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Stock Price and Exchange Rate Dynamics in an Emerging Economy: Evidence from Bangladesh

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Stock Price and Exchange Rate Dynamics in an Emerging Economy: Evidence from Bangladesh

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Dedicated to my parents

and wife

for their endless love, inspiration,
sacrifice and guidance.

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Rakibul Islam

Statement of Authorship

I hereby declare that the thesis entitled *"Stock Price and Exchange Rate Dynamics in an Emerging Economy: Evidence from Bangladesh"* submitted to the University of Rajshahi for the degree of Master of Philosophy in Finance is exclusively my own and original work prepared under the supervision of Professor Md. Shibley Sadique, PhD, Department of Finance, University of Rajshahi, Rajshahi, Bangladesh.

Except where reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis for which I have qualified for or been awarded another degree or diploma.

No other person's work has been used without due acknowledgement in the main text of the thesis.

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

Parts of this thesis were presented at conference/seminars and published as explained in the 'Thesis Related Research Outcomes'.

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Certificate

I have the pleasure to certify that the thesis *"Stock Price and Exchange Rate Dynamics in an Emerging Economy: Evidence from Bangladesh"* is an original work carried out by Mr. Rakibul Islam under my direct guidance and supervision. To the best of my knowledge, no part of the thesis, in any form, has been submitted to any other institute or university for a degree or diploma, or any other similar purposes.

I also certify that I have gone through the draft and final version of the thesis and found it satisfactory for submission to the University of Rajshahi for the Degree of Master of Philosophy in Finance.

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Abstract

This study examines stock price and exchange rate dynamics in Bangladesh by utilizing the daily data of stock price and exchange rate of BDT/USD from June 2003 to December 2016. The study period has been divided into two sample periods; one from June 02, 2003, to January 25, 2013, and the other from January 28, 2013, to December 30, 2016. The sample period one (June 02, 2003, to January 25, 2013) represents the period with more variance for both stock price and exchange rate because within this period different turbulent events have occurred (e.g. world economic meltdown, stock market crash etc.) while sample period two (January 28, 2013, to December 30, 2016) represents less variance for both stock price and exchange rate. In both periods it is observed that stock market have more variability than that in exchange market.

This study divides the analysis into three parts; one is individual efficiency analysis in terms of random walk hypothesis through different parametric and non-parametric tests for both stock market and exchange market, the second one is joint efficiency investigation through cointegration and causal relationship (long and short-run relationship) between them and the final one is the volatility dynamics in within and between those two market.

The individual efficiency analyses confirm the nonrandomness for stock price and exchange rate in both sample periods. Therefore, stock market and foreign exchange (FX) market are individually inefficient in Bangladesh.

Joint Efficiency investigation presents no long-run relation between stock market and FX market over the period of greater variance, but a unidirectional long-run relationship has been found running from stock market to FX market over the period of lower variance. On the other hand, bidirectional nonlinear causal relationship (stock price leading the relationship) is found in high variance period; but no linear or nonlinear short-run relationship exist in low variance period. Thus, the evidence of connectivity between stock market and FX market denies joint market efficiency in Bangladesh.

Finally, the volatility dynamics within and between stock and FX market has been investigated for both periods. The volatility dynamics within both markets approves significant past news effect and asymmetric news effect and volatility clustering within each market. The volatility dynamics between financial markets indicates volatility spillover (cross-market relationship) between stock market and FX market. It confirms the return spillover from stock market to foreign exchange market where it is negative for high variance period and positive for low variance period. Thus portfolio balance approach is observed, that is, past stock return have significant explanatory power over conditional mean of FX return. Volatility spillover investigations confirm negative bidirectional volatility spillover phenomena explaining Government intervention and behavior of foreign investors in the exchange market for both periods with less and more variance. The study also provides the evidence of effectiveness of cross market positive news in reducing the volatility in the financial market. These observations affirm the absence of weak form joint efficiency, that is, information of one market can be used to predict another market.

In general, the thesis contributes to the existing literature by confirming how the level and direction of connection between stock market and FX market changes with the extent of volatility in the sample period in Bangladesh. It also presents how information contents of the stock market affect FX market in Bangladesh and vice-versa. Overall, the study enriches the knowledge of functionality, volatility of and between stock and FX markets and also has implications for investors and regulators.

Acronyms

ADB	Asian Development Bank
ARCH	Autoregressive Conditional Heteroscedasticity
ARDL	Autoregressive Distributed Lag
ARMA	Autoregressive Moving Average
ASEAN	Association of Southeast Asian Nations
BRICS	Association of Brasil, Russia, India, China and South-Africa
BSEC	Securities and Exchange Commission of Bangladesh
CAPM	Capital Asset Pricing Model
CDBL	Central Depository Bangladesh Limited
CDs	Credit Default Swaps
CMDP	Capital Market Development Programme
CMDP2	Second Capital Market Development Programme
CSE	Chittagong Stock Exchange
DCC	Dynamic Conditional Correlations
DCCX	Exogenous Variables in Dynamic Conditional Correlations
DSE	Dhaka Stock Exchange
EG	Engle- Granger
EGARCH	Exponential Generalized Autoregressive Conditional Heteroscedasticity

EMH	Efficient Market Hypothesis
EMS	European Monetary System
ERM	Exchange Rate Mechanism
EU	European Union
FDI	Foreign Direct Investment
FPI	Foreign Portfolio Investment
FX	Foreign Exchange
IBOVESPA	Sao Paulo Stock Exchange Index
IBSA	India, Brazil, and South-Africa
IMF	International Monetary Fund
IOSCO	International Organization of Securities Commissions
KSA	Kingdom Saudi Arabia
LA	Latin American
LM	Lagrange Multiplier
M3	Broad Money
MDH	Mixture Distribution Hypothesis
M-FIAPARCH	Multivariate Fractionally Integrated Asymmetric Power Autoregressive Conditional Heteroscedasticity
MGARCH	Multivariate Generalized Autoregressive Conditional Heteroscedasticity
REER	Real Effective Exchange Rate
RWH	Random Walk Hypothesis
SEM	Secondary Exchange Market
TED	T-Bill and Eurodollar

TREC	:	Trading Right Entitlement Certificate
UAE	:	United Arab Emirate
UK	:	United Kingdom
USA	:	United States of America
VAR	:	Value at Risk
VECM	:	Vector Error Correction Model
VIX index	:	Chicago Board Options Exchange Volatility Index
WFE	:	The World Federation of Exchanges

Chapter 1

Introduction

1.1 Statement of the Problem

What makes it more interesting for more than three decades to study the interaction between foreign exchange market and equity market is their individual as well as combined effort to shape macroeconomic variables (e.g. Money supply, balance of trade, industrialization, capital movement) of a country with a broad explanatory power to define investors behavior, asset pricing, risk diversification and global equity movement (through FDI or Portfolio investment). The open market policy, practice of flexible exchange rate, and capital market development throughout the world provokes more dynamic relationship between foreign exchange market and equity market and this relation plays more significant role which eventually brings dynamism in the policy and strategy formulation and practice by the different parties (e.g. investors, financial institutions and regulators and government). It begins from the 1980s and early 1990s; especially the abolition of foreign exchange controls in emerging countries not only indicates international investment opportunities and portfolio diversification or cross-border capital movement but also invokes the volatility and dynamism of exchange rate and the risk with such investment. Furthermore, the time to time changing scenario of the world economy and country-specific differences aggravates risk in international market and dynamism of one economy influences the other more frequently and at a quick time.

The interaction of foreign exchange market and equity market can be traced back to classical economic theory; flow oriented models of exchange rate determination (Dornbusch & Fisher, 1980) confirms the impact of currency movement on international competitiveness and balance of trade position and thereby real output of a country, consequently direct effect on current and future cashflows of companies and their stock prices. Whereas monetarist models of exchange rate determination affirm the impact of stock price on the exchange rate, that is, share or equity is nothing but a wealth and wealth has a direct effect on demand for money which will, in turn, affect the exchange rate behavior (Gavin, 1989). This is often called substitution effect or wealth effect. Like wealth effect, portfolio approach or stock approach (Branson, 1983) claims the positive impact of share price on the exchange rate; here it is due to portfolio rebalancing not demand for money by the investors.

It is logical to study these two markets in Bangladesh, as because Bangladesh is an emerging economy (Helal & Hossain, 2013; IMF, 2016; Boumphrey, 2014; Rahman & Tantu, 2011) expanding its participation in foreign trade, following floating exchange rate regime, having a stable and rising GDP growth rate, investment level and capital market development.

1.2 Objectives of the Study

The overall objective of this study is to identify and explain long-run and short-run dynamic relation between equity market and foreign exchange market.

The specific objectives of this study are the following:

i. To identify individual efficiency of equity market and foreign exchange market.

ii. To identify joint efficiency of equity market and foreign exchange market.

iii. To identify the long-run relationship between equity market and foreign exchange market.

iv. To identify short-run causal relationship between equity market and foreign exchange market.

v. To identify the existence of volatility in equity market and foreign exchange market.

vi. To identify the existence of volatility spillover between equity market and foreign exchange market.

vii. To identify the direction of spillover between equity market and foreign exchange market.

1.3 Research Questions of the Study

It is theoretically true that financial market has priced its assets incorporating all past, public and private information according to efficient market theory. As long as random walk hypothesis is true for asset pricing, weak form of efficiency prevails in the market with its unpredictability for future pricing or return. If two financial markets are interlinked, then any change in pricing in one market invokes another in its pricing to reflect that change, because of efficient market hypothesis. However, in real world, it leads to mixed results on the interaction between stock market and exchange market for developed and emerging economies. Due to mixed result, this study further examines the relationship between stock price and exchange rate in an emerging economy, Bangladesh, under the following research questions:

i. Are financial markets of Bangladesh, like equity market and foreign exchange market individually efficient?
ii. Are equity market and foreign exchange market cointegrated in the long-run; are they jointly efficient or not?
iii. What is the short-run relationship between them? What is the overall direction of causality?
iv. Does volatility exist in equity market and foreign exchange market? If exists, does volatility spreads from one to the other market? If volatility spillover exists, what is the direction of that spillover? What are the implications for transmission mechanism of these shocks?

1.4 Research Gaps and Contributions

The extant literature on stock market and foreign exchange market interaction covers only developed and developing world from European, American and Oceania region while a less attention has been given on the Asian economies especially South Asian region except India and Pakistan. When it comes to the country like Bangladesh, studies are very few and inadequate in numbers (Muhammad & Rasheed, 2003; Rahman & Uddin, 2008; Rahman & Uddin, 2009). Hence, this study summarizes the research gap and explains a way to fill the gap in what follows:

Samples

The paper uses daily data of the stock price and exchange rate in Bangladesh for the period of June 2003 to December 2016. None of the literature earlier consists of this period of time and that high-frequency data in Bangladesh. The special character of these time duration is as follows:

- It covers the period from the start of the floating exchange rate in Bangladesh,
- It covers the time of world economic meltdown at 2008, as exchange rate of US dollar is used in the analysis,
- It covers the time period for stock market crash in Bangladesh in December 2010,
- It covers high-frequency data that is daily data; to analysis, the direct interaction between stock and foreign exchange market since monthly or yearly data may not show the true interaction.

Methodology

- To the best of the author's knowledge, there is no other study related either stock price or exchange rate have used stationary test considering structural break, random walk hypothesis by using Wright's alternative variance ratio and cointegration test considering structural break, non-linear causality test to define individual character and combined nature of stock price and exchange rate in Bangladesh.

- Further, there is no other research to study the side by side comparison for the existence of volatility of stock price and exchange rate in Bangladesh. Here this study uses GARCH and EGARCH model to present and compare the volatility in those markets.
- Finally, this may be the first ever paper to study volatility spillover relationship for stock price and exchange rate in Bangladesh. In that case, this study use bivariate EGARCH model to know volatility spillover in those markets.

1.5 Significance of the Study

Stock market and foreign exchange market have influenced the economy in so many ways- their depth, information absorption nature, behavior lead the conversion and transformation in decision making and conducting operations for individuals, firms, industries, and countries for short to long-run. While their interaction would be more puzzling for practitioners and it is broadly more informative for defining micro and macro level operations of a country. Therefore the significance of this study explained below in terms of micro and macro level;

Micro-level significance: The foremost micro level significance would be for individual investors and firms to hedge currency risk. How does exchange rate behave, stock market changes, and how they interact can change the real income or assets and receivables or payables for a firm. The more the quicker the hedging decision is made, the less the earnings variability for the firm or investors. Thus, it also affects the export and import decision of a firm. In addition, it has an impact on the firm's financing and investment decision.

Macro-level significance: In case of macro-level significance, the foremost significance is the stabilizing the economy, as exchange rate and stock price are broadly related to money supply, inflation, interest rate of a country. Any uneven change in stock market or exchange rate may cause major disruption in the economic activity of a country. Further, the international capital movement, growth of export and import based industry have been influenced by exchange rate movement and performance of equity market of a country. Basically, at the period of financial contagion, the knowledge of causal relation between these two markets provides greater insight and rapid decision making for the regulatory agencies of a country.

The interaction between equity market and foreign exchange market has great significance due to following reasons:

- Investors

Firstly, the presence of market risk suggested by Capital Asset Pricing Model (CAPM) induces the investors to diversify risk through investing multinational equities susceptible to the changes in foreign exchange markets as the change in exchange rate means a change in the value of wealth to the investors.

Secondly, if there is return causality between foreign exchange market and equity market, investors can exploit trading strategy to reap the profit, especially in the financial turbulent period.

Finally, Information on volatility spillover effect guides to price options and optimize portfolios. Further, the time to time discovery of volatility spillover produces useful information for the application of value at risk (VAR) and hedging strategies.

- Regulatory Body

The dynamic relation between equity market and exchange market helps policymakers and regulatory body to monitor and detect the potential financial contagion and control international capital flow and finally stabilize the equity market and foreign exchange market and the position in international financial system. (NG, 2000; Abbas, 2010; Mao, 2013)

1.6 Structure of the Study

This study of stock price and exchange rate dynamics in Bangladesh has been explored under six chapters. This study commenced with the introductory chapter (Chapter 1) indicating the problem statement, research questions and objectives of the study, research gap and prospective contribution of the study, significance and target beneficiary of the study and delimitation of the research. After explaining the reason, objectives and expected contribution of this research, the study incorporates a review of literature in Chapter 2 that explains basic theories of market efficiency, theoretical and empirical literature on the relationship between stock price and exchange rate. Chapter 3 discusses historical evolution and operations of stock market and foreign exchange market and exchange rate of BDT/USD in Bangladesh. Chapter 4 elaborates the methodology of this study. This chapter includes sources, nature of data and authenticity and reliability of data source, followed econometric methodology used.

After chapter four, the research results are given and discussed in Chapter 5. Finally, Chapter 6 consists of findings and conclusion of the research.

Chapter 2

Literature Review

2.1 Introduction

The literature review chapter explores the stock market and foreign exchange market relationship theoretically and empirically. Before explaining their market interaction, this chapter starts its review on the informational efficiency in financial market theoretically, because it is the flow of information and its absorption that can change the market behavior and dynamics. Then theoretical literature on stock market and exchange market are presented. While presenting empirical evidence, this study first seeks the evidence of financial market integration without FX market and then focus on the stock market and exchange market interaction. This empirical evidence on stock and exchange market relationship has been explained in terms of developed economies and emerging economies. Overall, this chapter tries to identify diversity in findings, research gap in the literature.

2.2 Theories of Financial Market Efficiency

This study focuses on the dynamics of two financial market, stock market, and foreign exchange market in terms of efficient market hypothesis (EMH) which assumes rational investors and the actions of rational investors to eliminate pricing anomalies if there is any because there is no such way to predict the market to generate abnormal gain. (Arnold, 2008, p. 565)

2.2.1 Efficient Market Hypothesis (EMH)

Asset prices are efficient meaning prices already incorporated all available information and only normal rate of return prevailed in the market. Because instantaneous and rational absorption of new information by the market propelled market efficiency in terms of asset price and size. As a result, the prerequisite for market efficiency is that asset prices should follow random walk; price changes are random and unpredictable (Bodie *et al.*, 2008, p. 358).

2.2.2 Levels of Efficiency

Basically, there are three forms of market efficiency. Those are

- Weak-form efficiency: Asset prices fully reflect all historical price information as if past price movement cannot be used to predict future prices in an efficient market. (Bodie *et al.*, 2008)
- Semi-strong form efficiency: Asset prices not only include past price movements but also comprise all publicly available information like earnings and dividend announcement etc. If the market is semi-strong form of efficient,

least or minimum success of fundamental analysis is achievable to break down the future prices.

- Strong-form efficiency: It covers not only the past prices or volume and/or available public information but also the private information to be adjusted and reflected in the current prices of an asset. As a result, strong form of efficiency offers normal profit for all the market participants, even for insiders too. (Bodie *et al.*, 2008)

2.3 Theoretical Relation between Exchange Rate and Stock Price

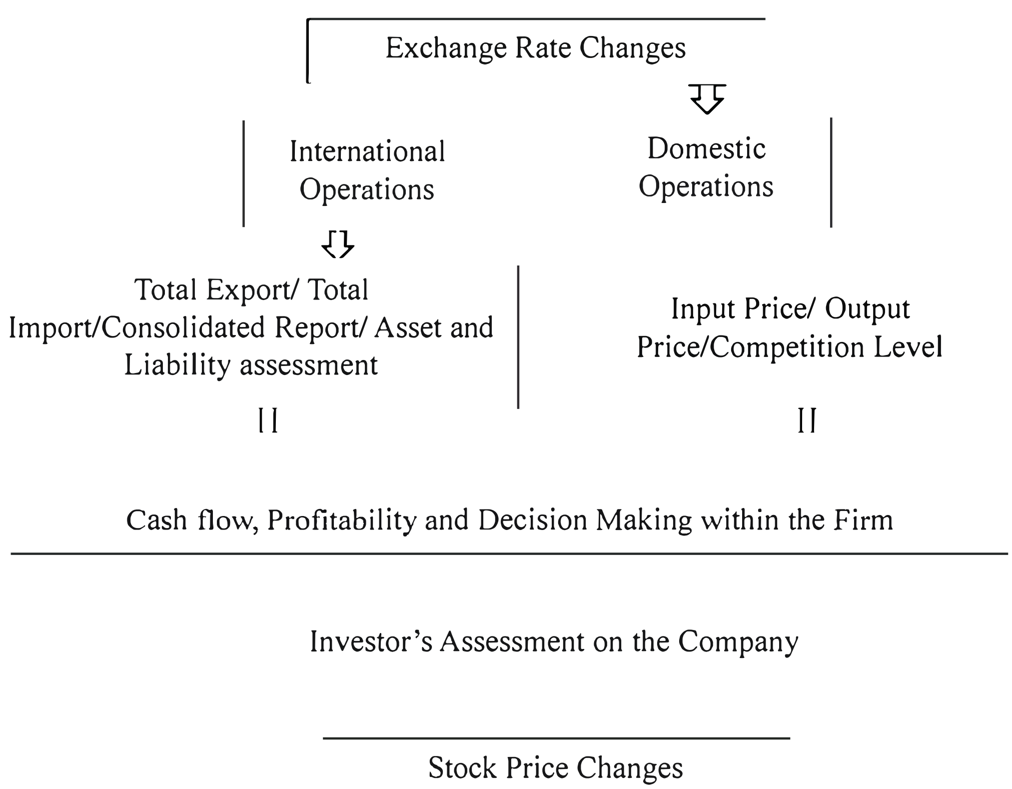
Basically, there are two approaches for defining the connection between stock price and exchange rate. First one is 'Traditional Approach' and second one is 'Portfolio Approach'.

The traditional approach leads to the causal relationship from exchange rate to the stock price and explained in the flow-oriented exchange rate model proposed by Dornbusch and Fisher (1980). This model of exchange rate determination follows the interest rate parity and goods market hypothesis and inflicts on the performance of current account balance. It confirms the effect of currency on international competitiveness. As a result, it will further affect total income, cost of fund and real output of a country. Therefore, companies' present and future cash-flows are affected and share price of those companies do change. For example, if Bangladeshi Taka appreciates against American Dollar, this will eventually lead the exporting goods expensive for foreign countries and importing goods cheaper for domestic companies.

As a result, there will be fall in foreign demand and export size and rise in import demand and import size. Consequently, future cash-flows are affected by exchange rate changes.

Further, Fauziah *et al.* (2015) have asserted the explanation of Adler and Dumas (1984) on the influence of exchange rate on stock price not only from external operation but also from domestic macroeconomic condition derived by exchange rate changes.

Figure 2.1: Effect of Exchange rate on Stock Price



Source: Fauziah *et al.* 2015

Unlike traditional approach, monetary model of exchange rate determination gives emphasize on the capital accounts for exchange rates changes. This approach suggests that causality can occur from stock price to exchange rates. Here, if the domestic interest rate falls below relative to foreign interest rate, the demand for foreign financial asset rises relative to domestic financial asset. As a result, demand for foreign currency rises and domestic currency falls. Branson (1983) and Frankel (1983) put forwarded portfolio balance approach and extended the monetary model. The portfolio balance theory assumes shares and equity as a wealth and wealth has a direct effect on exchange rate changes. They argue that any changes in share price have an impact on the wealth and liquidity, so it can bring changes to demand for money and thus affect the exchange rates. Say for example, if there is a rise in stock price, which is nothing but a rise in wealth for investors, and thus affects the demand for money which will, in turn, raise the interest rates. Eventually, rising interest rate leads to increase in capital inflows, and therefore domestic currency appreciates.

Figure 2.2: Effect of Stock Price on Exchange Rate

Stock Price Changes

Change in Investor's Reactions in Stock Market

The Change in Investment Fund Flow Entrance
(The Changes of *Capital Flow*)

The Changes of Supply and Demand of Local Currency

Exchange Rate Changes

Sources: Fauziah *et al.* 2015

Other than these two broad approaches, different researchers (Muhammad & Rasheed, 2003; Abbas, 2010) suggest that both exchange rates and stock prices are influenced by a number of common factors. Therefore, there is no linkage between exchange rates and stock prices.

2.4 Reviews of Empirical Literature

2.4.1 Interaction between Different Financial Markets

Azad (2009) has examined individual efficiency, joint efficiency and market contagion in three East Asian stock markets namely, China, Japan and South Korea. The author has used daily closing price of indices where Shanghai SE Composite for China, Nikkei 225 stock average for Japan and Korea SE stock Index for South Korea to cover the period from July 2, 1996, to December 24, 2006, with 2650 observations for this study. He has used random walk hypothesis to test individual market efficiency, cointegration hypothesis to examine joint efficiency and finally contagion hypothesis for short-run causality between these markets. This study has reported that Japanese and South Korean markets are individually efficient while Chinese stock market is informational inefficient, yet all three markets are jointly inefficient. Though all are interdependent in long-run, contagion hypothesis prevails only between Japanese and South Korean stock market.

Ya and Yuntan (2010) have investigated the long-run and short-run dynamic linkage between US stock market and China (by mainland as well as Hong Kong) during two crisis period of Asian Financial Crisis at 1997 and Subprime crisis from 2007 to 2010.

The Authors has presented a unique feature of analyzing both return causality relationship and volatility spillover effects in a single paper. Initially, they have sought long-run relationship between different markets by using Johansen Cointegration test and short-run return effect analyzed through Granger Causality. Then they have used generalized impulse response to check more information regarding movement over the time. Finally, Multivariate GARCH-BEKK model has been applied to find volatility spillover effect between different stock indices. On the way to meet the aim of this study, they have used daily data noticing the fact (Cheol & Sangdal, 1989) that the weekly or monthly data would be too long and if any relationship captured may not last more than a few days only. In specific they have used daily closing price measured by local currencies and the raw data was taken from HanSeng Index in HongKong, Shanghai Stock Exchange (A-share and B share), Shenzhen Stock Exchange (A-share and B-share), and S & P 500 Composite Index in the US. After analyzing the data, the empirical results suggest no evidence of long-run relationship on stock indices between China and US. In terms of return spillover, Hong Kong market does Granger cause other markets except for Shenzhen A-share market under Asian Crisis; in the meantime, Shanghai A-share and US markets have feedback effects on Hong Kong. However, during the subprime crisis, unidirectional return causalities found obvious from mainland China to Hong Kong and the US. Finally, GARCH-BEKK model shows that volatility spillover between the US and Hong Kong is significant, and US market is more powerful than Hong Kong during Asian Crisis. There is no spillover effect evident between the US and mainland China except a negative effect on current volatility in Shenzhen B- share market by the US, still, it remains significant and asymmetric volatility spillover effect between the US and Hong Kong during Subprime crisis. In subprime crisis, US market positively affects the Shanghai B-share and Shenzhen A-share market but negatively influences the Shanghai A-share market and Shenzhen B-share market. Unlike Shenzhen B-share market, all mainland stock markets have feedback effect on current volatility in the US. Furthermore, they have found a unidirectional volatility spillover from Hong Kong to mainland China. They have reported that overall dynamic interactions between China and US have been incremented during subprime crisis relative to the Asian crisis.

Karim and Karim (2012) re-investigates the linkages among five selected ASEAN emerging stock markets (Malaysia, Thailand, Indonesia, the Philippines and Singapore) from January 1988 to December 2010 applying Autoregressive Distributed Lag (ARDL) bound testing approach. This study advocates the market integration among the ASEAN stock markets during before, after-1997 and after U.S. subprime financial crisis. Their study finds that ASEAN stock markets are becoming more interdependent after the financial crisis and tend to diminish long-run diversification benefit for investors.

Aloui (2011) studies emerging stock markets of Latin America (LA) to examine the volatility spillovers by using daily closing index for Argentina, Brazil, Chile, and Mexico for the period from January 2, 1995, to September 15, 2009. They have used Multivariate Fractionally Integrated Asymmetric Power ARCH model with dynamic conditional correlations of Engle (1982) (DCC-E) (M-FIAPARCH-DCCE) with a Student-t distribution to find eventual volatility spillovers not only in mean returns but also in conditional variance. They try to add more insights into the volatility spillovers phenomenon by considering long-memory and asymmetry in emerging stock markets behavior. They find asymmetry, fat tails and long memory in common for all LA stock markets' volatility. In addition, FIAPARCH model captures strong evidence of long memory. They have pointed out the evidence of joint power effect and long memory in conditional variance for LA stock markets. They have shown the appropriate M-FIAPARCH with DCC specification to capture volatility spillover and shift in conditional correlation behavior. Further, they present inconsistency in conditional correlations rather time-varying movements. Time-varying movements increase its trends during the LA domestic financial catastrophes and the recent global economic meltdown period. Furthermore, the multivariate cointegration tests find common trends in DCCs share over time. Again, the pair-wise DCCs response to impulse functions reveals close connection between LA emerging stock markets' volatility indicating transmission of risk information across the neighboring markets. Moreover, the variance decomposition analysis and the impulse response functions have jointly displayed that their peculiar volatility shocks mostly affect the conditional correlations. A priori, structural changes in local or international economy potentially affect the interactive linkage between stock markets. The results point out the importance of volatility spillovers in sampling countries. Further, volatility shocks between these countries are explained through the very nature of asymmetry and long memory in each emerging stock market. In addition, they identify major shifts in relationship at the time of financial crisis in LA by multivariate cointegration, vector error correction model, and Cholesky variance decomposition analysis. On the practical side, these results may be useful for international portfolio managers and LA stock market authorities.

2.4.2 Relationship between Stock Price and Exchange Rate

- **Developed Economies**

Min *et al.* (2013) have studied six OECD countries, namely US, Japan, UK, Canada, Australia, Switzerland for the period of January 2006 to December 2010 to explore the dynamic correlation between exchange rate change and stock returns during and after the financial crisis. At first, they have estimated conditional correlation by using DCC-MGARCH model where substitution effect dominates wealth effect in US and Japan, while wealth effect found stronger in UK, Canada, and Australia. Then, in the second phase of this study, they have employed Bai-Perron test and Markov-Switching model to estimate different phases of regime switching to each corresponding currency representative country's capital market during the crisis. Here, they also run Granger causality test and find exchange rate changes Granger cause the stock returns during the contagion phase of the US financial crisis for Australia, Canada, Japan, Switzerland, and the US. Then, authors have confirmed the changing phases of dynamic correlations between stock returns and exchange rate changes by applying GARCH with dummy variable and show DCCs between stock return and exchange rate changes. These correlations are accelerated in US and Japan after Lehman failure, declined in Canada, UK, and Australia during contagion period and increased in the US, Japan, and Switzerland during herding or post-crisis adjustment period. Finally, they have used VIX index, TED spread, and CDs spread to define their effect on the DCC between stock return and exchange rate changes with DCCX model. The empirical results report the positive impact of VIX index and TED spread and negative effect of CDs spread on conditional correlation of two financial markets.

