Int. Journal of Economics and Management 12 (S2): 619-631 (2018)

IJEM
International Journal of Economics and Management
Journal homepage: http://www.ijem.upm.edu.my

Stock Market Linkage and Impact of the Sub-Prime Mortgage Crisis: Evidence from Mainland China and Hong Kong

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ABSTRACT

This study investigates the linkage between Mainland China and Hong Kong stock markets pre and post 2007 U.S. sub-prime mortgage crisis. We employ Dynamic Conditional Correlation GARCH (generalised autoregressive conditional heteroscedasticity) model to identify the association of weekly market returns based on volatility spillover effects from 2000 to 2007 (pre-crisis), and 2008 to 2017 (post-crisis) respectively. Our study reports significant linkage between the two stock markets with the sub-prime mortgage crisis contributes to strengthening the relationship. In particular, based on the volatility spillover effect, the long-term equilibrium linkage between the two markets is steady and inseparable due to strong economic ties. Our results highlight the importance of policy implications, especially on how regulators should deal with the increased market interconnectedness and on the diversification opportunities by investors.

JEL Classification: G01, G11,

Keywords: China; stock market linkage; volatility spillover effects; DCC-GARCH; sub-prime mortgage crisis

Article history:
Received: 21 June 2018
Accepted: 29 November 2018

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INTRODUCTION

The effectiveness of geographical diversification strategy lies on the performance correlation between markets. Previous studies have shown that different stock markets are becoming more integrated and that major financial markets have increased the linkage between different countries or regions (see, for instance, Aggarwal and Rivoli, 1989; Hamao et al., 1990; Ghosh et al., 1999; Cha and Oh, 2000; Leong and Felmingham, 2003; Tian, 2007; So and Tse, 2009; Chien et al., 2015). With economic integration increasing gradually, the stock market between different regions has shown greater relevance over the last few decades. In particular, studies on linkage between stock markets have become an important aspect of stock market research, which could have great implications on diversification strategy and regulatory policy (Karolyi and Rene, 1996; Jan et al., 2000; Phylaktis and Ravazzolo, 2005).

In recent years, the Hong Kong stock market has become increasingly reflective of the Chinese economy, and has acted as a closer proxy to China growth. Examining the linkage between the China Mainland and the Hong Kong stock markets and exploring the mutual changes of the two stock markets is of significance as it can promote mutual cooperation and establish investment mechanism to allow coordination of regulations. Furthermore, the occurrence of economic crisis tends to make the global economy pay more attention to its bad risk conduction effect, with increasing research on the influence of cronyism amongst economic subjects. The US sub-prime mortgage crisis broke out in July 2007, which swept through major financial markets globally. China, as the second largest economy and the largest trading country, was not immune to the global financial turmoil. Consequently, China had a stock market crash with both the Shanghai and Hong Kong stock markets encountering substantial difficulties during the crisis. It was a serious blow to Chinese stock market investors' confidence and a negative expectation to long-term market development. Hong Kong market, with an increasing role to be an international China gateway for global investors, may start to lose its attractiveness as a single market in portfolio diversification strategy if the two markets has become highly integrated.

Since the Asian financial crisis in 1997, the rapid transmission of financial risks among different regions has received increasing attention. This is largely due to the linkage among the Asian countries, and the dynamic correlation among the world developed financial markets. The synchronised stock market crash of China mainland and Hong Kong stock markets in 2007 should receive serious attention. It has triggered psychological panic and pessimism to investors in China's capital market frustrating both investment and consumer confidence. Understanding the transmission mechanism and the linkage among the stock markets is crucial for market investors and market regulators. Moreover, in recent years, the mainland stock market introduced a series of important reforms. In addition to the cross listings of shares, QFII (Qualified Foreign Institutional Investors) and QDII (Qualified Domestic Institutional Investors) system has been shown to strengthen the linkage between the mainland and Hong Kong stock markets since 2003. In 2014, a new policy named "Shanghai-Hong Kong Stock Connect" was introduced and launched, which has a great impact on the relationship between these two stock markets. If we are able to understand the impact of policy changes and the level of integration between the two stock markets, investors could better reduce the potential risks and policymakers are able to develop market operation rules to ensure healthier development of both markets and the economies.

