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Return and volatility spillovers effects: Evaluating the impact of Shanghai-Hong Kong Stock Connect

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ABSTRACT

This study investigates the impact of the recently introduced Shanghai-Hong Kong Stock Connect. Using high frequency data and dynamic forecasting techniques, we find that the new Stock Connect does contribute to the increasing importance of the Chinese mainland stock market and economic activity. A weak and unstable cointegration relationship is found after this event. Additionally, the Stock Connect has also increased the conditional variance of both stock markets. We observe a leading role of the Shanghai stock market to the Hong Kong stock market in terms of both mean and volatility spillover effects after the Stock Connect. Our study indicates that the opening up of stock markets in China could enhance the leading power, influence the risk level and improve the market efficiency of the Chinese mainland stock market, since the volatility spillover effect from Shanghai to Hong Kong is strengthened. Besides, our results have important policy implications, especially on how policy makers should deal with the increased market interconnectedness and for portfolio managers in choosing potential hedging instruments. The success of Shanghai-Hong Kong Stock Connect provides valuable operational experience for the forthcoming Shenzhen-Hong Kong Stock Connect which could further improve the market efficiency in China.

1. Introduction

Economic globalization and the increasing process of financial liberalization make international financial markets more integrated and correlated than ever before. Many authors (see for example Bekaert and Harvey (1997)) have argued that openness in financial systems can increase the international financial linkage and enhance stock markets correlation. Strong linkages between different stock markets globally can reduce the isolation of local markets, increase the ability to react rapidly to the news from other markets and reduce the benefit of international diversification. A spillover occurs when price changes in one market produce a lagged impact on the other markets. The spillover effect can exist among different countries and also among different financial markets within one country. Since the US October Crash (the famous Black Monday 19 October 1987), research on the spillover effects between different equity markets have been widely undertaken. Many researchers have observed spillover effects in relations to returns and volatility between different financial markets. Some studies have found short term or long term interdependence and causality of the returns among different stock markets. In this regard, Eun and Shim (1989) use daily stock returns to examine financial innovation transmission mechanisms and observe return spillovers from the US to the nine largest stock markets. In addition to the influence on market returns, the flow of information can have a major influence on volatility patterns. Therefore, understanding return and volatility spillover effects across different markets is important, as it can enable investors, governments and financial institutions to have a better understanding of the dynamic relationships among different stock markets and impacts of the information flow across markets. Understanding the spillover effects is also helpful in devising market policies, making asset and investment allocation decisions and designing appropriate hedging strategies. Although the existing literature focuses on developed financial markets, it is important to extend spillover effect analyses to emerging markets as they develop fast and become the big players in the global economy. It is this aspect that China, being the largest emerging financial market, becomes a suitable research market to re-examine return and volatility spillover dynamics.

China, as the largest developing country and the second largest economy in the world, plays an increasingly important role in the global economy. Over 30 years of economic reforms which started in 1978 have a huge influence on the Chinese economy and financial markets. After the rapid development of the economy, China becomes

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one of the main drivers in the global economy. In the early 1990s, China established two stock markets, namely the Shanghai stock market and the Shenzhen stock market. After the establishment of these two stock markets, both stock markets experienced a rapid development and have become more influential regionally and globally. The Chinese stock market became the second largest stock market in the world after its capitalization surpassed Japan in 2007. However, China has still not fully opened up its financial markets to the rest world and some restrictions still exist with unique characteristics. In the process of integrating its financial markets, the Chinese government has taken several steps to liberalize its financial markets. For example, China divides its stock markets into different categories, where the A share market is for Chinese domestic investors and the B share market is for foreign investors. In order to balance advantages and disadvantages of fully opening up Chinese financial markets to the global citizens, China has developed two programs: QDII (Qualified Domestic Institutional Investors) and QFII (Qualified Foreign Institutional Investors) which allow only qualified domestic institutional investors to invest abroad and qualified foreign institutional investors to invest in Chinese domestic financial markets. As a result of these changes, Chinese financial markets are now more correlated with the rest of the world. On the other hand, Hong Kong is one of the largest and most liquid financial markets in Asia. The Hong Kong stock market, just behind China and Japan in terms of market capitalization, is China's closest financial hub and has a significant economic, political, and geographical interrelationship with the mainland. Therefore the regions have close ties and are expected to exhibit high levels of market linkages. Given the presence of similar investor groups and cross-listed regional companies, the connection between mainland China and Hong Kong has a significant influence on Hong Kong's return (Yi et al., 2009). In order to link Shanghai and Hong Kong stock markets, a pilot program (Shanghai-Hong Kong Stock Connect) was launched on 17 November 2014. As a result, restrictions on both domestic and international investors were relaxed and it is expected that the two stock markets will become more integrated. Given the launch of Shanghai-Hong Kong Stock Connect and the availability of high frequency data, it is timely to investigate the interdependence and linkages between mainland China and Hong Kong stock markets. Although there exists some studies on spillover effect between China and other countries, for example Johansson and Ljungwall (2009) and Zhou et al. (2012), there has been very little research on the impact of significant events on return and volatility spillovers between China and Hong Kong. Furthermore, it should be noted that Shanghai-Hong Kong Stock Connect provides the first opportunity to retail investors outside mainland China to trade on the Chinese A share market. The impact of this event would result in a significant increase in the capital flows between the Shanghai and Hong Kong stock exchanges in both directions. This significant event motivates this research and provides a real opportunity to examine whether the mean and volatility spillover effects change after the introduction of Shanghai-Hong Kong Stock Connect. While focusing specifically on the event of Shanghai-Hong Kong Stock Connect, this study aims to fill the gap in the literature by examining the influence of Shanghai-Hong Kong Stock Connect on the market returns and volatility. We use the stock market price indexes to investigate the integration of the Shanghai and Hong Kong stock markets and consider the price movement, mean and volatility spillover effects, and the volatility behaviour of the market integration before and after this event. We break the sample into two sub periods: Pre- and Post-Shanghai-Hong Kong Stock Connect periods using various GARCH models. Our analyses contribute to the literature by shedding new light on the dynamic relationships between the Shanghai and Hong Kong stock markets.

2. The Status of Shanghai-Hong Kong Stock Connect

A major change in the structure of the Chinese stock markets was underway since the time Shanghai-Hong Kong Stock Connect was launched. On 10 April 2014, the China Securities Regulatory Commission (CSRC) and the Securities and Futures Commission (SFC) made a joint announcement to approve, in principle, the development of the pilot program (Shanghai-Hong Kong Stock Connect) to establish the mutual access between mainland China and Hong Kong stock markets. Seven months later, the program was officially launched on 17 November 2014. Shanghai-Hong Kong Stock Connect provides a cross-boundary investment channel between the Shanghai and Hong Kong stock markets so that investors in each stock market can trade stocks listed in the other market through the local clearing house and brokers. This is a landmark event in the reforms of the Chinese stock markets and it is able to relax restrictions and reshape financial structures of both the Chinese and Hong Kong stock markets. For the first time, Shanghai-Hong Kong Stock Connect is able to provide a feasible, controllable and expandable channel for mutual markets access between mainland China (Shanghai) and Hong Kong for a broad range of investors, paving the way for further opening up of the Chinese financial markets and RMB internationalisation (HKEX, 2015b). This pilot program is expected to significantly increase the capital flow between the Shanghai and Hong Kong stock markets in both directions given that the Chinese mainland investors will have the opportunity to invest in the major companies listed on the Hong Kong Stock Exchange. On the other hand, Hong Kong and international investors will get access to the Shanghai A share market in a less restrictive manner than ever before. This arrangement is expected to lead to both outward and inward financial markets liberalization and enable intensive interactions between the Shanghai and Hong Kong stock markets.

After the launch of Shanghai-Hong Kong Stock Connect, eligible Chinese mainland investors can purchase eligible shares listed on the Hong Kong Stock Exchange (HKSE) via their own local brokers, while Hong Kong and international investors will be able to purchase eligible shares listed on the Shanghai Stock Exchange (SSE) through their local brokers as well. In terms of the eligible stocks, only certain stocks in the Shanghai A share market will be included in Northbound Trading of Shanghai-Hong Kong Stock Connect at the initial stage. Other products like bonds, Exchange Traded Funds (ETF), B shares and other securities are not included at this stage. This trading arrangement also includes all the constituent stocks (which are reviewed from time to time) of the SSE 180 Index, the SSE 380 Index, and the SSE listed A shares that are not included as constituent stocks of the above indices but which have corresponding H shares listed on HKSE except those which are not traded in RMB and under risk alert. The number of total eligible securities is estimated to be 568 (as at 10 April 2014) and those shares account for about 90% of all SSE A Shares in terms of market capitalization and about 80% of all SSE A Shares in terms of average daily turnover.[1] For eligible stocks to be included in Southbound Trading, only equities listed on the Main Board will be included in Shanghai-Hong Kong Stock Connect. At the initial stage, trading under this pilot program will be subject to an Aggregate Quota (Maximum Cross Boundary Investment Quota) together with a Daily Quota. The Northbound Aggregate Quota and Daily Quota are set at RMB 300 billion and RMB 13 billion respectively, while the Southbound Aggregate Quota and Daily Quota are set at RMB 250 billion and RMB 10.5 billion respectively.[2]

There are several benefits for international investors to trade through Shanghai-Hong Kong Stock Connect. Firstly, investors outside of mainland China can participate in one of the fastest growing and the

[1] Market cap statistics as at end of Mar 2014; Average Daily Turnover statistics are for Jan-Mar 2014. Source: Shanghai-Hong Kong Stock Connect For investing in SSE securities.

[2] For further information see Shanghai-Hong Kong Stock Connect Information Book for Investors (2015), http://www.hkex.com.hk/eng/market/sec_tradinfra/chinaconnect/Documents/Investor_Book_En.pdf

world's second largest economy and invest in unexploited market. It has been argued that multinational corporations and foreign direct investment are attracted to China due to its enormous market potential when more economic sectors and regions are opened up (Tseng and Zebregs, 2002). Secondly, this program provides an opportunity for all investors to diversify their investment portfolio with stocks from the Shanghai stock market as it covers a large number of SSE listed shares. It also provides new opportunity for international investors to invest with RMB as they do not need to have an account in mainland China. In addition, all fund transfers will be processed in Hong Kong for safety and efficiency (HKEX, 2015a). There are also some benefits for Chinese domestic investors. Obviously, the implementation of Shanghai-Hong Kong Stock Connect provides a new channel for both international and domestic investors to access both the Shanghai and Hong Kong stock markets and promote business and export expansion. It is reasonable to expect that these gradual steps towards a comprehensive financial liberalization adopted in China will continue causing significant increases in the integration of the Chinese financial markets with the rest of the world.