Karoui (2006) has examined six Latin American countries, seven Asian countries, four European nations, and one African country, total of 18 countries, to examine the volatility relation between equity return and foreign exchange (FX) rate. The author has studied sensitivity of index to FX rate volatility of local currencies with respect to USD, GBP, and JPY. He shows significant relationship between FX volatility and stock return volatility. The correlation study suggests significant sensitivity of indices to FX rate almost the alike for JPY (69%), USD (66%), and GBP (63%). In addition, the author has examined sector index against exchange rate volatility and found a positive relationship between them for most of the sector index covered. He has noticed FX risk is slightly less with respect to JPY, and GBP compared to USD. The comparison between FX rate volatility and stock return volatility has observed more volatility in sector index for almost half of total sample considered relative to FX rates. Moreover, he has analyzed the relation between them across the country and confirmed the preference of investors and corporations in concentrating on either on portfolio or on cross-country operation, not sector wise diversification, to minimize the exposure of FX risk. Therefore, the fact approves the growing correlation between countries and reduction in the benefit of geographical diversification. Finally, the paper has presented analyze on different factors i.e., Stock market development, economic development, familiarity, and capital control as determinants for the correlation between stock market and FX rate. The simple cross-section regression model in that regard has explored significant impact of foreign ownership restriction and international capital market control on the relation between stock market and FX rate volatility. As the study reports that whether the countries are under managed floating or independently floating does not possess any influence on the correlation between stock return volatility and FX volatility; the author has prescribed corporation and investors to be conscious on flow movements rather than on the type of FX rates. Therefore, the empirical results here largely support the hypothesis of positive transmission mechanism.

Caporale *et al.* (2013) have investigated six advanced economies namely US, UK, Canada, Japan, the Euro Zone, and Switzerland to explore the nature of linkage between stock market return and exchange rate changes. They have used weekly data from August 2003 to December 2011 and divided the period under pre-crisis (06/08/2003 to 08/08/2007) period and crisis period (15/08/2007 to 28/12/2011) to identify how banking crisis did affect the relation between stock return and exchange rate. The application of bivariate GARCH-BEKK model has found the evidence of unidirectional spillover from stock return to exchange rate changes in the US and the UK, while opposite direction in Canada, and bidirectional feedback in the Euro and Switzerland during the financial crisis. In addition to GARCH-BEKK model, they have employed causality in variance test for crisis period and find the causality in variance from stock return to exchange rate changes in Japan, opposite direction in Eurozone and Switzerland, and of bidirectional feedback in US and Canada. The authors have stated that in the line of these findings, the investors cannot utilize stock price and exchange rate as an effective instrument for hedging and portfolio diversification strategies except in the UK.

Bodart and Reding (1999) show potential effects of exchange rate regime and associated degree of exchange rate variability on the conditional volatilities and correlation on stock and bond markets. They have focused on the exchange rate mechanism (EMS) of European Monetary System (EMS) applying domestic daily returns on the stock and bond markets of six European countries over the period from

January 2, 1989, to December 19, 1994. They have reported three important insights from their study. Firstly, although they are unable to present any linkage between FX market and Stock market, they have marked significant linkage between the pattern of volatility in FX market and Bond market through GARCH (1, 1) application. They interpret this result as a confirmation that the uncertainty surrounding the conduct of domestic monetary policy is a crucial determinant of bond price volatility; however, the stock market volatility is more related to the overall underlying macroeconomic uncertainty. Secondly, the result of threshold analysis suggests substantial evidence of credible peg of exchange rate resulted in a fall in bond market while rejecting the volatility transfer hypothesis. Thirdly, they have noticed the clear impact of Exchange rate on international bond and stock market correlations. In particular, a rise in ERM exchange rate variability leads to falling in the conditional correlation of daily returns on the bond market between Germany and other European countries. They advocate the presumption that credibly fixed exchange rate maximize the international correlations of bond market with the application of a strong coordination of domestic monetary policies. Though they have found less significant effect from exchange rate variability on stock market of Germany, they attribute this feature as a larger influence of idiosyncratic shock on domestic stock prices. Finally, they support the conjecture that variations in the patterns of volatilities and correlations on bond and stock markets can be, at least partially and in a proximate way, attributed to exchange rate regime effect.

Solnik (1987) has used both quarterly and monthly data of stock return and exchange rate in real form. He has found an overall negative relation between real stock returns and real exchange rates and a positive relation observed in the sub-period from 1979 to 1983. Actually, he has examined the effect of exchange rates, interest rates and inflationary expectation on stock prices from nine countries i.e. Japan, France, Canada, Belgium, Netherlands, Switzerland, Germany, U.K., and the U.S. He has reported positive but insignificant impact of currency depreciation on stock market of US compared to change in inflationary expectation and interest rates.

Kanas (2000) empirically investigates stock market and exchange market volatility in USA, UK, Canada, Japan, Germany, and France. He utilizes daily data and employs a bivariate Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) model. He shows the significant symmetric volatility spillover running from stock market to exchange market for all countries except Germany. Though he is unable to detect any significant spillover from FX market to stock market, he explains his findings of insignificant volatility spillover by the inability of daily data to capture the impact of trade-flows on exchange rate.

Yang and Doong (2004) analyze the FX market and stock markets of G-7 countries in an attempt to show both first moment and second moment spillover from one financial market to another. They use weekly data (Friday close) and employ a bivariate EGARCH model. The results indicate asymmetric spillover from stock market to FX market in the USA, Japan, Italy, and France, whereas volatility in exchange rate has less impact on the volatility in stock price.

Raghavan and Dark (2008) notice a unidirectional return and volatility spillover from USD/AUD exchange rates to Australian All Ordinaries Index (AOI) by using daily data of USD/AUD exchange rates and AOI index from January 1995 to December 2004. One major drawback of this study is that it disregards the likelihood of asymmetric volatility in financial asset prices that positive and negative shocks may induce a different degree of volatility.

Guo and Savickas (2005) advocate monetary model of exchange rate determination after analyzing quarterly changes in exchange rates for seven countries (Canadian dollars, German marks, French francs, Italian liras, Japanese yens, Swiss francs, and British pounds) over the period 1973:Q1 to 1998:Q4 against firm level or industry wise idiosyncratic stock volatility. They find that there is a significant positive relation between idiosyncratic volatility and future exchange rate in France, Germany, and Japan. They specify that the higher lever stock volatility is related to future appreciation of US dollar in different countries.

Nieh and Lee (2001) have studied the relation between stock price and exchange rate for G-7 countries over 1993 to 1996. They have used daily close stock market index and exchange rate data for the study. They apply both Engle-Granger (EG) two-steps and the Johansen multivariate maximum likelihood cointegration tests for long-run relationship and VECM for short-run dynamics. They detect no long-run link between stock price and exchange rate for each G-7 country. However they have noticed significant short-run link in German, Italian, Canadian, Japanese and UK market, but they fail to present any correlation between the variables in the USA.

Kim (2003) has examined the dynamic relation between stock price and exchange rate from January 1974 to December 1998 in the USA. He has employed error correction approaches to analyze the monthly data of stock price and exchange rate and exposed the negative relation between common stock and exchange rate.

Kurihara (2006) has analyzed stock prices in Japan and USA, exchange rate (Yen/USD), the Japanese interest rate from March 2001 to September 2005 to examine the interaction between macroeconomic variables and daily stock price in

Japan. Unlike domestic interest rate, exchange rate and US stock market significantly affect stock market in Japan.

Ozair (2006) has investigated quarterly data for the period of 1960 to 2004 to detect the causal relationship between stock price and exchange rate in the USA. He has employed both cointegration and causality approach but fails to show any relationship between stock price and exchange rate.

Tahir and Ghani (2004) study the relationship between stock prices and exchange rates of the British pound, Japanese Yen, German mark by employing monthly data for the period from January 1992 to November 2002 in Bahrain. They have used cointegration, error correction model, and Granger causality to find the evidence of short-run, long-run and causal relation between the variables. The empirical results indicate long-run bidirectional causality between stock price and exchange rate of yen and pound, and short-run unidirectional causal relation from stock price to exchange rate for them. However, exchange rate of German mark does not pose any relation (short or long term) to the stock price in Bahrain. Finally, they recommend the goods market approach of exchange rate determination.

Alexandra and Livia (2007) apply monthly data of stock price and exchange rates from 1999 to 2007 to capture the dynamic linkage between exchange rate and stock price in Romania. They use both nominal effective exchange rate and real effective exchange rates against the BET and BET-C indices of Bucharest Stock Exchange. They apply cointegration and Granger causality test to indicate the long-run and short-run relation among the variables. They confirm long-run relation between stock price and exchange rate changes and conclude exchange rate as leading variable to the changes in stock prices.

Hatemi and Irandoust (2002) try to estimate causal relationships between stock price and exchange rates in Sweden by using monthly stock prices and nominal effective foreign rates from 1993 to 1998. They employ Granger causality test and capture a unidirectional causality running from stock prices to effective exchange rates.

Bahmani and Sohrabian (1992) conduct a research on the nexus between stock prices and exchange rates in the United States of America (USA). The research covers data of S&P 500 index and effective exchange rate of dollar for the period from July 1973 to December 1988 and uses Granger causality and cointegration analysis. The results indicate bidirectional causality between stock index and exchange rate. The cointegration analysis confirms no long-run relation between them.

Aggarwal (1981) studies the stock price and exchange rate of USA from 1974 to 1978 to detect the relation between stock price and trade-weighted US dollars. He finds a positive correlation between US stock price and trade-weighted US dollar and rationalizes the result by reporting that a depreciation of country's currency results from a rise in selling assets denominated in local currency pushed by a decline in stock price. In addition, he shows weak long-run relation compared to short-run relation between them.

Ajayi and Mougoue (1996) choose the period from 1985 to 1991 to examine the short-run and long-run linkage between stock market and exchange rates for USA, Canada, UK, Japan, France, Germany, Italy, and the Netherlands. They analyze the daily data by employing cointegration and error correction model and find a significant short and long-run feedback relationship between stock price and exchange rate. They reveal the short-run negative impact of the rise in aggregate domestic stock price on the domestic currency value, while in long-run it becomes a positive influence of stock price on domestic currency value. Whereas, a negative long and short-run effect of currency depreciation has prevailed. They explain this negative relation by the higher inflation expectations of economic agents as stock price rises and that expectation results in a lower demand for local currency.

Kose *et al.* (2010) use daily observations of stock price and exchange rates of US dollar, Euro, Pound Sterling, Japanese Yen, Swiss Franc and two baskets of currencies as per the secretariat of foreign trade of Turkey for the period from February 23, 2001 to November 04, 2009, in Turkey. They employ Granger causality tests to detect the presence and direction of the nexus between stock price and exchange rate. However, they notice that there is a unidirectional causality from stock price to exchange rate.

Stavarek (2005) assesses the long-run and short-run dynamics between exchange rate and stock price in nine developed countries i.e. USA, UK, France, Germany, Hungary, Poland, Czech Republic, Slovakia, and Australia. The cointegration mechanism cannot reveal any long-run relation between stock price and exchange rate for the period from 1970 to 1992, as this period includes the Brettonwood system, currency snake, and European Exchange Rate Mechanism for which very little fluctuation of exchange rate is allowed within a tight band. However, the period from 1993 to 2003 capture a strong long-run relation between stock market and currency market in four developed countries (Australia, USA, UK, and Germany). The VECM framework confirms the stock oriented model (positive impact of the rise in stock price on currency appreciation) of exchange rate determination for USA and UK, Flow oriented model (negative effect of currency value on the stock price) of exchange rate determination for Australia and Monetary model for Germany.

However, the application of Granger causality test on non-cointegrated variables indicates no short-run causality in other EU countries except France in the study. Finally, they conclude on the dominance of stock-oriented model of exchange rate determination.

Bello (2013) studies the association between stock market in USA and exchange rates of Chinese Yuan, Japanese Yen, Euro, and Pound Sterling from 2000 to 2012. He finds a significant negative relation between Japanese Yen and US stock market, and positive association between Yuan, Euro, and Pound with US stock prices. He confirms the devaluation of Yuan by Chinese government prove a competitive advantage to exporters of China in international market.

Sekmen (2011) analyzes the exchange rate volatility and stock return for the period from 1980 to 2008 in the USA. The application of autoregressive moving average (ARMA) models find the negative impact of exchange rate volatility on stock return in the USA and he signifies that the ineffectiveness of the available hedge instrument to mitigate the negative influence of currency volatility on trade volume in stock market.

Xiaolan and Yizhong (2008) use daily data of exchange rate of RMB and stock indices of A share and B share from July 22, 2005, to June 27, 2007, to detect the stock price and exchange rate relationship in China. They run cointegration tests, Granger causality test and Impulse response function. The results reveal the evidence of short-run bidirectional causality between exchange rate and Stock index of A share.

Tsagkanos and Siripoulos (2013) use an advanced econometric technique of structural nonparametric cointegrating regression to examine the relationship between exchange rate and stock price in USA and EU. They study the period of financial crisis of 2008-

2012 and capture short-run causality from stock prices to exchange rate in USA and long-run causality in same direction in EU.

Alagidede *et al.* (2010) study the stock markets and FX markets in five developed countries i.e. Canada, Australia, Japan, Switzerland, and United Kingdom for the period from January 1992 to December 2005. The application of causality test cannot detect any long-run relationship between stock price and exchange rates. However, Granger causality analysis finds strong evidence of short-run causality from exchange rate to stock price in Canada, Switzerland, and the UK, a weak reverse evidence for Switzerland. They further use Hiemstra and Jones (1994) nonlinear causality test and find causality from stock price to exchange rate in Japan and a weak causality in other direction for Switzerland.

Michelis and Ning (2010) use Symmetric Joe-Clayton (SJC) copula approach for the monthly data on real stock return and USD/CAD exchange rate return over 1995-2006 in Canada. They show tail dependency where both series follow less on right than on left tail of their joint distribution. They interpret this asymmetric dependency on monetary policy asymmetry regarding interest rate against the changes in exchange rate at the time of higher or lower commodity prices.

Summary of Literature Reviews on Developed Economies

Author	Country	Sample	Method	Results
Min *et al.* (2013)	Six OECD countries, namely US, Japan, UK, Canada, Australia, Switzerland	January 2006 to December 2010	DCC-MGARCH model Bai-Perron test and Markov-Switching model for the crisis period Granger causality test	Substitution effect dominates wealth effect in US and Japan, while wealth effect found stronger in UK, Canada, and Australia Exchange rate changes Granger cause the stock returns during the contagion phase of the US financial crisis
Karoui (2006)	Eighteen countries	Daily Data: 1994 to 2003	Correlation analysis for sector index against exchange rate volatility, simple cross-section regression model	Significant relationship between FX volatility and stock return volatility A positive relationship between them for most of the sector index covered Approve the growing correlation between countries and reduction in the benefit of geographical diversification Foreign ownership restriction and international capital market control on the relation between stock market and FX rate volatility Regime choice does not have any impact on that relation Support the hypothesis of positive transmission mechanism.
Caporale *et al.* (2013)	Six advanced economies: US, UK, Canada, Japan, the Euro Zone, and Switzerland	Weekly data: August 2003 to December 2011	Bivariate GARCH-BEKK, causality in variance test	Unidirectional spillover from stock return to exchange rate changes in the US and the UK, while opposite direction in Canada, and bidirectional feedback in the Euro and Switzerland during the financial crisis Causality in variance from stock return to exchange rate changes in Japan, opposite direction in Eurozone and Switzerland, and of bidirectional feedback in US and Canada

Bodart and Reding (1999)	Six European countries	Daily data: January 2, 1989, to December 19, 1994.	GARCH (1,1) model and threshold analysis	No linkage between FX market and Stock market and, significant linkage between the pattern of volatility in FX market and Bond market Significant impact of Exchange rate on international bond and stock market correlations Supports exchange rate regime effect on both market.
Solnik (1987)	Nine Developed Countries	Quarterly and monthly data: 1979 to 1983	Review	Overall negative relation between real stock returns and real exchange rates A positive relation observed in the sub-period
Kanas (2000)	USA, UK, Canada, Japan, Germany, and France	Daily data	Bivariate (EGARCH) model	Significant symmetric volatility spillover running from stock market to exchange market
Yang and Doong (2004)	G-7	Weekly data (Friday close)	Bivariate EGARCH	Asymmetric spillover from stock market to FX market in USA, Japan, Italy, and France, whereas volatility in exchange rate have less impact on the volatility in stock price
Raghavan and Dark (2008)	Australia	Daily data: January 1995 to December 2004	GARCH model	Unidirectional return and volatility spillover from USD/AUD exchange rates to Australian All Ordinaries index (AOI)
Guo and Savickas (2005)	Seven countries	Quarterly data: 1973: Q1 to 1998: Q4	OLS Regression	Significant positive relation between idiosyncratic volatility and future exchange rate in France, Germany, and Japan.
Nieh and Lee (2001)	G-7	Daily close 1993 to 1996	EG two-steps, Johansen multivariate cointegration and VECM	No long-run link Significant short-run link in German, Italian, Canadian, Japanese and UK market, no correlation between the variables in the USA

Kim (2003)	USA	Monthly data: January 1974 to December 1998	Error correction approach	Negative relation stock price and exchange rate
Kurihara (2006)	Japan and USA	March 2001 to September 2005	OLS, cointegration and VAR	Exchange rate and US stock market significantly affect stock market in Japan.
Ozair (2006)	USA	Quarterly data: 1960 to 2004	Cointegration and causality approach	No relationship
Tahir and Ghani (2004)	Bahrain	Monthly data: 1992 to 2002	Cointegration, error correction model, and Granger causality	Long-run bidirectional causality Short-run unidirectional causal relation from stock price to exchange rate Recommend the goods market approach of exchange rate determination
Alexandra and Livia (2007)	Romania	Monthly data: 1999 to 2007	Cointegration and Granger causality test	Find long-run relation Exchange rate as leading variable
Bahmani and Sohrabian (1992)	USA	July 1973 to December 1988	Granger causality and cointegration analysis	Bidirectional causality No long-run relation
Aggarwal (1981)	USA	1974 to 1978	Correlation and cointegration	Positive correlation Weak long-run relation
Ajayi and Mougoue (1996)	USA, Canada, UK, Japan, France, Germany, Italy, and Netherlands	Daily data: 1985 to 1991	Cointegration and error correction model	Significant short and long-run feedback relationship Short-run negative impact of the rise in aggregate domestic stock price on the domestic currency value, while in long-run it becomes a positive influence of stock price on domestic currency value -Whereas a negative long-run and short-run effect of currency depreciation on stock market.

Kose *et al.* (2010)	Turkey	Daily Data: February 23, 2001, to November 04, 2009.	Granger causality tests	Unidirectional causality from stock price to exchange rate
Stavarek (2005)	USA, UK, France, Germany, Hungary, Poland, Czech Republic, Slovakia, and Australia	1970 to 1992 before trade liberation After the period from 1993 to 2003	Cointegration VECM	NO long-run relation before trade liberation Strong long-run relation after in AUS, US, UK, Germany. Find evidence of stock-oriented model (positive impact of the rise in stock price on currency appreciation) of exchange rate determination for USA and UK and Flow oriented model (negative effect of currency value on the stock price) of exchange rate determination for Australia and Monetary model for Germany
Bello (2013)	USA	2000 to 2012	Correlation, regression	Find a negative relation between Japanese Yen and US stock market, and positive association between Yuan, Euro, and Pound with US stock prices Devaluation of Yuan by Chinese government proves a competitive advantage to exporters of China in international market.
Sekmen (2011)	USA	1980 to 2008	Autoregressive moving average (ARMA) models	Negative impact of exchange rate volatility on stock return Ineffectiveness of the available hedge instrument
Xiaolan and Yizhong (2008)	China	Daily data: July 22, 2005, to June 27, 2007.	Cointegration tests, Granger causality test and Impulse response function	Short-run bidirectional causality

Tsagkanos and Siripoulos (2013)	USA and EU	Financial crisis of 2008-2012	Structural nonparametric cointegrating regression	Stock prices causes exchange rates in short-run in USA and stock prices causes exchange rates in long-run in EU.
Alagidede *et al.* (2010)	Canada, Australia, Japan, Switzerland, and United Kingdom	January 1992 to December 2005	Cointegration. Granger causality, Hiemstra-Jones nonlinear causality test	No long-run relationship Short-run causality from exchange rate to stock price in Canada, Switzerland, and UK, a weak reverse evidence for Switzerland Non-linear causality from stock price to exchange rate in Japan
Michelis and Ning (2010)	Canada	Monthly data on real form: 1995-2006	Symmetric Joe-Clayton (SJC) copula approach	Asymmetric dependency on monetary policy regarding interest rate against the changes in exchange rate at the time of higher or lower commodity prices.

- **Emerging Economies**

Kim and Choi (2006) have investigated the linkage between stock index futures markets and foreign exchange market by using daily return data of KOSPI 200 futures, won/dollar exchange rate, KOSPI interest rate (CDs) for the sample period of February 1999 to June 2004. The authors have classified their sample period in terms of the pre-crisis and post-crisis period for in-depth focus on the relation. They have reported that future price has significant explanatory power in forecasting stock price and exchange rate through Granger causality test. Then, they have presented the Generalized Impulse Response to confirm both portfolio approach and price discovery function of stock exchange futures market. Thus, the impact from stock index futures market to FX market is significant. Finally, they have suggested that it is the pursuance of effective measure in advance could stabilize an FX market and /or circumvent the second shock, if a shock already smashes the future market.

Phylaktis and Ravazzola (2005) conduct a study on the long-run and short-run relationship between stock price and exchange rate in six Pacific basin countries i.e. Hong Kong, Indonesia, Malaysia, Singapore, Thailand, and the Philippines for the period 1980 to 1998. They utilize month-end stock price and exchange data to investigate the effect of external control and financial crisis at mid-1997 on the link between stock price and exchange rates. They perform the basic cointegration methodology to detect long-run relationship between stock market of each six Pacific countries, its real exchange rate and US stock market; where parameter consistency checked by recursive based estimation. Further, they apply multivariate Granger causality test to detect the short-run relationships between these markets. Nonetheless, they initially found no linkage between exchange rate and stock market in each Pacific basin country except Hong Kong. Later, they use US market as a conduit to their relation. Then trivariate model finds the link between foreign exchange and stock. They notice positive link between stock price and exchange rate in 1990's. But they cannot find any influence of FX restriction on the linkage between domestic stock and FX markets. However, they confirm the influence of US stock market on these economies by multivariate causality tests. Finally, they show the short-lived impact of the Asian crisis in these economies, and Indonesia and Thailand as the most badly affected economy from this crisis.

Chai-Anant and Ho (2008) investigate the activity and relation of daily transactions of foreign investors with market returns and exchange rate fluctuations in six emerging countries i.e., Thailand, Taiwan, Philippines, Korea, Indonesia, and India from 1999 to 2006. They employ standard time series techniques to examine day to day relation in full sample of each market. They capture on average 'chase return' character of foreign investors and show positive 'feedback trading' behavior in net equity markets, while currency returns pronounce little for net equity purchases. They also affirm foreign investors as 'big fish' in the small ponds' of Asian financial markets, through a substantial relation of net purchases (sales) with near-term currency appreciations (depreciations). These on average relationships are highly observed in Thailand, Taiwan, Korea, and lesser extent in India and weak in smallest and least active markets of Indonesia and Philippines with lower foreign investor participation. Unlike idiosyncratic nature of equity outflow, they find equity inflow as more a regional phenomenon after a cross-market analysis. Further, they point out that foreign investors are more optimistic than domestic investors are in stabilizing the stock market at the time of financial crisis.

Mozumder *et al.* (2015) recently re-examine dynamics of stock price and exchange rate in terms of volatility spillover effect in three developed countries (Spain, Netherlands and Ireland) and three emerging countries (Brazil, South Africa and Turkey) for the period 2001 to 2012 splitting the whole sample period into pre-crisis period of January 2001 to July 2007, crisis period of August 2007 to March 2009 and post-crisis period of April 2009 to December 2012. They have employed EGARCH model and captured unidirectional volatility spillover effect from stock prices to exchange rates in developed countries; whereas in emerging economy, it appears opposite direction between two financial markets in South Africa and Turkey and a bidirectional volatility spillover only in Brazil. They show asymmetric volatility spillover effects between stock price and exchange rates both in developed and emerging economies, especially at crisis time it becomes more apparent. Therefore, they indicate informational inefficiency in both FX market and equity market, as one market having the predictive power over the other and suggest portfolio manager diversify risk by including both assets in a separate basket.

Apte (2001) emphasizes the daily data of stock return and FX rate changes for the period of 1991 to 2000 in India. He applies of bivariate EGARCH model to identify the volatility spillover effect between FX market and stock market. The result confirms a significant volatility spillover from exchange market to stock market.

Mishra *et al.* (2007) analyze volatility spillovers between the stock and foreign exchange markets from the period of 1993 to 2003 in India. They report a bidirectional volatility spillover between these markets except for S&P CNX NIFTY and S&P CNX 500. The authors indicate tandem movement and existence of long-run association between these two markets.

Wu (2005) tries to detect the stock market and FX market relationship in terms of volatility spillover effects in Japan, South Korea, Indonesia, Philippines, Thailand, Singapore and Taiwan over 1997-2000. The study reveals a bidirectional spillover effect between stock price and exchange rate in almost all countries.

Walid *et al.* (2011) consider weekly data of four emerging markets i.e. Malaysia, Singapore, Hong Kong and Mexico to study the effect of exchange rate changes on stock market volatility. On that regard, they use a two-regime Markov-Switching EGARCH model. The model explains the evidence of regime switching behavior in volatility of emerging countries stock markets and regime dependency of the relationship between exchange rate and stock prices. This result indicates the asymmetric volatility spillover of FX markets to stock markets.

Kumar (2013) construct a bivariate GARCH model to study the volatility spillover relation between stock and FX markets in India, Brazil, and South-Africa (IBSA countries). The empirical results suggest the existence of two-way volatility spillover link between stock and FX market in IBSA countries and indicate the dominance of stock market than FX market in mean and variance interactions and spillovers.

Moore and Wang (2014) focus on the sources of linkage between stock return and real exchange rates for developed and emerging countries. They employ GARCH BEKK methodology proposed by Diebold and Yilmaz and find trade balance as the main source of dynamic correlation between financial markets in each emerging nation, whereas the driving force of developed markets is interest rate differentials.

Fang and Millar (2002) observe the influence of day-to-day currency depreciation (appreciation) on Korean stock market returns during Korean financial crisis of 1997-2000. They find the evidence of bidirectional causality between FX market and stock market. Nonetheless, the currency depreciation lead a negative impact on stock returns, Volatility in FX rate depreciation have positive effect on stock returns and stock market volatility reacts to exchange rate depreciation volatility, that is a feedback relation running between them.

Haughton and Iglesias (2013) have studied two Caribbean countries i.e. Trinidad and Tobago and Jamaica and four Latin American countries i.e. Argentina, Brazil, Chile and Mexico from 2002 to 2012 to study the relationship between stock market and exchange rate movements. They have used monthly data and employed Autoregressive Distributed Lag (ARDL) model. They have divided the whole sample into two subsamples, one as before financial crisis of 2008 and another one is after 2008. The study starts with three different unit root test, those are Augmented Dickey fuller, the Zivot ad Andrews test with one structural break and Clemente, Montanes and Rayes test with two structural breaks. The unit root examination reports significant structural breaks in exchange rate and stock price and other control variables and validates the choice of subsample for the study. Then, the ARDL model bound tests indicates the superiority of stock-oriented model over flow oriented models for stock market and exchange rate dynamics in Argentina, Brazil, and Jamaica. Finally, they have used GARCH (1, 1) in ARDL model to improve the results and found significant volatility in all six markets. The result reveals the significant impact of stock price on exchange rates, specifically in crisis and the whole period for Jamaica, all three periods of before and after crisis and whole sample for Trinidad and Tobago, and crisis period for Argentina, Mexico, and Chile.

Gulati and Kakhani (2012) have studied the causal relationship between stock market and exchange rate. They have used exchange rate of USD against INR (INR/$) and Indian stock market index (SENSEX and NIFTY 50) over 2004 to 2012 and applied Granger causality and correlation test. They have found no relation between exchange rate and stock market in India that result is consistent with the findings of Bhattacharya and Mukherjee (2003) and Nath and Samanta (2003).

