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Reforms' Effects on Chinese stock markets world integration - An Empirical analysis with t-DCCGARCH

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Reforms' Effects on Chinese stock markets world integration - An Empirical analysis with t-DCC-GARCH model

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Abstract

In recent years the Chinese government has instituted a series of reforms to restructure and open the Chinese financial system. This paper studies the dynamic correlations and sensitivities between Chinese mainland stock market and five major stock markets with the multivariate *t*-DCC-GARCH model. We also consider a *Normal*-DCC model and results show that *t*-DCC improves slightly the results. The analysis of reforms' effects on dynamic correlations and sensitivities prove that the Chinese mainland market is more closely tied to Asian stock markets over time, followed by the United States, and with relatively lower correlations with Europe and the United Kingdom. We highlight that the implementation of reforms changes theirs correlations and sensitivities over time. Since the reforms, the correlation between China and international stock markets has been reinforced.

Keywords

DCC-GARCH, bivariate t distribution, Chinese Stock Market, Dynamic Correlation, Time-varying sensitivity, Chinese reforms

JEL Classification Codes: C32, C58, G15, F65

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1. Introduction

In the past decade, China's economy has developed rapidly, more and more foreign investors are interested in China's financial markets. On May 2018, MSCI started to include China’s A shares in the MSCI emerging market index, which highlights the importance of Chinses stock markets. The Chinese government announced to continue to liberalize the A-share market in order to better integrate into the global economy. By the end of 1990, with the establishment of the Shanghai and Shenzhen stock exchanges, until today, in order to adapt to the Chinese economic growth and gradual opening of China's financial market, the stock markets have experienced several very important stages of development and reforms.

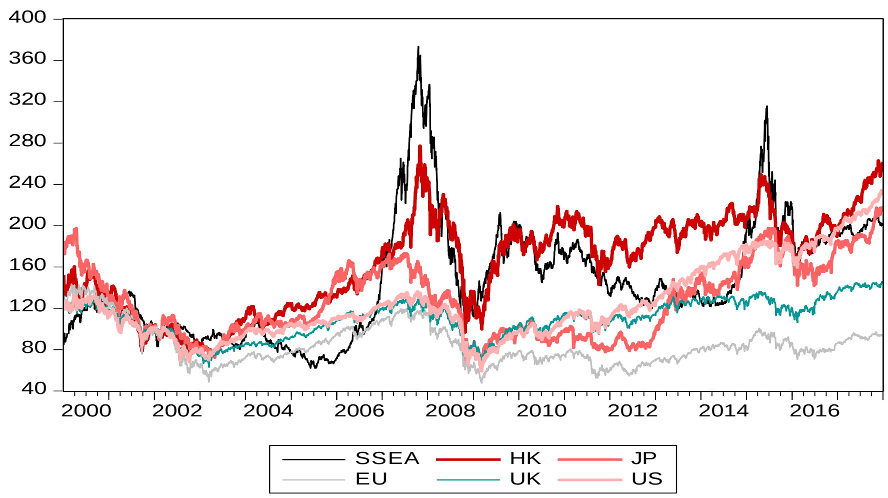
Especially since China jointed WTO at the end of 2001, it has received more and more international attention. In order to gradually open the Chinese stock market, in 2002, the Chinese government has started to implement a program QFII “Qualified Foreign Institutional Investor” which allows specified licensed international investors with the right to direct access to mainland China’s stock exchanges. Along with the internationalization of China’s financial market, the links between China’s stock markets and other countries are also changing. Chow and Lawler (2003) found no significant correlation between shanghai and New York stock market returns from 1992 to 2002. However, Chiang and Chen (2016) highlight that the relationships between Chinese stock markets and others global stock markets have been influenced by structural changes in China financial system as QFII.

During 2001-2006, Chinese government established a series of reforms to continuously adjust the Chinese financial system to economic development needs. The state is undergoing reforms to reduce state-owned shares in 2000 in order to separate government functions from the enterprises. This reform has not positive effect to realize the enterprise value (Xiang and Fu, 2015). Until June 24, 2002, the State Council issued a notice to stop the reduction through the domestic stock exchange. The Shanghai Composite Index rose 9.35% on the day. However, the Chinese stock market’s structure was special, which consists of Non-tradable shares (NTS) and tradable shares (TS). All B shares and H shares are TS, A shares were divided into NTS and TS (Liu and Lu, 2007). At the end of 2004, the NTS accounted for 64% of total shares. To convert Non-tradable shares into tradable shares, the Chinese government has established the Non-tradable share reform in April 2005. As of December 2006, 96% of listed companies have completed the NTS reform. The split share reform improves corporate governance and reduces the negative effect of non-tradable shares (Yu, 2013). This reform changes also the linkages between the three Chinese stock markets and improves Chinese market’s structure (Mestre-Zhou and Mestre, 2018). In the meantime, another program QDII “Qualified Domestic Institutional Investor” is put into effect. Like QFII, it allows domestic investors to access foreign securities markets via an institutional investor which has certain qualifications approved by China Securities Regulatory Commission (CSRC).

In order to adapt to the needs of national economic development and foreign trade, the central bank announced, on July 2, 2005, the implementation of a managed floating rate system based on market supply and demand with reference to a basket of currencies. After the reform of Renminbi Yuan (RMB), the exchange rate has a long-run relationship with the Chinese stock markets, particularly, it influences Shanghai A share index in the long term (Guo et *al*, 2008, Zhang, et *al*, 2008). On October 16, 2007, the Chinese stock market reached its highest level (6092.06 points). However, with the outbreak of the US subprime mortgage crisis, international stock markets plummeted. Before the crisis international, there is not a direct relationship between the mainland stock markets and US market, but a lower relationship with Hong Kong (Li, 2007). During the crisis, the correlation has been reinforced between the Asia-Pacific countries, Europe and the US (Hyde et *al*, 2007).