3. A brief review of existing literature

A spillover occurs when the price changes in one market produce a lagged impact on the other markets. Spillover effects can exist among different countries and also among different financial and equity markets within one country. Moser (2003) identifies three leading activities that could result in spillover effect, namely international trade, counterparty defaults and portfolio rebalancing. Ross (1989) uses information transmission theory to explain the volatility spillovers and indicates that the spillovers between financial markets could be used to explain the process of information transmissions and the efficiency of the stock markets because price and volatility are related to the rate of information flow. In addition, the liberalization process and globalization of capital markets improve the possibilities for national markets to react rapidly to new information from international markets and hence increase the co-movement of international financial markets (Booth et al., 1997; Roll, 1992).

As the emerging markets become important investment destinations, researchers are increasingly interested to know how fast emerging markets are integrated with the rest of the world as they become more attractive to international investors. Various studies have reported evidence of the spillover effect from the developed markets (e.g. the US and Japan) to the Asian markets, including Hong Kong, Taiwan, Singapore, Korea and Thailand before the Asian Crisis (John Wei et al., 1995; Kim and Rogers, 1995; Hu et al., 1997; Liu et al., 1998). Miyakoshi (2003) uses bivariate EGARCH model and observes that only the US (not Japan) can significantly influence Asian market returns, however, the volatility of the Asian market is influenced more by the Japanese market than by the US. Wongswan (2006) uses high frequency data to show that macroeconomic information announcements in developed countries (the US and Japan) have significant but short-lived impact on emerging markets (Korean and Thai) volatility and intraday volume. Gallo and Otranto (2008) report price spillovers from the Hong Kong stock market to Korea and Thailand. They also show evidence of the interdependence with Malaysia and co-movement with Singapore. Their empirical evidence implies that the Hong Kong financial market plays a dominant role and that these Asian countries are more linked with the Hong Kong stock market. Chiang et al. (2007) apply a dynamic conditional correlation model to nine Asian daily stock returns series to confirm a contagion effect during the Asian financial crisis. Their study identifies two phases of the Asian crisis and finds a shift in variance during the crisis period. Engle et al. (2012) model the interrelations of equity market volatility in 8 East Asian countries before, during, and after the Asian currency crisis and observe that Hong Kong transmits greater risks to the others as a net creator of volatility. Lean and Teng (2013) find strong financial integration between Malaysia and China and between Malaysia and India, but the volatility spillover from the US to Malaysia disappeared in the short term.

Since the Global Financial Crisis (GFC) in 2007, some studies focused on the spillover effects during GFC period. Cheung et al. (2009) examines the impact of the 2007–2009 Global Financial Crisis on the interrelationships among global stock markets and find enhanced leadership of the US market with respect to the UK, Hong Kong, Japanese, Australian, Russian and Chinese markets. Yilmaz (2010) indicate that volatility and return spillovers behave very differently during crisis and non-crisis periods when he examined return and volatility spillovers across 10 major East Asian countries. Beirne et al. (2010) investigate volatility spillovers using data from 41 countries. Their study shows that spillovers from regional and global markets are present in the vast majority of emerging markets and spillovers in mean returns dominate in emerging Asia and Latin America. However, it is reported that spillovers in variance appear to play a key role in emerging Europe markets. Singh et al. (2010) point out that there exists evidence of price and volatility spillovers among fifteen countries across North American, European and Asian stock markets when including the same day effect and indicate greater regional influence among Asian markets than European and the US markets. Samarakoon (2011) find bi-directional and asymmetric interdependence and contagion between the US and emerging markets with important regional variations, suggesting that interdependence is driven more by the US market shocks, while contagion is driven more by emerging markets shocks. More recently, Kenourgios and Padhi (2012) investigate both equity and bond markets in emerging countries and find evidence of contagion during the Russian crisis, the Asian financial crisis, the subprime crisis, but no evidence in the Argentine turmoil. Zheng and Zuo (2013) introduces a Markov switching causality method to find evidence of the existence of spillover effects among most markets including the US, UK, Germany, Japan and Hong Kong and indicates that bilateral volatility spillover effects are more prominent over turmoil or crisis episodes, especially during the Asian financial crisis and subprime mortgage crisis periods. There are also some other studies focusing on the spillover effect. Lee (2013) examines the range-based volatility and finds that there are global spillover effects from the US to Taiwan and regional spillover effects from Japan to Taiwan. Gjika and Horváth (2013) find strong correlated relationship among stock markets in Central Europe and indicate that the correlations increased over time and remained high during the financial crisis. Hwang (2014) finds evidence of contagion among four Latin American countries (Argentina, Brazil, Chile and Mexico) and observes that there are structural changes in mean and volatility of the correlation coefficients. Alotaibi and Mishra (2015) find significant return spillover effects from regional (Saudi Arabia) and global (the US) markets to Gulf Cooperation Council (GCC) markets.

However, the research on the spillover effect between Chinese financial markets and other markets are limited as compared to research undertaken in other regions. Brooks and Ragunathan (2003) report no evidence of volatility spillover between the Chinese A Share and B share markets. Wang and Firth (2004) indicate that the overnight returns on all the Greater China stock indices (Shanghai, Shenzhen, Hong Kong and Taipei) can be estimated by using information from at least one of the three developed markets' daytime returns (Tokyo, London and New York). They find that the contemporaneous return spillovers are generally unidirectional from more advanced major international markets to the Chinese stock markets. However, Lin et al. (2009) suggest that A Share indices have never been correlated with world markets and that B Share indices exhibit a low degree of correlation with western markets (0–5%) but a slightly higher degree of correlation with other Asian markets (10–20%). Wang and Wang (2010) examine stock market linkages among Greater China, the US and Japan in terms of price and volatility spillover effects, suggesting that volatility spillovers are stronger than price spillovers

Table 1
Summarized descriptive statistics.

	Full Sample				Pre-Shanghai-Hong Kong Stock Connect				Post-Shanghai-Hong Kong Stock Connect			
	P_{SSEC}	P_{HSI}	R_{SSEC}	R_{HSI}	P_{SSEC}	P_{HSI}	R_{SSEC}	R_{HSI}	P_{SSEC}	P_{HSI}	R_{SSEC}	R_{HSI}
Observations	43923	43,923	43,922	43,922	22,143	22,143	22,142	22,142	21,780	21,780	21,780	21,780
Mean	7.888641	10.08891	1.52E−05	2.47E−06	7.721023	10.08720	8.59E−06	1.40E−06	8.059053	10.09066	2.19E−05	3.56E−06
Median	7.808523	10.08702	1.96E−05	−3.54E−06	7.734113	10.08393	1.98E−05	−1.71E−06	8.079387	10.09084	1.93E−05	−5.32E−06
Maximum	8.293908	10.16687	0.078639	0.020413	7.827278	10.13994	0.011114	0.020413	8.293908	10.16687	0.078639	0.019057
Minimum	7.617537	10.02278	−0.061499	−0.015330	7.617537	10.03719	−0.009840	−0.014474	7.799014	10.02278	−0.061499	−0.015330
Std. Dev.	0.189569	0.026770	0.000864	0.000544	0.054955	0.028370	0.000404	0.000508	0.108611	0.024918	0.001157	5.79E-04
Skewness	0.274698	−0.030385	10.37952	3.417095	−0.336718	0.109690	−0.873385	1.666668	−0.637627	−0.178342	8.730442	4.581285
Kurtosis	1.601824	2.175542	2302.944	328.7961	2.175018	1.726128	74.55586	336.2063	3.244215	2.924074	1441.002	315.5261
Jarque-Bera	4130.098	1250.752	9.68E+09	1.94E+08	1046.358	1541.592	4.73E+06	1.02E+08	1529.967	120.6865	1.88E+09	8.87E+07

Note: P_{SSEC} and P_{HSI} denote the natural logarithms of Shanghai Stock Exchange Composite Index and Hong Kong Hang Seng Index respectively. R_{SSEC} and R_{HSI} denote the continuously compounded returns for Shanghai Stock Exchange Composite Index and Hong Kong Hang Seng Index respectively. The first return observation is calculated based on the first and second log price data, thus naturally lose one observation.

between the Greater China markets and the developed markets of the US and Japan. Since 1997, when the political sovereignty of Hong Kong reverted to People's Republic of China, the integration of the two economies has steadily increased. Thus few studies have examined the dynamic relationship between Chinese stock markets and the Hong Kong stock market. Li (2007) uses asymmetric BEKK GARCH framework to report evidence of unidirectional volatility spillovers from Hong Kong to Shanghai and Shenzhen, but no evidence of a direct linkage between mainland China and the US stock market. To some extent, the research finding indicates a weak integration of the Chinese stock exchanges with the regional developed market. With mainland China adopting more open financial and economic policies, international investors could benefit from portfolio diversification as a result of adding stocks from mainland China to the investment portfolio. In another study by Zhou et al. (2012), it is observed that volatility interactions among the Chinese, Hong Kong, and Taiwanese markets are more prominent than those among the Chinese, Western, and other Asian markets, indicating that Chinese financial markets are integrated in the Greater China region. However, the connections and correlations among Asian stock markets have become increasingly more evident in recent years. Allen et al. (2013) report evidence of volatility spillovers from the Chinese stock market to its neighbours and trading partners, including Australia, Hong Kong, Singapore, Japan and the US. Their results show existence of significant volatility spillovers across these markets in the pre-Global Financial Crisis periods, but no significant evidence of spillover effects from China to related markets during the Global Financial Crisis. Huang and Kuo (2015) use trivariate BEKK GARCH model to investigate the trilateral relationship among China, Hong Kong and the Taiwan stock markets from 2000 to 2010. The findings suggest that the Hong Kong and Taiwan stock markets are significantly affected by mainland China, implying that the Chinese mainland stock market plays a leading role in the information transmission. Given that Shanghai-Hong Kong Stock Connect was an important announcement in capital market development and integrating China with the rest of the world, it is timely to empirically investigate the impact of such a breakthrough on price and volatility spillovers.

