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Stock Market Integration and Financial Crises: Evidence from Chinese Sectoral Portfolios

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Abstract: This paper assesses China's integration with the global stock market during crisis and non-crisis periods within a two-beta Capital Asset Pricing Model framework. We obtain time-varying global and national systematic risks for ten Chinese sectors from a state-space representation and investigate how these risks are priced within and without crisis. Crisis is modelled by, firstly, a dummy variable approach and, secondly, the Markov regime-switching technique. Consistent with the literature, the degree of integration with the global market is found to be strengthened in crises. Complete integration is, however, only evident in the recent financial crisis and then not in all sectors. In other high-volatility episodes, partial integration is more evident, suggesting the opportunity for international risk diversification into China even in crises. Particular to the Chinese context, the weak integration of some sectors that appear to show financial openness may be because public sector equity holdings leave those sectors exposed to national systematic risk through a political channel.

Keywords: Asset pricing; Financial crisis; Regime-switching; Stock market integration; Time-varying systematic risk

JEL Classifications: C32, F36, G12, G15

1. Introduction

The extent of cross-border integration of stock markets is an important consideration when gauging the potential benefits of international portfolio diversification. The study of stock market integration has led naturally to a discussion of whether the benefits of such diversification might disappear during crises - when stock market indices may be more highly correlated. To date, few studies have examined the desirability of international equity diversification into China during crisis and non-crisis periods. The rapidly increasing importance of China within the global economy makes this a significant omission. We address this omission by investigating the impact of financial crises on China's asset pricing within the framework of an augmented Capital Asset Pricing Model (CAPM) using data for ten industry-specific sectors during 1997-2013.

Following Stehle (1977) and Jorion and Schwartz (1986), we carry out the empirical analyses within an augmented CAPM framework, namely an international CAPM augmented with orthogonalised national excess return and a domestic CAPM augmented with orthogonalised global excess return. In the CAPM context, markets are "integrated" if systematic risk relative to the global market is the only significant factor in asset pricing in the local market. Discovering that the national risk also makes a significant contribution is evidence against the integration hypothesis. Discovering that only the national risk is significant would be evidence in favour of "segmentation".

The two-beta asset-pricing model provides a benchmark for modelling how Chinese sectoral portfolios price the global and national systematic risks. However, the portfolio returns might vary between tranquil and crisis periods because of changes in exposures to systematic risks (Vermeulen, 2013). We therefore control for crises when testing for risk exposures.

Acknowledging potential heterogeneity in the components of aggregate stock market indices, we apply the procedure developed in Li (2013) to Chinese sectoral data. The application to the sectoral data implicitly controls for cross-sector heterogeneity in financial openness and strategic importance and ensures fair tests of the statistical significance of global and national systematic risks across sectors. We find that, at the sectoral level, the degree of integration with the global market is not positively related to the extent of financial openness. In the case of China, sectors that are open are also considered strategically important by the authorities, making the sectors prone to state interference and thus exposed to the national systematic risk, - limiting their chances of complete integration with the global market. Our study therefore helps explain why seemingly more open markets may not necessarily be more integrated with the global market, providing empirical evidence to support the assertion (Bakeart, 1995; Li, 2013) that the degree of market integration is not necessarily associated with direct barriers to investment.

Our study has implications for financial decision-making. We confirm that market integration strengthens in crises but may not be complete. Even the scale of the recent financial crisis left five out of ten sectors under study only partially integrated with the global market. In other high-volatility episodes, also, it is partial integration that becomes more evident. These findings suggest some opportunity for international portfolio diversification into China even in crises - when other national markets become more strongly integrated with the global market.

The remainder of the paper is organised as follows. Section 2, reviews the literature on stock market integration and the impact of financial crises on such integration. Section 3 describes our empirical framework. We implement the test procedures in section 4. Section 5 concludes.

2. Literature Review

Our paper relates most closely to the growing literature on stock market integration in the context of asset pricing models. Stehle (1977) finds that the pricing of US securities is significantly related to a global market portfolio. Conversely, Jorion and Schwartz (1986) find strong evidence of segmentation relative to the North American market in the pricing of Canadian stocks during 1963-1982. Mittoo (1992) examines the integration between Canadian and US stock markets during 1977-1986 using the augmented CAPM and a multi-factor pricing model. Both models suggest that segmentation occurs during 1977-1981 and integration during 1982-1986. Wang and Di Iorio (2007) apply the approach of Jorion and Schwartz (1986) to the investigation of the segmentation / integration of three China-related stock markets and find that Chinese A-, B- and H-share markets were all segmented from the global market during 1995-2004. Li (2013) finds evidence of partial integration, i.e. positively priced national and global systematic risks in all the Chinese stock markets except the unrestricted Shanghai B-share market during 2000-2010. The Shanghai B-share market is, unexpectedly, found to be segmented from the global market, motivating us to further explore the issue of China's stock market integration.

A question of particular interest for international investors and policymakers is whether stock market integration strengthens in times of crisis. The literature has addressed this question through focusing on the impact of crises on stock market interdependence. Karolyi and Stulz (1996) and Ang and Chen (2002), confirm that markets are more highly correlated in periods of global crisis. Although Forbes and Rigobon (2002) question whether correlations across multi-country returns are *significantly* higher during crisis periods subsequent studies, such as Boyer, *et al.* (2006) and Rodriguez (2007) confirm the higher correlations during crises. As for the recent global financial crisis, while Morales and Andreosso-O'Callaghan (2012) do not find stronger correlations between the market returns in the US and ten major Asian economies, Aloui, *et al*. (2011) observe stronger and more persistent dependency on the US market for Brazil and Russia, whose national incomes are highly dependent on world commodity prices, than for China and India, whose economic growth is largely influenced by exports of finished-products. On balance, the literature on stock market interdependence points to stronger correlations between national market returns in crises.

While Beine, *et al.* (2010) suggest that the increase in stock market interdependence is due to simultaneous deterioration of fundamentals across countries, Vermeulen (2013) argues that the reason may be an increased propensity for hedging during crisis periods, when risk-averse investors attempt to stabilise their wealth by increasing their acquisition of foreign assets that are less correlated with their domestic equities. This argument inspires us to investigate the impact of financial crises in the setting of an asset-pricing model, where exposures to national and global risks can be estimated separately.

