International Review of Accounting, Banking and Finance

IRABF
© 2013

Volume 5, No. 2, Spring 2013 Page81~101

Impact of Nontradable Share Reform of the A-share Market on China-Related Stock Markets

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Abstract: This study explores whether the nontradable share reform of the A-share market in recent years simultaneously improved market liquidity, market quality, correlations and return volatilities, and price adjustments related to returning equilibrium to some, all or only one of the A-, B-, H-share and red chip markets at the expense of others given the possible simultaneous benefit to these markets. Our study found that the reform of the A-share market improved the liquidity of the A-share and red-chip markets. The first stage of the reform also significantly improved the return volatilities of the H-share and red-chip markets. Transaction costs related to the H-share market and the price gap of the A- and B-share markets improved after the second stage of the reform. Thereafter, most correlations between any two markets significantly increased, the cross-market influence between most markets significantly increased, and the cross-market influence of the spillover effect from the A-share market to the H-share market significantly increased. Finally, after the first stage of the reform, the effect of price discovery on the A-share Shanghai market was larger than that on the B-share Shanghai market, and the effect on the A-share Shenzhen market was larger than that on the H-share and red chip markets. This study provides a helpful reference for investors in the Chinese and Hong Kong stock markets.

JEL: G14, P33, F36; Keywords: China-backed Stock Markets, Nontradable Share Reforms, MGJR-GARCH, Price Discovery, Red Chips

I. Introduction

The PRC implemented a separate share class system in its stock market in May 1992, whereby a listed company separates its shares into tradable shares and nontradable shares, each trading at difference prices and according to different mechanisms.[1] Major shareholders forge numbers or embezzle corporate assets because nontradable shareholders cannot earn profits directly by trading their shares on the open market. Previous studies confirmed that poor market performance in recent years resulted from poor corporate governance and nontradable share problems (Feng et al., 2005; Feng and Xu, 2007; Genevieve and Wei, 2005; Kato and Long, 2005). The China Securities Regulatory Commission (CSRC) announced its initiative for nontradable share reform effective 29 April 2005. In essence, the reform aimed to eliminate the dichotomy in the circulation of listed stocks. This reform was expected to help internationalise and have a far-reaching effect on China's capital markets.[2] The second stage of the reform commenced one year after the initiation of the first stage. This second stage expanded the coverage and variety of companies included in the reform.[3] A solution to the nontradable A-share problem will benefit all interested parties and the long-term development of Chinese-listed firms and stock markets.

In addition to A-share listed companies, the reform includes A-share listed companies that issue B or H shares. In addition, based on the interaction between shares listed in parallel on Chinese equity markets, the reform should simultaneously benefit China-backed A and B shares in the Shanghai and Shenzhen stock markets and H shares and red chips in the Hong Kong stock markets. An analysis of the influence of the process of introducing reforms into China-related stock markets on market activity, quality, correlations and volatility of equity returns, and the price discovery from reverting to cointegration equilibrium in the Shanghai, Shenzhen and Hong Kong stock markets can be useful reference for investors in these markets who participate in property management, dynamic hedging strategies and arbitrage trading. This type of analysis will also benefit the CSRC through a review of the effect of nontradable share reform of A shares during recent years.

[1] The PRC enforced a separate share class system to avoid influence from the dominating position of public enterprises on stock markets.

[2] Effectively, this reform will address the defects in the system that have led to a distorted stock pricing mechanism and that have undermined the reforms to state-owned asset management.

[3] The secondstage of the reform is expected to face three major challenges as it proceeds: 1. Non-floatable stocks regain floatability; 2. Firms that have undergone share reform are able to seek refinancing; and 3. New shares are issued as completely floatable shares.

The recent rapid growth in trading volume and total market value of the Hong Kong Stock Exchange can be attributed to the high quality of the Chinese enterprises choosing to list on this market and the surge in investments from around the world in China.[4] Companies listed on Chinese stock markets usually issue A shares, and if they require foreign currency, they may issue B shares. Corporations may also choose to list on the Hong Kong stock market and issue H shares (state-owned shares), or use a back-door listing method by listing on the Hong Kong exchange through a foreign-registered shell company (red chip shares). Although these different types of shares are listed on separate markets and are held by investors from different regions, the operational range and source revenue are China-centric. Although the nontradable share reform in the A-share market did not involve the B-share market and any reform plan decided on was the result of negotiations between tradable and nontradable shareholders in the A-share market, the reform plan established should have helped, and should continue to help, uphold the legal interests of B and H shareholders. Meanwhile, based on the interaction between shares with parallel listing on Chinese equity markets, the two-stages of nontradable share reform should simultaneously benefit A and B shares on the Shanghai and Shenzhen stock markets and H shares and red chips on the Hong Kong stock markets. Thus, the recent nontradable share reform of the A-share market benefitted all markets, some markets, or only one market at the expense of the others for companies with parallel-listing on Chinese equity markets. Based on the few studies that discussed the influence of market quality, cross-market linkages and the speed of mean reversions on cointegration among A shares, B shares, H shares and red chips resulting from the nontradable share reform of the A-share market, this study focuses on the effect of the two stages of nontradable share reform on the stock markets in Shanghai, Shenzhen and Hong Kong.

The remainder of this paper is organised as follows. Section 2 explores the literature on the effect of Chinese stock market liberalisation on market quality, return correlation, volatility and price discovery. Section 3 describes the measurements of market liquidity and quality, the data period of the samples and the method used in this study. The empirical results are discussed in Section 4. Section 5 presents the conclusions.

[4] In recent years, the Hong Kong stock market has served as the main centre for raising capital by Mainland Chinese corporations. The so-called issued shares of Chinese enterprises refer to state-owned shares and red chip shares. Issued shares of Chinese enterprises are also called H shares, which are shares of state-owned corporations that are approved by the China Securities Regulatory Commission (CSRC) for listing on the Hong Kong Stock Exchange. Red chip shares refer to shares of Chinese enterprises that use a foreign registered company to list on the Hong Kong Stock Exchange and whose operations, markets, and capital are China-centric.

