“Bangladeshi equity indices and random walk”

AUTHORS	Chu V. Nguyen Muhammad Mahboob Ali Jonathan Davis

ARTICLE INFO	Chu V. Nguyen, Muhammad Mahboob Ali and Jonathan Davis (2015). Bangladeshi equity indices and random walk. *Banks and Bank Systems*, *10*(1), 8-14
RELEASED ON	Thursday, 26 March 2015
JOURNAL	"Banks and Bank Systems"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

Chu V. Nguyen (USA), Muhammad Mahboob Ali (Bangladesh), Jonathan Davis (USA),

Bangladeshi equity indices and random walk

Abstract

This study applies Lo and MacKinlay's methodology on the daily movements of three Bangladeshi equity indices: CSE-30, CSCX, and CASPI. Contrary to the conventional wisdom and empirical results of earlier studies, the results suggest that the Bangladeshi CSE-30 index, joint period, two, four, eight and sixteen period returns do not follow the random walk. Except for the four day period, return series of the CASPI, CASPI, the CSCE and their investigated individual periodical return series follow a random walk. These findings indicate that investors and portfolio managers cannot profit by trading component stocks of these indices that follow a random walk based solely on past price movements. They can, however, still include stocks from these indices in their portfolios as international diversification strategies.

Keywords: financial economics, Bangladeshi CSE-30 index.
JEL Classification: C22, F36, G14.

Introduction

Recent advances in telecommunications, internet technology, transportation, and information systems have enabled the rapid acceleration of world trade, international travel, global information exchange, and the movement of financial assets among nations. The increased volume of international trade is based on the exponential growth in the international flow of financial assets, which, in turn, has been fueled by the adherence to post-World War II neoclassical export development as well as higher membership and participation in the World Trade Organization.

In this new era of globalized economies and capital markets, a number of new and old investment avenues are lately becoming popular. Equity markets are one of the most rapidly developing investment avenues, and abroad international movement toward an equity culture has taken root, as traditional bank financing takes a back seat to the emergence of globally-interconnected capital markets (Gagan and Fatehgarh, 2010).

Additionally, international equity markets have recently provided highly-profitable investment opportunities for those seeking optimum rates of return on a worldwide basis. Among the international equity markets, certain developing economies, such as those in Latin America, the Middle East and North Africa, the European Union, advanced Pacific Rim countries, and Asia, share many features in common with developed economies. The impacts of these new developments on emerging markets are twofold. First, they broaden and deepen the equity markets. Second, they provide resources to improve the infrastructures of those markets, including information technology. These improvements in turn remove some of the opaque characteristics of their equity markets, which is a necessary condition for an efficient market.

In perfectly efficient markets, new information is reflected in all markets simultaneously. Markets in most emerging and developing economies, however, are traditionally not expected to be efficient. As articulated by Floros (2011), if two markets are not efficient, investors and traders can use past information to predict prices or future returns in the market.

It is also reasonable to infer from the differences in development, economic policies, governance, culture, and other institutional arrangements, that each of the countries in these groups may feature very different equity holding risk profiles. This may cause the indices and the returns on the market equity portfolios to be different and seemingly independent among superficially similar economies.

Moreover, it appears that nations are becoming less segmented and more efficient over time. A possible explanation for this is a shift toward liberalization within the region. To this end, Bakaert and Harvey (1997) find that index returns for liberalized emerging markets tend to exhibit a lower variance from and a higher correlation with other liberalized emerging markets. Gentzoglanis (2007) argues that liberalization should be matched with regulations to protect investors in order to increase market efficiency and economic growth. Lamba (2005) observes that countries in the South and Southeast Asian regions have experienced considerable political and social turmoil in recent years.

The empirical analysis in this paper is directed toward Bangladesh for several reasons. First, the Asian countries, including Bangladesh, are perhaps the most unique in relation to themselves and to developed nations; second, the internationalization of the Bangladeshi economy is clear from the steady growth in garment exports combined with remittances from overseas. These two sources totaled almost $15 billion and 13% of GDP in 2013, and are the largest contributors to the current account surplus and record foreign exchange holdings of Bangladesh. Third, and most importantly, the 1997 Asian financial crisis precipitated a new level of international macroeconomic policy coordination among international economies, and particularly the Asian region.

