8. INTERNATIONAL EQUITY DIVERSIFICATION BETWEEN THE UNITED STATES AND BRICS COUNTRIES

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Abstract

This study uses an enhanced powerful nonparametric cointegration test developed by Bierens (1997) to re-investigate whether there are long-run benefits from international equity diversification between the United States and BRICS countries (i.e., Brazil, Russia, India, China, and South Africa), over the period July 1997 to March 2012. The results of this test suggest that the United States markets (for both Dow Jones 30 and S&P 500) are pairwise cointegrated with the stock markets of the BRICS countries. These findings should prove valuable to individual investors and financial institutions.

Keywords: international equity diversification, BRICS countries, long-run investment portfolios, nonparametric cointegration test

JEL Classification: C32, F21

I. Introduction

The purpose of this study is to explore whether there are long-run benefits from international equity diversification for the investors from the United Sates who invest in the equity markets of the BRICS countries, namely Brazil, Russia, India, China and South Africa. Empirical studies have employed cointegration techniques to investigate whether these putative long-run benefits exist (see Taylor and Tonks, 1989; Chan *et al.*, 1992; Kasa, 1992; Arshanapalli and Doukas, 1993; Roger, 1994; Chowdhury, 1994, Arshanapalli *et al*., 1995; Masih and Masih, 1997; and Kanas, 1999; Chang, 2001 and Chang *et al*., 2009). According to these studies, asset prices from two

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different efficient markets cannot be cointegrated. If a pair of stock prices is cointegrated, then one stock price can be forecasted from the other stock price. If that is the case, there are no gains from portfolio diversification.

The Johansen cointegration test (Johansen, 1988; Johansen and Juselius, 1990) has been widely employed in the above-mentioned studies. This popular cointegration test, developed on the basis of a linear autoregressive model, implicitly assumes that the underlying dynamics are in linear form. Yet, there is ample empirical evidence against the linear paradigm. Theoretically, there is no reason to believe that the economic systems must be intrinsically linear (see Barnett and Serletis, 2000). Empirically, there are many studies showing that financial time series such as stock prices exhibit nonlinear dependencies (see Hsieh, 1991; Abhyankar *et al.*, 1997). The Monte Carlo simulation evidence in Bierens (1997) indicated that the standard Johansen cointegration framework presents a *min-specification* problem when the true nature of the adjustment process is nonlinear and the speed of adjustment varies with the magnitude of the disequilibrium. The work of Bake and Fomby (1997) also suggested a potential loss of power in standard cointegration tests under threshold autoregressive data generating processes.

Motivated by the above-mentioned considerations, in this study we re-examine the issue of stock market integration for the markets of the United States and the BRICS countries, using a more powerful nonparametric cointegration test developed by Bierens (1997). The results of this test suggest that the United States stock markets (for both Done Jones 30 and S&P 500) were pairwise cointegrated with all the stock markets of the BRICS countries during the period from July 1997 to March 2012. Our cointegration findings can be interpreted as evidence that a long-run linkage exists between the United States and the BRICS countries, and thus, there is no potential gains for the investors from the United States who want to diversify in BRICS equity markets, or vice versa. These results should prove valuable to individual investors and financial institutions.

We find the BRICS countries to be an interesting sample for the investigation of stock market behavior for several reasons. Firstly, there has been an exponential rise in the growth and economic power of the emerging markets ever since the 1990s, with the emerging economies in general, and the transition economies in particular, having received widespread attention within the literature. Clearly, the BRICS economies stand out among all of the emerging economies, having demonstrated remarkable economic progress over recent years. Ever since the recognition of their status in the study - *Dreaming with BRICs: The Path to 2050* - (Wilson and Purushortaman, 2003), the emerging markets of the BRICS countries have continued to make significant contributions to the global economic growth, and seem likely set to do so for many decades to come; indeed, these economies are poised to become larger, in US dollar terms, than the G6[4]. Secondly, it is estimated that about two-thirds of the anticipated increase in GDP by the BRICS economies is likely to come from higher-end real

[4] *In the early report, only Brazil, Russia, India, and China constituted the BRIC group; South Africa was added the follow-up, giving the current version of BRICS. The G6 refers to the United States, the United Kingdom, Japan, Germany, France, and Italy.*

growth. The BRICS countries are already playing important roles in global financial development, exerting significant influences on economic growth throughout the global economy and markets. Third, there are more funds invested in BRICS stock markets and investors in BRICS countries also show keen interests to the United States and other developed stock markets. Our empirical results are helpful to their investment decisions.