Figure 1 provides a snapshot on the general comparisons between the Mainland and Hong Kong markets in terms of their geographical economy size and GDP per capita over last few decades, as well as the performance of economic growth and changes in stock market capitalisation before and after the sub-prime crisis. While the economic size has grown rapidly over the last few decades, there is still a significant gap in income per capita between the Mainland and Hong Kong. The comparison of GDP growth also suggests that Hong Kong is more sensitive to the world economic changes as compared with the Mainland, which did not fall into a recession in years 2008-2009. On the other hand, the role of Hong Kong stock market has become more significant since year 2000. Despite the hit of the said crisis, it market capitalisation-to-GDP ratio has tripled to more than 1200% from below 300%. At the same time, the Mainland's ratio also experienced a respectable growth from 30% to about 70%. It suggests that the role of Hong Kong market could still be more than a connector to the Mainland in recent years.

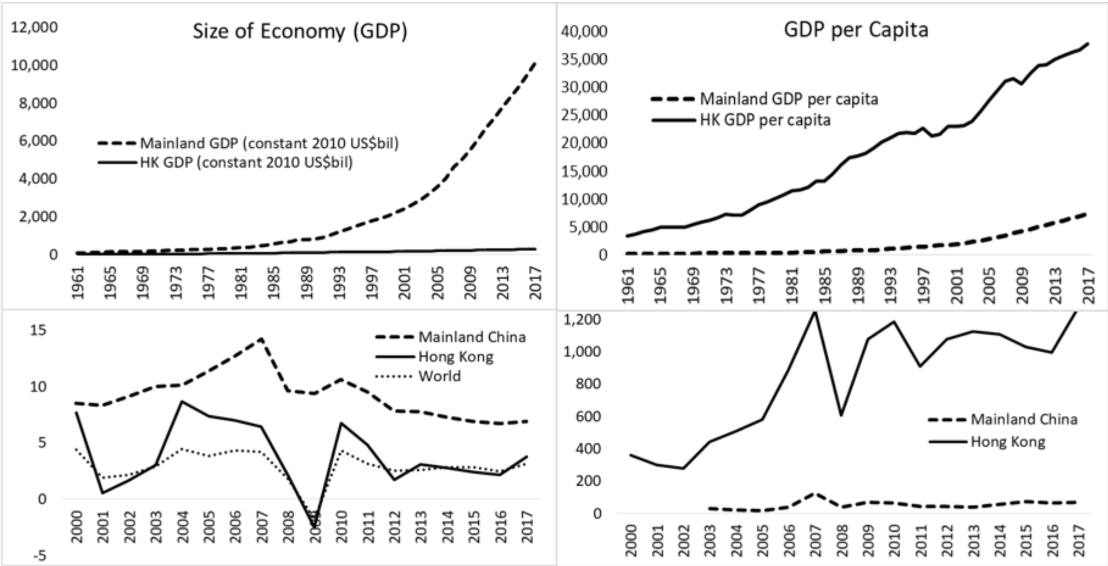

Figure 1 Comparisons between Mainland China and Hong Kong

The overall objectives of this study is to examine (i) the linkage between the China Mainland (Shanghai) and the Hong Kong stock markets pre and post sub-prime crises between 2000 and 2017; and (ii) the impact of the sub-prime crisis on such linkage. By using the Dynamic Conditional Correlation generalised autoregressive conditional heteroscedasticity (DCC-GARCH) technique, we empirically examine the degree of linkage changes between the two stock markets, and discuss the possible causes of such linkage before and after the crisis.

In the previous studies, there are still limited literature devoting to the impact of the sub-prime crisis on the linkage of the two stock markets. In this study, we focus on the role of sub-prime crisis on the linkage change between the Mainland and Hong Kong stock markets. We divide the analysis into two parts based on the timing of sub-prime crisis in 2007. By comparison of the degree of linkage between these two stock markets, we discuss the change and the impact of sub-prime crisis on the linkage between the two markets. This also serves as a more updated study on the relationship since the inception of Shanghai-Hong Kong Stock Connect, which we believe to have a significant impact on the change in relationship due to the much easier market access by investors from both markets. By end of 2017, it is reported to have more than a trillion US dollars' worth of transactions generated by the stock connect scheme since 2014. Nevertheless, the net impact is subject to further investigation as crisis period could have changed the linkages among markets (see, for e.g., Cha and Oh, 2000; Leong and Felmingham, 2003; Goh et al., 2005), in addition to the expected contagion during crisis (Singh and Kaur, 2015; Wang and Liu, 2016).

The next section of the paper presents the literature review. In Section 3, we outline the methodology and discuss our data sources, model concept, model estimation and the techniques adopted. Section 4 presents our results and discussion and Section 5 offers conclusion with some recommendations.