Given the aforementioned, it is important to empirically investigate the efficiency of the Bangladeshi equity market over the last 10 years. Contrary to the conventional wisdom and empirical results of earlier studies (Simu, 2012), the results of this study suggest that, while the Bangladeshi CSE-30 index is still inefficient, the CSCX and CASPI indices in Bangladesh follow a random walk. These findings indicate that investors and portfolio managers cannot profit by trading based solely on past price movements using component stocks of these two indices. They can, however, include stocks in these indices in their portfolios as international diversification strategies.

The remainder of the study is organized as follows: Section 1 reviews the literature; Section 2 discusses the methodology and the model's specification; Section 3 describes the data and reports the empirical results; Section 4 discusses the empirical results; and the final section provides some concluding remarks.

1. Literature review

The early work of Fama (1965) suggests that stock price movements exhibit insignificant autocorrelations. Thus, one cannot profit by trading based solely on past price movements. This idea is substantiated later in a survey of the extant literature (Fama and French, 1988). Since then, a number of authors have nevertheless discovered significant autocorrelations in both U.S. and non-U.S. stock returns. These findings put to question the perception that stock returns follow a random walk.

As indicated by Azad (2009), Chan, Gup and Pan (1997) investigate the inter-linkages among international equity markets and interpret their empirical findings of no cointegration among these markets as evidence of joint market efficiency. Lence and Falk (2005) cite a sample of studies that apply cointegration procedures to test for market efficiency in equity markets, security markets, foreign exchange markets, commodity markets and banking product markets. However, Lence and Falk (2005) argue that cointegration of asset prices may not be used for assessing market integration and/or market efficiency but may be used to draw inferences about preferences and endowment processes. Dwyer and Wallace (1992) also articulate that the cointegration is neither a necessary nor a sufficient condition for market efficiency.

Worthington and Higgs (2004) and Olienyk, Schwebach and Zumwalt (1999) interpret the evidence of Granger causal relationships between the cointegrated markets as a violation of (joint) market efficiency. Lim, Gallo and Swanson (1998) also posit that investors can devise trading strategies to exploit any inherent inefficiency between markets.

Chang and Ting (2000) apply Lo and MacKinlay's methodology on the weekly movements of the Taiwan composite value-weighted stock market index over the period of 1971-1996. These authors conclude that the movements of that index do not fit a random walk. Lock (2007) applies the same model over the 1990-2006 sample and finds that the Taiwan composite stock index moves in a random walk fashion, as do the returns for the individual stocks within that index.

Lo and MacKinlay (1988) not only refuted the random walk hypothesis for US weekly returns, but they also presented later researchers with a powerful variance ratio test for the investigation of the applicability of the random walk hypothesis as a description of stock price movements for non-U.S. markets. This test is predicated upon the fact that, for price movements that follow random walks, the variance of the log-price relatives, log Pt -log Pt -1, sampled at regular intervals of length time t, is n times the variance of the log-price relatives sampled at intervals of length t/n. Hence, the variance of the monthly sampled log-price relatives with a sampling interval of length four weeks is four times that of the weekly sampled. The test statistic derived by Lo and MacKinlay (1988) to test if a series of price movements follows a random walk is robust to many forms of heteroscedasticity and non normality.

For the Bangladeshi equity market, Simu (2012) investigates the existence of randomness in return series of Chittagong Stock Exchange (CSE). All Share Price Index (CASPI) by calculating the return series using monthly values of the index for the period from 2001 to 2011. Empirical analysis reveals that the values are statistically dependent. The results do not conform to the existence of random walk in stock returns in CSE. The data series is also found to be stationery; that is, it does not follow a random walk. More interestingly, the author reported that the return series deviates from normal distribution, which suggests the suitability of the Lo and MacKinlay (1988) testing procedure to study Bangladeshi equity indices.

