The Volatility Dynamics of the Greater China Stock Markets

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Abstract

This paper examines whether the stock markets of China, which has witnessed rapid growth over the past decade, and those of the Greater China have common factors that are related to Mainland China regionally, politically, or ethnically, and if so, the manner in which these are interrelated. To achieve these objectives, we used the dynamic linear latent factor model (DLLFM) to verify the common existence of heteroscedasticity and systematic jump risk in the Greater China stock markets. Using the Greater China stock markets such as Hong Kong, Taiwan, Singapore, Malaysia, and Indonesia from January 2 2001 to October 29 2012, this paper finds the Greater China stock markets have both GARCH effects and the systematic jump risk in common. According to the main estimated results of this paper, jump risk comes every 0.86 trading day in the Greater China stock markets, with the estimated jump frequency parameter λ being 1.1659. Finally, approximately 26% of the common factors of the Greater China stock market can be explained by the Mainland China stock market risk. Particularly, the common factors of the Greater China stock markets are related more closely to the A-share market than the B-share market.

Keywords: Greater Stock Markets, DLLFM, Jump-risk, Heteroscedasticity

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1. Introduction

China has experienced rapid economic growth over the past decade. Its annual growth rate of 7% is a rare achievement in the context of the global economy. The Mainland China stock markets, mainly that of Shanghai and Shenzhen, play a major role in such economic growth. The Mainland China stock market volume has rapidly increased since 1990. Hong Kong and Taiwan, which are closely related to Mainland China regionally and politically, play a crucial role in its economy as well as stock market. Above all, the 1997 handover of Hong Kong to China, resulting in the integration of Hong Kong's stock market—an advanced financial market—into China's then undeveloped stock market, has supported China's stock market both quantitatively and qualitatively. Unlike other countries, the Mainland China stock markets are classified into A-share and B-share markets for investment. The A-share market, restricted to domestic investors, is traded in Yuan, one of the currency units in RMB. Only Chinese citizens, corporations, and QFII[1] are qualified to invest in this market. In the B-share market, the face value is recorded in RMB, but foreigners and institutional investors can trade in USD and HKD as well. Since February 2001, however, domestic investors have also been allowed to trade freely in the B-share market.

There have been increasingly intensive studies on the Mainland China and the Greater China stock markets, driven by China's economic growth. The main direction of such studies is the interaction of the stock markets of Mainland China, Hong Kong, and Taiwan. Chakravaty *et al.* (1998) used bivariate analysis to investigate China's and Hong Kong's stock markets. As a result, they suggested that the stock markets are interrelated, albeit slightly. Likewise, Yeh and Lee (2000) conducted an analysis on the stock markets of the Greater China, including Mainland China, Hong Kong, and Taiwan, by using a GJR GARCH model for asymmetric volatility and a VAR model for market interaction. The analysis led to the conclusion that each stock market shows different leverage effects and feedback effects. It also indicated that the Hong Kong stock market exerts a temporary influence on the B-share markets of the Shanghai and Shenzhen stock markets as well as the Taiwan stock market. According to Cheng and Glascock (2005), there are weak nonlinear dynamics in the interrelationships among the stock markets of the Greater China region, consisting of Mainland China, Hong Kong, and Taiwan.

Furthermore, there are studies on the causal relation between China and the Greater China stock markets, which can be explained by examining the markets and effects of market-to-market information warfare. Huang *et al.* (2000) used Granger causality analysis to show a causal

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[1] QFII (Qualified Domestic Institutional Investor) refers to a foreign investor who is qualified to purchase A-shares, which are invested in by the Chinese only, directly from the Shanghai and Shenzhen Stock Exchanges.

relationship between the Shanghai and Shenzhen stock markets and reported the unidirectional causality between the Hong Kong Hang Seng and Taiwan Taiex indexes.

Unlike previous studies, the purpose of this study tries to estimate the latent common factors among the Greater China stock markets using an econometric model. The common factors that are proved to exist will be investigated for their relations to the Mainland China stock markets. To achieve this purpose, DLLFM (Dynamic Linear Latent Factor Model) is used to analyze common heteroscedasticity and jump risk of the five stock markets of representative countries of the Greater China regions, namely, Hong Kong, Taiwan, Singapore, Malaysia, and Indonesia. DLLFM assumes heteroscedasticity due to the data characteristics of financial time series and makes an econometrically more precise assumption, as it considers the possibility of jump associated with information inflow. Thus, it can verify whether systematic jump, in addition to GARCH effects, is a factor commonly applicable to the Greater China stock markets. In this sense, it differs from previous studies on simple interactions of the Greater China stock markets. While previous studies focus on such as causality, lead-lag, and cointegration relations with the Mainland China stock markets, this study examines the common factors of the Greater China stock markets and the degree of their applicability to the Mainland China stock markets.

This study is organized as follows: Section 2 introduces DLLFM to identify the latent common factors of the Greater China stock markets. Section 3 discusses the results of the empirical analysis on the common factors assumed in DLLFM and on the Mainland China stock markets. Section 4 provides a summary and conclusions.

2. Dynamic Linear Latent Factor Model for the Greater China Stock Markets

This study uses DLLFM (Dynamic Linear Latent Factor Model), which is suggested by Chang and Kim (2009), to estimate the common factors in the Greater China stock markets. DLLFM is a multivariate latent factor model with jump that expands the latent factor model of Diebold and Nerlove (1989) by adding discrete jumps to an unobserved factor formula and includes GARCH-type heteroscedasticity into the error terms and idiosyncratic noise terms of common factors. It is expressed as follows:

$$Y_t = \gamma f_t + \eta_t, \;\; \eta_t | \Psi_{t-1} \sim N(0, H_t)$$

$$f_t = \sigma_t \xi_t + \sum_{j=0}^{q_t} v_{jt}, \;\; \epsilon_t = \sigma_t \xi_t, \;\; \epsilon_t | \psi_{t-1} \sim N(0, \sigma_t^2), \;\; \xi_t \sim N(0,1)$$

$$q_t \sim \frac{e^{-\lambda} \lambda^j}{j!}, v \sim N(\mu, \nu^2)$$

$$\sigma_t^2 = \beta_0 + \beta_1 \epsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2$$

