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Capturing volatility and its spillover in South Asian countries

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HIGHLIGHTS:

1. This paper studies the volatility and its spillover among South Asian countries to assess the impact of recession on the nature of volatility by decomposing the long period into two sub periods.
2. It uses Granger Causality and C GARCH M model for studying the volatility spillover across markets.
3. There exists significant bidirectional causality between stock market of U.S. and India for both short terms as well as for long term which is not disturbed by recession, but not in other countries.
4. It is also observed that volatility of all South Asian countries is of long term nature.
5. This paper will be useful for both investors and regulators in decision making.

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ABSTRACT

This paper intends to study volatility and its spillover among South Asian Countries through use of Granger causality test. Using the daily closing prices of major index of each country in South Asia, the Granger causality and C GARCH M models asses the impact of recession on the nature of volatility by decomposing the long period into two sub periods. The study finds significant bidirectional causality between Stock market of U.S. and India for both short terms as well as for long term which is not disturbed by recession. But the recession has changed causal relation among other countries. The recession has created higher shock impact on the permanent component of the volatility of stock market of all South Asian countries. It is also observed that volatility of all South Asian countries is of long term nature. In addition, the observed spillover effects are unstable over time in the sense that the spillover changed its nature after beginning of recession.

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1.0 Introduction

Volatility is associated with unpredictability, uncertainty and has implications for variance risk. Generally, people tend to see volatility as a symptom of market disruption whereby securities are not being priced fairly and the capital market is not functioning as well as it should. Changes in the volatility of stock market returns are capable of having significant negative effects on risk averse investors and the economy. Unfortunately, there is no generally agreed upon definition of spillovers in the financial literature and therefore, the closely related concepts 'spillover', 'contagion', 'interdependence' and 'co-movement' are often used interchangeably. Volatility spillover can be described as transmission of volatility from one market to another. Volatility spillover has attracted attention of many researchers as International stock markets have experienced ever-increasing interaction with one another during the past decade. Volatility and returns have been closely synchronized across national stock markets as a

result of economic integration, development of stock markets, financial deregulation and liberalization, and the reduction of information and transaction cost. Shocks in one stock market or in one region are very likely to transmit to other markets and regions (for example, the East Asian crisis that started from Thailand and spread out in the whole region rapidly and pervasively). Therefore, it is very critical for the investors to understand the behavior of the volatility and mean spillover so as to efficiently implement international hedging strategies with global diversified portfolios. International diversification is often considered as the best instrument to improve portfolio performance. Because correlations between asset returns from different markets are usually lower than correlations within the same market, international diversification enable the investors to shift to investments of high risk and expected return without altering the overall risks of their portfolios. This benefit would be reduced if international stock markets tend to move together and volatility transmits across borders. Moreover, to understand the volatility and mean spillover also helps the policy makers better evaluate the regulatory proposals, supervising and restricting the international cash flows and hence protecting national markets and national economy from the international shocks. This is especially vital to the emerging stock markets that are in the process of liberalization and deregulation.The intensity of spillovers may of course vary over time, and the nature of any time variation is of potentially great interest.

For many years but especially following the late 1990s Asian crisis, much has been made of the nature of financial market interdependence, both in terms of returns and return volatilities (King, Sentana and Wadhwani, 1994; Forbes and Rigobon, 2002).

Given this background the study intends to achieve following objectives:

1. To study the volatility spillover effect among South Asian Countries through use of Granger causality test.
2. To capture the nature of volatility in South Asian Countries.
3. To decompose conditional variances into a long run time varying trend component and a short run transitory component, this reverts to the trend following a shock by using CGARCH M model.
4. To investigate whether market provides higher returns during high volatility period.
5. To capture the impact of Recession on South Asian countries by decomposing whole period into two sub periods i.e. 1st Apr, 2006- 30th Nov, 2007 and 1st Dec, 2007- Mar, 2011.

2.0 Literature review

Interests in the integration of international financial markets have generated a considerable amount of work in this area. Studies such as Hilliard (1979), Errunza and Losq (1985), and Malliaris and Urrutia (1992) focus on the degree of interdependence and causality among national stock markets. While many studies find low correlations among national stock index returns, results from recent studies (Eun and Shim, 1989 and Arshanapalli and Doukas, 1993) seem to indicate that the interdependence between international stock markets has increased, particularly after the October 1987 stock market crash. Liu and Pan (1997) also observed that the spillovers increase substantially after the October 1987 stock market crash.

Hamao et al. (1990), King and Wadhwani (1990), Cheung and Ng (1992), Theodossiou and Lee (1993), and Susmel and Engle (1994) have a focus on examining the volatility transmission in addition to the mean spillover effect. They found significant mean and volatility spillovers from the U.S. market to other national stock markets and structures of information transmission seem to have changed since the 1987 stock market crash. Bekaert and Harvey (1997) analyzed the volatilities of emerging equity markets and found that the volatility is strongly influenced by global factors in the fully integrated markets but is more likely to be influenced by local factors in the segmented markets. Ng (2000) examined the magnitude and the variation of volatility spillovers from Japan and the US to pacific-basin stock markets.

Du et al. (2011) assessed factors that potentially influence the volatility of crude oil prices and the possible linkage between this volatility and agricultural commodity markets. He interpreted volatility spillover among crude oil, corn, and wheat markets after the fall of 2006 which can be largely explained by tightened interdependence between crude oil and these commodity markets induced by ethanol production. Alom et al. (2010) examined cross country mean and volatility spillover effects of food prices across selected Asian and Pacific countries namely Australia, New Zealand, South Korea, Singapore, Hong Kong, Taiwan, India and Thailand by using CGARCH models of conditional variance. He found that volatility spillover effects are stronger than mean spillover effects. Wei (2009) investigated the spillover effects of the unexpected exchange rate shock of the USD, Yen, and Eurodollar to the China Renminbi (RMB) within the domestic and Chinese stock markets through CGARCH. He found that the USD-RMB unexpected exchange rate shock has a stronger spillover effect on the U.S. domestic stock markets, but not on the Yen and Eurodollar exchange rate markets within their respective local stock markets.

