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Equity Diversification in Two Chinese Share Markets: Old Wine and New Bottle

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Abstract

This study provides evidence that there exist long−run benefits for investors from diversifying in two Chinese share markets over the period January 5, 2000 to December 31, 2005. The evidence is based on tests for pairwise cointegration between the Shanghai and Shenzhen¡¦s A−share and B−share stock price indexes, using five cointegration tests, namely PO, HI, JJ, KSS, and BN approaches. The results from these five tests are robust and consistent in suggesting that these two Chinese share markets are not pairwise cointegrated with each other. These findings could be valuable to individual investors and financial institutions holding long−run investment portfolios in these two Chinese share markets.

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ABSTRACT

This study provides evidence that there exist long-run benefits for investors from diversifying in two Chinese share markets over the period January 5, 2000 to December 31, 2005. The evidence is based on tests for pairwise cointegration between the Shanghai and Shenzhen's A-share and B-share stock price indexes, using five cointegration tests, namely PO, HI, JJ, KSS, and BN approaches. The results from these five tests are robust and consistent in suggesting that these two Chinese share markets are not pairwise cointegrated with each other. These findings could be valuable to individual investors and financial institutions holding long-run investment portfolios in these two Chinese share markets.

Key Words: Chinese Share Markets, Equity Diversification, Nonlinear, Cointegration tests

JEL Classification: C32, F21

1. INTRODUCTION

This study aims to explore whether there exist any long-run benefits from equity diversification for investors who invest in two Chinese share markets, namely those of Shanghai and Shenzhen Stock Exchanges. Recent empirical studies have employed cointegration techniques to investigate whether there exist such long-run benefits from international equity diversification (see Taylor and Tonks, 1989; Chan et al., 1992; Arshanapalli and Doukas, 1993; Roger, 1994; Chowdhury, 1994; Kwan et al., 1995; Masih and Masih, 1997; Liu et al., 1997; Kanas, 1999 and Chang and Caudill, 2006). According to these studies, asset prices from two different efficient markets cannot be cointegrated. Specifically, if a pair of stock prices is cointegrated then one stock price can be forecasted by the other stock price. Thus, these cointegration results suggest that there is no gain from portfolio diversification.

In this study, we test for pairwise long-run equilibrium relationships between two Chinese share markets by employing five techniques of cointegration tests, namely PO, HI, JJ, KSS and BN approaches.[1] The findings of our five tests all suggest that the two Chinese share markets are not pariwise cointegrated with each other. The finding of no cointegration can be interpreted as evidence that there were no long-run linkages between these two Chinese share markets and thus, there exist potential gains for investors from diversifying in these two Chinese share markets. These results are valuable to investors and financial institutions, holding long-run investment portfolios in these two Chinese share markets.

The major motivations for this study are three folds. First, China is a rapidly expanding emerging market and the rapid growth of the Chinese economy has attracted the attention of international investors. Second, the government policy of gradual relaxation of restrictions on foreign investments in Chinese share markets has further enhanced the importance of the Chinese share markets to international equity investors. Third, the last decade has seen a significant increase in the integration of world capital markets. In light of pressure for incorporating developing economy stock markets into global investment strategies, studies on thin security markets have increased in importance. Empirical results from stock markets such as the Chinese share markets are of great importance to global fund investors who may, be planning to invest in these two Chinese share markets.

The remainder of this study is organized as follows. Section 2 describes the data used. Section 3 presents the methodologies employed and discusses the findings. Finally, Section 4 concludes.

[1] PO, HI, JJ, KSS and BN are abbreviations for five types of cointegration tests of Phillips and Ouliaris's (1990) multivariate trace statistic, Harris and Inder's (1994) KPSS unit root-based, Johansen and Juselius (1990) maximum likelihood and Kapetanios, Shin and Snell's (2003) Nonlinear unit root-based approaches, and Bieren's (1997) nonparametric approach, respectively.

2. DATA

Daily closing price indexes for A-share and B-share from both Shanghai and Shenzhen Stock Exchanges are used in this study and the period extends from January 5, 2000 to December 31, 2005. Data are collected from the Core Pacific Securities Investment Trust Co. Ltd, Taiwan. All series are measured in natural logs.