$$H_t = diag\{h_{1t}, h_{2t}, \cdots, h_{nt}\}$$
$$h_{it} = \alpha_{i0} + \alpha_{i1}\eta_{it-1}^2 + \alpha_{i2}h_{it-1},\ i = 1, \cdots, n$$

where Y_t is the $(N \times 1)$ vector of percentage changes of the Greater China stock indexes follow the vector stationary processes, η_t is the $(N \times 1)$ vector of idiosyncratic noises, and f_t is a common factor which consists of jump and heteroscedasticity. $\gamma = (1, \gamma_1, \cdots, \gamma_N)'$ is the $(N \times 1)$ vector of constant that is called "factor loading" in the factor analytic literature and shows the sensitivity of a common factor movements for each stock index rate of return. Note that the first element of γ is set equal to unity. This is necessary to fix the scale of common and idiosyncratic conditional variances. q_t is a Poisson random variable with λ parameter. It is assumed that each Poisson event causes a discrete jump of size $exp\{v_j\}$, $j = (1,2, \cdots, q_t)$. Hence, the jumps are assumed to be independently lognormally distributed random variables, which are independent of ξ_t, and v_j is assumed to be an identical, independent, and normally distributed random variable with mean μ and variance ν^2. The conditional variance of ϵ_t and η_t is supposed to follow a GARCH (1,1) process. ψ_{t-1} and Ψ_{t-1} denote the information set.

To estimate the dynamic linear latent factor model, the Kalman Filter is used after establishing a state-space model as follows:

Observation equation : $Y_t = Z_t\alpha_t$

State equation : $\alpha_t = \zeta^{(J)} + T_t\alpha_{t-1} + R_t^{(J)}w_t$

where Z_t is the $\left(n \times (J + n + 2)\right)$ matrix of zeros with the first column replaced by γ, the factor loading, and the submatrix of Z_t, column 3 through $(n + 2)$ and rows 1 through n, are replaced by the identity matrix. $\alpha_t = \left(f_t, \epsilon_t, \eta_{1t}, \ \cdots, \eta_{nt}, \tilde{v}_{1t}, \tilde{v}_{2t}, \cdots, \tilde{v}_{Jt}\ \right)'$, $\tilde{v}_{jt} = v_{jt} - \mu$ is demeaned jump size variable. The constant vector is defined as $\zeta^{(J)} = (j \cdot \mu, 0, \cdots, 0)'$ and superscript *(j)* denotes the dependence of the variable on realizations of Poisson jump events. $T_t = O_{(J+n+2)\times(J+n+2)}$, and $R^{(J)}$ is the $(J + n + 2) \times (J + n + 2)$ matrix with the first row equal to $(1, 0, \cdots, 0, 0, \cdots, 0)$, for *j=0*, $(1, 0, \cdots, 1, 0, \cdots, 0)$, for *j=1*, $(1, 0, \cdots, 1, 1, \cdots, 0)$, for *j=2*, etc. Which is stacked on top of the $(J + n)$ -dimensional identity matrix. Finally, $E(w_t) = 0$ and $E(w_t w_t') = Q_t = diag\{\sigma_t^2, h_{1t}, \cdots, h_{nt}, v^2, \cdots, v^2\}$.

In addition, the conditional covariance matrix H_t is assumed to be diagonal. The covariance structure among variables is therefore solely driven by their codependence on a single common factor. The conditional variance of the *i*-th variable and the conditional covariance among variables *i, j* can be expressed as follows:

$$Var_{t-1}(Y_{it}) = \gamma_i^2 \left\{\sigma_t^2 + \sum_{j=0}^{q_t} Pr[q_t = j|\Psi_{t-1}] \cdot q_t \cdot v^2\right\} + h_{it}$$
$$Cov_{t-1}(Y_{it}, Y_{jt}) = \gamma_{\mathrm{i}}\gamma_{\mathrm{j}} \left\{\sigma_t^2 + \sum_{j=0}^{q_t} Pr[q_t = j|\Psi_{t-1}] \cdot q_t \cdot v^2\right\}, \quad i \neq j$$

If the model is assumed, considering heteroscedasticity and jump simultaneously, because the conditional covariance matrix H_t is a diagonal matrix, the conditional variance of the *i*-th variable is the value that adds the sum of the idiosyncratic volatility part of the *i*-th variable to the value obtained by multiplying the sum of diffusion and jump parts of common factors by the loading factor square of the *i*-th variable. The conditional covariance between variables *i* and *j* is then equal to the value obtained by multiplying the sum of diffusion and jump risk parts of common factors by each loading factor of *i*-th and *j*-th variables.

Moreover, σ_t^2 and h_{it} are assumed to follow the GARCH (1,1) process. The approximate QML estimates of the model can be obtained by maximizing the log-likelihood function(L) with respect to the unknown parameter (θ). The approximate sample conditional log-likelihood can be expressed as follows:

$$L = \sum_{t=1}^{T} ln(Pr[Y_t|\Psi_{t-1}]$$

3. Empirical results

3.1. Data

This study selects Hong Kong (HSI), Taiwan (TWS), Singapore (STI), Malaysia (KLCI), and Indonesia (JKSE) as representatives of the Greater China stock markets and uses daily indexes for each of their stock markets.[2] Shanghai Composite Index(SHS), Shanghai A- and B-share indexes are used for the Mainland China stock market to examine the characteristics of the Mainland China stock market. The data cover the period from January 2 2001 to October 29 2012.

