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Panel Cointegration of Chinese A and B Shares*

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Abstract

In this paper we study market segmentation and information flows in China's stock markets. By using panel data methods we test for a unit root in the price premium of domestic investors' A shares over foreign investors' B shares as well as cointegration between the prices of the A and B shares on the Shanghai and Shenzhen stock exchanges. We find that the A-share premia are nonstationary and the A- and B-share prices are not cointegrated up till January 2001. After February 2001, when domestic investors were allowed to trade B shares, the A-share premia become stationary and the A- and B-share prices cointegrated. Our findings suggest that the relaxation of the invest-

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ment restrictions decreased the information asymmetry betwen the A- and B-share markets in China.

JEL Classification: C32, G12, G15.

Key Words: Chinese A and B shares, Market segmentation, Information flow, Panel unit root and cointegration tests.

1 Introduction

The Chinese dual classes of shares (known as A and B shares) on the Shanghai and Shenzhen stock exchanges create a unique market, in which identical shares of the same firm are traded at the same time, in the same place, but at different prices by two segmented investor groups. Since the opening of the Chinese stock markets for B shares in 1992, domestic and foreign investors were segmented by the restrictions that domestic investors could only invest in A shares and foreign investors only in B shares. The trading restrictions were first relaxed in February 2001, when domestic retail investors were allowed to trade B shares, and again in December 2002, when Qualified Foreign Institutional Investors (QFII) were granted access to the A-share markets. The restrictions were relaxed further in April 2006, when Qualified Domestic Institutional Investors (QDII) were allowed to access foreign security markets.[1]

Segmentation between domestic and foreign investors is not unusual, but two observations stand out from the Chinese stock markets. First, Chinese domestic investors' A shares are sold at a significant premium over foreign B shares. In other markets, foreign shares typically trade at a premium over domestic shares. Second, the A- and B-share markets have their own pricing dynamics, i.e., the A- and B-share prices appear to move independently of each other in the long run (Kim and Shin 2000, Sjöö and Zhang 2000, Yang 2003, Wang, Kutan and Yang 2005 and Tian 2007). In statistical terms the

A-share premia are not mean reverting, but are nonstationary and integrated processes. The A- and B-share prices are not cointegrated. Cointegration between the A- and B-share markets implies information flows and Granger causality in at least one direction. The lack of a common trend or a non-stationary risk premium suggests that domestic and foreign investors are segmented.

The price differential between the A and B shares begins to disappear over time for a variety of reasons (Chan et al. 2007). The interesting question is whether the premia become stationary and the A- and B-share prices cointegrated. The lifting of the trading restrictions for domestic investors in February 2001 (McGuinness 2002) and foreign investors in December 2002 constitute policy changes, which enable us to investigate further the information flows between the A and B shares. The aim of this paper is to test whether the A- and B-share markets are informationally segmented before and after the deregulations. If the deregulations were effective, then the segmentation between the two investor groups should have decreased. However, Tian (2007) finds no cointegration between the A and B shares on the Shanghai stock exchange after the partial abolition of the investment restrictions for domestic investors.

Most of the previous papers have used the A- and B-share stock market indices. In this paper we use firm level data and recent advances in panel data econometrics to test a stationary A-share premium as well as cointegration between the A- and B-share prices. We take the policy changes into consideration by treating them as structural breaks. A structural break is found coinciding with the first deregulation in February 2001. However, no structural break is found related to the second deregulation in December 2002. We find that before the structural break, the A-share premia are nonstationary and the A and B shares are not cointegrated. But after the structural break, the A-share premia become stationary and the A and B shares cointegrated. Thus the information efficiency of the A- and B-share markets increased after the relaxation of the trading restrictions for domestic investors. More specifically, we find that the A- and B-share prices are cointegrated in the panel, but not all firms' A and B shares are cointegrated. To find out which firms' A and B shares are cointegrated, we estimate a probit model. The results show that firms with a small A-share premium, high growth rate and high B-share market capitalisation relative to the A-share market capitalisation are more likely to have cointegrated A and B shares.

The paper is organised as follows. In the next section we derive the cointegration implications of the A- and B-share prices in the present value model. Section 3 gives a brief review of China's stock markets and describes the data. Section 4 discusses panel unit root and cointegration tests. Section 5 presents the empirical results and explains the outcomes of the cointegration tests by a probit model. Section 6 contains the conclusions.

2 Pricing of Chinese A and B Shares

For modelling the price premium between domestic A and foreign B shares, it is common to assume that the log price difference is stationary. Then the A-share premium is given by the stationary risk premium. In most markets with dual classes of shares, domestic shares are sold at a discount over foreign shares. This can be explained by foreign investors being more diversified and therefore requiring a lower risk-adjusted rate of return. In the Chinese stock markets it is the other way around and the domestic investors' A shares trade at a premium. Fernald and Rogers (2002) argue that the A-share premium is explained by differences in expected returns by domestic and foreign investors. They attribute lower Chinese expected returns to the limited alternative investments available in China. Chakravarty, Sarkar and Wu (1998) present a model where the A shares trade at a discount if there is market segmentation but no information differences. However, as the information asymmetry between domestic and foreign investors increases, the A shares will begin to trade at a premium if domestic investors are better informed than foreign investors. The most extreme form of asymmetric information is when the A-share premium is nonstationary. Then domestic and foreign investors do not share information in the long run (Sjöö and Zhang 2000).