Pisedtasalasai and Harris (2006) investigated return and volatility spillover effects between the FTSE 100, FTSE 250 and FTSE Small Cap equity indices using the multivariate GARCH framework. He found that there are significant

spillover effects in both returns and volatility from the portfolios of larger stocks to the portfolios of smaller stocks. Baur and Jung (2006) investigated the contemporaneous correlation and the spillover effects between the US and the German stock markets around the opening of the two markets by taking intra-day data for the two blue chip indices: the Dow Jones Industrial Average (DOW) and the Deutsche Aktien index (DAX). He found that foreign daytime returns can significantly influence the domestic overnight returns for both the US and the German market and there is no evidence of spillovers from the previous daytime returns in the US to the DAX morning trading.

Worthington et al. (2005) examined the transmission of spot electricity prices and price volatility among the five regional electricity markets in the Australian National Electricity Market: namely, New South Wales, Queensland, South Australia, the Snowy Mountains Hydroelectric Scheme and Victoria. He used multivariate generalized autoregressive conditional heteroskedasticity model is used to identify the source and magnitude of price and price volatility spillovers. He found that results indicate the presence of positive own mean spillovers in only a small number of markets and no mean spillovers between any of the markets. Yang and Doong (2004) explored the nature of the mean and volatility transmission mechanism between stock and foreign exchange markets for the G-7 countries. He found asymmetric volatility spillover effect and showed that movements of stock prices will affect future exchange rate movements, but changes in exchange rates have less direct impact on future changes of stock prices. Christiansen (2003) examines mean and volatility spillover effects from both the US and Europe into the individual European bond markets. She founds mean-spillover effects to be almost negligible, whereas volatility-spillover effects to be substantial. Miyakoshi (2003) examined the magnitude of return and volatility spillovers from Japan and the US to seven Asian equity markets by using EGARCH model. He found that Firstly, only the influence of the US is important for Asian market returns; there is no influence from Japan. Secondly, the volatility of the Asian market is influenced more by the Japanese market than by the US.

Baele (2002) quantifies the magnitude and the time-varying nature of the volatility-spillover effects from the US (global effects) and the aggregate European stock markets (regional effects) into individual European stock markets. Wang et al. (2002) investigated how returns and volatilities of stocks are correlated for dually-traded stocks on two non-synchronous international markets (London and Hong kong) for the period from October 1996 to July 2000. He found evidence of returns and volatility spillovers from Hong Kong to London, and from London to Hong Kong. He also concluded that the Asian financial crisis has a significantly negative impact on most of the dually-traded stocks in the sample. Reyes (2001) examined volatility transfer between transfers between large and small-cap size-based stock indexes from the Tokyo Stock Exchange by using EGARCH and found that asymmetric volatility spillover from large-cap stock returns to small-cap stock returns, but not vice versa.

2.01 Research gap

The paper is primarily motivated by several reasons. Firstly, most studies that examine the mean and volatility spillover effects across international stock markets focus mainly on markets in the U.S., Japan, and Europe, with little attention paid to emerging markets. The South Asian markets included in the study have enjoyed remarkably rapid economic growth in the past decade and are gaining increasing influence in the world capital markets. Thus, the linkages of these emerging markets with other markets deserve closer attention. Secondly, only few researchers have used CGARCH M model which is superior to other models of GARCH. Thirdly, some researchers reported that volatility of stock returns is time-varying (Masulis et al. 1990; King and Wadhwani, 1990; Cheung and Ng, 1992; Theodossiou and Lee, 1993 and Susmel and Engle, 1994).

3.0 Materials and methodology

3.01 Data

The study considered six countries as representative of South Asia and one developed nation i.e. US to identify the volatility spillover from developed country. But due to the unavailability of long term data, we have deleted two countries i.e. Nepal and Maldives. This study used daily closing prices of Major index of each country which will be representing the countries. The prices are converted into US $ by taking monthly average exchange rate. Table 1 shows the indices used for various countries:

Table 01: List of Indices used for the study

S. No.	Indices	Countries	Data Period
1.	S&P 500 index	United States	01.04.2006 to 31.08.2012
2.	Colombo Stock Exchange All Share Index (CSEALL)	Sri Lanka	01.04.2006 to 31.08.2012
3.	DSE Index	Bangladesh	01.04.2006 to 31.08.2012
4.	KSE-100 Index	Pakistan	01.04.2006 to 31.08.2012
5.	Nifty	India	01.04.2006 31.08.2012

3.02 Methodology of the study

All the results are computed on the basis of R_t which is the rate of return r in period t, computed as logarithmic first difference. The descriptive statistic is calculated to know the nature of time series. Following tests are applied in this paper:

Stationarity test:

Unit root tests from Augmented Dickey Fuller (ADF) (Dickey & Fuller, 1981) technique is applied to each series to determine their order of integration.

$$X_t = In\ (S_t|S_{t-1})$$

Where X_t represents the return of Index.

Granger causality:

Granger causality is a technique for determining whether one time series is useful in forecasting another. Ordinarily, regressions reflect "mere" correlations. Granger (1969) defined causality as follows:

'A variable Y is causal for another variable X if knowledge of the past history of Y is useful for predicting the future state of X over and above knowledge of the past history of X itself. So if the prediction of X is improved by including Y as a predictor, then Y is said to be Granger causal for X.'

Granger presented a clear time series approach for testing for such causality that has since been used in many econometric studies. Relationship between two variables can be unidirectional, bidirectional (or feedback) and neither bilateral nor unilateral (i.e. independence means no Granger-causality in any direction). Granger causality testing applies only to statistically stationary time series. If the time series are non-stationary, then the time series model should be applied to temporally differenced data rather than the original data.

Consider a Vector Autoregressive model of two-equation as:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} A_{10} \\ A_{20} \end{bmatrix} + \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

Where,

A_{i0} = the parameters representing intercept terms

$A_{ij}(L)$ = the polynomials in the lag* operator L

ε_{it} = white-noise disturbances

In the two-equation model with p lags, y_{1t} does not Granger cause y_{2t} if and only if all of the coefficients of $A_{21}(L)$ are equal to zero. Again, if all variables in the VAR are stationary, Granger Causality can be tested by using a standard F-test of the restriction:

$a_{21}(1) = a_{21}(2) = a_{21}(3) = \ldots = a_{21}(p) = 0$

Where, $a_{21}(1)$, $a_{21}(2)$,... are the individual coefficients of $A_{21}(L)$.

ARCH LM:

Since GARCH family models can be applied only when series is hetroscedastic, ARCH LM test is used to check the heteroscedasticity. Engle (1982) introduced a new approach for modeling heteroscedasticity in a time series. He called it the ARCH (Autoregressive conditional heteroscedasticity) model. The process by which the variances are generated is assumed to be as follows:

$\sigma_1^2 = \alpha_0 + \alpha_1\mu^2_{t-1} + \ldots\ldots\ldots\ldots + \alpha_p\mu^2_{t-p}$

This equation is known as p^{th} order ARCH process.