3. Empirical Framework

3.1 Two-beta asset pricing models

Following Stehle (1977) and Jorion and Schwartz (1986), our empirical study is carried out within an augmented CAPM framework. We employ both an international CAPM augmented with a pure national systematic risk and a domestic CAPM augmented with a pure global systematic risk. The basic empirical models permitting time-varying systematic risks, as suggested by Li (2013) are as follows.

$$R_t = \mu_t^G + \beta_t^G R_{Gt} + \beta_t^{N-G} \omega_{(N-G)t} + e_t^G \qquad (1)$$

and

$$R_t = \mu_t^N + \beta_t^N R_{Nt} + \beta_t^{G-N} \omega_{(G-N)t} + e_t^N \qquad (1')$$

For each sectoral portfolio, β^G and β^N are the systematic risks relative to the global and national market returns, R_G and R_N, respectively. The terms β^{N-G}, β^{G-N} represent systematic risks relative to the national and global markets, that are independent of (respectively) the global and national markets. Empirical counterparts to the independent market returns, $\omega_{(N-G)}$ and $\omega_{(G-N)}$, are constructed by a least squares decomposition: an OLS regression of the national (/global) market return upon the global (/national) return produces residuals that are uncorrelated with the global (/national) return and thus serve as "pure" national (/global) returns. The intercepts of equations (1) and (1') are restricted respectively to be $\mu_t^G = \gamma_0(1-\beta_t^G) + \gamma_2\beta_t^{N-G}$ and $\mu_t^N = \delta_0(1-\beta_t^N) + \delta_2\beta_t^{G-N}$. We allow the parameters of equations (1) and (1') to follow random walks and use the Kalman smoothing technique to estimate the time-varying parameters in these state space models. The values for these time-varying parameters: μ_t^G, β_t^G, β_t^{N-G}, μ_t^N, β_t^N and β_t^{G-N}, can then be substituted respectively in the following two-factor asset pricing models, implied by the restrictions, to test for integration and segmentation:

$$\mu_t^G = \gamma_0(1-\beta_t^G) + \gamma_2\beta_t^{N-G} + \xi_t^G \quad (2)$$

and

$$\mu_t^N = \delta_0(1-\beta_t^N) + \delta_2\beta_t^{G-N} + \xi_t^N \quad (2')$$

A null hypothesis of integration can therefore be tested against the alternative of positive exposure to the purely national systematic risk as $H_0: \gamma_2 = 0$ vs. $H_A: \gamma_2 > 0$ in equation (2). Similarly a null of segmentation can be tested as $H_0: \delta_2 = 0$ vs. $H_A: \delta_2 > 0$ in equation (2'). As suggested by more recent literature such as Hardouvelis, *et al.* (2006), stock markets may be partially integrated when both the global and national systematic risks are significantly and positively priced in equations (2) and (2').

3.2 Impact of financial crises on asset pricing

To examine the impact of crises on stock market integration, we apply two approaches. Firstly, we introduce an indicator, D_t, for the recent global financial crisis, with D_t=1 from August 2007 to March 2009 and, D_t=0 otherwise. D_t interacts with the regressors in equations (2) and (2') to permit a structural break, as follows:

$$\mu_t^G = \gamma_0(1-\beta_t^G) + \gamma_2\beta_t^{N-G} + c_{\gamma_0}D_t(1-\beta_t^G) + c_{\gamma_2}D_t\beta_t^{N-G} + \xi_t^G \quad (2.1)$$

and

$$\mu_t^N = \delta_0(1-\beta_t^N) + \delta_2\beta_t^{G-N} + c_{\delta_0}D_t(1-\beta_t^N) + c_{\delta_2}D_t\beta_t^{G-N} + \xi_t^N \quad (2.1')$$

A hypothesis of integration during the crisis period is represented by $\gamma_2 + c_{\gamma_2} = 0$ in equation (2.1), whilst segmentation can be represented by $\delta_2 + c_{\delta_2} = 0$ in equation (2.1').

Schwert (1989 and 1990) shows that stock return volatility increases after stock prices fall during recessions and around financial or banking crises. Hence we can associate high-volatility periods with crises generally. As an alternative to the dummy variable approach described above, we also use the Markov two-state regime-switching technique to endogenously categorise episodes within the sample period into periods of high volatility or low volatility as follows.

$$\mu_t^G = \gamma_{0,s_t}(1-\beta_t^G) + \gamma_{2,s_t}\beta_t^{N-G} + \xi_t^G \quad (2.2)$$

and

$$\mu_t^N = \delta_{0,s_t}(1-\beta_t^N) + \delta_{2,s_t}\beta_t^{G-N} + \xi_t^N \quad (2.2')$$

where $var(\xi_t^G) = \sigma_{G,s_t}^2$ and $var(\xi_t^N) = \sigma_{N,s_t}^2$ with $s_t \in [1,2]$. The parameters in this system are estimated jointly by maximum likelihood. The estimated parameters with $s_t = 1$ ($/s_t = 2$) capture market behaviour during tranquil (/ turbulent) episodes.

4. Empirical Results

4.1 The data

The ten sectors under study are Basic Materials, Consumer Goods, Consumer Services, Financials, Healthcare, Industrials, Oil and Gas, Technology, Telecom, and Utilities. Before any formal statistical tests, we look at sectoral stock market activity, financial openness and strategic importance during the period to be studied.

Data for statistical modelling in this study are monthly time series from January 1997 until March 2013, covering the recent financial crisis and avoiding the early development of China's stock market. The global market portfolio is represented by the MSCI world all country index. The national market index is represented by Datastream's China A-share market index, as this covers the vast majority of stock listings on China's main stock exchanges in Shanghai and Shenzhen. The ten sectoral portfolios are represented by Datastream's A-share sectoral indices. All the Chinese indices are converted into US dollars, using dollar/yuan exchange rates obtained from the website of the US Federal Reserve. We use the US 30-day Treasury bill return, obtained from Kenneth French's website[1], as the risk-free rate for the world index and the interest rate for the Chinese 3-month time deposit as the risk-free rate for all the Chinese indices. The excess returns of the global index and the Chinese national and sectorial indices are calculated as the realised returns minus their respective risk-free rate.

