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An Empirical Study on the Short- and Long-Run Relationship between South Asian Emerging Stock Markets

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Abstract

This paper investigates the linkages between the four emerging stock markets of Bangladesh, India, Pakistan and Sri Lanka after a period of financial liberalisation in South Asia in 2000. The initial analysis was conducted for the period from January 2000 to December 2019 as well as for two sub-periods before and after the Global Financial Crisis of 2008. The paper examines whether the equity returns from these four markets become more linked after this crisis. During a crisis period, investors may attempt to diversify internationally whilst taking advantage of the 2000 financial liberalisation that took place in South Asia. More specifically, the paper investigates the existence of co-integration amongst the markets and convergence toward the long-run equilibrium using the vector error correction model. A single co-integrating vector for the entire period and in the post-crisis sub-period is found. Forecasting the returns one-week ahead using data for the period from January 2016 to December 2019 confirmed the robustness of the model used. An important implication of this finding is that linkages between the sample countries have increased over time, especially around the time of the Global Financial Crisis. As a result, the potential for diversifying risk by investing in all four of these South Asian countries is limited in the long-run because their equity markets move together over time.

Keywords: Crisis; Stock Market Integration; Southeast Asia

1. Introduction

Stock market integration has emerged as an important area of research over the last three decades, especially since the 1987 stock market crash (Arshanapalli and Doukas, 1993; Lehkonen, 2014; Chen, 2018). This interest has been further enhanced by several economic developments amongst countries at a regional level, including improved policy co-ordination (Diamandis, 2009; Frankel, 2016), relaxation of capital control measures (Masih and Masih, 2002; Bekaert and Harvey, 2017), improvements in information technology (Chow, 2017), developments in trading system technologies (Linnenlueke et al., 2016) and the introduction of new financial products (Phylaktis and Ravazzolo, 2005; Wagner and Margaritis, 2017). In addition, the deregulation and liberalisation policies in emerging financial markets have increased their linkages with world markets (Chow, 2017). These developments have resulted in the speedy dissemination of information amongst markets, reduced transaction costs and improved access to emerging markets for foreign investors.

The issue of stock market integration is important for two key reasons. First, if stock markets are integrated in the long-run and share a common stochastic trend, then long-run diversification benefits may be limited. Hence, co-integration between markets has implications for long-run diversification potential by providing information about whether markets tend to move together over time. Second, according to Granger (1986), two or more asset prices cannot be co-integrated within an efficient market since evidence of co-integration would suggest that prices are predictable based on historical information. Hence, findings of co-integration call the Efficient Market Hypothesis (EMH) in to question[1].

[1]However, Diamandis (2009) argued that findings of co-integration between stock market prices may not necessarily violate market efficiency because the co-integration of fundamentals may also lead to co-integration between stock prices. Thus, in the current article, we included a Vector Error Correction Model (VECM), a variance decomposition analysis and an impulse response function analysis, to further investigate the weak-form of the EMH in the South Asian markets.

This article contributes to the literature on stock market integration by examining the extent of both long- and short-run linkages and the effect of the 2008 Global Financial Crisis using weekly stock price index data for four South Asian stock markets over the period 2000-2019. In particular, the relationship between the four South Asian markets of Bangladesh, India, Pakistan and Sri Lanka are examined using the Johansen co-integration framework. In addition to the long-run analysis, short-run relationships between the markets are investigated by estimating a Vector Error Correction Model (VECM) for the markets, as well as conducting an impulse response function and variance decomposition analysis. Finally, a robustness check is conducted using data for the period January 2016 – December 2019.

The South Asian region is of interest for a number of reasons. First, very few studies about linkages between stock markets have focused on this region. The two exceptions to this generalisation are Narayan et al. (2004) and Lamba (2005) who examined the linkages between South Asian equity markets using daily data for the period 1995-2001 and 1997-2003, respectively[2]. Second, according to Hakkio and Rush (1991), the length of time is important in analysing a long-run relationship[3]. This finding is supported by Lahiri and Mamingi (1995), who argued that a long span of data is more preferable than a large number of observations for co-integration analysis. In this article, a time period of 19 years is used to investigate the long-run relationship between the four South Asian stock markets. Other studies, such as Yang et al. (2003)[4], considered only six and a half years of data for India and Pakistan as part of a broader investigation of market integration between 12 Asian markets.

Third, the South Asian markets in this study have all adopted liberalisation policies in recent years and allowed foreign investors to buy equities in locally listed companies. These policies have resulted in a rise in investment across the region and, hence, possibly accelerated trends towards integration (Khan et al., 2015). Fourth, a policy promoting harmonisation amongst stock markets in the region led to the establishment of the South Asian Federation of Exchanges (SAFE) in 2000. As a result of these growing economic and financial ties, as well as the common heritage amongst the countries, integration within the region may have increased.

Finally, previous studies have suggested that events of international importance often have an impact on market integration. For example, Arshanapalli and Doukas (1993) argued that, after the October 1987 crash, the degree of international co-movement amongst stock prices increased significantly. Similarly, Bowman et al. (2010) found that interdependence amongst stock markets increased significantly at the time of the 1997 Asian financial crisis, while Kang and Yoon (2011) concluded that the 2008 Global Financial Crisis strengthened the linkages between the Chinese stock market and the four stock markets of Hong Kong, Korea, Singapore and Taiwan. Other studies have analysed the change in stock market dependence during periods of financial turmoil and found an asymmetry in stock market co-movement, whereby stock market linkages are higher in bear markets as compared to bull markets (Kenourgios et al., 2011; Yarovaya and Lau, 2016). In the light of the substantive research, this paper includes the period of the 2008 Global Financial Crisis to determine whether the financial turmoil had a significant impact on the extent of co-integration between stock markets in South Asia.

The current analysis investigates the linkages between South Asian stock markets by estimating the relationship between equity prices using the Vector Autoregressive (VAR) co-integration technique. This study investigates multivariate co-integration using the Johansen (1988, 1991) method. Short-term relationships among the markets are then studied using a VECM, impulse response function analysis and variance decomposition analysis. Finally, a robustness check is conducted to check the accuracy of the model employed.

The remainder of this paper is organised as follows. In section 2, a brief overview of existing literature on the integration of stock markets is presented. Section 3 provides a short description of the South Asian markets considered in this paper. Section 4 describes the data and outlines the econometric methodology employed. Section 5 discusses the empirical results while Section 6 offers a number of concluding observations.

[2]These studies focus on an earlier and much shorter time period than that considered in the current paper. In addition, the main purpose of Lamba (2005) was on examining the interdependence of a subset of markets from the South Asian region with major developed markets. Furthermore, neither Narayan et al. (2004) nor Lamba (2005) examined the impact of the 2008 Global Financial Crisis on stock market interdependence in the South Asian region. More recently, Maher et al. (2017) examined this region using daily data for the period 2010-2014. However, again, this study ignored the impact of the 2008 Global Financial Crisis.