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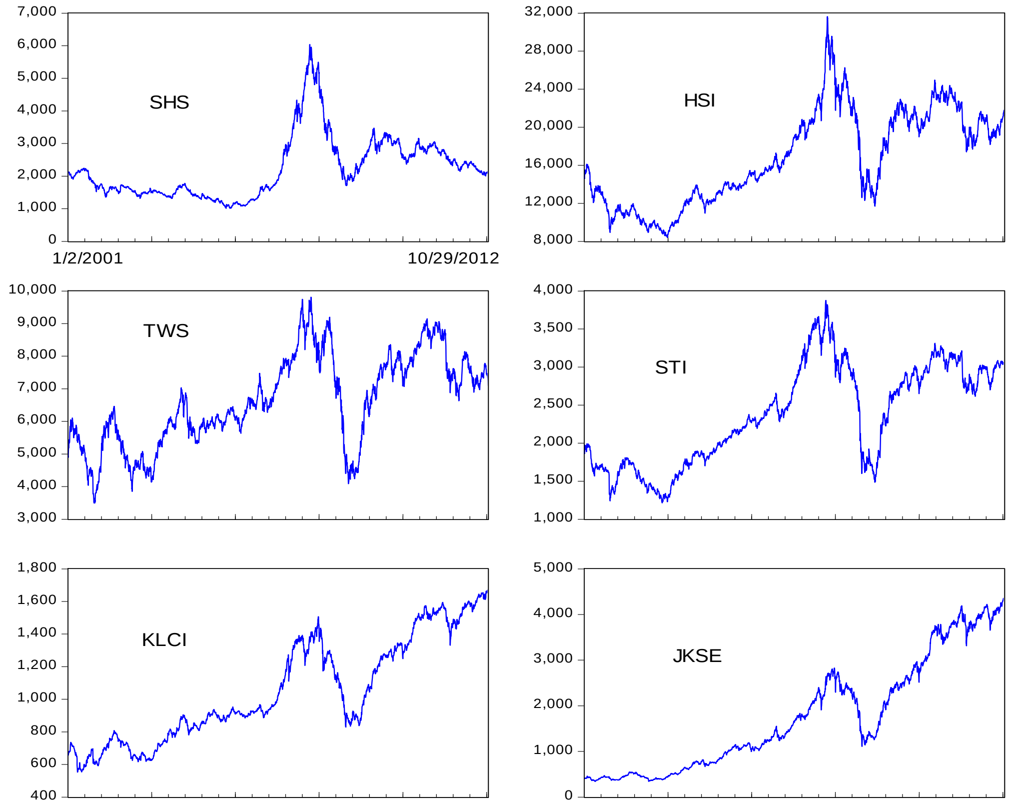
[2] Many previous studies restricted the range of the Greater China countries to Hong Kong and Taiwan. However, this study included Singapore, Malaysia, and Indonesia in the Greater China stock markets, since it regards the ethnic Chinese living in these countries as belonging to the Greater China economic zone.

3.2. DLLFM

Figure 1. Trend of the Mainland China and the Greater China Stock Markets (2/1/2001–29/10/2012)



Notes: This figure shows the indexes of the Mainland China and the Greater China stock markets, including the Mainland China (SHS), Hong Kong (HSI), Taiwan (TWS), Singapore (STI), Malaysia (KLCI), and Indonesia (JKSE) from upper-left.

Figure 1 shows the index trends in the Mainland China and the Greater China countries. The Mainland China and the Greater China stock markets demonstrate an overall rising trend until the global financial crisis of 2008, followed by a crash due to the subprime crisis. On the other hand, the Greater China stock markets exhibit several characteristics. Similar movements are observed within the three stock markets of Hong Kong (HSI), Taiwan (TWS), and Singapore (STI) and the two stock markets of Malaysia (KLCI) and Indonesia (JKSE), respectively. While Hong Kong, Taiwan, and Singapore have recovered from the global financial crisis and regained stability, both Malaysia's and Indonesia's stock markets have shown continuous growth since the global financial crisis of 2008 with no disruption from the recent European financial crisis.

Table 1 presents summary several descriptive statistics of index rates of return. Index rates of return are defined as one hundred times the continuously compounded percentage daily rates of return. The sample covers from February 1 2001 to October 29 2012. Index rates of return of China and the Greater China show a typical leptokurtic distribution with a fat tail. All of Jarque-Bera statistics reject normality. Only China (SHS) displays a negative mean in the index rate of return by country, while Indonesia and Malaysia in the Greater China region show relatively high means index rates of return. Such a trend is also observable in the high medians of Malaysia and Indonesia. The standard deviation, which can be considered a proxy of risk, is the highest for China at 1.778%, while it is the lowest for Malaysia at 0.963%.

Table 1. Sample Statistics of the Mainland China and the Greater China stock markets

This table demonstrates the sample statistics for the index rates of return in which the indexes of the Mainland China and the Greater China stock markets are defined as one hundred times the continuously compounded percentage daily rate of returns. This sample covers the period from January 2 2001 to October 29 2012 for China (SHS), Hong Kong (HSI), Taiwan (TWS), Singapore (STI), Malaysia (KLCI), Indonesia (JKSE).

	SHS	HSI	TWS	STI	KLCI	JKSE
Mean	-0.001	0.015	0.014	0.019	0.037	0.094
Median	0.029	0.038	0.033	0.045	0.052	0.129
Maximum	9.401	12.058	7.928	8.351	5.122	9.242
Minimum	-9.918	-10.647	-12.778	-15.517	-13.250	-12.771
Std. Dev.	1.778	1.637	1.629	1.376	0.963	1.643
Skewness	0.015	-0.126	-0.393	-0.631	-1.790	-0.873
Kurtosis	6.950	8.516	7.672	14.605	26.690	11.231
Jarque-Bera	1630.88	3186.07	2345.43	14240.67	59986.64	7398.89
(probability)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 2 presents the estimated results of DLLFM used to figure out the latent common factors of the Greater China stock markets. For the estimation of DLLFM, standardized data are used in which the rates of return of the Greater China stock markets are divided by the standard deviation after removing a sample mean from it. Estimation results verify that heteroscedasticity and systematic jump are the common factors in the Greater China stock markets. Parameters β_0, β_1, and β_2, which refer to heteroscedasticity, are significant. Most of the estimated values of jumps are also estimated to be significant. Especially, the common jump of the Greater China stock markets is observed to occur about every 0.86 of a day with the jump frequency λ of 1.1659. The estimated amount of the average jump indicates that occurrence of the common jump behavior of the markets can lead to the rise of the Greater China stock markets. Given that the index rate of return of the Hong Kong stock market is normalized to 1.0 in the factor loadings, that of Taiwan, Singapore, Malaysia, and Indonesia is 0.8166, 1.0004, 0.7198, and 0.7693, respectively. This suggests that Singapore, Hong Kong, and Taiwan are relatively more sensitive to the movement of common factors, while Malaysia and Indonesia are relatively less sensitive.