LITERATURE REVIEW

A number of studies have been found over the last decade to have investigated the linkage between the stock markets of Mainland and Hong Kong in China. In the case of the linkage between stock markets, two opposing arguments are noticed. Some studies indicate that there is no or a weak relationship between markets. For example, Bailey (1994) shows that in the early days of the Chinese stock market development, no significant interdependence was found between the Mainland stock market and the international stock markets in Southeast Asia especially before the 1997 financial crisis. Huang et al. (2000) collect the daily indices from October 1992 to June 1997 of the stock markets in Mainland China, Taiwan, Japan, Hong Kong and the US, and find that no long-term relationship between the stock market of Mainland China and their international counterparts. Zhu et al. (2004) and Li (2007) find market volatility spillover from Hong Kong to Shanghai, but not vice versa. In particular, Cheng and Glascock (2005) analyse the dynamic linkages between the Greater China Economic Area stock markets (GCEA) i.e. Mainland China, Hong Kong, and Taiwan, using weekly stock market price indices covering a period from 1993 to 2004. Based on the simple random walk, GARCH and autoregressive integrated moving average models, comparison highlights that the four markets of GCEA are neither co-integrated with the Japanese or the U.S. market nor were they co-integrated among each other.

Conversely, some researchers argue for a linkage between Mainland China and the Hong Kong stock markets. They highlight that both stock exchanges have a significant relationship or feedback in the economic activities of China. For instance, Poon and Fung (2000) support the hypothesis that there is inherently a stable link among red chips, H-shares and Mainland stock markets. They use the multivariate EGARCH-M model and find a significant volatility spillover effect between red chips, H-shares and the Shenzhen and Shanghai stock markets. The result shows that there is a co-movement between the Mainland and Hong Kong stock markets based on these three types of shares. Tian (2007) reinforces the view that there is a co-integrating and long-term causal relationship between the two stock markets -by using average monthly price data from 1993 to 2007 in order to avoid a high level of noise in daily data. They highlight that a long-term equilibrium relationship measured by co-integration has been merged between the Chinese A-share market and other markets in the greater China region. Surprisingly, they also find that the A-share market and Hong Kong stock market have a significant feedback relationship since the Chinese A-share market was only opened to the QFII in 2002. In a similar effort, Fan et al. (2009) enhance the conclusion that there is a linkage between Mainland China and the Hong Kong stock markets. They carry out weekly closing price for stock market indices for the period 1992 to the end of 2008, and determine the dynamic relationship between the Mainland and Hong Kong stock markets based on the Markov-Switching Vector Error Correction Model. They conclude that there exists a long-term relationship between Mainland China and Hong Kong especially post 1999.

In a more recent study, Huang and Kuo (2015) report that the Mainland China stock market significantly affects the Hong Kong and Taiwan markets through volatility spillover effects between 2000 and 2012. Utilising trivariate BEKK (Baba, Engle, Kraft, and Kroner)-GARCH model, they indicate that the Mainland stock market plays a leading role among these three stock markets. They find that these markets are closely linked. Such finding is later supported by Huo and Ahmed (2017) in their study of the impact of Shanghai-Hong Kong Stock Connect. Utilising high frequency data of one-minute interval, they conclude that the volatility spillover effect from Shanghai to Hong Kong is strengthened and stronger than the other way round. In our study, we are also interested in looking at the influence of the sub-prime crisis on the linkage change between the Mainland and Hong Kong stock markets. The following section outlines the methodology adopted for this study.

METHODOLOGY

The main purpose of this study is to investigate the linkage between the Mainland and Hong Kong stock market in China in light of 2008 sub-prime mortgage crisis. The DCC-GARCH model (see Engle and Sheppard, 2001), which is commonly used in dynamic correlation of time series, is to be used in this study. The following section describes our data collection, sampling procedure and the econometric techniques employed.

Model concept

Previous studies have highlighted that volatility plays an important role in measuring the size of the errors made in modeling returns and in other economic variables. Since the size of volatility is not constant but changes with time and could be predicted, it seems to be a good sign for asset and risk management. Research on volatility has indeed become a subject of research of financial time series since the 1970s, with the seminal research results being presented by Professor Engel's (see Enger, 1982) autoregressive conditional heteroscedasticity (ARCH) model. The ARCH model assumes that the conditional variance of the disturbance term is related to the past and is described as a function of the past disturbance term so that the ARCH model can capture the cluster of the volatility in the sequence to a certain extent.

However, during their study, the researchers find that although the ARCH model can describe volatility, but to obtain a better fit effect requires a considerable lag order, which will not only reduce the freedom degree of the model, but also increase the difficulty of parameter estimation and the possibility of the existence of multiple collinearity. In view of the above problem, scholars have carried out extensive researches, one of the most influential is generalised autoregressive conditional heteroscedasticity model (GARCH model), which is an extension of the ARCH model, developed by Bollerslev (1986). In addition to the lag of conditional variance of the disturbance term, the GARCH model also incorporates the disturbance term itself into the model. The GARCH model requires only a small lag order to represent the infinite order of the model, which makes the difficulty of model to be estimated parameters greatly reduced, so it has since then been widely used and further expanded.

