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The Cross-Border Price Discovery and the Shanghai-Hong Kong Stock Connect

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Abstract

This study mainly investigates the price discovery relationship between stock and futures markets and the cross-border price discovery relationship between Chinese and Hong Kong markets after the launch Shanghai-Hong Kong Stock Connect Progress. We find that this progress increases the speed of adjustment from the long-term equilibrium in the Chinese spot and futures markets. Moreover, the price discovery process mainly happens in Hong Kong's spot and futures markets. Final, cross-border price discovery is from Hong Kong to China after this progress.

JEL classification numbers: G15, G18
Keywords: Price Discovery, Shanghai-Hong Kong Stock Connect

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1. Introduction

Due to Shanghai-Hong Kong Stock Connect Progress (hereafter, SHSCP) being a new trading system[5], this new system attracts international funds into the Chinese market, enhances the RMB business and increases the offshore market demand in Hong Kong market. Bohl, Salm and Schuppli (2011) find that when the government policy makes the market more open, the market will attract more informed traders and increase the price discovery. There are few studies focusing our research investigates the impact of Shanghai-Hong Kong Stock Connect Progress on the price discovery relationship between two markets. Therefore, the two main objectives of this study are as follows. First, we examine the price discovery between spot and futures in Chinese and Hong Kong markets after and before SHSCP, representatively. Next, we examine the cross-border price discovery between the Chinese and Hong Kong's markets in spot or futures market after and before SHSCP. Investors can use this relationship of price discovery or cross-border price discovery to make investment decisions and judgments to earn profits.

Price discovery, will happen in the market with more information, is an important issue and plays a significant role between spot and futures markets.[6] Previous literature finds that price discovery will happen in the spot market (e.g. Bohl, Salm & Schuppli, 2011; Chen & Gau, 2010; Yang, Yang & Zhou, 2012) and in the futures market (e.g. Hou & Li, 2013; Tse, 1999; Zhong, Darrat & Otero, 2004). Bohl, Salm and Schuppli (2011) shown the government policy affect the price discovery. China Financial Futures Exchange reported the more restrictions on futures. Investors should be a least 20 times mock trading or prior trading experience of commodities futures experiences and each account must evaluate risk assessment to understand the degree of risk of investors before trading futures. After trading futures, the first five transactions day, the margin requirement must be a least 500,000 RMB and the position limit level.[7] Overall, the Chinese CSI 300 futures market has high trading barriers. Therefore the Chinese spot markets will have more information than the futures market, the price discovery will mainly happen in the spot market. On the contrary, Hong Kong is a mature market with lower volatility and higher stability. It also has lower trading cost than the Chinese market. From the trading cost perspective, the market with lower trading cost will attract informed traders and

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[5] To increase the financial status in Asia, Hong Kong Exchanges and Clearing Limited (HKEx), Shanghai Stock Exchange (SSE) and China Securities Depository and Clearing Corporation Limited (China Clear) set up Shanghai-Hong Kong Stock Connect Progress (SHSCP) on November 15, 2014.

[6] Price discovery is that security with more information should contribute more to the price discovery process; therefore, it adjusts less to deviation from the equilibrium. Schwarz and Szakmary (1994) indicate that the market with a lower speed of adjustment coefficient does not follow, but rather initiates, the mispricing, implying that the price discovery process takes place mainly in this market.

[7] Detailed Trading Rules on China Financial Futures Exchange reported:

" *(1) The position limit level for speculation shall be 5,000 lots per contract on either the long side or the short side. (2) if the total one-sided positions in a particular Contract are more than 100,000 lots after settlement on a particular trading day, the one-sided positions in such Contract held by a clearing member on the next trading day shall not exceed 25% of the aggregate one-sided positions in such contract.*"

contribute more to price discovery (Fleming, Ostdiek and Whaley, 1996; Frino and West, 2003). These characteristics attract many institutional investors who like to trade in the futures, and price discovery will mainly happen in the futures market. Therefore, we study whether the different of price discovery relationship between spot and futures in Chinese or Hong Kong markets, representatively.

There are few studies focusing our research investigates the cross-border price discovery between Chinese and Hong Kong stock (futures) markets. There is the geographical proximity, and similar cultural and political factors between Chinese and Hong Kong markets. Moreover, Hong Kong is a one of the financial centers in Asia; it was established earlier than the Chinese market. From cross markets research, Ghadhab and Hellara (2016) find that one markets' contribution to price discovery is greater when its trading costs are lower. Hong Kong's market has lower trading cost than the Chinese market does, causing the cross-border price discovery to mainly occur in Hong Kong's market.[8] Therefore, the cross-border price discovery relationship from Hong Kong to Chinese and Hong Kong markets in spot or futures, representatively.

