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Market Efficiency and Asymmetric Relationship between South Asian Stock Markets: An Empirical Analysis

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Abstract

This paper examines market efficiency and asymmetric cointegration among the South Asian stock markets using monthly data from January 1998 to December 2013. The structural breaks and wavelet based unit root tests indicate that the markets are efficient at least in the weak form. We use asymmetric cointegration and asymmetric error correction models to examine the dynamic relationship between the selected stock markets. Results suggest that Indian stock market impacts Pakistani stock market in long run. Bangladesh stock market impacts Sri Lankan stock market and the speed of adjustment to the positive shocks is higher and thus stock prices adjust quickly to the good news in comparison to the bad ones. The asymmetric error correction model shows unidirectional causality running from Indian stock market (Sri Lankan stock market) to Pakistani stock market (Bangladeshi stock market). The analysis provides implications for the investors while assigning the optimal weight of assets during portfolio formulation.

Keywords: asymmetric co-integration, market efficiency, stock markets, south Asia.

1. Introduction

The quality of a financial market depends on its efficiency to capture the new information. The Efficient Market Hypothesis (EMH) is considered as the key area of research in finance literature to understand and promote the quality of financial markets. The weak form of market efficiency postulates that asset prices reflect past information and hence follow a random walk with zero or positive drift. The resource allocation is impacted by the inefficiency of markets because the price signals tend to overstate or understate the effect of new information (Pagan, 1996). Though, some researchers claim that a complete efficient market is a Utopian scenario, but it has been proved by recent studies that the financial markets are becoming efficient with the passage of time (Wang *et al.*, 2009; Zunino *et al.*, 2008).

There are mixed empirical findings on the EMH in different stock markets. Some studies found that stock markets follow random walk while some found otherwise. The studies by Narayan and Smyth (2006), Hasanov and Omay (2012), Marashdeh and Shrestha (2008), Ozdemir (2008) and Awad and Daraghma (2009) found that stock markets follow random walk and hence are weak form efficient. Those who did not find the evidence for random walk include Tabak (2003) for the Brazilian stock market; Lima and Tabak (2004) for the Singaporean and Chinese stock prices; Sunde and Zivanomoyo (2008) for the Zimbabwean Stock market; Uddin and Khoda (2009) for the Bangladeshi stock prices; and Lingaraja *et al.* (2014) for the Chinese, Korean, Taiwan and Thai stock markets. In a recent study on South Asian stock markets' efficiency, Khan (2013) applied principal component analysis (PCA) and vector error correction model (VECM) and found that the South Asian markets of Bangladesh, India, Pakistan and Sri Lanka are not weak form efficient. Similarly, Seth and Sharma (2015) applied GARCH (1, 1) and documented inefficiency of the Indian and Pakistani stock markets.

Other relevant concern while analyzing the stock markets efficiency is enhanced co-movement among stock markets resulting from increased economic globalization. Past studies on stock markets cointegration have mainly focused on the developed stock markets (see e.g., Boubaker and Jouini, 2014; Lean and Ghosh, 2010; Lahrech and Sylwester, 2011). Lamba (2005) examined the dynamic relationship among South Asian and developed stock markets. He concluded that developed stock markets impact Indian stock market. Further, Pakistan and Sri Lankan stock markets were found isolated from the developed equity markets. More recently, Shahzad *et al.*, (2014) concluded that South Asian stock markets are interlinked in both long and short-run and the market integration has increased over time. Likewise, Khan (2013) applied linear methods to examine the relationship among the South Asian stock markets and concluded that these markets are integrated in long and short-run. However, the short-run linkages are relatively weak.

Notably, the traditional cointegration tests assume that the adjustment of stock prices to their long run is the same regardless of positive or negative shocks. However, the studies (Chiang, 2001; Sarantis, 2001) have shown that stock markets adjust quickly (slowly) in response to the negative (positive) shocks. The results of symmetric cointegration can be misleading, if the relationship between the variables is asymmetric (Enders and Siklos, 2001). Shen *et al.*, (2007) examined the asymmetric interdependence among the Chinese stock markets and found presence of asymmetry in stock markets' relationship. Keeping in view the importance of asymmetric (non-linear) reaction of stock markets to good and bad news, this study examines the efficiency and dynamic (symmetric and asymmetric) interdependence among the South Asian stock markets. The literature on South Asian stock markets efficiency and interdependence is not only scarce; the non-linear aspects are also yet to be explored.