4. Data description and research approach

This study uses the closing price of the Shanghai Stock Exchange Composite Index (SSEC) and the Hong Kong Hang Seng Index (HSI) data recorded at 1 min intervals retrieved from SIRCA and Thomson Reuters Tick History (TRTH). We use the high frequency data because we believe that the low frequency data may not fully reflect the information transmission process within a short horizon when the speed of the information transmission is fast. The sample period is from 2 July 2014 to 8 April 2015. From an econometric perspective and given the property of the high frequency data, 1 min interval over 7 months period, which gives us a total of 43923 data observations, is good enough to yield meaningful estimation results without a serious small sample bias. We believe with this sample window, we will precisely be able to capture the impact of Shanghai-Hong Kong Stock Connect while limiting other significant events that could influence the estimated results. The sample is further divided into two sub periods in order to investigate how the introduction of Shanghai-Hong Kong Stock Connect impacts both Shanghai and Hong Kong stock market behaviours. The first subsample which is referred to as the Pre-Shanghai-Hong Kong Stock Connect period, is from 2 July 2014 to 14 November 2014. The second sub period called the Post-Shanghai-Hong Kong Stock Connect period is from 17 November 2014 to 8 April 2015. The one minute returns are calculated as the difference in natural logarithms of the closing prices of both indices ($R_{i,t}=P_{i,t}-P_{i,t-1}, i = SSEC, HSI$), where $R_{i,t}$ denotes the continuously compounded return for index i at time t, and $P_{i,t}$ denotes the natural logarithms of the closing price of index i at time t. Usually, the Shanghai Stock Exchange starts trading from 09:30 am (Beijing time, same hereinafter) to 11:30 am in the morning and from 01:00 pm to 03:00 pm in the afternoon from Monday to Friday except holidays. However, the Hong Kong stock exchange starts trading from 09:30 am to 12:00 am in the morning and from 01:00 pm to 04:00 pm in the afternoon. To get reliable data, the index prices recorded before either the Shanghai or Hong Kong stock market opens or after either of them closes are excluded from the sample. Thus we only use the data from 09:30 am to 11:30 am and from 01:00 pm to 03:00 pm on a trading day. We also exclude the day when there is only one stock exchange opened. After eliminating weekends and holidays, our final data includes 43923 1-min price observations for the full sample period (22,143 observations for Pre-Shanghai-Hong Kong Stock Connect period and 21,780 observations for Post-Shanghai Hong Kong Stock Connect period). A brief descriptive statistics for the intraday 1-min closing prices and returns of SSEC and HSI are provided in Table 1. The statistics reported include the number of observations, the mean, the median, the maximum value, the minimum value, the standard deviation, the measure of skewness, the measure of kurtosis and the Jarque-Bera (JB) statistics. The mean of the SSEC return is larger than the mean of the HSI return for the full sample period, Pre- and Post-Shanghai-Hong Kong Stock Connect periods, implying that the Shanghai stock market is likely to provide higher return. In terms of the standard deviation, the standard deviation for the Shanghai stock market is larger than the Hong Kong stock market for the full sample period and the Post-Shanghai Hong Kong Stock Connect period, suggesting that SSEC is more volatile than HSI during the above periods. This is reasonable because higher risk equals greater return.

Table 2
Unit Root Test.

	ADF with Constant	Prob.	ADF with Trend	Prob.	PP with Constant	Prob.	PP with Trend	Prob.
Panel A: Full Sample Period								
P_{SSEC}	0.693612	0.9921	−1.810520	0.6999	0.679332	0.9918	−1.840584	0.6850
$\Delta P_{SSEC}(R_{SSEC})$	−78.71602	0.0001	−78.72565	0.0000	−166.0531	0.0001	−166.0341	0.0001
P_{HSI}	−1.474929	0.5466	−1.593387	0.7960	−1.394164	0.5869	−1.515418	0.8247
$\Delta P_{HSI}(R_{HSI})$	−200.0326	0.0001	−200.0323	0.0001	−199.8529	0.0001	−199.8519	0.0001
Panal B: Pre-Shanghai-Hong Kong Stock Connect								
P_{SSEC}	−0.723133	0.8392	−2.333925	0.4148	−0.710288	0.8424	−2.328034	0.4180
$\Delta P_{SSEC}(R_{SSEC})$	−53.17510	0.0001	−53.17390	0.0000	−133.9329	0.0001	−133.9302	0.0001
P_{HSI}	−1.607590	0.4787	−1.779815	0.7148	−1.569353	0.4983	−1.741193	0.7329
$\Delta P_{HSI}(R_{HSI})$	−141.5884	0.0001	−141.5880	0.0001	−141.4574	0.0001	−141.4562	0.0001
Panel C: Post-Shanghai-Hong Kong Stock Connect								
P_{SSEC}	−0.938619	0.7765	−1.841984	0.6842	−0.860496	0.8011	−1.793723	0.7081
$\Delta P_{SSEC}(R_{SSEC})$	−59.40365	0.0001	−59.40232	0.0000	−114.8932	0.0001	−114.8901	0.0001
P_{HSI}	−0.521320	0.8848	−2.139988	0.5227	−0.466079	0.8953	−2.115091	0.5368
$\Delta P_{HSI}(R_{HSI})$	−140.9578	0.0001	−140.9714	0.0001	−140.8624	0.0001	−140.8705	0.0001

Note: The ADF and PP tests test the null hypothesis of non-stationarity of the series (the time series have a unit root). The ADF and PP tests applied on are with constant and with trend. The lag selection for ADF test is based on Schwarz Info Criterion while the bandwidth selection for PP test is based on Newey-West Bandwidth.

After comparing the statistics of Pre-Shanghai-Hong Kong Stock Connect period and Post-Shanghai-Hong Kong Stock Connect period, we can see that both the mean and the standard deviation of each market have increased after Shanghai-Hong Kong Stock Connect, showing that this program could have some influence on the return and volatility behaviours of both stock markets. Based on the Jarque-Bera statistics, which tests for normality and goodness of fit, the closing prices and returns of both indices appear to be non-normally distributed (reject the null hypothesis for the normal distribution).

The research methodologies include unit root and cointegration tests, Granger Causality test, VAR technique, Impulse Response Analysis, univariate GARCH and multivariate GARCH models. We initially determine the order of integration of P_{SSEC} and P_{HSI} variables using Augmented Dickey-Fuller (ADF) test and PP test (Phillips and Perron, 1988) to conduct our unit root tests. Table 2 presents the results of the unit root tests at levels and in first differences for the full sample period, Pre- and Post-Shanghai-Hong Kong Stock Connect categories. From the results provided, the null hypothesis of unit roots cannot be rejected at the 1% level of statistical significance for both our series in the levels, but the null is rejected and the estimated values are less than the critical values and the P value is under 1% when the first difference of these variables is taken, indicating that they are integrated of order one. Hence, it is concluded that P_{SSEC} and P_{HSI} are non-stationary and integrated of order one I(1). If the two time series are found to be integrated of the same order, one should also test the existence of a stable long-run relationship between series. We further use Johansen-Juselius test (Johansen and Juselius, 1990) to conduct cointegration analysis in order to determine whether P_{SSEC} and P_{HSI} have any long-run relationship. The following two likelihood ratio statistics - trace statistic[3] and maximum eigenvalue statistic[4] are computed and the results are reported in Table 3. For Pre-Shanghai-Hong Kong Stock Connect period, both trace and maximum eigenvalue statistics in all the four tests are not statistically significant at the 5% significance level. We therefore cannot reject the null hypothesis of none cointegration relationship. As a result, Johansen Juselius Cointegration tests strongly reject the existence of at least one cointegration vector and show clear evidence of no cointegration relationships between the two series for Pre-Shanghai-Hong Kong Stock Connect period. This means that there is no specific long-term relationship between the two stock markets for that period. Our findings here are in line with Cheng and Glascock (2005) who find no evidence of cointegration relationship among the three Greater China Economic Area (GCEA) stock markets 1993–2004. Zhu et al. (2004) also could not find the cointegration relationship among the Shanghai, Shenzhen and Hong Kong stock markets from 1993 to 2001. Others who report similar findings include Huang et al. (2000) and Johansson and Ljungwall (2009). For Post-Shanghai-Hong Kong Stock Connect period, the trace and maximum eigenvalue statistics (no intercept and no trend category) indicate that we could reject H_0: there is no cointegration vector at the 5% significance level but could not reject H_0: there is at most 1 cointegration vector at the 5% significance level. This result indicates evidence of at least one cointegration relationship between the two series for Post-Shanghai-Hong Kong Stock Connect period. The contrary results for the two periods suggest that Shanghai and Hong Kong stock markets seem to have a weak and unstable long-term relationship. Our results here suggest that new program could strength the integration and co-movement between the two stock markets in the future. The new Shanghai-Hong Kong Stock Connect initiatives could accelerate the pace and dynamics of liberalization of the Chinese stock markets and improve long term investment environment. The results highlight the role of financial openness in financial integration between China and Hong Kong as argued by Su et al. (2007) who contend that increased financial openness has a greater role in accounting for stock market co-movements between mainland China and Hong Kong. Similarly for the full sample period, the trace and the maximum eigenvalue statistics (in the no intercept and no trend test) indicate that there exists one cointegrating relationship between the two time series at the 5% significance level.

We will use the Granger Causality test to examine the short-term relations between Shanghai and Hong Kong stock markets (Granger, 1969). According to the unit root test, the returns of the Shanghai Stock Exchange Composite Index and the Hong Kong Hang Seng Index, R_{SSEC} and R_{HSI} are stationary, hence the following VAR system is utilized to conduct causality tests:

$$R_{SSEC,t} = g_1 + \sum_{i=1}^{p} g_{11,i} R_{SSEC,t-i} + \sum_{i=1}^{p} g_{12,i} R_{HSI,t-i} + \varepsilon_{1,t} \quad (1)$$

$$R_{HSI,t} = g_2 + \sum_{i=1}^{p} g_{21,i} R_{SSEC,t-i} + \sum_{i=1}^{p} g_{22,i} R_{HSI,t-i} + \varepsilon_{2,t} \quad (2)$$

The first null hypothesis of Granger Causality is that the return of SSEC does not Granger cause the return of HSI and the second null hypothesis of Granger Causality is that the return of HSI does not Granger cause the return of SSEC. This is to test joint statistical significance of $g_{12,i}$ and $g_{21,i}$ respectively based on *F*-test. The F-statistics is calculated as follow:

[3] Trace statistic: $\lambda_{Trace}(r) = -T\sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i)$.

Table 3
Johansen- Juselius Cointegration Tests.

