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Equity Diversification in two Chinese Share Markets: Nonparametric Cointegration Test

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This study provides evidence that there exist long-run benefits for investors from diversifying in two Chinese share markets over the period January 2, 2000 to August 31, 2008. The evidence is based on tests for pairwise cointegration between the Shanghai and Shenzhen's A-share and B-share stock price indexes, using Bierens's (1997) nonparametric cointegration approaches. These findings could be valuable to individual investors and financial institutions holding long-run investment portfolios in these two Chinese share markets.

Keywords: Equity Diversification; Chinese Share Markets; Nonparametric Cointegration Test.

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; Masih and Masih, 1997; Kanas, 1999; Chang and Caudill, 2006; and Chang *et al.*, 2009). 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.

Johansen cointegration test has been widely employed in the above studies. This popular cointegration test is built on the basis of linear autoregressive model and implicitly assumes that the underlying dynamics are in linear form. However there is ample empirical evidence against the linear paradigm. Theoretically, there is no reason to believe that economic systems must be intrinsically linear. Empirically, there are a lot of studies showing that financial time series such as the stock prices exhibit nonlinear dependencies (Barkoulas and Travlos, 1998). 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

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disequilibrium. The work of Bake and Fomby (1997) also suggested a potential loss of power in standard cointegration tests under threshold autoregressive data generating process.

Motivated by the above consideration, in this study we re-examine the issue of stock market integration for two Chinese share markets, using a more powerful nonparametric cointegration test developed by Bierens (1997). The results from this test suggest that these stock price indexes from these two Chinese share markets are not pariwise cointegrated with each other, with the exception of Shanghai A-share and Shenzhen A-share, during the period from January 2, 2000 to August 31, 2008. 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. This result should prove valuable to individual investors and financial institutions.

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.

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 2, 2000 to August 31, 2008. Data starting from 2000 and ending at the August 2008 limit the adverse effects of the 1997 Asian financial crisis and 2008 Global Financial Panics, respectively. Data are collected from Thomson Datastream Database. All series are measured in natural logs. We first examine how these two share markets are correlated with each other. The summary statistics and correlation matrices for these four stock price index returns (or log price changes) can be visually appreciated in Tables 1 and 2, respectively. The market's average daily index returns are 0.0282%, 0.0746%, 0.0237% and 0.09% 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 B-share has the highest daily standard deviation of 2.4792%, whereas the Shanghai B-share has the lowest at 1.7665% 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 (see Table 2). The highest contemporaneous correlations are shown between the Shanghai A-share and Shenzhen A-share, while the lowest are shown for the Shanghai B-share and Shenzhen B-share.

Table 1
Summary Statistics

Market	*SHI_A*	*SZN_A*	*SHI_B*	*SZN_B*
Mean	0.0282%	0.0237%	0.0746%	0.0900%
Max.	9.3998%	9.2401%	28.2860%	26.7858%
Min.	-12.7565%	-12.7194%	-14.2625%	-13.3885%
Std.	1.7665%	1.8956%	2.4792%	2.3605%
Skew	-0.1794	-0.3143	0.6393	0.7034
Kurtosis	8.4496	7.6279	15.3529	14.9243
J-B	2300.436***	1682.287***	11894.97***	11118.97***
L-B(Q=3)	3.1487	2.8515	2.0380	5.3366
L-B(Q=6)	7.3992	7.5247	15.097**	8.9259
$L\text{-}B^2$(Q=3)	52.273***	116.49***	25.802***	40.827***
$L\text{-}B^2$(Q=6)	108.03***	200.20***	40.691***	49.947***

Note: ** and *** denote significance at the 5% and 1% levels, respectively.

Table 2
Correlation Matrix of Stock Price Index Returns (or Log Price Changes)

	SHI_A	*SZN_A*	*SZN_B*	*SHI_B*
SHI_A	1.000	0.940	0.651	0.689
SZN_A	0.940	1.000	0.647	0.708
SZN_B	0.651	0.647	1.000	0.803
SHI_B	0.689	0.708	0.803	1.000

3. METHODOLOGY AND EMPIRICAL RESULTS

3.1. Unit Root Tests

Recently, there is a 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, Shin, and Snell (2003) (henceforth, KSS test). Table 3 reports the KSS nonlinear stationary test results. The results indicate that the four series are integrated of order one. For comparison, this paper also applies three conventional unit roots techniques, which include ADF (Dickey and Fuller, 1981), KPSS (Kwiatkowski *et al.*, 1992) and PP (Phillips and Perron, 1988) tests. Table 4 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 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 a more powerful nonparametric cointegration test developed by Bierens (1997).

Table 3
Nonlinear Unit Root Tests Based on KSS Approach

Stock Market	*t statistic on* $\hat{\delta}$
HI_A	-0.92257
SZN_A	-0.9059
SHI_B	-2.01928
SZN_B	-1.86518

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.