Graphically, we observe on the Figure 1 that there are two periods when the Chinese mainland stock market (SSEA) has not the same trend with the other markets. The first phase stretches from March 2003 to July 2005. After the dot-com bubble in 2000, the international stock markets began to show a growth trend at the end of the first half of 2003, except for the Chinese Mainland stock market. Then, the second phase stretches from May 2010 to July 2014. Until early 2009, the Chinese stock markets started to rebound after the Subprime Crisis. After the rebound, Asia's stock markets have been negatively affected by the 2010 European debt crisis and the 2011 US debt crisis. In 2013, Asian stock markets rose, especially in the Japanese stock market. But the mainland stock market did not follow this growth. Because China's financial market is still not fully open to the outside world, and people have a negative attitude towards the stock market, investment in real estate and other low-risk wealth management products have set the stage for the 2015 China stock market crisis.

Figure 1: International market stock price indices in base 100(01/01/2002):



China's financial market is undoubtedly very attractive to foreign investors, the financial development promotes Chinese economic growth (Jalil et *al*, 2009). Before the period of liberalization (2003-2010), the China's stock market is isolated with the global and reginal markets, it has not any influences on the overseas markets, but the market liberalization and reforms change the international relationships (Li, 2012). Therefore, analyzing the correlation between the stock market returns can help investors reduce portfolio risk by diversifying internationally, or anticipate risks through the co-movement of other stock markets.

We study the relationship between the Chinese stock market and other markets over time considering all the reforms established. To what extent have the reforms enabled China to be more international and open? To address this question, we analyze the dynamic correlation between mainland stock market and five major stock markets. By comparing and analyzing these correlations, we can better appreciate the effect of China opening on its market behavior and on relationship between it and other international markets.

The remainder of this study is organized as follow. Section 2 presents the statistical data and methodology. The empirical finding and interpretation are reported in Section 3. And the conclusions are provided in Section 4.

2. Data and Methodology

2.1 Data

We used the daily closing stock indices period from January 3, 2000 to December 29, 2017 with a total of 4695 observations. There are two Chinese stock markets indices including the SSEA (Shanghai A share index), the HSI (Hang Seng Index), and some major markets indices consisting of the EU (Eurostoxx50), US (S&P500), UK (FTSE100) and Japan (Nikkei 225). In order to respect the stationary condition for DCC –GARCH model, Augmented Dickey-Fuller test (robust to the autocorrelation) and Philips-Perron (robust to the heteroskedasticity) are passed for all series. All stock series are DS (Difference Stationarity) without drift. So, after filtering by the first differences, we obtained the stationary stock returns.

Table 1 summarizes the characteristics of each series. By analyzing the standard deviation, we note that the Asian markets have the highest risk compare to the US-UK stock markets. KS (Kolmogorov-Smirnov) tests (Lilliefors, 1967) indicate that all series are non-normally distributed. And they have fat tails nature.

Table 1: Summary statistics of stock market daily returns: 01/03/2000-12/29/2017

	RSSEA	RHK	RJP	REU	RUK	RUS
Mean#	0.019	0.012	0.004	-0.007	0.002	0.013
Maximum#	9.400	13.407	13.235	10.438	9.384	10.957
Minimum#	-9.261	-13.582	-12.111	-9.011	-9.265	-9.470
Std. Dev.#	1.537	1.447	1.476	1.465	1.173	1.192
Skewness	-0.358	-0.097	-0.406	-0.055	-0.164	-0.208
Kurtosis	8.434	11.798	9.899	7.795	9.617	12.095
Kolmogorov-Smirnov	0.097***	0.087***	0.074***	0.075***	0.080***	0.100***

Note: #values multiplied by 100. **denote reject null hypothesis at the 5% critical value, ***1% critical value.

Table 2 presents the unconditional correlation coefficients of markets stock returns. In the one hand, the Chinese mainland stock market has higher positive correlation with Hong Kong and Japanese stock markets. The lowest correlation is with US stock market. In the other hand, Hong Kong stock market has the highest correlation with Japan, followed by the Chinese mainland stock market. As a more open stock market, Hong Kong has a higher linear relationship with EU, UK and USA than the mainland stock market.

Table 2: Correlations of stock market returns 01/03/2000-12/29/2017.

t-Statistic	RSSEA	RHK	RJP	REU	RUK	RUS
RSSEA	1					
RHK	0,367	1				
RJP	0,206	0,552	1			
REU	0,095	0,349	0,273	1		
RUK	0,107	0,386	0,294	0,853	1	
RUS	0,055	0,2	0,123	0,569	0,532	1

2.2 The DCC-GARCH Model

In order to study the time-varying correlations among the China, Hong Kong, US, Europe and Japan, we used the Engle's (2002) dynamic conditional correlation (DCC)-GARCH model which is useful for estimating of the correlations between the stock returns in bivariate case. At the same time, we observe in Table 1 that the series have the fat-tails nature and non-normality, combining DCC model with multivariate t distribution (Pesaran and al, 2007) will be appropriate.