2. Methodology and model's specification

As discussed in the literature review section, the methodology and the model were developed by Lo and MacKinlay in the 1980s. However, this study contributes to the literature by applying the old methodology and model to newly-available data from Asian emerging markets. To specify the model for the empirical investigation, this study follows Lo and MacKinlay's (1988) methodology and lets X_t denote the log of the price of a stock at time t. If $X_t = \mu + X_{t-1} + \varepsilon_t$, then the price variable is said to follow a random walk. Here, μ stands for an arbitrary drift parameter, and ε_t is the random disturbance term, allowed to vary with time and deviate from normality. This X_t is far more lenient than the traditional random walk specification; typically random walk models assume ε_t is identically and independently distributed (i.i.d.). If the movement of X_t does follow a random walk, then the variance of $X_t - X_{t-1}$ is $1/n$ times the variance of $X_t - X_{t-n}$. Furthermore, as shown by Lo and MacKinlay (1988), give n a finite number of price movements represented by $nq + 1$ consecutive X_{ts} (written as X_0, X_1, X_2,..., X_{nq}) and taken to be a segment from an infinite series, the question of whether $X_t = \mu + X_{t-1} + \varepsilon_t$ holds true for the entire series can be addressed by estimating the ratio of the variance of $X_t - X_{t-n}$ to $1/n$ the variance of $X_t - X_{t-1}$. Under the random walk hypothesis, this variance ratio has a value close to one.

Algebraically, let:

$$\hat{u} = \frac{1}{nq}\sum_{k=1}^{nq}(X_k - X_{k-1}) = \frac{1}{nq}(X_{nq} - X_0) \quad (1)$$

$$\hat{\sigma}_a^2 = \frac{1}{nq-1}\sum_{k=1}^{nq}(X_k - X_{k-1} - \hat{u})^2, \quad (2)$$

and

$$\hat{\sigma}_c^2(q) = \frac{1}{q(nq-q+1)(1-\frac{q}{nq})}\sum_{k=q}^{nq}(X_k - X_{k-q} - q\hat{u})^2 \quad (3)$$

then, as demonstrated by Lo and MacKinlay (1988), $\hat{\sigma}_a^2$ and $\hat{\sigma}_c^2$ (q) are unbiased estimators of $X_t - X_{t-1}$ and $X_t - X_{t-q}$, respectively. Additionally, let the variance ratio VR (q) be defined as:

$$VR(q) = \frac{\hat{\sigma}_c^2(q)}{\hat{\sigma}_a^2}, \quad (4)$$

where q = 2, 4, 8, and 16. Under the random walk hypothesis, the four variance ratios V (2), VR (4), VR (8) and VR (16) will all have values close to one since the variance of increments of a random walk is linear in the sample interval.

To test whether the variance ratios of the sampled price movements deviate enough from unity to reject the random walk hypothesis, Lo and MacKinlay (1988) derive the asymptotically standard normal statistic z (q) where:

$$z(q) = \frac{\sqrt{nq}[VR(q)-1]}{\sqrt{\sum_{j=1}^{q-1}\left(\frac{2(q-j)}{q}\right)^2\hat{\delta}(j)}}, \quad (5)$$

and

$$\hat{\delta}(j) = \frac{nq\sum_{k=j+1}^{nq}(X_k - X_{k-1} - \hat{\mu})^2(X_{k-j} - X_{k-j-1} - \hat{\mu})^2}{[\sum(X_k - X_{k-1} - \hat{\mu})^2]^2}. \quad (6)$$

Additionally, Lo and MacKinlay (1988) show that when $q = 2$, $[VR\ (q) - 1]$ estimates the first-order autocorrelation coefficient of $(X_t - X_{t-1})_s$. Therefore, if X_{ts} are daily prices, then VR (2) approximates the first-order autocorrelation of daily returns. As to the movement of the daily returns, as Lo and MacKinlay (1988) articulated, and as was later restated by Lock (2007), if the calculated statistic z (2) is neither large or small enough to reject the hypothesis that variance ratio VR (2) is approximately equal to 1 (the null hypothesis of random walk), the increments or the daily returns of the equity index under consideration follow a random walk.

Also, as shown by Richardson and Smith (1991), under the aforementioned assumption of i.i.d., the joint covariance matrix of ratio test statistics can be formed to calculate the standard Wald statistic to test the joint hypothesis that all q variance ratio statistics equal 1. Under the null hypothesis of a random walk, the Wald statistic is asymptotic Chi-Square (χ^2) with q degrees of freedom. The Wald statistic, which compound the vector of individual Variance Ratio statistics and their correlations, follows the χ^2 distribution. However, the χ^2 distribution may not be an appropriate approximation to the sampling distribution of Wald statistic because of the well-known right-skewness problem.