We use the dividend-ratio model or dynamic Gordon model (Campbell and Shiller 1988) as our framework for analysing the pricing of the A and B shares:

$$d_{it} - p_{it} = \sum_{j=0}^{\infty} \rho_i^j \mathrm{E}(r_{i,t+j} - \Delta d_{i,t+j} | \mathcal{F}_{it}) + c_i, \quad i = A, B, \tag{1}$$

where p_{it} is the log of the stock price at the end of time period t, d_{it} is the log of dividends paid during period t, r_{it} is the log return on the stock from time t to $t+1$ and ρ_i is the discount rate assumed to be less than one. The notation $\mathrm{E}(\cdot|\mathcal{F}_{it})$ is used for the conditional expectation and $\mathcal{F}_{it}$ is the information set of domestic or foreign investors at the beginning of period t. Finally, c_i is an immaterial constant arising from the linearisation. The model says that the log dividend-price ratio is given by the expected discounted value of all future returns $r_{i,t+j}$ and dividend growth rates $\Delta d_{i,t+j}$, discounted at the constant rate ρ_i, plus a constant c_i. In the model the nonstationarity of stock prices is driven by the nonstationarity of dividends, since the discount rate is assumed to be stationary.

We now derive the cointegration properties of the present value model of the A- and B-share prices. We assume that stock prices and dividends are integrated of order one, i.e., p_{it} and d_{it} are $I(1)$ processes. Following Engsted and Lund (1997), a linear combination of equations (1) with $i = A, B$ can be written as

$$
\begin{aligned}
& p_{At} - \beta p_{Bt} = (d_{At} - \beta d_{Bt}) \qquad (2) \\
& - \left(\sum_{j=0}^{\infty} \rho_A^j \mathrm{E}(r_{A,t+j} - \Delta d_{A,t+j} | \mathcal{F}_{At}) - \beta \sum_{j=0}^{\infty} \rho_B^j \mathrm{E}(r_{B,t+j} - \Delta d_{B,t+j} | \mathcal{F}_{Bt}) \right) \\
& + c,
\end{aligned}
$$

where $c = -(c_A - \beta c_B)$. We can interpret the second term on the right-hand side of (2) with $\beta = 1$ as the risk premium. It follows from (2) that if the dividends are cointegrated with cointegrating vector $\boldsymbol{\beta} = (1, -\beta)'$, then the A- and B-share prices will be cointegrated with the same cointegrating vector if the risk premium is stationary. In the Chinese stock markets, dividends paid to the A- and B-share investors are the same, which implies that they are cointegrated with $\boldsymbol{\beta} = (1, -1)'$ and that the A-share premium $p_{At} - p_{Bt}$ is stationary. We therefore get a testable implication of the model: If the A- and B-share prices are cointegrated, then the risk premium is stationary. The cointegrating relation between the A and B shares can be used to test a nonstationary risk premium and segmentation between the A- and B-share markets.

The efficient market hypothesis says that the prices of two stocks cannot be cointegrated because cointegration implies predictability in at least one direction. However, the A and B shares are the shares of the same firm. In this special case we would expect the A and B shares to be cointegrated (Sjöö and Zhang 2000), which would not violate the efficient market hypothesis.

3 Data

There are 1501 Chinese firms listing A shares, 109 firms listing B shares and 86 firms listing both A and B shares on either the Shanghai or Shenzhen stock exchange, as of October 2007. Not every firm issues B shares, and there are firms that only list B shares. In this paper only firms listing both A and B shares on either of the two stock exchanges are included in the data. The data set, which is collected from Datastream, contains 86 firms, 44 of which are listed on the Shanghai stock exchange and 42 on the Shenzhen stock exchange. The time series of stock prices are monthly, covering the sample period from January 1993 to October 2007. The sample period is divided into two subperiods: January 1993 to January 2001 and March 2001 to October 2007. The month February 2001, when the structural break caused by the partial merger of the A- and B-share markets occurred, is excluded from either of the subperiods. All B-share prices are converted into Chinese Yuan.

It is worth noting that the panel of A- and B-share prices is unbalanced. Table 1 shows the number of firms that listed both types of shares for each year between 1993 and 2007, while detailed information about the individual firms are provided in the Appendix. In 1993 there were only 31 firms listing both A and B shares. We see from the table that most of the firms in the sample listed both types of shares by 2000.