2.2.1 DCC-GARCH model

Let $\{y_t\}$ denote a bivariate return series$[y_{1,t} \quad y_{2,t}]$, the model can be expressed as:

$$y_t = E(y_t | \Omega_{t-1}) + r_t$$

$$r_t | \Omega_{t-1} = [r_{1,t} \quad r_{2,t}] \sim N(0, H_t)$$

$$H_t \equiv D_t R_t D_t$$

Where Ω_{t-1} is the information set through time t-1. The variable $y_{1,t}$ presents the series of Chinese stock market return, and $y_{2,t}$ presents other series of stock returns. $D_t = diag(\sqrt{h_{1,t}}, \sqrt{h_{2,t}})$, where the conditional variance obtained by univariate GARCH model, then D_t is the 2*2 diagonal matrix of time-varying standard deviations. So H_t will be positive definite when the correlation matrix R_t is positive definite. For each univariate error process, $r_{i,t} = \sqrt{h_{i,t}} \varepsilon_{i,t}$,$\forall i = 1,2$, and the condition variance $h_{i,t} = E_{t-1}(r_{i,t}^2)$, they follow a univariate GARCH (1,1) process following:

$$h_{i,t} = c_i + m_{i1} r_{1,t-1}^2 + n_{i1} h_{i,t-1} \quad , \forall i = 1,2$$

$$h_{ij,t} = \rho_{ij,t}\sqrt{h_{i,t}}\sqrt{h_{j,t}} \quad , i \neq j$$

The parameters of univariate GARCH, $c_i\ m_i\ and\ n_i$ need to be positive and $(m_{i1} + n_{i1}) < 1, \forall i = 1,2$, when the sum is equal to 1, we have IGARCH (Integrated GARCH) model (Engle, Bollerslev,1986).

In the DCC (1, 1)-GARCH(1,1) model, a conditional correlation matrix, R_t , is allowed to be time-varying. This matrix can be explained by an exponential smoothing, which can be represented as a geometrically weighted of standardized residuals and produced at each point in time:

$$\rho_{12,t} = \frac{\sum_{s=1}^{t-1} \lambda^s \varepsilon_{1,t-s}\varepsilon_{2,t-s}}{\sqrt{(\sum_{s=1}^{t-1} \lambda^s {\varepsilon_{1,t-s}}^2)(\sum_{s=1}^{t-1} \lambda^s {\varepsilon_{2,t-s}}^2)}} = [R_t]_{1,2}$$

Where λ is smoothing parameter, and the symmetric correlation matrix is:

$$[R_t]_{1,2} = \begin{bmatrix} 1 & \rho_{12,t} \\ \rho_{21,t} & 1 \end{bmatrix}$$

In order to compute this conditional correlation matrix, we need to know the conditional variance-covariance matrix, so the integration process followed by the variance (q) will be:

$$q_{1,2,t} = (1-\lambda)(\varepsilon_{1,t-1}\varepsilon_{2,t-1}) + \lambda(q_{1,2,t-1})$$

And the alternative process can be suggested by the GARCH (1, 1) model:

$$q_{1,2,t} = \bar{\rho}_{1,2} + a(\varepsilon_{1,t-1}\varepsilon_{2,t-1} - \bar{\rho}_{1,2}) + b(q_{i,j,t-1} - \bar{\rho}_{1,2})$$

Where $\bar{\rho}_{1,2}$ is the unconditional correlation between $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$, and a >0, b>0 and a+b <1. The Q_t = $(q_{ij,t}), \forall i,j = 1,2,$ will be positive definite for all t because it is a weighted average of positive definite matrices(S), positive semidefinite matrices $(\varepsilon_{t-1}\varepsilon'_{t-1})$, and positive definite matrices Q_{t-1} with non-negative parameters. The matrix structure DCC (1, 1) can be expressed:

$$Q_t = (1-a-b)S + a(\varepsilon_{t-1}\varepsilon'_{t-1}) + bQ_{t-1}$$

Where S is the unconditional correlation matrix of ε_t (where $\varepsilon_t = D_t^{-1} r_t$). If the a+b=1, it's the integration process, its matrix structure can be written as:

$$Q_t = (1-\lambda)(\varepsilon_{t-1}\varepsilon'_{t-1}) + \lambda Q_{t-1}$$

R_t will be positive definite when Q_t is symmetric and positive definite. Its conditions are defined as the following:

$$R_t = (Q_t^*)^{-1} Q_t (Q_t^*)^{-1}$$

where $Q_t^* = diag(\sqrt{q_{11,t}}, \sqrt{q_{22,t}})$

The average of covariance, $\bar{q}_{1,2}$, will be $\bar{\rho}_{1,2}$, and the average variance will be 1. The correlation estimator of bivariate will be written (Engle and Sheppard, 2001, Engle, 2002):

$$\rho_{12,t} = \frac{q_{12,t}}{\sqrt{q_{11,t}q_{22,t}}}$$

To improve the result analysis, we can compute the time-varying sensitivity from the dynamic covariance by the following equation (Bollerslev and *al*, 1988):

$$\beta_{12,t} = \frac{q_{12,t}}{q_{22,t}} \quad \text{and} \quad \beta_{21,t} = \frac{q_{12,t}}{q_{11,t}}$$

a) <u>Estimation of parameters of Normal-DCC</u>

The estimation of parameters for normal-DCC- GARCH, the log-likelihood function of the DCC can be maximized by two stages (Engle, 2002). We denote θ for the parameters in D_t, and ω for the parameters in R_t. In the case of bivariate, n=2. The log-likelihood function consists of a volatility part and a correlation part:

$$L(\theta, \omega) = L_V(\theta) + L_c(\theta, \omega)$$

The part of volatility:

$$L_V(\theta) = -\frac{1}{2}\sum_t (nlog(2\pi) + 2log|D_t| + r_t' D_t^{-2} r_t)$$

The part of correlation:

$$L_c(\theta, \omega) = -\frac{1}{2}\sum_t (log|R_t| + \varepsilon_t' R_t^{-1} \varepsilon_t - \varepsilon_t' \varepsilon_t)$$