On November 15, 2014, SHSCP entered both the Chinese and Hong Kong markets; this progressive step makes both markets more inseparable and attracts more investors to invest in both markets. The futures market still has high trading barrier and more open than stock market in Chinese market after SHSCP enabling the price discovery to happen in the spot markets. Therefore, we investigate whether price discovery relationship increase from stock market to futures market in Chinese market after SHSCP. However, Hong Kong become more mature capital market and the futures market still has lower trading barrier after SHSCP; thus, we investigate the price discovery has increased from the futures market to spot market. In term of cross-border price discovery, SHSCP allows investors to trade stocks between the Shanghai and Hong Kong stock markets, but not the trade futures. There is more information in the spot market; therefore, we examine whether the cross-border price discovery increases (decreases) from the Hang Seng spot (futures) market to Chinese stock markets (futures market).

Accompanying by this progress connects two different markets, we use the cointegration test to examine whether both markets have a long-term equilibrium relationship before and after SHSCP. If both markets have a long-term relationship, both markets will have a speedy adjustment in their cooperative relationship. Schwarz and Szakmary (1994) find that the price discovery process happens mainly in markets with a lower speed of adjustment coefficient. In this research, we use the vector error correction-dynamic conditional correlation generalized autoregressive condition heteroskedasticity (VECM-DCC-GARCH) model to investigate not only the price discovery between spot and futures prices on Chinese or Hong Kong

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[8] Chinese stock market's total trading cost is 0.37887% (brokerage: 0.25%, CCASS fee: 0.1%, transfer fee: 0.002%, handling fee: 0.00487%, security charge: 0.022%) and Hong Kong stock market's total trading cost is 0.3577% (brokerage: 0.25%, transaction levy: 0.0027%, transaction fee: 0.005%, CCASS fee: 0.1%).

markets, but also the cross-border price discovery between Hang Seng and Chinese market in spot or futures market before and after SHSCP.

This paper is divided into four sections. Section 2 illustrates our data and empirical model. Section 3 shows the empirical results. Section 4 concludes our paper.

2. Data and Research Method

2.1 Data

This research investigates the effect of the Shanghai-Hong Kong Stock Connect Progress on price discovery. Our data consist of Shanghai Composite index, China Stock Index (hereafter, CSI) 300 index and the Hang Seng Index, as well as the CSI 300 index futures and the Hang Seng Index futures.[9] We use the daily close prices of the stock index and the daily settlement prices of stock index futures contracts. The prices of Shanghai Composite index, CSI300 stock index and CSI300 stock index futures are obtained from the CSMAR database and the prices of the Hang Seng index and Hang Seng index futures are obtained from Datastream; the sample period extends from April 16, 2010 to December 31 2015.[10] The spot and the futures prices are expressed in natural logarithms by $s_t = \log(\mathrm{S_t})$ and $f_t = \log(\mathrm{F_t})$, and the continuously compounded daily returns are calculated as $\Delta s_t = (s_t - s_{t-1})$ and $\Delta f_t = (f_t - f_{t-1})$.

2.2 Research method

The dynamics of the cointegrated logarithms of two asset prices can be studied using a bivariate vector error correction model (VECM) in the following form:

$$\Delta x_t = \beta_{x,0} + \gamma_{xb} ec_{t-1}(1 - D_{SHSCP}) + \gamma_{xa} ec_{t-1} D_{SHSCP} + \sum_{j=1}^{p} \beta_{xx,j} \Delta x_{t-j} + \sum_{j=1}^{p} \beta_{xy,j} \Delta y_{t-j} + \varepsilon_{x,t} \quad (1)$$

$$\Delta y_t = \beta_{y,0} + \gamma_{yb} ec_{t-1}(1 - D_{SHSCP}) + \gamma_{ya} ec_{t-1} D_{SHSCP} + \sum_{j=1}^{p} \beta_{yx,j} \Delta x_{t-j} + \sum_{j=1}^{p} \beta_{yy,j} \Delta y_{t-j} + \varepsilon_{y,t} \quad (2)$$

where Δx_t and Δy_t are the two different markets; ec_{t-1} is the estimated error correction term. To investigate the changes before and after the SHSCP, we set a dummy variable, $\mathrm{D_{SHSCP}}$. If the time period is before SHSCP, $\mathrm{D_{SHSCP}}=0$; otherwise, if the time period is after SHSCP, $\mathrm{D_{SHSCP}}=1$. $\beta_{xy,j}$ ($\beta_{yx,j}$)

[9] Because this progress connects both China's and Hong Kong's capital markets, we also investigate the effect of this progress on price discovery between the Chinese and Hong Kong stock markets. However, since the Shanghai Composite index doesn't have futures contracts to trade in the market, we use its spot price to investigate the price discovery difference between the Chinese and Hong Kong stock markets.