The null hypothesis is:

H_0= There is no arch effect.

H_1= There is arch effect.

C GARCH-M:

We have used the Component GARCH Mean (CGARCH M) model proposed by Engle and Lee (1999) in our research as many researchers find it superior volatility model as CGARCH model makes it possible to model separately the effect of spillovers on stock return volatility in the short and long run (Christoffersen et al., 2006).

Following Equation represents the Mean equation:

$$X_t = \alpha_0 + \alpha_1 X_{t-1} + \varepsilon_t + \gamma\, h_t^2$$

Where α_0 represents intercept

X_{t-1} represents the lagged returns of different indices

γ represents risk premium

ε_t represents error term

$$h_t^2 = q_t + \alpha(\varepsilon_{t-1}^2 - q_{t-1}) + \beta(h_{t-1}^2 - q_{t-1})$$

$$q_t = \omega + \rho(q_{t-1} - \omega) + \varphi(\varepsilon_{t-1}^2 - h_{t-1}^2)$$

Where q_t represents intercept
α represents ARCH i.e. response to news
β shows GARCH effect
ω shows the long run component of conditional variance
ρ reflect AR term
φ represent forecasted error

4.0 Analysis and findings

All the results are computed on the basis of R_t which is the rate of return r in period t, computed as logarithmic first difference. We divide total time period into two subsamples ranging from Apr, 2006 to Nov, 2007 and Dec, 2007 to Mar, 2012 for the purpose of analysis. ADF test is applied on return with intercept, trend and intercept and none. Table 2 presents the result of unit root test. The ADF test rejects the null hypothesis of unit root in both sub periods as well as in total period which implies that returns of all indices are stationary. Therefore, it can be inferred that all the series are integrated of order one, i.e., I (1).

Table 02: Unit root test
Augmented Dickey Fuller test

Indices	Intercept			Trend & Intercept			None		
	1st Apr, 06 - 30th Nov, 07	1st Dec, 07 - 31st Mar, 12	1st Apr, 06 to 31st Mar, 12	1st Apr,06 - 30th Nov, 07	1st Dec, 07 -31st Mar, 12	1st Apr, 06 -31st Mar, 12	1st Apr, 06 - 30th Nov, 07	1st Dec, 07 - 31st Mar, 12	1st Apr, 06 - 31st Mar, 12
S&P 500 index	-12.9127 (0.0000)	-17.3735 (0.0000)	-12.9281 (0.0000)	-12.8982 (0.0000)	-17.3654 (0.0000)	-17.3817 (0.0000)	-12.9281 (0.0000)	-17.3816 (0.0000)	-17.9442 (0.0000)
Colombo Stock Exchange All Share Index (CSEALL)	-12.4011 (0.0000)	-17.4631 (0.0000)	-12.4424 (0.0000)	-12.3831 (0.0000)	-17.4066 (0.0000)	-17.4206 (0.0000)	-12.4424 (0.0000)	-17.4206 (0.0000)	-18.4412 (0.0000)
DSE Index	-9.9896 (0.0000)	-16.6764 (0.0000)	-10.0084 (0.0000)	-9.9683 (0.0000)	-16.6699 (0.0000)	-16.6826 (0.0000)	-10.0084 (0.0000)	-16.6826 (0.0000)	-17.4 (0.0000)
KSE-100 Index	-10.8873 (0.0000)	-17.5653 (0.0000)	-10.9129 (0.0000)	-10.861 (0.0000)	-17.5583 (0.0000)	-17.5719 (0.0000)	-10.9128 (0.0000)	-17.5781 (0.0000)	-17.1156 (0.0000)
Nifty	-14.5653 (0.0000)	-16.3573 (0.0000)	-14.5811 (0.0000)	-14.5482 (0.0000)	-16.3489 (0.0000)	-16.3654 (0.0000)	-14.5810 (0.0000)	-16.3654 (0.0000)	-19.4228 (0.0000)

Note: p values are reported in parentheses

Table 3 reports the statistical properties of data for the whole period i.e. 2006-2012. The results shows that returns of Colombo Stock Exchange All Share Index (CSEALL) of Sri Lanka has highest average returns amongst indices of all other countries. The volatility can be expressed in terms of standard deviation of return. Nifty exhibit highest standard deviation followed by DSE Index, S&P 500 index, KSE-100 Index and Colombo Stock Exchange All Share Index (CSEALL). All countries have distributions with positive excess kurtosis and are seen to have heavy tails. If the kurtosis exceeds 3, the distribution is said to be leptokurtic relative to the normal. This implies that the distribution of stock returns in these countries tend to contain extreme values. The Jarque-Bera is a test statistic for testing whether the series is normally distributed.

Table 03: Statistical properties of data for whole period

Indices	Mean	St Dev.	Skewness	Kurtosis	Jarque-Bera
	1st Apr, 06 - 31st Mar, 12	1st Apr, 06 - 31st Mar, 12	1st Apr, 06 - 31st Mar, 12	1st Apr, 06 - 31st Mar, 12	1st Apr, 06 - 31st Mar, 12
S&P 500 index	$6.64X10^{-5}$	0.0153	-0.2853	11.1552	4377.628 (0.0000)
Colombo Stock Exchange All Share Index (CSEALL)	0.0005	0.0110	-0.0092	7.0056	958.7054 (0.0000)
DSE Index	$-2.34X10^{-5}$	0.0156	-0.2431	9.8879	2656.216

KSE-100 Index	-3.63EX10^{-5}	0.0150	-0.6141	6.5842	(0.0000) 919.9482 (0.0000)
Nifty	0.0003	0.0196	-0.0841	9.6742	2830.461 (0.0000)

Note: p values are reported in parentheses

Table 4 presents the statistical properties of data for sub periods. The average return of all the indices decreased for all the indices after 30th November, 2007 except DSE Index. In period of Dec, 2007–Mar, 2012, standard deviation increased for S&P 500 Index, Colombo Stock Exchange All Share Index (CSEALL) and Nifty while it decreased for DSE Index and KSE-100 Index. The skewness has improved for all the indices after 30th November, 2007 except DSE Index and KSE-100 Index. The results also show that kurtosis has increased for all the indices except DSE Index. The Jarque-Bera test rejects the null hypotheses of normality in both sub periods. The above result implies that returns of S&P 500 Index, Colombo Stock Exchange All Share Index (CSEALL) and Nifty are associated with each other while returns of DSE Index and KSE-100 Index are not showing any association with other Indices.