The remainder of this study is organized as follows. Section II briefly reviews the previous literature. Section III presents a discussion of the data. Section IV presents the tests for cointegration and discusses the empirical findings with economics and policy implications. Section V concludes the paper.

II. Review of Literature

The relationship between the stock markets of developed countries and developing countries has been extensively examined in literature. However, the stock markets of BRICS (Brazil, Russia, India, China and South Africa) countries have received little attention separately despite the rapid growth and liberalization among these countries.

In this section, we will briefly describe the current literature regarding the interdependency between the BRICS stock markets and those of other developing and developed countries. The empirical findings in the literature on the cointegration of stock markets in the BRICS and other countries are mixed and in some cases even contradictory.

For instance, Wang and Iorio (2007) investigated the integration of three China-related stock markets, namely, the A-, B- and H-share markets, with both the Hong Kong stock market and the world market. An analysis of market segmentation versus integration using the Jorion and Schwartz model suggests that the A-share market was a segmented market during the period 1995–2004. However, evidence of a higher-level integration between the A- and B-share markets, and the A-share and Hong Kong stock markets is found in the sub-period tests. The hypothesis that the B- and H-share markets are becoming increasingly integrated with the world stock market is not supported.

Huyghebaert and Wang (2010) examined the integration and causality of interdependencies among seven major East Asian stock exchanges before, during, and after the 1997–1998 Asian financial crisis. For this purpose, they use daily stock market data from July 1, 1992 to June 30, 2003 in local currency as well as US dollar terms. Empirical study revealed that the relationships among the East Asian stock markets are time varying. While stock market interactions were limited before the Asian financial crisis, they found that Hong Kong and Singapore responded significantly to shocks in most other East Asian markets, including Shanghai and Shenzhen, during this crisis. After the crisis, shocks in Hong Kong and Singapore largely affected other East Asian stock markets, except for those in Mainland China. Finally, when they considered the role of the USA the empirical results showed that the USA strongly influenced stock returns in East Asia – except for Mainland China – in all periods.

Gambhir and Bhandari (2011) study the interdependency among BRIC stock markets primarily through cointegration and the Granger causality tests. Their study is a continuation of research on the issue of growing interdependency among the stock markets. They observed that stock prices among the BRIC countries are trending together. Furthermore, their study found that no stock market is playing a dominant role in influencing other markets. Compared with previous studies in the literature, their study found that stock market integration and causation between different markets have changed over the time. In brief, it can be concluded that the interdependencies among the stock markets in the world has increased and no clear direction of relationships exists in the sense of Granger causality, indicating the fact that influence of few markets has eroded over a period of time.

Gupta and Guidi (2012) attempted to explore the links between the Indian stock market and three developed Asian markets (i.e. Hong Kong, Japan and Singapore) using cointegration methodologies in order to explore interdependence. They further estimated the time-varying conditional correlation relationships among these markets, and found that correlations rose dramatically during periods of crisis and returned to their initial levels after the crisis. Finally, they investigated the presence of different volatility regimes across stock markets and suggested that international investors may find useful to model their portfolio by also considering how volatile the stock markets are. Their empirical results show that estimated probability of being in the low volatility state is the highest for all the considered stock markets, as well as the probability to switch from a medium- to high-volatility state. Results also suggest a short-run relationship and absence of a strong long-run relationship among these markets. They finally suggest that absence of long-run linkages among these markets may provide potential benefits for the investors that look at emerging markets to enhance their risk adjusted returns by including emerging markets in their portfolios.

Sudhakara and Wadhwa (2012) studied the cointegration between the BRIC emerging markets and the US and their results indicated that it was a varying degree of cointegration among the BRIC and US countries, which was mainly due to the trade relations between these countries.