2. Literature Review

Previous studies that investigated the lifting of stock investment restrictions on B shares for residents of China found that, after the preliminary steps toward liberalisation, price disparities between A and B shares narrowed and that the return correlation and cointegration relationships between the two markets strengthened and became tighter (Lu and Wang, 2007; Qiao et al., 2008; Sun et al., 2009).[5] Then, Lu and Wang (2007) proposed that opening the A-share market to foreign investors resulted in no structural change in terms of market efficiency. Moreover, a few studies, such as that by Feng and Xu (2007), explored the nontradable share reform and focused on whether the stocks of reform companies had positive significant abnormal returns. Thus, our paper seeks to fill the gap in the literature that tests the effect of the two stages of nontradable share reform of the A-share market on market activity, quality, return correlation, spillover effect of volatility, and price discovery reverting to equilibrium in the China-backed A-share, B-share, H-share and red-chip markets.

Sun et al. (2009) found that the liberalisation of B shares resulted in improvements in B-share market activity and quality without much adverse impact on the A-share market. Chinese corporations have a choice between issuing A shares or B shares on the Shanghai and Shenzhen stock exchanges, H shares on the Hong Kong Stock Exchange, or indirectly issuing red chips on the Hong Kong Stock Exchange through a foreign-registered company. Therefore, simultaneously considering and comparing the performances of A shares, B shares, H shares and red-chip shares is wise when analysing whether the liquidity and quality of the A-share market improved after the nontradable share reform of A shares.

Eun and Shim (1989) believed that the higher the economic integration between two stock exchanges, the higher the related changes in the two exchanges' stock prices. Wang and Iorio (2007) proposed that the regulation allowing QFIIs to directly invest in the A-share market would cause an increase in the correlation between the A-share and Hong Kong stock markets. Sun et al. (2009) used the correlation coefficients in the covariance equation of the bivariate GARCH to demonstrate that the correlation between A- and B-share returns

[5] Sun et al. (2009) demonstrated that, after lifting the restriction on investing in Bshares, the B-share market exhibited lower volatility and expected returns, and was also characterised by higher volumes and greater liquidity. Qiao et al. (2008) deemed that the relaxation of government restrictions on the purchase of B shares by domestic residents accelerated the integration of the A-share market with the B-share and Hong Kong markets. Lu and Wang (2007) found that the opening of the B-share market to domestic Chinese investors increased market efficiency in the A- and B-share markets and significantly reduced the price differential between A and B shares.

increased following the liberalisation of B shares. They also used the parameters in the variance equations of the bivariate GARCH to show that A-share volatility has a strong positive influence on next-day B-share volatility and that B-share volatility declined during the post-liberalisation period. Moreover, Qiao et al. (2008) and Chiu et al. (2005) found that market liberalisation accelerated the transmission of volatility between the A- and B-share markets by creating higher risk in stock markets in China.[6] As shown by Poon and Fung (2000), the indexes for A shares, B shares, H shares and red chips experience a spillover effect of asymmetric volatility. Hence, this study simply applies the MGJR-GARCH model to capture the heterogeneity and asymmetric volatilities among A shares, B shares, H shares and red chips and analyses whether the two-stage nontradable share reforms would increase the return correlation and the transmission of volatility from A shares to B shares, H shares and red chips.

Most prior studies confirmed support for the hypotheses of A-share and B-share market integration (Hasbrouck, 1995; Eun and Sabherwal, 2003; Kutan, 2007; Sun et al., 2009).[7] Sun et al. (2009) further used the vector error correction model (VECM) to determine that, following the liberalisation of B shares, the A-share market had a more significant impact on the B-share market than vice versa because only speculative local retail investors were allowed to enter the B-share market. Moreover, the differential demand argument supported by Sun and Tong (2000) suggested that at least one long-run relationship exists among the B-share, H-share and red-chip stock markets because foreign investors achieve the same diversification benefits from investing in H shares and red chips or B shares.[8] However, lifting the restriction on residents of China on trading of B shares caused a decline in the difference between demand elasticity for B shares and for A shares, which increased the correlations among A-, B-, H-share and red-chip prices. Therefore, we use the vector error correction model (VECM) to explore whether the adjustment speed at which A-share prices reverted to equilibrium among A-, B-, H-share and red-chip prices significantly increased during the post-reform period.

[6] Poon and Fung(2000) found that the fluctuations in the equity returns of H shares spread to and influenced the Shanghai and Shenzhen markets. In addition, H shares were influenced by the fluctuations in the returns of red-chip shares, and the influence of red-chip shares on the other stock markets was both greater and faster.

[7] For example, Hasbrouck (1995) and Eun and Sabherwal (2003) useda vector error correction model(VECM) to explore the mutual impact of the short-run return dynamics when deviations from the long-run equilibrium existed in these two markets.

[8] Whereas foreign investors can gain diversification benefits by investing in Chinese stocks other than B shares because ofthe existence of H shares and red chips,Chinese investors have few investment alternatives. Thus, in the initial stage, the demand elasticity for B shares is higher than that for A shares.

3. Methodology

3.1 Measurements of market liquidity and quality

To explore whether the liquidity and quality of the A-share market improved more than those of the B-share, H-share and red-chip markets following the nontradable share reform of A shares, we computed turnover as a measure of market liquidity, and we computed return volatility, the bid–ask spread and price premium as measures of market quality in the respective markets and for the three sub-periods of the pre-reform period, the first stage-reform period and the post-reform period. The results are shown in Table 1. The A-B pairs yielded statistics for our overall period for 86 firms that issued both A shares and B shares, and the A-H pairs yielded statistics during the same period for 28 firms that issued both A shares and H shares.[9] Data on red chips yielded statistics on 96 firms for all red chips during the same period. The data were collected from the Taiwan Economic Journal (TEJ) database.