Table 04: Statistical Properties of Data for sub periods

Indices	Mean		Standard Deviation		Skewness		Kurtosis		Jarque-Bera	
	1st Apr, 06 - 30th Nov, 07	1st Dec, 07- 31st Mar, 12	1st Apr, 06- 30th Nov, 07	1st Dec, 07- 31st Mar, 12	1st Apr, 06- 30th Nov, 07	1st Dec, 07- 31st Mar, 12	1st Apr, 06- 30th Nov, 07	1st Dec, 07- 31st Mar, 12	1st Apr, 06- 30th Nov, 07	1st Dec, 07 to 31st Mar, 12
S&P 500 index	0.0003	-4.07 X10^{-5}	0.0083	0.0175	-0.4304	-0.239	5.5396	9.2026	144.1115 (0.000)	1757.754 (0.000)
Colombo Stock Exchange All Share Index (CSEALL)	0.0009	0.0004	0.0104	0.0111	-0.8596	0.0805	6.549	7.058	104.3532 (0.000)	874.267 (0.000)
DSE Index	3.60 X10^{-5}	0.0001	0.0151	0.0086	-0.2660	-0.056	10.51	6.026	3450.644 (0.000)	103.215 (0.000)
KSE-100 Index	0.0004	-8.28 X10^{-5}	0.0186	0.0143	-0.5204	-0.645	3.604	7.590	13.2761 (0.000)	1247.63 (0.000)
Nifty	0.0018	-0.001	0.0172	0.020	-0.250	-0.008	8.046	9.814	513.3746 (0.000)	2019.90 (0.000)

Note: p values are reported in parentheses

As a step toward investigating the volatility spillover effect among South Asian countries, correlation test is applied on the returns of all the indices to know the association between the returns of all the indices. Table 5 reports the results of correlation test for the whole period and analysis reveals significant correlation among the returns of DSE Index and Colombo Stock Exchange All Share Index (CSEALL) which implies that returns of these indices get influenced by returns of each other.

Table 05: Correlation analysis for whole period

Indices	DSE Index	Nifty	KSE-100 Index	Colombo (CSEALL)	S&P 500 index
	1st Apr, 06 to 31st Mar, 12	1st Apr, 06 to 31st Mar, 12	1st Apr, 06 to 31st Mar, 12	1st Apr, 06 to 31st Mar, 12	1st Apr, 06 to 31st Mar, 12
DSE Index	1.0000				
Nifty	-0.0034	1.0000			
KSE-100 Index	0.0273	0.0401	1.0000		
Colombo (CSEALL)	-0.0588*	-0.0006	0.0040	1.0000	
S&P 500 index	-0.0457	0.0437	-0.0500	0.0352	1.0000

*Correlation is significant at 0.01 level (2-tailed)

Table 6 presents the result of correlation analysis for sub periods. The analysis shows that there is no significant correlation among the returns of all the indices except KSE-100 Index and Nifty (Dec, 2007- Mar, 2012). We found that returns of KSE-100 Index and Nifty became significantly correlated after November, 2007 which means that returns of these indices started influencing each other after beginning of recession.

Table 04: Statistical Properties of data for sub periods

Indices	DSE Index		Nifty		KSE-100 Index		Colombo (CSEALL)		S&P 500 index	
	1stApr, 06 - 30thNov, 07	1st Dec, 07- 31st Mar, 12	1stApr, 06- 30thNov, 07	1st Dec, 07- 31st Mar, 12	1stApr, 06- 30thNov, 07	1st Dec, 07- 31st Mar, 12	1stApr, 06- 30thNov, 07	1st Dec, 07- 31st Mar, 12	1stApr, 06- 30thNov, 07	1st Dec, 07 to 31st Mar, 12
S&P 500 index	1.0000	1.0000								
Colombo (CSEALL)	0.0169	0.0293	1.0000	1.0000						
DSE Index	-0.1065	-0.0285	0.0021	-0.0838*	1.0000	1.0000				
KSE-100 Index	-0.0589	-0.0057	-0.0426	0.0017	0.0153	0.0267	1.0000	1.0000		
Nifty	-0.0314	0.0017	-0.1200	0.0312	-0.1012	0.7225	0.0194	0.0020	1.0000	1.0000

Note: *Correlation is significant at 0.01 level (2-tailed)

Since all series are integrated of order one i.e. stationary at log difference, so we continue with the lag order selection criteria for testing the Granger Causality. The LR test [sequential modified LR test statistic (each test at 5% level)] is used as a primary determinant of how many lags to be include. As the LR criteria choose 9 lags so, we reach at this conclusion that 9 lags are optimal for the whole period. We also selected lag order of 5 for period of 1st Apr, 2006- 30th Nov, 2007 and lag order of 9 for period of 1st Dec, 07 to 31st Mar, 12.

With continuation of analysis, we proceed to perform the pair-wise Granger Causality test for all the series. Table 7 shows the results of pair wise Granger Causality test for whole period i.e. long term causality. According to results of table 7, return of Colombo Stock Exchange All Share Index (CSEALL) Granger Cause return of Nifty as p value is significant but returns of Nifty does not Granger Cause return of Colombo Stock Exchange All Share Index (CSEALL). It means the Granger Causality is (unidirectional) between the series, running from Sri Lanka to India and not the other way. P value is also significant for null hypothesis of return of S&P 500 index does not Granger Cause return of Nifty and return of Nifty does not Granger Cause return of S&P 500 Index. Therefore, we conclude that returns of S&P 500 Granger Cause return of Nifty the converse is also true, it means the Granger Causality is (bidirectional) between the series, running from India to U.S and the other way.