Rest of the study is organized as follows. Section 2 discusses the methodology. Section 3 presents the empirical findings. Final section concludes the paper.

2. Methodology

2.1. Unit Root Test

Stock markets are considered efficient, at least in weak form, if the series follows a random walk i.e. it is non-stationary. An efficient market immediately incorporates all the publically available information and hence a shock to the market persists permanently. Traditionally, the unit root tests are used by the researchers to examine the time series properties of stock market prices. Literature highlights different unit root tests to examine the weak form of market efficiency (for details, see Tiwari and Kyophilavong, 2014). Traditional unit root tests differ based on their assumptions. Testing unit root properties of a time series without incorporating the structural breaks may provide the biased results (Perron, 1990). Unit root test which caters for two structural breaks in the time series has been proposed by Clemente *et al.*, (1998). However, this test only utilizes the time domain. A wavelet based unit root test (Fan and Gencay, 2010) is better able to test the random walk by using both time and frequency domains. We have applied both Clemente *et al.* (1998) structural break and Fan and Gencay (2010) wavelet based unit root test to analyze the random walk hypothesis and to ascertain the order of integration before examining the cointegration.

2.2. Asymmetric Cointegration and Causality

The results of symmetric cointegration can be misleading, if the relationship between the variables is asymmetric (Enders and Siklos, 2001). It is because the errors used may have different speed of adjustments under positive and negative shocks. Enders and Siklos (2001) provided a solution to this problem by introducing an error correction term in the standard Engle-Granger two-step procedure. The proposed test is a two regime threshold cointegration methodology which gives proper adjustment to the asymmetric relationship (Enders and Siklos, 2001). The expression can be written as follows:

$$\Delta\varepsilon_t = I_t\rho_1\varepsilon_{t-1} + (1 - I_t)\rho_2\varepsilon_{t-1} + \sum_{i=1}^{p}\emptyset_i\,\Delta\varepsilon_{t-i} + \mu_t \quad (1)$$

Where, I_t is an indicator function i.e. $I_t = 1$ if $\varepsilon_{t-1} \geq 0$ and $I_t = 0$ if $\varepsilon_{t-1} < 0$. The noting point is that the indicator function depends on the *level* of ε_{t-1}. Enders and Siklos (2001) suggested an alternate threshold (momentum-threshold autoregressive (M-TAR)) that depends on the change in ε_{t-1}. Where, $M_t = 1$ if $\Delta\varepsilon_{t-1} \geq 0$ and $M_t = 0$ if $\Delta\varepsilon_{t-1} < 0$. Therefore, the null hypothesis (no cointegration) can be tested as $H_0\colon \rho_1 = \rho_2 = 0$. The null hypothesis can be tested through F-statistics using the TAR and M-TAR models, respectively. The TAR and M-TAR models' null hypothesis is thus denoted by Φ and Φ^*, respectively. The test statistics of both the models are similar to traditional F-statistics; however, the asymptotic distribution is nonstandard. Enders and Siklos (2001) used Monte Carlo simulation to test the null hypothesis of no cointegration and have provided the critical values for both Φ andΦ^*. When two series are found to be cointegrated, then the alternate hypothesis of asymmetric adjustment can be tested through null hypothesis of symmetric adjustment as $H_0\colon \rho_1 = \rho_2$.

The null hypothesis of symmetric adjustment against the alternate hypothesis of asymmetry can be tested using a standard F test. When the variables are threshold cointegrated then the speed of adjustment for the error correction term is asymmetric. When y_{t-1} is above its long-run equilibrium value ($=\gamma_0 + \gamma_1 X_{t-1}$) then adjustment is ρ_1. However, it is ρ_2 if y_{t-1} is below its equilibrium. The failure to reject the null hypothesis infers that the speed of adjustment is symmetric. In that case, Enders-Siklos's TAR model utilizes the Engle–Granger' ADF cointegration test. Whereas, in case of asymmetric cointegration between the two time series, the asymmetric Granger causality can be determined through asymmetric error-correction specification as follows:

$$\Delta y_t = \alpha_0 + \eta_{11} I_t \varepsilon_{t-1} + \eta_{12}(1 - I_t)\varepsilon_{t-1} + \sum_{i=1}^{p} \alpha_{1i} \Delta y_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta X_{t-i} + \mu_{1t}, \quad (2)$$

$$\Delta X_t = \beta_0 + \eta_{21} I_t \varepsilon_{t-1} + \eta_{22}(1 - I_t)\varepsilon_{t-1} + \sum_{i=1}^{p} \beta_{1i} \Delta y_{t-i} + \sum_{i=1}^{p} \beta_{2i} \Delta X_{t-i} + \mu_{2t} \quad (3)$$

Where, η_{11} and η_{12} represent the speed of adjustment coefficients, respectively. Similarly, η_{21} and η_{22} are the speed of adjustment coefficients for Δx_t under two regimes, respectively. Finally, the lead-lag relationship between y_t and x_t is analyzed through Granger causality test. The null hypothesis that x_t does not Granger cause y_t (y_t does not Granger cause x_t) can be specified as $H_0: \alpha_{2i} = 0,\ i = 1, \ldots\ldots, p$ ($H_0': \beta_{1i} = 0, i = 1, \ldots\ldots, p$).

3. Empirical Findings

3.1 Data

The data used in this study comprise of four South Asian stock markets namely Karachi Stock Exchange (KSE) of Pakistan, Bombay Sensex Index (BSI) of India, Dhaka Stock Exchange (DSE) of Bangladesh and Colombo Stock Exchange (CSE) All Share Index of Sri Lanka. The time period is from January 1998 to December 2013 with a total 192 monthly observations for each stock market. The data set is taken from Thomson Router (DataStream). The notations y_t and x_t, used in methodology section, are replaced by the name of respective country for the better understanding of results.

Figure 1 plots the standardized index levels of four South Asian stock markets. The graph reveals that South Asian markets have varying movements over the sample period. The plots show co-movement between all four stock markets with slight divergence over the sample period. The traditional linear cointegration models are unable to capture the time varying co-movement between the stock markets and thus nonlinear cointegration is very much needed (Siklos and Granger, 1997).

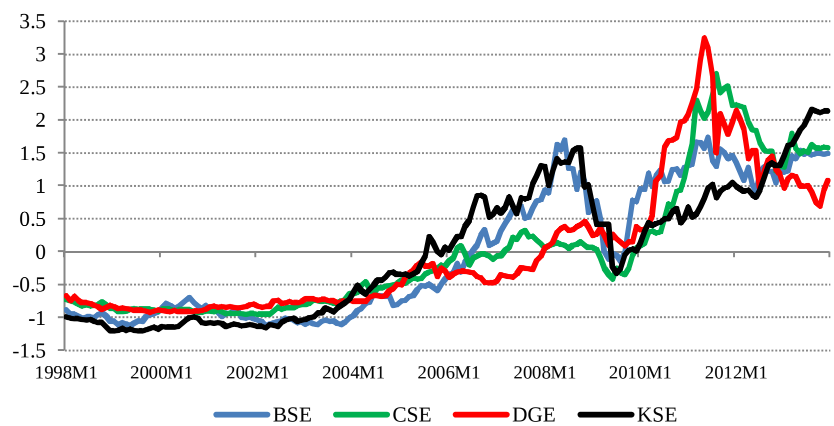

Figure 1: Trend of South Asian stock market indices – standardized prices.

Since, the trend of stock markets price series is clear from the Figure 1, we report the descriptive statistics of South Asian stock markets' monthly returns in Table 1. The statistics of returns are important to be shown from investment point of view. Pakistani stock market monthly returns are highest i.e. 1.1%, and it also has the highest standard deviation (8.7%). The average monthly stock returns are 0.9, 0.7 and 0.6 percent for Sri Lankan, Indian and Bangladeshi stock markets, respectively. The standard deviation of Bangladesh, Sri Lanka and India is 7.9, 7.3 and 7.2 percent, respectively. The higher volatilities in the South Asian markets are not surprising as it is a common behavior found in emerging stock market returns. The skewness (negative) and kurtosis values for the Pakistan stock market are also very high and this return pattern is somewhat desirable given the normal financial times. Negative skewness with higher kurtosis implies that most of the monthly returns fall towards the positive end of the distribution. The Jarque-Bera statistics indicate that return distribution of all four markets are non-normal.