Using the firm level stock price data, we first construct average prices of the A and B shares on the Shanghai and Shenzhen stock exchanges (denoted $PSHA_t$, $PSHB_t$, $PSZA_t$ and $PSZB_t$, respectively). The average price series are unweighted, but mimic the construction of the stock market indices. We cannot simply use the index of the A shares, since it includes all firms listing A shares on the market. Compared to the market indices, our average prices of the A and B shares are matched, i.e., the firms that are included in the average A- and B-share prices are the same. Then we calculate the A-share premium for the Shanghai and Shenzhen stock exchanges as $PSHAB_t = (PSHA_t - PSHB_t)/PSHB_t$ and $PSZAB_t = (PSZA_t - PSZB_t)/PSZB_t$, respectively. Figure 1 plots the A-share premia. We can see that in both markets, there is a dramatic decrease in the A-share premium associated with the relaxation of the restrictions for domestic investors in February 2001, but no noticeable effect from the relaxation of the restrictions for foreign investors in December 2002.

4 Panel Data Tests

Panel data unit root and cointegration tests are based on pooling the information in the individual tests in the panel. The main reason for using panel data is that the power of the individual tests to reject the null hypothesis of a unit root or no cointegration can be low.

We consider a panel which consists of $i = 1, \ldots, N$ units y_{it} observed over $t = 1, \ldots, T$ time periods. If there is a common T for all units, the panel is balanced. The number of time series observations can be different for each

Table 1: Number of firms listing both A and B shares. The table reports the number of firms which listed both A and B shares on the Shanghai or Shenzhen Stock Exchange between January 1993 and October 2007. The figures are end of year, except the year 2007 which are end of October.

Year	Shanghai Stock Exchange	Shenzhen Stock Exchange	Both Stock Exchanges
1993	16	15	31
1994	31	19	50
1995	31	23	54
1996	35	30	65
1997	38	35	73
1998	38	39	77
1999	40	39	79
2000	41	41	82
2001	44	42	86
2002	44	42	86
2003	44	42	86
2004	44	42	86
2005	44	42	86
2006	44	42	86
2007	44	42	86

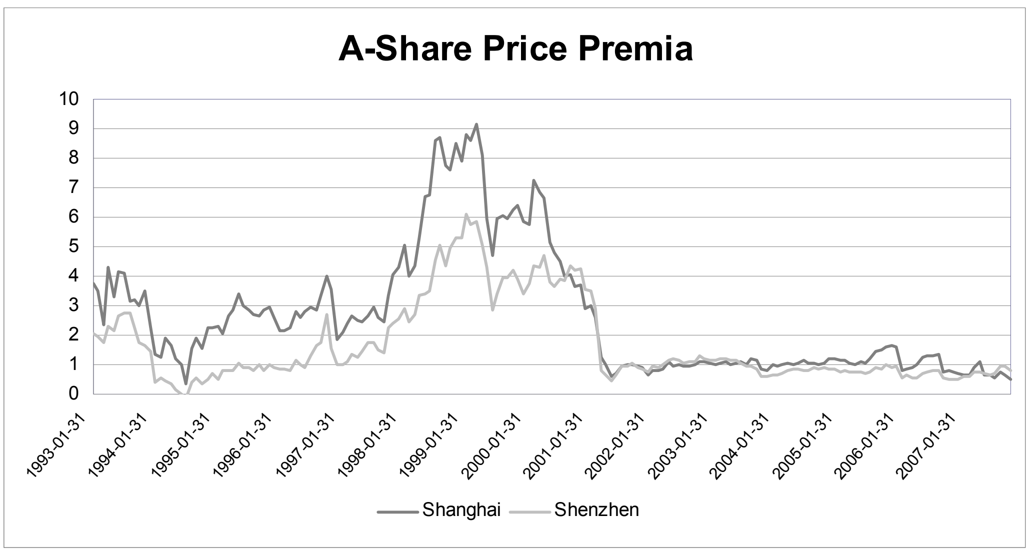

Figure 1: The premia of the A-share prices over the B-share prices on the Shanghai and Shenzhen stock exchanges. The sample period is January 1993 to October 2007.

unit, and then the panel is said to be unbalanced. The fact that the panel of Chinese A- and B-share prices is unbalanced has consequences for the panel unit root and cointegration tests that can be applied. We use standard Augmented Dickey–Fuller tests and likelihood ratio tests for cointegration for the units in the panel. The panel tests are based on the idea of the Fisher test suggested by Maddala and Wu (1999).

4.1 Panel Unit Root Tests

The Augmented Dickey–Fuller (ADF) unit root test (Dickey and Fuller 1981) is based on the model

$$\begin{aligned} \Delta y_{it} &= \mu_i + \rho_i y_{i,t-1} + \sum_{j=1}^{k_i-1} \gamma_{ij} \Delta y_{i,t-j} + \varepsilon_{it}, \quad \varepsilon_{it} \sim \mathrm{IID}(0, \sigma_i^2), \qquad (3) \\ i &= 1, \ldots, N, \quad t = 1, \ldots, T. \end{aligned}$$

The null hypothesis of a unit root is $H_{0i} : \rho_i = 0$ and the alternative hypothesis of stationarity is $H_{1i} : \rho_i < 0$ for all i. The panel unit root tests of Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) are both panel versions of the ADF test. The Levin, Lin and Chu (LLC) test is based on a pooled panel estimator, assuming all $\rho_i = \rho$. The Im, Pesaran and Shin (IPS) test relaxes the assumption that all the ρ_i are equal. Their panel test uses separate ADF regressions for each of the N units and is based on the mean of the ADF statistics. Both tests require that T is the same for each unit, i.e., the panel is balanced, so they cannot be used here since our panel of Chinese A- and B-share prices is unbalanced. A simple alternative is the Fisher test suggested by Maddala and Wu (1999). Let p_i denote the p-values from the individual ADF tests. The Fisher statistic is given by

$$\Lambda_1 = -2 \sum_{i=1}^{N} \ln p_i. \tag{4}$$

The test is an exact non-parametric test. The Λ_1 statistic has a χ^2 distribution with $2N$ degrees of freedom under the null hypothesis. In a simulation study, Maddala and Wu show that the Fisher test has better size and power properties than the LLC and IPS tests.