Muhammad and Rasheed (2003) investigate the nexus between stock price and exchange rate in India, Pakistan, Bangladesh and Sri Lanka applying monthly data over 1994 to 2000. They employ cointegration techniques. Although, they find no link between exchange rate and stock price in India and Pakistan while they observe a bidirectional long-run causality for Bangladesh and Sri Lanka.

Doong *et al.* (2005) have examined the dynamic interactions between stock price and exchange rate for six emerging Asian countries i.e. Malaysia, Indonesia, Philippines, Thailand South Korea and Taiwan from 1989 to 2003. They cannot find any long-run relation between them by using cointegration methodology. But the Granger causality test detects bidirectional causality in Malaysia, Indonesia, Korea and Thailand.

Further, they notice an extensive negative relation between stock return and exchange rate changes for all countries except for Thailand.

Vygodina (2006) examines the relationship between stock price and exchange rate for large cap and small cap stocks for 1987 to 2005. He notices Granger causality from large-cap stock to exchange rate by Granger causality methods. In addition, he shows stock price and exchange rate both are influenced by same macroeconomic variables while monetary policies have significant influence on the relation between exchange rate and stock price. Further, he confirms the nature of association between stock price and exchange rate is time variant.

Pan *et al.* (2007) study seven East Asian countries i.e. Malaysia, Japan, Hong Kong, Korea, Singapore, and Thailand for the period of 1988–1998 to investigate the dynamic relation between stock price and exchange rate. Though bidirectional causality found only in Hong Kong before Asian crisis of 1997, the unidirectional causality from exchange rate to stock price is present in Malaysia, Japan, and Thailand and causality from stock price to exchange rate is there in Korea and Singapore. While in the Asian crisis, Causality analysis reports a causal relation running from exchange rate to stock price for all countries except for Malaysia.

Erbaykal and Okuyan (2007) examine the nexus between exchange rate and stock price for thirteen emerging economies at different time period for each country. They use cointegration and Granger causality tests. The empirical results find unidirectional causality from stock price to exchange rate in five economies and bidirectional causality in three out of thirteen economies only. While rest of economies do not show any causal relationship between stock price and exchange rate.

Sevuktekin and Nargelecekenler (2007) investigate monthly data for the period of 1986 to 2006 and find positive bidirectional relation between exchange rate and stock price in Turkey.

Rahman and Uddin (2008) investigate the monthly nominal exchange rate of US dollar, Euro, pound sterling and Japanese yen-denominated in Bangladeshi Taka, and monthly stock index in DSE over June 2003 to March 2008 to reveal the interaction between stock price and exchange rate in Bangladesh. They find no long term relationship between the variables by the application of cointegration technique. Nonetheless, the Granger causality test detects that stock prices Granger cause exchange rates of Japanese yen and US dollar while no linkage found between stock price and exchange rate of Euro and Pound Sterling.

Rahman and Uddin (2009) further investigate the nexus between stock price and exchange rate from January 2003 to June 2008. This time the data covers average monthly nominal exchange rate of American dollar-denominated in Bangladeshi Taka, Pakistani Rupee and Indian Rupee and monthly indices of Dhaka stock exchange, Karachi Stock exchange and Bombay stock exchange. The application of cointegration and causality analysis indicates that there is no long-run and short-run relationship between stock price and exchange rate in those countries.

Lee *et al.* (2011) examine the relationships between stock price and exchange rates and further try to detect impact of unpredictability of stock return on their correlation by using weekly data over 2000 to 2008 in six emerging countries i.e., Malaysia, Indonesia, Philippines, Korea, Taiwan, and Thailand. They notice significant price spillovers running from stock returns to exchange rate changes in all countries except the Philippines. In addition, they confirm that the rise in stock market variability leads the higher correlations for all countries except for the Philippines.

Kutty (2010) investigates weekly data from 1989 to 2006 to detect the interactions between stock prices and exchange rates in Mexico. He uses Granger causality test to confirm the short-run association between them where stock price leads exchange rates, even though, there is no long-run relation between stock price and exchange rate.

Ahmad *et al*. (2010) go through a multiple regression analysis on stock return, interest rate and exchange rate over 1998-2009 in Pakistan. The result finds the evidence of significant effect of interest rate and exchange rate on stock returns.

Hussein and Mgammal (2012) examine the association among inflation, interest rates, stock price and foreign exchange rate by using both monthly and quarterly data for 2008- 2009 in two Gulf countries i.e. Kingdom Saudi Arabia (KSA) and United Arab Emirate (UAE). After employing Cointegration and causality analysis, they find significant positive short-run relationship between stock price and exchange rate while significant long-run negative relation is found in UAE. In case of KSA, they find the same short-run relation but no long-run relation between them except inflation.

Amarasinghe and Dharmaratne (2014) investigate the monthly data of stock return and exchange rate from 2003 to 2012 to detect the causal relation between stock returns and exchange rates in Sri Lanka. They check and confirm the stationarity of stock return at level and exchange rate at first differences. Then they implement Granger causality test on stationary data and find unidirectional causality from stock returns to exchange rates. Finally, they run regression to check the result of causality test and find the evidence of no relation between stock return and exchange rate in Sri Lanka.

Tavakoli and Masood (2013) study a monthly time series data on stock price and exchange rate over July 2002 to March 2012 in South Korea and Iran. They use VECH multiple generalized autoregressive conditional Heteroscedasticity (MGARCH) model to examine the nexus between stock price and exchange rate. They convert both variable of stock return and real exchange rate into growth rate to confirm stationarity of the variables. Then, they run the model and find only a unidirectional relationship running from stock return to exchange rate in South Korea, while no relation found in the Iranian economy.

Harjito and McGowan (2007) utilize Granger causality and Johansen cointegration methods in four ASEAN emerging economies i.e. Indonesia, Singapore, Thailand, Philippines for the period from 1993 to 2002 to explore the empirical relation between exchange rate and stock price. All the data are transformed into percentage change for analysis and then econometric methods are used. The result of Johansen cointegration test finds the evidence of long-run relation between stock price and exchange rate in all four countries. While the Granger causality test reports unidirectional causality from exchange rate to stock price, however, the presence of a feedback system is confirmed here with a dominant exchange rate as Singapore dollar.

Banerjee and Adhikary (2009) examine the effect of interest rate and exchange rate variability on Dhaka Stock Exchange (DSE) returns. They have used monthly data from 1983 to 2006 and found long-run relation among interest rate, exchange rate, and stock returns by applying cointegration mechanism where stock return is endogenous variable. However, the study cannot pronounce the short term impact of interest rate and exchange rate on stock return.

Morley (2009) studies both short and long-run relation between exchange rate and stock price by utilizing monthly data from January 1985 to April 2005 and applies the ARDL bounds testing approach. The test result suggests a long-run equilibrium relationship between stock price and exchange rate. Further, he notices a positive relation between them after using error correction models, while an extension of 12 months as out of sample forecasting reject the random walk hypothesis.

Abbas (2010) estimates monthly stock index and exchange rates from July 1997 to October 2009 for India, Pakistan, Sri Lanka, Indonesia, and Korea by applying Granger causality and Johansen Cointegration techniques. The result shows short-run causality from stock market to foreign exchange market for Pakistan and Sri Lanka, and from exchange markets to stock markets for India, and bidirectional causal link exists in Korea and Indonesia. Thus, he concludes that portfolio balance approach for Pakistan and Sri Lanka and traditional approach for India and feedback relation for Indonesia and Korea.

Yilanci and Bozoklu (2015) examine both symmetric and asymmetric non-linear causal linkage between stock prices and exchange rate over January 2000 to September 2011 in BRICS and Turkey. On that regard, they use Mackey-Glass model allowing symmetry and asymmetry in non-linear causal analysis. Though symmetric model indicates weak evidence, asymmetric model presents strong evidence of causal relation link between stock price and exchange rate and confirms the presence of speculative and noisy trading in both stock and exchange market.

Fredrick *et al.* (2014) examine the relation between stock price and exchange rate in Kenya for the period from January 01, 2012, to December 31, 2013. They use Pearson product-moment correlation test and found positive relation between exchange rate and share prices.

Sifunjo and Mwasaru (2012) study the exchange rates and stock price for the period from November 1993 to May 1999 to capture causal relation between stock price and exchange rates in Kenya. They confirm the stationarity of the data, run cointegration and then use error correction model for causality. The empirical results strongly claim a significant unidirectional causality from exchange rates to stock prices.

Ibrahim and Aziz (2003) use monthly data from 1977 to 1998 to analyze the dynamic relation between stock prices and macroeconomic variables (exchange rate, industrial production, money supply, consumer price index) in Malaysia. They use cointegration and vector autoregression methodology and statistical results present the negative linkage between stock price and exchange rates.

Aydemir and Demirhan (2009) examine the dynamic linkage between stock prices and exchange rate in Turkey over February 23, 2001, to January 11, 2008. The use of Toda and Yamamoto (1995) method finds bidirectional causality between stock indices and exchange rates.

Pekkaya and Bayramoglu (2008) investigate the causal linkage between exchange rate and stock prices of S&P 500 and Istanbul Stock Index for the period of 1990 to 2007 in Turkey. The application of Granger causality tests indicates a unidirectional causality from stock price of Turkey and US to exchange rates, while US stock market does Granger cause Turkey stock price and exchange rate.

Altin (2014) studies the effect of variations in exchange rate on stock indices in Turkey. He examines the daily data of Istanbul stock exchange by BIST 100 and exchange rates of Euro, Pound Sterling, US Dollar, Canadian Dollar, Australian Dollar, Japanese Yen, and Swedish Krona from January 01, 2001, to December 31, 2013. He utilizes the Johansen cointegration methods in the study and finds a significant relationship between stock index and exchange rate of Euro, US dollar, Pound Sterling, and Japanese Yen while the direction of relation from individual exchange rate and stock index remain different (positive for some while negative for other).

Abdalla and Murinde (1997) both exchange rates and stock prices in Pakistan, India, Korea, and the Philippines from 1985 to 1994 to capture causal relation between two financial markets in each country. The study employed bivariate vector auto regressive (VAR) model. The results indicate long-run relation between two financial markets in India and Philippines. Then, they use Granger causality to detect causal relation between stock and exchange market in Pakistan and Korea and error correction model to India and Philippines. The results imply stock prices Granger cause exchange rates in only Philippines while exchange rates cause stock price in India, Pakistan, and Korea.

Baharom *et al.* (2008) consider monthly real effective exchange rate (REER) and stock price index from January 1988 to December 2006 to detect the causal connections between exchange rate and stock prices in Malaysia. They divide the sample period into the pre-crisis period (January 1988 to June 1997) and post-crisis period (July 1997 to December 2006). They find no long term relation between exchange rate and stock price in Malaysia by using Johansen cointegration method. However, they affirm short-run causality between them.

Bonga-Bonga and Hoveni (2011) apply multi-step GARCH family model to examine the volatility spillover relation between equity market and FX market in South Africa. The statistical analysis on the data from July 1995 to October 2010 with appropriate model only captures unidirectional volatility spillovers from stock market to currency market.

Agrawal *et al.* (2010) choose Nifti returns and Indian Rupee-US dollar exchange rates from October 2007 to March 2009 to study the causal relationship between stock price and exchange rate in India. The use of Granger causality test detects a unidirectional causality from stock returns to the exchange rates.

Mlambo *et al.* (2013) use Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model to test the effect of volatility ın currency market on the Johannesburg Stock Exchange from 2000 to 2010 in South Africa. The study indicates a weak effect of currency volatility on the stock price. Thus, they recommend stock market of South Africa for foreign portfolio investment.

Lean *et al.* (2011) assess the co-movement between stock price and exchange rate from 1991 to 2005 in eight Asian countries i.e. Hong Kong, Indonesia, Malaysia, the Philippines, Singapore, Japan, Korea and Thailand. They include a structural break in the cointegrating vector for Gregory and Hansen (1996) test for individual country wise analysis and allow multiple structural breaks by using Westerlund (2006) panel lagrange multiplier (LM) cointegration test for panel wise investigation. They only manage to find weak long-run causality from exchange rate to stock price in Korea.

Finally, the Granger causality tests show that a short-run contemporaneous effect between stock price and exchange rate is evident in those countries.

Hwang (2004) analyzes the interactions between stock price and exchange rate by using monthly data on Korean stock exchange and exchange rate of won-dollar from January 1980 to July 1997 in Korea. The application of Engle-Granger two way cointegration tests finds that stock index and exchange rate are cointegrated. Though there is bidirectional relation in long-run, one-way causality from exchange rate to stock index is confirmed in short-run. He concludes on this short-run phenomenon by a negative impact of home currency devaluation on stock prices in Korea.

Fauziah *et al.* (2015) conduct a study the association between stock price and exchange rate in ten Asian countries i.e. China, India, South Korea, Japan, Thailand, Hong Kong, Indonesia, Malaysia, Singapore, and Taiwan from January 2009 to December 2013 by using Vector Correction Method (VECM). The study finds a long term stable relationship between exchange rate and stock prices in Asia. They further explain bidirectional causality running between them both in short-run and long-run in Asia.

Zubair (2013) utilize a trivariate VAR model on monthly data of All Share Index (ASI) of the Nigeria Stock Exchange and money supply (M2) and exchange rate from 2001 to 2011 in Nigeria. He employs Johansen cointegration and Granger causality test to detect the relationship among the variables at before and after the global financial crisis. Though no long-run relation can be captured in cointegration test, the result of Granger causality suggests a unidirectional causality from M2 to ASI only before the crisis. However, the study cannot show any direct relation between stock price and exchange rate in Nigeria.

Wickremasinghe (2012) considers monthly data on exchange rates for Indian rupee, Japanese yen, UK pound and US dollar in terms of Sri Lankan rupees and all share price index (ASPI) of Colombo Stock Exchange over 1986 to 2012. The study indicates no long-run relation between exchange rate and stock price, however, only shows a short-run unidirectional causality from stock price to exchange rate of US dollar.

Ghazali *et al.* (2008) study the Kuala Lumpur Composite Index (KLSE) and USD-MYR exchange rates from July 22, 2005, to March 23, 2007, in Malaysia. They show no long-run relationship between stock price and exchange rate. They further investigate for short-run relationship and the application of both Engle-Granger and Toda-Yamamoto causality test and indicate a unidirectional causality from stock price to exchange rate.

Hatemi-J and Roca (2005) assess the relationship between stock price and exchange rate for the period of prior and during Asian Financial Crisis of 1997 in Malaysia, Indonesia, Philippines and Thailand. They use leverage adjusted bootstrap causality tests and find causality from exchange rare to stock price in Indonesia and Thailand and causality from stock price to exchange rate in Malaysia before the crisis on one hand, and on the other, there is no causal relation during the crisis.

Araghi and Pak (2012) examine the impact of nominal exchange rate of Iranian Rial against US dollar on day close stock index from March 20, 2004, to March 20, 2010, in Iran. They find stationary at level for both series and existence of correlation between them. The empirical result of GARCH model indicates that there is a positive link between stock price volatility and exchange rate volatility.

Cakan and Ejara (2013) use both linear and nonlinear Granger causality test to examine exchange rate and stock price nexus from May 1994 to April 2010 for twelve emerging countries i.e. Brazil, India, Indonesia, Korea, Mexico, Philippines, Poland, Russia, Singapore, Taiwan, Thailand and Turkey. The application of linear Granger causality analysis indicates strong unidirectional causality from stock price to exchange rate for seven countries, namely, Turkey, Thailand, Brazil, India, Indonesia, Philippines, Singapore and weak for Poland and a strong unidirectional causality from exchange rate to stock prices for ten countries, namely, Turkey, Thailand, Mexico, Brazil, Indonesia, Korea, Philippines, Poland, Singapore, Taiwan. Whereas the non-linear Granger causality results imply bidirectional causal relations for nine of the countries i.e. India, Indonesia, Korea, Mexico, Philippines, Russia, Singapore, Thailand and Turkey and show only unidirectional causality from stock prices to exchange rates for Brazil and Poland. Finally, they recommend both portfolio balance theory and good market theory of exchange rate determination.

Akel (2014) attempts to check causal mechanism between FX markets and stock markets in nine transition countries i.e. Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Russia over 1995-2011. The paper uses Toda and Yamamoto (1995) approach for linear causality and Diks and Panchenko (2006) nonparametric approach for nonlinear causality tests. The paper shows a feedback relation between stock price and exchange rate only in Russia and exchange rates Granger cause stock prices in Czech Republic, Hungary, Poland, and Romania in both linear and nonlinear causality analysis.

Aslam (2014) analyzes the exchange rate of Pakistan Rupee in terms of US dollar and KSE 100 index from January 01, 2006, to December 31, 2012, and finds bidirectional causality between two-time series by using Granger causality test.

Dewenter *et al.* (2002) test the contemporaneous relationships between exchange rate and stock price changes in Mexican and Thai events by using event study methodology where the sensitivity of stock price changes are checked by the dates of large variation and unexpected fluctuation in bilateral exchange rate. The study finds significant changes in stock prices in individual firm, industry portfolio, and volatility for Mexican and Thai sample. Further, they indicate the benefit of US multinational firm from US dollar appreciation by the significant positive elasticity in both samples.

Murinde and Poshakwale (2004) examine the stock market and FX market interrelations for before (January 2, 1995, to December 31, 1998) and after (January 01, 1999, to December 31, 2003) acceptance of EURO in most EU economies. The study focuses on the daily data of stock index and nominal exchange rate In Hungary, Czech Republic and Poland. They indicate unidirectional causality from stock prices to exchange rate in Hungary; and bidirectional causality in Czech Republic and Poland for pre-Euro period. While, after the acceptance of Euro, exchange rate have unidirectional Granger causality to stock prices in all three counties. They further find positive correlation between two financial markets in both periods.

Tabak (2006) provides evidence of no long-run relationship rather a linear causal link from stock price and exchange rates and a non-linear causality from exchange rate to stock prices by using cointegration and causality technique on 1922 daily observations of closing of Sao Paulo Stock Exchange Index (IBOVESPA) and exchange rate of unit of Real per US dollar from August 01, 1994, to May 14, 2002.

Morales (2007) examines the short-run and long-run association between exchange rate and stock prices from 1999 to 2006 in four eastern European markets (Czech Republic, Hungary, Poland, and Slovakia) by using daily data not only from these countries but also from the USA, UK, and Germany. He finds cointegrating relationships only in Slovakia and shows no long-run and short-run association between stock price and exchange rate in any other countries. He further verifies causality and presents that exchange rates Granger cause stock prices in Hungary, Poland, and the Czech Republic. In addition, he finds causality from the exchange rate of Slovakia, Hungary, Poland and Czech Republic to the stock price in the UK.

Umer *et al.* (2015) use autoregressive distributed lag (ARDL) and causality models for stock prices and exchange rates from January 1998 to May 2014 for nine emerging countries (Brazil, Czech Republic, Hungary, Malaysia, Mexico, Poland, South Africa, Taiwan and Turkey). The sample period is subdivided into two period i.e. tranquil period (March 2001 to February 2008) and crisis period (March 2008 to December 2010). The results show causality from stock price to exchange rates in tranquil period whereas exchange rates Granger cause stock prices during crisis period.

Azman-Saini *et al.* (2003) use both bivariate and multivariate models on the causal relationship between exchange rates and stock prices for the period of 1990 to 2001 for Thailand. They find bidirectional causality between stock price and exchange rate by bivariate model. To confirm the result, they employ multivariate model where US stock prices are used. The result suggest bidirectional relationship for first period, but, unidirectional negative causality from exchange rate to stock price for second period, that fall in stock price is the outcome of depreciation of Thai Baht.

Mustafa and Nishat (2008) employ cointegration, error correction and granger trivariate model to examine the stock price and exchange rate relationships from July 1981 to June 2004 in Pakistan. They show only a significant causality running from exchange rate to stock price.

Summary of Literature Reviews on Emerging Economies

Author	Country	Sample	Method	Results
Kim and Choi (2006)	South Korea	Daily data: February 1999 to June 2004	Granger causality test, Generalized impulse response function	Future price has significant explanatory power in forecasting stock price and exchange rate Impact from stock index futures market to FX market is significant
Phylaktis and Ravazzola (2005)	Six Pacific basin countries	Monthly data in real form: 1980 to 1998	Cointegration, Multivariate Granger causality in trivariate model	Confirm the influence of US stock market on these economies by multivariate causality tests.
Chai-Anant and Ho (2008)	Six emerging countries: Thailand, Taiwan, Philippines, Korea, Indonesia and India	1999 to 2006: examine day to day relation between stock market and FX market	Standard time series techniques	Find substantial relation of net purchases (sales) with near-term currency appreciations (depreciations). Equity inflow as more a regional phenomenon unlike idiosyncratic nature of equity outflow, Foreign investors are more optimistic than domestic investors are in stabilizing the stock market at the time of financial crisis.
Mozumder *et al.* (2015)	Three developed and three emerging country	Daily data: 2001 to 2012	EGARCH model	Capture unidirectional volatility spillover effect from stock prices to exchange rates in developed countries, whereas in emerging economy, it appears opposite direction between two financial markets in South Africa and Turkey and a bidirectional volatility spillover only in Brazil. Find asymmetric volatility spillover

				effects between stock price and exchange rates both in developed and emerging economies, especially at crisis time it becomes more apparent.
Apte (2001)	India	Daily data: 1991-2000	Bivariate EGARCH	Significant volatility spillover from exchange market to stock market
Mishra *et al.* (2007)	India	1993 to 2003	Volatility cointegration model	Bidirectional volatility spillover Find tandem movement and existence of long-run association between these two markets.
Wu (2005)	Japan, South Korea, Indonesia, Philippines, Thailand, Singapore and Taiwan	1997-2000	Spillover model	Bidirectional spillover effect
Walid *et al.* (2011)	Malaysia, Singapore, Hong Kong and Mexico	Weekly data:	Two regime Markov-Switching EGARCH	The asymmetric volatility spillover of FX markets to stock markets.
Kumar (2013)	India, Brazil, and South-Africa (IBSA countries)	Daily data: 2000 to 2011	Bivariate GARCH	Existence of two-way volatility spillover link Indicate the dominance of stock market than FX market in mean and variance interactions and spillovers.
Moore and Wang (2014)	Developed and emerging countries	From Multiple start year to year 2006	GARCH BEKK methodology proposed by Diebold and Yilmaz	Find trade balance as the main source of dynamic correlation between financial markets in each emerging nation, whereas the driving force of developed markets is interest rate differentials.
Fang and Millar (2002)	Korea	Daily data: 1997-2000	Unrestricted bivariate GARCH-M model	Bidirectional causality The currency depreciation lead a negative impact on stock returns, Volatility in FX rate depreciation have positive effect on stock returns and stock market volatility reacts to exchange rate depreciation volatility, that is a feedback

				relation running between them.
Haughton and Iglesias (2013)	Two Caribbean countries i.e. Trinidad and Tobago and Jamaica and four Latin American countries i.e. Argentina, Brazil, Chile and Mexico	Monthly data: 2002 to 2012	Augmented Dickey Fuller, Zivot ad Andrews test with one structural break and Clemente, Montanes and Rayes test with two structural breaks. Autoregressive Distributed Lag (ARDL) and GARCH model.	Significant structural breaks ARDL model bound tests indicated the superiority of stock-oriented model over flow oriented models for stock market and exchange rate dynamics in Argentina, Brazil and Jamaica Significant volatility in all six markets Significant impact of stock price on exchange rates (specifically crisis period)
Gulati and Kakhani (2012)	India	2004 to 2012	Granger causality and correlation test	No relation
Muhammad and Rasheed (2003)	India, Pakistan, Bangladesh and Sri Lanka	1994 to 2000	Cointegration techniques	No link between exchange rate and stock price in India and Pakistan while they observed bidirectional long-run causality for Bangladesh and Sri Lanka.
Doong *et al.* (2005)	Six emerging Asian countries i.e. Malaysia, Indonesia, Philippines, Thailand South Korea and Taiwan	1989 to 2003	Cointegration and causality test	Find no long-run relation Bidirectional causality in Malaysia, Indonesia, Korea and Thailand Extensive negative relation between stock return and exchange rate changes for all countries except for Thailand.
Vygodina (2006)	USA	1987 to 2005	Granger causality methods	Stock price and exchange rate both are influenced by same macroeconomic variables while monetary policy has significant influence on the relation between exchange rate and stock price.

				The nature of association between stock price and exchange rate is time variant.
Pan *et al.* (2007)	Seven East Asian countries i.e. Malaysia, Japan, Hong Kong, Korea, Singapore, and Thailand	1988 – 1998	Granger causality, variance decomposition, and impulse response analysis	Though bidirectional causality found only in Hong Kong before Asian crisis of 1997, the unidirectional causality from exchange rate to stock price exist in Malaysia, Japan, and Thailand and from stock price to exchange rate revealed in Korea and Singapore. While in the Asian crisis, Causality analysis noticed a causal relation running from exchange rate to stock price for all countries except for Malaysia.
Erbaykal and Okuyan (2007)	thirteen emerging economies	Different sample period for different countries	Cointegration and Granger causality tests	Unidirectional causality from stock price to exchange rate in five economies and bidirectional causality in three out of thirteen economies only. While rest of economies do not show any causal relationship between stock price and exchange rate.
Sevuktekin and Nargeleceken ler (2007)	Turkey	Monthly data: 1986 to 2006	Cointegration and Granger causality tests	Positive bidirectional relationship between stock price and exchange rate.
Rahman and Uddin (2008)	Bangladesh	Monthly nominal data: June 2003 to March 2008	Cointegration and Granger causality tests	No long term relationship Stock prices Granger cause exchange rates of Japanese yen and US dollar while no linkage found between stock price and exchange rate of Euro and Pound Sterling.
Rahman and Uddin (2009)	Bangladesh, Pakistan, India	January 2003 to June 2008	Cointegration and causality analysis	No long-run and short-run relationship between stock price and exchange rate in those countries
Lee *et al.* (2011)	six emerging countries i.e., Malaysia, Indonesia,	Weekly data: 2000 to 2008	Smooth Transition Conditional Correlation (STCC) with	Significant price spillovers running from stock returns to exchange rate changes in all countries except in the Philippines. The rise in stock market variability leads the higher correlations for all countries

	Philippines, Korea, Taiwan, and Thailand		GARCH model	except for the Philippines
Kutty (2010)	Mexico	Weekly data: 1989 to 2006	Cointegration and causality analysis	No long-run relation Short-run association between them where stock price leads exchange rates
Ahmad *et al.* (2010)	Pakistan	1998-2009	Multiple regression analysis	Significant effect of interest rate and exchange rate on stock returns.
Hussein and Mgammal (2012)	Two gulf countries i.e. Kingdom Saudi Arabia and United Arab Emirate	Both monthly and quarterly data for 2008- 2009	Cointegration and causality analysis	Significant positive short-run relationship between stock price and exchange rate in UAE and KSA while significant long-run negative relation is found in UAE. And no long-run relation in KSA.
Amarasinghe and Dharmaratne (2014)	Sri Lanka	2003 to 2012	Causality analysis	Unidirectional causality from stock returns to exchange rates
Tavakoli and Masood (2013)	South Korea and Iran	Monthly real form data: July 2002 to March 2012	VECH -GARCH	A unidirectional relationship running from stock return to exchange rate in South Korea, while no relation found in the Iranian economy
Harjito and McGowan (2007)	Four ASEAN economies	1993 to 2002	Granger causality and Johansen cointegration methods	Evidence of long-run relation Unidirectional causality from exchange rate to stock price, however, the presence of a feedback system is confirmed here with a dominant exchange rate as Singapore dollar.
Banerjee and Adhikary (2009)	Bangladesh	Monthly data: 1983 to 2006	Cointegration mechanism	Long-run relation among interest rate, exchange rate and stock returns where stock return is endogenous variable.
Morley (2009)	UK, Japan and	Monthly data: 1985 to	ARDL bounds testing and	A long-run equilibrium relationship A positive short-run relation