Table 1 presents summary statistics of the returns under study. For the full sample period, the returns of the Chinese national and sectoral indices have higher standard deviation than does the global ("MSCI World") market index. This could have been due to the relatively low percentages of free-float shares within the sectoral and national indices. (A stock with a small float is generally more volatile than that with a large float.) This high volatility of the Chinese indices is compensated by higher than average returns in seven of the ten sectoral indices. During the recent crisis period, all of the equity indices under study exhibit increased variance and reduced mean returns. The increase in variance is higher for the Chinese indices, again compensated by smaller reductions in mean returns. It should be noted that the correlation between the Chinese A-share index and the MSCI all country index is lower in the crisis period than in the full period under study, contrary to the expectations of Longin and Solnik (1996) and Ang and Chen (2002).

Table 1. Summary statistics of the realized returns

	1997.01 – 2013.03		**2007.08-2009.03**	
	Mean (%)	s.d.(%)	Mean (%)	s.d.(%)
MSCI World AC index	0.287	5.262	-4.060	7.458
US risk-free rate	0.215	0.176	0.169	0.118
China A market index	0.322	8.589	-1.986	14.390
Chinese risk-free rate	2.233	0.595	2.844	0.619
Basic materials	0.207	10.664	-2.378	19.775
Consumer goods	0.384	9.429	-1.708	16.737
Consumer services	0.526	9.840	-2.390	17.293
Financials	0.416	10.022	-1.733	13.223
Healthcare	0.527	9.246	-0.327	14.671
Industrials	0.072	10.254	-2.004	16.393
Oil & Gas	0.483[a]	9.543[a]	-1.839	17.806
Technology	0.537[b]	10.802[b]	-1.389	18.897
Telecom	-0.189	11.918	-0.079	15.734
Utilities	0.334	9.183	-1.114	15.556
Correlation coefficient between World market and China A-market indices	0.17271		0.05409	

Notes: [a] Sample period is April 1998-March 2013; [b] Sample period is April 1997-March 2013.

[1] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

4.2 Estimates of the global and national systematic risks

We first estimate, for each of the Chinese sectoral portfolios, constant parameter versions of equations (1) - an international CAPM augmented with the purely national excess return, and (1') - a domestic CAPM augmented with the purely global excess return. The OLS coefficients, reported in Table 2, serve as estimates for a set of benchmark time-invariant systematic risks: β^G, β^{N-G}, β^N and β^{G-N}. For all sectors, except Consumer Goods, Technology and Utilities, the estimated parameters of equation (1') favour a null hypothesis of a simple domestic CAPM ($\beta^{G-N} = 0$) when tested at the 10% level of significance. In equation (1), β^{N-G}, the coefficient on the purely national excess return is significant and positive for all sectors, rejecting a simple international CAPM. The estimated domestic effects, β^N and β^{N-G}, are similar in magnitude and both positively signed; they are larger than the estimated global effects, β^G, and β^{G-N}. The balance of evidence obtained by this "constant-betas" approach favours segmentation rather than integration, inasmuch as domestic factors are essentially relevant to the pricing of Chinese equities. This result should, however, be treated as purely exploratory since the literature offers many reasons to question the adequacy of a constant parameter CAPM.

Table 2. Estimates of equations (1) and (1') by OLS for period 1997.01-2013.03

	Equation (1)			Equation(1')		
	μ 2-tailed	β^{G} 2-tailed	β^{N-G} 2-tailed/1-tailed	μ 2-tailed	β^{N} 2-tailed	β^{G-N} 2-tailed/1-tailed
Basic Materials	-2.054*** (0.285)	0.383*** (0.054)	1.149***/*** (0.033)	0.182 (0.292)	1.155*** (0.033)	0.055 (0.055)
Consumer Goods	-1.860*** (0.334)	0.158** (0.064)	0.969***/*** (0.039)	-0.020 (0.342)	0.957*** (0.038)	-0.119*/** (0.065)
Consumer Services	-1.731*** (0.339)	0.329*** (0.065)	1.002***/*** (0.040)	0.217 (0.347)	1.007*** (0.039)	0.043 (0.066)
Financials	-1.837*** (0.372)	0.272*** (0.071)	0.995***/*** (0.044)	0.082 (0.381)	0.994*** (0.043)	-0.012 (0.072)
Healthcare	-1.715*** (0.453)	0.128 (0.086)	0.803***/*** (0.053)	-0.190 (0.464)	0.793*** (0.052)	-0.101 (0.088)
Industrials	-2.184*** (0.360)	0.324*** (0.069)	1.030***/*** (0.042)	-0.187 (0.369)	1.033*** (0.042)	0.030 (0.070)
Oil & Gas [a]	-1.714*** (0.402)	0.342*** (0.075)	0.929***/*** (0.048)	0.101 (0.412)	0.937*** (0.047)	0.076 (0.076)
Technology [b]	-1.694*** (0.522)	0.133 (0.099)	0.989***/*** (0.063)	0.176 (0.535)	0.973*** (0.062)	-0.155*/* (0.100)
Telecom	-2.437*** (0.671)	0.211* (0.128)	0.861***/*** (0.079)	-0.783 (0.687)	0.857*** (0.077)	-0.035 (0.130)
Utilities	-1.907*** (0.339)	0.114* (0.065)	0.926***/*** (0.040)	-0.158 (0.347)	0.911*** (0.039)	-0.150**/*** (0.066)

Notes: The heteroscedasticity-consistent (Eicker-White) standard errors are in square brackets;
***, ** and * represent significance levels of 1%, 5% and 10%, respectively, against 1-tailed or 2-tailed alternatives, as indicated;
[a] Sample period is 1998.04-2013.03; [b] Sample period is 1997.04-2013.03.

To obtain time-varying systematic risks, we re-estimate equations (1) and (1'), using the Kalman smoothing technique, suppressing the first twenty data points to avoid instability and extreme values that are typical in the initialisation period of the smoothing algorithm. The time-varying systematic risks obtained from equations (1) and (1') are graphed in Figures 1 and 2 on the following pages, respectively. These figures show that the national systematic risks vary relatively more, especially in the sectors of Financials, Industrials, Telecom and Technology. The national systematic risks are confirmed to be greater than the global systematic risks in all cases. The estimates of the time-varying national systematic risk, β^N, in Figure 2 are approximately the same in magnitude as those of the purely national systematic risk, β^{N-G}, in Figure 1.