Table 1: Descriptive Statistics of Monthly Returns

	Pakistan	India	Sri Lanka	Bangladesh
Mean	0.011	0.007	0.009	0.006
Std. Dev.	0.087	0.072	0.073	0.079
Skewness	-1.157**	-0.440	0.256	-0.404
Kurtosis	7.597**	3.900**	3.705**	5.763**
J-B	211.9*** [0.000]	12.70*** [0.001]	6.083** [0.047]	66.32*** [0.000]
Observations	192	192	192	192

Note: Numbers in [] indicate the p-values. *** and ** indicate significance at 1% and 5% levels, respectively. J–B represents the Jarque–Bera test statistics.

The pair wise correlation between the stock market prices is listed in Table 2. The correlation between all four South Asian stock markets is significant and positive. The correlation between Pakistan and India stock prices is 0.9246 which is significant at 1% level. Highest correlation exists between Sri Lanka and Bangladesh i.e. 0.9311 (significant at conventional level). Pakistan and Bangladesh stock markets have the lowest correlation (0.7311) among the considered stock market pairs. These pair-wise correlation coefficients indicate the presence of high comovement between the South Asian. However, higher correlation does not necessarily imply cointegration. Further, correlation is a linear statistical measure and therefore, may not capture the non-linear dynamics of relationship between the stock markets.

Table 2: Correlation Between South Asian Stock Markets Price Indexes

	Pakistan	India	Sri Lanka	Bangladesh
Pakistan	1.000			
India	0.925*** (33.46)	1.000		
Sri Lanka	0.816*** (19.48)	0.884*** (26.11)	1.000	
Bangladesh	0.731*** (14.77)	0.874*** (24.79)	0.931*** (35.21)	1.000

Note: Numbers in () indicate the t-statistics. *** show the significance at 1% levels.

3.2 Unit Root Analysis

The first objective of this study is to examine the efficiency of South Asian stock markets. For this purpose, we apply time domain (allowing for two structural breaks) and wavelet based unit root tests. Results of Clemente *et al.*, (1998) two structural breaks unit root are reported in Table 3. Clemente et al. (1998) unit root test shows presence of two structural breaks in the time series data. Both Innovative Outlier (IO) model and the Additive Outlier (AO) model statistics show that all four stock market prices are non-stationary at levels.

Table 3: Clemente Et Al. (1998) Unit Root Test With Two Structural Breaks

	t-statistics	*TB1*	*TB2*
Panel A: Innovative outliers (IO)			
Pakistan	-3.415	2004M09***	2011M12***
India	-4.645	2005M03***	2009M01***
Sri Lanka	-4.692	2003M10***	2009M11***
Bangladesh	-4.371	2006M11***	2009M07***
Panel B: Additive Outliers (AO)			
Pakistan	-3.983	2005M03***	2012M05***
India	-4.030	2005M08***	2009M10***
Sri Lanka	-3.490	2005M11***	2010M10***
Bangladesh	-2.752	2004M05***	2009M06***

Note: Maximum lag length for the test is selected as 12. The critical value for two mean shifts i.e. structural breaks, for AO & IO, is -5.490 at 5% level of significance. TB1 and TB2 present first and second mean shift, respectively. *** Indicates significance at 1% level.

The results of structural break unit root test are verified through wavelet based unit root which takes into account both time and frequency domains of the time series. Table 4 reports the results of wavelet based unit root tests. We use Discrete Wavelet Transform (DWT) and Maximum Overlap DWT (MODWT) with Haar wavelet filter as suggested by Fan and Gencay (2010). The demeaned test statistics with DWT and MODWT fails to reject the null hypothesis of random walk. While the de-trended test statistics rejects the null hypothesis at 10% level only for Pakistan and Bangladesh stock market price series with MODWT specification. The overall analysis shows that the South Asian stock market price series are non-stationary and thus follows a random walk. We can safely draw that South Asian stock markets are weak form efficient, a property which is desirable for potential investors and normally found in well-functioning developed markets.