	Switzerland	2005	error correction models	
Abbas (2010)	India, Pakistan, Sri Lanka, Indonesia, and Korea	July 1997 to October 2009	Granger causality and Johansen Cointegration techniques	Short-run causality from stock market to foreign exchange market for Pakistan and Sri Lanka, and from exchange markets to stock markets for India, and bidirectional causal link exist in Korea and Indonesia
Fredrick *et al.* (2014)	Kenya	2012 to 2013	Pearson product moment correlation test	Found positive relation between exchange rate and share prices
Sifunjo and Mwasaru (2012)	Kenya	November 1993 to May 1999	Cointegration and error correction model	A significant unidirectional causality from exchange rates to stock prices
Ibrahim and Aziz (2003)	Malaysia	Monthly data: 1977 to 1998	Cointegration and vector autoregression model	Negative linkage between stock price and exchange rates
Aydemir and Demirhan (2009)	Turkey	2001 to 2008	Toda and Yamamoto (1995) method	Bidirectional causality between stock indices and exchange rates
Pekkaya and Bayramoglu (2008)	Turkey	1990 to 2007	Granger causality test	A unidirectional causality from stock price of Turkey and US to exchange rates, while US stock market Granger causes to turkey stock price and exchange rate
Altin (2014)	Turkey	2001 to 2013	Johansen Cointegration methods	Find significant relation while the direction of relation remain mixed
Abdalla and Murinde (1997)	Pakistan, India, Korea, and the Philippines	1985 to 1994	Bivariate vector autoregressive (VAR) model	Long-run relation in India and Philippines Stock prices Granger cause exchange rates in only Philippines while exchange rates cause stock price in India, Pakistan, and Korea.
Baharom *et al.* (2008)	Malaysia	Monthly data: 1988 to 2006	Granger causality and Johansen cointegration	No long term relation Affirm short-run causality between them

Bonga-Bonga and Hoveni (2011)	South Africa	July 1995 to October 2010	Multi-step GARCH family model	Unidirectional volatility spillovers from stock market to currency market.
Mlambo *et al.* (2013)	South Africa	2000 to 2010	GARCH	A weak effect of currency volatility on the stock price
Lean *et al.* (2011)	Eight Asian countries	1991 to 2005	Gregory and Hansen (1996) test and Westerlund (2006) panel Lagrange multiplier (LM) cointegration test	Weak long-run causality from exchange rate to stock price in Korea Short-run contemporaneous effect between stock price and exchange rate is evident in those countries
Hwang (2004)	Korea	January 1980 to July 1997	Engle-Granger two way cointegration test	Bidirectional relation in long-run One way causality from exchange rate to stock index
Fauziah *et al.* (2015)	Ten Asian countries	January 2009 to December 2013	Vector Correction Method (VECM)	A long term stable relationship Bidirectional causality in short and long-run in Asia
Zubair (2013)	Nigeria	2001 to 2011	Trivariate VAR model, Johansen cointegration and Granger causality	No long-run relation No direct relation between stock price and exchange rate in Nigeria
Wickremasinghe (2012)	SriLanka	1986 to 2012	Granger causality and cointegration techniques	No long-run relation A short-run unidirectional causality from stock price to exchange rate of US dollar
Ghazali *et al.* (2008)	Malaysia	July 22, 2005, to March 23, 2007.	Engle-Granger and Toda-Yamamoto causality test	No long-run relationship Unidirectional causality from stock price to exchange rate
Hatemi-J and Roca (2005)	Malaysia, Indonesia, Philippines and Thailand	Prior and during Asian Financial Crisis of 1997	Leverage adjusted bootstrap causality tests	Causality from exchange rare to stock price in Indonesia and Thailand and causality from stock price to exchange rate in Malaysia before the crisis on one hand, and on the other, there is no causal

				relation during crisis.
Araghi and Pak (2012)	Iran	2004 to 2010	GARCH model	A positive link between stock price volatility and exchange rate volatility
Cakan and Ejara (2013)	Twelve emerging countries	May 1994 to April 2010	Linear and nonlinear Granger causality test	Strong unidirectional linear causality from stock price to exchange rate for seven countries and a strong unidirectional linear causality from exchange rate to stock prices for ten countries Non-linear Granger causality results imply bidirectional causal relations for nine of the countries i.e. India, Indonesia, Korea, Mexico, Philippines, Russia, Singapore, Thailand and Turkey and show only unidirectional causality from stock prices to exchange rates for Brazil and Poland.
Akel (2014)	Nine transition countries	1995-2011.	Toda and Yamamoto (1995) and Diks and Panchenko (2006) approach for causality test	Exchange rates Granger cause stock prices in Czech Republic, Hungary, Poland, and Romania in both linear and nonlinear causality analysis.
Aslam (2014)	Pakistan	2006 to 2012	Granger causality test	Bidirectional causality
Dewenter *et al.* (2002)	Mexican and Thai	1994 to 1997	Event study methodology	Find significant changes in stock prices in individual firm, industry portfolio, and volatility for Mexican and Thai sample. Benefit of US multinational firm from US dollar appreciation by the significant positive elasticity in both sample.
Murinde and Poshakwale (2004)	EU economies: Hungary, Czech Republic and Poland	Daily data: 1995 - 2003 for before and after acceptance of EURO	Causality test	Unidirectional causality from stock prices to exchange rate in Hungary; and bidirectional causality in the Czech Republic and Poland for pre-Euro period. After the acceptance of Euro, exchange rates Granger cause stock prices in all

				three counties. They further find positive correlation between two financial markets in both periods.
Tabak (2006)	Brazil	Daily data: August 1994 to May 2002	Cointegration and causality technique	No long-run relationship A linear causal link from stock price and exchange rates and a non-linear causality from exchange rate to stock prices
Morales (2007)	Four eastern European markets	Daily data: 1999 to 2006	Cointegration and causality analysis	No long-run and short-run association Further investigations reveal exchange rates Granger cause stock prices in Hungary, Poland, and Czech Republic. In addition, they find causality from the exchange rate of Slovakia, Hungary, Poland and Czech Republic to the stock price in UK.
Umer *et al.* (2015)	Nine emerging countries	January 1998 to May 2014 for the Tranquil period and crisis period	Granger Causality	Causality from stock price to exchange rates in tranquil period whereas exchange rates Granger cause stock prices during the crisis period
Azman-Saini *et al.* (2003)	Thailand	1990 – 2001	Bivariate and multivariate models on the causal relationship	Bidirectional causality by bivariate model Bidirectional relationship for first period, but, unidirectional negative causality from exchange rate to stock price for second period.
Mustafa and Nishat (2008)	Pakistan	July 1981 to June 2004	Cointegration, error correction and granger model	A significant causality running from exchange rate to stock price

2.5 Conclusion

From literature, the stock price and exchange rate is more a short run dynamics and less a long run relationship. In addition, most of the researches focus only on the linear relationship and specifically there is no works on nonlinear dynamics between stock price and exchange rate in Bangladesh. No works earlier made on comparative investigations between these two financial markets in Bangladesh.

It can be said from the review of empirical literature that there are very few studies for stock price and exchange rate interactions in Bangladesh, therefore any further study have enough opportunity to search the gaps and fill those gaps in the literature.

Chapter 3

Overview of Stock Market and Foreign Exchange Market in Bangladesh

3.1 Introduction

This chapter will briefly explain the evolution, mechanism, growth, upsurge and downturn of the Dhaka Stock Exchange (DSE) and the regulatory agencies operating in DSE. Next, it will provide a short review on foreign exchange market and exchange rate of Bangladeshi Taka over the years, how the exchange rate regime changes over different period, how different shocks affect the exchange rate or market, and how the regulatory body responds through intervention or changing the regime.

3.2 Historical Evolution and Operations of Stock Market in Bangladesh

Dhaka Stock exchange (DSE) begins its operations from April 28, 1954, with the establishment of East Pakistan Stock Exchange Association Ltd, while the formal stock trading started from 1956. Dhaka stock exchange (DSE), the first and major stock market in Bangladesh got its name after the revision of the name East Pakistan Stock Exchange Association Ltd in 1964. Although it was incorporated in 1954, official trading in Dhaka Stock exchange commenced in 1956. Due to the liberation war in 1971, DSE remain closed for five years. It started its operation again in 1976 with only nine listed companies and total paid-up capital of Tk. 137.52 million (Chowdhury, 1994). Within only seven years it reached the market capitalization of TK. 812 million in 1983. Listed companies of this market increases to 92 in 1986. A rapid growth of DSE has been witnessed in the 1990s and the Chittagong Stock Exchange (CSE), the second stock market of Bangladesh, has been established at December 1995; as the economy becomes more open and flexible, and democratic Government took charges of the country. As on June 2018, the total number of companies listed in DSE is 305 and market capitalization of all listed companies shares is BDT 3,219,423 million (Dhaka Stock Exchange, 2018).

3.2.1 Major Events

Every stock market in the world confronts some major setbacks. US stock market witnessed Black Monday, Dotcom Bubble, Subprime Loan Default, and Flash Crash in the year 1987, 2000, 2007-2009, 2010 respectively, and Chinese stock market suffers

Black Monday and Tuesday in 2015. Asian stock market-Thailand, Indonesia, South Korea, Philippines crash occurred in 1997 due to the fear of financial contagion, Russian financial crisis took place in 1998 for domestic debt default. (List of stock market crashes and bear markets, n. d.).

Just like any other stock market in the world, the stock market of Bangladesh experienced collapse in 1996 and in 20010-2011.

Crash of 1996

The first crash was witnessed in 1996 when intense rise in market turnover, market capitalization, and index value observed in both DSE and CSE from January to November and downturn began at December. Actually, the index fell so rapidly that the DSE General index of 3064.99 at November 1996 reached at 749.85 in November 1997 (Unnayan Onneshan, 2011). This unprecedented downturn due to speculative attack and incompatibility of immediate decisions of regulatory body shockingly damaged investors' confidence (Unnayan Onneshan, 2011).

Crash of 2010-2011

The bubble started to grow in mid-2009 when DSE general index was 2914.53 and it reached at 5654.88 in April 2010. During November 2010, each of the days was the record-breaking peak for the DSE. From early December 2010 the bubble started to burst and about 3.62 percentage fall occurrs in December and DSE general index loses 30.5 percent over the next three months. This falling trend continues, as the DSE General index reached 3503.145 in early April 2013 from 4649.327 in mid-November 2011. (Unnayan Onneshan, 2011)

3.2.2 Regulatory Changes

The first separate regulatory authority for capital market of Bangladesh, Securities and Exchange Commission of Bangladesh (BSEC), has been established in June 1993 with the formation of Securities and Exchange Commission Act, 1993. BSEC has the mission to protect the interest of investors, develop and maintain fair, transparent and efficient securities markets, ensure proper issuance of securities and compliance with securities laws. (Securities and Exchange Commission of Bangladesh, 2014).

After the stock market collapse in 1996, the Government brings structural changes under Capital Market Development Program (CMDP) prescribed by the Asian Development Bank from November 20, 1997. The aims of CMDP are as follows: (i) strengthen market regulation and supervision, (ii) develop the stock market infrastructure, (iii) modernize stock market support facilities, (iv) increase the supply of securities in the market, (v) develop institutional sources of demand for securities in the market, and (vi) improve policy coordination (Securities and Exchange Commission of Bangladesh, 2014). In the line of CMDP, automated trading system for both DSE and CSE was commenced in 1998 and a separate public limited company for electronic book entry and clearing named Central Depository Bangladesh Limited (CDBL) was established in August 2000 (Chowdhury, 2014). These developments gear up the investors' confidence again and raise market index, market capitalization and turnover.

Later, high vulnerability and major collapse in 2010-2011 intensify the need for capital market reform in Bangladesh. Hence, DSE took some major structural changes like increasing capacity of the traders up to six lacs trade in each day, new upgraded trading application of MSA plus (web based trading software) for probable surge in trades

(About MSA Plus, n.d.). The Government started Second Capital Market Development Programme (CMDP2) financed by the ADB. Both of stock exchanges are demutualized from 2013. Further Government introduces Dhaka Stock Exchange (Trading Right Entitlement Certificate) Regulations in 2013 and Dhaka Stock Exchange (Investors' Protection Fund) Regulations in 2014 for better transparency and protection for investors (TREC Regulations, 2013; Investors' Protection Fund Regulations, 2014). Now BSEC has been recognized by International Organization of Securities Commissions (IOSCO) as A category regulatory body for capital market development. From February 11, 2014, the live trading has been monitored after the installation of surveillance software by BSEC (Securities and Exchange Commission of Bangladesh, 2014).

Further, Dhaka stock exchange standardizes its circuit breaker. It replaces simultaneous use of percentage and figure based circuit breaker system by only percentage based break in Trade from April 30, 2015. DSE launches mobile application "DSE INFO" on November 25, 2015, and inaugurates "DSE-Mobile" on March 09, 2016, to provide easy access to trade and real-time market information for investors. SGS United Kingdom certified the management system of DSE fulfilling the requirements of ISO 9001:2008 on October 30, 2016. Recently, Dhaka Stock Exchange Limited (DSE) has earned full membership of The World Federation of Exchanges Limited (WFE) on June 06, 2017. (Dhaka Stock Exchange, 2017)

3.3 Overview of Foreign Exchange Market and Exchange Rate in Bangladesh

As capital market and money market facilitate the fund flow from surplus economic units to deficit economic units of a country, foreign exchange market ensures smooth exchange of different currencies for international transactions (export, import, remittance, foreign direct investment, etc.). Actually foreign exchange market evolves with the choices of exchange rate regime in Bangladesh. Prior to 1993, there was no market for foreign exchange except the central bank of Bangladesh, the Bangladesh Bank (BB), bestowed with the service of currency exchange and non-existence of current account convertibility put BB at the position to determine exchange rate (official rate) by its own authority to optimize the supply of and demand for foreign currencies. From 1993, it was comparatively open market for foreign exchange with the advent of current account convertibility. Finally, free-floating exchange market for Bangladesh started from 2003 (Bangladesh Bank, 2003).

3.3.1 Exchange Rate Regimes

From the evolution of Bangladesh as an independent nation till present, the country has gone through different exchange rate regimes as discussed below (Hossain & Ahmed, 2000 and Chowdhury, 2000):

Fixed or Pegged Exchange Rate Regime

The foreign exchange rate in Bangladesh was fixed or pegged at different magnitude or types from 1972 to 2003.

- **Pegged to Pound: 1972 to 1979**

  From 1972 to 1979, Bangladeshi currency was pegged to Pound Sterling but in that time a sudden devaluation of domestic currency in May 1975 compel Bangladesh Bank to adhere managed float till 1979,

- **Currency Weighted Basket Pegged: 1979 to 1982**

  Then again Bangladesh embark on fixed exchange regime (currency weighted basket method) and pegged its currency against major trading partners and pound sterling remains as intervening currency for exchange rate determination from August 1979 to 1982.

- **Trade Weighted Basket Pegged: 1983 to 1999**

  Later, the basket was changed into trade-weighted basket and the US dollar was adopted as the intervening currency from 1983 to 1999.

- **Crawling Peg: 2000 to 2003**

  For 2000 to 2003, Bangladesh moved into adjusted pegged system where adjustment made to correct the rate if there is unusual change the exchange rate.

Floating Exchange Rate Regime: 2003 to Present

The era of fully market based floating exchange rate began from May 31, 2003, in Bangladesh (Bangladesh Bank, 2003). In this phase, the Bangladesh Bank (BB) announces abolition of preannounced bands in exchange rate for foreign exchange transactions with authorized dealers (banks) and these dealers have the power to determine the rate as per the demand and supply condition in the exchange rate market. However, Bangladesh Bank also guaranteed the regulations and scrutiny of the market, and if needed, it would intervene the market through foreign currency and money market transactions for the betterment of the foreign exchange market and economy.

3.3.2 Regulatory Changes

The rise in kerb market became apparent after 1983 as a secondary exchange market (SEM) simultaneously where different exchange rate was permitted under diverse export benefit schemes like Home Remittances Scheme, Export Bonus Scheme etc. However, this kerb market for exploring export and foreign investment led mismatch between SEM rate and official rate, which raised irregularities in regulatory decision making and further invoked imbalances in the economy. Since Bangladesh bank is the regulatory body of foreign exchange in Bangladesh as per Foreign Exchange Regulation Act of 1947, it unified these two rates from January 1992 and opened the market for foreign exchange by currency convertibility in 1994 and gradually increases the spread for authorized dealers from BDT 0.10 to BDT 0.30. Thus, functionality of interbank currency market has improved and inflow of foreign remittance through authorized channel has augmented. As a result, current account deficit is decreased and foreign reserves are increased (Akhtaruzzaman & Begum, 2015).

3.3.3 Overall Scenario of Exchange Rate

The overall exchange rate behavior in foreign exchange market of Bangladesh from TK. 7.76/USD at the end of 1971-72 to Tk. 77.81/USD at the end of 2014-2015 can be marked by the choice of exchange rate regime. Before 2003, all the rates are pegged at different magnitude, while after 2003 it has been free floating.

Table 3.1 below shows year-end exchange rate of USD denominated in Bangladeshi taka from the financial year 1971-72 to 2014-2015. During financial year 1974-1975, the exchange rate experience highest devaluation about 72% change from earlier year due to fall of pound sterling in world market by high oil prices, rise in inflation and slow economic growth in UK. Then devaluation was evident in the year 1980-81, 1981-82, 1982-83 by 23%, 22%, and 11%, respectively, due to oil price hike. Then Government revised the currency basket into trade-weighted basket from 1983 to 1999. From 1983 to 2000, exchange rate of Bangladeshi Taka was gradually devalued ranging 0 to 6% except in the year 1984-85 and 1991-92. Finally, before embarking on free-floating exchange rate mechanism, the adoption of adjustable pegged mechanism exerts a major devaluation of 12% at year 2000-01 because of the fall in foreign portfolio investment (FPI) and rise in oil price in world market.

Table 3. 1: Year End Exchange Rate

Period	BDT/USD	Change
1971-72	7.76	000
1972-73	7.35	-0.05
1973-74	7.93	0.08
1974-75	13.65	0.72
1975-76	14.95	0.10
1976-77	15.52	0.04
1977-78	15.06	-0.03
1978-79	15.12	0.00
1979-80	14.73	-0.03
1980-81	18.10	0.23
1981-82	22.11	0.22
1982-83	24.50	0.11
1983-84	25.20	0.03
1984-85	28.00	0.11

1985-86	30.30	0.08
1986-87	31.00	0.02
1987-88	31.50	0.02
1988-89	32.27	0.02
1989-90	34.90	0.08
1990-91	35.79	0.03
1991-92	39.00	0.09
1992-93	39.80	0.02
1993-94	40.25	0.01
1994-95	40.10	0.00
1995-96	41.75	0.04
1996-97	43.65	0.05
1997-98	46.30	0.06
1998-99	48.50	0.05
1999-00	51.00	0.05
2000-01	57.00	0.12
2001-02	57.90	0.02
2002-03	57.90	0.00
2003-04	60.43	0.04
2004-05	63.75	0.05
2005-06	69.67	0.09
2006-07	68.80	-0.01
2007-08	68.52	0.00
2008-09	69.06	0.01
2009-10	69.45	0.01
2010-11	74.15	0.07
2011-12	81.82	0.10
2012-13	77.77	-0.05
2013-14	77.63	0.00
2014-15	77.81	0.00

Source: Statistics Department, Bangladesh Bank.

In free-floating exchange rate system, the market initially shows the signs of absorbing shocks very quickly and remains strong to heavy transactions. But at 2005-06, it shows volatile nature of the market because, at that time, the country experiences a heavy rise in Broad money (M3) and international oil price. This volatility forces BB to intervene the foreign exchange market. Exchange rate of BDT bounces back immediately after that financial year and it continues to be relatively unchanged till 2010-11. The consecutive two years of 2010-11 and 2011-12 a heavy lose in the value of BDT has been observed because of the rise in international oil price, domestic stock market crash and lack of effective Government intervention. Then Government again establishes control over exchange rate fluctuation through direct intervention.

3.4 Conclusion

The stock market and foreign exchange market are two vital financial markets in Bangladesh; both have a significant role in the development of the country. This study tries to explore their behavior and interactions over the sample period by using DSE index value as the stock price in the stock market and exchange rate of BDT/USD as the price of foreign currency in FX market in Bangladesh.

Chapter 4

Research Methodology

4.1 Introduction

This chapter presents and explains methodology of the study. The whole section is structured under two broad heads: 4.2 presents sample size and sources of data, and 4.3 is a description of the econometric methodology. Section 4.2 explains the data sources, their authenticity, reliability, and the size of the sample. Section 4.3 begins with the basics of data transformation, descriptive analysis followed by methodology to measure individual and joint efficiency and causality. Finally, methodology for individual and joint volatility dynamics of stock price and exchange rate has been discussed.

4.2 Sources of Data and Sample Size

The study attempts to reveal the short-run and long-run dynamics of stock index and exchange rate of US dollar in Bangladesh. The stock index data has been gathered from the library and website of Dhaka Stock Exchange while the exchange rate data has been collected from DataStream.

The Dhaka stock index data consists of DSE General Index (DSE-Gen) and DSE Broad Index (DSEX). Exchange rates of different periods are the exchange rate of US Dollar in terms of Bangladeshi Taka (BDT/USD). Both the data series are of daily frequency showing day to day price and rates.

There are two stock markets operating in Bangladesh (i.e. Dhaka Stock Exchange and Chittagong Stock Exchange) and same securities are listed in both markets. However the Dhaka Stock Exchange (DSE) is comparatively the older and larger stock market. Therefore it should be a better representative for the stock price changes over the time in Bangladesh.

The sample data set covers the periods from June 2, 2003, to December 30, 2016, for daily BDT/USD exchange rate and stock price respectively. This time period has been segmented into two parts, the first part represents the time from June 2, 2003, to January 27, 2013, while the second part covers data from January 28, 2013 to December 30, 2016. This time segmentation is relevant for the analysis of causal relation between stock price and exchange rate as during the first segment both stock market and exchange market goes through numerous changes and modifications. Newly adopted floating exchange rate system on May 29, 2003, leads major disruption from 2004 to 2007 in the foreign exchange market. Bangladesh Bank has to strongly intervene the market in 2008 in response of world economic meltdown and this intervention has been continued up to 2010. On the other hand, stock market of Bangladesh observes bubble from 2007 to late 2010 and finally the bubble bursts in December 2010 and the market continues to collapse up to late 2011 (Alam, 2012). The whole 2011 and 2012 was the major correction and regulatory decision making year. In January 2013, DSE introduced standard and poor's method of index calculation and replaced all old market indices by new indices. Therefore the relation between stock price and exchange rate under vulnerable and transitional market condition can be evaluated in first segments of time period. While the second segment of time will present this relation at the time of less vulnerable and more stable market situation.

Over the said time period, the data comprises 3545 observations where 2520 observations on stock price reflected by DSE General Index (DSEGen) from June 2, 2003, to January 27, 2013, and rest 1025 observations on stock price by DSE Broad Index (DSEX) from January 28, 2013, to December 30, 2016, since DSE general index replaced by DSEX. Therefore the whole analysis of stock price and exchange rate relationship conducted under two sample period, where sample I covers the first 2520 observations and sample II covers rest 1025 observations. Besides, the study period begins from 2003, as because Bangladesh takes its floating exchange rate policy from 2003, earlier it was fixed or pegged exchange rate system.

Other than the above mentioned theoretical and practical justification of sample segmentation, the study uses test of equality for sample variances (Levin & Rubin, 2006) with the null of equal variance of both period to statistically prove whether there is difference in variance for two sample periods for stock price and exchange rate data.

Table 4.1 presents the test of equality for two sample variance. For stock price data, it is found that calculated F statistics for the test of two sample period variance is greater than critical F statistics (i.e. 61.09 > 1.09). Thereby, there is significant difference in variance of two sample period of stock price data. Like stock price sample variance differences, exchange rate sample variance differences are statistically significant (calculated F value is greater than critical F value i.e. 225 > 1.09).

Table 4. 1: Test of Equality for two Sample Variance

	Stock Price Data		Exchange Rate Data	
F-Test Two-Sample for Variances	*Sample I*	*Sample II*	*Sample I*	*Sample II*
Mean	7.868065	8.402689	4.226737	4.356657
Variance	0.393878	0.006447	0.008446	3.75E-05
Observations	2520	1025	2520	1025
df	2519	1024	2519	1024
F	61.09497		225.1809	
P(F<=f) one-tail	0.0		0.0	
F Critical one-tail	1.091064		1.091064	

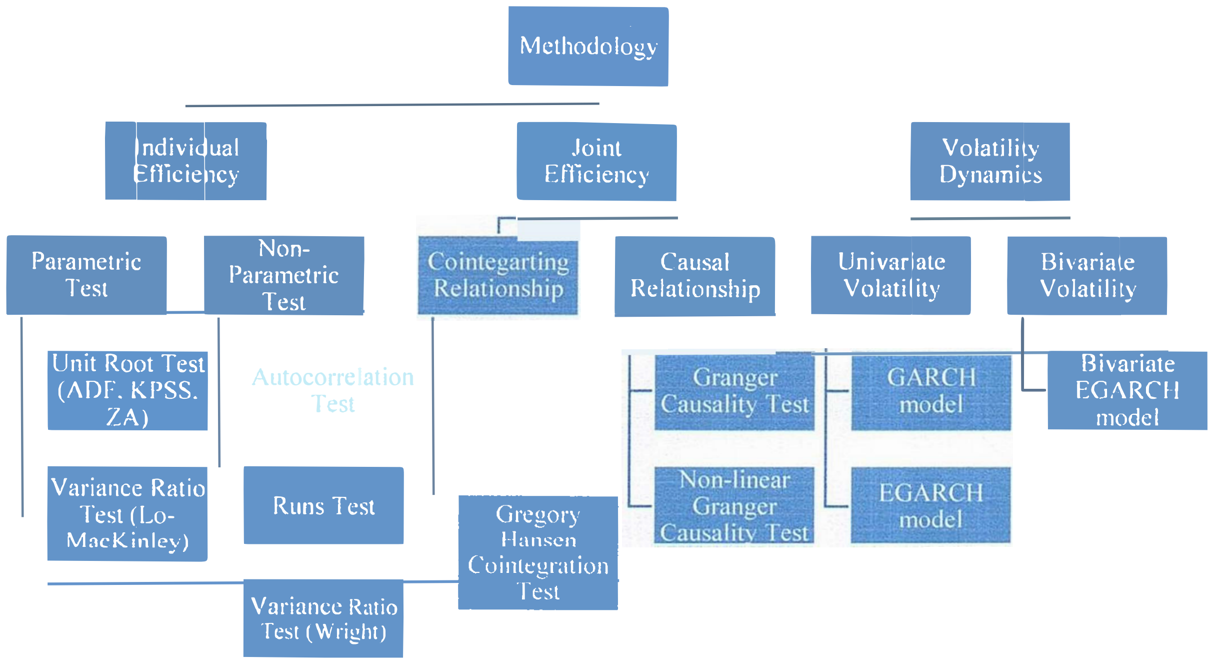
Notes:

a. H_o: Variance of Sample Period I is equal to the variance of Sample Period II
b. Test Statistics: $F = \frac{S_1^2}{S_2^2}$, where S_1^2 and S_2^2 are the sample variances for sample period I and II respectively. The greater the ratio departs from the value of 1, the more the likelihood for unequal variance.

4.3 Econometric Methodology

The econometric methodology consists into three different aspects of investigation in stock market and foreign exchange market. The figure 4.1 presents all these aspects of methodology of this study and these aspects are individual efficiency, joint efficiency and volatility dynamics. Firstly, individual efficiency investigation has been carried out through both parametric test (i.e. unit root test and Lo-Mackinlay variance ratio test) and non-parametric test (i.e. autocorrelation test, runs test, Wrights variance ratio test). Secondly, joint efficiency study is conducted by cointegration and causal analysis where conintegration has been checked by Engle Granger cointegration test and Gregory Hansen cointegration test and Causality has been verified by linear and

Figure 4. 1: Methodology



nonlinear Granger causality test. Finally volatility dynamics of stock price and exchange rate has been investigated through univariate volatility analysis by GARCH and EGARCH model and bivariate volatility analysis by bivariate EGARCH model.

Before discussing empirical econometric methodology for the study, it would be convenient to explain the data transformation and preliminary data analysis to prepare the data for pertinent econometric application.

4.3.1 Data Transformation

The raw data of daily closing stock index and closing exchange rate of BDT/USD have been transformed to natural log because the log transformation is used to stabilize the variance of the distribution. Then, both the series transformed into return series by differencing immediate past day value from the value at present time (first difference of price series is the return series), that is the only stock price, exchange rate and return series for stock price and exchange rate would be,

Table 4. 2: Data Transformation Equation

Variables	Symbols used
Stock price	$Ln(P_t)$
Exchange rate	$Ln(X_t)$
Return series for Stock price	$Ln(P_t)$- $Ln(P_{t-1})$
Return series for Exchange rate	$Ln(X_t)$- $Ln(X_{t-1})$

4.2.2 Preliminary Data Analysis and Descriptive Statistics

The study goes through several preliminary data analysis and test for both the time series data. These preliminary data analysis includes graphical presentation (see Section 5.2) for all the series (stock price and exchange rate series at their level, return series of stock price and exchange rate) to define various characteristics of the data series. These characteristics may include (Taylor, 2005, p. 69-82):

i. whether the distribution is normal or not (distribution is approximately symmetric or fat tails or high peak);
ii. whether there is any or no correlation between different time intervals;

iii. whether there is positive dependence between absolute return on nearby lags or leads and same for squared return.