The volatility part of the log-likelihood is the sum of individual GARCH likelihoods, which is maximized in the first stage by separately maximizing each term. The resulting log-likelihood function in the first stage is:

$$L_V(\theta|r_t) = -\frac{1}{2}\sum_{i=1}^{n} (Tlog(2\pi) + \sum_{t=1}^{T} (\log(h_{i,t}) + \frac{r_{i,t}^2}{h_{i,t}})$$

$$\hat{\theta} = argmax\{L_V(\theta|r_t)\}$$

The elements of θ correspond the parameters of the univariate GARCH model. The correctly specified log-likelihood of the second stage is used to estimate the correlation parameters, $\omega = (a, b)$, conditioning this parameter estimated ($\hat{\theta}$) in the first stage:

$$L_c(\omega|\hat{\theta}, r_t) = -\frac{1}{2}\sum_{t=1}^{T} (\log(|R_t| + \varepsilon_t' R_t^{-1} \varepsilon_t)$$

$$\max_{\omega}\{ L_c(\omega|\hat{\theta}, r_t)\}$$

b) t-DCC model

The conditional log likelihood function is:

$$L(\varrho) = \sum_{t=1}^{T} \log(\frac{\Gamma(\frac{v+n}{2})}{\Gamma(\frac{v}{2})}) - \frac{n}{2}\log(\pi(v-2)) - \frac{1}{2}\log(|D_t R_t D_t|) - \frac{n+v}{2}\log(1 + \frac{r_t' D_t^{-1} R_t^{-1} D_t^{-1} r_t}{v-2})$$

Where $\varrho = (c_1, m_{11}, n_{11}, c_2, m_{21}, n_{21}, v)$. Comparing with normal-DCC, t-DCC cannot use two steps procedure to estimate the parameters, because of the same bivariate series should require a common degree of freedom (v) for the multivariate t distribution (Pesaran and Pesaran, 2007, 2010). The maximum likelihoods of ϱ based on r_t(t=1…T), can be calculated by maximization of function $L(\varrho)$ respecting ϱ

$$\hat{\varrho} = argmax\{ L(\varrho)\}$$

3. Empirical Finding and Interpretation

3.1 Time-varying correlations and sensitivities

In order to analyze the dynamic correlation between the Chinese mainland stock return (SSEA) and the other markets, we estimate the t-DCC-GARCH model for each pairwise variable. Between China and USA, the time difference is 12-13 hours. Therefore, the opening and closing times of the Chinese and US stock markets have one day lagged. With the same methodology, we estimated the dynamic conditional correlation among $SSEA_t$ and US_{t+1}, and US_{t-1}. For the EU and UK, we keep the time delay.

The DCC-model of Engle (2002) supposes that both the returns and standardized residuals are normally distributed. But the Gaussian assumption cannot consider the fat-tailed nature of the distribution of returns. We present the parameters estimators of the t-DCC-GARCH model in Table 3 and Normal-GARCH in A1. According to the results, the parameters of t-DCC and normal-DCC are slightly different, but they are similar in nature. For the bivariate variables, the estimate of v are relatively closer to 6. As indicate Pesaran and Pesaran (2007), this fact justifies the use of t-distribution. The parameters of SSEA and HK are improved by t-DCC, but conversely, certain parameters of JP and UK become no significant. After comparing their log-likelihood, the parameters of t-DCC are slightly approved.

The sum of the estimates of parameters is very close to unity. Assumption null hypothesis (the IGARCH hypothesis) is $1 - m_{i1} - n_{i1} = 0$, or 1-a-b=0, against the hypothesis alternative $1 - m_{i1} - n_{i1} \neq 0$, or $1 - a - b \neq 0$. We find that the IGARCH hypothesis is significantly rejected for SSEA, and also for the correlation between China and Hong Kong, and US.

Table 3: Results of bivariate t-DCC-GARCH (1, 1) model

t-DCC	SSEA	HK	SSEA	JP	SSEA	EU	SSEA	UK
m	0.0585	0.0505	0.0573	0.0814	0.0572	0.0849	0.057	0.1118
	[0.008]***	[0.005]***	[0.008]***	[0.095]	[0.008]***	[0.035]**	[0.008]***	[0.085]
n	0.9354	0.9473	0.936	0.9113	0.9358	0.913	0.9359	0.8843
	[0.009]***	[0.005]***	[0.010]***	[0.105]***	[0.010]***	[0.036]***	[0.010]***	[0.085]***
1-m-n	0.0061	0.0022	0.0067	0.0073	0.0070	0.0021	0.0071	0.0059
	[0.003]**	[0.002]	[0.003]**	[0.012]	[0.001]***	[0.005]	[0.003]***	[0.009]
a	0.0048		0.0039		0.008		0.002	
	[0.001]***		[0.001]***		[0.004]*		[0.001]***	
b	0.9946		0.9951		0.9609		0.9973	
	[0.001]***		[0.001]***		[0.023]***		[0.001]***	
1-a-b	0.0006		0.0010		0.0311		0.0007	
	[0.0003]**		[0.001]		[0.020]		[0.001]	
v	5.73		6.15		6.31		6.58	
log-likelihood	28459.65		27768.58		27948.95		29130.63	
t-DCC	SSEA	US	SSEA	Ust-1	SSEA	Ust+1		
m	0.0579	0.0929	0.0578	0.0928	0.0577	0.0931		
	[0.008]***	[0.021]***	[0.008]***	[0.021]***	[0.008]***	[0.022]***		
n	0.9358	0.9061	0.9359	0.9062	0.936	0.9058		
	[0.009]***	[0.021]***	[0.009]***	[0.021]***	[0.009]***	[0.022]***		
1-m-n	0.0063	0.0010	0.0063	0.0010	0.0063	0.0011		
	[0.003]**	[0.005]	[0.003]***	[0.005]	[0.003]**	[0.004]		
a	0.0057		0.0136		0			
	[0.004]		[0.006]**		[0.004]			
b	0.9508		0.9278		0.933			
	[0.023]***		[0.039]***		[0.761]			
1-a-b	0.0435		0.0586		0.0670			
	[0.022]**		[0.035]*		[0.756]			
v	5.85		5.93		5.91			
log-likelihood	29244.03		29270.04		29233.72			