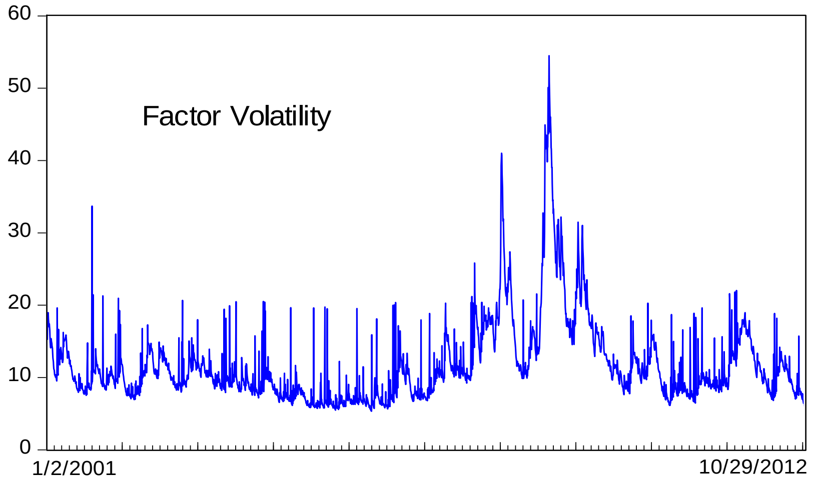
Table 2. The Estimation Values of DLLFM (2/1/2001–29/10/2012)

This table reports the estimates of the DLLFM. The data are used after standardizing daily returns, computed as one hundred times the logarithmic differences of the indexes of Hong Kong (HSI), Taiwan (TWS), Singapore (STI), Malaysia (KLCI), and Indonesia (JKSE), covering the period from January 1 2001 to October 29 2012. The rate of return of the Hong Kong (HSI) index was normalized to 1.0 in the factor loadings.

Parameter	Estimate	*t*-value
β_0	0.0028	(2.459)
β_1	0.1346	(6.613)
β_2	0.8617	(42.364)
λ	1.1659	(6.333)
μ	0.0989	(2.709)
υ	0.1043	(1.126)
γ_1(Hong Kong)	1.0000	-
γ_2(Taiwan)	0.8166	(36.401)
γ_3(Singapore)	1.0004	(45.305)
γ_4(Malaysia)	0.7198	(32.475)
γ_5(Indonesia)	0.7693	(31.233)
α_{10}	0.0024	(2.912)
α_{11}	0.0647	(4.844)
α_{12}	0.9270	(64.207)
α_{20}	0.0032	(3.066)
α_{21}	0.0589	(5.832)
α_{22}	0.9355	(88.110)
α_{30}	0.0031	(3.070)
α_{31}	0.1307	(5.016)
α_{32}	0.8606	(32.917)
α_{40}	0.0135	(4.050)
α_{41}	0.1689	(6.601)
α_{42}	0.8255	(31.612)
α_{50}	0.0142	(5.078)
α_{51}	0.1709	(8.178)
α_{52}	0.8232	(44.273)
Log Likelihood	-13229.49	

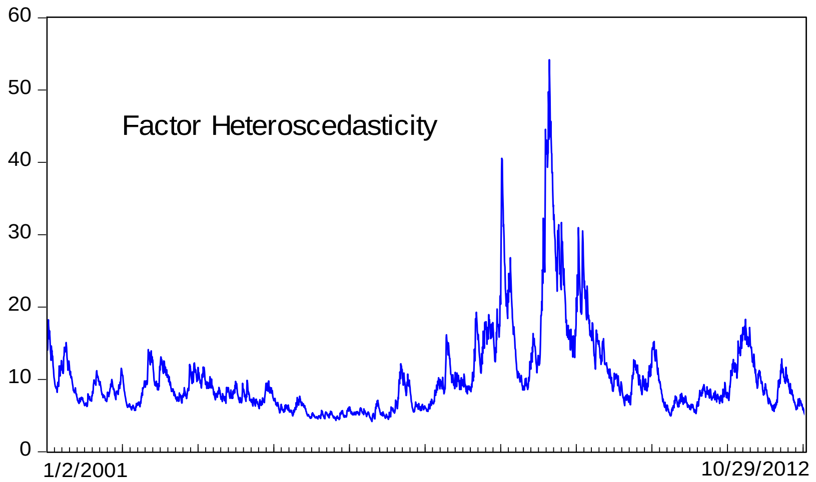
Figure 2 illustrates the common factors of the Greater China stock markets, which are estimated from DLLFM. The common factors are assumed to be heteroscedasticity and systematic jump risk in DLLFM. Figures 3 and 4 demonstrate heteroscedasticity and systematic jump risk, respectively. First, annualized conditional volatility, including both heteroscedasticity and systematic jump risk, as shown in Figure 2, was annualized by multiplying it by $\sqrt{255}$, the average number of trading days in a year. Annualized conditional volatility, which is the common factors of the Greater China stock markets, is 11.81% on average, 54.50% at maximum, and 5.23% at minimum. The highest annualized conditional volatility occurred in October 31 2008, which coincided with the period of the global financial crisis of 2008.

Figure 2. Annualized Conditional Volatility (2/1/2001–29/10/2012)



Notes: This figure shows annualized conditional volatility, which is the common factors of the Greater China stock markets, estimated from DLLFM. Annualized conditional volatility can be calculated from the daily volatility multiplied by $\sqrt{255}$,. The vertical axis indicates percentage.