Table 07: Granger Causality test for whole period

Null Hypothesis	Lags	Obs	Prob.	Decision
Return of Colombo Stock Exchange All Share Index (CSEALL) does not Granger Cause return of DSE Index	9	1425	0.9690	Do not reject
Return of DSE Index does not Granger Cause return of Colombo Stock Exchange All Share Index (CSEALL)			0.5299	Do not reject
Return of Nifty does not Granger Cause return of DSE Index	9	1425	0.4771	Do not reject
Return of DSE Index does not Granger Cause return of Nifty			0.64731	Do not reject
Return of KSE-100 Index does not Granger Cause return of DSE Index	9	1425	0.2978	Do not reject
Return of DSE Index does not Granger Cause return of KSE-100 Index			0.2532	Do not reject
Return of S&P 500 index does not Granger Cause return of DSE Index	9	1425	0.2784	Do not reject
Return of DSE Index does not Granger Cause return of S&P 500 index			0.55401	

				Do not reject
Return of Nifty does not Granger Cause return of Colombo Stock Exchange All Share Index (CSEALL)	9	1425	0.8338	Do not reject
Return of Colombo Stock Exchange All Share Index (CSEALL) does not Granger Cause return of Nifty			0.0345	Reject
Return of KSE-100 Index does not Granger Cause return of Colombo Stock Exchange All Share Index (CSEALL)	9	1425	0.5053	Do not reject
Return of Colombo Stock Exchange All Share Index (CSEALL) Cause return of KSE-100 Index			0.1225	Do not reject
Return of S&P 500 index does not Granger Cause return of Colombo Stock Exchange All Share Index (CSEALL)	9	1425	0.2951	Do not reject
Return of Colombo Stock Exchange All Share Index (CSEALL) Cause return of S&P 500 index			0.2331	Do not reject
Return of KSE-100 Index does not Granger Cause return of Nifty	9	1425	0.6907	Do not reject
Return of Nifty does not Granger Cause return of KSE-100 Index			0.7384	Do not reject
Return of S&P 500 index does not Granger Cause return of Nifty	9	1425	0.0001	Reject
Return of Nifty does not Granger Cause return of S&P 500 index			$5.1x10^{-6}$	Reject
Return of S&P 500 index does not Granger Cause return of KSE-100 Index	9	1425	0.3837	Do not reject
Return of KSE-100 Index does not Granger Cause return of S&P 500 index			0.9734	Do not reject

Table 8 presents the result of Granger Causality test for sub periods. For period of Apr, 06-Nov, 07, p value is significant only for 3 null hypotheses: Return of S&P 500 index does not Granger Cause return of Nifty; Return of Nifty does not Granger Cause return of S&P 500 index; Return of S&P 500 index does not Granger Cause return of KSE-100 Index. It means Granger Causality is (bidirectional) between the series of U.S. and India, running from U.S. to India and the other way while Granger Causality is (unidirectional) between the series of U.S. and Pakistan, running from U.S. to Pakistan and not the other way. For period of Dec, 07-Mar,12, p value is significant for null hypotheses of Return of S&P 500 index does not Granger Cause return of Nifty and Return of Nifty does not Granger Cause return of S&P 500 index. This shows that Granger Causality is (bidirectional) between the series of U.S. and India, running from U.S to India and the other way.

Table 08: Granger causality test for sub periods

	Lags		Obs.		Prob.		Decision	
Null Hypothesis	1stApr, 06 - 30thNov, 07	1st Dec, 07- 31st Mar, 12	1stApr, 06- 30thNov, 07	1st Dec, 07- 31st Mar, 12	1stApr, 06- 30thNov, 07	1st Dec, 07- 31st Mar, 12	1stApr, 06- 30thNov, 07	1st Dec, 07- 31st Mar, 12
Return of Colombo Stock Exchange All Share Index (CSEALL) does not Granger Cause return of DSE Index	5	9	265	1081	0.1857	0.9896	Do not reject	Do not reject
Return of DSE Index does not Granger Cause return of Colombo Stock Exchange All Share Index (CSEALL)					0.0914	0.2527	Do not reject	Do not reject
Return of Nifty does not Granger Cause return of DSE Index	5	9	265	1081	0.8965	0.3516	Do not reject	Do not reject
Return of DSE Index does not Granger Cause return of Nifty					0.9674	0.0603	Do not reject	Do not reject

Return of KSE-100 Index does not Granger Cause return of DSE Index	5	9	265	1081	0.8982	0.0089	Do not reject	Do not reject
Return of DSE Index does not Granger Cause return of KSE-100 Index					0.0621	0.5982	Do not reject	Do not reject
Return of S&P 500 index does not Granger Cause return of DSE Index	5	9	265	1081	0.9671	0.1407	Do not reject	Do not reject
Return of DSE Index does not Granger Cause return of S&P 500 index					0.9691	0.1799	Do not reject	Do not reject
Return of Nifty does not Granger Cause return of Colombo Stock Exchange All Share Index (CSEALL)	5	9	265	1081	0.8282	0.8666	Do not reject	Do not reject
Return of Colombo Stock Exchange All Share Index (CSEALL) does not Granger Cause return of Nifty					0.4104	0.6403	Do not reject	Do not reject
Return of KSE-100 Index does not Granger Cause return of Colombo Stock Exchange All Share Index (CSEALL)	5	9	265	1081	0.4016	0.2201	Do not reject	Do not reject
Return of Colombo Stock Exchange All Share Index (CSEALL) Cause return of KSE-100 Index					0.7478	0.8877	Do not reject	Do not reject
Return of S&P 500 index does not Granger Cause return of Colombo Stock Exchange All Share Index (CSEALL)	5	9	265	1081	0.7872	0.9013	Do not reject	Do not reject
Return of Colombo Stock Exchange All Share Index (CSEALL) Cause return of S&P 500 index					0.6300	0.8234	Do not reject	Do not reject
Return of KSE-100 Index does not Granger Cause return of Nifty	5	9	265	1081	0.1791	0.4995	Do not reject	Do not reject
Return of Nifty does not Granger Cause return of KSE-100 Index					0.4049	0.3367	Do not reject	Do not reject
Return of S&P 500 index does not Granger Cause return of Nifty	5	9	265	1081	0.0032	0.0036	Reject	Reject
Return of Nifty does not Granger Cause return of S&P 500 index					0.0268	$9.6x10^{-6}$	Reject	Reject
Return of S&P 500 index does not Granger Cause return of KSE-100 Index	5	9	265	1081	0.0139	0.3099	Reject	Do not reject

Return of KSE-100 Index does not Granger Cause return of S&P 500 index	0.1904	0.4747	Do not reject	Do not reject

We have applied ARCH LM test to check the presence of heteroscedasticity. Table 9 reports the results of ARCH LM test. This test rejects the null hypotheses of no ARCH effect for all the indices in both sub periods and whole period which implies that ordinary regression model will be inefficient to check the volatility spillover effect. Therefore, we have to apply CGARCH-M model which take care of heteroskedastic.