[10] The reason that our sample period starts from April 16, 2010 is because CSI 300 stock index futures was introduced on China Financial Futures Exchange since then. CSI 300 stock index futures is consists of 300 large capitalization and actively traded stocks listed in Shanghai (187 stocks) and Shenzhen (113 stocks) on 28 October 2016.

and $\beta_{xx,j}$ ($\beta_{yy,j}$) are the coefficients of short-term predictive power, and can be measured by the reaction of two returns to different markets', or their own, lagged value.

This model includes short-run relationships, signifying the predictive power of one variable for the other in the two different markets. We use Granger causality to test whether the two markets can be impacted by each other in the short-run. We use the following null hypothesis: $H_0{:}\,\beta_{yx,1} = \beta_{yx,2} = \cdots = \beta_{yx,p} = 0$ ($H_0{:}\,\beta_{xy,1} = \beta_{xy,2} = \cdots = \beta_{xy,p} = 0$); if the null hypothesis is rejected, it indicates that there is a Granger causality relationship from X to Y (Y to X) market. If both hypotheses are rejected, there is a bidirectional Granger causality between X and Y.

The parameters γ_{xb} and γ_{yb} (γ_{xa} and γ_{ya}) capture the long-term causality relationship between the X and Y markets before (after) SHSCP.[11] The X and Y markets will be taken to be bidirectional causality where γs are statistically significant. If γ_{xb} (γ_{xa}) is statistically significant and γ_{yb} (γ_{ya}) is not statistically significant, then the decision rule is that there is unidirectional long-term causality running from Y to X before (after) SHSCP. If γ_{yb} (γ_{ya}) is statistically significant and γ_{xb} (γ_{xa}) is not statistically significant, then unidirectional long-term causality runs from X to Y before (after) SHSCP.

We put γ_{xb} and γ_{yb} (γ_{xa} and γ_{ya}) into a simple common factor weight measure before (after) SHSCP to test the price discovery in both markets, as proposed by Schwarz and Szakmary (1994). This measure can be written as:

$$\theta_{yb} = \frac{|\gamma_{xb}|}{|\gamma_{xb}|+|\gamma_{yb}|} \; and \; \theta_{xb} = 1 - \theta_{yb} \tag{3}$$

$$\theta_{ya} = \frac{|\gamma_{xa}|}{|\gamma_{xa}|+|\gamma_{ya}|} \; and \; \theta_{xa} = 1 - \theta_{ya} \tag{4}$$

Take the spot and futures markets, for example. θ_{yb} and θ_{ya} (θ_{xb} and θ_{xa}) are the common factor weights of the price discovery process in the futures (spot) market before or after SHSCP.[12] If the price discovery only happens in the futures (spot) market after SHSCP, $\theta_{ya} > \theta_{xa}$ ($\theta_{xa} > \theta_{ya}$). This measure implies that the lower speed of the adjustment coefficient may be experiencing the mispricing

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[11] In X and Y markets, when the Y is higher than the equilibrium value, the error correction term will have a negative price change on the Y and a positive price change on the X market. Similarly, if X price is below its equilibrium value, the arbitrageurs will buy the X and the price will increase. We expect different signs of the error correction coefficient $\gamma_{xb}>0$ and $\gamma_{yb}<0$ ($\gamma_{xa}>0$ and $\gamma_{ya}<0$) before (after) SHSCP. Tswei and Lai (2009) find that it is possible that both error correction coefficients of the spot and futures markets have the same sign, which can be explained by over-reaction to the futures market and under-reaction to the spot market.