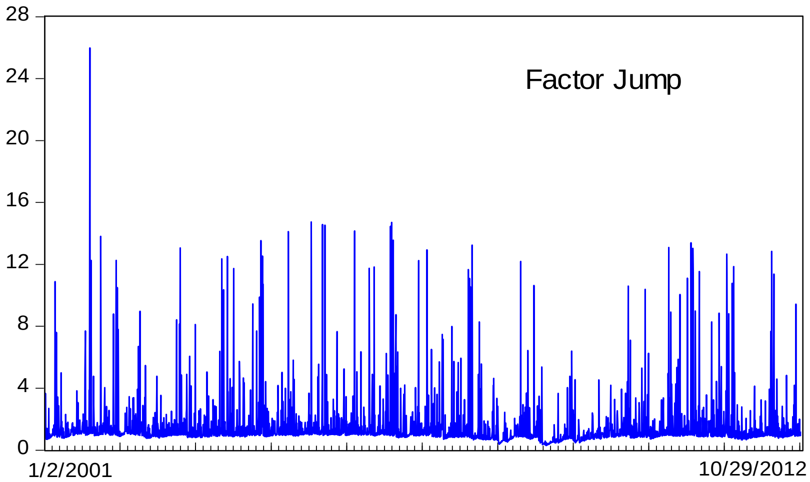
Figure 3. Heteroscedasticity of the Common Factors (2/1/2001–29/10/2012)



Notes: This figure shows heteroscedasticity of the common factors estimated from DLLFM. Heteroscedasticity can be calculated from the daily volatility multiplied by $\sqrt{255}$. The vertical axis indicates percentage

Figure 3 shows heteroscedasticity part of the common factors estimated from DLLFM. It shows a similar trend to that seen in Figure 2, whereby the similarity increases during the global financial crisis. On the other hand, with regard to the jump-driven part of the common factors, as shown in Figure 4, risks weighted by systematic jumps are higher in the periods other than the period of financial crisis.

Figure 4. Jumps of the Common Factors (2/1/2001–29/10/2012)

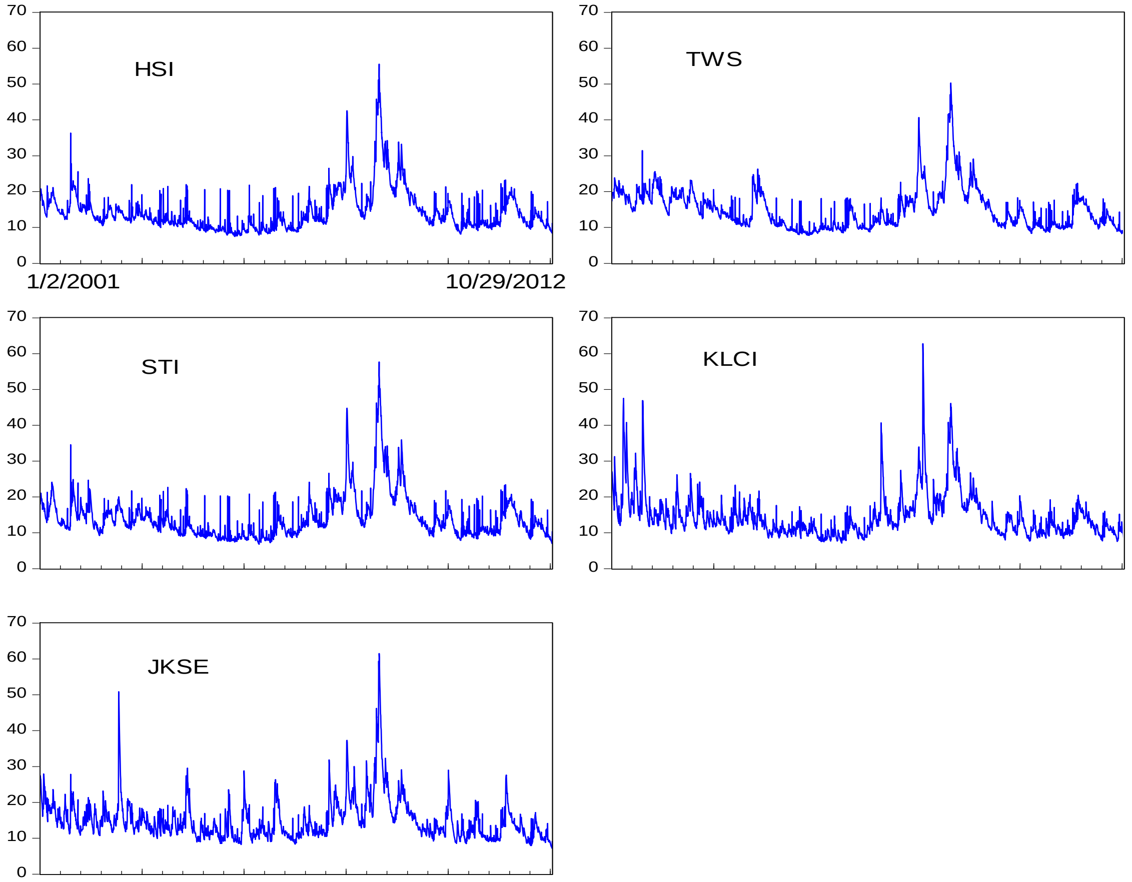


Notes: This figure shows jumps of the common factors estimated from DLLFM. Jumps can be calculated from the daily volatility multiplied by $\sqrt{255}$. The vertical axis indicates percentage

Figure 5 illustrates total volatility, which is weighted by the common factors of the Greater China stock markets using the factor loadings and then adds idiosyncratic volatility of individual markets. It can be observed that the movements of total volatility of individual Greater China stock markets rarely differ from each other. Average values of the total volatility do not show any significant difference, with Hong Kong showing 14.42%, Taiwan 14.96%, Singapore 14.22%, Malaysia 14.72%, and Indonesia 15.09%. By contrast, the maximum value of the total volatility of Malaysia is 62.78%, which is approximately 12.48% higher than that of Taiwan, which is 50.30%. The period of the maximized total volatility for Malaysia (the maximum value = 62.78%) appear on March 11 2008, which is different from that for other Greater China stock markets, that is, October 31 2008. Therefore, Figure 6 shows the idiosyncratic volatility of individual stock Greater China markets excluding the common factors, taking into account each stock market's different sizes of average volatility.