[3] Weekly data for 19 years is a reasonably long time period for analysing the long-run relationship. For example, Lamba (2005), Hassan et al, (2008) and Alkulaib et al, (2009) employed six and a half years of data, six years of weekly data and six years of daily data, respectively. Since financial markets are thought to respond to events relatively quickly, a 19-year time span should be sufficient to uncover any long-run relationship.

[4] Yang et al. (2003) also examined the impact of crisis conditions on stock market interdependence between a sample of Asian markets and the US and Japan. However, this study focussed on the 1997 Asian crisis rather than the 2008 Global Financial Crisis that is examined in the current paper.

2. Literature Review

There are a number of strands to the existing literature on stock market integration. These strands have focused on various markets, used different sample periods, and employed different data frequencies. In addition, they have used different econometric techniques and interpreted their results from various perspectives. Baillie and Bollerslev (1989) argued that the use of returns data may result in a loss of important information when prices between markets are co-integrated. This observation calls the results of studies that use an ARCH-type methodology for analysing linkages between stock markets returns into question (Chan et al., 1992; Booth et al., 1997). As a result, studies have used price data and employed co-integration techniques to study integration between markets.

A number of researchers have examined the level of integration between various emerging and developed markets and found mixed results. For example, Gilmore and McManus (2002) discovered no long-run relationship between US equity prices and those of the three Central European markets of the Czech Republic, Hungary and Poland. Syriopoulos (2004) extended the sample of Central European stock markets studied to include Slovakia and found one co-integrating vector between the equity prices of these markets and those of Germany and the US. More recently, Singh and Singh (2016) examined the US and BRIC (Brazil, Russia, India and China) stock markets over the period from 2004 to 2014 and found no evidence of significant co-movement.

Other studies have focused on regional blocs of markets such as the European Union (EU), the Association of South East Asian Nations (ASEAN) and the area covered by the former North American Free Trade Agreement (NAFTA). These studies have documented that integration between these markets increased after the establishment of the trading blocs. For example, Phengpis and Apilado (2004) found that stock markets of the European Monetary Union (EMU) countries were more strongly integrated as compared to their non-EMU counterparts. The authors argued that the stronger economic ties between these countries contributed to the increased integration of their stock markets. Using daily, weekly and monthly data covering both the pre- and post-NAFTA periods, Aggarwal and Kyaw (2005) concurred with this view. In particular, they examined the NAFTA countries for the period 1988-2001[5] and found that the markets were co-integrated in the post-NAFTA period only. In a study of ASEAN countries, Click and Plummer (2005) analysed stock market integration using daily and weekly data over the period July 1998 to December 2002. Their results indicated that a single co-integrating vector was present irrespective of the model specification employed. However, one issue with their analysis was the time period studied; only four and a half years of data were tested. As noted earlier, any reliable analysis of long-run equilibrium relationships requires a lengthy time period (Hakkio and Rush, 1991; Lahiri and Mamingi, 1995; Aggarwal and Kyaw, 2005).

International studies in the area of integration have tended to focus on two main themes. First, Chen et al. (2002), Gilmore and McManus (2002), Narayan et al. (2004), Syriopoulos (2004), Lamba (2005), Phylaktis and Ravazzolo (2005), Diamandis (2009), Kang and Yoon (2011), Yarovaya and Lau (2016) and Chevallier et al. (2018) suggested that integrated markets offer limited diversification benefits for international investors. For example, Chen et al. (2002) argued that integrated markets behave like a single market and, hence, the assets which investors can include in their portfolios in order to diversify risk may be less than a simple counting of the assets available. Narayan et al. (2004) suggested that co-integrated markets share a long-run stochastic trend which makes them less attractive for foreign investors in the long-run; however, they admitted that short-run benefits may be available. More recently, Chevallier et al. (2018) argued that strong integration between regional markets can reduce potential gains from international portfolio diversification and expose the countries in a region to increasing contagion risk.

The second theme in the literature has focused on the implications of integration for stock market efficiency. For example, MacDonald and Power (1994), Chan et al. (1997) and Diamandis (2009) highlighted that, if asset prices in various markets are co-integrated, the weak-form of the EMH is violated because price changes in one market will be significantly influenced by lagged price changes in another market. Thus, lagged price changes in one market may be used to predict current price changes in another market. By contrast, Masih and Masih (1999, 2002) and Narayan et al. (2004) argued that co-integration does not necessarily indicate that markets are inefficient; rather, they suggested that markets would only be inefficient if any predictability resulted in risk-adjusted excess returns.

It is evident from the substantive literature that research into market integration has focused mainly on developed markets. Research in the South Asian region in particular is scarce. The present study focuses on this region and investigates the inter-relationships between the markets. In addition, the impact of the 2008 Global Financial Crisis on the sample markets is analysed in order to yield an insight into the effect of international events on the emerging stock markets of South Asia[6].

[5] The NAFTA agreement came into force on 1st January 1994 (Aggarwal and Kyaw, 2005). It was replaced on 30th September 2018 by the US-Mexico-Canada-Agreement (USMCA) (Tasker and Scheel, 2018).

[6] Although the focus of Narayan et al. (2004) was on examining the dynamic linkages between markets in the South Asian region, the authors focused on an earlier and much shorter time period relative to the period examined in the current paper. Specifically, Narayan et al. (2004) studied the period 1995-2001. Thus, this paper studies the time period immediately after that examined by Narayan et al. (2004) and, importantly, the current paper considers the impact of the 2008 Global Financial Crisis on stock market interdependence in the South Asian region.

3. Overview of South Asian Emerging Stock Markets

In order to attract foreign investment, most emerging economies liberalised access to their stock markets during the late 1980's and early 1990's (Bekaert et al., 2003). It has been argued that this strategy of market deregulation in developing economies has yielded a number of benefits. For example, Henry (2000) found that, in the post-liberalisation period, both Latin American and Asian developing markets experienced a growth in investment and a reduction in the cost of capital. These results are supported by Kim and Singal (2000) who documented that the liberalisation of a country's stock market not only attracted foreign investors but also resulted in the development of the capital market and an increase in real economic growth. By contrast, a number of authors have suggested that stock market liberalisation is associated with increased volatility due to the "destabilising effect" of foreign investors (Sing, 1997; Kassimatis, 2002; Jayasuriya, 2005).

Stock markets in the South Asian region commenced a period of liberalisation in the early 1990's. These markets officially relaxed their restrictions on investment by foreign investors in 1991 and 1992 (Bekaert et al., 2003). Surprisingly, the process of liberalisation started in 1991 in Bangladesh and Sri Lanka, the two smallest markets in the region, possibly because the domestic markets for savings in these countries were insufficient to fund a growing demand for investment by locally listed firms. Pakistan followed in February 1992, while India was the last to permit foreign investors to invest directly in listed companies in November 1992. Although the practice of liberalisation started at around the same time for the sample countries, the process varied from one country to another. For example, Bangladesh initially focused on non-residents while Sri Lanka only allowed investment in companies incorporated abroad.