Given that β^N includes the component of the global excess return that is not orthogonal to the national excess return, we interpret the same magnitude of β^{N-G} and β^N as evidence suggesting that such global excess return may have minimal influence on the excess returns in the Chinese markets. The estimates of the global systematic risk, β^G, in Figure 1 are generally higher than the estimated purely global systematic risk, β^{G-N}, of Figure 2, confirming that the component part of the national excess return which is not orthogonal to the global excess return is amplifying the effect of the global excess return. These conclusions reinforce the impression, gained from OLS estimation of the constant-parameter models, that the national excess returns play a more significant role than the global ones in the pricing of Chinese portfolios. Since most of the Chinese industry-based indices are less sensitive to the changes in the global market return, there appears to be some suggestion that these sectors may provide international investors with an opportunity for risk diversification.

4.3 Tests for integration versus segmentation

In order to formally test for integration versus segmentation during the period under study, we substitute the time-varying coefficients of equations (1) and (1') into equations (2.1) and (2.1'), respectively. The estimated results for equations (2.1) and (2.1') are reported in Table 3. These results suggest that an analysis with time-varying betas leads to conclusions that differ from those obtained under a fixed-beta constraint, where estimation favoured a simple domestic CAPM ("segmentation"). Now, with time-varying betas, the segmentation hypothesis requires $\delta_2 = 0$ in equation (2.1'), and we find this only for the Consumer Goods sector. Additionally, in this sector, the coefficient, δ_0, of the national systematic risk is correctly signed[2] and statistically significant, suggesting that the national systematic risk is the only significant factor in its asset pricing. In all other sectors there is evidence of international influence on China's asset pricing, albeit with an unexpected negative sign in some cases. Specifically, we reject the null hypothesis of $\delta_2 = 0$ in favour of $\delta_2 > 0$ in the sectors of Basic Materials, Financials, Healthcare, Oil and Gas, and Utilities. The coefficient of the national systematic risk, δ_0, is correctly signed and statistically significant in all these sectors, except Utilities. Hence these sectors, except for Utilities, are 'partially integrated' with the global market as in Hardouvelis, *et al.* (2006).

[2] In equations (2.1) and (2.1'), the coefficients γ_0, δ_0, $(\gamma_0 + c_{\gamma_0})$, $(\delta_0 + c_{\delta_0})$ should be negative in order for the global and national systematic risks to be positively priced.

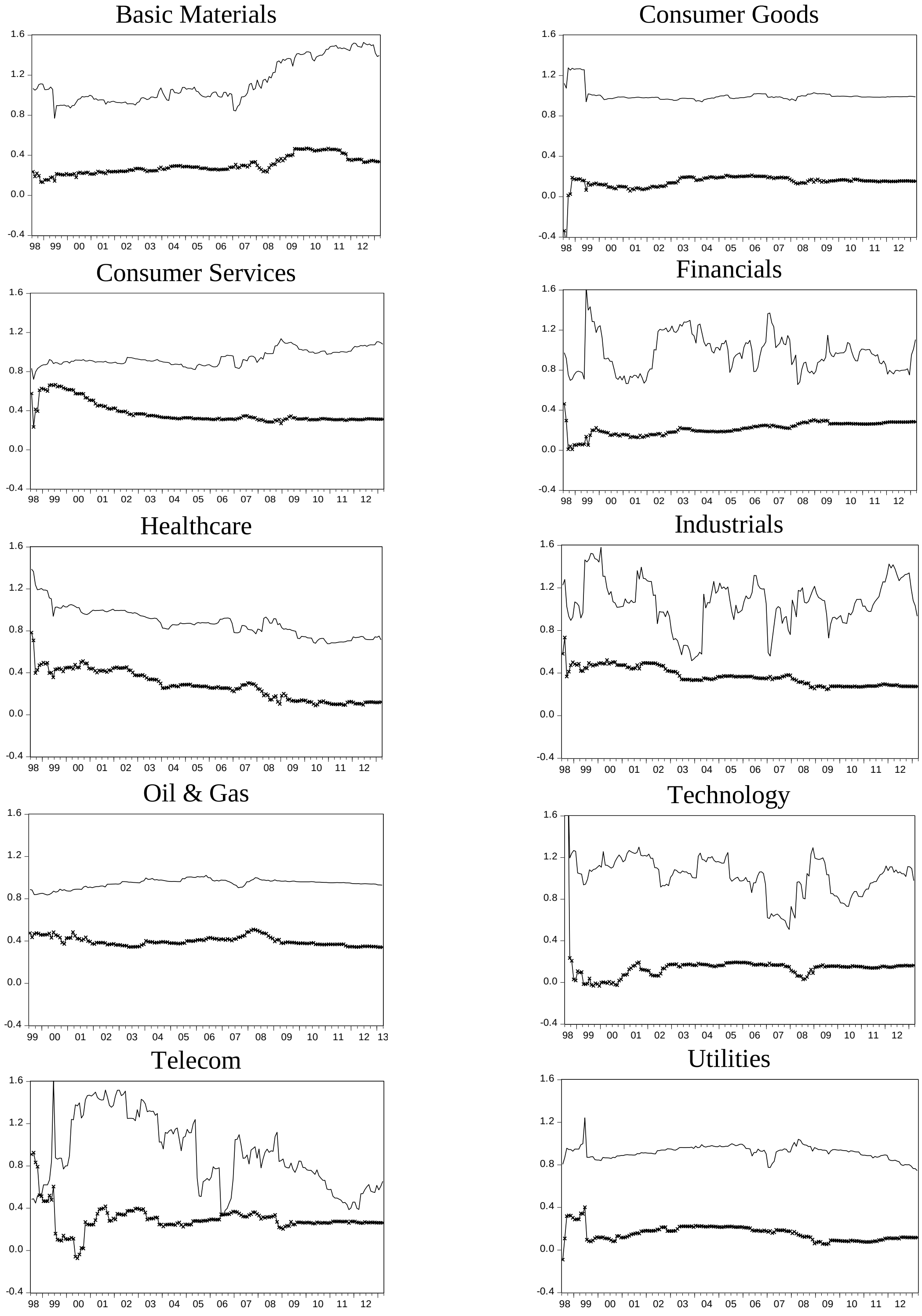

Figure 1. Time-varying systematic risks: global and purely national

Notes: Lines drawn as -x-x-x- represent the global systematic risk (β^G) and those drawn as — are the purely national systematic risk (β^{N-G}). These are estimated from equation (1) by the Kalman smoothing technique.