Then, we defined the variables used in this study. Turnover is the number of shares traded separately divided by the total number of outstanding A, B, H and red-chip tradable shares. Turnover is traditionally used as a proxy for liquidity and was used as a measure of the level of speculation in the Chinese market by Mei et al. (2005). Return volatility is the standard deviation of daily returns and can be used to measure risk and the level of speculation. The bid–ask spread is the ratio of the bid–ask difference to the midpoint, for which the respective bidding and asking prices are the daily closing bid and ask quotes. The spread is an important component of market transaction costs and can be regarded as a better measure for liquidity (Hasbrouck, 2006). The B-share (H-share) price premium is $\left(P_B - P_A\right)/P_A$ $(\left(P_H - P_A\right)/P_A)$ and represents the cross-sectional average of the B-share (H-share) price premiums for the 86 (28) sample firms on the SHSE and SZSE (SEHK). The definition provides a direct interpretation of whether there is a discount of $P_B\left(P_H\right)$ over P_A.

3.2 Data

The pre-reform period extended from 1 January 2002 to 28 April 2005, the first stage-reform period was from 29 April 2005 to 28 April 2006, and the post-reform period was from 29 April 2006 to 30 June 2009. Singling out this sub-period of the first stage of reform is also important for our long-term analyses on the lasting effect of the reform policy because the

[9] Among the A-B pairs, 44 pairs of stocks traded on the SHSE and 42 pairs traded on the SZSE. Among the A-H pairs, 18 pairs of stocks traded on the SHSE and 10 pairs traded on the SZSE.

A-, B-, H-share and red-chip markets were quite volatile during this transitional period. We used daily data for the A- and B-share indices on the Shanghai and Shenzhen stock markets (hereafter, SHA, SHB, SZA and SZB) and the H-share and red-chip indices on the Hong Kong stock markets (hereafter, HS and RC) during the 1 January 2002 to 30 June 2009 period. We consider 1 January 2002 as the starting date of the data period because China's B-share market partially opened in February 2001 to Chinese local investors and the effect of B-share liberalisation may have existed from February 2001 to December 2001.

3.3 Estimations of the MGJR-GARCH and VECM

The research by Eunet al. (1989), Wang et al. (2007) and Sun et al. (2009) demonstrated that the correlation among different stock returns increased when the degree of integration or lifting of restrictions among different stock markets increased. Sun et al. (2009) also found that A-share volatility had a strong positive influence on B-share volatility when the market opened up. To capture the correlation and asymmetric volatility of China-related stock returns for investors to diversify their portfolios, we established the multivariate GJR-GARCH model (hereafter MGJR-GARCH). In addition, we added the dummy variables D_1 and D_2 to this model to analyse whether the two stages of nontradable share reforms increased the correlation coefficient between any two stock returns for the A, B, H and red chip shares and increased the influence of volatility from A shares to B shares, H shares and red chips because the reform should simultaneously benefit China-backed stocks. The MGJR-GARCH model is expressed as follows (1):

$$\Delta P_t^i = \alpha_0^i + \alpha_1^i \Delta P_{t-1}^a + \alpha_2^i \Delta P_{t-1}^b + \alpha_3^i \Delta P_{t-1}^h + \alpha_4^i \Delta P_{t-1}^c + \alpha_5^i D_1 + \alpha_6^i D_2 + \varepsilon_t^i$$

$$\begin{aligned} h_{i,t} = {} & \beta_{i0} + \beta_{i1} h_{i,t-1} + \beta_{i2}\varepsilon_{i,t-1}^2 + \beta_{i3}\varepsilon_{i,t-1}^2 I_{i,t-1} + \beta_{i4} D_1 \varepsilon_{a,t-1}^2 + \beta_{i5} D_1 \varepsilon_{b,t-1}^2 + \beta_{i6} D_1 \varepsilon_{h,t-1}^2 \\ & + \beta_{i7} D_1 \varepsilon_{c,t-1}^2 + \beta_{i8} D_2 \varepsilon_{a,t-1}^2 + \beta_{i9} D_2 \varepsilon_{b,t-1}^2 + \beta_{i10} D_2 \varepsilon_{h,t-1}^2 + \beta_{i11} D_2 \varepsilon_{c,t-1}^2 \end{aligned}$$

$$I_{i,t-1} \begin{cases} 1, & if \varepsilon_{i,t-1} < 0 \\ 0, & if \varepsilon_{i,t-1} \geq 0 \end{cases} \qquad (1)$$

$$h_{ij,t} = \left[\rho_{ij,0} + \rho_{ij,1} D_1 + \rho_{ij,2} D_2 \right] \sqrt{h_{i,t} h_{j,t}} \quad i \neq j$$

where $i = (a, b, h, c)$ represents the A-share, B-share, H-share and red-chip index; ΔP_t^i = (ΔP_t^a, ΔP_t^b, ΔP_t^h and ΔP_t^c) measures the A-share, B-share, H-share and red-chip index returns; D_1 is set to 1 after the first stage of the reform was launched and before the second stage of the reform was launched; D_2 is set to 1 after the second stage of the reform was launched; h_i = (h_a, h_b, h_h, and h_c) represents conditional variances of the i index returns, respectively; and h_{ab}, h_{ah}, h_{ac}, h_{bh}, h_{bc}, and h_{hc} are the conditional covariances that capture the extent of the co-movement of the two of the A-share, B-share, H-share and red chip markets, which is the focus of our test. If the correlation between the two markets increased, $\rho_{ij,1}+\rho_{ij,2}(i \neq j)$ is expected to be significantly positive in the covariance equation. β_{i3} significantly different from zero indicates that the respective reaction to positive and negative news in the A-share, B-share, H-share and red-chip market is asymmetric.