Following this process of liberalisation, the markets have performed well and the number of listed companies has increased significantly. A period of political stability and relative peace within and amongst the countries has also attracted more foreign investment into the region. The countries have entered into regional trade and cooperation agreements, such as the South Asian Association for Regional Cooperation (SAARC) in 1985. As a result, various trade and financial sector reforms were introduced, such as the South Asia Free Trade Area (SAFTA, 1995) and the South Asian Federation of Exchanges (SAFE, 2000)[7].

Table 1 shows summary statistics for the four South Asian stock markets. A visual inspection of the table reveals that India is the largest market in the region in terms of the number of listed companies. However, the values for this measure have varied from year to year. For example, the lowest number of Indian companies listed was in 2004, whilst the highest was in 2015. Despite this variability, the number of companies listed on the Bombay Stock Exchange (BSE) is greater than the other three exchanges combined. Pakistan had the second largest number of quoted companies in the region while Bangladesh and Sri Lanka are very similar in size. The turnover ratios show that equities in India and Pakistan are more actively traded than their counterparts in Bangladesh and Sri Lanka. In fact, Sri Lanka reported the lowest turnover ratio of only 8.6 per cent in 2015; in this country, investors did not actively alter their portfolios of equities during that year.

[7] In these agreements, the four countries of Bangladesh, India, Pakistan and Sri Lanka are all members, together with Bhutan, the Maldives and Nepal.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of Listed Companies														
Bangladesh	239	247	250	262	269	278	290	236	209	216	229	481	274	543
India	5650	5644	4730	4763	4796	4887	4921	4955	4987	5112	5191	5294	5541	5835
Pakistan	712	701	661	661	652	654	653	629	644	638	573	550	557	N/A
Sri Lanka	238	244	245	239	237	235	234	231	241	253	287	289	294	294
Market Capitalisation (USD million)														
Bangladesh	1193	1622	3317	3035	3610	6793	6671	7068	15683	23546	17479	N/A	N/A	N/A
India	131011	279093	387851	553074	818879	1819101	645478	1179235	1615880	1015370	1263335	1139000	1558000	1567000
Pakistan	10200	16579	29002	45937	45518	70262	23491	33239	38168	32763	43676	N/A	N/A	N/A
Sri Lanka	1681	2711	3657	5720	7769	7553	4326	8133	19923	19437	17045	18807	23665	20802
Market Capitalisation (% of GDP)														
Bangladesh	2.5	3.1	5.8	5.0	5.8	9.9	8.0	6.7	9.5	15.0	14.5	14.5	N/A	N/A
India	25.7	46.5	55.7	68.3	89.5	154.6	54.4	64.6	82.3	69.9	58.8	61.3	76.56	71.8
Pakistan	14.3	20.1	30.2	41.9	35.7	49.2	14.9	5.3	19.7	16.7	16.9	16.9	N/A	N/A
Sri Lanka	10.2	14.9	18.2	23.4	27.5	23.4	12.0	14.3	27.9	33.8	28.8	25.3	29.8	25.8
Trading Value (USD million)														
Bangladesh	666	327	890	1000	943	4746	9240	14601	14601	2224	1443	N/A	1451	N/A
India	197118	284802	379085	443175	638484	1107550	1049748	1088889	258574	9638000	1196000	N/A	N/A	N/A
Pakistan	26030	66598	73872	140996	126560	100452	54359	23527	23527	645445	616074	537777	730704	562900
Sri Lanka	318	769	582	1138	1003	966	1022	885	4995	4796	1674	1533	2598	N/A
Stock Traded Turnover Ratio (%)														
Bangladesh	57.1	23.2	36.1	32.2	28.8	92.3	137.3	212.6	133.5	93.9	65.0	65.0	N/A	N/A
India	165.0	138.5	115.5	93.6	94.4	83.4	85.2	119.3	75.0	28.5	57.7	47.2	46.9	50.9
Pakistan	346.2	497.4	322.6	375.7	276.1	171.9	115.9	82.9	36.9	57.4	31.5	31.5	N/A	N/A
Sri Lanka	21.3	34.7	18.4	23.7	14.8	12.7	17.2	14.2	23.8	24.6	9.8	8.1	11.0	8.6

Table 1: Summary Statistics for Four South Asian Stock Markets, 2002-2015

Sources: Standard and Poor's (2009, 2010); World Bank Development Indicators (Various Years). The table shows summary statistics for the South Asian stock markets of Bangladesh, India, Pakistan and Sri Lanka over the period 2002-2015. Specifically, the table shows the number of listed companies, market capitalisation information, trading value and turnover for the Dhaka stock exchange (Bangladesh), the Bombay stock exchange (India), the Karachi stock exchange (Pakistan) and the Colombo stock exchange (Sri Lanka). N/A indicates that data are not available.

4. Data and Methodology

The analysis focuses on both the short- and long-run dynamic relationships between the four South Asian stock markets over the period January 2000 to December 2015 - a total of 833 observations were analysed. Weekly data for the Bangladesh All Share Price Index (BDSE), the Indian National-200 Price Index (BSE), the Karachi SE-100 Price Index (PKSE) and the Sri Lanka All Share Price Index (SRLK) were obtained from Datastream[8]. The choice of these markets was determined mainly by the availability of data, the relatively large size of these markets in the region and the expected financial and economic linkages between these markets. All index prices were obtained in local currencies[9].

The Chow test was conducted to test for a structural break in the series. The results of the test indicated a highly significant F-statistic value of 27.666 with probability of F (3828) = 0.000. Hence the null hypothesis of no structural break is rejected for the break point on December 19, 2008 justifying the pre- and post GFC periods. A further reason for analysing the data pre- and post-2008 is to facilitate an examination of the impact of financial liberalisation as well as portfolio changes following the Global Financial Crisis; this strengthens the case for the sub-period analysis undertaken.

Table 2 shows descriptive statistics for the weekly changes in the share prices of the South Asian markets. All of the four markets offered positive returns on equity. The risk associated with the return was higher for India, Bangladesh and Pakistan; for Sri Lanka, risk was relatively low. The skewness and kurtosis measures show that Bangladeshi and Sri Lankan returns are positively skewed whereas Indian and Pakistani returns are significantly negatively skewed and leptokurtic. The skewness and kurtosis statistics are further supported by the results from the Jarque-Bera test, which indicates that the null hypothesis of normality is strongly rejected.