With the continuous development of capital markets and the connection among financial markets are becoming closer, the methods and models of multivariate time series are also given greater attention. Essentially, the DCC-GARCH model aims to summarise the dynamic properties of two or more series. A dynamic conditional correlation stabilised by eliminating the variance related instruments and variables and the relationship between them is assumed to increase modeling flexibility. Time-varying parameter model tells the impact at different times through the calculation of current correlation between variables of interest as a function of past realisations of both the volatility of the variables and the correlations between them. The DCC-GARCH model is an innovative and useful method for effectively dealing with the time-series mean and variance overtime changes among the time-varying parameter models. The model allows us to study the evolution of relational overtime in multivariate settings by relaxing model assumptions and to provide researchers an opportunity to revive the use of time series data for testing.

Model estimation

The estimation of DCC-GARCH model is divided into two stages, which simplify the estimation of a time-varying correlation matrix. Whilst step one estimates the univariate GARCH model coefficients, and accounts for conditional variance. The standardised residuals from step one are then used as inputs to estimate a time-varying correlation matrix. Step two is aimed at estimating the dynamic conditional correlation matrix. There is an insightful advantage of employing the DCC-GARCH model because it allows asymmetries, which means that the weights are different for positive and negative changes to a series.

Rate of return

To study the impact of regional stock markets on the stock market in another region, the first step is to calculate the stock rate of return. The purpose of decomposition is to examine the impact of information transmission on the impact of the rate of return.

We employ the method outlined by Hamao et al. (1990) to define the rate of return of a complete trading week: the previous week's closing price to current week's closing price. Based on our analysis using the GARCH model, we aim to obtain the return rate of these two stock markets before we commence formulating our model so that the return rate R can be expressed as $\ln(P_{i,t} / P_{i,t-1})$, where i indicates Mainland and Hong Kong stock markets, and $P_{i,t}$ is the closing price of the market in period t.

Estimate GARCH model

Equation $\gamma_t = \mu + \varepsilon_t$ is the return time series, where μ is the expected return[1] and ε_t is an error term with zero-mean. Although the series ε_t is not relevant, the series does not require continuous independence. For instance, it can present conditional variance. The GARCH model assumes the specific parameter form of this conditional variance.

$$h_t^{\,2} = \omega + \alpha\varepsilon^2{}_{t-1} + \beta h^2{}_{t-1} \tag{1}$$

where α denotes the influence degree of the existing information on the next period of fluctuation, and the larger the α, the higher the sensitivity of the market to the new information. β is the decay coefficient,

[1] Our trials with and without an autoregresssive component in the mean equations show a high consistency in its GARCH models. This is probably because the coefficient of lag returns remain largely insignificant when they are included in the mean equations. Therefore, we stay focused within the scope of pure volatility changes using DCC-GARCH for the correlation changes between the two series (without making it an ARMA-GARCH in modelling the relationship between markets, which should require another perspective of discussion).

indicating that the conditional covariance is affected by the degree of lag. In addition, the coefficient $\lambda = \alpha + \beta$ reflects the persistence of the market return volatility, the closer the λ is to 1, the longer the trend of the volatility trend in the future. Equation (1) can be generalised to account the conditional variance for more lags. So that the GARCH (p,q) model can be assumed as Equation (2):

$$h_t^{\,2} = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon^2{}_{t-i} + \sum_{j=1}^{p} \beta_j h^2{}_{t-j} \tag{2}$$

Bayesian Information Criterion or Akaike Information Criterion can be chosen for the best model (p and q). The former is often more concise than the latter. Therefore, each GARCH specification for normalising each n return time series can be generalised to the GARCH (p, q) model, where p and q can be chosen differently for each return time series such as the approach of Bayesian Information Criterion. This study uses p=1 and q=1 following the suggestion by Bollerslev et al. (1992) which has then become the most commonly adopted GARCH model for financial time series in the literature.