The Fisher test depends on the assumption of independence of the p-values. If the independence assumption is violated, an asymptotic test can be constructed using the statistic

$$\Lambda_2 = \frac{\sqrt{N}(\overline{\pi} - 2)}{2}, \tag{5}$$

where

$$\overline{\pi} = -\frac{2}{N} \sum_{i=1}^{N} \ln p_i. \tag{6}$$

The asymptotic distribution of the Λ_2 statistic is standard normal. The rejection region is one-sided and the test rejects for large values of Λ_2.

4.2 Panel Cointegration Tests

Larsson, Lyhagen and Löthgren (2001) suggest a test of cointegration in panels based on the likelihood ratio test of Johansen (1996). Let $\mathbf{y}_{it} = (y_{1it}, \ldots, y_{pit})'$ be a p-dimensional time series. Larsson, Lyhagen and Löthgren consider the following heterogenous vector autoregressive model

$$\mathbf{y}_{it} = \boldsymbol{\mu}_i + \sum_{j=1}^{k_i} \mathbf{\Pi}_{ij} \mathbf{y}_{i,t-j} + \boldsymbol{\varepsilon}_{it}, \quad \boldsymbol{\varepsilon}_{it} \sim \mathrm{IID}(\mathbf{0}, \mathbf{\Omega}_i), \quad i = 1, \ldots, N, \quad t = 1, \ldots, T, \tag{7}$$

where $\mathbf{\Pi}_{ij}$ are $p \times p$ parameter matrices. The corresponding heterogenous error correction model is

$$\Delta \mathbf{y}_{it} = \boldsymbol{\mu}_i + \mathbf{\Pi}_i \mathbf{y}_{i,t-1} + \sum_{j=1}^{k_i-1} \mathbf{\Gamma}_{ij} \Delta \mathbf{y}_{i,t-j} + \boldsymbol{\varepsilon}_{it}, \tag{8}$$

where $\mathbf{\Pi}_i$ is a $p \times p$ matrix of rank $r_i \leq p$ and $\mathbf{\Gamma}_{ij} = -\sum_{m_i=j+1}^{k_i} \mathbf{\Pi}_{ij}$ are $p \times p$ parameter matrices. The cointegration rank hypothesis is formulated as

$$H_0 : \mathrm{rank}(\mathbf{\Pi}_i) \leq r_i \quad \text{against} \quad H_1 : \mathrm{rank}(\mathbf{\Pi}_i) = p \qquad \text{for all } i = 1, \ldots, N. \tag{9}$$

The likelihood ratio statistic for the hypotheses (9) is

$$Q_i = -T_i \sum_{m=r_i+1}^{p} \ln(1 - \widehat{\lambda}_{im}), \tag{10}$$

where the eigenvalues $\widehat{\lambda}_{i1} > \cdots > \widehat{\lambda}_{ip} > 0$ are the solutions to an eigenvalue problem (see Johansen 1996 and Larsson, Lyhagen and Löthgren 2001). The panel test is given by the average of the individual likelihood ratio statistics, and requires that there is a common T for all units. The test cannot be used here, since our panel of Chinese A- and B-share prices is unbalanced. Similar to panel unit root tests, Fisher tests of cointegration in panels can be based on the p-values from the individual likelihood ratio tests and (4)–(6).

5 Empirical Results

This section reports the empirical results of the panel tests for a stationary A-share price premium and cointegration between the A- and B-share prices as well as the probit results. As mentioned in Section 3, the sample period is split into two subperiods. The first sample period is January 1993 to January 2001 and the second sample period is March 2001 to October 2007. The structural break in February 2001 caused by the relaxation of trading restrictions for B shares is left out of the sample. We tested for a structural break in the estimated models using Chow tests (not reported) and the tests confirm that there is a structural break around February 2001. We tested for a second structural break in November 2002, but found no evidence of it. The number of time series observations for the first sample period is $T = 97$, but for many firms there are much fewer observations. This is clear from Table 1, which reveals that when the sample period begins in January 1993, only 16 firms listed both A and B shares on the Shanghai stock exchange and 15 on the Shenzhen stock exchange. We have left out firms with less than four years of data or less than $T = 48$ monthly observations. Consequently, firms listed after February 1997 are not included in the panel for the first sample period. This results in $N = 35$ firms on the Shanghai stock exchange and $N = 31$ on the Shenzhen stock exchange for the first sample period. For the second sample period we have $T = 81$ time series observations for all firms and $N = 44$ and $N = 42$ firms, respectively. Thus, for the first sample period we have fewer cross-section units (firms) than for the second sample period.