Statistic Country

	Bangladesh	India	Pakistan	Sri Lanka
N	833	833	833	833
Mean	0.0026	0.002	0.0037	0.003
Maximum	0.2684	0.1584	0.1303	0.1796
Minimum	-0.2863	-0.1897	-0.2009	-0.1133
Std. Dev	0.0342	0.0343	0.0331	0.0269
Skewness	0.0055	-0.6345	-0.9908	0.6722
Kurtosis	19.037	6.1994	7.8525	8.3342
Jarque-Bera	8927.5*	411.18*	953.56*	1050.3*

Correlation Coefficients of the Weekly Return Series

	Bangladesh	India	Pakistan	Sri Lanka
Bangladesh	1			
India	0.0456	1		
Pakistan	0.0128	0.1556	1	
Sri Lanka	-0.0195	0.1695	0.0481	1

Table 2: Descriptive Statistics of the Weekly Return Series, 2000 – 2015

Table 2 details the descriptive statistics for the four South Asian stock markets included in the study over the 16 year period 2000-2015. In particular, the table shows the number of observations (N), the mean (Mean), maximum (Maximum) and minimum (Minimum) weekly return and the standard deviation (Std. Dev) of the weekly return. The table also details the skewness (Skewness), kurtosis (Kurtosis) and the Jarque-Bera test (Jarque-Bera) for normality. Finally, the table shows the Pearson correlation coefficients between the returns of each pair of stock markets. An * indicates significance at the five per cent level.

The lower panel of Table 2 shows the correlation coefficients between the weekly returns of the four markets. In general, the correlations between the markets are low. For example, the correlation coefficients range from a low of -0.0195 for Bangladesh and Sri Lanka, to a high of 0.1695 for India and Sri Lanka. All of the coefficient values are less than 0.20. These low correlations among the sample markets indicate that there may be significant diversification benefits for investors in the South Asian region, at least in the short-run.

4.1. Unit Root Tests

Using regression analysis for non-stationary variables leads to spurious results about the estimated parameters and the degree of association (Brooks, 2019). Therefore, before testing for co-integration, the order of integration of the stock prices must be determined. To test for a unit root, this paper employed the Augmented Dickey-Fuller (ADF) test (1979) and the Phillips and Perron (P-P) (1988) test.

[8] Weekly data have the advantage of minimal problems of overlapping time periods and non-synchronicity of returns as compared to daily data.

[9] Click and Plummer (2005) found that currency denominations have no impact on the results for ASEAN-5 stock markets.

4.2. *Co-integration Test*

Johansen (1988) and Johansen and Juselius (1990) provided a method of estimating a multivariate VECM based on a VAR(k) model with Guassian errors and its implications on equilibrium. Their process has the advantage of capturing both long- and short-term dynamic relationships of a system based on the series being examined.

Let X_t be a vector of *4* stock market indices which are individually non-stationary and are integrated of the same order (for example, I(1)). The VAR (k) model can be written as:

$$\boldsymbol{X_t = \mu + A_1 X_{t-1} + A_2 X_{t-2} + A_3 X_{t-3} + \ \ldots\ldots + A_k X_{t-k} + \varepsilon_t} \qquad [\mathbf{1}]$$

Where X_t is an *4*×1 vector of I(1) stock index series, A_k is an *4×4* coefficient matrix, t = 1,2,3,....T and ε_t is a vector of white noise error terms. The VAR (k) model in [1] can be written as a VECM which takes the form:

$$\boldsymbol{\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \Gamma_3 \Delta X_{t-3} + \ \ldots\ldots + \Gamma_{k-1} \Delta X_{t-k} + \Pi X_{t-k} + \varepsilon_t} \qquad [\mathbf{2}]$$

Where Δ is a first difference operator, Γ is a *4×4* coefficient matrix representing the short-term dynamics and is defined as:

$$\boldsymbol{\Gamma_m = -I + \sum_{i=1}^{m} A_i \qquad m = 1, 2, 3, \ldots\ldots\ldots k-1} \qquad [\mathbf{3}]$$

And Π is a *4×4* matrix of coefficients representing long-term dynamics and is defined as:

$$\boldsymbol{\Pi = -I + \sum_{i=1}^{k} A_i} \qquad [\mathbf{4}]$$

Where Π is the long-term coefficient matrix and its rank r determines the number of co-integrating vectors. If Π has a rank r, then there are r co-integrating relationships between the X_t or 4-r common stochastic trends. The number of co-integrating vectors shows the extent to which the stock markets in this study are integrated. If Π has full rank (r=4), there are no stochastic trends and all elements of the X_t vector are stationary, or I (0), and no co-integration is identified. If Π has a rank of zero, there are no stationary long-term equilibrium relationships amongst the elements of X_t. When Π has a reduced rank such that 0 < r < 4, there exists r co-integrating vectors. In this latter case, Π can be factorised into $\alpha\beta'$, where both α and β are $4 \times r$ matrices. The β matrix gives the co-integrating vectors where α is the adjustment matrix giving the amount of each co-integrating vector entering each of the equations for the VECM.

Johansen (1988, 1991) suggested two methods for estimating the number of co-integrating vectors: the trace test (λ_{trace}) and the maximum eigenvalues test (λ_{max}). The λ_{trace} statistic is a joint test of the null hypothesis that the number of co-integrating vectors is less than or equal to r against a general or unspecified alternative hypothesis of more than r co-integrating vectors. The λ_{max} statistic conducts a separate test on each of the eigenvalues. The null hypothesis in this case is that the number of co-integrating vectors is r against an alternative that there are $r + 1$ relationships. Both the λ_{trace} and λ_{max} test statistics have non-standard distributions and their critical values depend on the values of *n*-r, the number of non-stationary components and whether constants and trends are included in each of the equations (Brooks, 2019). In this paper, the critical values are based on those proposed by MacKinnon-Haug-Michelis (1999).

5. Empirical Results

5.1. Unit Root Test Results

Table 3 reports the results for both the ADF and P-P unit root tests for the stock indices of the four South Asian markets. The test results show that the null hypothesis that each of the stock indexes has a unit root in level form is not rejected for all of the four markets over the three time periods examined. In their first differenced form, the null hypothesis of a unit root in each of the series is not rejected for any of the four markets[10]. Therefore, the series are non-stationary in level form and stationary in first differenced form. All of these series are stationary after taking their first difference, or I (1), and, hence, co-integration analysis can be employed.

[10] The unit root tests were also performed including a time trend and constant for the four markets. The results indicated that the series are integrated of order 1, I(1). Furthermore, the unit root tests were performed with a break, showing that the series were non-stationary in levels and stationary in first difference, although the t-statistics values were different from those shown in Table. 3.