Estimate DCC-GARCH model

DCC-GARCH model can be generalised to account for more lags in the conditional correlation in the step two as follows:

$$\gamma_t = \mu + \varepsilon_t \tag{3}$$
$$\varepsilon_t \sim N(0, h_t) \tag{4}$$
$$h_t = D_t R_t D_t \tag{5}$$

where equations (3) and (4) is conditional mean equation of the return rate and the error term is assumed to be zero mean normal conditionally multivariate, and the variance-covariance matrix as shown Equation (5), where D_t is a diagonal matrix of the time varying standard deviations from univariate GARCH models with $\sqrt{h_{i,t}}$ on the i_{th} diagonal. R_t is a time-varying correlation matrix. As indicated, the elements follow the first step, univariate GARCH process of following equation: $h_{i,t}{}^2 = \omega_i + \alpha_i \varepsilon^2{}_{i,t-1} + \beta_i h^2{}_{i,t-1}$ where ω_i is a constant term, α_i captures the ARCH effect, i.e. conditional volatility, β expresses the coefficient of the conditional variance is effected by the degree of lag, and $\lambda = \alpha + \beta$ measures the volatility persistence. Equation (6) is the evolution of the correlation in the DCC-GARCH model:

$$Q_t = (1 - q_a - q_b)\bar{Q} + q_a \varepsilon_{t-1}\varepsilon'_{t-1} + q_b Q_{t-1} \tag{6}$$

where Q_t is an unconditional variance–covariance matrix of residuals with its standard unconditional variance–covariance $\bar{Q}_t$ matrix and q_a , q_b are non-negative scalar parameters which satisfying $q_a + q_b < 1$ because there is no unit diagonal elements of Q_t in Equation (5. Then scale it to obtain the appropriate correlation matrix R_t of Equation (7):

$$R_t = (Q_t^*)^{-1} Q_t (Q_t^*)^{-1} \tag{7}$$

where Q_t consists of $q_{ii,t}$, $q_{jj,t}$, $q_{ij,t}$ and Q_t^* is the unconditional covariance between the series which consists of the diagonal elements of Q_t . Furthermore, a typical element of R_t is the form of $\rho_{\mathrm{ij}} = q_{jj,t} / \sqrt{q_{ii,t} q_{jj,t}}$ where i, j =1, 2, and $i \neq j$, which is the most significant element that represents the correlation coefficient between two stock markets in this methodology.

Data Sources

This study uses the rate of return of weekly closing price of the Shanghai Composite Index (SHI) and the Hang Seng Index of Hong Kong (HSI) to measure the development of the stock markets in the Mainland and Hong Kong. Data is obtained from Yahoo Finance covering the period from January 2000 to March 2017. After rejecting stock market mismatches in the sample (for e.g. due to holidays), a total of 1766 valid matching data are selected.

RESULTS AND DISCUSSION

Table 1 illustrates the descriptive statistics of return series of HSI (RHSI) and the SHI (RSHI). As shown in Table 1, the Shanghai stock market has a higher mean average return than Hang Seng while the median is lower than Hang Seng. This indicates that Chinese Mainland stocks have a higher average return rate with a more positive skewness. The maximum return rate of Shanghai stock market is also higher than the Hang Seng stock market. Correspondingly, the standard deviation of Shanghai index return volatility is greater.

Table 1 Result of Descriptive Statistics

	RSHI	RHSI
Mean	0.0870	0.0521
Median	0.0264	0.1819
Maximum	13.9447	11.7189
Minimum	-14.8979	-17.8154
Std. Dev.	3.4324	3.1058
Jarque-Bera	191.1581***	226.5161***
Observations	883	883

Note: we use Jarque-bera (JB) statistic to check whether the sequence is subject to a normal distribution where *, **, *** denotes the rejection of null hypothesis at significance levels of 10%, 5%, 1% respectively. JB statistics validate that series are not normally distributed as the Table 1 shown.

Granger and Newbold (1974) find that there would be a spurious regression phenomenon if the time series were not stationary. Therefore, we first perform the test on the stationarity of the sequence. In this paper, we examine stationarity of the variables using Augmented Dickey Fuller (ADF) unit root test and the null hypothesis is that there is a unit root in the return series.

Table 2 illustrates the ADF t-statistics and the critical value of HSI and SHI returns respectively, where *, **, *** represent that the return series reject the null hypothesis at the 10%, 5%, 1% significance level. The unit root test results show that the t-statistics of sequences are less than the critical value at the 1% significance level. It indicates the null hypothesis of unit root presence can be rejected and suitable for time series analysis without spurious regression.

Table 2 Result of ADF Test

	ADF：t-statistics	Critical value at 1% significant level	Probability
RHSI	-29.69489***	-3.43754	0.0000
RSHI	-27.70929***	-3.43754	0.0000

In the financial market literature, time series may show a certain degree of autocorrelation due to investor sentiment, the persistence and coherence of market factors. If autocorrelation exists, it is necessary to establish the corresponding mean model to improve the model fitting effect. Therefore, it is necessary to test the autocorrelation of the sequence before establishing the model. This paper adopts Ljung-Box Q-statistics to test the autocorrelation of the sequences.