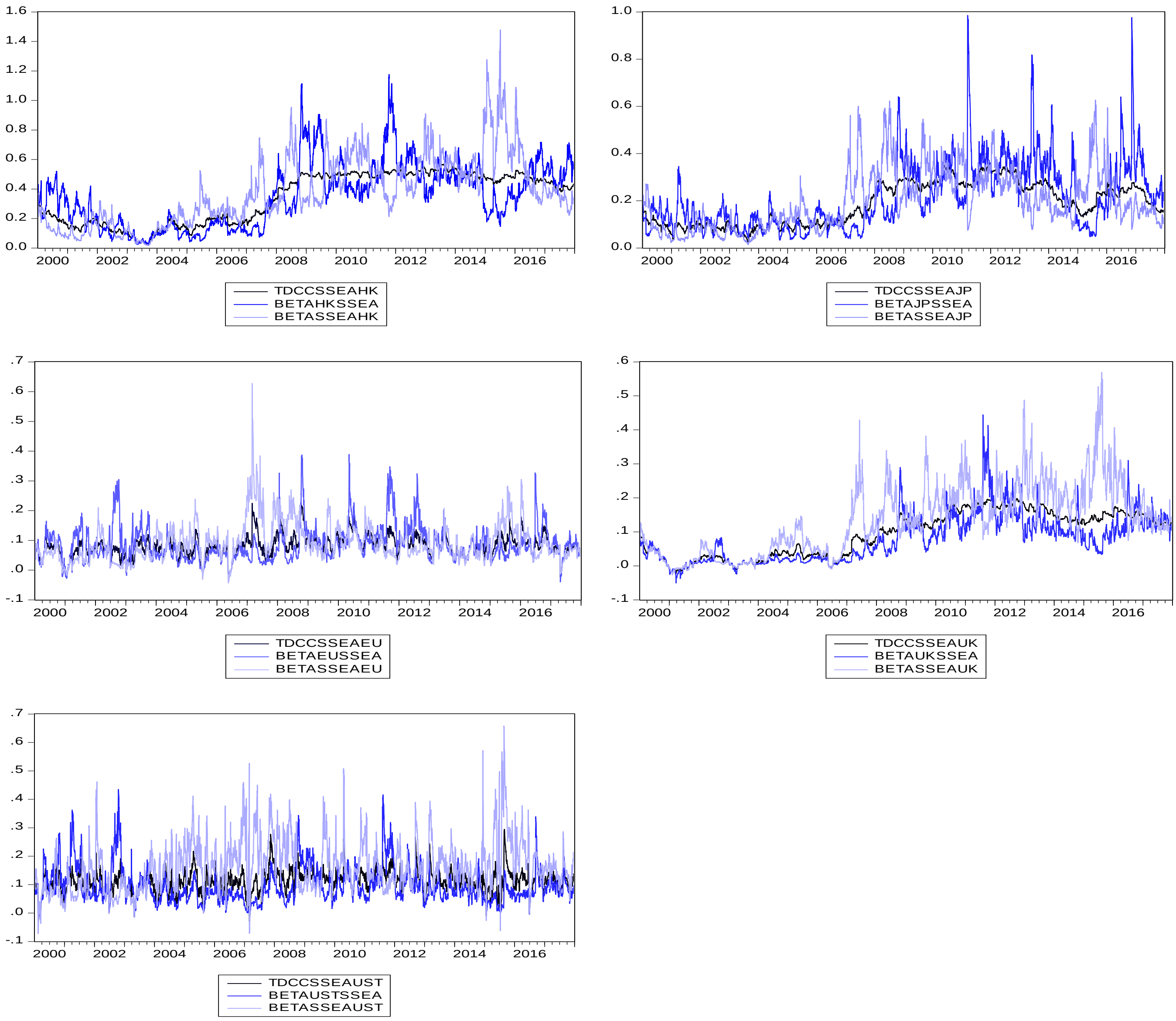
Note: *denote reject null hypothesis at the 10% critical value, ** 5% critical value, ***1% critical value. The values in the parenthesis are the standard deviation.

In the DCC cases, we notice that the US_{t-1} is correlated significantly with China. The mean value of the conditional correlation between SSEA and US_{t-1} is 0.112 instead of 0.051. It' means that the stock market quotes of the previous day in USA will affect China's stock market that day.

We summarize (Appendix, A2) the characteristics of each conditional correlation series. The Normal-DCC and t-DCC provide similar results, except for the EU, but they share the similar trend and evolution. We observe also that the correlation SSEA-US has not the same trajectory than others. Compared with others graphs, we don't clearly observe a trend in the correlation between China and the Unites States. The value of average conditional correlation with Hong Kong is the highest, and with the highest standard deviation, followed by the Japanese stock market. On the contrary, the lowest conditional correlation is between SSEA and US, with the less volatility, followed by the UK stock market and EU stock market. This result corresponds to the unconditional correlations presented in Table 2. The correlation between China and other stock markets has been strengthened since 2006.