Panel A: Full Sample Period								
Hypothesized	No Deterministic Trend in Data				Linear Deterministic Trend in Data			
No. of CE(s)	No Intercept, No Trend		Intercept, No Trend		Intercept, No Trend		Intercept, Trend	
	Trace Statistic	Prob.	Trace Statistic	Prob.	Trace Statistic	Prob.	Trace Statistic	Prob.
None	13.10577	0.0369	15.58280	0.1948	3.536803	0.9373	10.02451	0.9239
At most 1	0.601625	0.4993	1.915390	0.7945	0.001953	0.9615	3.319793	0.8366
	Max-Eigen Statistic	Prob.	Max-Eigen Statistic	Prob.	Max-Eigen Statistic	Prob.	Max-Eigen Statistic	Prob.
None	12.50414	0.0296	13.66741	0.1084	3.534850	0.9049	6.704717	0.9197
At most 1	0.601625	0.4993	1.915390	0.7945	0.001953	0.9615	3.319793	0.8366
Panel B: Pre-Shanghai-Hong Kong Stock Connect								
	Trace Statistic	Prob.	Trace Statistic	Prob.	Trace Statistic	Prob.	Trace Statistic	Prob.
None	7.949009	0.2406	12.91870	0.3704	5.713610	0.7291	14.19968	0.6411
At most 1	0.402297	0.5893	4.663391	0.3223	0.502744	0.4783	4.685601	0.6419
	Max-Eigen Statistic	Prob.	Max-Eigen Statistic	Prob.	Max-Eigen Statistic	Prob.	Max-Eigen Statistic	Prob.
None	7.546712	0.2056	8.255313	0.5175	5.210866	0.7150	9.514082	0.6707
At most 1	0.402297	0.5893	4.663391	0.3223	0.502744	0.4783	4.685601	0.6419
Panel C: Post-Shanghai-Hong Kong Stock Connect								
	Trace Statistic	Prob.	Trace Statistic	Prob.	Trace Statistic	Prob.	Trace Statistic	Prob.
None	16.26587	0.0104	18.60462	0.0831	11.29507	0.1940	17.03495	0.4124
At most 1	3.892448	0.0576	6.062778	0.1859	2.203992	0.1377	5.958834	0.4656
	Max-Eigen Statistic	Prob.	Max-Eigen Statistic	Prob.	Max-Eigen Statistic	Prob.	Max-Eigen Statistic	Prob.
None	12.37342	0.0313	12.54184	0.1567	9.091081	0.2786	11.07612	0.5055
At most 1	3.892448	0.0576	6.062778	0.1859	2.203992	0.1377	5.958834	0.4656

Note: Our lag length selection is based on Akaike Information Criterion (AIC) and 9 lags are selected to process Johanse-Juselius Cointegration Tests.

$$F = \frac{(SSR_r - SSR_u)/n}{SSR_u/[T - (2n+1)]} \tag{3}$$

where SSR_r is the sum of squared residuals from restricted equation and SSR_u is the sum of squared residuals from unrestricted equation. T is the number of observations while n is the number of lags. The lag selection is based on Akaike Information Criterion (AIC). If one or some of $g_{12,i}$ are not zero, we can assume that the return of the Hong Kong Hang Seng Index Granger causes the return of the Shanghai Stock Exchange Composite Index. In order to obtain additional insight into the dynamic characteristics in the two stock markets, we further conduct an impulse response analysis where the Cholesky decomposition is used to orthogonalize the underlying errors.

We examine the volatility behaviours and apply Generalized Autoregressive Conditional Heteroscedastic (GARCH) models in this section. The study initially uses the univariate GARCH model incorporated with a dummy variable and then considers a multivariate GARCH-style model. Engle (1982) introduced Autoregressive Conditional Heteroskedasticity (ARCH) model to address the heteroskedasticity problem in the prediction of the conditional variance of financial time series. In the GARCH model introduced later by Bollerslev (1986), the conditional variance is modified to have the linear relationships with the lagged squared residual value from the mean equation and the lagged conditional variance. Empirical research show that GARCH models do not only provide a robust and reliable method of estimating volatility, but also have been found to fit time-varying volatility fairly well and is more parsimonious compared with the ARCH model (Poon and Granger, 2003). GARCH(1,1) is the simplest and one of the most popular model for volatility forecasting with conditional variance$\sigma_t^2{=}a_0{+}a_1\varepsilon_{t-1}^2{+}b_1\sigma_{t-1}^2$. In 1993, Glosten, Jagannathan and Runkle introduced GJR GARCH (henceforth) which allows for asymmetric effect in the response (leverage effect) (Glosten et al., 1993). Therefore, the positive and negative shocks which represent good news and bad news have different impact on volatility forecasting.

Under GJR GARCH framework, the conditional variance equation is given as: $\sigma_t^2{=}a_0{+}a_1\varepsilon_{t-1}^2{+}\varphi_1\varepsilon_{t-1}^2 d_1{+}b_1\sigma_{t-1}^2$ where d_1 is a dummy variable, when $\varepsilon_{t-1}<0$, d_1=1, when $\varepsilon_{t-1}>0$, d_1=0. Based on the GJR GARCH model, we introduce a modified GJR GARCH model with the dummy variable. Firstly, we run the following mean equations:$P_{SSEC,t}{=}c_{SSEC}{+}\lambda_{SSEC}P_{SSEC,t-1}{+}\varepsilon_{SSEC,t}$ and $P_{HSI,t}{=}c_{HSI}{+}\lambda_{HSI}P_{HSI,t-1}{+}\varepsilon_{HSI,t}$ respectively, and use the Lagrange Multiplier Test to examine time-varying volatility (ARCH effect). The LM statistics rejects the null hypothesis of no ARCH effect in the residual term of the above equation which indicates the presence of time-varying volatility in both Shanghai and Hong Kong stock markets. We then estimate the modified GJR GARCH model which is presented as follows:

The mean equation of GJR GARCH model for the Shanghai stock market is:

$$P_{SSEC,t} = c_{SSEC} + \lambda_{SSEC}P_{SSEC,t-1} + \varepsilon_{SSEC,t},\ \ \varepsilon_{SSEC,t}|\Omega_{t-1}\sim N(0, \sigma_{SSEC,t}^2) \tag{4}$$

The modified conditional variance equation for the Shanghai stock market is:

$$\sigma_{SSEC,t}^2 = a_{SSEC,0} + a_{SSEC,1}\varepsilon_{t-1}^2 + b_{SSEC,1}\sigma_{t-1}^2 + \phi_{SSEC,1}\varepsilon_{t-1}^2 d_1 + d_{SSEC}{*}DUMMY_t \tag{5}$$

The mean equation of GJR GARCH model for the Hong Kong stock market is:

$$P_{HSI,t} = c_{HSI} + \lambda_{HSI}P_{HSI,t-1} + \varepsilon_{HSI,t},\ \ \varepsilon_{HSI,t}|\Omega_{t-1}\sim N(0, \sigma_{HSI,t}^2) \tag{6}$$

The modified conditional variance equation for the Hong Kong stock market is:

$$\sigma_{HSI,t}^2 = a_{HSI,0} + a_{HSI,1}\varepsilon_{t-1}^2 + b_{HSI,1}\sigma_{t-1}^2 + \phi_{HSI,1}\varepsilon_{t-1}^2 d_1 + d_{HSI} * DUMMY_t \tag{7}$$

whereΩ_{t-1} is the information set available at the time t−1, $DUMMY_t$=1 if $P_{SSEC,t}$ and $P_{HSI,t}$ are observed after 17 November 2014 when Shanghai-Hong Kong Stock Connect program was implemented, 0 otherwise. The ARCH effect is captured by the parameter $a_{SSEC,1}$ ($a_{HSI,1}$)

while $b_{SSEC,1}$ ($b_{HSI,1}$) captures the GARCH effect, and $a_{SSEC,1}+b_{SSEC,1}$ ($a_{HSI,1}+b_{HSI,1}$) measures the persistence of the impact of shocks to the conditional variance. A GARCH (1,1) process is weakly stationary if $a_{SSEC,1}+b_{SSEC,1}<1$ ($a_{HSI,1}+b_{HSI,1}<1$). The coefficient d_{SSEC}(d_{HSI}) captures the incremental influence of Shanghai-Hong Kong Stock Connect program on the volatility of the Shanghai and Hong Kong stock markets respectively.

Moving to the multivariate GARCH models, one general version introduced by Bollerslev et al. (1988) is VECH GARCH model where the conditional variance and covariance are a function of all lagged conditional variance and covariance. The model is specified as follows:

$$h_t = C_0 + \sum_{i=1}^{q} A_i \eta_{t-i} + \sum_{j=1}^{p} B_j h_{t-j} \tag{8}$$

where h_t=vech(H_t), η_t=vech($\varepsilon_t\varepsilon_t^T$), vech(·) denote the operator that stacks the lower triangular part of a symmetric d×d matrix into d(d+1)/2 dimensional vector, A_i and B_j are d(d+1)/2 dimensional parameter matrices. H_t denotes conditional variance covariance matrix. However, the number of parameters for VECH GARCH model is very large and thus hard to be estimated. Engle and Kroner (1995) introduced BEKK (Baba, Engle, Kraft and Kroner) model to simplify the estimation process by reducing the number of parameter. BEKK GARCH model can economize on the parameters by imposing restrictions both within and across equations. The bivariate VAR-BEKK GARCH model in mean equation is expressed as:

$$R_t = G_0 + \sum_{i=1}^{p} G_i R_{t-i} + \varepsilon_t, \ \ \varepsilon_t|\Omega_{t-1}\sim N(0, H_t) \tag{9}$$

where R_t is a vector of returns for SSEC and HSI, $R_t=\begin{pmatrix} R_{SSEC,t} \\ R_{HSI,t} \end{pmatrix}$ and $\varepsilon_t$is a vector of Gaussian error returns for SSEC and HSI, $\varepsilon_t=\begin{pmatrix} \varepsilon_{SSEC,t} \\ \varepsilon_{HSI,t} \end{pmatrix}$. The conditional variance equation of BEKK GARCH(1,1) model is outlined as:

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon_{t-1}'A + B'H^{t-1}B$$

$$H_t = \begin{bmatrix} c_{11} 0 \\ c_{21} c_{22} \end{bmatrix}' \begin{bmatrix} c_{11} 0 \\ c_{21} c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} a_{12} \\ a_{21} a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} a_{12} \\ a_{21} a_{22} \end{bmatrix} + \begin{bmatrix} b_{11} b_{12} \\ b_{21} b_{22} \end{bmatrix}' H_{t-1} \begin{bmatrix} b_{11} b_{12} \\ b_{21} b_{22} \end{bmatrix} \tag{10}$$

In order to capture the asymmetric response of the volatility, Kroner and Ng (1998) incorporated asymmetric effect into BEKK GARCH model where Eq. (10) becomes:

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon_{t-1}'A + B'H_{t-1}B + D'\eta_{t-1}\eta_{t-1}'D$$

$$H_t = \begin{bmatrix} c_{11} 0 \\ c_{21} c_{22} \end{bmatrix}' \begin{bmatrix} c_{11} 0 \\ c_{21} c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} a_{12} \\ a_{21} a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} a_{12} \\ a_{21} a_{22} \end{bmatrix} + \begin{bmatrix} b_{11} b_{12} \\ b_{21} b_{22} \end{bmatrix}' H_{t-1} \begin{bmatrix} b_{11} b_{12} \\ b_{21} b_{22} \end{bmatrix} + \begin{bmatrix} d_{11} d_{12} \\ d_{21} d_{22} \end{bmatrix}' \eta_{t-1}\eta_{t-1}' \begin{bmatrix} d_{11} d_{12} \\ d_{21} d_{22} \end{bmatrix} \tag{11}$$

where $\eta_{t-1} = \begin{bmatrix} \max(0, -\varepsilon_{SSEC,t-1}) \\ \max(0, -\varepsilon_{HSI,t-1}) \end{bmatrix}$

The matrix D captures the asymmetric property of the time-varying variance-covariance where if any coefficient in D is positive and significant, a normal asymmetric effect exists. Accordingly, a bad news event will cause a larger volatility of stock markets than a good news event.