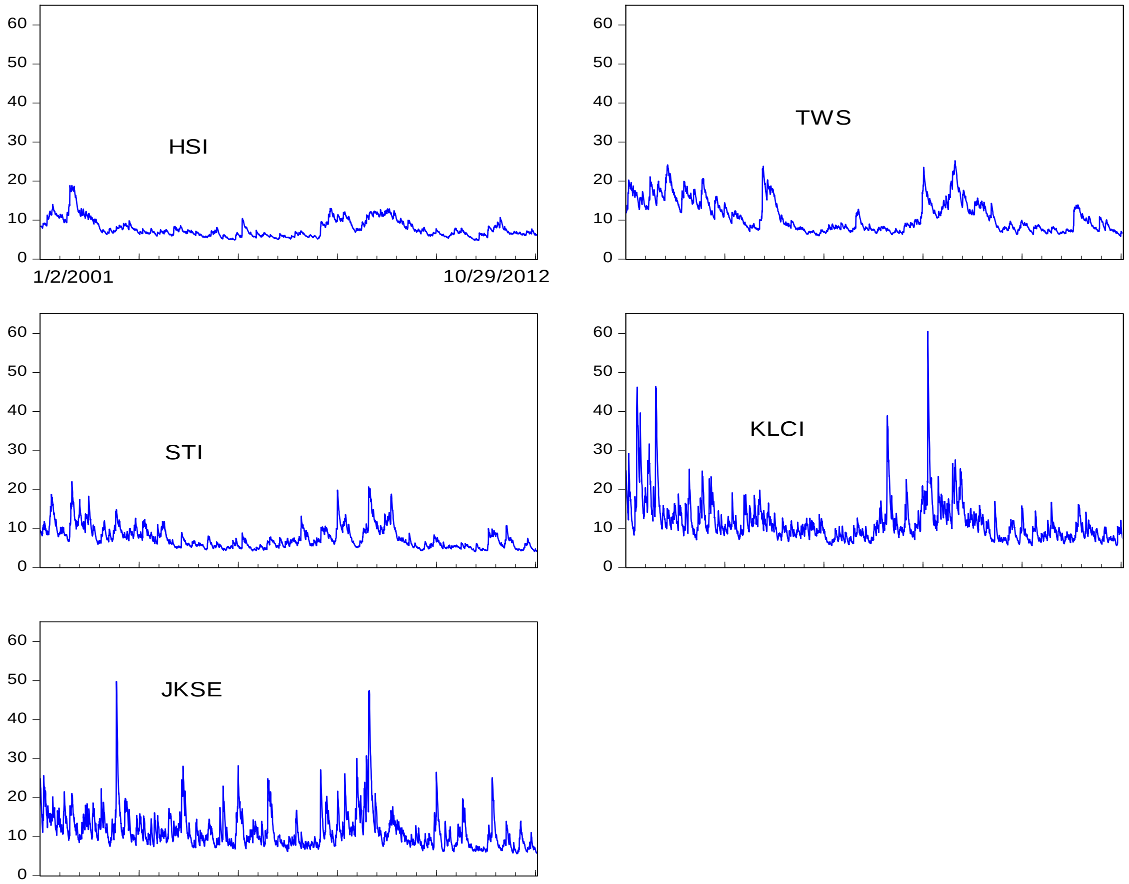
Figure 6 implies that Malaysia and Indonesia have high idiosyncratic volatilities, unlike other Greater China stock markets. The difference is more clearly manifested during the global financial crisis of 2008. The average of idiosyncratic volatilities are not significantly different, with 7.905% for Hong Kong, 11.06% for Taiwan, 7.57% for Singapore, 11.64% for Malaysia, and 11.64% for Indonesia. However, Hong Kong displays the lowest value, while Malaysia and Indonesia show the highest. Unlike the results of the total volatility analyzed above, Hong Kong, Taiwan, and Singapore show relatively lower idiosyncratic volatilities during the global financial crisis of 2008. On the other hand, Malaysia and Indonesia display the highest idiosyncratic volatilities for the period of the financial crisis. This implies that the idiosyncratic risks of Malaysia and Indonesia in the Greater China stock markets are relatively higher and increase during the global financial crisis of 2008.

Figure 5. Total Volatility of the Greater China Stock Markets (2/1/2001–29/10/2012)



Notes: This figure shows total volatility of the Greater China stock markets. Total volatility is weighted the common factors using the factor loadings and then adds idiosyncratic volatility. It depicts Hong Kong (HSI), Taiwan (TWS), Singapore (STI), Malaysia (KLCI), and Indonesia (JKSE) from upper-left.

Figure 6. Idiosyncratic Volatility of the Greater China Stock Markets (2/1/2001–29/10/2012)



Notes: This figure shows the idiosyncratic volatility of the Greater China stock markets estimated from DLLFM. Each idiosyncratic volatility can be calculated from the daily idiosyncratic volatility multiplied by $\sqrt{255}$. It depicts Hong Kong (HSI), Taiwan (TWS), Singapore (STI), Malaysia (KLCI), and Indonesia (JKSE) from upper-left.

Table 3 outlines the results of the Shanghai Composite index rates and the index rates of return of Shanghai A- and B-shares, estimated by the jump-diffusion GARCH model.[3] The estimation results reveal that most parameters relating to jump and heteroscedasticity are statistically significant, thus evidencing the existence of jump and heteroscedasticity in the Mainland China stock markets. The jump risk with relatively high statistical significance occurred in Shanghai Composite index rates of return around every 4.5 days (0.2239), demonstrating no great difference between A-share (4.5 days)

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[3] Jump-Diffusion GARCH model

$$R_t = \alpha_0 + \sum_{j=0}^{q_t} v_{jt} + \epsilon_t, \;\; \epsilon_t = \sigma_t \xi_t, \;\; \epsilon_t | \psi_{t-1} \sim N(0, \sigma_t^2), \;\; \xi_t \sim N(0,1), \; q_t \sim \frac{e^{-\lambda}\lambda^j}{j!}, v \sim N(\mu, v^2)$$

$$\sigma_t^2 = \beta_0 + \beta_1 \epsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2$$

and B-share (4.1 days) markets; thus, it is notable that the Shanghai Composite index is almost equal to the jump frequency of the A-share market, which is mainly traded in by domestic citizens.