Moreover, Sun et al. (2009) used the VECM to propose that because only speculative retail investors are allowed to enter the B-share market, the influence of the A-share market increased during the price discovery process after the liberalization of B shares. There exists an interaction among shares listed on parallel equity markets in China attributable to investors' diversifying their portfolios, and the market price discovery process was enhanced as a result of lifting the restrictions or proceeding with the reform. Thus, this study applies the VECM to analyse whether the A-share market plays a more important role in the price discovery process than the B-share, H-share and red-chip markets after the reform of the A-share market. We separately construct the VECM in the pre-reform and post-reform periods to compare the differences in price discovery:

$$\Delta P_t^i = \alpha_0^i + \alpha_1^i Z_{t-1} + \sum_{j=1}^{q} \alpha_{j+1}^i \Delta P_{t-j}^a + \sum_{j=1}^{q} \alpha_{j+1+q}^i \Delta P_{t-j}^b + \sum_{j=1}^{q} \alpha_{j+1+2q}^i \Delta P_{t-j}^h + \sum_{j=1}^{q} \alpha_{j+1+3q}^i \Delta P_{t-j}^c + \varepsilon_t^i, \quad (2)$$

where $i=(a,b,h,c)$ represents the A-share, B-share, H-share and red chip index and α_1^a, α_1^b, α_1^h and α_1^c measure the adjustment degree of A shares, B shares, H shares and red chips reverting to their equilibrium, respectively.[10] In detail, if the coefficient of the error-correction term on i-share returns is significant, the short-term stock returns apparently revert to the previous long-term equilibrium in the next term as the deviation occurs. If the absolute value of the i-share coefficient $|\alpha_1^i|$ is smaller than that of the j-share coefficient $|\alpha_1^j|$ $(i \neq j)$ in the post-reform period, correction occurs less through an adjustment in prices of the i-shares than that of the j-shares; thus, the i-share prices revert to equilibrium faster than the j-share

[10] ΔP_t^a, ΔP_t^b, ΔP_t^h and ΔP_t^c measure the A-share, B-share, H-share, and red-chip returns. $Z_{t-1}=(P_{t-1}^a - c_0 - c_1 P_{t-1}^b - c_2 P_{t-1}^h - c_3 P_{t-1}^c)$ represents the error-correction term between the A-share price P_t^a, the B-share price P_t^b, the H-share price P_t^h, and the red-chip price P_t^c.

prices. This result implies that, in terms of price discovery, the i-share market has had a more significant effect on the j-share market than vice versa following the reform of nontradable shares.

4. Empirical Results

4.1 Analysis of market liquidity and quality

This study first performs a t-test to examine whether significant changes exist in the means of turnover, return volatility, bid–ask spread and price premium for the pre-, during- and post-reform periods. If the nontradable share reform improved the liquidity and quality of a market, there will be an increase in turnover, a decrease in volatility and a decrease in spread. Moreover, the price difference between A- and B-share (or H-share) stocks should be narrower.

The results in Table 1 indicate that, regardless of whether for the A-B or A-H pairs, all A-share stocks exhibited a significant increase in turnover during and after the reform period. That is, the reform helped activate the A-share market. In addition, there was a significant increase in the turnover of red chips in the post-reform period. This phenomenon is understandable because a company issuing A shares can list on the Hong Kong exchange through a foreign-registered shell company; thus, the stock liquidity of red chips was also activated after the reform. However, the results for B or H shares indicate that there was no significant change in the mean turnover either during or after the reform.

For the A-B pairs, A- and B-share stocks exhibited significantly higher volatility during and after the reform period. However, for the A-H pairs, the volatility of H shares declined during the reform period, only to significantly reverse after the reform. The volatility of red chips also fell during the reform period but could not be sustained following the reform. Hence, the first stage of the reform helped improve the volatilities of H shares and red chips, but the improvements were not subsequently sustained. The bid–ask spread was reduced only for H-shares after the reform period. Hence, transaction costs for the H-share market declined following the reform. A slight decrease in the price gap between A-share and B-share prices occurred during the reform period, but this decrease became significantly larger during the post-reform period than during the reform period.

To summarise, the results in Table 1 indicate that the nontradable share reform in the A-share market improved the liquidity of the A-share and red chip markets. Moreover, the return volatilities of H-share and red-chip markets significantly improved during the first stage of the reform, and the transaction cost of the H-share market and price gaps of the A-and B-share markets significantly improved after the second stage of the reform.

Table 1 Turnover, return volatility, bid–ask spread and price premium for the A-B share pairs, A-H share pairs and red chips

Variable	Sample	Observation	Mean Before	Mean During	Mean After	Mean Change During-Before	Mean Change After-Before
Turnover	A&B						
	A Share		2.569	2.634	2.685	0.065	0.051
		86				(1.671*)	(2.650**)
	B Share		0.348	0.363	0.290	0.015	-0.058
						(0.294)	(-0.631)
	A&H						
	A Share		1.345	1.936	3.155	0.591	1.810
		28				(1.650*)	(2.602**)
	H Share		0.913	0.907	0.917	-0.005	0.004
						(-0.015)	(0.011)
	Red		0.502	0.410	0.621	-0.092	0.119
	Chips	96				(-1.401)	(1.725*)
Return	A&B						
Volatility	A Share		2.351	3.330	4.168	0.979	1.817
		86				(4.298***)	(11.981***)
	B Share		2.164	2.935	3.360	0.772	1.196
						(5.826***)	(22.504***)
	A&H						
	A Share		2.501	2.699	3.867	0.198	1.366
		28				(1.048)	(7.453***)
	H Share		2.880	2.529	4.402	-0.351	1.522
						(-2.112**)	(5.246***)
	Red		3.560	3.262	3.653	-0.298	0.391
	Chips	96				(-1.704*)	(0.447)
Bid-ask	A&B						
Spread	A-Share		0.024	0.024	0.024	0.000	0.000
		86				(0.021)	(0.019)
	B Share		0.053	0.053	0.053	0.000	0..000
						(0.028)	(0.035)
	A&H						
	A Share		0.005	0.007	0.004	0.002	-0.001
		28				(1.524)	(-0.946)
	H Share		0.031	0.027	0.022	-0.004	-0.093
						(-0.533)	(-1.689*)
	Red		0.018	0.017	0.019	-0.001	0.001
	Chips	96				(-0.092)	(0.161)
Price	A&B						
Premium	B Share	86	-0.645	-0.611	-0.686	-0.034	-0.041
						(-0.712)	(-1.735*)
	A&H						
	H Share	28	-0.501	-0.083	-0.49	0.418	0.052
						(1.590)	(0.726)

Notes: The numbers in parentheses denote the t-statistics; ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively.