5. Major findings and results analysis

5.1. Granger causality results, VAR results and impulse response analysis

The Granger Causality relationship between Shanghai and Hong Kong stock markets (using markets returns of SSEC and HSI) is presented in Table 4. It is observed that there exists a bidirectional causal relationship between Shanghai and Hong Kong stock markets in the Pre-Stock Connect period. However, in the Post-Stock Connect period, we can only reject the hypothesis of the return of SSEC does not Granger Cause the return of HSI at 1% level while that of the return of HSI does not Granger Cause the return of SSEC cannot be rejected at the 1% significance level, and therefore there is only one unidirectional Granger Causality relationship from Shanghai to Hong Kong after Shanghai-Hong Kong Stock Connect. We use VAR forecasting technique to further analyse the financial market behaviours where Table 5 displays the results. During the Pre-Shanghai-Hong Kong Stock Connect period, the behaviour of return significantly depends on its own past values in the two markets. In terms of the cross-market impact, the lagged returns of SSEC (lag1, 2, 5 and 7) are observed to be able to predict the current return of HSI at the 5% significance level. On the other hand, the lagged returns of HSI (lag1, 3 and 8) are also good predictors for that of SSEC at the 5% significance level. The results show strong evidence of bilateral causal feedback relationship between the two markets before Shanghai-Hong Kong Stock Connect program. This is in line with the results reported by Zheng and Chen (2013) who also find bidirectional causality relationship and consistent with our Granger Causality tests. Looking at the Post-Stock Connect period, the autoregressive behaviours for the returns of SSEC and HSI are different. As most of the lagged SSEC's coefficients are statistically significant, the return of SSEC indicates a strong autoregressive feature. However, only one lagged coefficient of HSI (lag 6) is statistically significant, implying that the Hong Kong stock market has a weak autoregressive dynamic. Surprisingly, the cross market effects between the two markets are observed to be weaker compared with the results in Pre-Stock Connect period. Only one lagged return in each market is seen to have a significant impact on the returns of the other market at the 5% significance level. The predictive power of the

Table 4
Granger Causality Test.

Null hypothesis:	Pre-Shanghai-Hong Kong Stock Connect		Post-Shanghai-Hong Kong Stock Connect	
	F-Statistic	Prob.	F-Statistic	Prob.
R_{SSEC} does not Granger Cause R_{HSI}	13.8077	3.00E−20	21.3498	1.00E−32
R_{HSI} does not Granger Cause R_{SSEC}	11.2746	5.00E−16	1.80179	0.0716

Note: the test procedure is based on bivariate VAR(8) model and the optimal lag length selection of 8 is based on AIC.

Table 5
VAR results.

Pre-Shanghai-Hong Kong Stock Connect				Post-Shanghai-Hong Kong Stock Connect			
	R_{SSEC}		R_{HSI}		R_{SSEC}		R_{HSI}
$R_{SSEC}(-1)-g_{11,1}$	0.0672*	$R_{SSEC}(-1)-g_{21,1}$	0.0807*	$R_{SSEC}(-1)-g_{11,1}$	0.2170*	$R_{SSEC}(-1)-g_{21,1}$	0.0492*
	(0.0000)		(0.0000)		(0.0000)		(0.0000)
$R_{SSEC}(-2)-g_{11,2}$	0.1672*	$R_{SSEC}(-2)-g_{21,2}$	0.0313*	$R_{SSEC}(-2)-g_{11,2}$	0.0403*	$R_{SSEC}(-2)-g_{21,2}$	0.0041
	(0.0000)		(0.0006)		(0.0000)		(0.3141)
$R_{SSEC}(-3)-g_{11,3}$	0.0918*	$R_{SSEC}(-3)-g_{21,3}$	0.0117	$R_{SSEC}(-3)-g_{11,3}$	−0.0291*	$R_{SSEC}(-3)-g_{21,3}$	0.0039
	(0.0000)		(0.2074)		(0.0002)		(0.3329)
$R_{SSEC}(-4)-g_{11,4}$	0.0140	$R_{SSEC}(-4)-g_{21,4}$	0.0041	$R_{SSEC}(-4)-g_{11,4}$	−0.0353*	$R_{SSEC}(-4)-g_{21,4}$	0.0067
	(0.0519)		(0.6622)		(0.0000)		(0.0956)
$R_{SSEC}(-5)-g_{11,5}$	-0.0291*	$R_{SSEC}(-5)-g_{21,5}$	-0.0226*	$R_{SSEC}(-5)-g_{11,5}$	−0.0201*	$R_{SSEC}(-5)-g_{21,5}$	0.0005
	(0.0001)		(0.0152)		(0.0112)		(0.9039)
$R_{SSEC}(-6)-g_{11,6}$	-0.0279*	$R_{SSEC}(-6)-g_{21,6}$	-0.0024	$R_{SSEC}(-6)-g_{11,6}$	−0.0206*	$R_{SSEC}(-6)-g_{21,6}$	0.0027
	(0.0001)		(0.7991)		(0.0093)		(0.5066)
$R_{SSEC}(-7)-g_{11,7}$	-0.0289*	$R_{SSEC}(-7)-g_{21,7}$	0.0193*	$R_{SSEC}(-7)-g_{11,7}$	−0.0195*	$R_{SSEC}(-7)-g_{21,7}$	−0.0019
	(0.0000)		(0.0350)		(0.0136)		(0.6402)
$R_{SSEC}(-8)-g_{11,8}$	-0.0444*	$R_{SSEC}(-8)-g_{21,8}$	0.0028	$R_{SSEC}(-8)-g_{11,8}$	−0.0080	$R_{SSEC}(-8)-g_{21,8}$	0.0039
	(0.0000)		(0.7554)		(0.3055)		(0.3290)
$R_{HSI}(-1)-g_{12,1}$	0.0478*	$R_{HSI}(-1)-g_{22,1}$	0.0282*	$R_{HSI}(-1)-g_{12,1}$	−0.0127	$R_{HSI}(-1)-g_{22,1}$	−0.0050
	(0.0000)		(0.0001)		(0.4057)		(0.5209)
$R_{HSI}(-2)-g_{12,2}$	−0.0067	$R_{HSI}(-2)-g_{22,2}$	-0.0113	$R_{HSI}(-2)-g_{12,2}$	0.0071	$R_{HSI}(-2)-g_{22,2}$	0.0006
	(0.2218)		(0.1117)		(0.6418)		(0.9429)
$R_{HSI}(-3)-g_{12,3}$	−0.0115*	$R_{HSI}(-3)-g_{22,3}$	-0.0079	$R_{HSI}(-3)-g_{12,3}$	0.0302*	$R_{HSI}(-3)-g_{22,3}$	−0.0089
	(0.0357)		(0.2652)		(0.0479)		(0.2523)
$R_{HSI}(-4)-g_{12,4}$	0.0038	$R_{HSI}(-4)-g_{22,4}$	-0.0142*	$R_{HSI}(-4)-g_{12,4}$	0.0105	$R_{HSI}(-4)-g_{22,4}$	−0.0072
	(0.4929)		(0.0455)		(0.4906)		(0.3565)
$R_{HSI}(-5)-g_{12,5}$	0.0063	$R_{HSI}(-5)-g_{22,5}$	0.0029	$R_{HSI}(-5)-g_{12,5}$	−0.0067	$R_{HSI}(-5)-g_{22,5}$	0.0057
	(0.2509)		(0.6832)		(0.6608)		(0.4676)
$R_{HSI}(-6)-g_{12,6}$	0.0079	$R_{HSI}(-6)-g_{22,6}$	0.0003	$R_{HSI}(-6)-g_{12,6}$	−0.0281	$R_{HSI}(-6)-g_{22,6}$	−0.0278*
	(0.1499)		(0.9635)		(0.0657)		(0.0004)
$R_{HSI}(-7)-g_{12,7}$	−0.0035	$R_{HSI}(-7)-g_{22,7}$	-0.0121	$R_{HSI}(-7)-g_{12,7}$	−0.0220	$R_{HSI}(-7)-g_{22,7}$	−0.0042
	(0.5259)		(0.0859)		(0.1490)		(0.5902)
$R_{HSI}(-8)-g_{12,8}$	0.0109*	$R_{HSI}(-8)-g_{22,8}$	-0.0117	$R_{HSI}(-8)-g_{12,8}$	−0.0275	$R_{HSI}(-8)-g_{22,8}$	−0.0103
	(0.0453)		(0.0971)		(0.0705)		(0.1830)
Constant−g_1	6.73E−6*	Constant−g_2	3.72E−07	Constant−g_1	1.92E−05*	Constant−g_2	2.05E−06

Note: The estimated model is VAR(8) as shown in Eqs. (1) and (2) and the lag length selection of 8 is based on AIC. The P value of the coefficient is given in parentheses and
* Indicates rejection of the null hypothesis at the 5% level of significance.

lagged returns of HSI for the current return of SSEC becomes less significant after this event, as all the coefficients of the lagged returns of HSI in SSEC equation are statistically insignificant except for lag 3. In contrary, we observe a lagged 1 return of SSEC has a significant influence to the return of HSI, as the coefficient is statistically significant at the 1% significance level. Our results suggest that the information transmission from Shanghai to Hong Kong is faster than the opposite direction. In addition, when we compare the significant level and absolute values of these two coefficients, we see that $g_{21,1}$ is larger and more significant than $g_{12,3}$ (0.0492 vs 0.0302, 1% vs 5%**)**. As a result, the mean spillover effect from Shanghai to Hong Kong is more prominent than the opposite direction in Post-Stock Connect period. This evidence here is indicative of the strategic leadership role the Shanghai stock market plays after Shanghai-Hong Kong Stock Connect program. The results for Post-Stock Connect period are consistent with Qiao and Lam (2011) who argue that the Chinese stock markets are nowadays playing a very influential role among the stock markets in the Greater China region, including Hong Kong. However, other studies such as Tian (2008) reports that the mainland China stock markets continue to be heavily influenced by Hong Kong stock market despite rapid development in recent years. Overall, the stock returns are predictable in both Shanghai and Hong Kong stock markets by their own lagged returns for both periods, implying serial correlation features in both markets but the cross market effect becomes weaker after Shanghai-Hong Kong Stock Connect program. However, the mean spillover effect from Shanghai to Hong Kong is found to be faster and stronger than Hong Kong to Shanghai in Post-Shanghai-Hong Kong Stock Connect period.