Whereas the Shanghai Composite index and A-share market coefficient show little difference for heteroscedasticity, the relatively high value of the ARCH coefficient in the B-share market indicates that volatility in the B-share market is more sensitive to market movement. However, volatility is expected to last longer in the future, with the value of $\beta_1 + \beta_2$, that is, the persistence of volatility estimated as being higher in the A-share market than in the B-share market. In other words, the finding clarifies that foreigners or foreign institutional investors are more sensitive to market movement than domestic investors are, whereas persistence is markedly longer for the market in which mainly domestic investors trade. Figure 7 shows annualized conditional volatility of the Shanghai Composite index and A- and B-share index rates of return, which are estimated by Jump-Diffusion GARCH model in Table 4. Shanghai Composite index and A-share index showed a similar volatility movement, the B-share index showed the highest annualized conditional volatility of 142.21% at its peak on June 5 2007.

Table 3. Estimation Values of the Jump-Diffusion GARCH Model (2/1/2001–29/10/2012)

This table is given by Jump-Diffusion GARCH model. Data are Shanghai Composite index (SHS) and A- and B-share index rates of return computed as one hundred times the logarithmic difference of their levels and cover February 1 2001 to October 29 2012. Numbers in parentheses are *t*-values.

Parameter	SHS	A-shares	B-shares
α_0	-0.0198	-0.0189	0.0246
	(-0.662)	(-0.999)	(0.924)
λ	0.2234	0.2206	0.2438
	(2.902)	(2.964)	(6.850)
μ	0.0329	0.0281	-0.0774
	(0.535)	(2.198)	(-1.085)
ν	2.2000	2.2142	3.1469
	(7.142)	(7.273)	(13.521)
β_0	0.0130	0.0131	0.0630
	(2.219)	(2.323)	(4.049)
β_1	0.0777	0.0780	0.2431
	(4.821)	(4.976)	(6.873)
β_2	0.9137	0.9134	0.7397
	(52.075)	(54.028)	(20.731)
Log Likelihood	-4667.86	-4665.77	-5130.27

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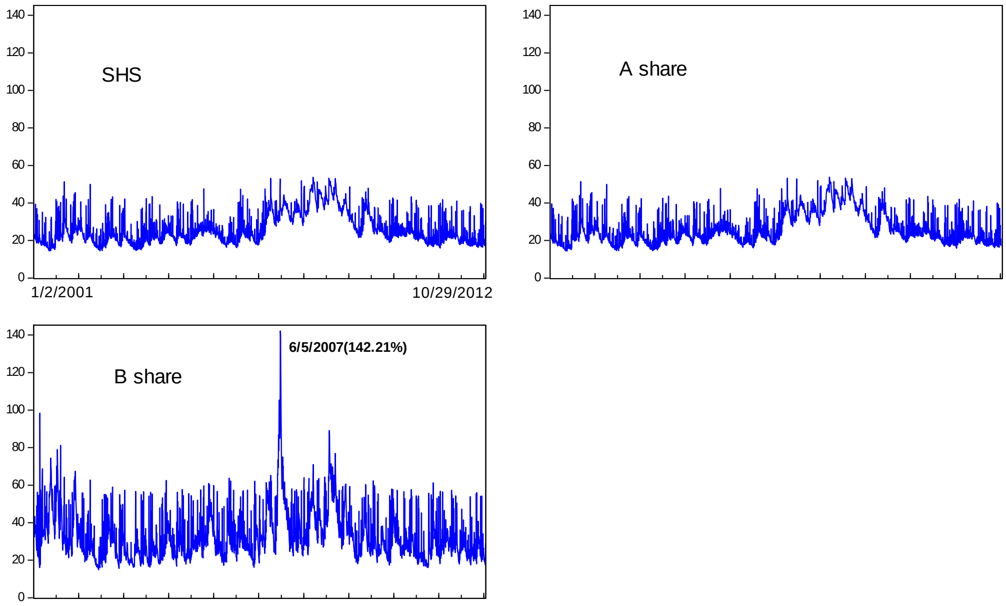
Figure 8. Annualized Conditional Volatility of the Mainland China Stock Markets (2/1/2001–29/10/2012)



Notes: This figure shows annualized conditional volatility of the Shanghai Composite index (SHS), A-shares and B-shares, estimated from Jump-Diffusion GARCH model. Annualized conditional volatility can be calculated from the daily volatility multiplied by $\sqrt{255}$. The vertical axis indicates percentage.

3.3. Common Factors of the Greater China and the Mainland China

As a result of DLLFM estimation, the common factors of the Greater China stock markets can be explained by systematic jump risk and heteroscedasticity arising from stochastic error terms. Further, results estimated from Jump-Diffusion GARCH model confirm that jump risk and heteroscedasticity exist in the Mainland China stock markets. First, the relation between the common factors of the Greater China stock markets (fGC_t) and annualized conditional volatility of Shanghai Composite index ($CVol_t$) in Mainland China is studied.

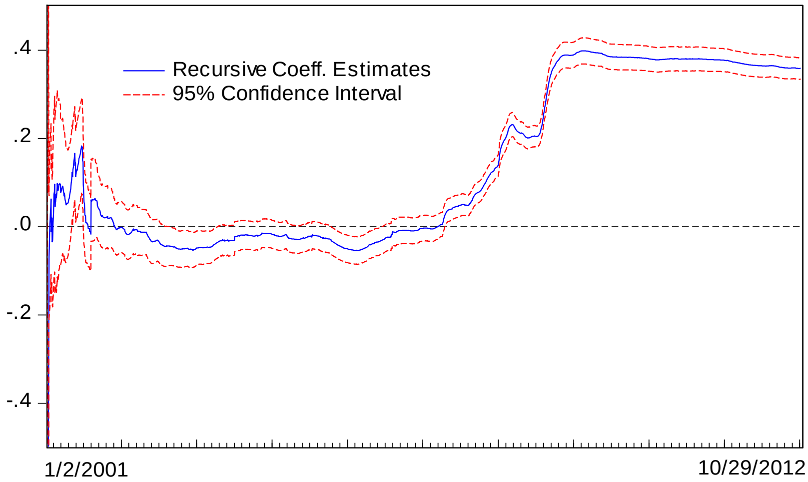
$$fGC_t = 2.3703 + 0.3592CVol_t + \epsilon_t$$

(7.045) (29.460)

$$\overline{R^2} = 0.257$$

A dependent variable fGC_t of the formula above is the annualized conditional volatility estimated by common factors of the Greater China stock markets. An explanatory variable $CVol_t$ refers to annualized conditional volatility of the rate of return of the Shanghai Composite index, estimated from Jump-Diffusion GARCH model. The estimated result shows that the risk associated with the Mainland China stock market accounted for about 25.7% of common factors of the Greater China stock markets. Figure 8 shows results of recursive least squares on the formula above with a 95% confidence interval. Given that the period that does not include 0 comes after March 2007 in Figure 8, it is not appropriate to use the market risk of the Mainland China stock market to explain the common factors of the Greater China stock markets before 2007.