Table 4: Results of Wavelet Based Unit Root Test

	Wavelet type	
	DWT	MODWT
Panel A: Demeaned test statistics ($\hat{S}_{T,1}^{LM}$)		
Pakistan	-3.0904	-6.1486
India	-2.7243	-5.4204
Sri Lanka	-4.4346	-8.8230
Bangladesh	-5.2123	-10.370
Panel B: Detrended test statistics ($\hat{S}_{T,1}^{Ld}$)		
Pakistan	-17.166	-34.333*
India	-12.423	-24.846
Sri Lanka	-15.598	-31.196*
Bangladesh	-12.964	-25.929

Note: Critical values for FG demeaned unit root test are -40.38, -27.38, and -21.75 at 1%, 5% and 10%, respectively. Critical values for FG detrended unit root test are -50.77, -36.54, and -30.23 at 1%, 5% and 10%, respectively. *** indicates significance at 1% level. DWT and MODWT stands for discrete wavelet transform and maximum overlap discrete wavelet transform, respectively. Bartlett bandwidth in the calculation of the long-run variance is equal to 20.

3.3. Symmetric Cointegration

All the time series are integrated of order one i.e. *I*(I) and hence it is appropriate to further proceed with the cointegration analysis. The results of Engle-Granger cointegration analysis between the South Asian stock market pairs are reported in Table 5. The results indicate cointegration between Pakistan and Indian stock markets. The value of ADF statistics is –2.209 which is significant at 5% level. Sri Lankan and Bangladesh stock markets are also cointegrated with ADF statistic value of -3.195, which is significant at 1% level.

Table 5: Engle–Granger ADF Cointegration Results

	E-G ADF statistics	$Q_{LB}(4)$	Cointegration
Pakistan and India	-2.209**	0.220	Yes
Pakistan and Sri Lanka	-1.667	0.208	No
Pakistan and Bangladesh	-1.159	0.798	No
India and Sri Lanka	-2.154	0.002	No
India and Bangladesh	-2.193	0.915	No
Sri Lanka and Bangladesh	-3.195***	0.559	Yes

Note: The 5% critical value is -1.95 (Engle and Yoo, 1991). *** and ** indicate significance at 1% and 5% levels, respectively. The significance level of Ljung-Box Q statistics is denoted by QLB (p); the serial correlation test is based on p=4 autocorrelation coefficients.

3.4. Asymmetric Cointegration

We have adopted the TAR and M-TAR models to examine the asymmetric cointegration and the conventional cointegration relationship between the South Asian stock markets. Table 6 indicates the estimated results of both models for six pairs. Similar to our previous findings of EG test, Pakistan-India and Sri Lanka-Bangladesh stock market pairs are cointegrated. That is, for these two pairs of stock markets, null hypothesis of no cointegration are rejected using the M-TAR models. The null hypothesis of symmetric cointegration ($\emptyset$ = 5.906) is rejected at 5% level of significance in case of Pakistan and Indian stock markets. Bangladesh and Sri Lankan stock markets ($\emptyset$ = 5.629) are also linked over long term. The null hypothesis of symmetric cointegration ($\rho_1 = \rho_2$) based on TAR is not rejected for all six pairs of South Asian stock markets as the F statistics are less than critical values. However, the M-TAR model rejects the null hypothesis of symmetric cointegration between Pakistan-India and Sri Lanka-Bangladesh stock market pairs. The F statistics for Pakistan and India stock market pair is 4.043, which is significant at 10% level. Similarly, F statistics is 4.893 (significant at 5% level) for the Sri Lanka and Bangladesh stock markets. These findings suggest that the speed of adjustment to the long term equilibrium is different for positive and negative shocks and hence the South Asian stock markets are not frictionless.

Table 6: Enders-Siklos (2001) Asymmetric Cointegration Results

	$\emptyset$ (H_0: $\rho_1 = \rho_2 = 0$)			F (H_0: $\rho_1 = \rho_2$)	
	TAR Φ	M-TAR Φ*		TAR: *F*-test	MTAR: *F*-test
Pakistan and India	3.885	5.906**		0.074	4.043*
Pakistan and Sri Lanka	1.064	1.574			
Pakistan and Bangladesh	1.102	0.910			
India and Sri Lanka	2.227	2.033			
India and Bangladesh	3.350	2.774			
Sri Lanka and Bangladesh	3.125	5.629**		0.050	4.893**

Note: ***’ ** and * indicate the significance levels at 1%, 5% and 10%, respectively. The critical values are obtained from Table 1 of Enders and Siklos (2001).