Based on Table 6, results from impulse response analysis using bivariate VAR model for both Pre- and Post-Shanghai-Hong Kong Stock Connect periods. For the Pre-Stock Connect period, a shock in the Shanghai stock market has strong positive effect on the return of HSI (0.000155 for the first follow up period), while the Shanghai stock market exhibits a weak response to the shock from Hong Kong after the second follow up period (0.000023 for the second follow up period). In the Post-Stock Connect period, the response of HSI to the shocks in the Shanghai stock market increases to 0.000282 for the first follow up period. However, the Shanghai stock market exhibits nearly no change in the response of shocks from the Hong Kong stock market. We see a stronger response from both markets to the shocks originated from their own market compared with the shocks from other market, indicating that process of the information transmission cross markets is decaying. We see that the response has a short life feature since there are little changes after the fourth follow up period. Overall, we can see that a shock from the Shanghai stock market seems to have stronger impact on the Hong Kong stock market as opposed to the other way round. The short run dependence of the market return in Hong Kong to the shocks that arise from the Shanghai stock market appears to be increasing while the impact of shocks in HSI on Shanghai stock market is weaker in the Post-Stock Connect period. This means the Hong Kong stock market tends to be more responsive to the shocks in Shanghai. While our observation here is consistent with the results of the Granger Causality test and VAR analysis after this event, it is also indicative of the increased importance of the Chinese stock market in the Asia Pacific region and it influence in the information transmission.

Table 6
Impulse response functions.

Period	Pre-Shanghai-Hong Kong Stock Connect				Post-Shanghai-Hong Kong Stock Connect			
	Response of R_{SSEC} to:		Response of R_{HSI} to:		Response of R_{SSEC} to:		Response of R_{HSI} to:	
	R_{SSEC}	R_{HSI}	R_{SSEC}	R_{HSI}	R_{SSEC}	R_{HSI}	R_{SSEC}	R_{HSI}
1	0.000392	0.000000	0.000155	0.000482	0.001121	0.000000	0.000282	0.000498
2	3.37E−05	2.30E−05	3.60E−05	1.36E−05	0.000240	−6.32E−06	5.37E−05	−2.49E−06
3	6.84E−05	−1.02E−06	1.42E−05	−3.18E−06	9.85E−05	2.19E−06	1.62E−05	−2.05E−08
4	4.48E−05	−2.00E−06	9.92E−06	−3.40E−06	7.13E−06	1.52E−05	7.65E−06	−4.36E−06
5	2.36E−05	3.32E−06	5.37E−06	−6.91E−06	−3.64E−05	8.79E−06	6.72E−06	−2.80E−06
6	5.59E−06	2.92E−06	−4.73E−06	1.35E−06	−4.23E−05	−6.72E−07	7.30E−07	3.30E−06
7	−1.39E−06	3.90E−06	−1.44E−08	1.76E−07	−5.01E−05	−1.43E−05	−6.38E−06	−1.37E−05
8	−1.08E−05	−1.10E−06	4.47E−06	−5.35E−06	−4.81E−05	−1.47E−05	−6.92E−06	−2.48E−06
9	−1.97E−05	5.19E−06	−2.30E−06	−5.32E−06	−3.50E−05	−1.79E−05	−2.40E−06	−5.87E−06
10	−8.28E−06	−5.96E−07	−1.76E−06	1.65E−07	−1.21E−05	−4.62E−06	−2.36E−06	−7.33E−07

Note: This table presents impulse responses to Choleshy one standard deviation shock in VAR Eqs. (1) and (2).

5.2. Volatility behaviour analyses using GJR GARCH Model

Table 7 presents the volatility estimates for the Shanghai stock market and the Hong Kong stock market based on the GJR GARCH model with a dummy variable for the full sample period. All the coefficients are statistically significant at the 5% level except the constant coefficient in the mean equation of SSEC. Firstly, the coefficients λ_{SSEC} and λ_{HSI} are statistically significant in the mean equations, suggesting that there is serial correlation in both Shanghai and Hong Kong stock markets. Moving to the conditional variance equations, coefficients $a_{SSEC,1}$ and $a_{HSI,1}$ measure the impact of the lagged square error term in the mean equation which relates to the impact of price changes in the previous period on the current volatility. If they are higher, the recent news could have a greater impact on the conditional volatility. The coefficients $b_{SSEC,1}$ and $b_{HSI,1}$ capture the impact of the lagged conditional volatility on the current conditional volatility and therefore indicate the effect of the old news (already available news) on the current conditional volatility. Generally, we do observe evidence of significant ARCH and GARCH effects in the conditional volatility of both stock markets since the coefficients $a_{SSEC,1}$, $a_{HSI,1}$, $b_{SSEC,1}$ and $b_{HSI,1}$ are statistically significant at the 1% significance level. According to the results, both the recent news and old news appears to have slightly higher impact on the Hong Kong stock market compared to the Shanghai stock market. This implies that information transmission in Hong Kong is a little more efficient than Shanghai but the difference seems to be narrowing.

The sum $a_{SSEC,1}$ and $b_{SSEC,1}$($a_{HSI,1}$and $b_{HSI,1}$) measures the persistence of the conditional volatility of the Shanghai stock market (the Hong Kong stock market), whereby if they are greater and closer to unity, the volatility is more integrated (or permanent) and therefore implies more persistence. We observe that the sum of $a_{SSEC,1}$ and $b_{SSEC,1}$ is 0.7191, while the sum of $a_{HSI,1}$and $b_{HSI,1}$ is 0.7500, suggesting that Hong Kong stock market is slightly more persistent. If the sum $a_{SSEC,1}$ and $b_{SSEC,1}$($a_{HSI,1}$and $b_{HSI,1}$) is less than 1, the GARCH model is mean reverting and conditionally heteroskedastic, but has a constant unconditional variance (Engle, 2001). The unconditional variance, given by$1/(a_{SSEC,1}+b_{SSEC,1})$ and $1/(a_{HSI,1}+b_{HSI,1})$, is 1.391 for Shanghai and 1.333 for Hong Kong. This shows that the Shanghai stock market is more volatile than Hong Kong. This is expected because the Hong Kong stock market is more opened and developed compared to the Chinese mainland stock markets. The participation of foreign investors is more likely to improve market competitiveness, enhance information efficiency and increase liquidity level as they are better informed and engage more in portfolio investment. Since the Chinese mainland stock market has not been fully opened to the world, we could observe a higher volatility as domestic individual investors may play more important roles than foreign investors. However, we observe the gap is quite small, implying that China is on its way to open its door to foreign investors and Shanghai-Hong Kong Stock Connect is one of the most important reforms in financial liberalisation.

The coefficients $\varphi_{SSEC,1}$ and $\varphi_{HSI,1}$, capturing the asymmetric effects are statistically significant, suggesting both stock markets react differently on good news and bad news. The coefficient $\varphi_{SSEC,1}$ is negative, indicating that the conditional volatility of the Shanghai stock market is more sensitive to good news but more resistant to bad news. For the Hong Kong stock market, the coefficient $\varphi_{HSI,1}$ is positive, pointing out

Table 7
Results from GJR GARCH with dummy variable.

Variable	Shanghai Stock Market				Variable	Hong Kong Stock Market			
	Coefficient	Std. error	z-Statistic	Prob.		Coefficient	Std. error	z-Statistic	Prob.
	Mean equation					Mean equation			
c_{SSEC}	2.33E−06	0.000146	0.015912	0.9873	c_{HSI}	0.001208	0.000206	5.857927	0.0000
λ_{SSEC}	0.999999	1.89E−05	53017.12	0.0000	λ_{HSI}	0.999898	2.16E−05	46228.57	0.0000
	Variance equation					Variance equation			
$a_{SSEC,0}$	5.64E−08	1.05E−09	53.79944	0.0000	$a_{HSI,0}$	1.75E−07	1.27E−08	13.71399	0.0000
$a_{SSEC,1}$	0.120175	0.002197	54.69594	0.0000	$a_{HSI,1}$	0.149989	0.006852	21.89127	0.0000
$\phi_{SSEC,1}$	−0.083679	0.005142	−16.27314	0.0000	$\phi_{HSI,1}$	0.049994	0.021212	2.356874	0.0184
$b_{SSEC,1}$	0.598982	0.004715	127.0301	0.0000	$b_{HSI,1}$	0.599991	0.017393	34.49627	0.0000
d_{SSEC}	6.86E−07	8.71E−09	78.84132	0.0000	d_{HSI}	4.82E−08	9.08E−10	53.09352	0.0000

Note: $(a_{SSEC,1}+b_{SSEC,1})$ and $1/(a_{SSEC,1}+b_{SSEC,1})$ are 0.719157 and 1.390517 for Shanghai respectively, while $(a_{HSI,1}+b_{HSI,1})$ and $1/(a_{HSI,1}+b_{HSI,1})$ for Hong Kong are 0.749980 and 1.333369 respectively.

that the Hong Kong stock market intensifies in response to the bad news in the previous period. The dummy coefficients for both stock markets are positive and statistically significant. This evidence suggests that we can reject the null hypothesis that the introduction of Shanghai-Hong Kong Stock Connect has no impact on the volatility behaviours of both Shanghai and Hong Kong stock markets. Given that the coefficient is positive, we believe that the introduction of Shanghai-Hong Kong Stock Connect has increased the volatility level of both markets following the implementation of these changes. As a result, the new changes have significant positive impacts on the expected conditional variances of both Shanghai and Hong Kong stock markets. This is not surprising as market openness allows foreign investment and encourages both individual and institutional investors to invest in mainland China and Hong Kong through innovative ways. Moreover, the activeness of both markets fosters market efficiency which is improved through pooling of information and resources together. It is understandable that the process towards a greater financial openness in emerging markets to foster increased risks as a more flexible regulatory structure fosters excessive risk-taking by investors and firms especially in the initial stages. This is in line with some studies which report that financial liberalization may have significantly increased volatility of stock markets in a large number of developing countries (Jaleel and Samarakoon, 2009; Bley and Saad, 2011; Afef, 2014). Reforms toward a greater financial liberalization could contribute to higher stock market volatility as foreign investors may be able to speculate in the domestic market with a short-selling strategy and thus increase the general stock volatility (Umutlu et al., 2010). Financial integration also makes domestic markets more vulnerable to external crises since they are less insulated (Bley and Saad, 2011).