[12] γ_{xb} and γ_{yb} (γ_{xa}, and γ_{ya}) are the error correction coefficients which measure the speed of adjustment in response to deviations from the long-term equilibrium.

phenomenon, causing the price discovery to happen mainly in this market.[13]
We use a multivariate generalized autoregressive conditional heteroskedasticity (GARCH) modeling framework and assume that conditional variances follow GARCH(1,1) processes in the following form:

$$h_{xx,t} = \omega_x + \delta_{x,1} h_{xx,t-1} + \delta_{x,2} \varepsilon_{x,t-1}^2 \quad (5)$$

$$h_{yy,t} = \omega_y + \delta_{y,1} h_{yy,t-1} + \delta_{y,2} \varepsilon_{y,t-1}^2 \quad (6)$$

where we need to restrict both sums of $\delta_{x,1}$+$\delta_{x,2}$ and $\delta_{y,1}$+$\delta_{y,2}$ to be lower than 1, and ω_x (ω_y), $\delta_{x,1}$ ($\delta_{y,1}$) and $\delta_{x,2}$ ($\delta_{y,2}$) are all non-negative values. If we comply with this restriction, it means that the model is stationary and has volatility clustering. We use dynamic conditional correlation (DCC) model which was proposed by Engle (2002). The variance-covariance matrix of residuals can then be rewritten as:

$$H_t = \begin{bmatrix} h_{xx,t} & \omega_{xy,t}\sqrt{h_{xx,t}h_{yy,t}} \\ \omega_{xy,t}\sqrt{h_{xx,t}h_{jyy,t}} & h_{yy,t} \end{bmatrix} = D_t G_t D_t \quad (7)$$

where ω_{xy} denotes the conditional correlation coefficient between two prices. D_t= diag($h_{xx,t}^{1/2}$ ... $h_{yy,t}^{1/2}$). diag(a) is a matrix operator creating a diagonal matrix with the vector along the main diagonal, and G_t is a time-varying correlation matrix by Engle (2002) as follows:

$$G_t = (1-\kappa_1-\kappa_2)\bar{G} + \kappa_1 \mu'_{t-1}\mu_{t-1} + \kappa_2 G_{t-1} \quad (10)$$

where $\bar{G}$ is assumed to be a positive definite matrix and the two parameters must be κ_1, κ_2>0 and $\kappa_1 + \kappa_2$<1 to satisfy a stability constraint. $\mu'_{t-1}\mu_{t-1}$ is a lagged function of the standardized residuals.

3. Empirical Results

3.1 Descriptive Statistics and Unit Root Test

Table 1 shows the descriptive statistics on returns. In the CSI 300 index and Hang Seng index, each of their spot and futures returns exhibits similarity in terms of mean and standard deviation. All of their skewness are lower than 0 and their

[13] It should be noted that there are other popular measures used to assess the relative contributions of different markets to price discovery process such as the common factor weights of Gonzalo and Granger (1995) and information shares developed by Hasbrouck (1995). Theissen (2002) and Bohl et al. (2011) posit that Schwarz and Szakmary (1994) measurement has similar qualitative results with information shares and can be derived from Gonzalo and Granger (1995)'s framework.

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kurtosis are higher than 3, signifying that the data are all skewed left and leptokurtic. The Jarque-Bera test statistics (JB) in our data are significant at the 1% level, signifying that all return series do not follow normal distribution.

Table 1: Descriptive Statistics of Returns

Country	CSI300 index		Hang Seng index		Shanghai index
Items	**Spot**	**Futures**	**Spot**	**Futures**	**Spot**
Mean	0.0076	0.0049	0.0002	0.0009	0.0091
Std. Dev.	1.6285	1.8375	1.1790	1.2458	1.5396
Skewness	-0.6029	-0.5213	-0.1612	-0.1435	-0.8191
Kurtosis	4.0252	8.5624	3.1812	3.4295	5.5519
Jarque-Bera	1020.38***	4299.8***	590.88***	684.495***	1884.81***

Note: *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 2 shows the unit root tests. First, we use the Augmented Dickey-Fuller (ADF) test; the results show that the null hypotheses are rejected for all returns irrespective of the constant or trend term, implying that all series are stationary. Second, we use the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests; the results show that all the statistics are lower than the critical value, implying that the returns are stationary.[14]

Table 2: Unit Root Tests for Returns

Item		ADF		KPSS	
		Constant	**Trend**	**Constant**	**Trend**
CSI300 index	**Spot**	-6.8650***	-6.8838***	0.2527	0.0527
	Futures	-6.8633***	-6.8745***	0.2128	0.0453
Hang Seng index	**Spot**	-25.5356***	-25.5271***	0.0426	0.0431
	Futures	-26.0687***	-26.0602***	0.0403	0.0406
Shanghai index	**Spot**	-6.9008***	-6.9370***	0.3102	0.0536

Note: *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 3 reports the results of Johansen cointegration test, and the results of cointegration test before and after SHSCP are respectively.[15] In term of before SHSCP, the cointegration statistic values only significant at the 1% level between the spot and futures prices in the CSI300 or Hang Seng markets, respectively. Noteworthily, the results the cointegration tests are all significant at 10% level after SHSCP, but those in rank 1 are not significant. This paper found the long-term relationship between spot and futures markets on Hong Kong or Chinese markets, and also the long-term relationship between the Hong Kong and Chinese market on spot or futures markets. Therefore, there are strong relationships enhanced the overall strength of China's capital markets and the competitiveness both sides after

[14] The prices of all series are non-stationary.