4.2 Results of the MGJR-GARCH model

Tables 2 and 3 show the results from using the MGJR-GARCH model for the returns of SHA, SHB, HS, RC and SZA, SZB, HS and RC, respectively. The first dummy variable D_1

showed a significant increase in the returns on A shares and red chips during the first stage of the reform period. This result indicates that the first stage of the reform led to higher returns for A shares and red chips, but had no impact on the returns of B shares and H shares. Moreover, the second dummy variable D_2 exhibited a significant increase in the returns on A shares and B shares during the second stage of the reform period. This result indicates that the second stage of the reform led to higher returns for A shares and B shares and had no effect on the returns for H shares and red chips.

The correlation coefficients for any two markets in the covariance equation with significant t-values showed that the returns from any two types of shares were correlated before the reform, as expected. Most importantly, the correlation between A shares and B shares did not increase during the first stage of the reform period with the inclusion of an insignificant dummy variable $\rho_{ab,1} \times D_1$ because the initial nontradable share reform did not cover a variety of companies; hence, the correlation between A shares and B shares did not obviously increase. Then, the reform gradually benefited investors who held B shares, H shares and red chips, and the number of companies that joined the reform obviously increased. Thus, except for the linkages between the A-share and B-share markets in Shanghai, the linkages between any two of the A-share, B-share, H-share and red-chip markets were strengthened during this period by the significant respective dummy variables $\rho_{ab,2} \times D_2, \rho_{ah,2} \times D_2, \rho_{as,2} \times D_2, \rho_{bh,2} \times D_2, \rho_{bs,2} \times D_2,$ or $\rho_{hs,2} \times D_2$. The results show that the correlations for any two of the A-share, B-share, H-share and red-chip markets increased except for the correlation between the A-share and B-share markets in Shanghai following the second stage of the reform. Our results are consistent with those of Sun et al. (2009) and Wang et al. (2007) because lifting the market policy in one market causes an increase in the correlation between that market and the corresponding market.

The parameters concerned with own-market influence in the variance equations $\varepsilon_{i,t-1}^2$ show that, for the overall sample, $D_1 \times \varepsilon_{i,t-1}^2$ significantly declined for red chip shares, indicating that the unconditional volatility of red chips significantly declined during the initial reform period. For the Shenzhen (Shanghai) sample, the unconditional volatility denoted by $D_1 \times \varepsilon_{i,t-1}^2$ of the SZA (SHB) significantly declined (increased) during this period. Then, for the overall sample, $D_2 \times \varepsilon_{i,t-1}^2$ significantly increased for A shares and red chips, indicating that the unconditional volatility of A shares and red chips increased during the second stage of the reform period. For the Shenzhen sample, the unconditional volatility denoted by $D_2 \times \varepsilon_{i,t-1}^2$ of the SZB significantly increased during the same reform period.

The results for cross-market influence enable us to understand the information flows across markets. During the first reform period, except for H-share volatility (SZB volatility), which had a strong positive influence on the next-day B-share volatility (SZA volatility), the most significant and negative $\varepsilon_{j,t-1}^2$ indicated that, during the initial reform stage, most of the volatility in one market significantly and negatively influenced volatility in the other market on the next day. This result may explain why the first stage of the reform was so short and why volatility transmissions among these markets were negative. However, during the second-stage reform, most values of $\varepsilon_{j,t-1}^2$ were significant and positive except for the H-share volatility, which had a strong negative influence on the next-day SZA volatility (SHB volatility). This result implies that the cross-market influence between most markets significantly increased following the opening up of the second stage of the reform and that the opening of market policy in one market accelerates the volatility transmissions between that market and the corresponding market, consistent with the results of Sun et al. (2009), Qiao et al. (2008) and Chiu et al. (2005). More specifically, after the second stage of the reform opened up, the SHA (SZA) volatility had a strong positive influence on the next-day volatility of B shares, H shares and red chips (volatility of H shares). The consistent results indicate that an obvious spillover effect existed from the A-share market to the H-share market after the second stage of the reform.

It is also abundantly clear that the β_{i3} are significantly different from zero, suggesting that the respective responses of the volatility of A-share, B-share, H-share and red-chip residuals to positive and negative news in the corresponding market are asymmetric. These results imply that the MGJR-GARCH model can capture the asymmetric effects of the positive and negative volatilities of any two of the A-, B- and H-share indices and the red-chip market indices.