Table 3 illustrates the result of Ljung-Box Q test of both HSI and SHI returns where *, **, *** represent that the return series reject the null hypothesis at the 10%, 5%, 1% significance level. Since the null hypothesis of Ljung-Box Q test is there is no p-order autocorrelation in the sequence, this null hypothesis can be rejected that there is autocorrelation both in returns of Shanghai and Hang Seng stock markets.

Table 3 Result of Q-test

	Level		First difference	
	Q-statistic	Probability	Q-statistic	Probability
RHSI	28.009	0.013**	236.50	0.000***
RSHI	12.043	0.007***	211.92	0.000***

There is not only autocorrelation of financial time series, but also heteroscedasticity. The basic idea of the ARCH effect is that the occurrence of a noise at a certain moment follows a normal distribution at a time when the mean of the normal distribution is zero and the variance is a time-varying amount (i.e., a conditional heteroskedasticity). Furthermore, the variance over time is the linear combination of the squared noise values of the past finite term (i.e., autoregressive). It means that the sequence has heteroskedasticity.

ARCH effects are prevalent in the time series of financial markets and are therefore widely used in this field. In order to carry out dynamic analysis of the stock market and, we should first examine the ARCH effect of the time series of the two markets. The null hypothesis of ARCH effect test is states the absence of ARCH effect in the residual sequence. ARCH effect test is usually a Lagrange multiplier test for the presence or absence of autoregressive conditional heteroscedasticity in the residual term. If the F-statistic rejects H_0, then there is an ARCH effect-conditional autoregressive effect in the residual sequence, which the residual is affected by its own lag order and heteroscedasticity does exist. Table 4 shows the ARCH effect test results of HSI and SHI returns, indicating that we can reject the null hypothesis at the 1% significance level. There is existence of ARCH effect in both HSI and SHI return rate sequences.

Table 4 Result of ARCH Test

SHI				HSI			
F-statistic	12.932	Prob.	0.0003	F-statistic	25.045	Prob.	0.0000
Obs*R-square	12.773	Prob.	0.0004	Obs*R-square	24.469	Prob.	0.0000

Empirical results of DCC-GARCH model

The objective of this paper is to investigate the linkage between China Mainland and Hong Kong stock markets based on the timing of sub-prime mortgage crisis. To be more persuasive, we select 31 December 2007 as the cut-off point of the sub-prime crisis, of which 415 trading days of 2000-2007 before crisis, and 468 trading days of 2008-2017 after crisis.

The order of DCC-GARCH is based on the previous literature of Bollerslev et al. (1992). The study implies that DCC-GARCH (1, 1) can well fit the volatility of financial and economic phenomena with the simplicity is taken into account. Hence, this paper chooses the DCC-GARCH (1, 1) model to analyse the volatility of the returns. In the DCC-GARCH test result, α denotes the influence degree of the existing information on the next period of fluctuation. The larger the α, the higher the sensitivity of the market to the new information. β is the decay coefficient, indicating that the conditional covariance is affected by the degree of lag. In addition, the coefficient $\lambda = \alpha + \beta$ reflects the persistence of the market rate of return fluctuations, the closer the λ is to 1, the longer the trend of the volatility trend in the future. The significance of these coefficients are based on t-statistics. This section is divided into two parts based on the sub-prime crisis

Empirical result before sub-prime mortgage crisis

Table 5 shows the result of DCC-GARCH model before sub-prime mortgage crisis. Since α denotes the influence degree of the existing information on the next period of fluctuation, and α of RHSI is 0.0850 which is higher than RSHI, it indicates that Hong Kong stock market is more responsive to new information than Mainland of China. Furthermore, the β value of Hang Seng stock market is large than Shanghai stock market, indicating that the speed of decline of Hang Seng stock market is faster. In addition, the λ value of both Shanghai and Hang Seng stock markets are close to 1, but Hang Seng is slightly closer to 1 than Shanghai, which shows that the volatility trend of both markets will continue in the future, and the Hong Kong stock market will be longer than the Mainland.

Table 5 Result of DCC-GARCH Model Before Crisis

Coefficient	RSHI	RHSI
c	0.7779	0.0967
Prob.	0.0000	0.0053
α	0.0803	0.0850
Prob.	0.0000	0.0000
β	0.8366	0.9061
Prob.	0.0000	0.0000
λ	0.9169	0.9911

Figure 1 shows the dynamic correlation coefficient before sub-prime mortgage crisis which illustrates the dynamic correlation coefficient between Shanghai stock market and Hang Seng stock market before the crisis, where horizontal axis is the number of trading days and vertical axis is the dynamic correlation coefficient. The dynamic correlation coefficient between the Hong Kong stock market and the Mainland stock market has shown some changes over years 2000 to 2007.