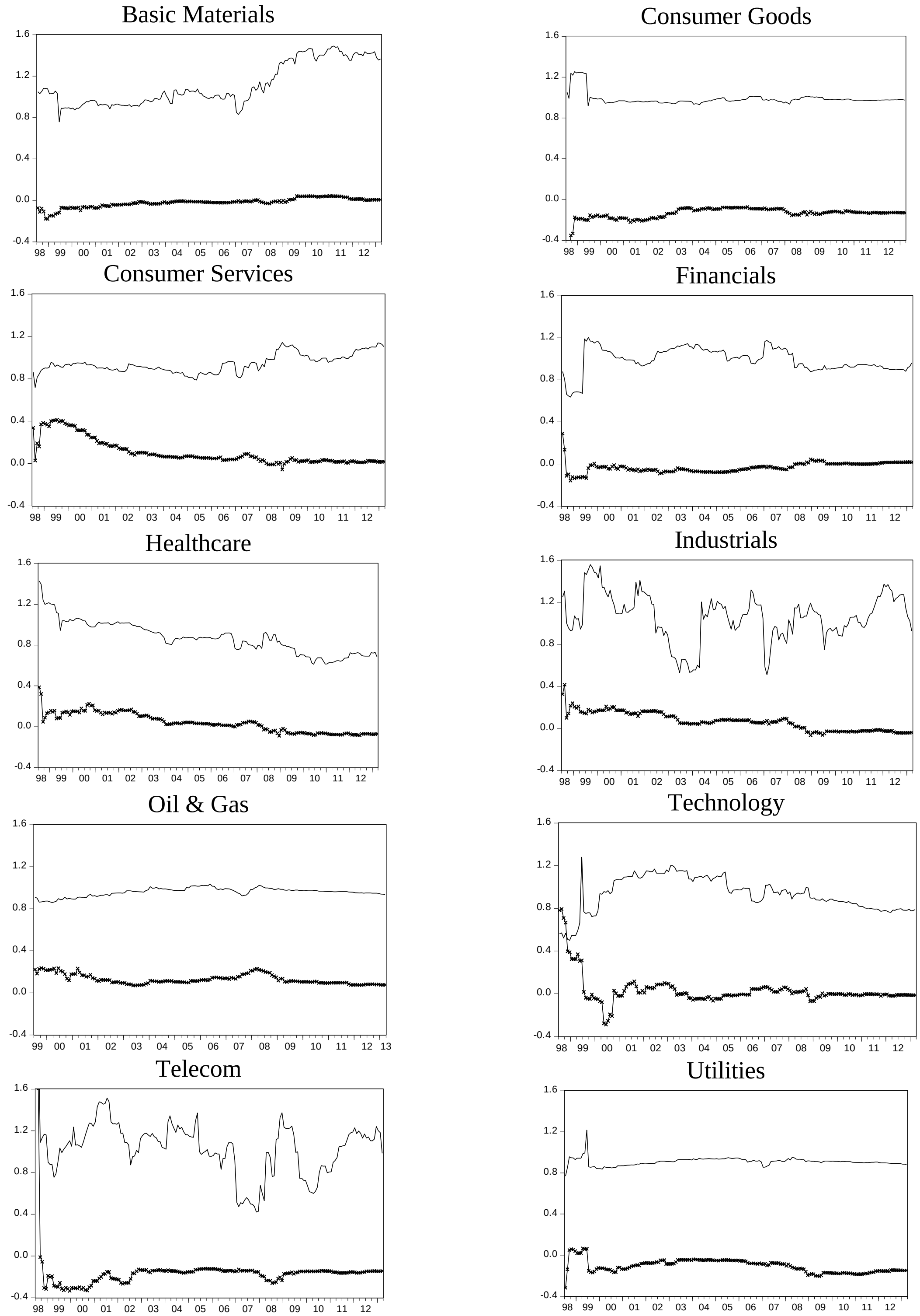

Figure 2. Time-varying systematic risks: national and purely global

Notes: Lines drawn as -x-x-x- represent the purely global systematic risk (β^{G-N}) and those drawn as — are the national systematic risk (β^{N}). These are estimated from equation (1') by the Kalman smoothing technique.

Table 3. OLS estimates of equations (2.1) and (2.1') during period 1998.07-2013.03 [a]

	Basic Materials	Consumer Goods	Consumer Services	Financials	Healthcare	Industrials	Oil & Gas [b]	Technology	Telecom	Utilities
Equation (2.1): Testing the integration hypothesis										
γ_0	-2.364*** (0.059)	-1.492*** (0.463)	3.142*** (0.524)	-4.001*** (0.121)	-2.113*** (0.148)	-2.719*** (0.375)	-6.499*** (0.849)	-0.578*** (0.150)	-3.603*** (0.219)	-1.844*** (0.175)
γ_2	-0.211*** (0.037)	-0.688** (0.395)	-4.446*** (0.349)	0.497*** (0.096)	-0.126 (0.119)	-0.733*** (0.217)	2.461*** (0.551)	-0.411*** (0.123)	0.270** (0.160)	-0.076 (0.161)
$c_{\gamma 0}$	0.976*** (0.390)	3.167 (4.316)	-3.271 (3.365)	0.051 (0.681)	3.035* (2.225)	-3.714* (3.279)	6.567*** (2.700)	-0.853* (0.648)	2.046 (1.679)	1.608* (1.152)
$c_{\gamma 2}$	-0.456** (0.229)	-2.760 (3.659)	2.845 (2.323)	0.037 (0.508)	-2.980* (2.077)	3.089* (2.120)	-3.901** (1.534)	0.227 (0.624)	-1.840* (1.287)	-1.627* (1.032)
$\gamma_0 + c_{\gamma 0}$	-1.388** (0.386)	1.675 (4.291)	-0.129 (3.324)	-3.950*** (0.607)	0.922 (2.220)	-6.433** (3.257)	0.068 (2.562)	-1.431** (0.637)	-1.558 (1.665)	-0.237 (1.138)
$\gamma_2 + c_{\gamma 2}$	-0.667*** (0.226)	-3.448 (3.673)	-1.601 (2.296)	0.534 (0.498)	-3.107* (2.073)	2.356 (2.109)	-1.439 (1.431)	-0.133 (0.611)	-1.570 (1.277)	-1.703** (1.020)
Equation (2.1'): Testing the segmentation hypothesis										
δ_0	-1.389*** (0.061)	-4.297*** (0.551)	-1.567*** (0.442)	-3.319*** (0.337)	-0.599** (0.243)	-1.232*** (0.255)	-8.599*** (0.694)	-2.896*** (0.318)	-3.164*** (0.254)	3.433*** (0.545)
δ_2	1.785*** (0.284)	0.078 (0.222)	-3.495*** (0.278)	7.314*** (0.644)	3.891*** (0.451)	-4.909*** (0.545)	4.441*** (0.381)	-2.755*** (0.317)	-0.988*** (0.306)	2.461*** (0.436)
$c_{\delta 0}$	0.562** (0.254)	3.352 (4.081)	1.350 (1.595)	-0.166 (2.383)	-0.521 (0.729)	-0.437 (1.787)	9.327*** (3.619)	3.060*** (0.784)	-4.172*** (1.606)	-4.346* (2.722)
$c_{\delta 2}$	-12.47*** (3.124)	0.708 (1.015)	9.862*** (3.527)	2.768 (6.440)	-4.078* (2.857)	4.463 (4.108)	-1.527** (0.662)	-0.227 (1.243)	-5.514** (2.918)	-2.508* (1.600)
$\delta_0 + c_{\delta 0}$	-0.827*** (0.247)	-0.944 (4.044)	-0.216 (1.532)	-3.485* (2.359)	-1.120* (0.690)	-1.668 (1.768)	0.728 (3.552)	0.164 (0.716)	-7.335*** (1.586)	-0.913 (2.671)
$\delta_2 + c_{\delta 2}$	-10.68*** (3.111)	0.786 (0.990)	6.366** (3.516)	10.10* (6.407)	-0.187 (2.822)	-0.447 (4.072)	2.914*** (0.541)	-2.982*** (1.201)	-6.502** (2.902)	-0.047 (1.539)