Then, we compute the time-varying sensibilities under t-DCC model in order to improve the analysis of correlation. Figures 2 illustrate the dynamic condition correlations between China and international stock markets with t distribution. Table 4 summarizes the results.

Figures 2: Dynamic conditional correlation and Sensitivity between SSE A shares index and other indices.



Note: we use UST to present the series US_{t-1}

Tables 4: Summary statistics of time-varying sensitivity

4.1: Summary statistics of time-varying sensitivity of SSEA to other countries.

	BETASSEAHK	BETASSEAJP	BETASSEAEU	BETASSEAUK	$BETASSEAUS_{(t-1)}$
Mean	0.379	0.197	0.091	0.133	0.163
Median	0.339	0.172	0.077	0.128	0.151
Maximum	1.479	0.627	0.628	0.570	0.658
Minimum	0.015	0.015	-0.044	-0.027	-0.072
Std. Dev.	0.233	0.121	0.062	0.102	0.089

4.2 Summary statistics of time-varying sensitivity of other countries to SSEA.

	BETAHKSSEA	BETAJPSSEA	BETAEUSSEA	BETAUKSSEA	$BETAUS_{(t-1)}SSEA$
Mean	0.350	0.212	0.086	0.078	0.095
Median	0.354	0.175	0.076	0.071	0.078
Maximum	1.177	0.986	0.389	0.445	0.435
Minimum	0.022	0.033	-0.040	-0.051	-0.026
Std. Dev.	0.215	0.139	0.058	0.069	0.062

By analyzing the dynamic correlation and sensitivity reported in figure 2, we observe, for the others countries, the trend changed around 2002 with a great growth around 2006, so after each reform, the sensitivity of China's financial market to other financial markets will be enhanced. This strong rise in correlation coincides with the reforms previously presented. This result confirms the objective of the reforms packet to progressively open Chine Financial System. During international crisis, the Chinese stock market has a stronger correlation with others markets because it was more opened and subjected to international risk sources. After the crisis, around 2012, the global economy slowly recovered but we note that the correlation between mainland China and other countries has attenuated (except Hong-Kong). On December 4, 2012, the Shanghai stock exchange index reached the lowest level (1949.46 points) of the year because of the rise of investment in foreign stock markets and the China's real estate market led to a decrease in funds invested in the stock market. The correlation with the Hong Kong stock market, at the opposite, still remains at the same level. Because at the end of 2011, the program RQFII "RMB Qualified Foreign Institutional Investor" was launched in Hong Kong market and was limited to only Hong Kong subsidiaries of Chinese financial institutional. On April 10, 2014, the program Shanghai-Hong Kong stock Connect was announced. Investors in each market are now able to trade securities in each other's markets through their exchange trading and clearing facilities.

Thus, by comparing the sensitivities means presented in table 4, we notice that the Chinese mainland stock market is more sensitive to UK and US than they are sensitive to china, the opposite for Japan. Compared to Hong Kong, they are highly sensitive each other. The sensitivity between China and EU to each other is similar.

Since 2013, CSRC announced to expand the RQFII scheme to other countries. The United Kingdom is the first country outside of Asia to be given a license of this type. Consequently, we notice that SSEA correlation with others countries increases in 2014 and reach a pick in the second part of 2015 during a bubble period in China's Stock Market. The Table 5 summarizes the means of sensitivities and dynamic correlation by periods.

Table 5: summarizes the results by providing a synthesis of dynamic correlations and sensitivities for each period.

	Mean	2000-2002	2003-2006	2007-2009	2010-2014	2015-2017
SSEA-HK	Betahkssea	0.239	0.109	0.417	0.521	0.429
	Betasseahk	0.139	0.184	0.433	0.533	0.565
	ρ_t	0.168	0.136	0.391	0.511	0.456
SSEA-JP	Betajpssea	0.131	0.097	0.203	0.336	0.246
	Betasseajp	0.083	0.102	0.318	0.252	0.224
	ρ_t	0.095	0.093	0.232	0.278	0.209
SSEA-EU	Betaeussea	0.087	0.06	0.08	0.112	0.083
	Betasseaeu	0.049	0.082	0.153	0.084	0.097
	ρ_t	0.058	0.065	0.099	0.092	0.084
SSEA-UK	Betaukssea	0.021	0.013	0.078	0.143	0.114
	Betasseauk	0.024	0.041	0.163	0.207	0.212
	ρ_t	0.020	0.022	0.102	0.164	0.142
SSEA-$Us_{(t-1)}$	$Betaus_{(t-1)}ssea$	0.129	0.067	0.095	0.106	0.076
	$Betasseaus_{(t-1)}$	0.099	0.161	0.196	0.164	0.193
	ρ_t	0.101	0.098	0.120	0.124	0.114

We observe that the correlations and sensitivities became stronger after 2006 and sharply increase. Consequently, during the international crisis in 2007, Chinses stock market have been affected. But after this crisis, the Chinese stock market and other stock markets still maintain a high degree of connection and sensitivity. This observation indicates that reforms have succeeded in making the Chinese mainland stock market more international.

In 2011 during the RQFII announcement, the Shanghai sensitivity to Hong Kong stock market is higher that Hong Kong sensitivity to China. Similar results for UK. During the Debt Crisis period, EU is more sensitive to Chinese stock market than the other way around. During the Speculative Period of 2014-2015 in China, the SSE A shares index became more and more sensitive to the other markets, except for Japan.