Table 4
Results of the Unit Root Tests: Stock Price Index from 2000/1/2 to 2008/8/31

	Levels			*First Differences*		
Price Index	*ADF*	*PP*	*KPSS*	*ADF*	*PP*	*KPSS*
SHI_A	-0.932522 (0)	-0.9325 [0]	1.6110 [33]***	-44.6689 (0)***	-44.6506 [2]***	0.2507 [1]
SZN_A	-0.855237 (0)	-0.9145 [7]	1.2088 [33]***	-42.1341 (0)***	-42.1984 [6]***	0.2562 [7]
SHI_B	-2.066567 (1)	-2.0963 [16]	1.3249 [33]***	-39.5197 (0)***	-40.2743 [15]***	0.2490 [16]
SZN_B	-1.889372 (0)	-1.8915 [13]	4.1695 [33]***	-41.2215 (0)***	-41.6740 [12]***	0.1445 [13]

Note: *** indicates significance at the 0.01 level. The number in parenthesis indicates the lag order selected based on the recursive t-statistic, as suggested by Perron (1989). The number in the brackets indicates the truncation for the Bartlett Kernel, as suggested by the Newey-West test (1987).

3.2. Testing for Cointegration

Bierens (1997) pointed out that one of the major advantages of his nonparametric method lies in its superiority to detect cointegration when the error correction mechanism is nonlinear. We have followed Granger and Teräsvirta (1993) by employing a nonlinear test on our error-correction term. The results indicate that the true nature of the adjustment process is nonlinear and that the speed of adjustment varies with the magnitude of the disequilibrium for all pairs of stock price indexes (results are not presented here but are available upon request). Hence we have full confidence in using this test in our study.

The Bierens nonparametric cointegration test considers the general framework as:

$$z_t = \pi_0 + \pi_1 t + y_t \tag{1}$$

Where π_0 $(qx1)$ and π_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's method is based on the generalized eigenvalues of matrices $A_m$and and $(B_m + cT^{-2} A_m^{-1})$, whereandare defined in the following matrices:

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

$$B_m = 2T\sum_{k=1}^{m}(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)\Delta z_t)(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)\Delta z_t)' \quad (3)$$

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 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 cointegration rank r. To estimate r, Bierens (1997) proposed two statistics. One is the λ 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 $g_m\ (r_0)$ test, which is computed from the Bierens's generalized eigenvalues:

$$\hat{g}_m(r_0) = \begin{cases} (\prod_{k=1}^{n}\hat{\lambda}_{k,m})^{-1}, if....r_0 = 0 \\ (\prod_{k=1}^{n-r}\hat{\lambda}_{k,m})^{-1}(T^{2r}\prod_{k=n-r+1}^{n}\hat{\lambda}_{k,m}), if...r_0 = 1,....,n-1 \\ T^{2n}\prod_{k=1}^{n}\hat{\lambda}_{k,m}, if....r_0 = n \end{cases} \quad (4)$$

This statistic employs the tabulated optimal values (see Bierens, 1997, Table 1) for m when > 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 $\hat{r}_m = \arg\min_{r0<n}\{\hat{g}_m\ (r_0)\}$. This statistic is useful to double-check on the determination of r.

Table 5 reports the results from the Bierens's nonparametric cointegration test and the results demonstrate the null hypothesis of no cointegration can not be rejected for all the cases with the exception of Shanghai A-share and Shenzhen A-share one case. We only report the results of thetest and the results of $g_m(r)$ test are suppressed here for space consideration but are available upon request. The λ test results suggest that there exists long-run relationship in only Shanghai A-share and Shenzhen A-share one case. Our empirical results suggest that there exist long-run diversification benefits for investors who invest in these two Chinese share markets. On account of the superiority of the nonparametric method to detect cointegration when the error–correction mechanism is nonlinear, we firmly believe that our results are considerably more reliable than those derived from the conventional Johansen approach. In fact, with regard to the presence of nonlinearity, Ma and Kanas (2000) and Coakley and Fuertes (2001) have found discrepancies between the results from the Johansen approach and those from the Bierens approaches.

Table 5
Cointegration Test Based on Bierens's Nonparametric Approach
G1. λ min Test

Stock Markets	*Hypothesis*	*Test Stat.*	*5% critical value*	*Test Stat.*	*10% critical value*	*Conclusion*
SHI_A vs.	$H_0: r = 0$ $H_a: r = 1$	1.86017	(0,0.017)	0.02950	(0,0.005)	r = 0
SZN_B	$H_0: r = 1$ $H_a: r = 2$	1.27375	(0,0.054)	1.27375	(0,0.111)	
SHI_B vs.	$H_0: r = 0$ $H_a: r = 1$	0.80084	(0,0.017)	0.19459	(0,0.005)	r = 0
SZN_A	$H_0: r = 1$ $H_0: r = 2$	3.35301	(0,0.054)	3.35301	(0,0.111)	
SHI_A vs.	$H_0: r = 0$ $H_a: r = 1$	0.00762**	(0,0.017)	0.00000*	(0,0.005)	r = 1
SZN_A	$H_0: r = 1$ $H_a: r = 2$	1.47148	(0,0.054)	1.47148	(0,0.111)	
SHI_B vs.	$H_0: r = 0$ $H_a: r = 1$	0.05955	(0,0.017)	0.00005*	(0,0.005)	r = 0
SZN_B	$H_0: r = 1$ $H_a: r = 2$	0.21055	(0,0.054)	0.21055	(0,0.111)	

Note: **Indicates significance at the 0.05 level.

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 2, 2000 to August 31, 2008. The evidence is based on tests for pairwise cointegration between the Shanghai and Shenzhen's A-share and B-share stock price indexes, using Bierens's (1997, 2004) nonparametric cointegration approaches. The results from this test indicate that these two Chinese share markets are not pairwise cointegrated with each other, with the exception of Shanghai A-share - Shenzhen A-share. 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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