Notes: [a] Sample period is truncated to avoid the initialisation period of the smoothing algorithm.

[b] Sample period for Oil and Gas is 1999.01-2013.03.

Standard errors are in brackets. ***, ** and * represent levels of significance at 1%, 5% and 10% respectively for a one-tailed test for all estimates except for $c_{\gamma 0}$, $c_{\gamma 2}$, $c_{\delta 0}$, and $c_{\delta 2}$.

Meanwhile, the complete integration hypothesis, i.e. $\gamma_2 = 0$ in equation (2.1), is supported in two sectors: Healthcare and Utilities. Additionally, in these two sectors, the coefficient, γ_0, of the global systematic risk is correctly signed and statistically significant, suggesting that the global systematic risk is the only significant factor in asset pricing of these sectors. Despite its low degree of financial openness, Healthcare, an emerging and non-strategic industry, is integrated with the global market. As a strategically important sector, on the contrary, Utilities may rely on the strategic stockholders' implicit guarantee of its finance, reducing the incentive to price the national systematic risk and leading to integration with the global market. In all other sectors, purely domestic influences are relevant to pricing, albeit with a negative sign in some cases. Of these sectors, Financials and Oil and Gas are confirmed partially integrated with the global market as they expose positively to both systematic risks in equation (2.1). Like the sector of Utilities, both Financials and Oil and Gas score highly in the measurement of strategic importance. However, the sectors of Financials and Oil and Gas are considered as backbones of the Chinese economy and are more prone to political interference than is Utilities. Thus, these sectors are exposed to the national systematic risk through a political channel, limiting their chances of complete integration with the global market.

Overall, Table 3 suggests that the polarised extremes, "integration" and "segmentation", are evident in only a small number of industries. In the majority of the sectors under study, both the global and domestic systematic risks appear to be priced, albeit with an unexpected sign in some cases, favouring a conclusion of "partial integration" and thus leaving some opportunity for useful diversification of international portfolios by inclusion of Chinese equity assets - though this may require a considered selection of the sectors in which to invest.

4.4 Impact of crises on asset pricing

4.4.1 Changes to risk exposures in the recent global financial crisis

Table 3 also reports $c_{\gamma_0}, c_{\delta_0}, c_{\gamma_2}, c_{\delta_2}$, the estimated coefficients of the interaction terms in equations (2.1) and (2.1') that suggest how the asset pricing mechanism changes during the crisis. Vermeulen (2013) argues that, during crises, risk-averse investors may attempt to stabilise their wealth by increasing their exposures to foreign equities offering relatively low correlation with their domestic stock market. Therefore, we would expect increased exposures to the global systematic risk ($c_{\gamma_0} < 0$) or to the purely global systematic risk ($c_{\delta_2} > 0$). However, Table 3 shows only two cases of $c_{\gamma_0} < 0$, as opposed to four cases of $c_{\gamma_0} > 0$, and only one case of $c_{\delta_2} > 0$, versus five cases of $c_{\delta_2} < 0$, suggesting that it may have been more likely for the Chinese sectors to decrease, rather than increase, their exposures to the global risk factor during the crisis.

On the other hand, we observe a greater number of cases where the sectors decrease their exposures to the national risk factor in the crisis. For example, there are five cases of $c_{\gamma_2} < 0$ (decreased exposure to the purely national systematic risk), as opposed to only one case of $c_{\gamma_2} > 0$, and three cases of $c_{\delta_0} < 0$ (decreased exposure to the national systematic risk) versus two cases of $c_{\delta_0} > 0$.

The null hypothesis of integration during the global financial crisis ($\gamma_2 + c_{\gamma_2} = 0$) cannot be rejected in seven of the ten sectors. Among these seven sectors, the coefficient of the global systematic risk during the crisis ($\gamma_0 + c_{\gamma_0}$) is correctly signed and statistically significant in the sectors of Financials, Industrials and Technology. Given that the global systematic risk is the only significant factor in the pricing of these portfolios, the sectors of Financials, Industrials and Technology appear to become fully integrated with the global market during the crisis. The null hypothesis of segmentation ($\delta_2 + c_{\delta_2} = 0$) can be rejected in favour of significant exposures to the purely global systematic risk ($\delta_2 + c_{\delta_2} > 0$) in three sectors. Among these three sectors, Consumer Services and Oil and Gas are fully integrated with the global market during the crisis, given that their exposures to the national systematic risk ($\delta_0 + c_{\delta_0}$) are statistically insignificant.

Overall, we find stronger evidence of complete integration during the global financial crisis. The number of sectors that are integrated with the global market has increased to five in the global financial crisis from two in the period excluding the crisis. Our findings do offer some support for the suggestion that stock market integration strengthened in the recent global financial crisis. It seems that the stronger integration with the global market is the consequence of investors' effort to decrease their exposure to the national systematic risk rather than to increase that to the global systematic risk in the crisis. As the global systematic risk is the only significant risk factor in more sectors, there is less room for international risk diversification into the Chinese equities in the crisis.