As a part of preliminary analyses to generate only rough measure, the study follows descriptive statistics of the series to provide some basic characteristics of the distribution of the series. The descriptive statistics include mean, standard deviation, skewness and kurtosis of the data series and finally present Jarque-Bera test for normality. The mean of the series answers the average stock price, exchange rate and return of exchange rate and stock price, whereas standard deviation explains how diverse the values of each series from its average. The skewness of the series measures the lack of symmetry. A distribution is said to be symmetric only if both sides of the distribution from its central looks just same. Unlike skewness, kurtosis measures how peak the distribution is. A distribution with high kurtosis has a sharp peak at the mean decline rapidly, while a low kurtosis likely to have a flat top at the mean.

The normal distribution indicates zero value for skewness and 3 for kurtosis. The positive value for skewness indicates the distribution is skewed to the right, that is, right tail is heavier than left tail, while negative skewness means skewed left where left tail is heavier than right tail. While kurtosis value more than 3 indicates a leptokurtic distribution contrasting a less than 3 value of kurtosis meaning platykurtic distribution. The values calculated from the formula of skewness and kurtosis further use to measure the normality of the distribution by Jarque–Bera test. Jarque-Bera test has the null hypothesis of a normal distribution, the test statistics are distributed as χ^2 with the degrees of freedom of 2. The null hypothesis is rejected only if the test statistics is less than the calculated value. The formula for Jarque–Bera (JB) is:

$$JB = n\left[\frac{S^2}{6} + \frac{(K-3)^2}{24}\right] \quad (1)$$

Where n = no. of observations, S = coefficient of skewness, K= coefficient of kurtosis. The formula is for ordinary series. If the residuals of regression equation tested for JB normality test, the formula will be same except the number of observations minus number of regressors.

4.3.3 Methodology for Individual Market Efficiency

The study investigates the weak form of efficiency for stock market and foreign exchange market. This individual efficiency has been evaluated under random walk hypothesis, that is, historical price or return is random and thus cannot be used for predicting future price or return. Hence, the movement of the price or return is independent and identically distributed (Fama, 1970). Under this individual efficiency measurement, each financial market has been empirically examined by unit root test and stationary test, autocorrelation test, variance ratio test and runs test.

- **Parametric Stationarity Tests**

Within this parametric test of unit root and stationary test, the study uses both stock price and exchange rate data at level (price data) and at first difference (return data). Actually, both level and differenced data are used to define the order of integration, so that, their relationship of joint interaction can be evaluated. Whereas individual efficiency is basically judged by using the return series for stock price and exchange rate.

i. Unit Root Test- Augmented Dickey-Fuller (ADF) Test

To fulfill the necessary condition of random walk, the analysis of stationary is a must. A series is random; it has to be non-stationarity which suggests no tendency to the long-run deterministic path. Augmented Dickey-Fuller (ADF) test is the augmentation of Dickey-Fuller test (DF) where more than one lag of the series can be used. Like the DF test, the ADF test is proposed by Dickey-Fuller (1981) with the null hypothesis of non-stationarity that a series does contain a unit root against the alternative hypothesis of stationarity.

These hypotheses are tested by three forms of ADF test to detect the presence of unit roots in the series of stock index and exchange rate.

Table 4. 3: ADF Test Equations

Test	P_t = Stock price		X_t = Exchange rate	
Unit root	$\Delta P_t = \delta P_{t-1} + \Sigma\beta i \Delta P_{t-i} + u_t$	(2)	$\Delta X_t = \delta X_{t-1} + \Sigma\beta i \Delta X_{t-i} + u_t$	(5)
Unit root with drift	$\Delta P_t = \alpha_0 + \delta P_{t-1} + \Sigma\beta i \Delta P_{t-} + u_t$	(3)	$\Delta X_t = \alpha_0 + \delta X_{t-1} + \Sigma\beta i \Delta X_{t-i} + u_t$	(6)
Unit root with drift and trend	$\Delta P_t = \alpha_0 + \delta P_{t-1} + \alpha_{2t} + \sum_{i=1}^{p} \beta_i \Delta P_{t-i}$	(4)	$\Delta X_t = \alpha_0 + \delta X_{t-1} + \alpha_{2t} + \sum_{i=1}^{p} \beta_i \Delta P_{t-i}$	(7)

The test is applied to both the original series (in logarithmic form) that is price series and the first difference series that means the return series. It should be noted when ADF test is applied to the series at level, the aforementioned equations will remain same without containing Δ; because Δ indicates first difference of the series. For both series, the study has measured the *t*-statistics $t = \delta \text{var}(\delta)$ and compared it against respective critical values at different significance level (99%, 95%). That is, if the *t*-statistics is lower than the critical value, null hypothesis cannot be rejected and the decision would be that the series (stock price or exchange rate) contain unit root.

However, each of the models for ADF tests, the study chooses the lags according to Schwarz Bayesian Information Criterion (SBIC), where minimum value of SBIC determines the lag length. SBIC is preferred to commonly used Akaike Information Criteria (AIC) because SBIC selects right model under few lags compared to model with more lags chosen by AIC. The rule is that the more the lags, the lesser the strength of a test to reject null, while the fewer the lags the greater the chances of rejecting the null hypothesis when it is true. That is, fewer lags lead to greater Type I error whereas greater lags intensify Type II error in the model. (Ya & Yuntan, 2010)

Brooks (2008) criticize ADF test because it has biasness to the process of stationary though a root is within the non-stationary boundary, that is, the non-stationary process has very low power in this test.

ii. Stationary Test- Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) Test

Kwiatkowski *et al.* (1992) developed a test alternative to ADF to subdue its problems where the null hypothesis is assumed to be stationary against alternative hypothesis of non-stationarity. KPSS is a lagrange multiplier test having two-step processes for stationary evaluation. Firstly, we have to regress the dependent variable P_t or X_t on a drift or drift and time trend and find the OLS residual ε_t and then compute the partial sums $S_t = \sum_s^t \varepsilon_s$. Further, the calculation of test statistics follows Verbeek (2004).

$$\text{KPSS LM}_P = \frac{S_{t_p}^2}{\hat{\sigma}_{\varepsilon_p}^2} \quad (8)$$

Where $S_{t_p} = \sum_{s=1}^{t} \varepsilon_{S_p}$ and $\hat{\sigma}_{\varepsilon_p}^2$ is the estimated error variance from the regression for stock price or return $P_t = \alpha_p + \varepsilon_{t_p}$ or $P_t = \alpha_p + \beta_p + \varepsilon_{t_p}$.

$$\text{KPSS LM}_X = \frac{S_{t_x}^2}{\hat{\sigma}_{\varepsilon_x}^2} \quad (9)$$

Where $S_{t_x} = \sum_{s=1}^{t} \varepsilon_{S_x}$ and $\hat{\sigma}_{\varepsilon_x}^2$ is the estimated error variance from the regression for exchange rate or return, $X_t = \alpha_x + \varepsilon_{t_x}$ or $X_t = \alpha_x + \beta_x + \varepsilon_{t_x}$.

KPSS test overcomes the drawback of ADF test as KPSS test has higher power over the power of ADF test (Tabak, 2006). The study follows both ADF and KPSS test to test unit root and stationary process. Then compare the results of these two to detect whether they have same conclusion or not. Unless they are same in their conclusion, the study takes the result of KPSS test as a more robust result compared to ADF test result. (Ya & Yuntan, 2010)

iii. Zivot-Andrews Unit Root Test:

The conventional unit root tests (like ADF, KPSS test) do not assume structural break in the series. Disregarding structural break in the series weakens the strength of rejecting unit root at the time of true alternative hypothesis of stationarity (Waheed *et al.* 2006). Zivot and Andrews (1992) introduces three models; first one considers unknown break at the level, second one considers unknown break at trend and third one assumes one unknown break in combination of level and trend to investigate unit root process in the series. These three models are given below:

Model 1: $\Delta y_t = \alpha_1 + \delta y_{t-1} + \alpha_{2t} + \gamma DL_t + \sum_{i=1}^{k} \beta_i \Delta y_{t-i} + u_t$ (10)

Model 2: $\Delta y_t = \alpha_1 + \delta y_{t-1} + \alpha_{2t} + \theta DT_t + \sum_{i=1}^{k} \beta_i \Delta y_{t-i} + u_t$ (11)

Model 3: $\Delta y_t = \alpha_1 + \delta y_{t-1} + \alpha_{2t} + \gamma DL_t + \theta DT_t + \sum_{i=1}^{k} \beta_i \Delta y_{t-i} + u_t$ (12)

Where DV_t are the dummy variables indicating break in level in the first model, break in trend in the second model and break in both level and trend in the third model at any potential shift (T_{SB}). These dummy variables are defined as follow:

$DV_t = \begin{Bmatrix} 1 & if\ t > T_{SB} \\ 0 & otherwise \end{Bmatrix}$ for first and third model, and

$DV_t = \begin{Bmatrix} t - T_{SB} & if\ t > T_{SB} \\ 0 & otherwise \end{Bmatrix}$

Zivot Andrews's procedure considers each point as a probable break date (T_{SB}) and sequential regression operation conducted for each possible shift. The model takes only that date among all possible break dates when one-sided *t*-statistics is minimized. The minimum *t*-statistics appears to be Zivot Andrews (ZA) test statistics under the null hypothesis of unit root (δ=0) against the alternative hypothesis of stationarity assuming one break point. Many studies (Sen, 2003; Waheed *et al.* 2006) have pointed out the superiority of model three over other two models of ZA unit root test.

iv. Lo-MacKinlay Variance Ratio Tests

Variance ratio test examines the random walk hypothesis by comparing variances of differences of data over different intervals. If we assume that the data follows random walk, then variance of an *n* period difference should be equal to *n* times the variance of one period difference. In this study, Lo-Mackinlay (1988) test for variance ratio (VR) has been applied considering both homoscedasticity and heteroscedasticity in the series of stock return and exchange rate return. Further, rank based and sign based variance ratio test prescribed by Wright (2000) on non-parametric section used to generate more robust results.

The null hypothesis of variance ratio test is that whether the variance of a return series (stock or exchange rate) is independently and identically distributed that is iid. If the series is not iid, the series follows the random walk. If the S_t is stock return series with T sample size then following the Lo and MacKinlay (1988), the variance ratio would be:

$$\mathrm{VR} = \left\{\frac{1}{TQ}\sum_{t=q+1}^{T}\left(S_t + S_{t-1} + S_{t-2} + \cdots \ldots \ldots \ldots + S_{t-q} - q\hat{\mu}\right)\right\} \div \left\{\frac{1}{T}\sum_{t=1}^{T}(S_t - \hat{\mu})^2\right\} \quad (13)$$

Where $\hat{\mu} = T^{-1}\sum_{i=1}^{T} S_t$ and numerator is $1/q$ times variance of S_t after summing by q, (investment duration). If this ratio is close to 1, then S_t is a random walk unless it is not iid. Lo and MacKinlay (1988) identifies that if S_t follows random walk then

$$T^{1/2}(VR - 1) \rightarrow N_d\left[0, \frac{2(2q-1)(q-1)}{3q}\right],$$

Then, the normal asymptotic test statistic assuming homoscedasticity for the null of random walk is,

$$M_1 = (VR - 1)\left[\frac{2(2q-1)(q-1)}{3qT}\right]^{-1/2} \quad (14)$$

Now, following the Lo and MacKinlay (1988) robust test statistic to assume conditional heteroscedasticity in stock return series is,

$$M_2 = (VR - 1)\left[\left(\sum_{j=1}^{k-1} \frac{2(2q-j)}{q}\right)^2 \delta_j\right]^{-1/2} \quad (15)$$

Where

$$\delta_j = \left\{\sum_{t=j+1}^{T} (S_t - \hat{\mu})^2 (S_{t-j} - \hat{\mu})^2\right\} \div \{[\sum_{t=1}^{T} (S_t - \hat{\mu})^2]^2\}$$

Lo and MacKinlay (1988) confirm that if S_t follows random walk, then VR follows asymptotic normal distribution with zero mean and standard deviation of 1 for M_2.

Similarly, if X_t is exchange return series with T sample size then following the Lo and MacKinlay (1988), the variance ratio would be:

$$\mathrm{VR} = \frac{\left\{\frac{1}{Tq} \sum_{t=q+1}^{T} (X_t + X_{t-1} + X_{t-2} + \cdots \ldots\ldots + X_{t-q} - k\hat{\mu})\right\}}{\left\{\frac{1}{T} \sum_{t=1}^{T} (X_t - \hat{\mu})^2\right\}} \quad (16)$$

Where $\hat{\mu} = T^{-1} \sum_{i=1}^{T} X_t$ and numerator is *1/q* times variance of S_t after summing by q, (investment duration). If this ratio closes to 1 then S_t is a random walk unless it is not iid. Lo and MacKinlay (1988) identifies that if S_t follows random walk then

$$T^{1/2}(VR - 1) \rightarrow N_d \left[0, \frac{2(2q-1)(q-1)}{3q}\right]$$

Then, the normal asymptotic test statistic assuming homoscedasticity for the null of random walk is,

$$M_1 = (VR - 1)\left[\frac{2(2q-1)(q-1)}{3qT}\right]^{-1/2} \quad (17)$$

Now, following the Lo and MacKinlay (1988) robust test statistic to assume conditional heteroscedasticity in stock return series is,

$$M_2 = (VR-1)\left[\left(\sum_{j=1}^{k-1}\frac{2(2q-j)}{k}\right)^2 \delta_j\right]^{-1/2} \tag{18}$$

Where

$$\delta_j = \left\{\sum_{t=j+1}^{T}(X_t - \hat{\mu})^2\left(X_{t-j} - \hat{\mu}\right)^2\right\} \div \{[\sum_{t=1}^{T}(X_t - \hat{\mu})^2]^2\}$$

Lo and MacKinlay (1988) confirm that if S_t follows random walk, then VR is asymptotic normal distribution with zero mean and standard deviation of 1 for M_2.

- **Non-Parametric Test**

i. Autocorrelation Test

Autocorrelation test is the test of serial correlation of a return of a series to its lagged returns. Unless the correlation coefficient is zero, there must be some degree of serial dependence.

If y_t is the covariance-stationary time series and $(\rho)k$ is the K^{th} order of autocorrelation coefficient, then serial correlation coefficient is

$$\rho(k) = \frac{Cov(y_t, y_{t-k})}{\sqrt{Var(y_t)}\sqrt{Var(y_{t-k})}} = \frac{Cov(y_t, y_{t-k})}{Var(y_t)} \tag{19}$$

Now, Ljung and Box (1978) formed Q-statistics has been used to identify whether all of autocorrelation coefficients are statistically different from zero. Ljung Box Q statistics is follows:

$$Q_{LB} = n(n+2)\sum_{k=1}^{m}\frac{\rho^2(k)}{n-k} \tag{20}$$

When calculated value of Q_{LB} is greater than the critical value of X^2 with m degree of freedom, then the null hypothesis of no serial correlation is rejected because there is at least one $\rho(k)$ is statistically different from zero.

ii. Runs Test

Runs test (Wald & Wolfwitz, 1940) have the null hypothesis of randomness in observed series and it ignores the normality assumption of the distribution. The approach determines whether the successive changes in the distribution is independent measured by the number of runs in the series. A run is defined by Siegel (1956) as "a succession of identical symbols which are followed or preceded by different symbols or no symbols at all". These runs can be categorized according to the changes in the series as, a plus or minus or zero against rise, fall and no change in the series, respectively. Eventually, the distribution of changes has to be replaced by the distribution of symbols. The total number of runs indicates the degree of randomness in the series.

Therefore the runs test examines the randomness of the series, how direction of one observation in the series affects another. It is calculated by comparing actual number of runs in contrast to the expected numbers:

The expected number of runs is,

$$\mu = \frac{2n_1n_2}{n_1+n_2} + 1 \qquad (21)$$

Where, μ = expected runs, n_1 = positive changes of series that means values above the mean of the series, n_2 = negative changes of series that means values below the mean of the series. If the sample size is large, n_1 and n_2 are more than 20, the test statistics approximately normally distributed. Now variance can be found by,

$$\sigma^2 = \frac{2n_1n_2(2n_1n_2 - n_1 - n_2)}{(n_1+n_2)^2(n_1+n_2-1)} \tag{22}$$

Now,

$$Z = \frac{R-\mu}{\sqrt{\sigma^2}} \tag{23}$$

If there is a significant difference between actual and expected number of runs, then the series is not random. Market is highly sensitive to information only if the actual number of runs is significantly below the expected number of runs, and vice-versa (Poshakwale, 1996). Finally, Test statistics have to be compared against critical values to examine the null hypothesis that the sample values are generated from random process.

iii. Wright's Alternative Variance Ratio Tests

Wright (2000) substitutes ranks as (R_1 and R_2) and signs as (S_1 and S_2) against M_1 and M_2 of Lo and MacKinlay variance ratio test. Wright VR test is more useful than Lo and MacKinlay VR test for two reasons, one ranks and signs base test do not require normal asymptotic distribution and secondly it shows exact estimation which has minimum distortion even under conditional heteroscedasticity (Charles & Darne, 2009).

Let, y is the first difference of a variable that is return data for stock price or exchange rate. Then r (y) is the rank of y_t from y_1 to y_T as T observations are given. $r(y)$ is a randomly permuted from the number of 1 to T along same probability for the null of randomly distributed y_t and k is the investment horizon factor alternative of q specified in Lo-Mackinlay VR test. Wright (2000) proposes the $R_1$and R_2 statistics as follows,

$$R_1 = \left[\frac{\frac{1}{Tk}\sum_{t=k+1}^{T}(r_{1t}+r_{1t-1} \ldots\ldots + r_{1t-k})^2}{\frac{1}{T}\sum_{i=1}^{T} r_{1t}^2} - 1 \right] \times \left[\frac{2(2k-1)(k-1)}{3kT} \right]^{-1/2} \tag{24}$$

and

$$R_2 = \left[\frac{\frac{1}{Tk}\sum_{t=k+1}^{T}(r_{2t}+r_{2t-1} \ldots\ldots + r_{2t-k})^2}{\frac{1}{T}\sum_{i=1}^{T} r_{2t}^2} - 1 \right] \times \left[\frac{2(2k-1)(k-1)}{3kT} \right]^{-1/2} \tag{25}$$

where,

$$r_{1t} = r(y_t) - \frac{T+1}{2} \Big/ \sqrt{\frac{(T-1)(T+1)}{12}} \text{ and } r_{2t} = \emptyset^{-1}\left(\frac{r(y_t)}{T+1}\right)$$

Where, $\emptyset^{-1}$is inverse standard normal cumulative distribution function.

The sign-based tests are defined as follows:

$$S_1 = \left[\frac{\frac{1}{Tk}\sum_{t=k+1}^{T}(s_t+s_{t-1} \ldots\ldots + s_{t-k})^2}{\frac{1}{T}\sum_{i=1}^{T} s_t^2} - 1 \right] \times \left[\frac{2(2k-1)(k-1)}{3kT} \right]^{-1/2} \tag{26}$$

$$S_2 = \left[\frac{\frac{1}{Tk}\sum_{t=k+1}^{T}(s_t^*+s_{t-1}^* \ldots\ldots + s_{t-k}^*)^2}{\frac{1}{T}\sum_{t=1}^{T} s_t^{*2}} - 1 \right] \times \left[\frac{2(2k-1)(k-1)}{3kT} \right]^{-1/2} \tag{27}$$

where, $(s_t^*)_{t=1}^{T}$ is an iid sequence, each element of which is 1 or -1 with probability 0.5. The test S_2, which is related to the conservative test that a series is a random walk with drift (Campbell & Dufour, 1997), controls for the probability of Type I error in finite samples and is robust to conditional heteroscedasticity, here S_2 has been disregarded for the analysis. Further, Wright (2000) shows that both R_1 and R_2 have better power than that of M_1 and M_2 tests. He also shows that even though the sign-based tests generally have less power than the rank-based tests, they still have more power than the Lo-MacKinlay tests.

4.3.4 Methodology for Joint Market Interaction

The joint efficiency of financial market depicts that the information of one market cannot be used to predict the information of another market. Thus, the joint inefficiency occurs, when the series of two financial markets move jointly in short-run or long-run. As a result, the markets are integrated then these markets are jointly inefficient (Azad, 2009). This study attempts to detect this cointegrating relationship between stock market and foreign exchange market by using Engle–Granger (1987) cointegration test with no structural change and Gregory and Hansen (1996) cointegration test with structural break.

i. Engle-Granger Cointegration Test

Engle and Granger (1987) developed a two-step procedure for common stochastic trend. It is one of the most fundamental and commonly used cointegration techniques, as the process is really simple where linear equations are formed taking each prospective variable as dependent variable in an equation while others remaining variables are independent and assuming the variables are integrated at order I(1) and e_t is I(0). The estimation follows the basic model of;

$$Y_{it} = \mu_{i1} + \beta^T X_t + e_{it} \quad t = 1,2,3 \ldots \ldots, n. \tag{28}$$

Here, the parameter μ is intercept and β is the coefficient of explanatory variable.

Therefore the equations for this study are as follows:

$$P_t = \alpha_t + \beta X_t + \varepsilon_{t_p} \quad t = 1,2,3 \ldots \ldots, n \tag{29}$$

and

$$X_t = \alpha_t + \beta P_t + \varepsilon_{t_x} \quad t = 1,2,3 \ldots \ldots, n \tag{30}$$

Where P_t is the stock price and X_t is the exchange rate and both are integrated at order one I(1). The residuals from these equations are stored for the second step of operation of cointegration test. Here, residuals are tested for stationarity (conduct ADF test for unit root). If the residuals are stationary, then the variables under this study have long-run time-invariant relationship. The ADF tests for residuals with null hypothesis of no cointegration are as follows:

$$\Delta\hat{\varepsilon}_{pt} = \delta\hat{\varepsilon}_{t-1} + \Sigma\beta i \Delta\hat{\varepsilon}_{t-i} + u_t$$

$$\Delta\hat{\varepsilon}_{xt} = \delta\hat{\varepsilon}_{t-1} + \Sigma\beta i \Delta\hat{\varepsilon}_{t-i} + u_t \tag{32}$$

ii. Gregory-Hansen Cointegration Test

The time-invariant nature of Engle and Granger process invokes this study to focus on the cointegration test with structural breaks which may be in the form of changes in intercept or slope or both intercept and slope. Because, it may be correct to have time-invariant relation over long period but after a period there may be a new log run relation, thus a shift or adjustment for new equilibrium is obvious. Gregory and Hansen (1996) formulate models for cointegration test with shifts in long-run relationship. They propose three models with structural break and these are as follows:

a. Level shift (C)

$$Y_{it} = \mu_{i1} + \mu_{i2}\emptyset_{i\tau} + \beta^T X_t + e_{it} \quad t = 1, \ldots \ldots, n. \tag{33}$$

Here, μ_1 is the intercept before shift and μ_2 is the shift in intercept

b. Level shift with trend (C/T)

$$Y_{it} = \mu_{i1} + \mu_{i2}\emptyset_{i\tau} + \alpha_1 + \beta^T X_t + e_{it} \qquad t = 1, \dots\dots.., n. \tag{34}$$

Here this study includes time trend (α_1)in the model.

c. Regime shift (C/S)

$$Y_{it} = \mu_{i1} + \mu_{i2}\emptyset_{i\tau} + \beta^T X_t + \beta^T X_t \emptyset_{i\tau} + e_{it} \qquad t = 1, \dots\dots.., n. \tag{35}$$

Here, this study includes shift in the slope vector.

Each of these structural break models, a dummy variable have been used ($\emptyset_{it}$), which is defined as follows:

$$\emptyset_{i\tau} = \begin{cases} 0 & if\ t \le [n\tau], \\ 1 & if\ t > [n\tau], \end{cases}$$

where the unknown parameter $\tau \epsilon$ (0,1) denotes the relative timing of the change point, and [ ] denotes integer part.

Now, this study sets the empirical models for cointegration with shift in the line of aforementioned models prescribed by Gregory and Hansen. The models are as follows:

For level shift (C)

$$P_{it} = \mu_{i1} + \mu_{i2}\emptyset_{i\tau} + \beta^T X_t + e_{it} \tag{36}$$

$$X_{it} = \mu_{i1} + \mu_{i2}\emptyset_{i\tau} + \beta^T P_t + e_{it} \tag{37}$$

For level shift with trend (C/T)

$$P_{it} = \mu_{i1} + \mu_{i2}\emptyset_{i\tau} + \alpha_1 + \beta^T X_t + e_{it} \tag{38}$$

$$X_{it} = \mu_{i1} + \mu_{i2}\emptyset_{i\tau} + \alpha_1 + \beta^T P_t + e_{it} \tag{39}$$

For regime shift (C/S)

$$P_{it} = \mu_{i1} + \mu_{i2}\emptyset_{i\tau} + \beta^T X_t + \beta^T X_t \emptyset_{i\tau} + e_{it} \tag{40}$$

$$X_{it} = \mu_{i1} + \mu_{i2}\emptyset_{i\tau} + \beta^T P_t + \beta^T P_t \emptyset_{i\tau} + e_{it} \tag{41}$$

Where P_t is the stock price and X_t is the exchange rate series, the cointegration test is performed for both as endogenous variables. The equations for stock price and exchange rate are estimated following standard OLS for each probable feasible break point $\epsilon\, T$. Then like Engle and Granger residual based test, the null of no cointegration has been tested. Here, ADF test on residuals of each of the equation for all probable break in the sample has been conducted against the critical values for different break test presented by Gregory and Hansen (1996).

iii. Granger Causality Test

After conducting cointegration analysis for long run relationship between stock price and exchange rate, the study leads both linear and nonlinear causality test for shortrun connection between them. Granger (1969) proposed Granger-Causality test, one of the most basic mechanisms to detect linear causal relationship between two variables following simple vector autoregressions (VAR):

$$X_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{j=1}^{n} \beta_j X_{t-j} + \mu_{1t} \tag{42}$$

$$Y_t = \alpha_0 + \sum_{i=1}^{m} \gamma_i X_{t-i} + \sum_{j=1}^{m} \delta_j Y_{t-j} + \mu_{2t} \tag{43}$$

In case of two variables X and Y, with the assumption of uncorrelated disturbances (μ_{it} and μ_{2t}), equation (42) shows the influence of lagged Y on the X and equation (43) represents the influence of lagged X on the Y. The null hypothesis of absence of causal relationship between X and Y variable is confirmed, unless $\sum \alpha_i$ and $\sum \gamma_i$ both are significantly different from zero. The study checks their significance through standard F test. For stock price and exchange rate granger–causal relationship, following equations are used:

$$P_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i X_{t-i} + \sum_{j=1}^{n} \beta_j P_{t-j} + \mu_{1t} \quad (44)$$

$$X_t = \alpha_0 + \sum_{i=1}^{m} \gamma_i P_{t-i} + \sum_{j=1}^{m} \delta_j X_{t-j} + \mu_{2t} \quad (45)$$

There are two shortcomings of Granger causality test, one is specification bias that is the influence of other variables on dependent variables and the other is the spurious regression because of non-stationarity in time series. (Gujarati, 1995)

iv. Non-linear Granger Causality Test

Since granger causality test is not applicable for capturing nonlinear causality. To check non-linear relationship between the variables, the study opts to nonlinear granger causality test. To this end, this study has used Diks and Panchenko (2006) test.

If the lagged vectors are $X_t^{L_x} == (X_{t-L_x+1,\ldots\ldots,}X_t)$ and $Y_t^{L_y} == (Y_{t-L_y+1,\ldots\ldots,}Y_t)$with the lag of X and Y greater or equal to 1, $(L_x, L_y \leq 1)$, then the null hypothesis of information contained in $X_t^{L_x}$ has nothing to express beyond $Y_t^{L_y}$, that is L_{t+1} explained as;

$$H_0: Y_{t+1} \left| \left(X_t^{L_x};\, Y_t^{L_y}\right) - Y_{t+1} \right| Y_t^{L_y} \quad (46)$$

Now, the test statistics of DP test follows;

$$T_n(\varepsilon_n) = \frac{n-1}{n(n-2)}\sum_i^n \begin{pmatrix} \hat{f}x,z,y(X_i,Z_i,Y_i)\hat{f}y(Y_i) - \\ \hat{f}x,y(X_i,Y_i)\hat{f}y(Y_i,Z_i) \end{pmatrix} \quad (47)$$

Where, ε_n is the bandwidth as per the sample size n and $f_w(W_i)$ is local density estimator of a d_w variate random vector W at W_i (for details of test statistics please see appendix A). For $l_x = l_y = 1$, if $\varepsilon_n = Cn^{-\beta}$ $(C > 0, \frac{1}{4} < \beta < \frac{1}{3})$ then test statistics is asymptotic to normal distribution. For drawing statistical decision for this test statistics, the study follows Diks and Panchenko's way of one tail test.