3.5 Asymmetric Error Correction Model (AECM)

The results of asymmetric cointegration shown in the last section indicate that Pakistan-India and Sri Lanka-Bangladesh stock market pairs are asymmetrically cointegrated. In this section, we analyze the asymmetric error correction models to further explore the short- and long-run dynamics of relationship. In the M-TAR model, error correction term ε_t displays more 'momentum' in one direction than the other direction. Suppose $|\rho_1| < |\rho_2|$ then $\Delta\hat{\varepsilon}_{t-1} \geq 0$ and $\Delta\hat{\varepsilon}_{t-1} \leq 0$ show less and substantial adjustments, respectively. The M-TAR model is more appropriate to explain the asymmetric adjustment (Shen et al., 2007). Following Shen et al., (2007), we have only considered the M-TAR model to estimate the asymmetric cointegration between Pakistan-India and Sri Lanka-Bangladesh stock market pairs.

3.5.1. Pakistan-India Stock Market Pair

The results of asymmetric error correction model (M-TAR) between Pakistan and Indian stock markets are shown in Table 7. Akaike and Bayesian information criterion are used for the selection of appropriate lag-length i.e. four (04). The long-run equilibrium relationship between Pakistan and Indian stock markets is presented below:

$$\text{Pakistan}_t = -419.0 + 0.766^{*}\text{India}_t + \hat{\varepsilon}_t$$

(-1.581) (33.460)

The t-statistic values are shown in parentheses. The long-run relationship indicates that 1% change in Indian stock markets results in 0.76% change in the Pakistan stock market. The speed of adjustments (η_{11} and η_{12}) for positive and negative values of $\Delta\hat{\varepsilon}_{t-1}$ to the long-run equilibrium are estimated through co-efficients of $M_t\hat{\varepsilon}_{t-1}$ and $(1 - M_t)\hat{\varepsilon}_{t-1}$ terms. The co-efficients for the positive and negative lagged error terms are 0.019 and -0.047, respectively. Both the coefficients are insignificant with the t values of 0.617 and -1.329, respectively. These findings reveal that there is no difference between the stock prices adjustment to the bad and good news. The short-run (lead-lag) relationship between the stock markets is examined through the granger causality test. The null hypotheses that the Indian stock market does not granger cause the Pakistan stock market is rejected at the 1% significance level. Therefore, we can conclude that unidirectional causality runs from Indian stock market to Pakistan stock market.

Table 7: Results of AECM for Pakistan and Indian Pair

	$\Delta\mathbf{Pakistan_t}$		$\Delta\mathbf{India_t}$	
Constant	153.0**	(2.036)	115.2	(1.038)
$M_t\hat{\varepsilon}_{t-1}$	0.019	(0.617)	0.069	(1.483)
$(1-M_t)\hat{\varepsilon}_{t-1}$	-0.047	(-1.329)	-0.016	(-0.314)
$\Delta\mathbf{I}^+_{t-1}$	-0.046	(-0.480)	0.010	(0.073)
$\Delta\mathbf{I}^+_{t-2}$	0.063	(0.661)	0.058	(0.414)
$\Delta\mathbf{I}^+_{t-3}$	0.066	(0.678)	0.015	(0.106)
$\Delta\mathbf{I}^+_{t-4}$	0.155	(1.645)	-0.215	(-1.549)
$\Delta\mathbf{I}^-_{t-1}$	0.084	(0.900)	-0.051	(-0.371)
$\Delta\mathbf{I}^-_{t-2}$	0.379***	(4.092)	-0.087	(-0.634)
$\Delta\mathbf{I}^-_{t-3}$	0.203*	(1.939)	0.203	(1.308)
$\Delta\mathbf{I}^-_{t-4}$	0.152	(1.489)	0.447***	(2.966)
$\Delta\mathbf{P}^+_{t-1}$	0.366**	(2.349)	0.155	(0.675)
$\Delta\mathbf{P}^+_{t-2}$	-0.33**	(-2.051)	0.292	(1.228)
$\Delta\mathbf{P}^+_{t-3}$	-0.048	(-0.305)	-0.007	(-0.030)
$\Delta\mathbf{P}^+_{t-4}$	-0.055	(-0.349)	-0.196	(-0.841)
$\Delta\mathbf{P}^-_{t-1}$	-0.175	(-1.508)	-0.043	(-0.248)
$\Delta\mathbf{P}^-_{t-2}$	-0.111	(-0.944)	-0.165	(-0.951)
$\Delta\mathbf{P}^-_{t-3}$	-0.003	(-0.026)	0.045	(0.285)
$\Delta\mathbf{P}^-_{t-4}$	-0.063	(-0.597)	-0.219	(-1.416)
$I -/\rightarrow P$	4.421***	[0.000]	1.527	[0.150]
$P -/\rightarrow I$	1.674	[0.110]	0.967	[0.460]
Diagnostics				
R^2	0.241		0.127	
AIC	2898.98		3045.03	
BIC	2963.60		3109.65	
Q_{LB} (4)	0.959		0.943	
Q_{LB} (8)	0.576		0.939	