We first examine how these four stock markets are correlated with each other. The summary statistics and correlation matrices for these four stock market index returns (or log price changes) can be visually appreciated in Table 1. The market's average daily index returns are 0.12%, 0.15%, 0.14% and 0.16% for Shanghai A-share, Shanghai B-share, Shenzhen A-share and Shenzhen B-share, respectively, over this empirical sample period. Regarding the standard deviation, we find that the Shanghai A-share has the highest daily standard deviation of 4.02%, whereas the Shanghai B-share has the lowest at 3.65% over the sample period. Table 1 also shows that index returns for each market are leptokurtic since the relative large value of the kurtosis statistic (larger than three) suggests that the underlying data are leptokurtic, or heavily tailed and sharply peaked about the mean when compared with the normal distribution. The Jarque-Bera test also leads to the rejection of normality in the data sets of these our markets' daily returns data sets. Regarding the correlation matrix, we find that all the correlations are positive and significant. The highest contemporaneous correlations are shown between the Shanghai A-share and Shenzhen A-share, while the lowest are shown for the Shanghai A-share and Shenzhen B-share.

Insert Table 1 about here

3. METHODOLOGY AND EMPIRICAL RESULTS

3.1. 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 index should be integrated of the same order (see Granger, 1986). In order to fully investigate the stationary property of each stock index, this paper applies three unit roots techniques, which include ADF (Dickey and Fuller, 1981), KPSS (Kwiatkowski et al., 1992) and PP (Phillips and Perron, 1988) tests.[2]

Panel A, B and C in Table 2 report the results of non-stationary tests for Shanghai's A-share and B-share and Shenzhen's A-share and B-share stock price indexes using ADF, KPSS and P-P tests, respectively. Each stock price index is

[2] The null for KPPS is I(0), whereas it's I(1) for other two tests, ADF and PP.

nonstationary in levels and stationary in first differences, suggesting that the stock price indexes are integrated of order one, I(1). On the basis of these results, we proceed to test whether these two Chinese share markets are cointegrated using the Multivariate Trace $\hat{P}_z$ test, Harris-Inder test, the Johansen method and the KSS's (Kapetanios, Shin and Snell, 2003) approach.

3.2. Testing For Cointegration

3.2.1. PO Cointegration Test based on the Multivariate Trace Statistic $\hat{P}_z$

Following Phillips and Ouliaris (1990), we consider the following bivariate cointegrating regression

$$X_{1t} = a + bX_{2t} + Z_t \tag{1}$$

where Z_t are the residuals of the cointegrating regression from Equation (1), and X_{1t} and X_{2t} are the two share price indexes to be tested for cointegration, According to Phillips and Ouliaris (1990), the $\hat{P}_z$ statistic tests the null hypothesis of no cointegration, and is calculated as

$$\hat{P}_z = T\ trace[\Omega_p T^{-1}\sum_1^T X_t X_t'] \tag{2}$$

where $\Omega_p = T^{-1}\sum_1^T Z_t Z_t' + T^{-1}\sum_1^k W_{sk}\sum_{s+1}^T (Z_t Z_{t-s} + Z_{t-s}Z_t')$ for some choice of lag window such as $W_{sk} = (1 - s/(k+1))$ (see Phillips and Ouliaris, 1990), T is the sample size, $X_t' = (X_{1t}, X_{2t})$, X_{1t} and X_{2t} are the two share price indexes to be tested for cointegration, and Z_t are the residuals from estimating Equation (1) with orthogonal least squares. According to Phillips and Ouliaris (1990, Table IV), the 5% critical value for the $\hat{P}_z$ statistic for one explanatory variable is 55.2202. If the computed value of the statistic is greater than 55.2202, then we reject the null hypothesis of no cointegration. Table 3 reports the $\hat{P}_z$ test result. The computed statistics for each pair of share price indexes are all lower than the critical value of 55.2202, thus the null hypothesis of no cointegration cannot be rejected.

<Insert Table 3 about here>

3.2.2 HI Cointegration Test based on KPSS Unit Root

Harris-Inder approach is basically an extension of the test proposed by Engle and