3. Data and empirical results

3.1. Data. This study utilizes three daily stock price indices of the Bangladeshi economy: CSE-30, CSCX, and CASPI. The daily data set used in this investigation covers the period of 2004:02:15 to 2014:08:20. All time-series data are obtained from the Bangladeshi Chittagong Stock Exchange database.

3.2. Empirical results. As previously mentioned, the variance ratio VR (q), q = 2, 4, 8 and 16 specifies more than one test period; therefore, there are two sets of test results which are reported in the estimation results. The "Joint Tests" are the tests of the joint null hypothesis for all periods and the "Individual Tests" are the variance ratio tests applied to individual periods. More specifically, the Chow-Denning maximum $|z|$ statistics and their approximated p-values, which are used to test the joint random walk hypothesis of the first four periods, are reported. The Chow-Denning maximum $|z|$ statistic is calculated using the standardized maximum modulus with infinite degrees of freedom. Additionally, the Wald (Chi-Square) statistic is used to test the joint hypothesis of a random walk of all 16 periods. The degrees of freedom and p-value associated with the Wald statistic are reported. The normal statistics $z(q)$, $q = 2, 4, 8$ and 16 testing a random hypothesis for each of the periods (2, 4, 8, and 16) and their p-values are also calculated.

The empirical results for CSE-30, CSCX, and CASPI are reported in Tables 1, 2, and 3, respectively. The variance test ratio statistics with their $\pm 2^*$ standard error bands are also reported in Figures 1, 2, and 3, respectively.

Table 1. CSE-30-variance ratio test results, data 2004:02:15 to 2014:08:20

A. Joint tests		Value	Degrees of freedom	Probability
Max |z| (at period 16)*		1.336510	2559	0.5509
Wald (Chi-Square)		8.076826	4	0.0888
B. Individual tests				
Period	Var. Ratio	Std. Error	*z*-Statistic	Probability
2	0.991012	0.019768	-0.454651	0.6494
4	0.972149	0.036983	-0.753074	0.4514
8	1.034931	0.058475	0.597361	0.5503
16	1.116294	0.087013	1.336510	0.1814

Source: *Probability approximation using studentized maximum modulus with parameter value 4 and infinite degrees of freedom.

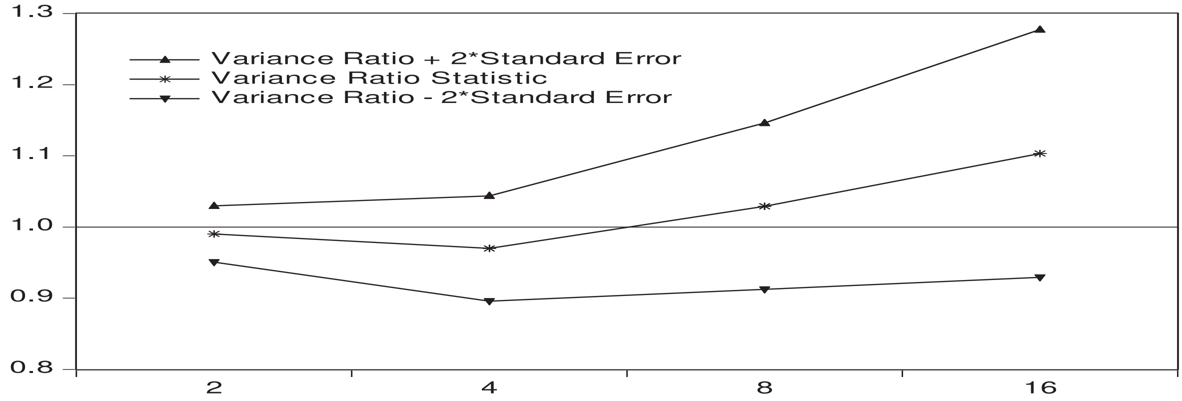

Fig. 1. CSE-30-variance ratio statistic with ± 2*standard error bands

Table 2. CSE-30-variance ratio test results, data 2004:02:15 to 2014:08:20

A. Joint tests		Value	Degrees of freedom	Probability
Max |z| (at period 8)*		3.124484	2559	0.0071
Wald (Chi-Square)		12.34020	4	0.0150
B. Individual tests				
Period	Var. Ratio	Std. Error	*z*-Statistic	Probability
2	1.035399	0.019768	1.790700	0.0733
4	1.058800	0.036983	1.589937	0.1118
8	1.141064	0.058475	2.412396	0.0158
16	1.271872	0.087013	3.124484	0.0018

Source: *Probability approximation using studentized maximum modulus with parameter value 4 and infinite degrees of freedom.