Note: Numbers in () and [] are t-ratios and p-values, respectively. ***, ** and * indicate the significance levels at 1%, 5% and 10%, respectively. The critical values are obtained from Table 1 of Enders and Siklos (2001). The significance level of Ljung-Box Q statistics is denoted by QLB (*p*); the serial correlation test is based on *p*=4 and 8 autocorrelation coefficients. AIC and BIC represent Akaike information criterion and Bayesian information criterion, respectively.

3.5.2. Sri Lanka-Bangladesh Stock Market Pair

Table 8 reports the results of asymmetric error correction model (M-TAR) between Sri Lanka and Bangladesh stock markets. The lag-length four based on Akaike and Bayesian information criterion is selected to whiten the disturbance terms. The long-run equilibrium relationship between Sri Lanka and Bangladesh stock markets is shown below:

$$\text{Sri Lanka}_t = -0.118 + 1.016^{*}\text{Bangladesh}_t + \hat{\varepsilon}_t$$
$$(-0.697) \quad (44.202)$$

The t-statistic values are shown in parentheses. The long-run equilibrium relationship indicates that 1% change in Bangladesh stock market results in 1.016% change in the Sri Lankan stock market. As indicated previously, the speed of adjustments (η_{11} and η_{12}) for positive and negative values of $\Delta\hat{\varepsilon}_{t-1}$ to the long-run equilibrium are estimated through the coefficients of $M_t\hat{\varepsilon}_{t-1}$ and $(1 - M_t)\hat{\varepsilon}_{t-1}$ terms. The coefficients for the positive and negative lagged error terms are -0.097 and -0.052, respectively. The speed of adjustment to the positive shocks is higher and statistically significant (1% level) with the t values of -3.147. The findings suggest that stock prices adjust quickly to the good news in comparison to the bad news. The short-run (lead-lag) relationship between the stock markets is examined through granger causality test. The null hypotheses that the Bangladesh stock market does not granger cause the Sri Lankan stock market cannot be rejected with the test statistics F = 1.484. The null hypotheses that the Sri Lankan stock market does not granger cause the Bangladesh stock market is rejected at 1% level of significance with the test statistics F = 3.045. Finally, we can conclude that uni-directional causality runs from Sri Lankan stock market to Bangladesh stock market.