Granger (1987) mixed with the KPSS unit root test. According to Harris and Inder (1994), the test is specified as

$$Y_t = X_t'\beta_0 + \delta_t + \varepsilon_t, \varepsilon_t \sim IN(0, \sigma^2) \quad (3)$$

$$X_t = X_{t-1} + v_t \quad (4)$$

$$\delta_t = \delta_{t-1} + w_t \quad (5)$$

Where Y_t is the dependent variable, X_t is a vector of nonstationary explanatory variables and δ_t is a random walk in the residuals of the cointegration Equation (3). If the Equations (3) to (5) are the true data generating processes, then the presence of the random walk components in the residuals will ensure Y_t and X_t not to be cointegrated. However, if the variance of the random walk component (σ_w^2) is restricted to zero then the random walk component reduces to a constant for all t. In this case, Equation (3) will represent a cointegrating relationship between Y_t and X_t with constant and stationary residuals. As indicated by Harris and Inder (1994), testing the null hypothesis of $\sigma_w^2 = 0$ against the alternative $\sigma_w^2 > 0$ will test the null hypothesis of cointegration against the alternative of no cointegration. In the case of Harris-Inder test, the first step is to estimate Equation (3) by OLS to obtain the error term, and then the KPSS test is applied to check for unit roots in the residuals. Table 4 reports the results from Harris-Inder test indicating the null hypothesis of cointegration are rejected for all cases.

<Insert Table 4 about here>

3.2.3. JJ Cointegration Tests based on Maximum Likelihood Ratio

Following Johansen and Juselius (1990), we construct a p-dimensional (2 x 1) vector autoregressive model with Gaussian errors, expressed by its first-differenced error correction form as

$$\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + ... + \Gamma_{k-1} \Delta Y_{t-k+1} - \Pi Y_{t-1} + \mu + \varepsilon_t \quad (6)$$

where Y_t are share price indexes studied, ε_t is i.i.d. N(0, Σ), $\Gamma_i = -I + A_1 + A_2 + ... + A_i$, for i=1,2,...,k-1, and $\Pi = I - A_1 - A_2 - ... - A_k$. The Π matrix conveys information about the long-run relationship between Y_t variables, and the rank of Π is the number of linearly independent and stationary linear combinations of variables studied. Thus, testing for cointegration involves testing for the rank of Π matrix r by examining whether the eigenvalues of Π are significantly different from zero.

Johansen and Juselius (1990) propose two test statistics for testing the number of cointegrating vectors (or the rank of Π), namely, the trace (T_r) and the maximum eigenvalue (L-max) statistics. The Johansen method applies the maximum likelihood procedure to determine the presence of cointegrating vectors in nonstationary time series. It is well known the cointegration tests are very sensitive to the choice of lag length. Schwartz Criterion (SC) was used to select the number of lags required in the cointegration test. A VAR model is first fit to the data to find an appropriate lag structure. Table 5 presents the results from the Johansen and Jueslius (1990) cointegration test. As shown in this table, both T_r statistic and L-max statistic suggest that the null hypothesis of no cointegration cannot be rejected.

<Insert Table 5 about here>

3.2.4. KSS Cointegraion Tests based on Nonlinear Unit Root

Incorporating with the non-linear unit root test, the Kapetanios et al.'s (2003) approach is also an extension of the Engle and Granger (1987) cointegration test. According to Kapetanois et al. (2003), the test is specified as

$$Y_t = X_t'\beta_0 + \delta_t + \varepsilon_t, \varepsilon_t \sim IN(0, \sigma^2) \qquad (7)$$

$$\Delta\varepsilon_t = \gamma\varepsilon_{t-1}\{1-\exp(-\theta\varepsilon_{t-1}^2)\} + \nu_t \qquad (8)$$

where Y_t is the dependent variable, X_t is a vector of nonstationary explanatory variables and $-2 < \gamma < 0$. We are now interested in testing the null hypothesis of $\theta = 0$ against the alternative $\theta > 0$. Under the null ε_t follows a linear unit root process (no cointegration), whereas it is nonlinear stationary ESTAR process under the alternative (non-linear cointegration). However, the parameter γ is not identified under the null hypothesis. Following Luukkonen et al. (1988), Kapetanios et al. (2003) use a first-order Taylor series approximation to $\{1-\exp(-\theta\varepsilon_{t-1}^2)\}$ under the null $\theta = 0$ and approximate Equation (8) by the following auxiliary regression:

$$\Delta\varepsilon_t = \xi + \delta\varepsilon_{t-1}^3 + \sum_{i=1}^{k} b_i\Delta\varepsilon_{t-i} + \nu_t, \quad t = 1, 2, \ldots, T \qquad (9)$$

Then, the null hypothesis and alternative hypotheses are expressed as $\delta = 0$ (no cointegraiton) against. $\delta < 0$ (non-linear ESTAR cointegration). The simulated critical values for different K are tabulated at KSS's Table 1 of their paper. Table 6 reports the results from the KSS test and further demonstrate the null hypothesis of no cointegration can not be rejected for all six cases.