4.3.5 Methodology for Volatility Dynamics

To detect volatility in stock market and foreign exchange market, this study follows the autoregressive conditional heteroscedastic (ARCH) process and its extension such as generalized ARCH models both in terms of symmetric and non-symmetric volatility. The study further analyses the volatility clustering and leverage effect for each market. Finally, the multivariate GARCH model has been applied to capture existence and direction of the volatility spillover from one market to another.

i. ARCH Effect Detection:

As this study conducted on stationary time series, while the time series often have the conditional variances that change over time, therefore, it applies generalized autoregressive conditional heteroscedastic (GARCH) Model. Therefore it is rather more sensible, before estimating GARCH models to detect the conditional heteroscedasticity (ARCH effects) in each series. Here, the lagrange multiplier (LM) test for ARCH effects proposed by Engle (1982) is used to detect the hetroscedasticity in residual for each stock return and exchange rate return series. The test requires the residuals from an ordinary least square (OLS) regression of conditional mean equation. Here, this study uses AR (1) process for both series and conditional mean equation as follows:

$$\Delta P_t = \beta P_{t-1} + u_{pt} \tag{48}$$

$$\Delta X_t = \beta X_{t-1} + u_{xt} \tag{49}$$

After running the above regressions, residuals u_{pt} and u_{xt} are saved. Then squared residuals are regressed, the regression equation would be,

$$\hat{u}_{pt}^2 = p_1 + p_2\hat{u}_{rt-1}^2 + p_3\hat{u}_{rt-2}^2 + \cdots + p_q\hat{u}_{rt-q}^2 + v_{pt} \tag{50}$$

$$\hat{u}_{xt}^2 = x_1 + x_2\hat{u}_{xt-1}^2 + x_3\hat{u}_{xt-2}^2 + \cdots + x_q\hat{u}_{xt-q}^2 + v_{xt} \tag{51}$$

Where v_{pt} stands for the error term of stock price in squared residual equation and v_{xt} is the error term of exchange rate squared residual equation. Where the null hypothesis of no ARCH effect for each of the squared residual of the stock return and the exchange rate return has been examined against the test statistics, which is the number of observations multiplied by the coefficient of multiple correlation. The test follows χ^2 distribution with q degrees of freedom.

ii. Univariate Volatility Analysis-GARCH Model

Engle (1982) recommended a model with systematical time variant variance of return where conditional variance is the function of previous squared residuals from the return, known as autoregressive conditional heteroskedastic (ARCH) model. Later, Bollerslev (1986) generalised the ARCH models as GARCH that extends the dependence of conditional variance on its earlier lagged value and that is the generalization of ARCH model (GARCH). This study follows GARCH specification rather than ARCH model because the GARCH model is more parsimonious and less likely to breach non-negativity constraints (Brooks, 2008, p. 393).

Symmetric GARCH VS Asymmetric GARCH

Symmetric GARCH models assumes that the equal effect of good or bad news on volatility while asymmetric GARCH shows the asymmetry and the leverage effects on the volatility. Here, this study will use both symmetric and asymmetric GARCH model and then compare the results for both types to define which one is more parsimonious for the study.

Symmetric GARCH

GARCH (p, q) Model: The generalized ARCH model denoted as GARCH (p, q) model, where p is the number of lagged variance term and q is the number of lagged squared residuals of the return. It is proved as adequate model and very popular to use GARCH (1, 1) specification (Brooks, 2008, p. 393-394). Therefore the mean and variance equation would be,

Mean equation: $y_t = a_o + \beta y_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_t^2)$ (52)

Variance equation: $\sigma_t^2 = \omega_o + \delta_1 \sigma_{t-1}^2 + \gamma_1 \varepsilon_{t-1}^2; \quad \omega_o, \delta_1, \gamma_1 >= 0$ (53)

Where in mean equation, y_t is asset return, a_o is the constant term, β is the coefficient of past return (γ_{t-1}) and ε_t is the disturbance term which is independently and identically distributed (iid) with mean zero and time-varying conditional variance.

While in variance equation, σ_t^2 is conditional variance, ω_o is constant term representing the long term independent variance, σ_{t-1}^2 is the GARCH term showing forecasted variance at time t-1, ε_{t-1}^2 is the ARCH term that is past squared residual from mean equation and all the parameters are non-negative i.e. $\omega_o, \delta_1, \gamma_1 >= 0$.

Here, the mean equation shows how past return and constant term explain the current return of a series. Actually, this mean equation is the example of AR (1) process. On the other hand, variance equation represents time–varying relationship where conditional variance is explained by past variance and past squared error or disturbance term from the mean equation. The power of past variance explains how the variability of any series is dependent to the past variability of that series, that is, volatility clustering effect and the strength of squared residuals from mean equation identifies how the arrival of news could affect the variance of the series.

iii. Univariate Volatility Analysis-EGARCH Model

The exponential GARCH or EGARCH model developed by Nelson in 1991 explains the asymmetry in volatility response for positive and negative shock (good or bad news). Here the conditional variance equation can be written in GARCH (1, 1) as;

$$ln\sigma_t^2 = \omega_o + \delta_1 ln\sigma_{t-1}^2 + \gamma_1 \frac{\varepsilon_{t-1}}{\sqrt{ln\sigma_{t-1}^2}} + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{ln\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] \tag{54}$$

Where, $ln\sigma_t^2$ is logarithm of conditional variance, ω_o is constant, δ_1 is the coefficient of past conditional variance, γ_1 is for detecting information asymmetry through the sign of past error term, that is if $\gamma_1 < 0$ means significant negative relationship between volatility and return and eventually captures the leverage effect, α is for capturing how conditional variance varies with the changes of news relative to its corresponding expectation through the difference between absolute lagged error term $\frac{|\varepsilon_{t-1}|}{\sqrt{ln\sigma_{t-1}^2}}$ and expected value $\sqrt{\frac{2}{\pi}}$.

This model improves the pure GARCH specification by two ways, firstly it allows asymmetries in response of volatility against good news and bad news along leverage effect and secondly, the models doesn't require artificial imposition of non-negativity constraints, because of log of conditional variance is positive, even if the parameters (δ_1, γ_1 and α) become negative. (Brooks, 2008; p. 406)

iv. Volatility Spillover Analysis-Bivariate EGARCH Model

This study followed the Kim *et al.* (2003) to capture the volatility spillover from one market to another. This model is an extension of Nelson (1991) univariate EGARCH (1, 1) model. Different authors (Jebran & Iqbal 2016; Mozumder *et al.*, 2015; Kumar, 2013; Caporale *et al.*, 2013) have used and recommended EGARCH model for volatility relationship between stock market and foreign exchange market. Like other GARCH model, it has two equations, one mean (return) equation and another is conditional variance equation. Therefore, the bivariate return equations can be written as follow;

$$P_t = a_o + \beta_1 P_{t-1} + \beta_2 X_{t-1} + \varepsilon_{pt} \quad (55)$$

$$X_t = a_o + \beta_1 P_{t-1} + \beta_2 X_{t-1} + \varepsilon_{xt} \quad (56)$$

The return equation for stock return denoted in equation (55) where the dependent variable is stock return (P_t) and the explanatory variable is one day lag of stock return (P_{t-1}) having coefficient of β_1 and one day lag of exchange rate return (X_{t-1}) having coefficient of β_2 and residuals of stock return is (ε_{pt}). Therefore, this equation will identify the return spillover from exchange rate to stock price. On the other hand, the return equation for exchange rate return denoted in equation (56) where the dependent variable is exchange rate return (X_t) and the explanatory variable is one day lag of stock return (P_{t-1}) having coefficient of β_1 and one day lag of exchange rate return (X_{t-1}) having coefficient of β_2 and residuals of exchange rate return is (ε_{xt}). Therefore, this equation will identify the return spillover from stock price to exchange rate.

Variance equation would be,

$$ln\sigma_{p,t}^2 = \omega_o + \delta_1 ln\sigma_{p,t-1}^2 + \gamma_1 \frac{\varepsilon_{p,t-1}}{\sqrt{ln\sigma_{p,t-1}^2}} + \alpha_1 \left[\frac{|\varepsilon_{p,t-1}|}{\sqrt{ln\sigma_{p,t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] + \gamma_2 \frac{\varepsilon_{x,t-1}}{\sqrt{ln\sigma_{x,t-1}^2}} +$$

$$\alpha_2 \left[\frac{|\varepsilon_{x,t-1}|}{\sqrt{ln\sigma_{x,t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] \quad (57)$$

$$ln\sigma_{x,t}^2 = \omega_o + \delta_1 ln\sigma_{x.t-1}^2 + \gamma_1 \frac{\varepsilon_{x,t-1}}{\sqrt{ln\sigma_{x,t-1}^2}} + \alpha_1 \left[\cdot \frac{|\varepsilon_{x,t-1}|}{\sqrt{ln\sigma_{x,t-1}^2}} \quad \sqrt{\frac{2}{\pi}} \right] + \gamma_2 \frac{\varepsilon_{p,t-1}}{\sqrt{ln\sigma_{p,t-1}^2}} +$$

$$\alpha_2 \left[\frac{|\varepsilon_{p,t-1}|}{\sqrt{ln\sigma_{p,t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] \quad (58)$$

The conditional variance equation of stock return shown in equation (57) where like univariate EGARCH specification it contains volatility clustering effect by past conditional variance of stock return ($ln\sigma_{p,t-1}^2$) with coefficient of δ_1; leverage effect by past news of stock return denoted by past standardized residual $\frac{\varepsilon_{p,t-1}}{\sqrt{ln\sigma_{x\ t-1}^2}}$ having its coefficient of (γ_1), news effect relative to its expectation in stock return $\left[\frac{|\varepsilon_{p,t-1}|}{\sqrt{ln\sigma^2_{p,t-1}}} - \sqrt{\frac{2}{\pi}}\right]$ shown in (α_1). The equation (57) have another two explanatory variables to explain the volatility spillover from exchange rate to stock price, where γ_2 shows the leverage effect of past news from exchange rate return denoted by past standardized residual of exchange rate $\frac{\varepsilon_{x,t-1}}{\sqrt{ln\sigma^2_{x,t-1}}}$; and α_2 captures past news effect of exchange rate relative to its expectation $\left[\frac{|\varepsilon_{x,t-1}|}{\sqrt{ln\sigma^2_{x,t-1}}} - \sqrt{\frac{2}{\pi}}\right]$, and this residual exchange rate actually derived from the return equation of exchange rate (56).

The conditional variance equation of exchange rate return, where volatility spillover from stock price to exchange rate will be evaluated, shown in equation (58) where δ_1 captures the effect of past conditional variance (volatility clustering effect) of exchange rate return $(ln\sigma^2_{x,t-1})$, γ_1 captures leverage effect of past news of exchange rate return denoted by past standardized residual $\frac{\varepsilon_{x,t-1}}{\sqrt{ln\sigma^2_{x,t-1}}}$, α_1 presents the past news effect of exchange rate return relative to its expectation $\left[\frac{|\varepsilon_{p\,t-1}|}{\sqrt{ln\sigma^2_{p,t-1}}} - \sqrt{\frac{2}{\pi}}\right]$, γ_2 shows the leverage effect of past news from stock return denoted by past standardized residual of stock return $\frac{\varepsilon_{x,t-1}}{\sqrt{ln\sigma^2_{x,t-1}}}$; and α_2 captures past news effect of stock return relative to its expectation $\left[\frac{|\varepsilon_{x,t-1}|}{\sqrt{ln\sigma^2_{x,t-1}}} - \sqrt{\frac{2}{\pi}}\right]$, and this residual stock return actually derived from the return equation of stock price (55). Obviously, the latter two coefficients are for volatility spillover from stock price to exchange rate.

For the optimization of GARCH models, the BFGS algorithm is applied. In all GARCH estimation, this study exclusively followed normal error distribution.

The robustness of each of the GARCH models can be evaluated using a number of diagnostics tests. The Ljung-Box (1978) Q test statistics will be used to examine the null hypothesis of no autocorrelation in the estimated squared standardized residuals up to a specific lag. Also, Engle's (1982) LM test will be used to test the null hypothesis of no remaining ARCH effects up to a specific order. In fact, if GARCH model is specified correctly, then the estimated standardized residuals should behave like white noise, i.e., they should not display serial correlation, ARCH effect, or any other type of non-linear dependence.

4.4 Conclusion

This study of stock price and exchange rate dynamics are evaluated in terms of efficiency explored in the econometric methodology where the logarithm of stock price and exchange rate and first difference of both the series (return series) are shown. The examination of stationary process will be conducted for all the series and the series contains the stationary process will be used as the variable for the whole study. Therefore, the unit root test is not only the test for weak form efficiency but also the test of selecting stationary variable for further analysis. Then in all case, this study follows the return series in the methodology. The variance ratio test, autocorrelation test, and runs test are used for investigating random walk hypothesis of each of the return series to identify the weak form of efficiency in those markets. After that, the joint market interactions are evaluated in long-term (Engle-Granger cointegration methods and Gregory Hansen cointegration method) and short-term basis (Granger causality method and Diks and Panchenko nonlinear causality method). If any discrepancy found in the results of both long-run methods, this study will take Gregory Hansen test because of considering break in this study. While if there is any difference in short-run results, it will take the result of nonlinear causality method upon the existence of nonlinearity in the series. Finally, the dynamics of stock price and exchange rate volatility methods are shown.

Chapter 5

Research Results and Discussion

5.1 Introduction

This chapter offers a discussion of the empirical results of the stock price and exchange rate dynamics in Bangladesh over the period of June 2003 to December 2016. The chapter begins with a discussion of the descriptive statistics of the variables used in econometric analysis in Section 5.2. Then the chapter discusses the estimation results found by econometric analysis. Discussion of estimation results follows a sequential line of analysis for individual efficiency, joint efficiency and causality and finally volatility dynamics. Individual efficiency for both stock market and foreign exchange market in Bangladesh has been explained in Section 5.3, while Section 5.4 shows joint efficiency and causality and finally Section 5.5 depicts volatility within and between stock and foreign exchange market.

5.2 Summary Statistics and Preliminary Analysis

The summary statistics for both stock price and exchange rate of BDT/USD at their level and first difference are shown in Table 5.1 and Table 5.2, respectively. Each of the tables contains descriptive statistics for respective series for sample period I (June 02, 2003, to January 25, 2013) and sample period II (January 28, 2013, to December 30, 2016).

Table 5.1 firstly presents lower mean value for both the series (stock price and exchange rate at level) in sample period I than sample period II. For sample period I, the daily average stock index value is 7.86 (in actual term after antilog transformation 2612), while average exchange rate of BDT/USD is 4.226 (in actual term BDT 68.5 per USD). For sample period II, the daily average stock index is 8.40 (in actual term 4459), while average exchange rate of American dollar is 4.356 (in actual term BDT 78 per USD).

Secondly, the variability in the series has been shown by the standard deviation of each series. Here the standard deviation for stock price series is 62.75 percent and for exchange rate series is 9.1 percent in sample period I. Whereas, in sample period II, the standard deviation for stock price series is 8.02 percent and for exchange rate series is 0.61 percent. Therefore, stock price has greater variability than exchange rate for both sample periods. In addition, the sample period I shows higher standard deviation for both series than sample period II. Especially, standard deviation of stock price in sample period I is substantially higher than sample period II. Thus, both sample period presents exchange rate as less variable than stock price series.

Thirdly, here both periods show negative skewness for stock price and positive skewness for exchange rate. As a result, stock prices are skewed left presenting heavier left tail whereas exchange rate series are skewed right presenting heavier right tail.

Table 5. 1 : Descriptive Statistics for Data at Level

	Period I (June 2 2003 to January 27 2013)		Period II (January 27 2013 to December 30 2016)	
	Stock Price	Exchange Rate	Stock Price	Exchange Rate
Mean	7.868065	4.226737	8.402689	4.356657
Standard Deviation	0.627597	0.091900	0.080293	0.006124
Skewness	-0.027327	0.124807	-0.901174	1.007444
Kurtosis	2.016486	2.886896	3.901049	3.498313
Jarque-Bera	101.880	7.886	173.411	183.991
Observations	2520	2520	1025	1025
Correlation Matrix				
Stock Price		0.738538		-0.030133
Exchange Rate	0.738538		-0.030133	

Note: All the series are log-transformed.

Fourthly, in sample period I, the kurtosis is 2.016 to 2.886 and less than 3. This describes the flat peaks around the mean. Hence, this indicates fat tails for each series (platykurtic distribution). On the other hand, in sample period II, the kurtosis is 3.498 to 3.901 that is higher than 3. This describes the sharp peaks around the mean. Hence, this indicates thin tails on both sides of each series (leptokurtic distribution).

Finally, Jarque-Bera statistics are statistically significant for both series and reject the null hypothesis of normal distribution.

The correlation matrix shows that stock price and exchange rate is highly positively correlated in sample period I and negatively correlated in sample II.

Table 5.2 presents the descriptive statistics for stock price and exchange rate at first difference or return data. Firstly, in sample period I, the daily average stock return is 0.065 percent while average exchange rate return of US dollar is 0.012. On the other hand, in sample period II, the daily average stock return is 0.0185 percent while average exchange rate return of US dollar is -0.093 percent. Therefore, the sample period I shows greater mean values for both series than sample period II.

Secondly, in sample period I, the standard deviation for stock return series is 1.6 percent and exchange rate return series is 0.31 percent. Meanwhile, in sample period II, the standard deviation for stock return series is 0.84 percent and for exchange rate returns series is 0.079 percent. Therefore, stock return has greater variability than exchange rate return series. The sample period I show higher standard deviation for both series than those in sample period II. Therefore, both sample periods present stock return with greater variability than exchange rate return series.

Thirdly, here both periods show negative skewness for stock return and positive skewness for exchange rate return. As a result, stock return series are skewed left presenting heavier left tail whereas exchange rate return series are skewed right presenting heavier right tail.

Table 5. 2: Descriptive Statistics for Data at First Difference

	Period I (June 2 2003 to January 27 2013)		Period II (January 27 2013 to December 30 2016)	
	Stock Return	Exchange Return	Stock Return	Exchange Return
Mean	0.000659	0.000121	0.000185	-933E-06
Standard Deviation	0.016123	0.003175	0.008463	0.000793
Skewness	-0.128148	2.852897	-0.122191	2.456142
Kurtosis	29.50185	118.1237	10.23098	67.47566
Jarque-Bera	73753.44	1395033	2235.643	178573.9
Observations	2520	2520	1025	1025
Correlation Matrix				
Stock Return		0.007262		0.002441
Exchange Return	0.007262		0.002441	

Note: All the series are log-transformed and first differenced.

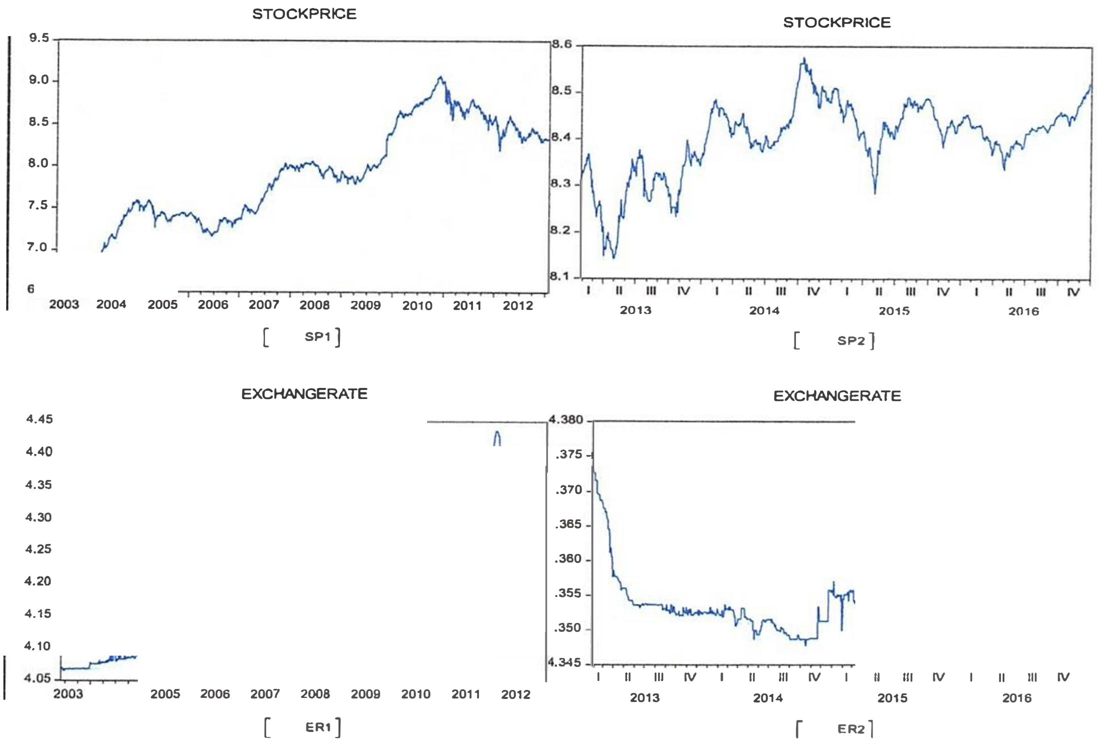
Fourthly, both the kurtosis is higher than 3 for all return series. This describes the sharp peaks around the mean. Hence, this led to thin tails on both sides of each series (leptokurtic distribution).

Finally, Jarque-Bera statistics is statistically significant for both series and reject the null hypothesis of normal distribution.

The correlation matrix shows that stock return and exchange rate return is positively correlated in both sample periods.

The time series plot has been shown in Figure 5.1 to present the scenario of both stock price and exchange rate BDT/USD over the sample period.

Figure 5. 1: Stock Price and Exchange Rate Series



Note: SP1 and ER1 represent stock price and exchange rate series respectively, for sample I. SP2, ER2 represent price series for sample period II.

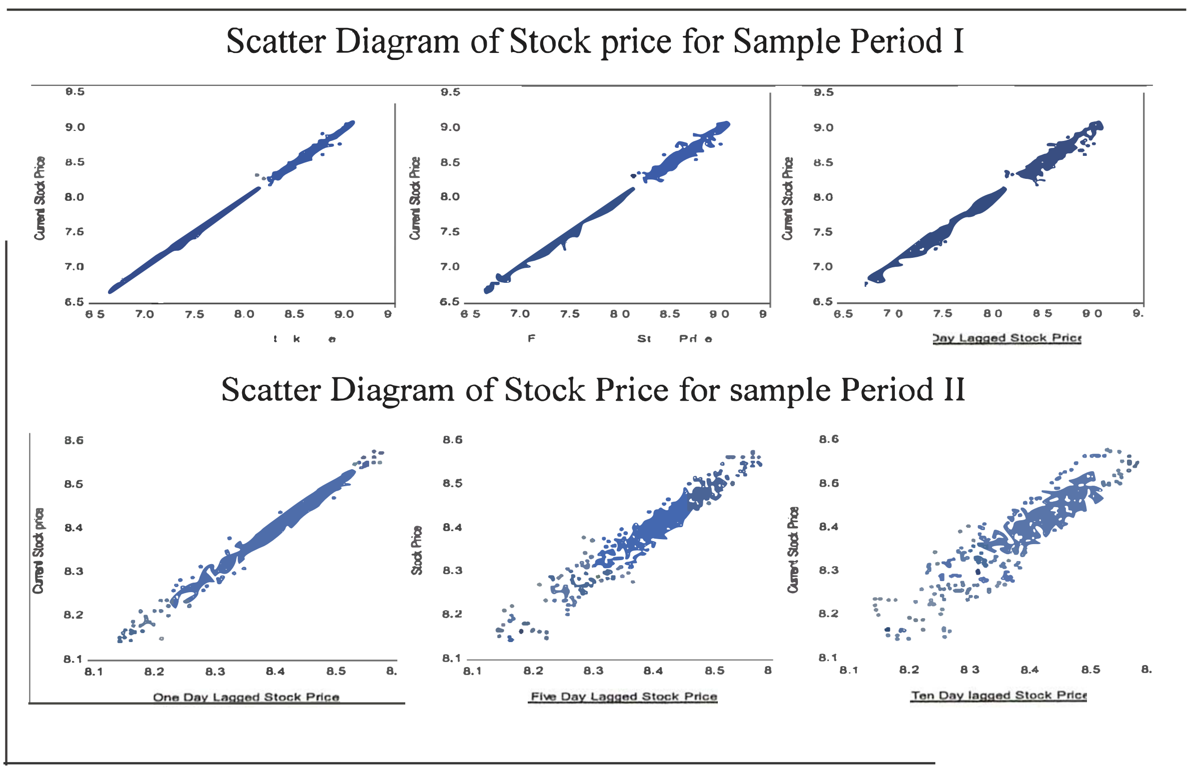
Figure 5.1 represents the stock price data for sample period I and sample period II by SP1 and SP2, respectively, and exchange rate for sample period I and II by ER1 and ER2 return, respectively. Here, from SP1, one can easily identify a gradual rising trend from 2003 to 2009, momentum of heavy price ups from mid-2009 to late 2010 and then abrupt fall, finally stabilized from the mid-2012 with regular ups and down. And SP2 continues with regular market movement within range of natural log of stock price 8.15 to 8.55 up to 2016.

On the other hand, ER1 shows a long stable exchange rate from the beginning 2007 to late 2010 with very little variation. Prior to 2007, it was a heavy price appreciation of

American Dollar from 2005 to mid-2006. Starting from the end of 2010 to 2012, a quick upsurge leads the exchange rate to a new stabilized rate. While ER2 presents exchange rate for sample period II where a fall in exchange rate observed in 4th quarter of 2013 and continues the depreciation of US dollar up to fourth quarter of 2014. The rise of exchange rate at end of 2015 and 2016 appreciates US dollar in Bangladesh.

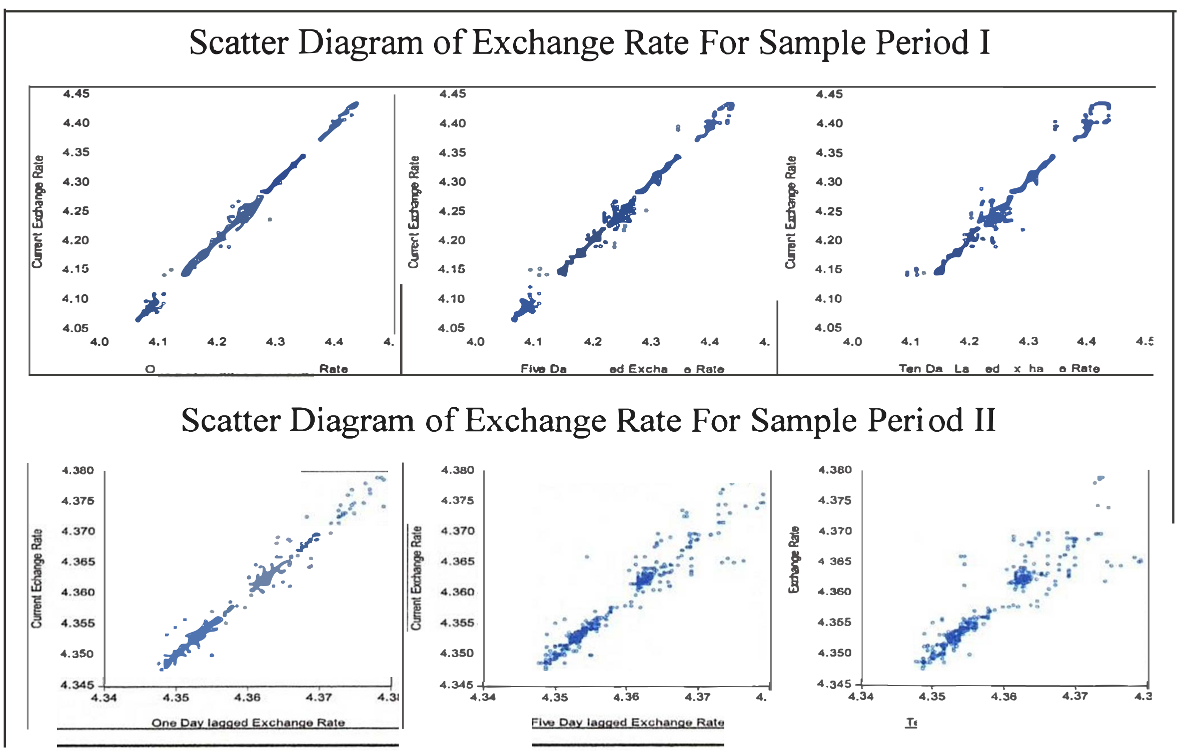
After the descriptive statistics to define the normality of the series, and time series plot for market scenario over the time, Graphical method like scatter diagram is used to roughly show one of the very common features of time series, dependency on past data.