Li (2013) investigated China's asset pricing mechanism with an aim to test for integration between the Chinese and global stock markets. By estimating the augmented CAPM through the Kalman smoothing technique for the A- and B-share indices of the Shanghai and Shenzhen stock exchanges during 2000–2010, Li (2013) found that most of the indices' global and national systematic risks changed slowly and the national systematic risk was generally much higher than the global one. These observations suggest that investing in the Shanghai A-share and Shenzhen A- and B-share markets may not significantly increase the global systematic risk of an international portfolio, offering a diversification opportunity. Li (2013) also found that the degree of integration is not simply a matter of the level of legal restrictions imposed on the stock market. It depends on other factors, such as nature of shares and the composition of foreign investors on the stock exchanges, too. The implications for emerging economies are that the indirect barriers as well as the legal barriers to international investment should be removed in order to reap the benefits of stock market integration. Li (2013) further suggested that the authorities should make their stock exchanges appealing to international as well as regional investors.

Ahmad *et al*., (2013) examined the financial contagion in an emerging market setting by investigating the contagion effects of GIPSI (Greece, Ireland, Portugal, Spain and Italy), USA, UK and Japan markets on BRIICKS (Brazil, Russia, India, Indonesia, China, South Korea and South Africa) stock markets. During the Euro-zone crisis period (October 19, 2009–January 31, 2012), their empirical results indicated that among the GIPSI countries, Ireland, Italy and Spain appeared to be most contagious for the BRIICKS markets as compared to Greece. Their study reported that Brazil, India, Russia, China and South Africa were strongly hit by the contagion shock during the Euro-zone crisis period. However, Indonesia and South Korea reported only interdependence and not contagion. From policy perspective, their findings provide useful implications for possible decoupling strategies to insulate the economy from contagious effects.

Zhang *et al*., 2013) found that the recent financial crisis has changed permanently the correlations between BRICS and the developed United States and European stock markets. They estimated about 70% of BRICS stock markets' conditional correlation series demonstrate an upward long-run trend with the developed stock markets. Their results provide convincing evidence that the declining diversification benefits are a long-run and world-wide phenomenon, especially after the recent financial crisis.

Recently, Zhang and Li (2014) examined the co-movement between the Chinese and United States stock markets over the period between January 4, 2000 and January 13, 2012. They show that there is no cointegration relationship between the two markets, even when allowing for structural change. Their conditional correlation fluctuates around an upward trend, which has shifted upward since the recent financial crisis, and the short-run fluctuations are driven by volatility shocks from the two markets. They also find a strong impact of the US market on the Chinese market, especially when the latter undergoes extreme movements. These findings should have important policy implications for both the United States and Chinese regulators.

While previously mentioned studies focused most on the interdependency between the BRICS stock markets and those of other developing and developed countries, most of them using the linear Johansen cointegration test (Johansen, 1988; Johansen and Juselius, 1990), no study focused specifically on the US equity market interaction with the BRICS (Brazil, Russia, India, China and South Africa) countries using nonlinear unit root test and nonparametric cointegration test. The present study hopes to fill the gap of finding out the interdependence and co-movement of United States stock markets with the BRICS stock markets using both nonlinear unit root test of Kapetanios *et al*., 2003) and nonparametric cointegration test of Bierens (1997).

III. Data

The data set consists of weekly stock market indices for the United Sates and the BRICS countries (i.e., Brazil, Russia, India, China, and South Africa). The stock market indices for the BRICS countries are the BOVESPA Index for Brazil, the RTS Index – Price Index for Russia, the BSE (100) for India, both Shanghai and Shenzhen Composite Indexes for China, and the FTSE/JSE Index for South Africa. For the United States, both the Dow Jones industrial Average Index and S&P stock price

Index are used in our study. Sample periods cover from July 1997 to March 2012. Data are collected from the Datastream database. All indices are based on the local currencies and all series are measured in logs. Following Chowdhury (1994), we match the 8 time series by omitting some observations. For example, seasonal festival or holiday entries (and others) are omitted to guarantee that each pair of countries has entries on a given date. According to Chowdhury (1994), this procedure solves the problem of the data gap caused by holidays and other nonworking days.

Table 1 reports the summary statistics of stock market returns for the United States and BRICS countries. We find that most of the weekly index returns are positive, and that Russia and the United States (S&P 500) have the highest and lowest average weekly index returns, of 0.3866% and 0.0558%, respectively. Table 1 also shows that index returns for all countries are leptokurtic. The relatively large value of the kurtosis statistic (larger than three) suggests that the underlying data is leptokurtic, or heavily tailed and sharply peaked about the mean when compared to the normal distribution. The Jarque-Bera test also leads to rejection of normality on these eight equity returns data sets; these results can be attributed to the investment strategies of global investors and speculators searching for alternative investment areas.