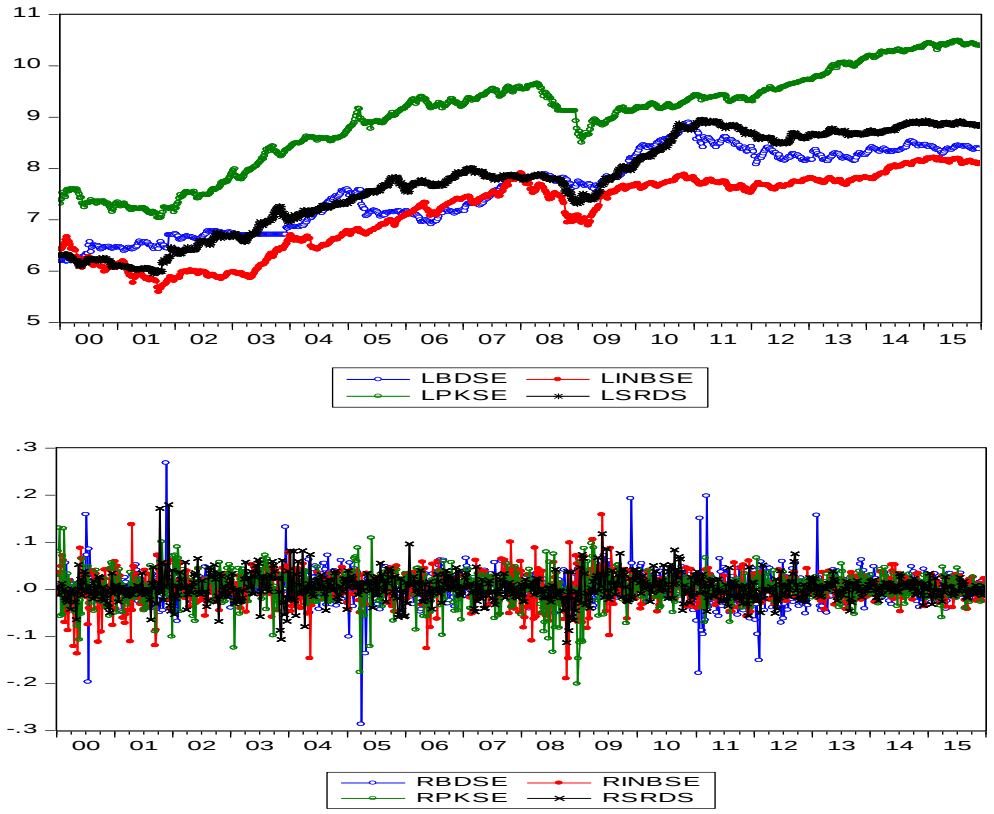


Figure 1: Time Series Plots of the Series in Level and First Differenced Form

Panel A: Results for the Whole Sample Period, January 2000 to December 2015

	ADF		P-P	
Country	**Level**	**1st Diff**	**Level**	**1st Diff**
Bangladesh	2.07	-27.23*	1.86	-27.39*
India	1.26	-16.88*	1.39	-26.12*
Pakistan	2.60	-24.97*	2.60	-25.01*
Sri Lanka	2.58	-24.03*	2.31	-24.95*

Test critical values: -2.57 at the one per cent level and -1.94 at the five per cent level.

Panel B: Results for Sub-Period January 2000 to December 2008

	ADF		P-P	
Country	**Level**	**1st Diff**	**Level**	**1st Diff**
Bangladesh	2.34	-19.51*	2.18	-19.62*
India	2.11	-17.58*	1.78	-17.77*
Pakistan	2.67	-17.79*	2.70	-17.95*
Sri Lanka	2.49	-17.69*	2.14	-17.87*

Test critical values: -2.57 at the one per cent level and -1.94 at the five per cent level.

Panel C: Results for Sub-Period January 2009 to December 2015

	ADF		P-P	
Country	**Level**	**1st Diff**	**Level**	**1st Diff**
Bangladesh	0.75	-18.93*	0.68	-18.97*
India	0.35	-11.33*	0.23	-19.05*
Pakistan	1.16	-17.33*	1.05	-17.69*
Sri Lanka	1.58	-15.93*	1.29	-16.92*

Test critical values: -2.57 at the one per cent level and -1.94 at the five per cent level.

Table 3: Unit Root Test Results

The table shows the unit root test results using the ADF and the P-P tests. Panel A summarises the results for the whole sample period, while Panels B and C show the results for the first and second sub-periods, respectively. The critical values are based on MacKinnon (1996). An * indicates statistical significance.

5.2. Multivariate Co-integration Test Results

Table 4 documents the results from estimating equation [1] based on the λ_{trace} statistic and the λ_{max} eigenvalues statistic for Bangladesh, India, Pakistan and Sri Lanka. In particular, Panel A reports the results for the whole sample period from January 2000 to December 2015, while Panels B and C show the results for the sub-periods from January 2000 to December 2008 and from January 2009 to December 2015, respectively.

A visual inspection of Panel A reveals that the null hypothesis $r = 0$ can be rejected since the λ_{trace} statistic of 52.31 for the South Asian stock markets is greater than the critical value at the five per cent level of significance. The λ_{max} test statistic has a value of 25.94, which is less than its critical value of 27.58, and is significant at the ten per cent level. Both tests indicate that the markets have one co-integrating vector in the entire sample period since the analysis fails to reject the null for values of $r > 0$ but rejects the null for $r > 1$.

When considering the co-integration in different sub-periods, Panel B indicates that the λ_{trace} and λ_{max} test statistic values are lower than the five per cent significance level for the period from January 2000 to December 2008. This result suggests that there is no evidence of co-integration between the markets during this period even though there is a process of harmonisation between the sample markets after the establishment of SAFE in 2000, and may be explained by the fact that this period was characterised by an incomplete harmonisation and no concrete integration of the region's markets.

According to Panel C, the λ_{trace} and λ_{max} statistics are higher than their critical values at the five per cent level of significance for the null hypothesis of $r = 0$; the null hypothesis is therefore rejected by both tests and one co-integrating vector is detected during the second sub-period. The values for the test statistic are greater than the corresponding critical value, which indicates rejection of the null hypothesis of no co-integration between the stock market indices of the South Asian region over the period from January 2009 to December 2015. Thus, the markets have a common trend after the 2008 Global Financial Crisis which suggests that there may be fewer diversification benefits for international investors because of co-movement between the index returns. The results also suggest that integration within the region has increased after the 2008 Global Financial Crisis. The results indicate no evidence of cointegration in the pre-GFC period whereas the post-GFC period is characterised by cointegration in the series suggesting that linkages among the markets increased after the GFC. Specifically, the markets show more linkages after the crisis, which also indicates that global events of importance may have had a common impact on the behaviour of these markets as equity indices plunged. The results also suggest that the market liberalisation policies highlighted in Section 3 have increased portfolio equity flows between the countries and caused shares prices in the region to move together.

Rank	Trace Test	Critical Value	p-value	Max Test	Critical Values	p-value
Panel A: January 2000 to December 2015						
0	52.31*	47.85	0.01	25.94**	27.58	0.08
1	26.36	29.80	0.12	18.04	21.13	0.13
2	8.32	15.49	0.43	7.09	14.26	0.48
3	1.23	3.84	0.27	1.23	3.84	0.27
Panel B: January 2000 to December 2008						
0	39.48	47.86	0.24	19.09	27.58	0.41
1	20.38	29.80	0.40	16.26	21.13	0.21
2	4.12	15.49	0.89	4.12	14.26	0.85
3	0.01	3.84	0.95	0.01	3.84	0.95
Panel C: January 2009 to December 2015						
0	56.66*	47.86	0.01	31.48*	27.58	0.01
1	25.18	29.80	0.16	18.72	21.13	0.11
2	6.45	15.49	0.64	6.02	14.26	0.61
3	0.43	3.84	0.51	0.43	3.84	0.51

Table 4: Multivariate Johansen Co-integration Test Results

Critical values are based on MacKinnon-Haug-Michelis (1999): An (*) and (**) denotes significance of the test statistic at the five and ten per cent level, respectively.