Figure 5. 2a: Current Stock Price vs. Past Stock Price



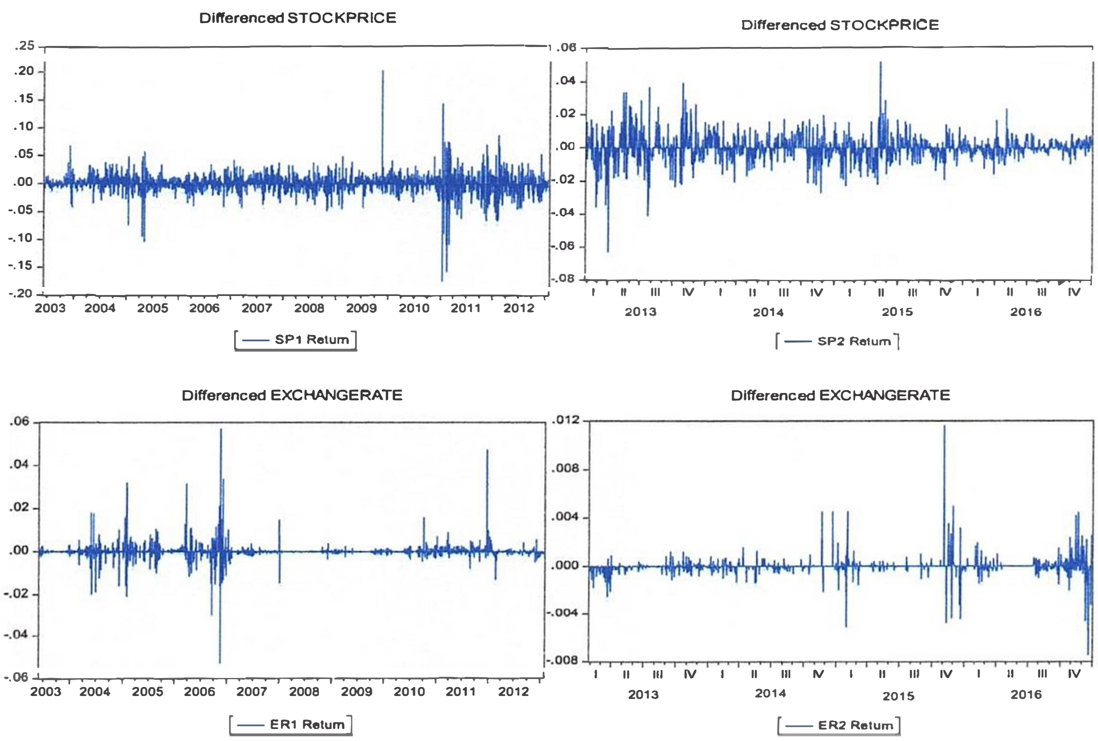
All the six scatter diagrams in Figure 5.2a presents the dependency of stock price to its different past value, the more the straighter the line, the more the connectivity between stock price to its past value, as the current stock price on the vertical axis changes along the changes of its lagged value on the horizontal axis. While figure 5.2b presents current exchange rate vs. past exchange rate on six diagrams, where like stock price, exchange rate simultaneously changes with its lagged value, though some shift from upward sloping straight line is evident because of abrupt change in some days. Nonetheless, both the figure portrays another stylized fact that stock price and exchange rate series both are positively related to its own past value and the relationship is strong for nearby lags and weak for distant lags.

Figure 5. 2b: Current Exchange Rate vs. Past Exchange Rate



Another stylized fact for time series data, positive dependence between absolute return on nearby lags, that is, volatility clustering can be shown by the graphical presentation of the first difference of both data series. As the first difference of stock price shows the return from stock market and first difference of exchange rate presents the exchange rate return. Here in Figure 5.3 shows return series on vertical axis and year on the horizontal axis; where SP1 return and SP2 return represent stock price return for sample period I and II, respectively, and ER1 return and ER2 return represent exchange rate return series for sample period I and II, respectively.

Figure 5. 3: Stock Return and Exchange Rate Return



Note: SP1 return and ER1 return represent stock price return and exchange return respectively for sample I and SP2 return and ER2 return represent return series for sample period II.

Actually, all return series figure indicate time-varying volatility (volatility clustering) character, that a small changes followed by a small change and the large variance followed by large variance.

5.3 Results of Individual Efficiency

- **Parametric Tests for Individual Efficiency**

i. ADF Test Results

The unit root of two series at their level and first differences for sample period I and sample period II are shown through ADF test in Table 5.3. In Panel A for sample period I, the results show the rejection of null hypothesis of unit root for all equations of ADF test for both the first differenced series of exchange rate and stock price at 1 percent significance level. Therefore, the stationarity of the series is only achieved at the first difference series from this study indicating the non-randomness of the return series.

In Panel B for sample period II, the results show the rejection of null hypothesis of unit root for all equations of ADF test for both the first differenced series of exchange rate and stock price at 1 percent significance level and only exchange rate at level rejects the null hypothesis at 5 percent and 1 percent significance level for with constant and with constant and trend equation, respectively.

Table 5. 3: ADF Test Results

Panel A: Sample Period I				
	Stock Price		*Exchange Rate*	
Model	At level	At First Differences	At level	At First Differences
No Constant	2.058	-54.189***	2.382	-63.112***
With Constant	-1.880	-54.276***	-0.813	-63.218***
With Constant and Trend	-0.846	-54.322***	-1.677	-63.205***
Panel B: Sample Period II				
	Stock Price		*Exchange Rate*	
Model	At level	At First Differences	At level	At First Differences
No Constant	0.495	-11.092***	-0.356	-34.399***
With Constant	-2.029	-11.101***	-2.782**	-34.386***
With Constant and Trend	-2.682	-11.099***	-4.135***	-34.470***

Notes:
a. H_o: Series contains a unit root
b. *** represents significance at 1% level.

ii. KPSS Test Results

KPSS test has improved the power of non-stationary process unlike ADF test and the test has been estimated with the null hypothesis of stationarity in the level series (price series) and first differences series (return series) of both exchange rate and stock price. The test results of KPSS test has been presented in Tables 5.4 and it clearly shows that stock price and exchange rate series both are non-stationary at their level as the null hypothesis of stationary process cannot be accepted at 1 percent level of significance.

Table 5. 4: KPSS Test Results

Panel A: Sample Period I				
	Level Series		*First Differenced Series*	
Model	Stock Price	Exchange Rate	Stock Return	Exchange Rate Return
With Constant	5.471***	4.920***	0.334	0.094
With Constant and Trend	0.326***	0.625***	0.121	0.093
Panel B: Sample Period II				
	Level Series		*First Differenced Series*	
Model	Stock Price	Exchange Rate	Stock Return	Exchange Rate Return
With Constant	1.586***	1.632***	0.046	0.402
With Constant and Trend	0.511***	0.653***	0.049	0.092

Notes:
a. H_o: Series is stationary
b. *** represents significance at 1% level.

That is stock price and exchange rate are random and cannot be predicted by their past price or rate. However, the results turn into the acceptance of null when this study use first differenced data (return series) for both stock price and exchange rate and proves that the past return has its repetition on the future return. Since ADF test results on exchange rate series for sample period II (Panel B) is not the same as that of KPSS test results, this study accepts the KPSS results because of the superiority of KPSS over ADF test. (Ya & Yuntan, 2010)

Now, for sample period I, both tests (ADF and KPSS) lead to same results for stock market and exchange market inefficiency. Therefore, stock price produces the return which can be predicted by its past return which is consistent with the findings of Karim (2013) and so does exchange rate of American dollar in terms of Bangladeshi taka which is in the same line of conclusion by Palermo (2003), Sifunjo *et al.* (2008), Mabakeng and Sheefeni (2014).

iii. Zivot-Andrews Unit Root Test Results

Zivot Andrews (ZA) test results presented in Table 5.5 indicate the stock return and exchange rate return series do not contain unit root at 1 percent significance level, thereby rejecting the randomness in the first-differenced series and indicating the stationarity while assuming single break in each of the models for both sample periods.

Table 5. 5: Zivot Andrews Test Results

	Panel A: Sample Period I			
	Level Series		*First Differenced Series*	
Model	Stock Price	Exchange Rate	Stock Return	Exchange Return
Level	-2.317	-2.652	-35.250***	-63.374***
	7/26/2011	1/2/2008	12/6/2010	4/3/2006
Trend	-2.274	-2.058	-35.095***	-63.234***
	10/14/2010	2/3/2005	1/20/2010	8/16/2011
Level and Trend	-3.994	-3.123	-35.274***	-63.449***
	11/16/2009	11/16/2006	12/6/2010	3/31/2006
	Panel B: Sample Period II			
	Level Series		*First Differenced Series*	
Model	Stock Price	Exchange Rate	Stock Return	Exchange Return
Level	-4.292	-5.271	-11.358***	-25.175***
	10/28/2013	11/4/2015	10/14/2014	12/4/2015
Trend	-4.082	-4.313	-10.689***	-34.625***
	1/24/2014	8/15/2014	3/24/2016	30/8/2013
Level and Trend	-4.370	-5.026	-11.370***	-25.165***
	10/28/2013	11/4/2015	2/4/2014	12/4/2015

Notes:

a. H_o: Series contains a unit root
b. *** indicates significance at 1% level
c. Date is written as month-date-year.

For sample period I (Panel A), since the superiority of model ZA test considering combined break at level and trend over other two ZA models guides this study to accept break in stock return and exchange return at December 06, 2010, and March 31, 2006, respectively. For sample period II (Panel B), this model finds break in stock return and exchange return at October 14, 2014, and April 12, 2015, respectively.

iv. Variance Ratio Test Results

Since both ADF and KPSS test results deny the necessary condition of non-stationary process of random walk for return series while approves for price series of stock price and exchange rate. This study uses Lo and MacKinlay variance ratio test for both return series and test results presented for sample period I and sample period II in Table 5.6. The Lo and MacKinlay variance ratio test have been performed assuming homoscedasticity (M_1) and heteroscedasticity (M_2).

From the Table 5.6, the test statistics are highly significant for the lag of 2, 5, 10, 20, 30 and 40 for stock price return series in both cases of homoscedasticity and heteroscedasticity. While the exchange rate return series indicates the rejection of martingale process for the entire lag of 2, 5, 10, 20, 30 and 40 in case of homoscedasticity and heteroscedasticity.

Therefore, in both cases of Lo-MacKinlay variance ratio reject the random walk or martingale process for stock price return series and exchange rate return series.

Table 5. 6: Variance Ratio Test Statistics

Panel A: Sample Period I

	Stock Price		Exchange Rate	
Lags (k)		M_2	M_1	
2	-28.238***	-7.437***	-30.531***	-3.417***
5	-18.713***	-6.226***	-19.097***	-2.725***
10	-13.643***	-5.435***	-13.585***	-2.473***
20	-9.650***	-4.408***	-9.684***	-2.236**
30	-7.890***	-3.826***	-7.919***	-2.089**
40	-6.838***	-3.435***	-6.854***	-1.992**

Panel B: Sample Period II

	Stock Price		Exchange Rate	
Lags (k)	M_1	M_2		
2	-17.254***	-8.209***	-16.252***	-3.957***
5	-12.136***	-6.636***	-11.985***	-3.763***
10	-8.564***	-5.249***	-8.643***	-3.271***
20	-6.123***	-4.189***	-6.141***	-2.745***
30	-5.006***	-3.593***	-5.044***	-2.422**
40	-4.352***	-3.202***	-4.372***	-2.204**

Notes:

a. H_o: Variance of a series follows random walk

b. ***, ** represent significance at 1% and 5% level, respectively.

c. M_1, M_2 represent Lo and MacKinlay (1988) test statistics assuming homoscedasticity and heteroscedasticity, respectively.

- **Non-Parametric Test for Individual Efficiency**

As non-parametric test does not assume normality, linearity and constant variance in the series, this study employs some non-parametric measure of randomness of series to strengthen and complement the analysis for individual efficiency.

i. Autocorrelation Test Results

The autocorrelation test on stock return and exchange return series have been analyzed by Ljung-Box Q statistics with the null of no serial correlation between each series to own different lags. The following Table 5.7 summarizes the results of Ljung-Box Q statistics up to 50 lags.

Table 5. 7: Summary of Autocorrelation Test

	Sample Period I				Sample Period II			
	Stock Return		Exchange Rate Return		Stock Return		Exchange Rate Return	
Lags	Q-stat	P-value	Q-stat	P-value	Q-stat	P-value	Q-stat	P-value
1	15.553	0.00	130.17	0.00	0.2106	0.646	5.3988	0.02
2	23.843	0.00	134.09	0.00	4.5881	0.101	8.3553	0.015
3	24.183	0.00	138.27	0.00	16.544	0.001	8.6389	0.034
4	25.343	0.00	140.91	0.00	20.845	0.00	9.5065	0.05
5	25.937	0.00	141.71	0.00	42.942	0.00	10.576	0.06
10	69.851	0.00	190.98	0.00	54.951	0.00	18.371	0.049
20	99.645	0.00	274.19	0.00	64.122	0.00	44.292	0.001
30	127.56	0.00	299.44	0.00	76.914	0.00	65.288	0.00
40	139.93	0.00	324.46	0.00	94.415	0.00	95.587	0.00
50	148.8	0.00	367.15	0.00	99.864	0.00	99.542	0.00

Notes:

a. H_0: Series is not serially correlated

b. $Q_{LB} = n(n+2)\sum_{k=1}^{m}\frac{\rho^2(k)}{n-k}$, where, $(\rho)k$ is the K^{th} order of autocorrelation coefficient $\rho(k) = \frac{Cov(y_t, y_{t-k})}{Var(y_t)}$, here y_t is the covariance-stationary time series.

c. Zero p-value indicates significance at 1% level and level of significance is assumed to be 5%.

The results indicate rejection of null, because, most of the observations in a series have the zero percent probability of no correlation to their lagged value. Hence both stock return and exchange return have a serial correlation between their own lags. The only exception to the overall autocorrelation test or stock return for sample period II is that DSEX return shows no autocorrelation for lag 1 and 2.

ii. Runs Test Results

The runs test has been utilized on the stock return and exchange rate return series and the observed results are displayed in Table 5.8.

From the Table 5.8 showing runs test results, it can easily be identified that there is significant difference between observed number of runs and expected number of runs. As a result, the test statistics significantly reject the null hypothesis of independence for each series, that is, both the series are not random. Here the negative z value for both series indicates greater expected number of runs than observed number of runs and positive serial correlation of each series.

Table 5. 8: Runs Test

	Sample Period I		Sample Period II	
	Stock Price	Exchange Rate	Stock Price	Exchange Rate
Number of obs	2520	2520	1025	1025
Number above cutoff	1024	1086	407	376
Number below cutoff	1496	1434	618	649
Number of runs	594	543	271	177
E(R)	1216.797	1236.971	491.782	477.144
Stdev(R)	24.214	24.616	15.321	14.864
Z-value	-25.720	-28.192	-14.410	-20.193
p-value (2-tailed)	0.000	0.00	0.000	0.000

Notes:

a. H_0: Series is nonrandom.

b. $Z = \frac{R-\mu}{\sqrt{\sigma^2}}$, where R means actual number of runs, μ is expected number of runs and σ^2 is the variance of expected number of runs.

iii. Wright Variance Ratio Test results

Different literature (e.g. Azad, 2009; Charles & Darne, 2009) confirms the superiority of Wright variance ratio test over Lo-MacKinlay variance ratio test; therefore, difference may prevail between the two test results. To check this, the study follows the results of Wright variance ratio test. The following Table 5.9 presents the Wright's variance ratio test results for daily stock return and exchange rate return for sample period I and sample period II.

Table 5. 9: Wright Variance Ratio Test Statistics

Panel A: Sample Period I						
	Stock Price			Exchange Rate		
Lags (k)	R_1	R_2	S_1	R_1	R_2	S_1
2	-24.864***	-26.294***	-15.720***	-22.152***	-23.688***	-8.428***
5	-17.518***	-18.205***	-9.691***	-15.638***	-16.615***	0.247
10	-12.493***	-13.020***	-6.051***	-11.027***	-11.834***	6.754
20	-8.780***	-9.129***	-3.380**	-7.860***	-8.465***	13.020*
30	-7.135***	-7.408***	-1.741	-6.390***	-6.914***	17.027***
40	-6.148***	-6.376***	-0.710	-5.483***	-5.957***	20.182***
Panel B: Sample Period II						
	Stock Price			Exchange Rate		
Lags (k)	R_1	R_2	S_1	R_1	R_2	S_1
2	-16.793***	-17.301***	-11.250***	-15.215***	-16.137***	3.625
5	-11.566***	-11.983***	-6.995***	-10.443***	-11.180***	12.495
10	-8.257***	-8.497***	-4.846***	-7.449***	-7.947***	20.447***
20	-5.898***	-6.059***	-3.476***	-5.245***	-5.617***	29.964***
30	-4.812***	-4.955***	-2.566**	-4.314***	-4.621***	36.466***
40	-4.166***	-4.299***	-2.016**	-3.782***	-4.027***	41.613***

Notes:

a. H_0: Variance of a series is independently and identically distributed
b. ***, ** and * represent significance at 1%, 5% and 10% level, respectively.
c. R_1, R_2 represent rank based Wright (2000) test statistics assuming conditional homoscedasticity and heteroscedasticity, respectively, and S_1 represents rank based Wright (2000) test statistics assuming homoscedasticity.

For sample period I (Panel A), test results indicate stock price return series rejects random walk hypothesis at all lags (k) for all three model of Wright variance ratio (R_1, R_2, and S_1) except at lag 30 and 40 in sign based model. Like stock return series, exchange rate return series cannot accept randomness at all lags at all three models except at lag 5 and 10 for S_1.

For sample period II (Panel B), test results indicate stock price return series rejects random walk hypothesis in at all lags for all three model of Wright variance ratio (R_1, R_2 and S_1). Like stock return series, exchange rate return series cannot accept randomness at all lags at all three models except at lag 2 and 5 for S_1.

Therefore, the overall results suggest that it rejects iid null, that is in all cases of rank based and sign based test statistics are greater than the critical value provided by Wright (2000). As a result, both stock price and exchange rate of Bangladesh are not individually efficient.

5.4 Results for Joint Market Interaction

i. Engle-Granger Cointegration Test Results

Engle-Granger cointegration test is used to detect the long-run cointegrating relationship between stock price and exchange rate. The test results for residual based ADF test for each of the series has been shown in the Table 5.10 and none of the tests is able to reject the null hypothesis of no cointegration. As a result, this test approves no long-run relationship between stock price and exchange rate even though it does not consider any structural break in the series.

Table 5. 10: Engle-Granger Test of Cointegration

Model	Sample Period I	Sample Period II
	Engle-Granger (ADF test statistics)	Engle-Granger (ADF test statistics)
Stock Return	-1.253	-2.008
Exchange Return	-0.735	-2.749

Notes:
a. H_0: Series are not cointegrated
b. Lags selected automatically according to BIC criteria.
c. Critical values for ADF test statistics collected from Davidson and MacKinnon (1993) are -3.90 and -3.33 at 1% and 5% significance level, respectively.

ii. Gregory-Hansen Cointegration Test Results

Since there would be a substantial decrease in power of Engle-Granger test if the cointegrating relationship has a break, this study employs the Gregory-Hansen test to allow breaks in intercept or intercept and trend or regime in the model.

However, the Gregory-Hansen cointegration test considers structural break at one unknown time in this study to detect the long-run relationship between the series. From the Table 5.11, it is clearly evident that there is no proof of long-run relationship in three different situations for both the models for sample period I (Panel A), which is relatively more vulnerable in terms of stock market crash and world economic meltdown. In addition, the results confirm the occurrence of break at the year of 2007, 2009, 2011 and 2013.

Similar results of no long-run relationship observed in developed economies like, G7 countries (Nieh & Lee, 2001), USA (Ozair, 2006; Bahmani & Sohrabian, 1992; Tsagkanos & Siripoulos, 2013), Canada, Australia, Japan, Switzerland, UK (Alagidede *et al.* 2010), China (Xiaolan & Yizhong, 2008), and for emerging economies like India, Pakistan, (Rahman & Uddin, 2009; Muhammad & Rasheed, 2003; Mostafa & Nishat, 2008; Wickremasinghe, 2012), Malaysia, Indonesia, Philippines, Thailand, South Korea, Taiwan (Doong *et al*., 2005; Baharom *et al*., 2008; Ghazali *et al.* 2008), Mexico (Kutty, 2010), ASEAN countries (Harjito & McGowan, 2007), Brazil (Tabak, 2006), Nigeria (Zubair, 2013).

Table 5. 11: Gregory Hansen Test

Panel A: Sample Period I						
	Gregory-Hansen (Level break)		Gregory-Hansen (Level and Trend break)		Gregory-Hansen (Regime break)	
	ADF statistics	Break Date	ADF statistics	Break Date	ADF statistics	Break Date
Stock price	-2.203	2007.08.03	-2.464	2004.12.09	-2.932	2009.12.03
Exchange Rate	-2.239	2011.08.16	-3.242	2008.07.23	-2.529	2009.11.06
Panel B: Sample Period II						
	Gregory-Hansen (Level break)		Gregory-Hansen (Level and Trend break)		Gregory-Hansen (Regime break)	
	ADF statistics	Break Date	ADF statistics	Break Date	ADF statistics	Break Date
Stock price	-4.272	2013.11.29	-4.306	2013.11.29	-4.250	2013.12.18
Exchange Rate	-5.223***	2015.11.10	-5.186**	2015.11.10	-5.444**	2015.10.29

Notes:

a. H_0: Series are not cointegrated
b. Lags selected automatically according to BIC criteria
c. Critical values for ADF test statistics collected from Gregory-Hansen (1996) are -5.13 and -4.61 at 1% and 5% significance level, respectively, for level shift,-5.45 and -4.99 at 1% and 5% significance level, respectively, for level and trend shift and -5.47 and -4.95 at 1% and 5% significance level, respectively, for regime shift.

For sample period II (Panel B), the results reveal a long-run relationship running from stock price to exchange rate with a break in year 2015 and no long-run relation from exchange rate to stock price only showing a break in 2013. This long run relation is observed in sample period II, which is a more stable period in stock market brought by inception and modification of stock index calculation, stock market regulation, and Government support, and the FX market by currency reserve and remittance growth. The finding of a long-run relationship between stock price and exchange rate in at least for one sample period in emerging countries is consistent with Apte (2001), Wu (2005) and Mozumder *et al.* (2015).

iii. Granger Causality Test Results

The causal relationship between stock price and exchange rate evaluated by Granger causality test and the following Table 5.12 suggest that none of the models of stock price or exchange rate reject the null hypothesis of no causal relationship; hence, there is no causal relationship between stock price and exchange rate. This result of no linear Granger causal relationship between stock price and exchange rate is consistent with the findings of Rahman and Uddin (2009).

Table 5. 12: Linear Granger Causality Results

Period	Linear Granger Causality Test	
	SP → ER	ER → SP
Sample Period I	1.179	1.085
	(0.311)	(0.369)
Sample Period II	0.143	0.705
	(0.99)	(0.645)

a. H_0: Lag length selected automatically according to AIC criteria.
b. Values without bracket represent F statistical value and in bracket ( ) represent p value.

iv. Non-linear Granger Causality Test Results

To identify the non-linear character of dependency between stock return and exchange rate, the study further check their causal relationship by non-linear Granger causality test. Here this study follows Diks and Panchenko (2006) procedure. The following

Table 5.13 represents the nonlinear Granger causality test statistics for two null hypotheses; one null hypothesis of exchange rate does not Granger cause stock return and the other that stock return does not Granger cause exchange return. This study uses VAR residuals for this nonlinear test so that only nonlinear relation can be investigated. The causal relation has been investigated up to eight lags for both sample periods. The appropriate bandwidth defined by the number of observations for each period.

Table 5.13: Non-linear Granger Causality Results

	Period I		Period II	
$L_s = L_x$	SP → ER	ER → SP	SP → ER	ER → SP
1	0.256	-0.335	-1.719	-1.704
2	1.260*	-1.137	-1.931	-2.197
3	1.647**	-0.577	-1.685	-1.655
4	1.996**	1.840**	-1.354	-2.744
5	2.061**	2.044**	-0.954	-2.539
6	1.940**	2.151**	-0.922	-2.260
7	1.886**	2.850***	-0.562	-1.388
8	1.701**	2.498***	-0.667	-1.406

Notes:

a. For period I, selected bandwidth is 0.9 and for period two, it is 1.

b. *, **, *** indicate 10%, 5% and 1% significance level, respectively.

For sample period I, the null hypothesis of non-causality from stock price to exchange rate has been rejected from the second to eighth lag at 5 percent significance level (only second lag is significant at 10 percent level) while non-causality from exchange rate to stock price is rejected from fourth to eighth lag at different significance level of 5 to 1 percent level of significance. Therefore, there is bidirectional nonlinear causal relation between stock price and exchange rate, but the precedence of stock price effect on exchange rate suggested by the results found in second and third lags. Thus, stock price is the lead variable for this bidirectional nonlinear causal relationship. The findings of bidirectional nonlinear causality between stock price and exchange rate is consistent with Yilanci and Bozoklu (2015), Cakan and Ejara (2013). On the other hand, none of the lags found any nonlinear causal relation between stock price and exchange rate for period II. The results of rejecting nonlinear causal relationship between these two variables are also observed in the study of Alagidede *et al.* (2010).

Therefore, it is observed that only short-lived bidirectional causality where stock price leads the relationship found at the period with high variance while no short-run causality is present at the period with less variance in Bangladesh.

5.5 Results on Volatility Dynamics

i. ARCH Effect Detection

The existence of autoregressive conditional heteroscedasticity (ARCH) in the series detects the presence of time-variant variance in the series. The lagrange multiplier (LM) test for ARCH effects shown in Table 5.14 has pointed out the statistical value greater than the critical value at 1 percent significant level and thus rejects the null of no ARCH effect.

Table 5. 14: ARCH Effect Detection

Equation	Stock Return	Exchange Return
Sample Period I	149.90***	229.24***
Sample Period II	96.77***	25.87***

a. H_0: There is no time variant variance in the series
b. *** indicates significance at 1% level.

ii. Univariate Volatility Analysis-GARCH Model

This study explores the volatility dynamics through symmetric volatility analysis for each market return. Hence, it applies GARCH (1, 1) model on the daily stock return and exchange rate return. The Table 5.15 presents the results for GARCH (1, 1) model for both stock return and exchange rate return for sample period I (June 02, 2003, to January 25, 2013) and sample period II (January 28, 2013, to December 30, 2016).

Table 5. 15: Results of GARCH (1, 1) Models

$$y_t = a_o + \beta y_{t-1} + \varepsilon_t ,$$

$$\sigma_t^2 = \omega_o + \delta_1 \sigma_{t-1}^2 + \gamma_1 \varepsilon_{t-1}^2$$

		Sample Period I		Sample Period II	
		Stock Return	Exchange Return	Stock Return	Exchange Return
Mean		0.001***	1E-08	4E-04*	-2E-05
Equation	β	-0.031	-0.527***	0.051	-0.149***
Volatility	ω_o	2E-05***	6E-10***	2E-07**	3E-08***
Equation	δ_1	0.818***	0.785***	0.933***	0.904***
	γ_1	0.121***	0.717***	0.066***	0.051***
Diagnostic	LM Test	0.009	0.013	2.808*	0.0043
Statistics	LQ(2)	0.227	0.032	2.998	0.0047
	LQ(5)	0.440	0.122	64.401***	0.1174
	LQ(20)	4.821	0.666	168.24***	0.504
	LQ (36)	10.304	1.145	294.92***	1.419

Notes:

a. For mean equations, dependent variables is y_t representing stock return or exchange rate return, where, a_o is constant, β is past stock or exchange rate return.

b. For volatility equation, dependent variable is $ln\sigma_t^2$ meaning volatility of stock price or exchange rate, where, ω_o is volatility constant, δ_1 is volatility clustering or GARCH effect, γ_1 is news effect or ARCH effect.

c. *** and ** represents 1% and 5% level of significance respectively.