IV. Methodology, Empirical Results and Implications

A. Unit Root Tests.

Studies have found that many macroeconomic and financial time series, including stock price series, contain unit roots dominated by stochastic trends (see Nelson and Plosser, 1982; Lee and Jeon, 1995). A necessary, but not sufficient, condition for cointegration is that each of the stock price indices be integrated of the same order (see Granger, 1986). There is a recent and growing consensus that stock price data might exhibit nonlinearities and that conventional tests for stationarity, such as the ADF unit root test, have low power in detecting the mean-reverting tendency of the series. For this reason, stationarity tests in a nonlinear framework must be applied. We use the nonlinear stationary test advanced by Kapetanios *et al*., 2003 - henceforth, the KSS test).

Following Kapetanios *et al*., 2003), the KSS test is based on detecting the presence of non-stationarity against a nonlinear, but globally stationary exponential smooth transition autoregressive (ESTAR) process. The model is given by

$$\Delta Y_t = \gamma Y_{t-1}\{1-\exp(-\theta Y_{t-1}^2)\} + \nu_t , \qquad (1)$$

where: Y_t is the data series of interest, v_t is an i.i.d. error with zero mean and constant variance, and $\theta \geq 0$ is the transition parameter of the ESTAR model and governs the speed of transition. Under the null hypothesis Y_t follows a linear unit root process, but Y_t follows a nonlinear stationary ESTAR process under the alternative. One problem with this framework is that the parameter, γ , is not identified under the null hypothesis. Kapetanios *et al.,* 2003) use a first-order Taylor series approximation for

$\{1-\exp(-\theta Y_{t-1}^{2})\}$ under the null hypothesis $\theta = 0$ and then approximate equation (1) by the following auxiliary regression:

$$\Delta Y_t = \xi + \delta Y_{t-1}^{3} + \sum_{i=1}^{k} b_i \Delta Y_{t-i} + \nu_t \text{, t = 1, 2,…., T} \tag{2}$$

In this framework, the null hypothesis and alternative hypotheses are expressed as $\delta = 0$ (non-stationarity) against $\delta < 0$ (non-linear ESTAR stationarity). The simulated critical values for this test were given in Table 1 of Kapetanios *et al.*, 2003). Table 2 reports the KSS nonlinear stationary test results. These results indicate that all share price index series are integrated of order one.

For the sake of comparison, we also incorporate the Augmented Dickey-Fuller (ADF), Kwiatkowski *et al.*, 1992, KPSS) and Phillips and Perron (1988, PP) tests into our study. All these three tests indicate that each stock price index is nonstationary in levels and stationary in first differences, suggesting that the stock price indices are integrated of order one, I(1). To save space, we do not report these results; the results are available upon request. Table 2 reports our nonlinear KSS test results that further confirm that all the stock price indices are nonstationary. On the basis of these results, we proceed to test whether the United States stock markets (for both Dow Jones 3 and S&P 500) are cointegrated with the BRICS stock markets, respectively, using the nonparametric cointegration approach of Bierens (1997).

B. Nonparametric Cointegration Test of Bierens (1997*)*

Similar to the properties of the Johansen approach, the Bierens' test statistic is also obtained from the solutions of a generalized eigenvalue problem, and the tested hypotheses are the same. The main difference is that, in the nonparametric approach, the generalized eigenvalue problem is formulated on the basis of two random matrices, which are constructed independently of the DGP. These matrices consist of weighed means of the system variables in levels and first differences, and they are constructed in such a way that their generalized eigenvalues share similar properties to those in the Johansen approach.

The Bierens' nonparametric cointegration test takes as the general framework:

$$z_t = \pi_0 + \pi_1 t + y_t \tag{3}$$

where: $\pi_0(qx1)$ and $\pi_1(qx1)$ are optimal mean and trend terms, and y_t is a zero-mean unobservable process such that Δy_t is stationary and ergodic. Apart from these regularity conditions, the method does not require further specification of DGP for z_t, and in this sense, it is completely nonparametric.