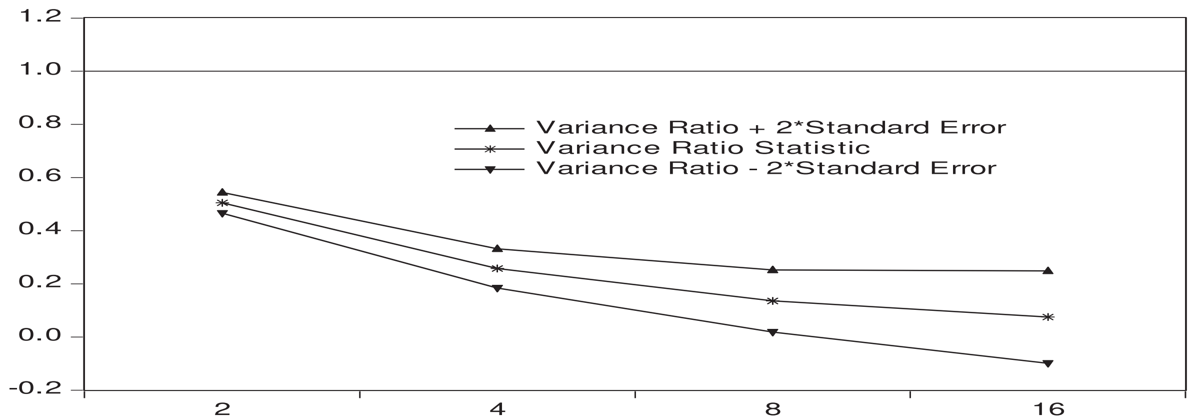

Fig. 2. CSCX-variance ratio statistic with ± 2*standard error bands.

Table 3. CASPI - variance ratio test results, data 2004:02:15 to 2014:08:20

A. Joint tests		Value	Degrees of freedom	Probability
Max |*z*| (at period 4)*		3.124484	2559	0.0071
Wald (Chi-square)		12.34020	4	0.0150
B. Individual tests				
Period	Var. Ratio	Std. Error	*z*-Statistic	Probability
2	1.035399	0.019768	1.790700	0.0733
4	1.058800	0.036983	1.589937	0.1118
8	1.141064	0.058475	2.412396	0.0158
16	1.271872	0.087013	3.124484	0.0018

Source: *Probability approximation using studentized maximum modulus with parameter value 4 and infinite degrees of freedom.

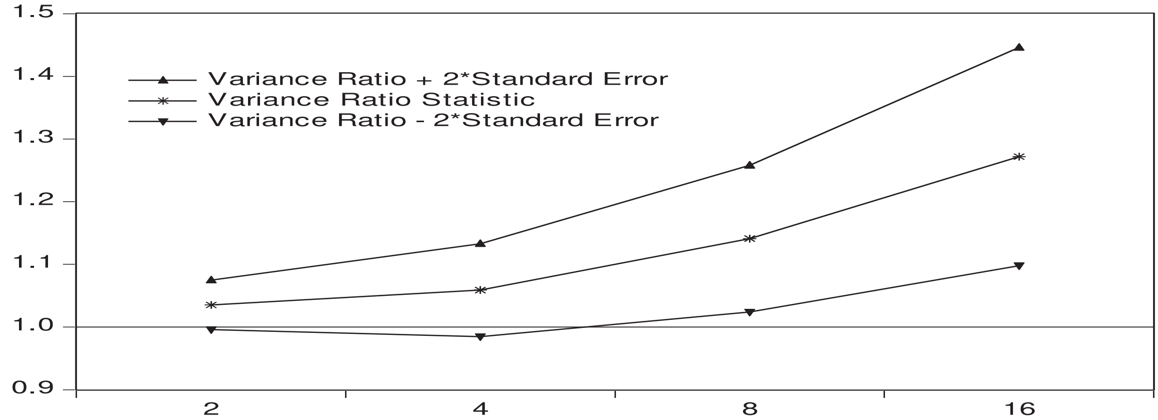

Fig. 3. CASPI - variance ratio statistic with ± 2*standard error bands.