Table 09: ARCH LM test for sub periods and whole period

Indices	F-statistic			Obs*R-squared		
	1st Apr, 06 - 30th Nov, 07	1st Dec, 07 - 31st Mar, 12	1st Apr, 06 - 31st Mar, 12	1st Apr, 06 to 30th Nov, 07	1st Dec, 07 - 31st Mar, 12	1st Apr, 06 - 31st Mar, 12
S&P 500 index	4.0789	43.09846	64.20519	30.8698	284.1433	413.1936
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Colombo (CSEALL)	7.547979	20.33063	21.86275	49.09594	156.7746	173.9503
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
DSE Index	8.3657	46.6951	61.21393	52.7689	300.9604	399.338
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
KSE-100 Index	6.170021	9.492161	18.52494	42.73062	79.62638	150.2046
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Nifty	3.042878	7.326742	10.40372	24.57499	62.55631	88.44279
	(0.002334)	(0.0000)	(0.0000)	(0.003479)	(0.0000)	(0.0000)

Note: p values are reported in parentheses

For a closer examination of volatility spillover, C GARCH M model is fitted to the data. Table 10 reports the results of mean equation of CGARCH M for whole period. The GARCH Coefficient is included in mean equation to test risk premium. In mean equation, the relation of returns of all the indices is checked with the lagged returns of all the Indices for testing mean spillover among all the indices. The results show that coefficient of GARCH is not significant for any index. The results show that returns of S&P 500 Index is significantly influenced by lagged returns of DSE Index and its own lagged returns. The returns of Colombo Stock Exchange All Share Index (CSEALL) are also significantly influenced by lagged returns of S&P 500 Index. The coefficient of constant is significant only for KSE-100 which implies that the returns of these indices depend on factors other those included in the equation. The analysis also provides evidences of mean spillover among the returns of KSE-100 Index and its own lagged returns as well as lagged returns of Colombo stock exchange all share index (CSEALL).

Table 10: C GARCH M (Mean Equation) for whole period

Indices	GARCH	C	Nifty	KSE-100 Index	DSE Index	Colombo (CSEALL)	S&P 500 Index
S&P 500 index	0.3764	0.0006	-0.0085	0.0072	-0.0946*	0.0289	0.0480*
	(0.8517)	(0.0781)	(0.5434)	(0.6914)	(0.0001)	(0.0559)	(0.0247)
Colombo (CSEALL)	0.9403	0.0003	-0.0151	0.0127	0.0016	0.0179	0.2463*
	(0.8016)	(0.3849)	(0.2327)	(0.2821)	(0.9144)	(0.2105)	(0.0000)
DSE Index	-0.2787	0.0006	0.0190	0.0164	-0.0067	-0.0495	-0.0219
	(0.8983)	(0.0651)	(0.1469)	(0.281)	(0.6823)	(0.0732)	(0.3162)
KSE-100 Index	-2.0414	0.0012*	0.0035	0.0852*	0.0258	-0.0368*	-0.0378
	(0.4685)	(0.0188)	(0.8414)	(0.0091)	(0.2454)	(0.0104)	(0.2004)
Nifty	0.4895	0.0007	0.0601	0.0246	0.0123	-0.0302	-0.0040
	(0.8277)	(0.3222)	(0.0596)	(0.3807)	(0.6809)	(0.2946)	(0.9176)

Note: p values are reported in parentheses, *Indicates significance at 5%

Table 11 reports the results of mean equation of C GARCH M for sub periods. The coefficient of GARCH is significant only for returns of Colombo Stock Exchange All Share Index (CSEALL) during Apr, 2006-Nov, 2007 which implies that stock market of Sri Lanka provide higher returns during the high volatility period. The coefficient of constant is significant only for KSE-100 (Dec, 2007-Mar, 2012) and Nifty (Apr, 2006- Nov, 2007) which implies that the returns of these indices depend on factors other those included in the equation. We observed that current returns of S&P 500 Index are significantly influenced by lagged returns of DSE Index during Dec, 2007-Mar, 2012. The returns of Colombo Stock Exchange All Share Index (CSEALL) are significantly influenced by lagged returns of Nifty and S&P 500 in both sub periods. The returns of DSE Index is significantly (negative) influenced by its own lagged returns. The analysis revealed that returns of KSE-100 Index became significantly related with lagged returns of its own as

well as with lagged returns of Colombo Stock Exchange All Share Index (CSEALL) and S&P 500 Index after Nov, 2007. The returns of Nifty are significantly related with its lagged returns as well as with lagged returns of Colombo Stock Exchange All Share Index (CSEALL).

Table 12 summarizes the results of variance equation of C GARCH-M for whole period. The coefficient of ω (intercept) is significant for all the indices which measures time invariant permanent level of volatility. This implies that there is minimum level of permanent volatility which will be always in the market irrespective of time and factors considered in the study. The coefficient of ρ measures permanent component of volatility which is positive and higher than the ones corresponding to the transitory component, reflecting the fact that the permanent volatility component is stronger than the short-term one. Thus, volatility in South Asian countries is of long term nature. The coefficients corresponding to the error term (φ) are in most of the cases positive, suggesting a higher shock impact on the permanent component of the volatility. This can be explained by the fact that the present database include data of Apr, 06-Mar, 2012 which was period of recession and most of the south Asian countries had a destabilized macroeconomic environment. The transitory component ($\alpha+\beta$) i.e. short term component of volatility is negative for Nifty, confirming long-term nature of shocks.