5.1 Unit Root Tests

We begin by testing for a unit root in the A-share premium $p_{Ait} - p_{Bit}$, where p_{Ait} and p_{Bit} are the logs of the A- and B-share prices of firm i, using a standard ADF test. All the estimated models include a constant and the lag length is set to $k = 2$ based on the AIC and BIC information criteria. Table 2 reports the means of the ADF statistics and the p-values for the Shanghai and Shenzhen markets, and both markets. The Fisher statistics Λ_1 are computed using the p-values from the individual ADF tests and (4). We have also computed the asymptotic Fisher test Λ_2 based on (5), as a way of dealing with potential cross-section dependence. In Table 2 we see that we cannot reject the null hypothesis of a unit root in the A-share premium for the first sample period, but for the second sample period we overwhelmingly reject the unit root. For the first sample period the p-values from the Λ_1 and Λ_2 tests agree very closely, as they should if the tests are reliable, and for the second sample period both p-values are less than 0.001. Looking at the individual tests (not reported), we find that for the first sample period there is not a single test which rejects the null hypothesis of a unit root at the 10% level. Thus there is no statistical evidence of a stationary A-share premium in the first sample period. For the second sample period 27 tests reject the null hypothesis of a unit root at the 10% level, 24 tests at the 5% level and 16 tests at the 1% level on the Shanghai stock exchange, and 24, 19 and 10 tests, respectively, on the Shenzhen stock exchange. We therefore find that most firms' A-share premium is stationary, but not all firms'. Our conclusions from the unit root tests are that before the relaxation of the trading restrictions in February 2001, the A-share premia or risk premia are nonstationary, but become stationary afterwards.

5.2 Cointegration Tests

Next we test whether the A- and B-share prices are cointegrated. Let $\mathbf{y}_{it} = (p_{Ait}, p_{Bit})'$ be the bivariate time series of the logs of the A- and B-share prices of firm i. Due to market segmentation, there might not be a homogenous relation between the A- and B-share prices. The cointegration test allows for a nonhomogeneous relation by testing whether the vector $\boldsymbol{\beta} = (1, -\beta)'$ multiplied by the log price vector $\mathbf{y}_{it}$ is a stationary relation. In this case $p_{Ait} - \beta p_{Bit}$ is stationary with β differing from 1. All the estimated models

Table 2: Panel unit root tests for the A-share premium. The full sample period is January 1993 to October 2007. Notes: N is the number of firms, $\overline{\tau}$ is the mean of the ADF statistics, $\overline{p}$ is the mean of the p-values, Λ_1 is the Fisher statistic and Λ_2 is the asymptotic Fisher statistic.

	N	$\overline{\tau}$	$\overline{p}$	Λ_1	p-value	Λ_2	p-value
			Sample period 1993(1)–2001(1)				
Shanghai	35	−1.813	0.374	74.409	0.337	0.373	0.355
Shenzhen	31	−1.572	0.493	48.673	0.891	−1.197	0.884
Both markets	66	−1.700	0.430	123.082	0.699	−0.549	0.709
			Sample period 2001(3)–2007(10)				
Shanghai	44	−3.087	0.105	338.357	0.000	18.871	0.000
Shenzhen	42	−2.648	0.196	249.889	0.000	12.799	0.000
Both markets	86	−2.873	0.149	588.246	0.000	22.442	0.000

include an unrestricted constant and the lag length is set to $k = 1$ based on the AIC and BIC information criteria. Table 3 reports the means of the LR statistics and the p-values for the Shanghai and Shenzhen markets, and both markets. The Fisher statistics Λ_1 are computed using the p-values from the individual LR tests and (4). We have also compute the asymptotic Fisher test Λ_2 based on (5), as a way of dealing with potential cross-section dependence. In Table 3 we see that for the first sample period the A- and B-share prices are cointegrated in the panel on the Shanghai stock exchange, but not on the Shenzhen stock exchange. This is an interesting result, which suggests that the larger Shanghai market is more integrated than the smaller Shenzhen market and that there are information flows between domestic and foreign investors in the Shanghai market. For the second sample period we accept cointegration for both markets, but the statistical evidence for Shanghai is much stronger. For the first sample period the p-values from the Λ_1 and Λ_2 tests agree very closely and for the second sample period both p-values are less than 0.001. Turning to the individual tests, for the first sample period 5 tests reject at the 10% level, 2 tests at the 5% level and 1 test rejects at the 1% level on the Shanghai stock exchange, and 4, 2 and 0 tests, respectively, on the Shenzhen stock exchange. For the second sample period we find that most firms' A- and B-share prices are cointegrated, but not all firms'. On the Shanghai stock exchange 28 tests reject at the 10% level, 24 tests at the 5% level and 13 tests at the 1% level, and on the Shenzhen stock exchange 19, 13 and 5 tests, respectively. Our conclusions from the cointegration tests are that in the first sample period, if the Shanghai and Shenzhen markets are tested separately, there are information flows between the A and B shares on the Shanghai stock exchange, but not on the Shenzhen stock exchange. However, if the Shanghai and Shenzhen markets are tested jointly, then there are information flows between the two classes of shares. In the second sample period information flows between the two classes of shares are found no matter whether the Shanghai and Shenzhen markets are tested separately or jointly.