<Insert Table 6 about here>

3.2.5. Bierens' (1997) Non-Parametric Approach

Similar to the properties of the Johansen and Jueslius approach, the Bierens' test statistic is also obtained form the solutions of a generalized eigenvalue problem and, on the other, the hypotheses tested 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 are constructed such that their generalized eigenvalues share similar properties to those in the Johansen and Juselius approach.

The Bierens nonparametric cointegration test considers the general framework as:

$$z_t = \pi_0 + \pi_1 t + y_t \tag{10}$$

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 in the following matrices:

$$A_m = \frac{8\pi^2}{T}\sum_{k=1}^{m} k^2 \left(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)z_t\right)\left(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)z_t\right)' \tag{11}$$

$$B_m = 2T\sum_{k=1}^{m}\left(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)\Delta z_t\right)\left(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)\Delta z_t\right)' \tag{12}$$

Which 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 and Juselius likelihood ratio method, the ordered generalized eigenvalues of this nonparametric method are obtained as solution to the problem $\det[P_T - \lambda Q_T] = 0$ when the pair of random matrices $P_T = A_m$ and $Q_T = (B_m + cT^{-2}A_m^{-1})$ are defined. Thus, it can be used to test hypothesis on the coitnegration rank r. To estimate r, Bierens (1997) proposed two statistics. One is the λ min test, which corresponds to the Johansen's maximum likelihood procedure, to test for the hypothesis of $H_0(r)$ against $H_1(r+1)$. The critical values for this test are tabulated in the same article. Second is $g_m(r)$ test, which is computed from the Bierens's generalized eigenvalues:

$$\hat{g}(r) = \begin{cases} (\prod_{k=1}^{n} \hat{\lambda}_{k,m})^{-1}, if \ldots r = 0 \\ (\prod_{k=1}^{n-r} \hat{\lambda}_{k,m})^{-1} (T^{2r} \prod_{k=n-r+1}^{n} \hat{\lambda}_{k,m}), if \ldots r = 1, \ldots, n-1 \\ T^{2n} \prod_{k=1}^{n} \hat{\lambda}_{k,m}, if \ldots r = n \end{cases} \quad (13)$$

This statistic employs the tabulated optimal values (see Bierens, 1997, Table 1) for r, provided $r > n$, and $m = n$ is chosen when $n = r$. Then $\hat{g}_m(r)$ converges in probability to infinity if the true number of cointegrating vector is unequal to r, and $\hat{g}_m(r) = O_p(1)$ if the true number of cointegrating vector is equal to r. Therefore, we have $\lim_{n\to\infty} P(\hat{r}_m = r) = 1$, when $\hat{r}_m = \arg\min_{r<n}\{\hat{g}_m(r)\}$. Thus, this statistic is useful to double-check on the determination of r. As pointed by Bierens (1997), one of the major advantage of this non-parametric method is that its potential superiority at detecting cointegration when the error correction mechanism in non-linear.

Table 7 reports the results from the Bierens' nonparametric coitnegration test and the results further demonstrates the null hypothesis of no cointegration can not be rejected for all six cases. We only report the results of the $\lambda \min$ test and the results of $g_m(r)$, not reported here to save space, but are available upon request. These $\lambda \min$ test results suggest that there was no long-run relationship between these two Chinese share markets and thus confirm our conclusions from the Multivariate Trace Statistic $\hat{P}_z$, the Harris-Inder test, the Johansen's tests, and the KSS test. The lack of a long-run relationship suggests that there exist long-run diversification benefits for investors who invest in these two Chinese share markets.

<Insert Table 7 about here>

4. CONCLUSION

This study has provided evidence that there exist long-run benefits for investors from diversifying in two Chinese share markets over the period January 5, 2000 to December 31, 2005. The evidence is based on tests for pairwise cointegration between the Shanghai and Shenzhen's A-share and B-share stock price indexes, using four cointegration tests, namely PO, HI, JJ, KSS and BN approaches. The results from these five tests are robust and consistent in suggesting that these two Chinese share markets are not pairwise cointegrated with each other. These findings could be valuable to individual investors and financial institutions holding long-run investment portfolios in these two Chinese share markets.