3.2 Analysis of the effect of reforms

Since joining WTO at the end of 2001 to the end of 2006, Chinese government has implemented many different reforms in order to gradually open up the Chinese financial market. We refer to the period from the QFII that began in 2002 to the NTS reform that was basically completed at the end of 2006, called the reform period. In order to analyze the effect of reforms on dynamic correlations between mainland China and other markets, it is estimated with a dichotomous variable I_t. The equation is as follows:

$$\hat{\rho}_{ssea,i,t} = c + \varphi I_t + \varepsilon_t$$

where $\hat{\rho}_{ssea,i,t}$ is the dynamic conditional correlation of stock returns between SSEA and i (other markets), parameters c is the constant and φ the slope. We cut the period in two, so I_t=0 for the period from January 04, 2000 to the end of the reform period in December 31, 2006 because 96% of listed companies have completed NTS reforms, and I_t=1 for the period after the reforms. Table 6 presents the result of the regression estimated by the OLS (Ordinary Least Squares) model for the effects of the reforms.

Table 6: Estimates of the effect of the reforms on time-varying conditional correlation of stock returns.

	c	φ	R^2
$\hat{\rho}_{ssea,hk,t}$	0.149***	0.313***	0.823
	(90.21)	(147.53)	
$\hat{\rho}_{ssea,jp,t}$	0.094***	0.153***	0.712
	(84.69)	(107.71)	
$\hat{\rho}_{ssea,eu,t}$	0.062***	0.030***	0.164
	(80.69)	(30.32)	
$\hat{\rho}_{ssea,uk,t}$	0.021***	0.120***	0.803
	(31.58)	(138.15)	
$\hat{\rho}_{ssea,us(t-1),t}$	0.099***	0.021***	0.063
	(100.26)	(17.84)	

Note: *denote reject null hypothesis at the 10% critical value, ** 5% critical value, ***1% critical value. The values in the parenthesis are the t-stats.

The R-squared vary between 0.063 and 0.823, and the parameter for the dichotomous variable, φ, are positive and vary between 0.021 and 0.313. We observe that the parameter is the highest (0.313) for the Hong Kong-Shanghai correlation, followed by Japan (0.153) and UK (0.12). The lowest parameters are for the SSEA-EU and SSEA-US correlations but they are significant, however the R^2 are weaker.

The value of parameter $\hat{c}$ represents the estimated average correlation before the reforms. For the period after the reforms, the estimated average value of correlation is provided by $(\hat{c} + \hat{\varphi})$. We note that the correlation before the reforms period is lower than the correlation after reforms. These results are consistent with those presented in table 5. All the reforms lead up to a gradually opening of Chinese financial market. They have strengthened the correlation between mainland China and other international markets.

4. Conclusion

We highlight that the normal-DCC and t-DCC models are not totally different in their estimations. Therefore, under t-DCC model, we analyzed the dynamic correlations and sensitivities between Chinese mainland stock market and other major stock markets. Based on these correlations, we investigate the effect of Chinese policy reforms.

First, the Chinese mainland stock market has a higher dynamic correlation with one-day lagged US stocks market than US stock market at the moment t due to the time-difference between the two countries.

Second, the Chinese mainland stock market has the highest time varying correlation with Hong Kong stock market, followed by Japan. Geographically, the Chinese mainland market is more closely tied to Asian stock markets over time, followed by the United States, and with relatively lower correlations with Europe and the United Kingdom.

Third, after deciding to open gradually China's mainland stock market and implement a series of reforms, the level of correlation between China’s mainland stock market and other major markets has become stronger. Therefore, the mainland stock market is more sensitive to other markets, and also it became more sensitive during the financial crises. Other stock markets also showed higher sensitivity to the Chinese mainland market after the reforms.

Since 2018, even further, China will open its financial market. According to our analysis, the series of reforms have been implemented that modify China’s financial structure and the internationalization of financial markets. To conclude, we can consider that the reforms until 2006 represent a first step in the process of opening up the Chinese financial market by preparing it for a greater integration to the global financial system.

Appendixes

A1: Result of bivariate normal- DCC-GARCH (1, 1) model and

Normal-DCC	SSEA	HK	SSEA	JP	SSEA	EU	SSEA	UK
m	0.0596	0.0543	0.0596	0.1002	0.0596	0.0835	0.0596	0.1052
	[0.379]	[0.039]	[0.379]	[0.014]***	[0.379]	[0.025]***	[0.379]	[0.035]***
n	0.9389	0.9388	0.9389	0.8863	0.9389	0.9085	0.9389	0.8830
	[0.361]***	[0.042]***	[0.361]***	[0.016]***	[0.361]***	[0.026]***	[0.361]***	[0.036]***
1-m-n	0.0015	0.0089	0.0015	0.0135	0.0015	0.0080	0.0015	0.0118
	[0.018]	[0.003]**	[0.018]	[0.006]**	[0.018]	[0.003]***	[0.018]	[0.003]***
a	0.0062		0.0044		0.0026		0.0025	
	[0.001]***		[0.002]***		[0.001]**		[0.001]***	
b	0.9936		0.9946		0.996		0.9969	
	[0.001]***		[0.002]***		[0.002]***		[0.001]***	
1-a-b	0.0002		0.0010		0.0014		0.0006	
	[0.001]		[0.001]		[0.001]		[0.0004]	
log-likelihood	28165.23		27489.63		277665.72		28887.79	
Normal-DCC	SSEA	US	SSEA	Ust-1	SSEA	Ust-1		
m	0.0596	0.0891	0.0596	0.0893	0.0596	0.0893		
	[0.379]	[0.027]***	[0.379]	[0.028]***	[0.379]	[0.028]***		
n	0.9389	0.8993	0.9389	0.8992	0.9389	0.8994		
	[0.361]***	[0.028]***	[0.361]***	[0.028]***	[0.361]***	[0.028]***		
1-m-n	0.0015	0.0116	0.0015	0.0115	0.0015	0.0113		
	[0.018]	[0.003]***	[0.018]	[0.003]***	[0.018]	[0.003]***		
a	0.0062		0.0152		0			
	[0.005]		[0.007]**		[0.005]			
b	0.957		0.9214		0.9303			
	[0.049]***		[0.041]***		[0.243]***			
1-a-b	0.0368		0.0634		0.0697			
	[0.046]		[0.042]		[0.237]			
log-likelihood	28936.67		28963.51		28935.2			