5.3 Probit Analysis

In order to summarise the outcomes of the cointegration tests and in particular, to find out which firms' A- and B-share prices are cointegrated, we estimate a probit model for the second sample period. Note that for the sec-

Table 3: Panel tests for cointegration between the A- and B-share prices. The full sample period is January 1993 to October 2007. Notes: N is the number of firms, $\overline{Q}$ is the mean of the LR statistics, $\overline{p}$ is the mean of the p-values, Λ_1 is the Fisher statistic and Λ_2 is the asymptotic Fisher statistic.

	N	$\overline{Q}$	$\overline{p}$	Λ_1	p-value	Λ_2	p-value
			Sample period 1993(1)–2001(1)				
Shanghai	35	9.705	0.388	92.027	0.040	1.862	0.031
Shenzhen	31	8.777	0.451	65.218	0.366	0.289	0.386
Both markets	66	9.269	0.418	157.245	0.066	1.554	0.060
			Sample period 2001(3)–2007(10)				
Shanghai	44	16.689	0.115	309.516	0.000	16.697	0.000
Shenzhen	42	12.594	0.276	192.968	0.000	8.407	0.000
Both markets	86	14.689	0.193	502.485	0.000	17.819	0.000

ond sample period we find that the A- and B-share prices are cointegrated in the panel and most individual firms' A- and B-share prices are cointegrated. Among the 86 firms in the sample, only 2 firms are cointegrated in the first sample period but in the second sample period there are 36 firms with cointegrated A- and B-share prices, when the cut-off point $p_i \leq 0.05$ is used.

Define the binary dependent variable:

$$y_i = \begin{cases} 0, & \text{if } p_i > 0.05, \\ 1, & \text{if } p_i \leq 0.05, \end{cases} \qquad i = 1, \ldots, N,$$

where p_i denotes the p-value from the LR test for cointegration between the A- and B-share prices of firm i. The explanatory variables are the A-share premium, the log P/E ratio, the log market capitalisation and the log turnover of the A and B shares of the firm. The P/E ratio captures the market expectations of the firm's future earnings growth. Market capitalisation is used as a proxy for firm size and turnover measures the liquidity of the firm's shares. All variables are calculated as monthly averages. In addition to the accounting variables, the number of months the firm has been listing both A and B shares (the age of the firm's A and B shares) is included in the probit model. We expect that the longer the firm has been listing both types of shares, the more information flows there are between the A and B shares. Table 4 reports descriptive statistics for the explanatory variables.[2] Finally, the probit models include a stock exchange dummy variable (DSE) and industry dummy variables.

Table 5 reports the probit estimates. Model 1 contains all explanatory variables and model 2 only the statistically significant ones (we have used the significance level 5%). Model 3 is estimated without the P/E ratio of the B shares. In Table 5 we see that the coefficient on the A-share premium is negative and statistically significant, which is what we would expect. If domestic and foreign investors have similar valuations of the firm, the A-share premium will be small. Cointegration is therefore more likely to be found for firms with a small A-share premium. The coefficient on the P/E ratio of the B shares is positive and significant, indicating that the A and B shares of firms with high growth rates are more likely to be cointegrated. The coefficient on the P/E ratio of the A shares is insignificant. The market capitalisation of the A and B shares are both statistically significant but with opposite signs. Cointegration is therefore more likely to be found for firms with a high B-share market capitalisation relative to the A-share market capitalisation. The hypothesis that the coefficients are equal with opposite signs is rejected, though. The coefficient on the turnover of the A shares is negative and significant, but insignificant for the B shares. We do not have an explanation for the negative coefficient on the turnover of the A shares. The stock exchange and industry dummies are all highly significant, indicating that there are important differences between the Shanghai and Shenzhen stock exchanges and among industries. The Wald test for joint significance of model 2 is $W = 38.60$ (p-value 0.000). The Wald test for model 3 is $W = 26.42$ (p-value 0.006).

The results from the probit models show that not all firms in the panel are equal and cannot be treated as independent and identical draws from a population of firms with cointegrated A- and B-share prices. It casts further doubt on the use of the stock market indices to test for a unit root in the A-share premium and cointegration between the A and B shares.

Table 4: Descriptive statistics. The table reports the mean and standard deviation of the explanatory variables in the probit model. The sample period is March 2001 to October 2007.