4.4.2 Distinct market behaviour between low- and high-volatility periods

As noted previously in Table 1, volatility of the returns of Chinese sectoral indices increase substantially during the recent global financial crisis. Within the full sample period, there could be other high-volatility episodes. In this section, we therefore use the Markov two-state regime-switching approach to endogenously categorise the observed period into episodes of high volatility vs. low volatility and allow the representation of stock market behaviour, as in equations (2.2) and (2.2'), to have different parameter values during turbulent and tranquil periods. This regime-switching approach also helps to control for the 'non-tradable share reform' as well as the recent global financial crisis. The estimated results of equations (2.2) and (2.2') for the period of July 1998 - March 2013 with endogenous regime switching are reported in Tables 4 and 5, respectively.

The regimes are distinguished by the volatility measure, standard deviation of the regression residuals: $\sigma_s, s \in [1,2]$, where regimes 1 and 2 are the low-volatility and high-volatility states respectively. As in many other studies employing this method, the regimes are noticeably persistent for all the sectors, in the sense that the probabilities of staying in an existing state: $P(1,1)$ and $P(2,2)$ $(= 1 - P(1,2))$, are both large. Furthermore, the regime classification measure (RCM) takes values close to its lower limit, suggesting that our estimated two-state regime-switching model is able to distinctly classify the two alternative modes of behaviour for the Chinese portfolio returns.

When interpreting the test results, we still look for evidence of complete integration ($H_0: \gamma_{2s} = 0$ in Table 4) and positive exposure to the purely global systematic risk ($H_A: \delta_{2s} > 0$ in Table 5). We are also interested in whether conclusions differ between low-volatility periods and high-volatility periods.

According to the results for equation (2.2) in Table 4, there is no evidence of complete or partial integration during the low-volatility periods. We reject the null hypothesis of integration ($\gamma_{2,1} = 0$) in favour of negatively-priced purely national systematic risk ($\gamma_{2,1} < 0$) in all sectors but Consumer Services. In the Consumer Services sector, although this null hypothesis is rejected in favour of $\gamma_{2,1} > 0$, the coefficient of the global systematic risk, $\gamma_{0,1}$, is wrongly signed, failing to suggest that the Consumer Services sector is partially integrated with the global market. Similarly, we can reject the null hypothesis of segmentation ($\delta_{2,1} = 0$) in favour of negatively priced purely global systematic risk ($\delta_{2,1} < 0$) in all sectors, at the 10% level of significance – see Table 5. Overall a striking observation is that the purely national and purely global systematic risks are negatively priced in almost all sectors during the low-volatility periods. Investors do not wish to pay any positive premium to hedge against global and/or national downturns in the low-volatility periods.

Table 4. Estimates of equation (2.2) during 1998.07-2013.03[a] with Markov (two-state) regime-switching

	Basic Materials	Consumer Goods	Consumer Services	Financials	Healthcare	Industrials	Oil & Gas [b]	Technology	Telecom	Utilities
$\gamma_{0,1}$	-0.126*** (0.025)	-1.501*** (0.474)	2.887*** (0.159)	-3.485*** (0.065)	-2.624*** (0.114)	-4.533*** (0.181)	-4.606*** (0.236)	-1.533*** (0.052)	-3.988*** (0.098)	-2.123*** (0.032)
$\gamma_{2,1}$	-0.047*** (0.015)	-1.058*** (0.157)	2.830** (1.274)	-4.187*** (0.381)	-2.390*** (0.086)	-1.345*** (0.244)	-8.774*** (1.263)	-0.560*** (0.183)	-1.475* (1.009)	-0.529*** (0.170)
$\gamma_{0,2}$	-2.316*** (0.038)	-0.884* (0.550)	-4.631*** (0.106)	0.159*** (0.051)	-0.188** (0.084)	-0.447*** (0.104)	1.392*** (0.153)	-0.044 (0.045)	0.369*** (0.074)	-0.022 (0.034)
$\gamma_{2,2}$	-3.069*** (0.030)	-0.302* (0.185)	-3.841*** (0.858)	0.426 (0.391)	0.593*** (0.077)	-0.881*** (0.144)	3.069*** (0.772)	-0.226 (0.199)	-0.687 (0.726)	-1.034*** (0.153)
σ_1	0.002*** (0.001)	0.031*** (0.007)	0.028*** (0.004)	0.008*** (0.001)	0.018*** (0.003)	0.061*** (0.010)	0.006*** (0.001)	0.009*** (0.001)	0.101*** (0.012)	0.010*** (0.001)
σ_2	0.006*** (0.001)	0.093*** (0.012)	0.712*** (0.109)	0.240*** (0.066)	0.057*** (0.010)	0.144*** (0.021)	0.403*** (0.094)	8.098*** (1.335)	1.960*** (0.512)	0.034*** (0.006)
P(1,1)	0.940*** (0.034)	0.989*** (0.011)	0.984*** (0.014)	0.993*** (0.011)	0.985*** (0.011)	0.984*** (0.013)	0.980*** (0.012)	0.995*** (0.005)	0.995*** (0.006)	0.994*** (0.007)
P(1,2)	0.020** (0.011)	0.012* (0.009)	0.008 (0.008)	0.019 (0.040)	0.007 (0.008)	0.008 (0.009)	0.064 (0.044)	0.007 (0.007)	0.011 (0.015)	0.006 (0.007)
RCM	0.742	1.278	1.795	3.841	0.914	1.252	2.569	1.037	1.732	4.325

Notes: [a] Sample period is truncated to avoid the initialisation period of the smoothing algorithm.

[b] Sample period for Oil & Gas is 1999.01-2013.03.

***, ** and * represent levels of significance at 1%, 5% and 10% respectively for a one-tailed test on γ_{01}, γ_{21}, γ_{02} and γ_{22}.

σ_1 and σ_2 are standard deviations of the regression residuals in regimes 1 and 2 respectively.

P(i,j) are estimated transition probabilities, for switching from regime j to regime i.

The regime classification measure (see Ang and Bekaert, 2002) is defined as $\text{RCM} = 400 \times \frac{1}{T}\sum p_{1t}(1 - p_{1t})$, where p_{1t} is the probability that regime 1 is in force at time t, calculated using the recursive representation of Gray (1996). A value of 0 for RCM means perfect classification, while a value of 100 implies failure to classify.

