models satisfy the conditions of the GARCH theory based on Ljung -Box Q^2 statistics and ARCH-LM test.

Table-8
Estimates of the GARCH(1,1) and EGARCH(1,1) Model

Model		ω	α	β	γ	Q^2 (36)	LM(36)
	RDS30	0.008*	0.10*	0.88*	-	37.32	36.71
GARCH		(0.00)	(0.00)	(0.00)		(0.41)	(0.44)
	RDSES	0.008*	0.11*	0.87*	-	35.28	35.37
		(0.00)	(0.00)	(0.00)		(0.50)	(0.49)
	RDS30	-0.16*	0.19*	0.98*	-0.03**	36.02	36.69
EGARCH		(0.00)	(0.00)	(0.00)	(0.01)	(0.47)	(0.44)
	RDSES	-0.17*	0.19*	0.98*	-0.03**	33.99	35.03
		(0.00)	(0.00)	(0.00)	(0.03)	(0.57)	(0.51)

Notes: P-values are in brackets. * and ** mean significant at 1% and 5% levels respectively

5.3 Results of MGARCH Models

Table 9 reports the estimates of bivariate BEKK parameters in which all the coefficients are highly significant except B(2,1). Results reveal that the conventional stock market has the largest own ARCH effect with the coefficient value of 0.358 and there is evidence of a bidirectional ARCH effect between RDS30 and RDSES. The B(1,1) and B(2,2) GARCH parameters reveal that two conditional variances depend on their own history, while the RDSES has the largest own GARCH effect. A significant B(1,2) implies that a negative volatility spillover is running from conventional stock markets to Islamic stock markets in Bangladesh.

The estimated BEKK-GARCH model can be attained by substituting the following matrices:

$$A = \begin{bmatrix} 0.358 & 0.137 \\ -0.063 & 0.149 \end{bmatrix}$$
$$B = \begin{bmatrix} 0.948 & -0.021 \\ -0.002 & 0.973 \end{bmatrix}$$
$$C = \begin{bmatrix} 0.086 & 0 \\ 0.072 & 0.027 \end{bmatrix}$$

In particular, a significant B_{12} = -0.021 indicates the level of the volatility transmission from conventional stock markets to Islamic stock markets in Bangladesh. It implies that a 1% increase in returns of the DSE30 index transmits 2.1% volatility to DSES.

Table-9
Estimates of the GARCH-BEKK Model (RDS30/RDSES)

	Coefficient	Std. Error	T-Stat	P-Value
C(1,1)	0.086*	0.009	9.655	0.000
C(2,1)	0.072*	0.010	7.592	0.000
C(2,2)	0.027*	0.020	5.529	0.000
A(1,1)	0.358*	0.358	17.965	0.000
A(1,2)	0.137*	0.006	23.052	0.000
A(2,1)	-0.063*	0.015	-4.062	0.000
A(2,2)	0.149*	0.014	10.441	0.000
B(1,1)	0.948*	0.004	219.449	0.000
B(1,2)	-0.021*	0.003	-8.252	0.000
B(2,1)	-0.002	0.003	-0.611	0.541
B(2,2)	0.973*	0.006	173.354	0.000

Notes: * denotes significant at 1% level.

The performance of the MGARCH-CCC model is reported in Table 10. The results suggest the existence of own ARCH and GARCH effects in both markets as all of the estimated parameters are significantly different from zero and significant at 1% level. The positive and highly significant conditional correlation (0.91) between RDS30 and RDSES reflect the presence of strong direct interconnections between conventional and Islamic stock markets in Bangladesh.

Table-10
Estimates of the MGARCH-CCC Model (RDS30/RDSES)

	Coefficient	Std. Error	T-Stat	P-Value
C(1)	0.013*	0.004	3.776	0.000
C(2)	0.011*	0.003	3.409	0.000
A(1)	0.051*	0.009	5.830	0.000
A(2)	0.049*	0.011	4.613	0.000
B(1)	0.919*	0.012	67.128	0.000
B(2)	0.921*	0.017	54.270	0.000
R(2,1)	0.910*	0.005	169.718	0.000

Notes: * denotes significant at 1% level.

Results of time-varying dynamic conditional correlation estimation for RDSE30/DSES are presented in Table 11. The sum of A_i and B_i for each univariate GARCH estimation is almost close to 1 which presents the high persistence of conditional volatility. DCC(A) and DCC(B) are significant at 1% level of significance implying that the DCC model is favorable compared with the CCC model. Moreover, DCC(A)+DCC(B)=0.987 is less than 1 indicates that the conditional correlation process is mean reverting. Therefore, the correlations will return in time to the long-run unconditional level after a shock occurs.

Table-11
Estimates of the MGARCH-DCC Model (RDS30/RDSES)

	Coefficient	Std. Error	T-Stat	P-Value
C(1)	0.007*	0.003	2.817	0.000
C(2)	0.007*	0.003	2.617	0.000
A(1)	0.072*	0.012	5.989	0.000
A(2)	0.073*	0.016	4.566	0.000
B(1)	0.917*	0.014	65.561	0.000
B(2)	0.915*	0.019	48.896	0.000
DCC(A)	0.054*	0.012	4.525	0.000
DCC(B)	0.933*	0.017	53.934	0.000

Notes: * denotes significant at 1% level.

6. Conclusion

This study explores the cointegration and volatility spillover between Islamic and conventional stock markets in Bangladesh from 20 January 2014 to 25 June 2018. Employing the ARDL bounds testing procedure on daily log data of DS30 and DSES indices, we find that Islamic stock prices have a long-run positive impact on conventional stock prices and vice versa. The results of ECM reveal that the coefficients of error correction terms of both models are negative and statistically significant suggesting that there is bidirectional long-run causality running between conventional and Islamic stock prices in Bangladesh. Moreover, the short-run relationship between Islamic and conventional stock prices is also positive and significant at 1% level. Employing a univariate GARCH(1,1) model on DS30 and DSES returns, we find evidence of volatility clustering in both index returns which have a tendency to last a long time. Then, the results of the EGARCH (1, 1) model indicate that both markets are more sensitive to the bad news than with a good news. A bivariate GARCH-BEKK model is built to capture the existence of volatility spillover between returns of the Islamic and conventional stock indices. We find the existence of significant and negative volatility transmission from conventional to the

Islamic market. Specifically, a 1% increase in returns of the conventional DSE30 index transmits 2.1% volatility to Islamic DSES index. This study also employs a GARCH-CCC framework to examine the constant conditional correlation between two returns and the results show the evidence of strong direct interconnections between the markets. Finally, we test the presence of time-varying correlation between two equity market applying the GARCH-DCC model, and the results reveal that correlations are not only conditional but also significantly time-varying. The result also shows that the correlation process is mean reverting. Thus, we can comment that the GARCH-DCC model can provide much more useful information than what GARCH-CCC model can do.

Based on the above discussion, we conclude that conventional and Islamic stock markets in Bangladesh do not offer any diversification benefits to investors having both indices in their portfolios. Hence, stakeholders on the investment activity should pay attention to the behavior of co-movement and volatility transmission. Private as well as institutional investors should modify their investment strategy and asset allocation decisions accordingly to the cointegration and spillover effects. Future researchers can include South Asian markets to examine the co-movement and spillover effect from which Bangladesh may be strongly affected.

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