5.3. Volatility behaviour analyses using BEKK GARCH Model

Table 8 reports the parameters estimates on VAR(8)-BEKK-GARCH(1,1) with asymmetric effect which could capture well the evolution of the means and conditional volatility of the two stock markets returns and their interactions. The VAR results are very similar to the VAR analysis provided earlier. The returns of both Shanghai and Hong Kong stock markets have serial correlation feature as the current returns significantly depend on some of their past values. For cross market effect, the results indicate a bi-directional mean spillover effect. For Pre-Shanghai Hong Kong Stock Connect period, there are 4 lagged returns of HSI which are statistically significant at 5% for SSEC equation, implying a strong mean spillover effect from Hong Kong to Shanghai before Shanghai-Hong Kong Stock Connect. In contrast, we observe a weak mean spillover effect from Shanghai to the Hong Kong stock market. However, for the Post-Stock Connect period, there is only one lagged return of HSI that is statistically for SSEC equation compared to three under the HSI equation. This evidence is indicative of a strong mean spillover effect from Shanghai to Hong Kong in Post-Shanghai-Hong Kong Stock Connect period. We observe

Table 8
VAR(8)-BEKK-GARCH(1,1) with asymetric effect results.

Pre-Shanghai-Hong Kong Stock Connect Mean equation						Post-Shanghai-Hong Kong Stock Connect Mean equation					
	R_{SSEC}			R_{HSI}			R_{SSEC}			R_{HSI}	
$R_{SSEC}(-1)-g_{11,1}$	5.57E−03	(0.3989)	$R_{SSEC}(-1)-g_{21,1}$	0.0373	(0.1274)	$R_{SSEC}(-1)-g_{11,1}$	0.5647*	(0.0000)	$R_{SSEC}(-1)-g_{21,1}$	0.1003*	(0.0000)
$R_{SSEC}(-2)-g_{11,2}$	0.1566*	(0.0000)	$R_{SSEC}(-2)-g_{21,2}$	0.0224	(0.2849)	$R_{SSEC}(-2)-g_{11,2}$	−0.0161	(0.3471)	$R_{SSEC}(-2)-g_{21,2}$	3.21E−03	(0.6507)
$R_{SSEC}(-3)-g_{11,3}$	0.1014*	(0.0000)	$R_{SSEC}(-3)-g_{21,3}$	9.66E−03	(0.6525)	$R_{SSEC}(-3)-g_{11,3}$	-0.0720*	(0.0000)	$R_{SSEC}(-3)-g_{21,3}$	2.37E-03	(0.7543)
$R_{SSEC}(-4)-g_{11,4}$	9.82E−03	(0.0961)	$R_{SSEC}(-4)-g_{21,4}$	0.0417	(0.0829)	$R_{SSEC}(-4)-g_{11,4}$	−7.63E−03	(0.5110)	$R_{SSEC}(-4)-g_{21,4}$	0.0225*	(0.0056)
$R_{SSEC}(-5)-g_{11,5}$	−0.0216*	(0.0000)	$R_{SSEC}(-5)-g_{21,5}$	−0.0326	(0.0992)	$R_{SSEC}(-5)-g_{11,5}$	−0.0321*	(0.0000)	$R_{SSEC}(-5)-g_{21,5}$	−6.01E−03	(0.3449)
$R_{SSEC}(-6)-g_{11,6}$	−0.0332*	(0.0000)	$R_{SSEC}(-6)-g_{21,6}$	−0.0642*	(0.0001)	$R_{SSEC}(-6)-g_{11,6}$	−0.0290*	(0.0046)	$R_{SSEC}(-6)-g_{21,6}$	−4.85E−03	(0.3795)
$R_{SSEC}(-7)-g_{11,7}$	−0.0330*	(0.0000)	$R_{SSEC}(-7)-g_{21,7}$	0.0206	(0.3942)	$R_{SSEC}(-7)-g_{11,7}$	−0.0127	(0.2985)	$R_{SSEC}(-7)-g_{21,7}$	1.69E−03	(0.7732)
$R_{SSEC}(-8)-g_{11,8}$	−0.0402*	(0.0000)	$R_{SSEC}(-8)-g_{21,8}$	−0.0211	(0.3764)	$R_{SSEC}(-8)-g_{11,8}$	0.0170	(0.0721)	$R_{SSEC}(-8)-g_{21,8}$	0.0163*	(0.0000)
$R_{HSI}(-1)-g_{12,1}$	0.0536*	(0.0000)	$R_{HSI}(-1)-g_{22,1}$	0.0335*	(0.0330)	$R_{HSI}(-1)-g_{12,1}$	0.1832*	(0.0000)	$R_{HSI}(-1)-g_{22,1}$	0.0167	(0.0995)
$R_{HSI}(-2)-g_{12,2}$	0.0209*	(0.0000)	$R_{HSI}(-2)-g_{22,2}$	−8.21E−03	(0.6259)	$R_{HSI}(-2)-g_{12,2}$	0.0444	(0.0547)	$R_{HSI}(-2)-g_{22,2}$	−4.03E−03	(0.7339)
$R_{HSI}(-3)-g_{12,3}$	0.0117*	(0.0156)	$R_{HSI}(-3)-g_{22,3}$	0.0258	(0.1130)	$R_{HSI}(-3)-g_{12,3}$	0.0367	(0.1190)	$R_{HSI}(-3)-g_{22,3}$	−0.0178	(0.1558)
$R_{HSI}(-4)-g_{12,4}$	7.84E−03	(0.1300)	$R_{HSI}(-4)-g_{22,4}$	−0.0291	(0.0777)	$R_{HSI}(-4)-g_{12,4}$	−0.0471	(0.0762)	$R_{HSI}(-4)-g_{22,4}$	−0.0494*	(0.0000)
$R_{HSI}(-5)-g_{12,5}$	7.55E−03	(0.0720)	$R_{HSI}(-5)-g_{22,5}$	0.0366*	(0.0045)	$R_{HSI}(-5)-g_{12,5}$	0.0196	(0.3211)	$R_{HSI}(-5)-g_{22,5}$	0.0171	(0.0712)
$R_{HSI}(-6)-g_{12,6}$	0.0102*	(0.0170)	$R_{HSI}(-6)-g_{22,6}$	0.0151	(0.3081)	$R_{HSI}(-6)-g_{12,6}$	−0.0282	(0.2588)	$R_{HSI}(-6)-g_{22,6}$	−0.0234	(0.0545)
$R_{HSI}(-7)-g_{12,7}$	1.79E−03	(0.6757)	$R_{HSI}(-7)-g_{22,7}$	−8.87E03	(0.6422)	$R_{HSI}(-7)-g_{12,7}$	−0.0161	(0.4459)	$R_{HSI}(-7)-g_{22,7}$	−0.0125	(0.2965)
$R_{HSI}(-8)-g_{12,8}$	2.58E−03	(0.5139)	$R_{HSI}(-8)-g_{22,8}$	−0.0252	(0.1542)	$R_{HSI}(-8)-g_{12,8}$	−0.0160	(0.4832)	$R_{HSI}(-8)-g_{22,8}$	−0.0135	(0.2555)
Constant$-g_1$	1.26E−05*	(0.0000)	Constant$-g_2$	2.48E−06	(0.7788)	Constant$-g_1$	2.34E−05	(0.0592)	Constant$-g_2$	1.04E−05	(0.0850)

Pre-Shanghai-Hong Kong Stock Connect Variance equation			Post-Shanghai-Hong Kong Stock Connect Variance equation		
c_{11}	8.56E−05	(0.0818)	c_{11}	1.18E−03*	(0.0000)
c_{21}	7.65E−04	(0.1107)	c_{21}	4.04E−04*	(0.0000)
c_{22}	2.44E−05	(0.9986)	c_{22}	2.26E-04*	(0.0000)
a_{11}	0.2360*	(0.0000)	a_{11}	0.1288*	(0.0000)
a_{12}	−0.0149	(0.4521)	a_{12}	0.0385*	(0.0000)
a_{21}	−0.0806*	(0.0000)	a_{21}	0.4822*	(0.0000)
a_{22}	0.2842*	(0.0000)	a_{22}	0.0272*	(0.0126)
b_{11}	0.6477*	(0.0000)	b_{11}	−0.0874*	(0.0062)
b_{12}	0.0873	(0.1850)	b_{12}	−0.1321*	(0.0000)
b_{21}	0.1959*	(0.0000)	b_{21}	0.0383	(0.7404)
b_{22}	0.0449	(0.4693)	b_{22}	0.7931*	(0.0000)
d_{11}	−0.1466 *	(0.0000)	d_{11}	0.1927*	(0.0000)
d_{12}	0.1870*	(0.0000)	d_{12}	−0.0129*	(0.0040)
d_{21}	−0.0318*	(0.0032)	d_{21}	−0.1741*	(0.0000)
d_{22}	−0.2269 *	(0.0000)	d_{22}	0.2350*	(0.0000)

Note: this table shows the estimates of the multivariate VAR(8)-BEKK-GARCH(1,1) model with asymmetric effect. The parameters cij, aij, bij, dij and gij,t are the elements of the matrices C, A, B, D and G, as presented in Eq. (11). The model is estimated by Berndt, Hall, Hall, and Hausman (BHHH) algorithm method and there is no convergence in 50 iterations.
[*] Indicates rejection of the null hypothesis at the 5% level of significance.

the significant changes in terms of mean spillover effect between these two markets and conclude that the mean spillover effect from Shanghai to Hong Kong became stronger than the opposite direction after Shanghai-Hong Kong Stock Connect. Our results here are also indicative of the initial leadership role of the Shanghai stock market after the connect adoption as the information transmission efficiency for the Shanghai stock market improves significantly following the changes. This is unsurprising because Chinese authorities have already taken some steps to enhance financial openness and ensure an effective regulatory regime of the mainland stock market. Our results here are consistent with Qiao and Lam (2011) who elaborate that the Chinese stock markets in fact play a most influential role among the stock markets in the Greater China region, including the Hong Kong stock market.