Table 2. Estimated results of the MGJR-GARCH Model for the SHA, SHB, HS and RC returns

		Δp_t^a	Δp_t^b	Δp_t^h	Δp_t^c
Constant	α_0	-0.040(-1.309)	-0.063(-1.741)	0.092(2.679***)	0.037(0.984)
Δp_{t-1}^a	α_1	0.009(0.319)	-0.114(-2.987***)	-0.008(-0.302)	-0.015(-0.566)
Δp_{t-1}^b	α_2	-0.024(-1.089)	0.161(4.195***)	0.012(0.594)	-0.012(-0.617)
Δp_{t-1}^h	α_3	0.106(6.907***)	0.085(4.795***)	0.106(5.705***)	-0.014(-0.777)
Δp_{t-1}^c	α_4	-0.026(-1.563)	-0.016(-0.856)	-0.024(-1.309)	0.064(3.442***)
D1	α_5	0.122(2.285**)	0.063(0.869)	0.056(0.932)	0.130(2.008**)
D2	α_6	0.076(1.685*)	0.124(1.606*)	-0.029(-0.431)	-0.069(-1.006)
Constant	β_0	0.199(12.485***)	0.427(12.759***)	0.186(10.708***)	0.297(8.121***)
h_{t-1}	β_1	0.844(104.503***)	0.735(52.418***)	0.856(89.932***)	0.857(60.819***)
ε_{t-1}^2	β_2	0.013(2.760***)	0.024(3.040***)	0.016(3.897***)	-0.033(-8.636***)
$\varepsilon_{t-1}^2 I_{t-1}$	β_3	0.029(6.211***)	0.061(7.767***)	0.055(13.550***)	0.067(17.453***)
$D_1\varepsilon_{a,t-1}^2$	β_4	0.025(1.428)	-0.124(-2.868***)	-0.009(-1.304)	-0.016(-1.981**)
$D_1\varepsilon_{b,t-1}^2$	β_5	-0.003(-0.618)	0.132(4.090***)	0.001(0.288)	-0.006(-1.743*)
$D_1\varepsilon_{h,t-1}^2$	β_6	-0.010(-0.601)	0.268(3.821***)	0.024(1.490)	0.002(0.143)
$D_1\varepsilon_{c,t-1}^2$	β_7	-0.007(-0.837)	-0.113(-4.969***)	-0.026(-2.421**)	-0.026(-2.124**)
$D_2\varepsilon_{a,t-1}^2$	β_8	0.034(1.736*)	0.201(4.278***)	0.036(2.987***)	0.034(2.846***)
$D_2\varepsilon_{b,t-1}^2$	β_9	0.022(3.136***)	-0.027(-0.806)	-0.006(-1.036)	-0.001(-0.165)
$D_2\varepsilon_{h,t-1}^2$	β_{10}	0.011(0.582)	-0.265(-3.733***)	-0.024(-1.306)	0.016(0.836)
$D_2\varepsilon_{c,t-1}^2$	β_{11}	0.000(0.044)	0.080(2.976***)	0.051(2.810***)	0.043(2.572**)

		$h_{ab,t}$	$h_{ah,t}$	$h_{ac,t}$
$\sqrt{h_{a,t}h_{b,t}}, \sqrt{h_{a,t}h_{h,t}}, \sqrt{h_{a,t}h_{c,t}}$	$\rho_{ab,0}, \rho_{ah,0}, \rho_{ac,0}$	0.813(90.446***)	0.157(6.772***)	0.110(5.199***)
$\sqrt{h_{a,t}h_{b,t}}D_1, \sqrt{h_{a,t}h_{h,t}}D_1, \sqrt{h_{a,t}h_{c,t}}$	$\rho_{ab,1}, \rho_{ah,1}, \rho_{ac,1}$	0.010(0.556)	0.193(5.565***)	0.165(4.782***)
$\sqrt{h_{a,t}h_{b,t}}D_2, \sqrt{h_{a,t}h_{h,t}}D_2, \sqrt{h_{a,t}h_{c,t}}$	$\rho_{ab,2}, \rho_{ah,2}$,	-0.034(-1.925*)	0.157(5.257***)	0.160(4.318***)

		$h_{bh,t}$	$h_{bc,t}$	$h_{hc,t}$
$\sqrt{h_{b,t}h_{h,t}}, \sqrt{h_{b,t}h_{c,t}}, \sqrt{h_{h,t}h_{c,t}}$	$\rho_{bh,0}, \rho_{bc,0}, \rho_{hc,0}$	0.124(5.834***)	0.104(5.345***)	0.673(63.720***)
$\sqrt{h_{b,t}h_{h,t}}D_1, \sqrt{h_{b,t}h_{c,t}}D_1, \sqrt{h_{h,t}h_{c,t}}D_1$	$\rho_{bh,1}, \rho_{bc,1}, \rho_{hc,1}$	0.212(5.754***)	0.137(3.796***)	0.073(3.414***)
$\sqrt{h_{b,t}h_{h,t}}D_2, \sqrt{h_{b,t}h_{c,t}}D_2, \sqrt{h_{h,t}h_{c,t}}D_2$	$\rho_{bh,2}, \rho_{bc,2}, \rho_{hc,2}$	0.122(3.525***)	0.170(4.465***)	0.157(7.699***)

Notes: 1. The specifications of the MGJR-GARCH model are given in equation (1).

2. The numbers in parentheses denote the t-statistics; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 3. Estimated results of the MGJR-GARCH Model for the SZA, SZB, HS and RC returns