For sample period I, the mean equation of GARCH (1, 1) identifies significant effect of last days exchange return on current exchange return but unable to show any significant dependency of current stock return to its immediate last day return. On the other hand, the variance equation for both stock return and exchange rate return cannot reject the effect of last day conditional variance (GARCH) and last day squared residuals (ARCH) on explaining the conditional variance for respective stock return and exchange return. Diagnostic test of ARCH-LM test and autocorrelation confirms the robustness of the model.

Like GARCH (1,1) result in period I, the mean equation of GARCH(1, 1) for sample period II identifies significant effect of last days exchange return on current exchange return and unable to show any significant dependency of current stock return to its immediate last day return. For sample period II, the variance equation for both stock return and exchange rate return cannot reject the effect of last day conditional variance (GARCH) and last day squared residuals (ARCH) on explaining the conditional variance for respective stock return and exchange return.

Diagnostic test in stock return model by ARCH-LM test suggest marginal existence of auto-regressive conditional heteroscedasticity and autocorrelation results confirms persistence of memory for stock market volatility. While the diagnostic tests for exchange rate return GARCH model prove the robustness of the model.

iii. Univariate Volatility Analysis-EGARCH Model

It may be proved that GARCH (1, 1) is an adequate model for explaining the volatility of a market, until one disregard the asymmetry between the response of volatility to positive and negative shocks. Since the asymmetric volatility improves the results of symmetric GARCH model, the paper employs EGARCH model for each series to define individual volatility responses to the arrival of good news and bad news.

In the following Table 5.16, the EGARCH (1, 1) model for stock return and exchange rate return presents the results for mean equation, variance equation and diagnostic checking for both the market for sample period I and sample period II.

For sample period I, the mean equation shows highly significant past exchange rate return as same as the GARCH (1, 1) model, and no statistically significant explanatory power for the last day stock return on current stock return. More importantly, the variance equation for sample period I imparts the explanation for changes in conditional variance of return equation though three major variables, those are past conditional variance (volatility clustering), past error term (leverage effect) and difference between absolute error term and expected value (news effect), and all these coefficients found significant at 1 percent level for both stock market and exchange market. That is, past conditional variance positively affect the changes of current conditional variance while past error term negatively influences it, that is, capturing the leverage effect-negative news imparts more volatility relative to positive news. Finally, the model shows positive response of conditional variance of stock market or exchange market to the arrival of new news against its corresponding expectation. That is, any unexpected news intensifies the volatility of stock market or exchange market.

Diagnostic test of ARCH-LM test and autocorrelation confirms the robustness of the model.

Table 5.16: Results of EGARCH (1, 1) Models

$$y_t = a_o + \beta y_{t-1} + \varepsilon_t ,$$

$$ln\sigma_t^2 = \omega_o + \delta_1 ln\sigma_{t-1}^2 + \gamma_1 \frac{\varepsilon_{t-1}}{\sqrt{ln\sigma_{t-1}^2}} + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{ln\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right]$$

		Sample Period I		Sample Period II	
		Stock Return	Exchange Return	Stock Return	Exchange Return
Mean	a_o	0.001***	-2E-05***	2E-04	-9E-05***
Equation	β	0.007	-0.535***	0.059*	-0.197***
Volatility	ω_o	-0.919***	-0.474***	-0.126***	-0.524***
Equation	δ_1	0.909***	0.984***	0.996***	0.967***
	γ_1	-0.146***	-0.204***	-0.043***	-0.079***
	α	0.221***	0.615***	0.127***	0.100***
Diagnostic	LM Test	0.003	0.005	1.808	0.001
Statistics	LQ(2)	0.0262	0.046	2.002	0.004
	LQ(5)	2.2611	0.149	58.26***	0.047
	LQ(20)	11.934	0.558	172.47***	0.376
	LQ (36)	23.095	0.996	299.87***	1.231

Notes:

a. For mean equations, dependent variables is y_t representing stock return or exchange rate return, where, a_o is constant, β is past stock or exchange rate return.

b. For volatility equation, dependent variable is $ln\sigma_t^2$ meaning volatility of stock price or exchange rate, where, ω_o is volatility Constant, δ_1 is volatility clustering, γ_1 is leverage effect, α is news effect.

c. *** represents significance at 1% level.

For sample period II, the mean equation shows highly significant past exchange rate return as same as the GARCH (1, 1) model, and no statistically significant explanatory power for last day stock return on current stock return. The variance equation shows that all the coefficient significant are at 1 percent level of significance for both stock market and exchange market. Like EGARCH result found in sample period I, the sample period II confirm current level of variance is influenced by its past variance (volatility clustering), asymmetrically affected by past news (leverage effect) and susceptible to past news against expectation (news effect). The diagnostic tests for stock return equation for sample II confirm significant removal of autoregressive conditional heteroscedasticity and existence of memory in the volatility. While the diagnostic tests for exchange rate return GARCH model prove the robustness of the model.

The findings of volatility clustering, news effect and leverage effect from univariate volatility models for individual market volatility investigation are in the line of the findings of Karim (2013) for stock market and Abdalla (2012) for foreign exchange market.

iv. Volatility Spillover Analysis-Bivariate EGARCH Model

This study follows the bivariate ARCH-EGARCH model prescribed by Kim *et al.* (2003) for evaluating volatility spillover between stock return and exchange rate return. This Bivariate spillover model has two parts one is, the return equation and another is the volatility equation. There are two models as one stock return model- representing the relationship from exchange rate return to stock return in terms of mean and volatility spillover and another, exchange rate return model- representing the relationship from stock return to exchange rate return in terms of mean and volatility spillover. The following Table 5.17 presents the return and volatility spillover relation between exchange rate to stock price, and stock price to exchange rate with their respective diagnostic checking for sample period I and sample period II.

Table 5. 17: Bivariate ARMA-EGARCH Results

$$p_t = a_o + \beta_1 p_{t-1} + \beta_2 x_{t-1} + \varepsilon_{pt}\,, ln\sigma^2_{p,t} = \omega_o + \delta_1 ln\sigma^2_{p,t-1} + \gamma_1 \frac{\varepsilon_{p,t-1}}{\sqrt{ln\sigma^2_{p,t-1}}} + \alpha_1 \left[\frac{|\varepsilon_{p,t-1}|}{\sqrt{ln\sigma^2_{p,t-1}}} - \sqrt{\frac{2}{\pi}} \right] + \gamma_2 \frac{\varepsilon_{x,t-1}}{\sqrt{ln\sigma^2_{x,t-1}}} + \alpha_2 \left[\frac{|\varepsilon_{x,t-1}|}{\sqrt{ln\sigma^2_{x,t-1}}} - \sqrt{\frac{2}{\pi}} \right]$$

$$x_t = a_o + \beta_1 p_{t-1} + \beta_2 x_{t-1} + \varepsilon_{xt}\,, ln\sigma^2_{x,t} = \omega_o + \delta_1 ln\sigma^2_{x,t-1} + \gamma_1 \frac{\varepsilon_{x,t-1}}{\sqrt{ln\sigma^2_{x,t-1}}} + \alpha_1 \left[\frac{|\varepsilon_{x,t-1}|}{\sqrt{ln\sigma^2_{x,t-1}}} - \sqrt{\frac{2}{\pi}} \right] + \gamma_2 \frac{\varepsilon_{p,t-1}}{\sqrt{ln\sigma^2_{p,t-1}}} + \alpha_2 \left[\frac{|\varepsilon_{p,t-1}|}{\sqrt{ln\sigma^2_{p,t-1}}} - \sqrt{\frac{2}{\pi}} \right]$$

		Sample Period I		Sample Period II	
		Stock Return Equation ER→ SP	Exchange Return Equation SP → ER	Stock Return Equation ER→ SP	Exchange Return Equation SP → ER
Mean Equation	a_o	0.001***	-2E-05***	3E-04	-6E-05**
	β_1	0.008	-0.002***	-0.016	0.005**
	β_2	0.061	-0.560***	-0.209*	-0.244***
Volatility Equation	ω_o	-0.942***	-0.374 ***	-12.031 ***	-12.438***
	δ_1	0.902***	0.986***	-0.269***	0.142***
	γ_1	-0.155***	-0.184***	-0.026	-0.091**
	α_1	0.235***	0.625***	0.002	0.486***
	γ_2	0.054***	-0.087***	0.043	0.339***
	α_2	-0.117***	-0.150***	-0.388***	-0.163***
Diagnostic Statistics	LM Test	0.0243	0.003	5.983***	0.041
	LQ(2)	0.0477	0.0615	21.574***	0.362
	LQ(5)	3.1301	0.1958	124.84***	32.352
	LQ(20)	14.450	0.6934	244.32***	56.392
	LQ (40)	28.048	1.4271	385.92***	61.104

Notes:

a. For mean equations, dependent variables are p_t and x_t representing stock return and exchange rate return, respectively, where, a_o is constant, β_1 is past stock return, β_2 is past exchange return.

b. For volatility equation, dependent variables are $ln\sigma^2_{p,t}$ and $ln\sigma^2_{x,t}$ meaning stock price volatility and exchange rate volatility, respectively, where, ω_o is volatility Constant, δ_1 is volatility clustering, γ_1 is leverage effect, α_1 is news effect, γ_2 is cross market leverage effect and α_2 is cross market news effect.

c. *** and ** represents 1% and 5% level of significance respectively.

For sample period I, the return equation identifies significant effect of last days exchange return on current exchange return and unable to show any significant dependency of current stock return to its immediate last day return. But in terms of return spillover relationship between stock return and exchange rate return, only exchange return equation finds the return spillover from stock return to exchange rate return at 1 percent level of significance and the direction of spillover from stock return to exchange rate is negative. That means a unidirectional negative return spillover running from stock price to exchange rate in Bangladesh.

The volatility spillover within and between two markets are examined through variance equations stock return and exchange rate return. For sample period I, each of the variance equation confirms the dependency of own past volatility (volatility clustering), leverage effect of own past news and own past expected residuals or shock (news effect). Since Bivariate volatility equations have two more explanatory variables identifying the shock effect or spillover effect (cross-market news effect) from one market to another and asymmetry in the shock or news effect (cross-market leverage effect) from one market affecting the current volatility of another market.

For sample period I, the variance equation of exchange rate clearly identifies significant negative volatility spillover (cross-market news effect) running from stock return to exchange rate return and the significant asymmetry in the new effect (cross-market leverage effect) from stock return to current volatility of exchange return (at 1 percent level of significance). While the variance equation of stock return for investigating spillover from exchange rate volatility to stock return volatility find asymmetry in positive news effect (cross-market leverage effect) from exchange rate return to conditional volatility at 1 percent significance level. But the model also detects negative volatility spillover (cross-market news effect) from exchange rate return to stock return. Therefore, variance equations of the bivariate EGARCH model confirm bidirectional negative volatility spillover relationship between stock price and exchange rate. That is, the past volatility of one market negatively influence the volatility of another market in sample period I. Diagnostic test of ARCH-LM test and autocorrelation confirms the robustness of the model.

For sample period II, the return equation identifies significant effect of last days exchange return on current exchange return and unable to show any significant dependency of current stock return to its immediate last day return. But in terms of return spillover relationship between stock return and exchange rate return, only exchange return equation shows the return spillover from stock return to exchange rate return at 1 percent level of significance and the direction of spillover from stock return to exchange rate is positive. That means a unidirectional positive return spillover running from stock price to exchange rate for the period from January 28, 2013, to December 30, 2016, in Bangladesh.

For sample period II, the variance equation for stock return shows that there is no significant leverage effect, news effect, and cross-market leverage effect. But, past stock return variance (volatility clustering) and past news from exchange rate return have significant positive and negative effect respectively on current variance of stock return. The findings of no significant impact of news and leverage effect of stock market on variance of stock return contradict the findings of univariate EGARCH (1, 1). It means that the inclusions of spillover variable in EGARCH model actually weaken own past news effect and leverage effect on stock market for sample period II. It obviously reflects that volatility in stock return and exchange rate return depends on common blending variable so that any innovation in the exchange market exists simultaneously in the stock market. This phenomenon is supported by the mixture distribution hypothesis (MDH) of Clark (1973). For sample period II, the variance equation of exchange rate confirms significant effect of own past variance and asymmetry in own news (leverage effect) and own news effect on current level of exchange return variance. It also clearly identifies significant negative volatility spillover running from stock return to exchange rate and the significant asymmetry in positive news effect from stock return to current volatility of exchange return and both the significance found at 1 percent level.

For the sample period II, volatility spillover is running from stock return to exchange rate return and exchange rate return to stock return and this spillover is negative. The equation of stock return volatility suggest the news from exchange market is already present in stock market, as a result, only the news from exchange market have influence on the variance of stock market replacing news effect generated within the stock market. But, in case of the exchange rate variance equation for sample period II shows that two markets are different and have news effect from its own market (exchange market) and another market (stock market). This confirms the news generated from stock market is different from exchange market. Any news firstly set the stock market and then influences the exchange market. This contrasting phenomenon actually suggests that stock market lead the volatility spillover and any news from exchange market has feedback effect to the stock market.

The negative volatility spillover relationship can also be found in the study of Jebran and Iqbal (2016). Both positive and negative news asymmetry is also present in the studies of different researchers like Jebran and Iqbal (2016), Mozumder *et al.* (2015)

etc. The similar result of overall bidirectional volatility spillover between stock price and exchange rate observed in the studies of Developed economies (Caporale *et al.*, 2013) and emerging economies (Mozumder *et al.*, 2015; Mishra *et al.*, 2007; Wu, 2005; Kumar, 2013).

5.6 Conclusion

The three fold analysis for stock price and exchange rate dynamics in Bangladesh has been explored. The first segment of analysis for individual efficiency test under random walk hypothesis presents both stock and foreign exchange market is individually inefficient. The second segment of analysis for joint market interaction presents dominance of stock market over exchange market. Finally, estimated results for volatility dynamics for within and between these two markets presents significant past volatility effect, leverage effect, news effect within each market and unidirectional return effect from stock market to exchange market and bidirectional volatility relationship between those markets.

Chapter 6

Findings and Conclusion

6.1 Findings

Findings from Preliminary Analysis

- It is found that both the series of stock price and exchange rate are not normal and stock price have greater variability than foreign exchange rate for both sample periods studied in this study.
- The graphical presentation of both series shows divergent ups and down and stabilization point and pattern as they are two different markets.
- The rough measure (scatter diagram) of serial correlation finds dependency of observations in both series to their past value.
- Graphical presentation of first differenced data shows positive dependence between nearby lags for both the series.

Findings from Individual Efficiency Analysis

- The individual efficiency test results in Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) and Zivot and Andrews (ZA) test shows both the stock price and exchange rate series are non-stationary while stock return and exchange rate return series are stationary.
- For this divergent result found in the non-stationary process of random walk, this study further uses variance ratio test for stock price and exchange rate series with two different cases of homoscedasticity and heteroscedasticity. For those cases, stock return and exchange rate return series deny random walk.
- To confirm, the non-randomness of the series, this study uses non-parametric test (autocorrelation, runs test and Wright variance ratio test). Both tests confirm nonrandomness of each series. Therefore, both the markets are individually inefficient.

Findings from Joint Market Efficiency Analysis

The examination of joint efficiency has been conducted by long and short-run relationship between stock price and exchange rate in return series. The return relationship of both the market has been shown by using cointegration and causal analysis.

- Similar to Engle-Granger (EG) cointegration test, Gregory Hansen (GH) cointegration test with structural break cannot provide any statistically significant long-run relationship for sample period I, but for sample period II, GH test, unlike EG test, confirms a unidirectional long-run relationship from stock price to exchange rate in Bangladesh.

- Granger causality test shows no causal relationship between stock price and exchange rate.
- Since both the series are non-normal, this study proceeds to more robust causal analysis, non-linear causality test prescribed by Diks and Panchanko (2006) and finds bidirectional causality running between stock return and exchange rate return for the sample period I (period of more variability) where stock return is the leading variable to initiate the causal relationship. While, in the sample period II (period of less variability), no nonlinear causal relationship between stock return and exchange rate return has been found.

Findings from Volatility Analysis

The study further approaches to individual market volatility and volatility spillover analysis for these two markets.

- Preliminary analysis like lagrange multiplier (LM) test finds the existence of ARCH effects in both series in both sample periods. This preliminary analysis confirms the applicability of volatility analysis for stock price and exchange rate in Bangladesh.
- The univariate volatility analysis for individual market volatility divided into two ways- symmetric volatility and asymmetric volatility. The symmetric volatility analysis shows significant effect of past conditional variance (volatility clustering) and past variance of residuals (news effect) of each series to its individual volatility. Further, asymmetric analysis confirms past conditional variance (volatility clustering) and asymmetry news effect (leverage

effect) and expectation regarding the news (past news effect) for explaining volatility in each market.

- Bivariate EGARCH model detects negative return spillover from stock return to exchange rate return on the return equation for sample period I (period of high variance). Here, a fall in exchange return means appreciation in Bangladeshi Taka and depreciation in US dollar, since the exchange rate series stated in BDT for per US dollar, it supports the portfolio balance theory of exchange rate determination where a rise in stock value in a country leads to an appreciation of the currency of that country.

The variance equations of exchange rate return for sample period I confirm earlier univariate EGARCH results and include the spillover phenomena to it. Here, the shock from stock return negatively influences the variability of the foreign exchange return. That means any information different from the expectation in stock market is more pronounced in less variability of exchange rate in Bangladesh. It actually identifies that when there is more variability in stock return, there is less variability in exchange return. The equation further indicates existence of leverage effect in spillover, that is, negative news in stock market have greater influence than the positive news of that market have on the exchange rate market. That actually identifies the news pertaining to fall in stock return led less variability in the value of Bangladeshi Taka than a news relative to rise in stock return can do to the value of Bangladeshi Taka. This period also shows weak negative return and strong negative volatility spillover from exchange market to stock market, but it presents symmetry in news effect from exchange rate return to variability of stock return that positive and negative news produce the same magnitude of impact on the stock return variance. Hence, bidirectional volatility spillover has been confirmed in the sample period I.

While Bivariate EGARCH model detects positive return spillover from stock return to exchange rate return on the return equation for sample period II (period of less variance). Here, a rise in stock value of country is pronounced in the fall of the currency of that country. This phenomenon confirms the asset market theory and interest rate parity hypothesis, that is, any rise in the value of an asset in a country must have a corresponding fall in the value of the currency to offset the difference between the asset return between two countries. While the variance equations of exchange return for sample period II confirm earlier univariate EGARCH results and contain the spillover phenomena to it. Here, the shock from stock returns negatively influences the variability of the foreign exchange return just same as the findings from sample period I. But it shows positive leverage impact from stock return to exchange return. Thus the positive news in stock market has greater influence than the negative news has on lowering the variability of foreign exchange market. This period also shows weak negative return and strong negative volatility spillover from exchange market to stock market, but it shows symmetry in news effect from exchange rate return to variability of stock return that positive and negative news produce the same magnitude of impact on the stock return variance. Therefore, sample period II also reveals bidirectional volatility spillover relationship between stock price and exchange rate. However, this simultaneous relationship is initiated by stock return.

The findings from bivariate EGARCH model confirms portfolio balance approach that past stock return has significant explanatory power over conditional mean of exchange return. Whereas negative bidirectional volatility spillover phenomena can be explained with the argument that foreign exchange rate is often managed by central bank and allowed to move within an informal band and intervened strongly when there is volatility in any financial market. Another argument for negative volatility spillover may be that foreign investors do not get panicked as they take conscious decision. When there is a fall in the value of investment, foreign investors are unwilling to divest their investment immediately as this would mean to acknowledge the loss (Mozumder, *et al.* 2015). Again, they reduce their demand for local currency to buy stock when there is volatility or risk in stock market and vice-versa (Morales & O'Donnel, 2006). In search of cross market leverage effect in four cases (i.e. stock to exchange rate and exchange rate to stock price in low variance period and stock to exchange rate and exchange rate to stock price in high variance period), the study finds positive news is more effective in two cases, negative news in one case and both are equally effective in one case in reducing volatility in a market. These observations affirm the absence of weak form joint efficiency, that is, information of one market can be used to predict price movements in another market.

6.2 Conclusion

Dynamics of stock market and foreign exchange markets are apparent in defining domestic and international economics of a country. Further financial markets are highly susceptible to the information, and volume and investment horizon, domestic money supply, export-import and capital mobility are one way or another linked to the behavior of stock market and exchange rate of a country. Here this study approaches first on examining how efficient the stock market and foreign exchange market in Bangladesh, that is, past information of stock price (exchange rate) can be used to predict future stock price (exchange rate). Next, this study proceeds to the evaluation of long-run and short-run return relationship between stock price and exchange rate. Finally, this study explores volatility for stock price and exchange rate individually, and volatility relationship between them.

To conduct the research, this study utilizes daily data of the stock price and exchange rate from June 2003 to December 2016. After some preliminary analyses, this study starts its individual market efficiency analyses by unit root test, autocorrelation test, runs test, variance ratio test and confirms the absence of random walk theory for stock price and exchange rate in Bangladesh. Then study seeks return relationship between stock price and exchange rate, where long-run relationship examined by Engle-Granger cointegration test and Gregory-Hansen cointegration test with breaks and only a long-run relationship from stock price to exchange rate is detected by GH test for the period from January 28, 2013, to December 30, 2016. Unlike long-run relationship, this study can not provide any evidence of short-run return relationship after running linear Granger-Causality test. Then, this study uses non-linear Granger causality test and found bidirectional causality running between stock return and exchange rate return where stock market initiates the changes in exchange market for the period from June 02, 2003, to January 25, 2013. Then this study conducts research on volatility dynamic for individual market through symmetric volatility and asymmetric volatility analyses. Both analyses show significant effect from past shocks and volatility in explaining conditional variance of each series. But asymmetric model of EGARCH provide greater insight on individual market volatility by capturing leverage effect, that is, bad news exerts more volatility than good news does and the exchange rate is volatile against bad news and news against its expectation than the stock price is. Finally, volatility relationships through Bivariate EGARCH model confirm unidirectional return transmission effect from stock price to exchange rate and bidirectional volatility spillover relationship in Bangladesh.

Policy Implications

The policy implications of this study are explained in accordance of estimations and findings. As the study confirms the absence of random walk hypothesis in stock price and exchange rate in Bangladesh, these findings have great implication for investors and policy makers. In case of investor's perspective, the non-randomness in stock price and exchange rate open up opportunities for the investors to predict the return and make buy, hold and sell decision effectively. On the other hand, different regulatory agencies like Central Bank, Securities and Exchange Commission have to constantly regulate and intervene the market so that any single market participants cannot influence it.

The study shows a long run connection from stock price to exchange rate at low variance period and bidirectional non linear causal connection initiated by stock market at high variance period. These findings confirm the absence of joint market efficiency and the superiority of stock oriented model over flow oriented model of exchange rate determination in Bangladesh.

The univariate volatility analysis shows the significant past news effect and asymmetric news effect and volatility clustering in each market. Therefore, the policy makers should be more cognizant and prompt in reaction against news that could downturn the market.

The bivariate volatility investigation confirms unidirectional return spillover from stock price to exchange rate and bidirectional volatility spillover transmission. The core policy implication of this study is that Government agencies like Bangladesh Bank, Securities and Exchange Commission must have sufficient number of conscious and prudent intervention in the markets to stabilize exchange rate and stock price in Bangladesh. Other than that, joint efficient market hypothesis, any past information from one market cannot be used to predict another market is also rejected here in stock price and exchange rate volatility relationship. It may be very informative for the private and institutional investors to hedge the risk by investing in both markets.

Future Research

The contribution of this study to the literature is its synchronized analysis of individual financial market efficiency and joint market return and volatility relationship for an emerging country like Bangladesh. The use of most recent data made the findings more pragmatic for practitioners, academicians, and government agencies. This study can be further enriched by using more variables into consideration and analyze it under each of the breaks found. In particular, the study can be more informative if it uses more variable like money supply, inflation rate, interest rate, foreign trade so that the channels of shocks can be explored. It can be further extended if one combines regulatory interventions so that which intervening policy at what magnitude is effective for shock absorption within those channels. Hedging Activities can also be incorporated so that the reaction of individual and institutional investors on their hedging strategies can be evaluated and how these strategies affect the transmission channels.

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Appendix

Appendix to Chapter 3

A: Non-linear Granger Causality Test

As nonlinear granger causality test of Hiemstra and Jones (1994) suffers from serious distortion in results when sample size in different. Diks and Panchenko (2006) introduces a positive weight function g(X, Y, Z) for measuring conditional dependence to overcome the Hiemstra and Jones problem (over rejection of null hypothesis).

If the lagged vectors are $X_t^{L_x} == (X_{t-L_x+1,.....,}X_t)$ and $Y_t^{L_y} == (Y_{t-L_y+1,.....,}Y_t)$with the lag of X and Y greater or equal to 1, $(L_x, L_y \leq 1)$, then the null hypothesis of information contained in $X_t^{L_x}$ has nothing to express beyond $Y_t^{L_y}$, that is L_{t+1} explained as;

$$H_0: Y_{t+1} \left| \left(X_t^{L_x};\ Y_t^{L_y}\right) - Y_{t+1} \right| Y_t^{L_y} \qquad \text{(A.1)}$$

Now the X and Y both stationary time series of this null hypothesis, state the distribution of the $(L_x + L_y + 1)$ dimensional vector, $W_t = (X_t^{L_x};\ Y_t^{L_y}, Z_t)$ given $Z_t = Y_{t+1}$, to be invariant. Therefore ignoring time index and assuming lag 1 for both X and Y eventually equalize the conditional distribution of Z provided (X, Y) =(x, y) with

Z followed Y= y. The above equation (54) can be restated in terms of joint probability density function $f_{x,y,z}(X,Y,Z)$ and the realignment for null would have

$$E = \left[\left(\frac{f_{x,y,z}(X,Y,Z)}{f_y(Y)} - \frac{f_{y,z}(Y,Z)}{f_y(Y)}\frac{f_{x,y}(X,Y)}{f_y(Y)}\right)\right] = 0 \tag{A.2}$$

Then, Diks and Panchenko (2006) improve the null by using weighted function $g(X,Y,Z)$ for conditional dependence and restatement of eq. (A.2) is as follows:

$$E = \left[\left(\frac{f_{x,y,z}(X,Y,Z)}{f_y(Y)} - \frac{f_{y,z}(Y,Z)}{f_y(Y)}\frac{f_{x,y}(X,Y)}{f_y(Y)}\right) g(X,Y,Z)\right] = 0 \tag{A.3}$$

The weighted function assumed to be $g(X,Y,Z) = f_y^2 Y$ to deliver U statistic representation of the corresponding estimator for analytically asymptotic distribution. That is, X and Z conditionally independent on Y for each fixed value of y. Now DP test on null as per Diks and Panchenko 2006 implies:

$$q = E\left[f_{x,y,z}(X,Y,Z)f_y(Y) - f_{x,y}(X,Y)f_{y,z}(Y,Z)\right] = 0 \tag{A.4}$$

Given a local density estimator of a d_w variate random vector W at W_i explained as

$$\widehat{f_w}(W_i) = \frac{(2\varepsilon)^{-dw}}{n-1}\sum_{j,j\neq i}^{n} I_{ij}^{W}, \tag{A.5}$$

Where, $I_{ij}^{W} = I(\|W_i - W_j\| < \varepsilon_n)$ with $I(.)$ the indicator function and ε_n is the bandwidth as per the sample size n. Now, the test statistics of DP test follows;

$$T_n(\varepsilon_n) = \frac{n-1}{n(n-2)}\sum_i^n \begin{pmatrix} \hat{f}x,z,y(X_i,Z_i,Y_i)\hat{f}y(Y_i) - \\ \hat{f}x,y(X_i,Y_i)\hat{f}y(Y_i,Z_i) \end{pmatrix} \tag{A.6}$$

For $l_x = l_y = 1$, if $\varepsilon_n = Cn^{-\beta}$ $(C > 0, \frac{1}{4} < \beta < \frac{1}{3})$ then test statistics proved by Diks and Panchenko 2006 by satisfying,

$$\sqrt{n}\frac{(T_n(\varepsilon_n)-q)}{S_n}\xrightarrow{D}N(0,1) \qquad (A.7)$$

where $\xrightarrow{D}$ denotes convergence in distribution and S_n is an estimator of the asymptotic variance of $T_n(.)$ and Diks and Panchenko's way of one tail test implementation have been followed.