Moving to the conditional variance equations, Table 8 also outlines the spillover effects of intraday volatilities between Shanghai and Hong Kong stock markets for both Pre-and Post-Shanghai-Hong Kong Stock Connect periods using BEKK-GARCH conditional variance-covariance equation model. The diagonal parameters (i.e., a_{11} and a_{22}) of the matrix A, which capture the past shock effects of each market on the current volatility are statistically significant for both periods at the 5% significance level, implying that there are ARCH effects in both Shanghai and Hong Kong stock markets for both periods. The diagonal parameters (b_{11} and b_{22}) of the matrix B, which measure past volatility effects on the current conditional volatility in each market, are used to capture the GARCH effect. The coefficient b_{11} is found to be statistically significant for the Shanghai stock market in both periods, indicating there is strong GARCH effect in the Shanghai stock market. However, b_{22} is found to be statistically significant only in the Post-Stock Connect period for the Hong Kong stock market. The finding indicates that GARCH effects are observed only after Shanghai-Hong Kong Stock Connect and that the current conditional variances of HSI are considerably influenced by past conditional variance after this event.[5] We observe that the recent and old news has similar impact on the conditional volatility of Shanghai for both periods but only on the conditional variance of Hong Kong in the Post-Stock Connect period. However, only recent news could influence the conditional volatility of Hong Kong stock markets before the implementation of the Stock Connect program. This suggests that old news starts to become important after the introduction of the Stock Connect as capital flow from mainland China may be contributing to the importance of the old news. Looking at the volatility spillover effect, the off-diagonal parameters of the matrices A and B measure cross-market impacts, capturing shock spillovers and volatility spillovers between Shanghai and Hong Kong stock markets respectively. The coefficient a_{12} captures the cross market effect from the error term of the Shanghai stock market to the conditional variance of the Hong Kong stock market, while a_{21} captures the cross market effect in the opposite direction. The variable b_{12} measures the cross market effect from the lagged conditional variance of the Shanghai stock market to the conditional variance of the Hong Kong stock market, while b_{21} indicates the similar cross market effect in the opposite direction. As per the estimated results for the Pre-Stock Connect period, parameters a_{21} and b_{21} are statistically significant at the 1% significance level suggesting that the lagged shocks and the historical conditional volatility in Hong Kong is influencing the conditional variance of the Shanghai stock market. In contrast, parameters a_{12} and b_{12} are statistically insignificant at the 1% significance level for the Pre-Stock Connect period, showing that the lagged shocks and the historical conditional volatility in the Shanghai stock market do not have similar impacts on the current conditional volatility of the Hong Kong stock market. Therefore we can only observe the unidirectional shock and volatility spillover effect from Hong Kong to Shanghai before the Stock Connect initiatives. This finding could be explained due to the fact that the Hong Kong stock market is well-developed and more open to the rest of the world. It can therefore absorb information faster and more efficiently than the stock markets in mainland China. The coefficients a_{12} and b_{12} become statistically significant in Post-Stock Connect period but b_{21} coefficient becomes insignificant. This implies that the spillover effect from Shanghai to Hong Kong stock market (in terms of both the lagged shocks and the historical conditional volatility) occurs after the introduction of the Stock Connect arrangement. In terms of the absolute value, a_{21} (0.4822) is much larger than a_{12} (0.0385), implying a stronger shock spillover effect from Hong Kong to Shanghai. Since taking steps towards financial liberalisation and opening up of the Chinese stock markets, the shock spillover effect reported in the empirical analysis is consistent with the financial liberalisation process. The new findings in Table 8 show that the implementation of the Stock Connect could improve the information transmission running from the Shanghai stock market to the Hong Kong stock market in terms of volatility spillovers. As the government continue opening the Shanghai stock market to foreign investors, it will not be surprising that the Hong Kong stock market starts losing its influential power on the Chinese mainland stock markets. In a more recent study, Huang and Kuo (2015) argue that the Chinese mainland stock markets play a leading role in information transmission for the Hong Kong and Taiwan stock markets. In terms of the asymmetric effect, coefficients d_{11} and d_{22} are negative and statistically significant in the Pre-Stock Connect period but positive and statistically significant in the Post-Stock Connect period. We do observe that both stock markets are very sensitive to the good news but more resistant to bad news before the implementation of Stock Connect initiatives. Generally, the contagion effect from Hong Kong to Shanghai appears to be weaker in Post-Stock Connect and that mainland China stock markets are starting to become more influential regionally.

Overall, we have seen significant changes in mean and volatility spillover effects between Shanghai and Hong Kong stock markets over the period under the study. We also observe that the contemporaneous increases in the volatility seem to be driven by Shanghai-Hong Kong Stock Connect. Our result shows that the spillover effect in mean and volatility from Shanghai to Hong Kong are enhanced after Shanghai-Hong Kong Stock Connect, while the contagion effect from Hong Kong to Shanghai appear to be weaker in Post-Shanghai-Hong Kong Stock Connect period than the Pre-Stock Connect period. Our findings demonstrate that the mainland China stock markets start to become more influential regionally. Yi et al. (2009) provide various arguments in their interpretation of this phenomenon. Critically, changes in macroeconomic conditions, industry activities, economic growth patterns and micro-market structures in the mainland China would certainly exert a great deal of repercussions on the Hong Kong stock market. Besides, there are also many large state-owned companies listed in the Hong Kong Stock Exchange (some of them are cross-listed in both markets) which could contribute to the transmission of market shocks from mainland China to Hong Kong. As a result, the Chinese stock market could lead in the information absorption compared with the Hong Kong market. In addition, Hong Kong's heavy dependence on mainland China and the increasing number of cross-listed companies may contribute to the leading role of the Chinese mainland stock markets. Since both the international and domestic investors incorporate the volatility spillover relationship into their portfolio allocation, this study sheds light on how investors can benefit from the diversification. Volatility spillover is sometimes associated with a rise in the correlation between stocks, thereby reducing market diversification benefits for long investment horizon investors. Our results will be help investors better understand transmissions changes, origins and drivers of both the shock and volatility spillovers. However, it should be noted that, although mainland China seems to influence the Hong Kong stock market, the magnitude is relatively small. Thus investors may still be

[5] Other previous studies which have found a significant ARCH and GARCH effects in emerging markets include Beirne et al. (2013).

able to benefit from cross-markets asset diversification strategy between Shanghai and Hong Kong stock markets. However, they should reconsider portfolio and asset allocation across different markets from the perspectives of the geographical, industries, financial instruments and assets classes to achieve optimal portfolio diversification and maximizing investment returns (Balli et al., 2014).

6. Conclusion and some policy implications

This study aims to examine the impact of Shanghai-Hong Kong Stock Connect program on the dynamic relationship between Shanghai and Hong Kong stock markets. Our empirical research is among the first to investigate the impact of Shanghai-Hong Kong Stock Connect and provides a comprehensive analysis on the return and volatility behaviours of the Shanghai and Hong Kong stock markets using various quantitative methods. We use cointegration tests, Granger Causality tests and VAR model to examine the dynamics in the returns of the Shanghai and Hong Kong stock markets. We further conduct impulse response analysis and sensitivity tests. We also look at the volatility of the two stock markets by applying both univariate and multivariate GARCH models including GJR GARCH and BEKK GARCH models. A high frequency data (1 min's interval) of the Shanghai and Hong Kong stock markets indices is utilized to analyse the market dynamic behaviours. The dataset is from 02/07/2014 to 08/04/2015 which is about 3.5 months before and after the implementation for Shanghai-Hong Kong Stock Connect. Firstly, looking at the influence of Shanghai-Hong Kong Stock Connect, we find a significant long-term cointegration relationship between the Shanghai and Hong Kong stock markets in Post-Shanghai-Hong Kong Stock Connect period while we observe no cointegration relationship between these two markets before this program. Secondly, we observe that the return spillover effect from Shanghai to Hong Kong is faster and stronger than that from Hong Kong to Shanghai in the Post-Stock Connect period. Our impulse response analysis conducted as part of sensitivity tests shows that the Hong Kong stock market tends to be more responsive to the shocks in the Shanghai stock market in Post-Stock Connect period. Thirdly, the implementation of Shanghai-Hong Kong Stock Connect program has increased the conditional volatility level of both stock markets, since it opens the door for foreign investment and attracts both individual and institutional investors to participate in both Shanghai and Hong Kong stock markets. Fourthly, based on VAR BEKK model, we see an enhanced spillover effects in terms of mean and volatility from Shanghai to Hong Kong and weaker contagion effects from Hong Kong to Shanghai after the new initiative measures. This empirical evidence seems to suggest that the Chinese mainland stock markets could significantly affect the Hong Kong stock market through return and volatility spillover effects and plays a leading role in the information transmission regionally. In line with Raine and Adams (2015), our findings show that the enhanced openness of Chinese mainland stock markets does however contribute to the risk level, the market efficiency and the market activeness, since foreign investors generally tend to be more informed investor and contribute to the higher volatility. The success of Shanghai-Hong Kong Stock Connect provides valuable operational experience for expanding China's financial connections and further reforms on financial liberalization of the Chinese stock markets.

Policy wise, our research analysis here will be useful to international portfolio managers, investment service providers and policy makers. It is observed that the openness of the Chinese stock market to Hong Kong and the rest of the world could improve the rate of information flow and increase the degree of market efficiency as foreign participation increases. The success of Shanghai-Hong Kong Stock Connect program accelerates the gradual internationalisation of RMB, because it provides direct access to RMB denominated A share market and broadens the use of RMB. This program provides a very important data gathering experience for further reforms in the liberalisation of Chinese mainland financial markets. This learning experience will be critical to the success of the forthcoming Shenzhen-Hong Kong Stock Connect, Exchange-Traded Funds (ETFs) Connect, Futures Connect and Bond Connect. Shanghai-Hong Kong Stock Connect does give a potential successful guideline for future market openness programs, but other issues need to be considered before future connects initiatives are launched. As the Chinese financial markets continue to be integrated with the world, policy makers are facing an increasingly complex situation in which both domestic and overseas shocks can affect the local stock markets. Our study has important policy implications for portfolio managers. In line with Heymans and Da Camara (2013), we observe that as investor sentiments change following economic and policy shocks, individuals and portfolio managers may find it necessary to readjust their hedging strategies in order to protect their wealth. With the opening up of the Chinese stock market, both foreign and local investors will benefit from information sharing and risk management strategies and become more active in their participation. However, the adopted financial liberalization should follow a proper sequential process in order to avoid greater risk exposure and crisis. The gradual move and transition towards more open and developed markets based on financial system should also be supported by required changes in legal and institutional framework. We believe Shanghai-Hong Kong Stock Connect did consolidate the regional position of Shanghai as a regional financial centre and that the financial liberalisation of the Chinese mainland stock markets does make a positive contribution to the development of Chinese economic growth and financial system.

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