Figure 8. Common Factors of the Greater China Stock Markets and Market Risk of Mainland (2/1/2001–29/10/2012)



Notes: This figure shows the recursive least squares results in which an explanatory variable is set as annualized conditional volatility of Shanghai Composite index rate of return, estimated by Jump-Diffusion GARCH model, to explain the common factors of the Greater China stock markets, which is estimated from DLLFM. The dotted line indicates a 95% confidence interval.

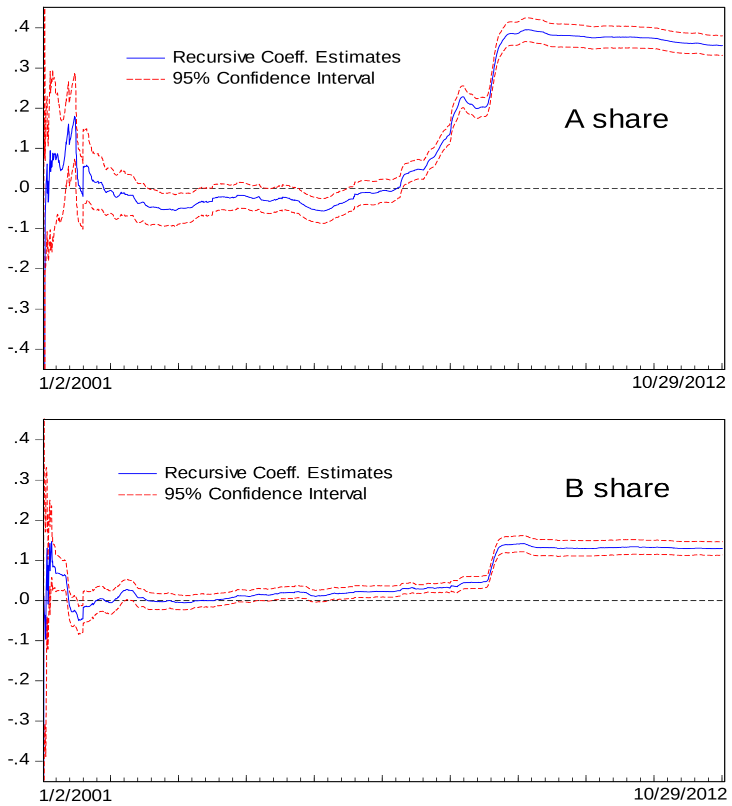
The difference between Shanghai A- and B-shares has been studied by subdividing the interrelations between the common factors of the Greater China stock markets and the Mainland China stock markets. A- and B-shares are markets distinguished from each other by domestic and foreign investors, respectively. They are indicative of the influence of domestic and foreign investors on the common factors of the Greater China stock markets. Table 4 shows the results of regression analysis of A- and B-share market risks based on the common factors of the Greater China stock markets. The results ascertain the significance of every estimated value. A-share market is about 2.8 times higher than B-share market in model $\overline{R^2}$. This demonstrates the greater tendency of the trade market predominated by domestic investors to display the common factors of the Greater China stock markets in the Mainland China stock markets as well.

Table 4. Common Factors of the Greater China stock markets and A- and B-share Market (2/1/2001–29/10/2012)

This table summarizes the OLS results in which an explanatory variable is set to be annualized conditional volatility of the Shanghai A- and B-share index rates of return, estimated by Jump-Diffusion GARCH model, to explain the common factors of the Greater China stock markets, estimated by DLLFM. Numbers in parentheses are *t*-values.

Parameter	A- shares		B-shares	
	Estimate	*t*-value	Estimate	*t*-value
β_0	2.4448	(7.280)	7.4515	(24.979)
β_1	0.3565	(29.291)	0.1307	(15.797)
$\overline{R^2}$	0.255		0.090	

Figure 9. Common Factors of the Greater China Stock Markets and A- and B-share Market (2/1/2001–29/10/2012)



Notes: This figure shows the recursive least squares results in which an explanatory variable is set as annualized conditional volatility of the Shanghai A- and B-share index rates of return, estimated by Jump-Diffusion GARCH model to explain annualized conditional volatility, which is a common factors of the Greater China stock markets, estimated by DLLFM. The dotted line indicates a 95% confidence interval.

Figure 9 demonstrates the results of conducting recursive least squares on Shanghai A- and B-shares in Table 4, with a 95% confidence interval. According to Figure 9, A- and B-shares begin to have a significant β_1 value around the same time. However, the β_1 value of the A-shares is relatively higher and more significant.

4. Summary and conclusions

Compared to a decade ago, the influence and importance of China's economy have increased both in Asia and globally. China's economy has been growing daily, owing to its huge territory and population, rich natural resources, and so on. Compared to other countries, China has also recovered relatively faster from the global financial crisis of 2008. Further, China's development supported the development of other countries belonging to the Greater China region in cultural, political, and geographical terms. The handover of Hong Kong in 1997, in particular, provided great momentum for the development of Chinese stock markets. Therefore, the Mainland China and the Greater China stock markets are expected to exercise more and more influence globally as they increase in importance beyond the boundary of Asia.

Against this backdrop, this study aims to figure out the latent common factors of the Greater China stock markets and their correlation with the Mainland China stock markets. As a result, it finds that the Greater China stock markets have the common factors: systematic jump risk of the market and heteroscedasticity arising from stochastic error terms. It is also confirmed that the risk associated with the Mainland China stock market accounts for about 26% of the common factors of the Greater China stock markets. With respect to the correlation regarding A- and B-share markets, the Greater China stock markets are more related to domestic investors in Mainland China, with the A-share market risk demonstrating a stronger explanatory power than the B-share market risk.

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