		Δp_t^a	Δp_t^b	Δp_t^h	Δp_t^c
Constant	α_0	-0.080(-2.004**)	-0.012(-0.249)	0.084(2.345**)	0.033(0.403)
□ P_{t-1}^{a}	α_1	-0.013(-0.677)	-0.170(-8.925***)	-0.062(-3.732***)	-0.042(-2.524**)
□ P_{t-1}^{b}	α_2	0.072(4.382***)	0.271(10.366***)	0.063(4.254***)	0.021(1.452)
□ P_{t-1}^{k}	α_3	0.066(3.799***)	0.084(4.430***)	0.106(5.260***)	-0.018(-0.915)
□ P_{t-1}^{c}	α_4	-0.026(-1.385)	0.01239(0.522)	-0.029(-1.429)	0.062(2.929***)
D1	α_5	0.195(2.660**)	0.047(0.498)	0.064(0.885)	0.129(1.659*)
D2	α_6	0.237(3.382**)	0.107(1.671*)	0.044(0.752)	0.075(1.228)
Constant	β_0	0.123(8.595***)	0.530(14.809***)	0.177(9.650***)	0.269(5.469***)
h_{t-1}	β_1	0.879(84.047***)	0.693(50.349***)	0.864(84.939***)	0.868(43.748***)
ε_{t-1}^2	β_2	-0.030(-9.022***)	-0.011(-1.638)	0.039(10.713***)	0.026(7.275***)
$\varepsilon_{t-1}^2 I_{t-1}$	β_3	0.085(25.026***)	0.125(18.766***)	0.028(7.784***)	0.006(1.660*)
$D_1\varepsilon_{a,t-1}^2$	β_4	-0.024(-2.376**)	0.036(1.307)	-0.027(-3.752***)	-0.001(-0.028)
$D_1\varepsilon_{b,t-1}^2$	β_5	0.041(7.821***)	0.033(1.361)	0.013(1.149)	-0.016(-3.934***)
$D_1\varepsilon_{h,t-1}^2$	β_6	-0.077(-8.308***)	0.106(2.130**)	0.005(0.308)	0.007(0.562)
$D_1\varepsilon_{c,t-1}^2$	β_7	0.023(1.287)	-0.068(-2.499**)	-0.011(-0.935)	-0.025(-2.046**)
$D_2\varepsilon_{a,t-1}^2$	β_8	0.020(2.779***)	0.003(0.349)	0.015(1.982**)	0.006(0.857)
$D_2\varepsilon_{b,t-1}^2$	β_9	0.020(3.075***)	0.075(5.454***)	-0.006(-0.759)	-0.005(-0.615)
$D_2\varepsilon_{h,t-1}^2$	β_{10}	-0.012(-2.263***)	-0.007(-0.952)	-0.001(-0.130)	0.015(2.473**)
$D_2\varepsilon_{c,t-1}^2$	β_{11}	0.023(2.768***)	0.022(1.866*)	0.032(3.107***)	0.022(2.215**)
		$h_{ab,t}$	$h_{ah,t}$	$h_{ac,t}$	
$\sqrt{h_{a,t}h_{b,t}}, \sqrt{h_{a,t}h_{h,t}}, \sqrt{h_{a,t}h_{c,t}}$	$\rho_{ab,0}, \rho_{ah,0}, \rho_{ac,0}$	0.798(155.574***)	0.147(5.033***)	0.107(3.687***)	
$\sqrt{h_{a,t}h_{b,t}}D_1, \sqrt{h_{a,t}h_{h,t}}D_1, \sqrt{h_{a,t}h_{c,t}}1$	$\rho_{ab,1}, \rho_{ah,1}, \rho_{ac,1}$	-0.013(-0.670)	0.177(3.583***)	0.159(3.163***)	
$\sqrt{h_{a,t}h_{b,t}}D_2, \sqrt{h_{a,t}h_{h,t}}D_2, \sqrt{h_{a,t}h_{c,t}}$	$\rho_{ab,2}, \rho_{ah,2}, \rho_{ac,2}$	0.015(2.130**)	0.267(6.845***)	0.253(6.704***)	
		$h_{bh,t}$	$h_{bc,t}$	$h_{hc,t}$	
$\sqrt{h_{b,t}h_{h,t}}, \sqrt{h_{b,t}h_{c,t}}, \sqrt{h_{h,t}h_{c,t}}$	$\rho_{bh,0}, \rho_{bc,0}, \rho_{hc,0}$	0.168(5.924***)	0.162(5.777***)	0.672(122.176***)	
$\sqrt{h_{b,t}h_{h,t}}D_1, \sqrt{h_{b,t}h_{c,t}}D_1, \sqrt{h_{h,}}$	$\rho_{bh,1}, \rho_{bc,1}, \rho_{hc,1}$	0.147(2.949***)	0.106(2.097**)	0.082(3.917***)	
$\sqrt{h_{b,t}h_{h,t}}D_2, \sqrt{h_{b,t}h_{c,t}}D_2, \sqrt{h_{h,}}$	$\rho_{ab,2}, \rho_{ah,2}, \rho_{ac,2}$	0.341(9.098***)	0.294(8.060***)	0.230(37.321***)	

Notes: 1. The specifications of the MGJR-GARCH model are given in equation (1).

2. The numbers in parentheses denote the t-statistics; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

4.3 Results of cointegration test and VECM

Because a cointegration test on multiple variables was conducted, this research employed the test by Johansen and Juselius (1990) and Johansen (1992) to separately examine the cointegration relationship among the SHA, SHB, HS and RC and among the SZA, SZB, HS and RC.[11] The results of the trace test in Table 4 show that, regardless of whether the Shanghai or Shenzhen stock market was considered, the statistics all reject the null hypothesis of no cointegration among the A-share, B-share and H-share indices and the red chip index before and after the nontradable share reform.

The results of Table 5 show the coefficients of the error-correction term in the VECM (the α_1 value in Eq. (2)) during the pre-reform and post-reform (including the first and second stages of the reform) periods. We present the coefficients of the error-correction term in the post-reform period except for those in the first or second stages of the reform period because no cointegration existed during the shorter first stage of the reform period. During the pre-reform period, the coefficients of the error-correction term for SHA and RC were significant, and the absolute value of the red-chip coefficient $\left|\alpha_1^c\right|$ was smaller than that of the A-share coefficient $\left|\alpha_1^a\right|$. Thus, during this period, the red-chip index reverted to equilibrium faster than the A-share index. This finding is consistent with the result of Poon and Fung (2000) in that the influence of red-chip shares on other stock markets is faster. However, during the post-reform period, the coefficients of the error-correction term for the SHA and SHB are significant, and $\left|\alpha_1^a\right|$ are smaller than $\left|\alpha_1^b\right|$. Thus, after the first stage of the reform, the A-share index reverted to equilibrium faster than did the B-share index. As expected, this implies that, in terms of price discovery, A shares had a more significant impact on B shares in the Shanghai market following the reform in the A-share market. However, the situation is slightly different for Shenzhen stocks. During the pre-reform period, the coefficients of the error-correction term for the SZA, SZB and RC were significant, and $\left|\alpha_1^a\right|$ was smaller than $\left|\alpha_1^c\right|$ and $\left|\alpha_1^b\right|$. That is, during this period, the A-share index reverted to equilibrium faster than the red-chip and B-share indices. Moreover, during the post-reform period, the coefficients of the error-correction term for the