5.3. Vector Error Correction Model Results

The multivariate Johansen co-integration test results reported in Table 4 indicate the presence of one co-integrating vector. Both the λ_{trace} and the λ_{max} tests confirm that a long-run relationship exists between these four markets, especially since 2008. The co-integration results in Table 4 indicate that the four markets have a tendency to co-move in the long-run. However, in the short-run, they may deviate from this equilibrium relationship. To further investigate the relationships between the four equity markets of South Asia, the VECM in equation [2] was estimated. The intuition behind the VECM analysis is that, when the markets are in equilibrium, part of the current changes in one

market reflect a tendency to respond to trends in returns from other countries. The VECM was used to examine the short- and long-run relationships between the four markets, and the results are reported in Table 5. The four panels of Table 5 show the results for each market in the system for the whole time period from 2000 to 2015. The end of each panel indicates whether or not the Error Correction Term (ECT) is significant at the five per cent level. The ECT results indicates how quickly the previous period deviation from the long-run equilibrium is corrected. The top of each panel reports the short-run impact for a market of both lagged changes in its own values as well as lagged and current changes in the other three markets.

Panel A	**Dependent Market**		**Independent Markets**	
Lag order				
(Weeks)	**ΔBDSE**	**ΔINBSE**	**ΔPKSE**	**ΔSRLK**
1	0.04	0.05	0.05	0.06
	(1.26)	(1.26)	(1.47)	(1.40)
2	0.03	0.01	-0.02	0.03
	(0.79)	(0.22)	(-0.42)	(0.61)
3	0.01	-0.02	0.03	0.04
	(0.12)	(-0.58)	(0.86)	(0.86)
	ECT -0.01*			
	(-3.51)			
Panel B	**ΔINBSE**	**ΔBDSE**	**ΔPKSE**	**ΔSRLK**
1	0.09*	-0.02	-0.01	0.03
	(2.69)	(-0.65)	(-0.13)	(0.69)
2	0.13*	0.00	-0.01	0.03
	(3.78)	(0.10)	(-0.33)	(0.55)
3	-0.02	0.00	0.03	0.00
	(-0.50)	(0.08)	(0.84)	(0.05)
	ECT 0.01*			
	(3.46)			
Panel C	**ΔPKSE**	**ΔBDSE**	**ΔINBSE**	**ΔSRLK**
1	0.10*	0.03	0.09*	0.05
	(2.84)	(0.08)	(2.66)	(1.04)
2	0.06	-0.01	0.06	0.03
	(1.67)	(-0.16)	(1.74)	(0.74)
3	0.04	0.01	0.01	-0.08
	(1.04)	(0.34)	(0.41)	(-1.78)
	ECT 0.00			
	(0.63)			
Panel D	**ΔSRLK**	**ΔBDSE**	**ΔINBSE**	**ΔPKSE**
1	0.06	-0.00	-0.01	-0.00
	(1.40)	(-0.14)	(-0.43)	(-0.15)
2	0.03	0.07*	0.08*	0.00
	(0.61)	(2.74)	(2.95)	(0.07)
3	0.04	-0.04	0.03	0.00
	(0.85)	(-1.42)	(1.21)	(0.05)
	ECT 0.00			
	(1.17)			

Table 5: Vector Error Correction Model Results

The ECT for the markets of Bangladesh, India, Pakistan and Sri Lanka is derived by normalising the co-integrating vector for that specific market. The figures in parenthesis are the t-statistics which test the null that the ECT is not statistically significant. Values with an * show significance at the five per cent level.

An inspection of Panel A indicates that there was an adjustment to a long-run relationship between the Bangladeshi market and the three markets of India, Pakistan and Sri Lanka. The ECT value -0.01 is an estimate of the adjustment parameter and the value in parenthesis (-3.51) is its t-statistic value. An analysis of the first part of Panel A highlights the short-run dynamics behind this long-run relationship. The statistics in the first part of Panel A reveals that the Bangladeshi market is not influenced by lagged values of its own performance. In addition, the t-statistics for each of the lagged changes in the indices of India, Pakistan and Sri Lanka show that changes in the Bangladeshi market are not influenced by variations in these three markets over the previous weeks.

The findings for India, which are shown in the second panel, indicate that the ECT is significant. This result suggests that a long-run relationship exists between the Indian market and the other three markets included in the analysis. The brunt of adjustment is on the smaller markets of the region, which suggests that the Indian market may be relatively independent in the system of the four markets in the long-run. In addition, it shows the leadership role of the Indian market in the region – that is, in the long-run, the Indian market is not led by the three relatively smaller

markets of the region. The t-statistic values for the lagged changes in the indices of Bangladesh, Pakistan and Sri Lanka show that these markets have no influence in the previous weeks on the Indian market, whereas changes in the Indian market are influenced in the short-run by changes in its own lagged values from the previous weeks.

Panel C of Table 5 reports the VECM results when Pakistan is the dependent market. It shows that no long-run relationship exists between Pakistan and Bangladesh, India and Sri Lanka. The ECT value of 0.00 is not significant at the five per cent level. A visual inspection of the individual t-statistics reveals that the lagged changes in the three markets have a significant effect on changes in Pakistan. In particular, lagged changes in the equity indices for India have a significant effect on the Pakistani market along with its own lagged values.

The last panel of Table 5 shows the results of the VECM for the Sri Lankan market. The error correction term is not statistically significant, indicating that there is no long-run relationship between the Sri Lankan market and the other three South Asian markets. An analysis of the individual t-statistic for the lagged changes indicates that contemporaneous changes in the Sri Lankan market are affected by changes in the Bangladeshi and Indian markets and changes in the lagged values of its own index over the previous weeks do not have a significant effect on the Sri Lankan market.

Overall, the results of the VECM for the four South Asian markets indicate that the stock markets of Bangladesh and India respond to disequilibrium in the price system in a fairly rapid fashion. In addition, stock price changes in these markets are predictable from their own lagged prices, as well as from price changes in the other three markets in the system. Therefore, the markets in the South Asian region violate the weak form of the EMH. From Table 5, it is also evident that these two markets have significant t-statistics for the ECT[11]. The coefficient value on the significant ECT also indicates a relatively rapid adjustment towards long-run equilibrium in the Bangladeshi market as compared with the Indian market. In addition, these results confirm the co-integration results in Table 4 regarding the existence of a long-run relationship between the markets.

5.4. Variance Decomposition Analysis

To analyse the relative importance of the variables in the system and to quantify the magnitude of temporal causality results, a variance decomposition analysis was conducted for the whole sample period. Table 6 reports the decomposition of error variance forecasts for each country. In particular, the table provides the decomposition of 1-, 5-, 10-, and 20-week ahead forecast error variances of the stock indexes into the fractions that are associated with the innovations in each of the four South Asian stock markets[12].