Variable	Mean	Std. dev.
A-share premium	0.921	0.407
A-share P/E ratio	191.190	212.033
B-share P/E ratio	117.791	164.248
A-share market capitalisation (bn Yuan)	3.996	3.879
B-share market capitalisation (bn Yuan)	1.071	1.162
A-share turnover (1000 shares)	64.281	106.118
B-share turnover (1000 shares)	31.856	26.606
Age of the firm's A and B shares (months)	149.047	29.252
Number of firms: 86		
Number of firms with cointegrated A and B shares: 36		

Table 5: Probit estimates of cointegration between the A- and B-share prices for the second sample period March 2001 to October 2007. The dependent variable equals 1 if the p-value from the LR test for cointegration $p_i \leq 0.05$ and 0 otherwise. The stock exchange dummy DSE equals 1 if Shangahai stock exchange and 0 otherwise. The industry dummies are $D1$ for electronics and telecom, $D2$ for manufacture, $D3$ for pharmacy, $D4$ for textile, $D5$ for transportation, $D6$ for real estate and $D7$ for services. The industry dummy $D7$ is set to zero since the model includes a constant. The t-values are obtained using robust standard errors, which are corrected for heteroscedasticity. * denotes statistically significant at the 10% level, ** denotes statistically significant at the 5% level, *** denotes statistically significant at the 1% level.

	Estimate	t-value	Estimate	t-value	Estimate	t-value
	Model 1		Model 2		Model 3	
A-share premium	−1.217*	−1.73	−1.959***	−3.04	−1.225**	−2.37
Log A-share P/E ratio	−0.411	−1.41				
Log B-share P/E ratio	1.071***	3.84	0.802***	3.25		
Log A-share market capitalisation	−0.908**	−2.04	−0.773*	−1.77	−0.882**	−2.06
Log B-share market capitalisation	1.230**	2.42	1.083**	2.33	0.663*	1.74
Log A-share turnover	−0.545	−1.54	−0.715**	−2.27	−0.461*	−1.84
Log B-share turnover	−0.303	−0.74				
Log age of A and B shares	−0.593	−0.68				
DSE	1.451***	3.46	1.212***	3.23	0.916***	2.57
$D1$	4.888***	4.19	4.506***	4.12	3.486***	3.76
$D2$	2.521***	3.73	2.178***	3.53	1.423**	2.42
$D3$	3.607***	2.94	3.018***	2.62	1.867*	1.82
$D4$	3.464***	3.07	3.166***	3.25	2.093**	2.47
$D5$	2.847***	3.82	2.438***	3.68	1.677**	2.40
$D6$	4.460***	3.68	3.991***	3.58	2.715**	2.43
Constant	5.760	1.03	1.775	0.55	6.653**	2.28
No. of observations	86		86		86	
Log likelihood	−34.124		−35.529		−42.349	

6 Conclusions

In this paper we have studied market segmentation and information flows on China's stock exchanges by testing the stationarity of the premium of domestic investors' A shares over foreign investors' B shares and cointegration between A- and B-share prices. The paper uses firm level data and panel methods. We find that the A-share premium is nonstationary and that the A- and B-share prices are not cointegrated in the period January 1993 to January 2001. However, after the structural break in February 2001, when the investment restrictions for domestic investors were relaxed, the A-share premia become stationary and the A- and B-share prices cointegrated. The probit analysis of the individual firms shows that cointegration is more likely to be found for firms with a small A-share premium, high growth rate and high B-share market capitalisation relative to the A-share market capitalisation. Our results suggest that the Chinese government's policy of partially abolishing the investment restrictions for domestic investors in February 2001 was successful, because it decreased the segmentation between the A- and B-share investors and increased the informational efficiency of the Chinese A- and B-share markets.

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Appendix

Table 6: Appendix. Firm information. The table reports the firms included in the sample, industry and the A- and B-share codes on the Shanghai and Shenzhen stock exchanges.

No	Firm	Industry	A-share Code	B-share Code
		Shanghai Stock Exchange		
1	Huangshan Tourism Development	Service	600054	900942
2	Shanghai Worldbest	Textile	600094	900940
3	Jinzhou Port	Transportation	600190	900952
4	Hainan Airlines	Transportation	600221	900945
5	Shanghai Kaikai	Industrial Manufacture	600272	900943
6	Inner Mongolia Eerduosi Cashmere Product	Textile	600295	900936
7	Shanghai Zhenhua Port Machinery.	Manufacture	600320	900947
8	Shanghai Nine Dragon	Manufacture	600555	900955
9	SVA Electron	Electronics & Telecom	600602	900901
10	Shanghai Erfangji	Manufacture	600604	900902
11	China Textile Machinery	Manufacture	600610	900906
12	Dazhong Transportation	Transportation	600611	900903
13	China First Pencil	Manufacture	600612	900905
14	Shanghai Wingsung Data Technology	Manufacture	600613	900904
15	Shanghai Dingli Technology Development	Manufacture	600614	900907
16	Shanghai Lianhua Fibre	Textile	600617	900913
17	Shanghai Chlor-Alkali Chemical	Manufacture	600618	900908
18	Shanghai Highly	Manufacture	600619	900910
19	Double Coin Holdings	Manufacture	600623	900909