A2: Summary statistics of dynamic correlations between Chinese mainland stock market and others markets

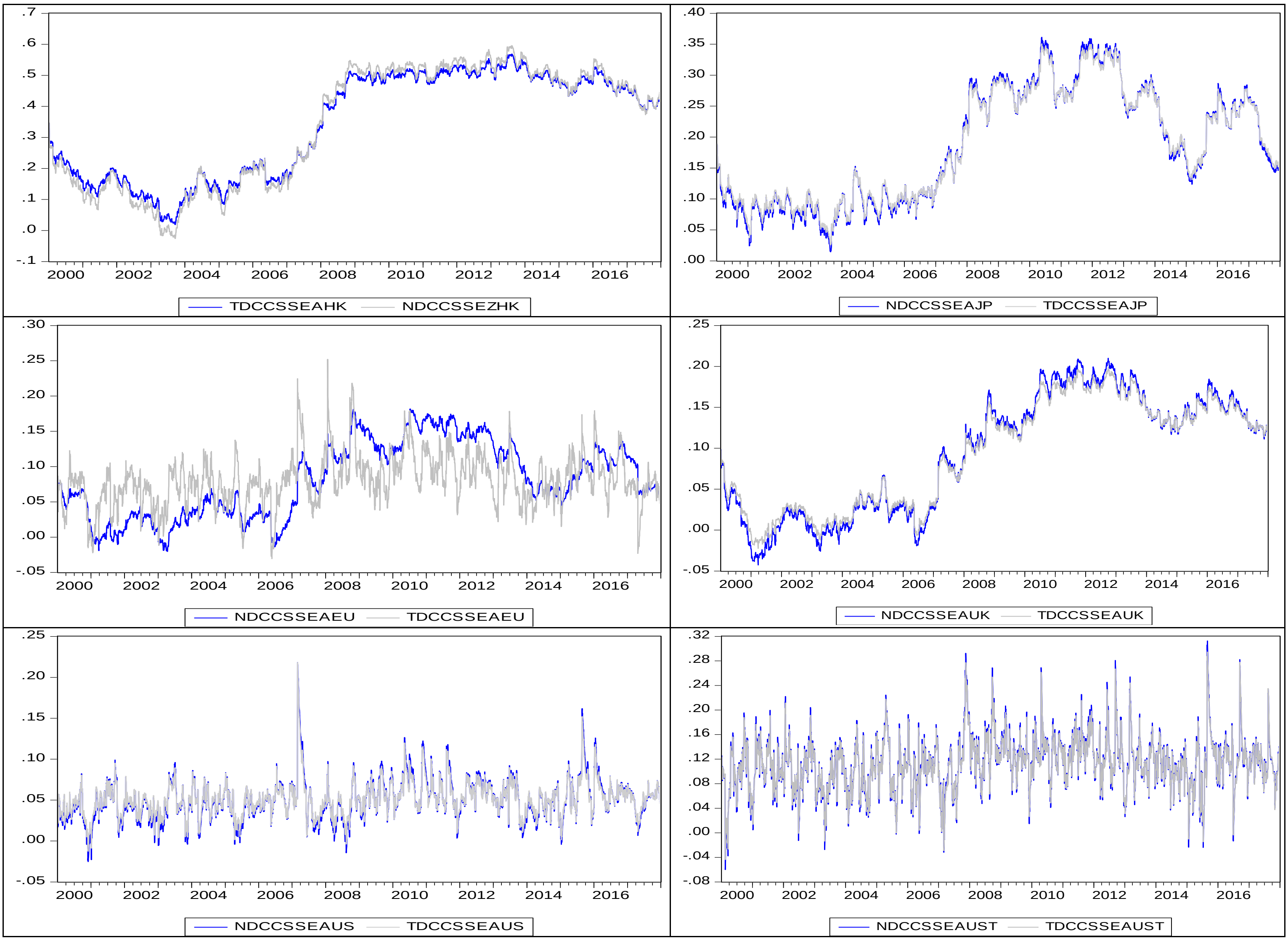
t-DCC

	TDCCSSEAHK	TDCCSSEAJP	TDCCSSEAEU	TDCCSSEAUK	TDCCSSEAUS(t-1)
Mean	0.342	0.187	0.080	0.095	0.112
Median	0.420	0.176	0.079	0.119	0.113
Maximum	0.569	0.351	0.252	0.199	0.295
Minimum	0.019	0.026	-0.031	-0.022	-0.043
Std. Dev.	0.168	0.088	0.036	0.065	0.041

Normal-DCC

	NDCCSSEHK	NDCCSSEAJP	NDCCSSEAEU	NDCCSSEAUK	NDCCSSEAUS(t-1)
Mean	0.342	0.186	0.081	0.095	0.113
Median	0.434	0.174	0.073	0.119	0.113
Maximum	0.596	0.361	0.182	0.211	0.313
Minimum	-0.026	0.015	-0.020	-0.043	-0.060
Std. Dev.	0.188	0.092	0.053	0.072	0.044

FigureA1: Conditional correlation with Normal-DCC and t-DCC GARCH model



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