The Bierens' method is based on the generalized eigenvalues of matrices A_m and $(B_m + cT^{-2}A_m^{-1})$, where A_m and B_m are defined by the following matrices:

$$A_m = \frac{8\pi^2}{T}\sum_{k=1}^{m} k^2 (\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)z_t)(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)z_t)' \quad (4)$$

$$B_m = 2T\sum_{k=1}^{m}(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)\Delta z_t)(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)\Delta z_t)' \quad (5)$$

where these matrices are computed as sums of outer-products of weighted means of z_t and Δz_t , and T is the sample size. To ensure invariance of the test statistics to drift terms, the weighted functions of $\cos(2k\pi(t-0.5)/T)$ are recommended here. Similar to the properties of the Johansen likelihood ratio method, the ordered generalized eigenvalues of this nonparametric method are obtained as the solution to the problem $\det[P_T - \lambda Q_T] = 0$ when the pair of random matrices $P_T = A_m$ and $Q_T = (B_m + cT^{-2}A_m^{-1})$ is defined. Thus, it can be used to test the hypothesis on the cointegration rank *r*. To estimate *r*, Bierens (1997) proposed two statistics. One is the $\lambda \min$ test, which corresponds to Johansen's maximum likelihood procedure, to test for the hypothesis $H_0(r)$ against $H_1(r+1)$. The critical values for this test are tabulated in the same article. The second statistic is the $g_m(r_0)$ test, which is computed from the generalized eigenvalues of Bierens:

$$\hat{g}_m(r_0) = \begin{cases} (\prod_{k=1}^{n}\hat{\lambda}_{k,m})^{-1}, if....r_0 = 0 \\ (\prod_{k=1}^{n-r}\hat{\lambda}_{k,m})^{-1}(T^{2r}\prod_{k=n-r+1}^{n}\hat{\lambda}_{k,m}), if...r_0 = 1,....,n-1 \\ T^{2n}\prod_{k=1}^{n}\hat{\lambda}_{k,m}, if....r_0 = n \end{cases} \quad (6)$$

This statistic employs the tabulated optimal values (see Bierens, 1997, Table 1) for *m* when $n > r_0$ while $m = n$ is chosen for $n = r_0$. It verifies $\hat{g}_m(r_0) = O_p(1)$ for $r = r_0$ and converges in probability to infinity if $r \neq r_0$. A consistent estimate of r is thus given by $\hat{r}_m = \arg\min_{r_0 < n}\{\hat{g}_m(r_0)\}$. This statistic is useful to double-check on the determination of *r*. As pointed out by Bierens (1997), one of the major advantage of this non-parametric method is its potential superiority in detecting cointegration when the error correction mechanism in nonlinear.

Tables 3-1 and 3-2 report the results of Bierens' nonparametric cointegration test when both the DJ and S&P serve as the base country, respectively; the results demonstrate that the null hypothesis of no cointegration can be rejected for all the cases. We only report the results of the $\lambda \min$ test; the results of the $g_m(r)$ test are suppressed here for reasons of space, but are available upon request. The $\lambda \min$ test results suggest that there is a long-run relationship in all the cases (see Tables 3-1 and 3-2). The findings of long-run linkages between the United States and the BRICS countries lead one to conclude that there is no long-run diversification benefits for investors from the United States who attempt to invest in the equity markets of the United States and BRICS countries. Our empirical results are consistent with those of Gambhir and Bhandari (2011), Sudbakara and Wadhwa (2012), Ahmad *et al*., 2013), Zhang *et al*., 2013), and Li (2013), but not consistent with those of Huyghebaert and Wang (2010), Gupta and Guidi (2012), and Zhang *et al*., 2014). We believe that our results are reliable on account of our use of the more powerful nonparametric cointegration test of Bierens (1997).

C. Economic and Policy Implications

Our empirical findings apparently support the hypothesis proposed by Bracker *et al.* 1999). They proposed that the extent of stock market integration might depend on certain macroeconomic variables that characterize and influence the degree of economic integration between two countries. As the degree of economic integration between countries varies over time, we may expect the extent of equity market integration to vary as well[5]. A possible explanation for our finding is that the international trade-ties between the United States and BRICS countries continued to increase over the past five years.