Table 13 presents the results of variance equation of C GARCH-M for sub periods. The coefficient of ω (intercept) which measures time invariant permanent level of volatility is near to zero (significant at 5%) for S&P 500 Index and DSE Index during Apr, 2006 -Nov, 2007 and for KSE-100 Index and Nifty during Dec, 07-Mar, 12. This implies that there is minute level of permanent volatility which will be always in the stock market of U.S., Bangladesh, Pakistan and India irrespective of time and factors considered in the study. The coefficient of ρ measures permanent component of volatility which is positive and higher than the ones corresponding to the transitory component for all the indices in both periods, reflecting the fact that the permanent volatility component is stronger than the short-term one. Thus, volatility in South Asian countries is of long term nature. In Apr, 2006-Nov, 2007, coefficients corresponding to the error term (φ) is positive for all the indices except Colombo Stock Exchange All Share Index (CSEALL). This suggests higher shock impact on the permanent component of the volatility of stock market of India (Nifty), Pakistan (KSE-100index), Bangladesh (DSE index) and U.S. (S&P 500 Index). We can observe that coefficient of error term is significantly negative for Colombo Stock Exchange All Share Index (CSEALL) which implies lower shock impact on the permanent component of the volatility of its stock market. In Dec, 2007-Mar, 2012, the coefficient of error term (φ) is significantly positive for all the indices which implies higher shock impact on the permanent component of the volatility of stock market of all South Asian countries. This can be explained by the fact that the recession started in Dec, 2007 and most of the south Asian countries had a destabilized macroeconomic environment during this sub period. In sub period of Apr, 2006-Nov, 2007, the transitory component ($\alpha+\beta$) i.e. short term component of volatility is negative for Nifty and DSE Index, confirming long-term nature of shocks in the stock market of India and

Table 11: C GARCH-M (Mean Equation) for sub periods

Indices	GARCH		C		Nifty		KSE-100 Index		DSE Inde		Colombo (CSEALL		S&P 500 Index	
	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12
S&P 500 Index	-40.342	-0.405	0.002	0.0008	-0.0073	0.0033	0.0426	-0.0025	-0.0317	-0.0856*	0.1087	-0.0007	0.0509	-0.0307
	(0.1074)	(0.8413)	(0.1803)	(0.0627)	(0.7994)	(0.8576)	(0.1361)	(0.9091)	(0.6942)	(0.0033)	(0.1258)	(0.9778)	(0.3844)	(0.2888)
Colombo (CSEALL)	47.139*	3.464	-0.003	0.0004	0.0113	-0.0216*	0.0207	-0.0021	0.0573	0.0100	0.2048	-0.0069	0.2582*	0.2662*
	(0.0122)	(0.4005)	(0.0604)	(0.2873)	(0.7463)	(0.0054)	(0.5005)	(0.9055)	(0.5836)	(0.4938)	(0.0696)	(0.656)	(0.0019)	(0.0000)
DSE Index	-63.472	-0.291	0.003	0.0006	0.0079	-0.0069	0.0081	0.0091	0.0197	-0.0352*	0.0078	-0.0451	0.0192	0.0202
	(0.4378)	(0.9023)	(0.38)	(0.1405)	(0.8275)	(0.6114)	(0.7784)	(0.6738)	(0.8113)	(0.0247)	(0.9346)	(0.1503)	(0.7484)	(0.4726)
KSE-100 Index	7.637	-5.983	-0.001	0.0017*	0.8113	-0.0041	0.0993	0.1043*	0.0969	-0.0162	-0.1708	0.0328*	-0.0011	0.0881*
	(0.268)	(0.0818)	(0.6636)	(0.0102)	(0.2991)	(0.8239)	(0.32)	(0.0034)	(0.6447)	(0.4005)	(0.5509)	(0.0114)	(0.9946)	(0.0024)
Nifty	-5.871	1.036	0.004*	$-1.9X10^{-5}$	-0.1762	0.0712*	0.0145	-0.0665	0.1079	-0.0132	0.0747	0.0701*	-0.0633	-0.0735
	(0.2427)	(0.6972)	(0.0386)	(0.9825)	(0.0774)	(0.045)	(0.8337)	(0.0627)	(0.5817)	(0.7173)	(0.7961)	(0.0205)	(0.6372)	(0.0947)

Note: p values are reported in parentheses, *Indicates significance at 5%

Table 13: C GARCH-M (Variance Equation) for sub periods

Indices	ω		ρ		φ		α		β		α+ β	
	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 - 3othNov, 07	1st Dec, 07 to 31st Mar, 12
S&P 500 index	$4.87X10^{-5}$*	0.0003	0.9368*	0.9871*	0.5172	0.1558*	-0.62	-0.1869	1.5242	0.5105	0.9042	0.3236
	(0.0000)	(0.1272)	(0.0000)	(0.0000)	(0.5511)	(0.0000)	(0.4624)	(0.0000)	(0.082)	(0.0001)		
Colombo (CSEALL)	0.0002	0.0006	0.9975*	0.9995*	-0.0187*	0.0271	0.3061	0.2428	0.0026	0.6765	0.3087	0.9193
	(0.1125)	(0.8253)	(0.0000)	(0.0000)	(0.0077)	(0.0849)	(0.0164)	(0.0000)	(0.988)	(0.0000)		
DSE Index	$4.82 X10^{-5}$*	0.0003	0.8414*	0.9894*	0.0443	0.1634*	-0.0386	-0.1877	-0.907	0.7389	-0.9462	0.5512
	(0.0000)	(0.245)	(0.0000)	(0.0000)	(0.3754)	(0.0000)	(0.2624)	(0.0000)	(0.000)	(0.0000)		
KSE-100 Index	0.0004	0.0002*	0.9097*	0.9517*	0.2367	0.1545*	0.1313	-0.0322	0.0724	-0.8385	0.2037	-0.8707
	(0.196)	(0.0000)	(0.0000)	(0.0000)	(0.2877)	(0.0000)	(0.5678)	(0.087)	(0.072)	(0.0000)		
Nifty	0.0004	0.0003*	0.9695*	0.9972*	0.1284*	0.0199*	-0.0115	0.0784	-0.9821	0.7848	-0.9936	0.8632
	(0.0815)	(0.0038)	(0.0000)	(0.0000)	(0.0003)	(0.0000)	(0.158)	(0.0002)	(0.000)	(0.0000)		

Note: p values are reported in parentheses, *Indicates significance at 5%

Bangladesh. In sub period of Dec, 2007-Mar, 2012, the transitory component is negative for KSE-100 index. This suggest that volatility is of short term nature for stock market of U.S., Bangladesh, India and Sri Lanka while volatility is of long higher shock impact on the permanent component of the volatility of stock market of term nature for stock market of Pakistan.