Percentage of Forecast Variance Explained by Innovations

Weeks	ΔBDSE	ΔINBSE	ΔPKSE	ΔSRLK
Relative variance in ΔBDSE				
1	100.00	0.00	0.00	0.00
5	98.77	0.54	0.24	0.44
10	98.75	0.55	0.25	0.45
20	98.75	0.55	0.25	0.45
Relative variance in ΔINBSE				
1	0.12	100.00	0.00	0.00
5	0.19	99.49	0.15	0.16
10	0.19	99.48	0.16	0.17
20	0.19	99.48	0.16	0.17
Relative variance in ΔPKSE				
1	0.00	1.84	98.16	0.00
5	0.03	4.12	95.38	0.46
10	0.03	4.14	95.38	0.47
20	0.03	4.14	95.36	0.47
Relative variance in ΔSRLK				
1	0.16	2.41	0.02	97.41
5	1.15	4.06	0.03	94.76
10	1.15	4.12	0.04	94.69
20	1.15	4.12	0.04	94.69

Table 6: Variance Decomposition Results

Figures in the first column refer to the time horizons (number of weeks)

[11] The ECT shows the long-run relationship, while the short-run relationship is evident from the lagged stock price changes in the four markets. It shows that, in the short-run, fluctuations in the Indian, Pakistani and Sri Lankan markets explain movements in each of the other markets. The importance of the Indian and the Pakistani markets in explaining price movements in other markets is due to the dominance of these markets in terms of their size and market capitalisation (see Table 1).

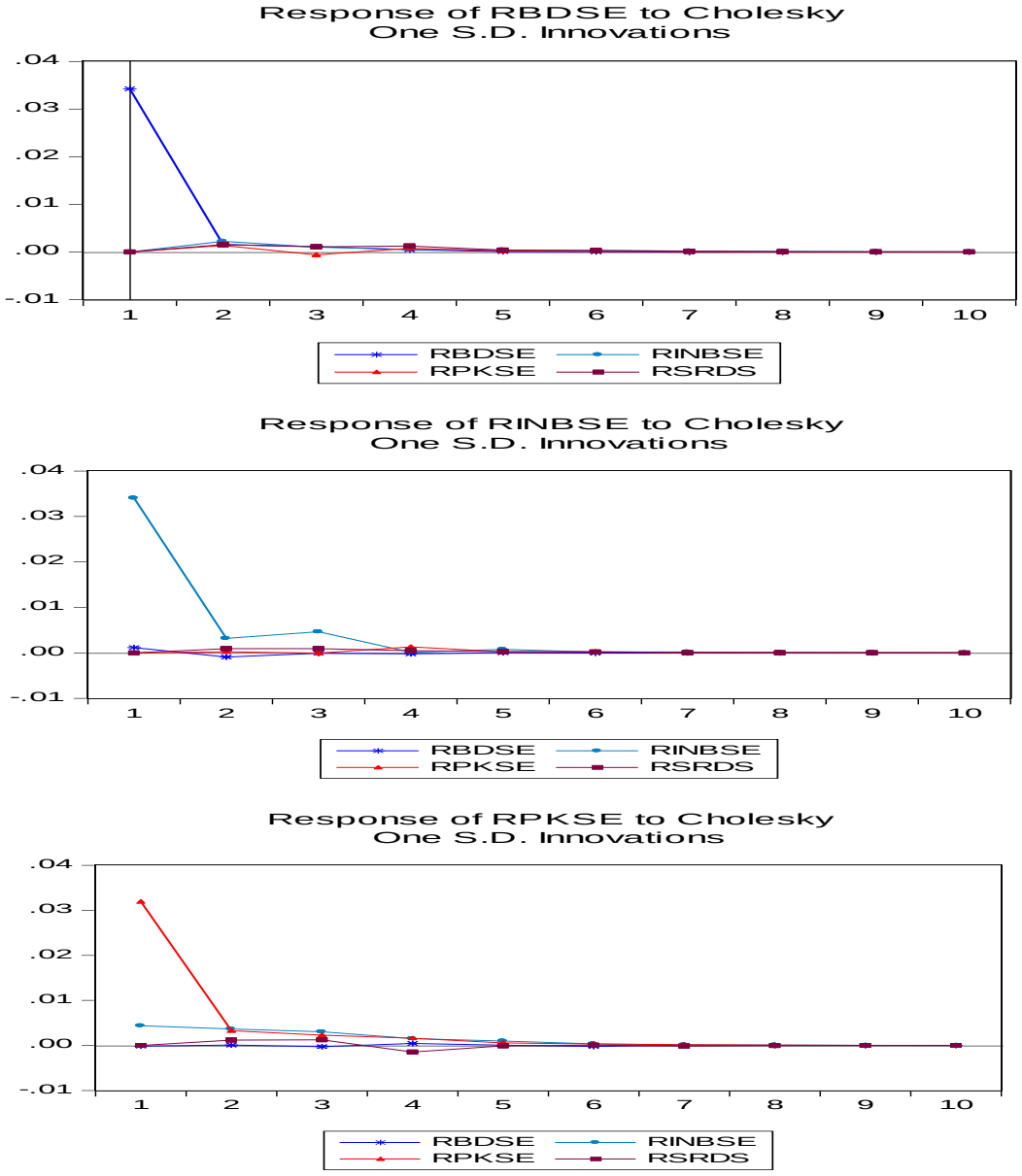
[12] The Variance Decomposition and Generalised Impulse Response Function Analysis are also based on the whole dataset.

Table 6 shows the linkages between the markets for both short- and long-run horizons ranging from one week to 20 weeks[13]. The proportion of the domestic stock index variance that can collectively be attributable to the variance in the other South Asian indices is different in the four markets. For example, at a 20-week horizon, the proportion of a domestic stock market index's variance that is collectively explained by other South Asian markets ranges from 0.52 per cent for India and 1.25 per cent for Bangladesh to almost 6.00 per cent for Sri Lanka and Pakistan.

The results indicate that, in the Pakistani and Sri Lankan markets, a relatively large fraction of the variation in the domestic stock index is explained by the Indian market. The Bangladeshi market is found to be less influenced by the other regional markets. Narayan et al. (2004) attributed the independence of the Bangladeshi stock market to its small size relative to the other markets in the region. The table also indicates that India, which is the largest market in the region, is the most influential market; volatility shocks in equity prices in India impact on stock prices in Pakistan and Sri Lanka.

5.5. The Generalised Impulse Response Function Analysis

A generalised impulse response function analysis was also conducted to further investigate the dynamic relationships between the South Asian stock markets. This analysis provides the dynamic responses of each stock market to an innovation in the market and in the other markets within the system. An analysis of an impulse response function shows the extent to which the shocks in one market are temporary or persistent in terms of the effects on their own and on the other markets in the system of four markets. Figure 1 shows the results from the impulse response function analysis conducted in the current paper.



[13] The order of the variables was changed and the time horizons were extended up to 50 weeks but the results did not change from those reported in the text.