Table 5. Estimates of equation (2.2') during 1998.07-2013.03[a] with Markov (two-state) regime-switching

	Basic materials	Consumer goods	Consumer services	Financials	Healthcare	Industrials	Oil & Gas [b]	Technology	Telecom	Utilities
$\delta_{0,1}$	-1.298*** (0.043)	-4.301*** (0.227)	-0.383*** (0.137)	-2.137*** (0.196)	0.254*** (0.045)	-0.838*** (0.098)	-5.147*** (0.250)	-0.518*** (0.075)	-3.622*** (0.107)	5.915*** (0.276)
$\delta_{2,1}$	-1.744*** (0.104)	-4.407*** (0.992)	-3.518*** (1.245)	-5.646*** (1.001)	-3.750*** (0.262)	-1.398*** (0.426)	-7.979*** (1.236)	-1.487* (0.924)	-2.813*** (0.465)	-4.719*** (0.678)
$\delta_{0,2}$	-1.058*** (0.295)	0.755*** (0.117)	-4.006*** (0.110)	8.730*** (0.353)	1.656*** (0.112)	-4.156*** (0.165)	4.770*** (0.094)	-6.159*** (0.109)	-0.833* (0.566)	3.458*** (0.248)
$\delta_{2,2}$	2.418*** (0.423)	-0.186 (0.312)	-2.901*** (0.586)	2.957* (1.917)	5.616*** (0.384)	-5.281*** (0.971)	1.789** (0.775)	1.075* (0.564)	-1.281*** (0.452)	-1.913*** (0.542)
σ_1	0.004*** (0.001)	0.009*** (0.002)	0.016*** (0.002)	0.024*** (0.003)	0.006*** (0.001)	0.018** (0.004)	0.006*** (0.001)	0.060*** (0.007)	0.014*** (0.002)	0.015*** (0.002)
σ_2	0.043*** (0.007)	0.283*** (0.038)	0.565*** (0.098)	0.903*** (0.218)	0.132*** (0.019)	0.963*** (0.149)	0.429*** (0.097)	16.123*** (3.431)	0.443*** (0.061)	0.034*** (0.007)
P(1,1)	0.975*** (0.015)	0.917*** (0.038)	0.975*** (0.015)	0.988*** (0.009)	0.982*** (0.014)	0.947*** (0.029)	0.981*** (0.012)	0.978*** (0.012)	0.975*** (0.020)	0.977*** (0.012)
P(1,2)	0.023 (0.017)	0.033** (0.018)	0.036* (0.022)	0.038* (0.034)	0.017 (0.012)	0.047** (0.026)	0.062 (0.044)	0.074* (0.045)	0.017* (0.013)	0.046** (0.027)
RCM	7.598	10.279	5.191	3.931	2.057	11.424	2.954	3.656	5.015	10.443

Notes: ***, ** and * represent levels of significance at 1%, 5% and 10% respectively for a one-tailed test on δ_{01}, δ_{21}, δ_{02} and δ_{22}.
Otherwise, the notes for table 4 apply here also.

In the high-volatility periods, there is no evidence of complete integration but there is evidence of partial integration. Although the null hypothesis of integration ($\gamma_{2,2} = 0$) cannot be rejected in three sectors, namely Financials, Technology and Telecom – see Table 4, the coefficients of the global systematic risk, $\gamma_{0,2}$, are either incorrectly signed or statistically insignificant in these three sectors, failing to suggest a pure international CAPM for these cases. Meanwhile, only one sector, i.e., Healthcare, is found to be partially integrated with the global market, as the null hypothesis of $\gamma_{2,2} = 0$ is rejected in favour of $\gamma_{2,2} > 0$ and the coefficient of the global systematic risk is correctly signed and statistically significant. Consistent with the result in section 4.3, Healthcare tends to be integrated with the global market one way or another.

On the other hand, there is more evidence of international influence on China's asset pricing in the high-volatility periods according to the results in Table 5. In these periods, the null hypothesis of segmentation ($\delta_{2,2} = 0$) is rejected in favour of positive exposure to the purely global systematic risk ($\delta_{2,2} > 0$) in five sectors. However, the exposures to the global factor have not led to any complete integration with the global market, as these five sectors appear to be also exposed to the national systematic risk, albeit negatively in some cases. In fact, two of those five sectors, namely, Basic Materials and Technology, positively expose to the national systematic risk ($\delta_{0,2} > 0$) additionally, hence these two sectors are partially integrated with the global market. Overall, international influence on China's asset pricing becomes stronger in the high-volatility periods, but only to the extent of partial integration at most.

5. Conclusions

This paper investigates China's asset pricing mechanism with the objective of detecting, at a sectoral level, the impact of financial crises on the integration of China's stock market with the global market. An exploratory analysis with fixed betas supports a simple domestic CAPM, implicitly rejecting a market integration hypothesis in every sector. This simple conclusion is refuted when we allow the national and global systematic risks and their pricing to be time-varying. Within such a time-varying setting, the conclusions vary between sectors and over time, suggesting that the question of whether a country's equity market is integrated or segmented may not be fully answered by looking only at an aggregate market index or assuming a stable structure over the sample period.

In the period excluding the recent global financial crisis, the polarized extremes of complete integration or segmentation are relatively rare, supporting at a sectoral level the suggestion (Hardouvelis, *et al*., 2006) that markets may be characterised as partially integrated. The extreme case of complete integration becomes more common during the crisis period, but such strong integration with the global market is specific to the recent crisis. In high-volatility periods more generally, it is partial integration that becomes more evident. The overall conclusion of partial integration leaves some opportunity for international risk diversification into the Chinese assets - though this may require a considered selection of sectors in which to invest and also on-going revision of portfolio choice.

The application of the procedure developed by Li (2013) to the sectoral data helps us understand better the unique case of China. In China, some relatively open sectors are also considered strategically important by the authorities, making them potentially prone to political interference and consequently exposed to the national systematic risk, thus limiting their chances of complete integration with the global market. However, this conjecture brings an unresolved question inasmuch as the Utilities sector, though it scores highly in the measurement of strategic importance, appears to be more integrated with the global market. It may be that differential levels of state ownership distinguish this sector from other strategically important sectors. The study of China's asset pricing might be extended in future research to explore whether the degree of state ownership can usefully be incorporated into the modelling framework.

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