Table 12: C GARCH-M (Variance Equation) for whole period

Indices	ω	ρ	φ	α	β	α+ β
	1stApr, 06 to 31st Mar, 12	1stApr, 06 to 31st Mar, 12	1stApr, 06 to 31st Mar, 12	1stApr, 06 to 31st Mar, 12	1stApr, 06 to 31st Mar, 12	1stApr, 06 to 31st Mar, 12
S&P 500 index	0.0002*	0.9774*	0.1236*	-0.1526*	0.3729*	0.2203
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0062)	
Colombo Stock Exchange All Share Index (CSEALL)	0.0001*	0.9476*	0.1896*	0.0806	0.4004	0.481
	(0.0000)	(0.0000)	(0.0000)	(0.0513)	(0.1908)	
DSE Index	0.0003*	0.9849*	0.1632*	-0.1771*	0.7466*	0.5695
	(0.0403)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	
KSE-100 Index	0.0002*	0.9518*	0.1525*	0.0497	0.3475	0.3972
	(0.0000)	(0.0000)	(0.0000)	(0.1361)	(0.4796)	
Nifty	0.0005*	0.9828*	0.0848*	0.0587*	-0.2338	-0.1751
	(0.0000)	(0.0000)	(0.0000)	(0.0231)	(0.5637)	

Note: p values are reported in parentheses, *Indicates significance at 5%

ARCH LM test is applied again to see whether there is any leftover arch effect in the series. Table 14 reports the result of ARCH LM test. ARCH LM test can not reject the null hypothesis of no heteroscedasticity for both sub periods as well whole period. Result shows that series don't have any leftover arch effect.

Table 14: ARCH LM test

Indices	F-statistic			Obs*R-squared		
	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 31st Mar, 12	1stApr, 06 to 3othNov, 07	1st Dec, 07 to 31st Mar, 12	1stApr, 06 to 31st Mar, 12
S&P 500 index	0.423285	0.898752	0.489388	3.9712	8.103735	4.421854
	(0.9209)	(0.5256)	(0.8825)	(0.9132)	(0.5237)	(0.8815)
Colombo Stock Exchange All Share Index (CSEALL)	0.556729	0.613499	1.079129	5.181779	5.545483	9.714122
	(0.8303)	(0.7863)	(0.3750)	(0.8181)	(0.7844)	(0.3741)
DSE Index	0.346238	1.105574	0.517852	3.263966	9.950644	4.678196
	(0.9577)	(0.3557)	(0.8625)	(0.9529)	(0.3545)	(0.86141)
KSE-100 Index	0.276249	0.926572	0.645465	2.615535	8.352552	5.826317
	(0.9802)	(0.5009)	(0.7586)	(0.9776)	(0.4991)	(0.7571)
Nifty	0.292011	0.191526	0.28206	2.762057	1.73764	2.551901
	(0.9760)	(0.9951)	(0.9797)	(0.9729)	(0.9949)	(0.9794)

Note: p values are reported in parentheses

5.0 Conclusion

The main objective of the study was to capture the nature of volatility and volatility spillover among South Asian countries through application of Granger Causality and CGARCH M. The analysis is done for long term (1st Apr, 2006-31st Mar, 2012) as well as short term period (1st Apr, 2006-30th Nov, 2007 and 1st Dec, 2007-31st Mar, 2012) for highlighting the impact of recession which started in 2007.

The results of long term period are analyzed in this paragraph. Since volatility can be measured through standard deviation which is highest for Nifty followed by DSE Index, S&P 500 index, KSE-100 Index and Colombo Stock Exchange All Share Index (CSEALL). This implies that volatility is highest in India followed by Bangladesh, U.S., Pakistan and Sri Lanka. The results of correlation showed significant correlation among returns of DSE Index and Colombo Stock Exchange All Share Index (CSEALL) which implies that returns of these indices get influenced by returns of each other. The result of Granger Causality depicts unidirectional causality running from Sri Lanka to India and bidirectional causality between India and U.S. The mean equation of CGARCH M depicts among returns of U.S. and Bangladesh as well as among returns of Pakistan and Sri Lanka. The Variance equation of CGARCH M helped in capturing nature of volatility. We found that volatility in South Asian countries is of long term nature. The

result also depicts a higher shock impact on the permanent component of the volatility. This can be explained by the fact that the present database include data of Apr, 06-Mar, 2012 which was period of recession and most of the south Asian countries had a destabilized macroeconomic environment.

This paragraph deals with the analysis of results for short term period. The analysis showed that average return of all the indices decreased for all the indices after 30th November, 2007 except DSE Index. In period of Dec, 2007-Mar, 2012, standard deviation increased for S&P 500 Index, Colombo Stock Exchange All Share Index (CSEALL) and Nifty while it decreased for DSE Index and KSE-100 Index. Therefore, we can conclude that returns of S&P 500 Index, Colombo Stock Exchange All Share Index (CSEALL) and Nifty are associated with each other while returns of DSE Index and KSE-100 Index are not showing any association with other Indices during Dec, 2007- Mar, 2012. For period of Apr 2006- Nov 2007, there was bidirectional Causality between the series of U.S. and India. The results also showed unidirectional causality between the series of U.S. and Pakistan, running from U.S. to Pakistan. For period of Dec, 07-Mar, 12, Granger Causality is (bidirectional) between the series of U.S. and India. This implies that causality between U.S. and Pakistan disappeared after Nov, 2007 which may be due to recession. The results of mean equation of CGARCH M depicts that stock market of Sri Lanka provide higher returns during the high volatility period only in pre recession period which disappeared in Dec, 2007. The result also showed that returns of Pakistan became significantly related with lagged returns of its own as well as with lagged returns of Sri Lanka and U.S. after Nov, 2007. We found that returns of U.S. get associated with the returns of Bangladesh after recession. The relation between returns of Sri Lanka, India and U.S. remained same even after the beginning of recession. The returns of India get significantly influenced by Sri Lanka. The result of variance equation suggests that permanent volatility component is stronger than the short-term one in both sub periods which implies that volatility in South Asian countries is of long term nature. The coefficient of error term ($\boldsymbol{\varphi}$) is significantly positive for all the indices during Dec,2007- Mar, 2011 which implies higher shock impact on the permanent component of the volatility of stock market of all South Asian countries. This can be explained by the fact that the recession started in Dec, 2007 and most of the south Asian countries had a destabilized macroeconomic environment during this sub period. The results also depicts that volatility became short term for stock market of U.S., Bangladesh, India and Sri Lanka while volatility in Pakistan became long term after recession.

Therefore, we can conclude that there is significant bidirectional causality between Stock market of U.S. and India for both short terms as well as for long term which is not disturbed by recession. But the recession has changed causal relation among other countries. The recession has created higher shock impact on the permanent component of the volatility of stock market of all South Asian countries. It is also observed that volatility of all South Asian countries is of long term nature. In addition, the observed spillover effects are unstable over time in the sense that the spillover changed its nature after beginning of recession.

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