No	Firm	Industry	A-share Code	B-share Code
20	Shanghai Jinqiao Export Processing Zone Dev.	Service	600639	900911
21	Shanghai Wai Gaoqiao Free Trade Zone Dev.	Service	600648	900912
22	Shanghai Jinjiang International Industrial Inv.	Service	600650	900914
23	Shanghai Lujiazui Development	Service	600663	900932
24	Jinshan Development	Manufacture	600679	900916
25	Shanghai Potevio	Electronics & Telecom	600680	900930
26	Shanghai Sanmao Enterprise	Textile	600689	900922
27	Shanghai Dajiang Stock	Manufacture	600695	900919
28	Jinan Qingqi Motorcycle	Manufacture	600698	900946
29	Huadian Energy	Manufacture	600726	900937
30	Tainjin Marine Shipping	Transportation	600751	900938
31	Shanghai Jinjiang International Hotels	Service	600754	900934
32	Eastern Communications	Electronics & Telecom	600776	900941
33	Huaxin Cement	Manufacture	600801	900933
34	Forever	Manufacture	600818	900915
35	Shanghai Yaohua Pilkington Glass	Manufacture	600819	900918
36	Shanghai Material Trading	Service	600822	900927
37	Shanghai Friendship Group Incorporated	Service	600827	900923
38	Shanghai Electric	Electronics & Telecom	600835	900925
39	Shanghai Diesel Engine	Manufacture	600841	900920
40	SGSB Group	Manufacture	600843	900924
41	Danhua Chemical Technology	Manufacture	600844	900921
42	Shanghai Baosight Software	Manufacture	600845	900926
43	Shanghai Automation Instrumentation	Manufacture	600848	900928
44	Shanghai Haixin Group	Textile	600851	900917

No	Firm	Industry	A-share Code	B-share Code
		Shenzhen Stock Exchange		
45	China Vanke	Real Estate	000002	200002
46	Shenzhen Properties & Recourses Dev.	Real Estate	000011	200011
47	CSG Holding	Manufacture	000012	200012
48	Konka Group	Manufacture	000016	200016
49	Shenzhen China Bicycle	Manufacture	000017	200017
50	Shenzhen Victor Onward Textile Industrial	Textile	000018	200018
51	Shenzhen Shenbao Industrial	Manufacture	000019	200019
52	Shenzhen Zhongheng Huafa	Electronics & Telecom	000020	200020
53	Shenzhen Chiwan Wharf Holdings	Transportation	000022	200022
54	China Merchants Property Development	Transportation	000024	200024
55	Shenzhen Tellus Holdings	Manufacture	000025	200025
56	Shenzhen Fiyta Holdings	Manufacture	000026	200026
57	Shenzhen Accord Pharmaceutical	Manufacture	000028	200028
58	Shenzhen SPG	Real Estate	000029	200029
59	Guangdong Sunrise Holdings	Real Estate	000030	200030
60	Shenzhen Nanshan Power Station	Manufacture	000037	200037
61	China International Marine	Manufacture	000039	200039
62	Shenzhen Textile Holdings	Textile	000045	200045
63	China Fangda Group.	Manufacture	000055	200055
64	Shenzhen International Enterprise	Service	000056	200056

No	Firm	Industry	A-share Code	B-share Code
65	Shenzhen Seg	Electronics & Telecom	000058	200058
66	Shijiazhuang Baoshi	Electronics & Telecom	000413	200413
67	Wuxi Little Swan	Manufacture	000418	200418
68	Guangdong Provincial Expressway Dev.	Transportation	000429	200429
69	Shandong Chenming Paper Holdings	Manufacture	000488	200488
70	Hainan Pearl River Holdings	Manufacture	000505	200505
71	Livzon Pharmaceutical Group	Pharmacy	000513	200513
72	Hefei Meilling	Manufacture	000521	200521
73	Dalian Refrigeration	Manufacture	000530	200530
74	Guangdong Electric Power Development	Manufacture	000539	200539
75	Foshan Electrical and Lighting	Manufacture	000541	200541
76	Jiangling Motors	Manufacture	000550	200550
77	Hubei Sanonda	Pharmacy	000553	200553
78	Changchai	Manufacture	000570	200570
79	Weifu High Technology	Manufacture	000581	200581
80	Anhui Gujing Distillery	Manufacture	000596	200596
81	Hainan Donghai Tourism Centre	Holdings Service	000613	200613
82	Chongqing Changan Automobile	Manufacture	000625	200625
83	BOE Technology Group	Electronics & Telecom	000725	200725
84	Lu Thai Textile	Textile	000726	200726
85	Bengang Steel Plates	Manufacture	000761	200761
86	Yantai Changyu Pioneer Wine	Manufacture	000869	200869

Notes

[1]The QDII is an investment scheme that works opposite to the QFII. Under this scheme domestic institutional investors authorised by the government can invest in overseas capital markets under the foreign exchange control system in China.

[2]The P/E ratio is very high for some firms. It indicates that there may be problems with the acounting data for these firms. We decided to include the P/E ratio of the B shares in model 2, since we found it highly significant. To safeguard against the potential biasing effect on the results, we report the results of a probit model without the P/E ratio. In Table 5, model 3, we see that the signs of the other coefficients remain unchanged but are smaller in magnitude (with the exception of the A-share market capitalisation) and the t-values are smaller.