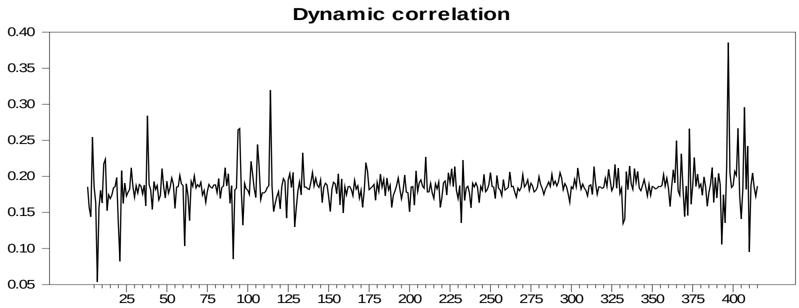

Figure 2 Dynamic Correlation Coefficient Before Crisis

In general, the dynamic correlation coefficient changes between 0.15-0.25 and the fluctuation range is broader, which indicates that the relationships between the two markets are more closely related to each other. Furthermore, the dynamic correlation coefficient between the two markets fluctuates more frequently and has significant peaks from January 2000 to May 2002, and then the dynamic correlation coefficient fluctuates more gently, mainly concentrated between 0.15 and 0.2. However, the fluctuation range of dynamic correlation coefficients expands to 0.1 to 0.4 with a number of significant abnormal peaks. Overall, there is a close volatility correlation between the Hong Kong and Shanghai stock markets.

Empirical result after sub-prime mortgage crisis

Compared with the result before sub-prime mortgage crisis, the value of α has experienced a significant change in these two stock markets. Table 6 shows the result of DCC-GARCH model after sub-prime mortgage crisis. α value of Shanghai stock market exceeds Hang Seng stock market. It indicates that the response of Shanghai stock market to new information is more sensitive than Hang Seng stock market after the financial crisis in years 2007 to 2017. However, the decline speed of Hang Seng stock market is still faster than Shanghai stock market where the value of β is unchanged compared with Shanghai. λ of Shanghai stock market increases from 0.9169 to 0.9809 compared with the pre-crisis period, which means that the volatility continues longer than the previously observed.

Table 6 Result of DCC-GARCH Model After Crisis

Coefficient	RSHI	RHSI
c	0.1934	0.2002
Prob.	0.0017	0.0053
α	0.1315	0.0964
Prob.	0.0000	0.0000
β	0.8494	0.8782
Prob.	0.0000	0.0000
λ	0.9809	0.9746

Figure 2 is the dynamic correlation coefficient graph after sub-prime mortgage crisis which illustrates the dynamic correlation coefficient between Shanghai stock market and Hang Seng stock market after sub-prime mortgage crisis, where horizontal axis is the number of trading days and vertical axis is the dynamic correlation coefficient. In general, the dynamic correlation coefficient basically changes between 0.2 and 0.6. In addition, it experiences a frequent fluctuation and there exist some peaks close to 0.8 from January 2008 to June 2009. The contagion effect of crisis is significant between the two markets. Then, the dynamic correlation coefficient fluctuates more gently from June 2009 to May 2015, mainly concentrated in the range of 0.15-0.2. An obvious increase is also observed thereafter, where the coefficient fluctuates around 0.35 to 0.45.

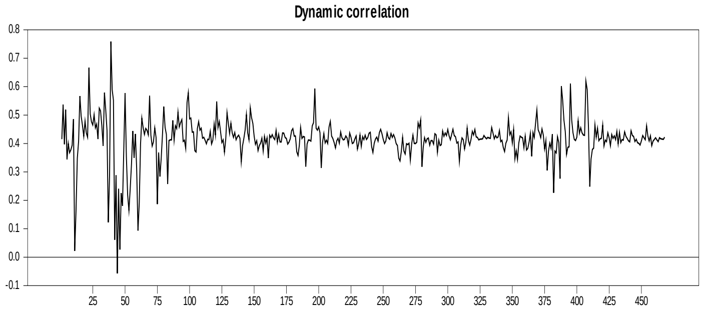

Figure 3 Dynamic Correlation Coefficient After Crisis

Comparative discussion

The main purpose of this study is to empirically analyse the linkage between the two stock markets by using the DCC-GARCH model and analysing the impact of both pre and post sub-prime mortgage crises. Based on the results of our DCC-GARCH model, this section offers a comparative evaluation of the two stock markets. Overall, our results support the findings by Poon and Fung (2000), Tian (2007), Fan et al. (2009), and Huang and Kuo (2015) that there is significant linkage between the Mainland and Hong Kong market.