[11] To attain the effect of cross comparison, this research uses the ADF test of Dickey-Fuller(1979), the PP test of Phillips and Perron(1988), and the KPSS test of Kwiatkowski et al.(1992) to separately examine the existence of unit roots in the A-share, B-share, and H-share markets and the red-chip index.The results of the unitroot testsconsistently indicate that the A, B, and H sharesor the red-chip index in these stock markets are the unit roots, and their first-order differences are stationary, confirming that the A, B, and H sharesand the red-chip index are I(1) sequences.

SZA, HS and RC were significant, and $|\alpha_1^a|$ was smaller than $|\alpha_1^h|$ and $|\alpha_1^c|$. As expected, this result indicates that, in terms of price discovery, the A shares in the Shenzhen market still had a more significant impact on the H shares and the red chips after the first stage of the reform. Although the A-share coefficients are smaller in absolute value terms for both the Shanghai and Shenzhen markets after the first stage of the reform, the change in the absolute value of the SHA coefficient was much larger than that of the SZA coefficient, indicating that the effect on the A shares in the Shanghai market was greater than that on the A shares in the Shenzhen market.

Table 4Results of the cointegration test

Hypothesised No. of CE(s)	Before the reform		After the reform	
	Eigenvalue	Trace Statistic	Eigenvalue	Trace Statistic
Panel A: Results of the cointegration test among the SHA, SHB, HS and RC				
None	0.026	48.026*	0.025	53.102**
At most 1	0.013	17.068	0.017	28.738*
At most 2	0.008	6.849	0.010	11.689
At most 3	0.001	1.119	0.002	1.778
Panel B: The Results of the cointegration among the SZA, SZB, HS and RC				
None	0.024	48.994*	0.026	45.250*
At most 1	0.012	18.429	0.013	25.992
At most 2	0.011	8.262	0.003	3.831
At most 3	0.000	0.003	0.001	1.241

Note: ** and * denote significance at the 5% and 10% levels, respectively.

Table 5 Coefficients of the error correction terms in the VECM

	ΔP^a	ΔP^b	ΔP^h	ΔP^s
Panel A: Coefficients of the error-correction terms for SHA, SHB, HS and RC				
Pre-reform	-0.0286 [-2.2561**]	0.0004 [0.0294]	0.0126 [0.8216]	0.0252 [1.6556*]
Post-reform	0.0184 [2.4791**]	0.0363 [4.0979***]	0.0049 [0.5225]	0.0115 [1.3799]
Panel B: The coefficients of the error-correction terms for SZA, SZB, HS and RC				
Pre-reform	0.0029 [1.7199*]	0.0068 [3.3988***]	0.0028 [1.5093]	0.0040 [2.1592**]
Post-reform	0.0008 [1.7425*]	0.0004 [0.8804]	0.0021 [3.9047***]	0.0018 [3.8741***]

Notes：1. The numbers in [ ] indicate t-statistics.

2. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

5. Conclusions

This study first analysed whether the liquidity and quality of the A-share market improved more than those of the B-share, H-share and red-chip markets following the nontradable share reform of A shares. Our results indicate that ownership of nontradable shares in the A-share market improved the liquidity of the A-share and red-chip markets, and significant improvement was observed in the return volatilities of the H-share and red-chip markets during the reform period and in transaction costs of the H-share market and in the price gap of the A-share and B-share markets during the post-reform period.

Then, this study established a MGJR-GARCH model to examine whether the two-stage nontradable share reforms increased the correlation between the returns of any two stocks for A, B and H shares and the red chips and whether they increased the influence of the volatility of A shares on that of B shares, H shares and red chips because the reform should simultaneously benefit the China-backed A- and B-share markets and the H-share and red-chip markets.

Our empirical results indicated that the correlation between A and B shares did not increase during the first stage of the reform period because the initial nontradable share reform did not cover a variety of companies. Then, when the reforms began to gradually benefit investors who held B shares, H shares and red chips and the number of companies that participated in the reforms increased gradually, the correlations for any two markets among the A-share, B-share, H-share and red-chip markets increased except for the correlation between the A-share and B-share markets in Shanghai after the second stage of the reform. This result is consistent with the results of Sun et al. (2009) and Lu and Wang (2007) in that the removal of market limitations caused an increase in the correlation between the corresponding two markets.

Moreover, during the initial reform stage, most of the volatility in one market significantly and negatively influences that of the other market on the next day. However, after the second stage of the reform period opened up, the cross-market influence between most markets significantly increased. This situation is consistent with the results of Sun et al. (2009), Qiao et al. (2008) and Chiu et al. (2005) in that the opening of market policy in one market accelerates the transmission of volatility between that market and the corresponding market. Furthermore, A-share volatility in Shanghai (in Shenzhen) had a strong positive influence on the next-day volatility of B shares, H shares and red chips (volatility of the H shares). The results indicate that, after the second stage of the reform period, a significant increase occurred in the cross-market influence of the spillover effect from the A-share market to the H-share market.

Finally, this study used the VECM to explore whether the A-share market plays a more important role in price adjustments to equilibrium than the B-share, H-share and red-chip markets after the reform of the A-share market. Our results show that, after the reform, the impact on A shares was larger than the impact on B shares in the Shanghai market in terms of price discovery, and the impact on A shares in the Shenzhen market was larger than the impact on H shares and red chips. In addition, in term of the changes in price adjustments between the pre-and post-reforms, the effect on the A shares in the Shanghai market was larger than the effect on the A shares in the Shenzhen market.

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