As we know, globalization, economic adjustment and integration among countries have increased relation among stock markets and the correlation may in turn compel investors' to allocate their funds and change their portfolios. The present paper is an attempt to understand this relationship between the United States and the BRICS countries. On one hand, from investor point of view, since we find the United States and BRICS stock markets are cointegrated, then the United States investors investing in these stock markets should know that their investment portfolios are not properly diversified and investing in them will not lead to long term gains from these investment portfolios. On the other hand, from policy perspective, policy makers need to understand the forces responsible in driving the stock market integration and such understanding will help in providing a better grasp of the global stock markets and the impact of those on their economies. It is hoped that the results of the present study would be useful for the U.S. individual and institutional investors who mainly focus on or invest in the BRICS stock markets and for the management of their portfolios and policy making.

V. Conclusion

Zhang *et al*., (2013) state that to reduce portfolio risk through diversification, a basic requirement is the weak correlation among different stock markets. The benefits of

[5] Our study focuses on using the cointegration technique, which is different from that of Bracker *et al.* (1999). Bracker *et al.* (1999) state, among other things, that international stock market integration is represented by a broad area of studies that involves different aspects of interactions among markets, emphasized the notion of a *lead-lag* relationship. If a *lead-lag* relationship exists, Bracker *et al.* (1999) suggested interpreting it as a presence of integration between two markets.

international diversification depend on the extent to which different stock markets are correlated or cointegrated. Since Grubel (1968) and Solnik (1974)'s pioneer works, the potential benefits of international diversification are well studied. The relationship between the stock markets of developed countries and developing countries has been examined extensively in literature. However, stock markets of BRICS (Brazil, Russia, India, China and South Africa) countries have received little attention separately, despite the rapid growth and liberalization among these countries.

Here our attempt is made to understand the interdependence of the United States stock markets with those of the BRICS countries. The present study uses an enhanced powerful nonparametric cointegration test developed by Bierens (1997) to re-investigate whether there were long-run benefits from international equity diversification between the United States and BRICS countries (i.e., Brazil, Russia, India, China, and South Africa), over the period from July 1997 to March 2012. The results of this test suggest that the US stock markets as represented by both the DJ and S&P indices are pairwise cointegrated with the stock markets of the BRICS countries. This means that the US stock market has a long term equilibrium relationship with the stock markets of the BRICS countries, indicating that the US investors have no diversification opportunity in these countries. Our empirical findings should prove valuable to individual investors and financial institutions holding long-term investment portfolios or setting optimal trading strategies in these markets.

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Table 1

Summary statistic (stock market return)

Country	Dow Jones	S_P500	Brazil	Russia	India	Shangha	Shenzhen	South Africa
Mean	-0.011655	-0.008858	-0.012351	-0.007489	-0.009773	-0.009163	-0.007808	-0.011432
Median	0.002543	0.001584	0.005569	0.004758	0.007036	0.000000	0.000000	0.003378
Maximum	0.106977	0.113559	0.217421	0.544976	0.152186	0.139447	0.154317	0.160396
Minimum	-9.488884	-7.250259	-11.07459	-8.739420	-9.123045	-7.724353	-6.793290	-10.42092
Std. Dev.	0.342974	0.262699	0.401894	0.322000	0.331067	0.280473	0.247811	0.376856
Skewness	-27.45449	-27.25475	-27.13568	-25.95643	-27.14052	-27.08289	-26.71190	-27.42270
Kurtosis	759.1387	751.7881	747.4199	704.1842	747.6046	745.5264	731.9503	757.9765
Jarque-Bera	18440241	18083931	17873828	15860531	17882689	17783132	17139643	18383673
Sum Sq. Dev.	90.45814	53.06926	124.2080	79.73314	84.28654	60.49332	47.22443	109.2135

Table 2

Nonlinear Unit Root Test based on Kapetanios et al.'s (2003. approach)

Country	t statistic on $\hat{\delta}$
Brazil	-0.821
Russia	-1.569
India	-0.763
China (Shanghai)	-1.536
China (Shenzhen)	-1.263
South Africa	-0.509
USA (Dow & Jones)	-1.762
USA (S&P 500)	-0.857

Notes: 1. Null Hypothesis is "The series has a unit root".

2. The critical values for t statistic on $\hat{\delta}$ are tabulated at Kapetanios *et al.*'s (2003. Table 1 of their paper. The critical values for 10%, 5%, and 1% are -1.92, -2.22, and -2.82, respectively.