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Table 1. Summary Statistics and Correlation Coefficients

Panel A. Summary Statistics of Stock Price Index Returns

	RSHA	RSHB	RSZA	RSZB
Mean	0.12%	0.15%	0.14%	0.16%
Std Dev	4.02%	3.65%	3.79%	3.72%
Minimum	-22.4%	-19.1%	-21.6%	-19.7%
Maximum	34.8%	26.3%	32.6%	24.3%
Skewness	1.799	1.236	1.875	1.644
Kurtosis	23.341	12.916	22.271	14.516
J-B	29,084.3*	4811.4*	25,436.5*	5,886.4*
L-Q(6)	22.98*	49.72*	33.32*	98.27*
L-Q(12)	37.86*	68.47*	38.86*	121.27*
L-Q(6) ^{2}	262.56*	224.76*	151.36*	422.78*
L-Q(12) ^{2}	278.16*	262.42*	161.59*	642.33*

Panel B. Correlation Matrix of Stock Price Index Returns (or log price changes)

	RSHA	RSHB	RSZA	RSZB
RSHA	1.000	0.397	0.871	0.321
RSHB	0.397	1.000	0.338	0.699
RSZA	0.871	0.338	1.000	0.369
RSZB	0.321	0.699	0.369	1.000

Note: * indicates significance at the 5% level.

Table 2. Unit Root Tests for Shanghai and Shenzhen Stock Price Indexes

	Panel A		Panel B				Panel C	
	ADF		KPSS Levels				PP	
			η_u		η_t			
Lsha	-0.638	(4)	24.145	[4]*	2.467	[4]*	-0.922	[1]
Lshb	0.955	(4)	3.981	[4]*	3.742	[4]*	1.112	[1]
Lsza	-1.288	(4)	21.221	[4]*	3.772	[4]*	-1.145	[1]
Lszb	0.112	(4)	4.223	[4]*	3.211	[4]*	0.657	[1]
			First-differences					
Dlsha	-17.583	(4)*	0.017	[4]	0.047	[4]	-32.258	[1]*
Dlshb	-16.312	(4)*	0.137	[4]	0.127	[4]	-29.327	[1]*
Dlsza	-16.743	(4)*	0.098	[4]	0.082	[4]	-33.567	[1]*
Dlszb	-15.482	(4)	0.223	[4]	0.137	[4]	-31.432	[1]*

Notes: 1. Lsha, Lshb, Lsza, and Lszb represent Shanghai and Shenzhen's A- and B-shares, respectively, in the logarithm form.
2. D- implies differencing in each variable.
3. The number in the parenthesis indicates the selected lag order of the ADF model. Lags were chosen based on Campbell and Perron's (1991) method.
2. The number in the bracket indicates the lag truncation for Bartlett kernel suggested by Newey-West test (1987).
3. * indicates significance at 5% level.

Table 3. PO Cointegration Test based on the Multivariate Trace Statistic $\hat{P}_Z$

Markets	$\hat{P}_z$ **statistic**
SHA-SHB	11.1233
SZA-SZB	15.7812
SHA-SZA	19.3767
SHB-SZB	25.2743
SHA-SZB	17.5117
SZA-SHB	12.5462

Note: The reported $\hat{P}_z$ statistic is based on a lag window of 6. Alternative lag windows of 1, 2, 3, 5, and 6 yield qualitatively similar results. The 5% critical value for the $\hat{P}_z$ statistic for one explanatory variable is 55.2202 (Phillips and Ouliaris, 1990, Table IV).

Table 4. HI Cointegration Test based on KPSS Unit Root

	6 lags		9 lags	
	η_u	η_t	η_u	η_t
SHA-SHB	7.422*	2.482*	5.729*	0.994*
SHA-SZA	9.392*	2.281*	6.128*	1.598*
SHB-SZB	7.345*	2.481*	5.179*	0.993*
SHA-SZB	3.135*	2.231*	2.295*	1.101*
SZA-SHB	9.113*	0.992*	7.655*	0.719*
SZA-SZB	8.211*	0.832*	5.872*	0.623*

Notes: 1. * indicates significant at 5% level.
2. Critical values are taken from Kwiatkowski et al. (1992)
3. The KPSS test based on lag windows of 6 and 9 lags yields qualitatively similar results.