4. Discussion of the empirical results

Tables 1, 2, and 3 report the Chow-Denning maximum $|z|$ statistics, the Wald (Chi-square) statistics as well as their approximated *p*-values which are used to test the joint null hypothesis and variance ratios and the test statistics z (q), q = 2, 4, 8 and 16 for the Bangladeshi equity indices: CSE-30, CSCX, and CASPI. The "Joint Tests" are the tests of the joint null hypothesis for all periods and the "Individual Tests" are the variance ratio tests applied to individual periods.

An analysis of the empirical results reported in Table 1 suggests that, based on the Chow-Denning maximum $|z|$ statistic and the Wald statistic, the Bangladeshi CSE-30 Index does not follow a random walk. This finding is consistent with the traditional wisdom that the equity markets in developing economies are not expected to be efficient.

However, a close look at the Chow-Denning maximum $|z|$ statistics and the Wald statistics reported in Tables 2 and 3 reveals that the null hypothesis of a random walk of joint and individual periods cannot be rejected for the Bangladeshi CSCX index. As to the CASPI index, the null hypothesis of a random walk of joint should be rejected at any conventional level. With the exception of the four day interval returns series, the random walk hypothesis for individual periods cannot be rejected at conventional levels of significance. These mixed empirical findings are quite unexpected for at least one of the authors, who has investigated the same issue for a group of South Asian countries (India, Pakistan and Sri Lanka) and found that the equity markets of these countries do not follow a random walk (Nguyen et al., 2012). As to the implications for investment strategy, the empirical results are consistent with the early findings by Fama (1965) that stock price movements exhibit insignificant auto-correlations. Thus, one cannot profit by trading based solely on past price movements.

One possible explanation for the above empirical findings regarding the CSCX and CASPI indices may be that international equity markets have recently provided highly-profitable investment opportunities to investors seeking optimum rates of return on a worldwide basis, and the Bangladesh economy has evolved to share many features in common with developed economies. The impacts of these new developments on the Bangladeshi equity market are that they broaden and deepen its stock market and provide resources to improve the infrastructure of the Bangladeshi market, including improved information technology. The improvement in the infrastructures and information technology in turn remove some of the opacity of the equity market, which, in turn, provides a necessary condition for an efficient market.

As articulated by Floros (2011), these empirical results reveal that investors and traders cannot use past information to predict future prices or returns in the component stocks of the Bangladeshi CSCX and CASPI indices. Consequently, the results affirm that investors can only diversify their portfolios to reduce the portfolio risk using the component stocks of these two indices. Furthermore, economic policy makers must have a comprehensive understanding of the transmission of price movements in the equity markets, especially during periods of high volatility. Appropriate policies may be designed to lessen the impact of financial crises.

Concluding remarks

This study applies Lo and MacKinlay's methodology to the daily movements of the three Bangladeshi equity indices: CSE-30, CSCX, and CASPI, over the period of February 15, 2004 – August 20, 2014. The empirical findings are mixed. More specifically, theestimation results indicate that the Bangladeshi CSE-30 index, joint period, two, four, eight, and sixteen period returns do not follow the random walk. Except for the four day period return series of the CASPI; CASPI, the CSCE and their investigated individual periodical return series follow a random walk. As to the implication for investment strategy for the indices that follow the random walk, the empirical results are consistent with the early findings by Fama (1965) that stock price movements exhibit insignificant autocorrelations. Thus, one cannot profit by trading based solely on past price movements in these selected Asian equity markets.

A plausible explanation for the mixed results may be that international equity markets have recently provided highly profitable investment opportunities to investors seeking optimum rates of return on a worldwide basis and the Bangladeshi economy has evolved to share many common features as developed economies. The impacts of these new developments on the Bangladeshi economy are that they broaden and deepen the equity markets. Also, they provide resources for its market to improve the infrastructures, including information technology. The improvements in the infrastructure and information technology in turn remove some of the opaque characteristics in its equity market. These are the necessary foundation for an efficient market.

Clearly, the empirical findings suggest that investors who invest in the component stocks of the indices that follow the random walk cannot take advantage of pricing inefficiencies, but they can use their component stocks for portfolio diversification. Furthermore, economic policymakers must have a comprehensive knowledge of transmission of price movements in regional equity markets, especially during periods of high volatility. Appropriate policies may be designed to lessen the impact of financial crises.