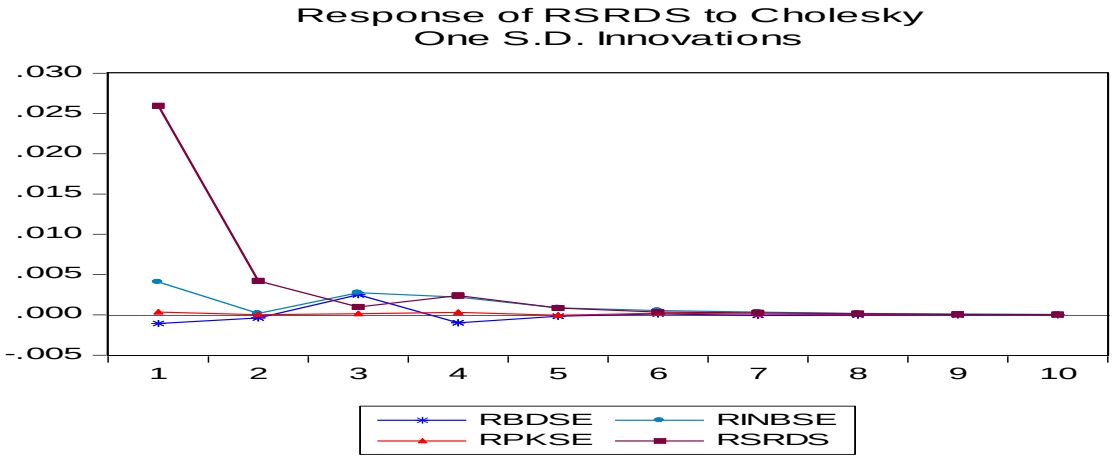


Figure 2: Generalised Impulse Response Function

The figure shows the impulse response function of Bangladesh (BDSE), India (INBSE), Pakistan (PKSE) and Sri Lanka (SRLK) to one standard deviation innovation in the four markets stock prices.

In terms of the impulse response function for the stock market in Bangladesh, a shock in the Indian market initially leads to a rise in the Bangladeshi market's equity values. The impact remains positive up to week four, after which the trend flattens out. Shocks to the Pakistani market have a positive effect on the Bangladeshi market as well, but this effect is minimal as compared to the Indian market and dies away soon after week two. Innovations in the Sri Lankan market initially have a negative effect on the Bangladeshi market which becomes positive after the third week and persists until week six.

The Indian market shows a different picture for the generalised impulse response function. Innovations in the Bangladeshi market have no significant effect on the Indian market. Shocks to the Pakistani market exhibit a positive effect on the Indian market which dissipates after week six. The Sri Lankan market has a declining positive effect on the Indian market. Overall, the Indian market does not appear to be affected by innovations in the other three markets.

According to the impulse response function for Pakistan, shocks in the Bangladeshi market have a minimal effect, while the Sri Lankan and Indian markets have positive effects on the Pakistani market. Initially, these two markets have an increasing impact which dies away soon after week six. Innovations in the Indian market have a positive but declining effect on the Pakistani market.

The impulse response function for the Sri Lankan market shows positive effects from innovations in the Indian market. Shocks in the Pakistani market have a positive effect on the Sri Lankan market for the first five weeks, which then becomes flat up to week eight. The Bangladeshi market initially has a negative effect on the Sri Lankan market which becomes positive after week three and persists until week five.

Overall, these results indicate that innovations in the Indian market have a significant effect on the three markets of the region. Information from the Indian market can be used to predict stock prices in the three regional markets, especially in Pakistan and Sri Lanka. This finding highlights the dominant role of the Indian market, which appears to lead the region's markets. In addition, the results from the generalised impulse response function further confirm the results from the VECM and from the variance decomposition analysis reported earlier.

Subsequent data from January 2016 to December 2019 were used to undertake a robustness check. In particular, the model (which incorporates linkages and past, own-market returns) was used to forecast the returns in each market one week ahead; these predictions were compared with actual returns using root mean square error calculations. The forecast evaluation measures the Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) and the Theil inequality coefficient. The VAR model used had the best forecast performance for all the variables as the value of RMSE was at a minimum and was less volatile. The RMSE values ranged from 0.012 to 0.061 for the four variables used in the VAR model, which indicates that the model is the best fit. The Theil inequality coefficient also had values of less than 1 for all of the variables, indicating a higher degree of forecasting accuracy. These measures indicate the robustness of the model used for analysis.

6. Conclusion and Policy Implications

The current paper adds to the literature on the relationships between national stock markets in the South Asian Region: namely those of Bangladesh, India, Pakistan and Sri Lanka. Most studies about this topic have tended to focus on the developed markets of the world; emerging stock markets are relatively less researched and research into the South Asian region is even more scant. The current paper focuses on South Asian emerging markets because of their recent liberalisation and harmonisation policies and the opening of these stock markets to international investment. Specifically, this paper investigated the behaviour of stock prices in four major South Asian stock

exchanges over the period January 2000 to December 2019. In particular, it examined whether the linkages between the equity prices of these four stock have increased – especially since the Global Financial Crisis of 2008 when investors may have altered their portfolios and invested internationally to diversify risk.

The analysis was based on both univariate and multivariate system approaches. A univariate approach was used for each market's stock prices; a unit root was found in all four stock price series. The multivariate Johansen (1988) co-integration technique suggested that the four South Asian markets share one long-run equilibrium relationship. The results also indicate that integration between the markets has increased in the period since the 2008 Global Financial Crisis. Meanwhile, the findings indicate that the earlier financial harmonisation policies in the region, which resulted from the formation of the South Asian Federation of Exchanges, may not itself have led to the convergence of South Asian stock markets; however, the global shock and more recent harmonisation policies may have contributed to the common trend among the stock markets in this region. The VECM indicated that fluctuations in the share prices in the region explain movements in the other sample stock markets with the exception of the Bangladeshi market. A variance decomposition analysis showed that a considerable proportion of the variance in stock index returns was attributable to variation in the Indian market. Results from the generalised impulse response function reinforced the findings from the VECM and variance decomposition analysis.

The findings of this paper have important implications for international investors. In particular, the results suggest that investment in the four South Asian stock markets studied may offer limited diversification benefits in the long-run because of the co-integration evidence uncovered; since the markets move together in the long-run, their long-run diversification potential may be poor. However, in the short-run, investors may gain substantial benefits due to low return correlations between the markets. Thus, international investors in the region need to consider the time period of their investment if they want to spread risk by investing in a mix of equities from Bangladesh, India, Pakistan and Sri Lanka. In addition, historical price changes in these markets can be used to predict future share price changes. Therefore, the markets are not weak form efficient and investors can gain from the study of past share returns. A final implication of the findings is that the governments of the four countries need to be aware that shocks to the equity prices of one country in the region may impact on the returns of another of the nations. This was especially true of Pakistan and India after the Global Financial Crisis. Governments and regulators in the different countries need to factor this risk of contagion into their policies. They may also need to monitor the wider regional financial environment when assessing the risks to their own national stock markets.

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