In general, the relationships between the two markets have become more closely related to each other according to the two dynamic correlation coefficient graphs. In other words, there is a significant dynamic correlation relationship between Mainland China and the Hong Kong stock market. The main dynamic correlation coefficient range has experienced expansion after the sub-prime mortgage crisis from 0.15-0.25 to 0.2-0.6. This clearly shows an increase of linkage between the two stock markets, which was enhanced by the sub-prime mortgage crisis during years 2007 to 2009 when the coefficient reaches the highest at around 0.8. Moreover, the α value of both stock markets have shown a large increase which means that both markets have become more sensitive to new information, especially Shanghai market. Overall, it appears that there is a close volatility linkage between the Hong Kong and Mainland stock markets. Essentially, the impact of the sub-prime mortgage crisis has played a greater role in this linkage and such trend may continue.

Apart from globalisation and common deregulation, we believe that such linkage is further enhanced by the Shanghai-Hong Kong Stock Connect launched since 2014, consistent with the argument by Huo and Ahmed (2017). Investors from each market are able to trade shares on the other market in a much more convenient manner. While the ease of restrictions on capital movements could foster integration (Huang et al. 2000), changes in underlying common productivity factor across markets should accelerate such process (see, for e.g., Fama and French, 1989; Campbell and Hamao, 1992). From the perspective of investors, the strengthened linkage may not be a good development since Shanghai and Hong Kong are two major markets that previously provide diversification opportunities. By end of year 2017, Shanghai stock market and Hong Kong stock market ranked number four and number seven respectively in terms of market capitalisation, totalled more than 9 trillion US dollars. Strong integration between the two markets implies a loss of a major market in terms of geographical diversification.

CONCLUSION

This study investigates the linkage between Mainland China and Hong Kong stock market before and after the sub-prime mortgage crisis. By using DCC-GARCH model, this paper aims to study the change of linkage in light of the impact of the crisis on the linkage between these two stock markets. The study reports that there is indeed a significant linkage between the two stock markets both pre and post crisis period. The results indicatethat the long-term equilibrium linkage between the two markets is steady, and inseparable due to the strong economic ties between Hong Kong and Mainland China.

The study also highlights that the sub-prime mortgage crisis has in fact strengthened the link between the two stock markets. Based on the empirical results, the dynamic correlation coefficient between these two stock markets has increased 2 to 3 times suggesting the rising volatility spillover effect after the sub-prime mortgage crisis. Interestingly, the study also reveals that both markets has increased sensitivity to new information. The reaction of both markets has become larger after the sub-prime mortgage crisis especially in Mainland stock market. In fact, the volatility spillover of both markets also has become larger, and the linkage between them has become closer. We suggest to have more academic studies on such changes in dynamic linkages across different markets, and thus to compare with those before the crisis period. For example, the Shenzhen market would be good to be highlighted in the future studies to represent the Mainland market since the Shenzhen-Hong Kong Stock Connect has been launched in the end of 2016.

In the light of the above, we make the following recommendations. First, as linkage enhances mutual influence between the two stock markets, greater integration emanates. Whether the Mainland stock market or Hong Kong stock market appears to be volatile, the volatility will be passed to each other. Therefore, the two stock markets should be considered together as a whole. After all, the development of any stock market may bring about volatility. It requires policy makers from both markets to strengthen communication and cooperation to avoid unnecessary spillover effects of their respective policies which cause disturbance to another market. Indeed, the purpose is to maintain a stable development of both markets.

Second, due to the linkage enhancement between these two stock markets, risk prevention and regulatory cooperation issues become more significant. It is to reduce the adverse impact of differing legal systems with conflicting issues stipulated by their respective laws and regulations. Therefore, the government should establish judicial assistance in the two regions, which would penalise unlawful activities to protect the interest of investors.

Third, it is incumbent to focus on the investment risks after the increase of linkage. While we agree that a stronger linkage is able to enhance information sharing and market efficiency, investors in both stock markets need to undertake a greater degree of risk aversion and pay more attention to the dynamics of the other side of the market. In addition, the increase of the linkage between the two stock markets means that the investment philosophy of participants from two stock markets will gradually converge as the risk of the two stock markets become more in line. It will, undoubtedly, reduce the effectiveness of portfolio risk diversification between the two markets.

Finally, we propose that the study of the relationship between the two markets can be extended to compare the impact of different crises other than the sub-prime, for example the Asian financial crisis, European sovereign debt crisis, U.S. debt ceiling crisis, etc. In addition, the future study could consider estimating the mediating effect of one market to another by incorporating the crisis-origin markets, for example the U.S. or the European countries, in the analysis to provide a better understanding of the relationship.

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