One of the limitations of this investigation is that it uses the daily data, which may suffer from biases associated with non-trading, the bid-ask spread, and asynchronous prices.

References

1. Azad, A.S. MS. (2009). Efficiency, Cointegration and Contagion in Equity Markets: Evidence from China, Japan and South Korea (December 2009), *Asian Economic Journal*, Vol. 23 (1), pp. 93-118. Available at SSRN: http://ssrn.com/abstract = 1366622.
2. Bakaert, G. and Harvey, C. (1997). Emerging Equity Market Volatility, *Journal of Financial Economics*, Vol. 43, pp. 29-77.
3. Chan, K.C., Gup, B.E. and Pan, M. (1997). International stock market efficiency and integration: a study of eighteen nations, *Journal of Business Finance and Accounting*, Vol.24, pp. 803-813.
4. Chang, K. and Ting, K. (2000). A Variance Ratio Test of the Random Walk Hypothesis for Taiwan's Stock Market, *Applied Financial Economics*, Vol.10, pp. 525-32.
5. Dwyer, G.P., Jr. and Wallace, M.S. (1992). Cointegration and market efficiency, *Journal of International Money and Finance*, Vol. 11, pp. 318-327.
6. Fama, E.F. (1965). The Behavior of Stock Market Prices, *Journal of Business*, Vol. 38, pp. 34-105.
7. Fama, E. and French, K. (1988). Permanent and Temporary Components of Stock Prices, *Journal of Political Economy*, Vol. 96, pp. 246-73.
8. Floros, C. (2011). Dynamic Relationships between Middle East Stock Markets, *International Journal of Islamic and Middle Eastern Finance and Management*, Vol. 4, pp. 227-236.
9. Gentzoglanis, A. (2007). Financial Integration, Regulation, and Competitiveness in Middle East and North African Countries, *Managerial Finance*, Vol. 33, pp. 461-476.
10. Gagan, D.S. and Fatehgarh, S.B. (2010). Are the Global Markets Inter-Linked? Evidence from the Literature, *Global Journal of Management and Business Research*, Vol. 10, No. 1, pp. 29-37.
11. Lamba, A.S. (2005). An Analysis of the Short- and Long-Run Relationships Between South Asian and Developed Equity Markets, *International Journal of Business*, Vol. 10, No. 4, 2005. Available at SSRN: http://ssrn.com/abstract = 830069.
12. Lence, S. and Falk, B. (2005). Cointegration, market integration and market efficiency, *Journal of International Money and Finance*, Vol. 24, pp. 873-890.
13. Lim, E.S., Gallo, J.G. and Swanson, P.E. (1998). The relationship between international bond markets and international stock markets, *International Review of Financial Analysis*, Vol. 7, pp. 181-190.

14. Lo, A.W. and MacKinlay, C. (1988). Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test, *Review of Financial Studies*, Vol. 1, pp. 41-66.
15. Lo, A.W. and MacKinlay, C. (1988). The Size and Power of the Variance Ratio Tests in Finite Samples: A Monte Carlo Investigation, *Journal of Econometrics*, Vol. 40, pp. 203-38.
16. Lock, D.B. (2007). The Taiwan stock market does follow a random walk, *Economics Bulletin*, Vol. 7, No. 3, pp. 1-8.
17. Nguyen, C.V., Paskelian, O.G. and Jones, K. (2012). Do Equity Indices in the Three Selected South Asian Countries, the UK and the US Follow a Random Walk?" Working paper to be presented at the Academy of International Business-Southwest Subchapter's Annual Conference, New Mexico, March 2013.
18. Olienyk, J.P., Schwebach, R.G. and Zumwalt, J.K. (1999). WEBS, SPDRs, and country funds: an analysis of international cointegration, *Journal of Multinational Financial Management*, Vol. 9, pp. 217-232.
19. Simu, T.H. (2012), *Indian Journal of Commerce & Management Studies*; May 2012, Vol. 3, No. 2, pp. 1-16.
20. Richardson, M. and Smith, T. (1991). Tests of Financial Models in the Presence of Overlapping Observations, *The Review of Financial Studies*, Vol. 4, pp. 227-254.
21. Worthington, A. and Higgs, H. (2004). Co-movements in Asia-Pacific equity markets: Developing patterns in APEC, *Asia-Pacific Journal of Economics and Business*, Vol. 8, pp. 79-93.