Table 5. JJ Cointegration Test based on Maximum Likelihood Ratio

	Trace test	5% critical value	L-max test	5% critical value
SHA-SHB				**(VAR lag = 4)**
$H_0: r \le 0$	10.167	15.41	10.183	14.07
$H_0: r \le 1$	0.648	3.76	0.648	3.76
SZA-SZB				**(VAR lag = 5)**
$H_0: r \le 0$	7.148	15.41	5.169	14.07
$H_0: r \le 1$	1.822	3.76	1.822	3.76
SHA-SZA				**(VAR lag = 27)**
$H_0: r \le 0$	7.136	15.41	4.146	14.07
$H_0: r \le 1$	1.523	3.76	1.523	3.76
SHB-SZB				**(VAR lag = 5)**
$H_0: r \le 0$	11.112	15.41	11.002	14.07
$H_0: r \le 1$	0.874	3.76	0.874	3.76
SHA-SZB				**(VAR lag = 5)**
$H_0: r \le 0$	5.142	15.41	4.678	14.07.
$H_0: r \le 1$	0.161	3.76	0.161	3.76
SZA-SHB				**(VAR lag = 2)**
$H_0: r \le 0$	9.618	15.41	7.123	14.07
$H_0: r \le 1$	1.398	3.76	1.398	3.76

Notes： 1. Critical values are taken from Osterwald-Lenum (1992).
2. r denote the number of cointegrating vectors.
3. Schwarzt Criterion (SC) was used to select the number of lags required in the cointegrating test. The computed Ljung-Box Q-statistics indicate that the residuals are white noise.

Table 6. KSS Cointegration Tests based on Nonlinear Unit Root

Countries	**T Statistic on** $\hat{\delta}$
SHA-SHB	-2.123
SZA-SZB	-2.139
SHA-SZA	-2.776
SHB-SZB	-2.162
SHA-SZB	-2.572
SZA-SHB	-1.701

Note: The critical values for t statistic on $\hat{\delta}$ are tabulated at KSS's (2003) Table 1 of their paper.

Table 7. Cointegration Test based on Bierens' Nonparemetric Approach

λ min Test	**Test**	**5% critical value**	**Test**	**10% critical value**
SHA-SHB		Conclusion r = 0		
$H_0 : r = 0$ $H_a : r = 1$	0.01986	(0, 0.017)	0.00058	(0, 0.005)
$H_0 : r = 1$ $H_a : r = 2$	--	(0, 0.054)	--	(0, 0.111)
SZA-SZB		Conclusion r = 0		)
$H_0 : r = 0$ $H_a : r = 1$	0.0184	(0, 0.017)	0.00622	(0, 0.005)
$H_0 : r = 1$ $H_a : r = 2$	--	(0, 0.054)	--	(0, 0.111)
SHA-SZA		Conclusion r = 0		
$H_0 : r = 0$ $H_a : r = 1$	0.1228	(0, 0.017)	0.0064	(0, 0.005)
$H_0 : r = 1$ $H_a : r = 2$	--	(0, 0.054)	--	(0, 0.111)
SHB-SZB		Conclusion r = 0		
$H_0 : r = 0$ $H_a : r = 1$	0.18132	(0, 0.017)	0.00712	(0, 0.005)
$H_0 : r = 1$ $H_a : r = 2$	--	(0, 0.054)	--	(0, 0.111)
SHA-SZB		Conclusion r = 0		
$H_0 : r = 0$ $H_a : r = 1$	0.2554	(0, 0.017)	0.0133	(0, 0.005).
$H_0 : r = 1$ $H_a : r = 2$	--	(0, 0.054)	--	(0, 0.111)

SZA-SHB		Conclusion r = 0		
$H_0 : r = 0$ $H_a : r = 1$	0.0251	(0, 0.017)	0.0065	(0, 0.005)
$H_0 : r = 1$ $H_a : r = 2$	--	(0, 0.054)	--	(0, 0.111)

Notes： 1. The $\lambda \min$ test is based on the generalized eigenvalues of matrices of A and $[B + cA^{-1}T^{-2}]$, where A and B are computed as sums of outerproducts of weighted means of y_t and Δy_t, y_t is unit root process, T is the sample size, and c is a positive constant. The value of c is 1, as suggested in Bierens (2004).

2. The critical values are from Bierens (2004). If the value of the $\lambda \min$ statistic is outside the critical region, then we do not reject the null hypothesis. If the value of the $\lambda \min$ statistic is within the critical region, then we reject the Ho. If both the null hypotheses are rejected then we conclude that r = 0, i.e. there is no cointegration (Bierens, 2004) (r denotes the number of cointegrating vectors)