Table 3-1

Cointegration Test based on Bierens's Nonparametric Approach
(λ min test)

USA Dow Jones as the base market)

Stock Markets	Hypothesis	Test Stat.	5% critical value	Test Stat.	10% critical value	Conclusion
USA vs. Brazil	$H_0 : r = 0$ $H_a : r = 1$	0.01319**	(0,0.017)	0.00048*	(0,0.005)	r = 1
	$H_0 : r = 1$ $H_a : r = 2$	0.11441	(0,0.054)	0.11441	(0,0.111)	
USA vs. Russia	$H_0 : r = 0$ $H_a : r = 1$	0.00137**	(0,0.017)	0.00100*	(0,0.005)	r = 1
	$H_0 : r = 1$ $H_a : r = 2$	4.98848	(0,0.054)	4.98848	(0,0.111)	
USA vs. India	$H_0 : r = 0$ $H_a : r = 1$	0.00849**	(0,0.017)	0.00236*	(0,0.005)	r = 1
	$H_0 : r = 1$ $H_a : r = 2$	0.04411	(0,0.054)	0.04411	(0,0.111)	
USA vs. Shenzhen	$H_0 : r = 0$ $H_a : r = 1$	0.00379**	(0,0.017)	0.00092*	(0,0.005)	r = 1
	$H_0 : r = 1$ $H_a : r = 2$	7.62423	(0,0.054)	7.62423	(0,0.111)	
USA vs. Shanghai	$H_0 : r = 0$ $H_a : r = 1$	0.00157**	(0,0.017)	0.00022*	(0,0.005)	r = 1
	$H_0 : r = 1$ $H_a : r = 2$	18.36772	(0,0.054)	18.36772	(0,0.111)	
USA vs South Africa	$H_0 : r = 0$ $H_a : r = 1$	0.00010**	(0,0.017)	0.00004*	(0,0.005)	r =1
	$H_0 : r = 1$ $H_a : r = 2$	0.18283	(0,0.054)	0.18283	(0,0.111)	

Note: * and ** indicate significance at the 0.10 and 0.05 levels, respectively.

Table 3-2

Cointegration Test based on Bierens's Nonparametric Approach (λ min test) (USA S&P 500 as the base market)

Stock Markets	Hypothesis	Test Stat.	5% critical value	Test Stat.	10% critical value	Conclusion
USA vs. Brazil	$H_0 : r = 0$ $H_a : r = 1$	0.00134**	(0,0.017)	0.00004*	(0,0.005)	r = 1
	$H_0 : r = 1$ $H_a : r = 2$	0.12653	(0,0.054)	0.12653	(0,0.111)	
USA vs. Russia	$H_0 : r = 0$ $H_a : r = 1$	0.00698**	(0,0.017)	0.00660	(0,0.005)	r = 1
	$H_0 : r = 1$ $H_a : r = 2$	5.01476	(0,0.054)	5.01476	(0,0.111)	
USA vs. India	$H_0 : r = 0$ $H_a : r = 1$	0.00411	(0,0.017)	0.00249*	(0,0.005)	r = 1
	$H_0 : r = 1$ $H_a : r = 2$	0.04769	(0,0.054)	0.04769	(0,0.111)	
USA vs. Shenzhen	$H_0 : r = 0$ $H_a : r = 1$	0.00112**	(0,0.017)	0.00024*	(0,0.005)	r = 1
	$H_0 : r = 1$ $H_a : r = 2$	9.78913	(0,0.054)	9.78913	(0,0.111)	
USA vs. Shanghai	$H_0 : r = 0$ $H_a : r = 1$	0.00057**	(0,0.017)	0.00000*	(0,0.005)	r = 1
	$H_0 : r = 1$ $H_a : r = 2$	19.57625	(0,0.054)	19.57625	(0,0.111)	
USA vs. South Africa	$H_0 : r = 0$ $H_a : r = 1$	0.00517**	(0,0.017)	0.00000*	(0,0.005)	r =1
	$H_0 : r = 1$ $H_a : r = 2$	0.17761	(0,0.054)	0.17761	(0,0.111)	

Note: * and ** indicate significance at the 0.10 and 0.05 levels, respectively.