Table 8: Results of AECM for Sri Lanka and Bangladesh Pair

	$\Delta \mathbf{Srilanka_t}$		$\Delta \mathbf{Bangladesh_t}$	
Constant	7.314	(0.373)	33.119	(1.144)
$M_t \hat{\varepsilon}_{t-1}$	-0.097***	(-3.147)	0.039	(0.872)
$(1-M_t)\hat{\varepsilon}_{t-1}$	-0.052	(-1.408)	-0.024	(-0.440)
$\Delta \mathbf{B}^{+}_{t-1}$	0.109	(0.976)	0.257	(1.571)
$\Delta \mathbf{B}^{+}_{t-2}$	-0.074	(-0.655)	0.123	(0.740)
$\Delta \mathbf{B}^{+}_{t-3}$	0.2*	(1.718)	-0.087	(-0.508)
$\Delta \mathbf{B}^{+}_{t-4}$	0.155	(1.348)	0.164	(0.972)
$\Delta \mathbf{B}^{-}_{t-1}$	0.223	(1.344)	-0.136	(-0.558)
$\Delta \mathbf{B}^{-}_{t-2}$	0.077	(0.492)	0.337	(1.464)
$\Delta \mathbf{B}^{-}_{t-3}$	-0.195	(-1.273)	0.29	(1.286)
$\Delta \mathbf{B}^{-}_{t-4}$	-0.141	(-0.925)	0.425*	(1.897)
$\Delta \mathbf{S}^{+}_{t-1}$	-0.021	(-0.181)	0.447***	(2.636)
$\Delta \mathbf{S}^{+}_{t-2}$	-0.145	(-1.216)	0.167	(0.951)
$\Delta \mathbf{S}^{+}_{t-3}$	0.212*	(1.773)	-0.709***	(-4.013)
$\Delta \mathbf{S}^{+}_{t-4}$	0.021	(0.195)	-0.06	(-0.382)
$\Delta \mathbf{S}^{-}_{t-1}$	0.094	(1.081)	-0.256**	(-1.991)
$\Delta \mathbf{S}^{-}_{t-2}$	-0.083	(-0.938)	0.139	(1.061)
$\Delta \mathbf{S}^{-}_{t-3}$	-0.151*	(-1.708)	0.354***	(2.709)
$\Delta \mathbf{S}^{-}_{t-4}$	0.368***	(4.166)	-0.31**	(-2.380)
$B -/\rightarrow S$	1.485	[0.170]	0.149	[0.230]
$S -/\rightarrow B$	3.045***	[0.000]	3.333***	[0.000]
Diagnostics				
R^2	0.299		0.251	
AIC	2499.017		2644.289	
BIC	2563.639		2708.911	
Q_{LB} (4)	0.272		0.973	
Q_{LB} (8)	0.125		0.747	

Note: Numbers in () and [] are t ratios and p-values, respectively. ***’ ** and * indicate the significance levels at 1%, 5% and 10%, respectively. Critical values are taken from Table 1 of Enders and Siklos (2001). The significance level of Ljung-Box Q statistics is denoted by QLB (*p*); the serial correlation test is based on *p*=4 and 8 autocorrelation coefficients. AIC and BIC represent Akaike information criterion and Bayesian information criterion, respectively.

4. Conclusion

This study is an effort to examine the market efficiency and asymmetric relationship between the South Asian stock markets. In doing so, we utilize the wavelet based unit root test proposed by Fan and Gencay (2010). The proposed test can accommodate multiple breaks and non-linearity in the time series data. Monthly data from January 1998 to December 2013 has been used for analysis. Results of time and frequency domain unit root suggest that South Asian stock markets follow random walk and thus are weak form efficient. After analyzing the efficiency of the stock markets and order of integration, we have examined the symmetric and asymmetric cointegration. Previous work on stock market cointegration assumes a constant speed of adjustment for both positive and negative shocks. However, the findings of symmetric cointegration tests can be misleading, if the relationship between the markets is asymmetric. To overcome the shortcoming, we analyze the dynamic linkage using both symmetric and asymmetric cointegration models. Both symmetric and asymmetric cointegration tests confirm cointegration between Pakistani and Indian, and Sri Lankan and Bangladeshi stock markets. Indian stock market impacts Pakistani stock market in long-run. The impact of Bangladesh stock market on Sri Lankan market is higher and stock prices adjust quickly to the good news in comparison to the bad ones. The asymmetric error correction model also confirms these results in short-run.

These findings are interesting for the regional and international investors looking for diversification benefits of traditional asset classes. However, the existence of asymmetric relationship between the markets also shows that financial crises can have differential impact on stock markets. In case of crises, slow adjustments to the shock can not only have a devastating impact on the equity assets' portfolio but may also result in regional contagion.

We analyzed the monthly data to avoid the model specification issues i.e. serial correlation and conditional heteroskedasticity arising from the use of high frequency (daily) data. The studies have shown that high frequency stock markets data exhibits long memory (Chow et al., 2001). Recently, developed fractionally cointegrated vector autoregressive (FCVAR) methodology as described by Johansen and Nielsen (2012) can be utilized to study the dynamic relationship between South Asian stock markets in the presence of long memory process.

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