[15] The table 3 show the results of Lmax test. The results of Trace test is similar with Lmax test.

Shanghai-Hong Kong Stock Connect policy. SHSCP helps the Chinese markets to become more international and attract more institutional investors; moreover, the programme consolidate the position of Shanghai and Hong Kong as financial centers.

Table 3: Cointegration Tests

Items	Hypothesized No. of CE(s)	Before SHSCP	After SHSCP
CSI 300 Spot and Futures	0	52.003***	14.669**
	1	4.8087	0.3685
Hang Seng Spot and Futures	0	133.40***	61.02***
	1	5.9665	0.1453
Hang Seng Spot and Shanghai Spot	0	12.904	10.304*
	1	7.3311	0.5178
CSI 300 Spot and Hang Seng Spot	0	10.997	11.566**
	1	7.0616	0.1523
CSI 300 Futures and Hang Seng Futures	0	11.082	12.951**
	1	6.686	0.3345

Note: *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

3.2 Price Discovery between Spot and Futures Markets

Table 4 shows the estimation results of VECM-DCC-GARCH model of spot and futures. As shown in Panel A, the error correction coefficients of spot market for CSI 300 before and after SHSCP (γ_{xb} and γ_{xa}) are not statistically significant. In contrast, the error correction coefficients in the futures before and after SHSCP (γ_{yb} = -24.88 and γ_{ya}= -14.70) are statistically significant at 10% and 1% level respectively. These results indicate that these is the unidirectional long-term causality relationship from spot to futures market in China market. On the other hand, the error correction coefficients of Hang Seng before SHSCP in spot markets, γ_{xb} = 11.19, is significant at the 10% level and in the futures markets γ_{yb} = 2.875 is not significant. Therefore, the unidirectional long-term causality relationship is from the futures to the spot in Hong Kong before SHSCP.

We use common factor weight measurements to measure price discovery abilities of CSI 300 spot and futures markets before and after SHSCP. The common factor weights of θ_{yb} (θ_{xb}) and θ_{ya} (θ_{xa}) gauge price discovery ability of futures (spot) market before and after SHSCP. The common factor weights are θ_{yb}= 0.173 and θ_{ya}= 0.099 before and after SHSCP; thus, this result indicates that CSI 300 spot market dominates price discovery process. Because the CSI300 futures market in the Chinese market is a new market with lots of transaction restrictions to traders in the futures market; therefore, the result of price discovery happening in the spot markets in China. Moreover, the common factor weight before SHSCP is higher than after SHSCP, indicating that SHSCP allows investors to trade stocks between the Shanghai and Hong Kong stock markets, but not allows the trade futures. Therefore, there is more information in the spot market in China enabling the price discovery to happen in the spot markets. This finding deepens price discovery process in Chinese stock market after SHSCP and that SHSCP helps Chinese capital become more open.

The common factor weights are θ_{yb}= 0.80 and θ_{ya}= 0.822 before and after SHSCP in the Hong Kong market. This finding shows that price discovery mainly happens in the futures market. As the trading futures in Hong Kong is a mature capital market, lower transaction costs and ease of shorting; thus, price discovery mainly occurs in the futures market. After SHSCP, this connection has enhanced Hong Kong's financial status; it has become more international and open, and the price discovery in the futures market has increased.

In variance equations, as shown in panel C, all of the values of ω_x, ω_y, $\delta_{x,1}$, $\delta_{y,1}$, $\delta_{x,2}$ and $\delta_{y,2}$ are non-negative values and the sum of $\delta_{x,1}$+$\delta_{x,2}$ and $\delta_{y,1}$+$\delta_{y,2}$ is lower than 1. It means that the model is stationary and has volatility clustering. In the DCC equation, κ_1 and κ_2 are non-negative, and the value of $\kappa_1 + \kappa_2$ is lower than 1. It means that the volatility will transform with time. We also applied the Ljung-Box Q test to investigate whether the residuals of return have autocorrelation. As shown in panel D, the LB Q and LB Q^2 statistics for 20 lags are not significant for standard residuals and squared standard residuals; they are non-auto-correlated.

Table 4: VECM-DCC-GARCH Model Estimation of Spot and Futures

Panel A: Mean Equation of VECM-DCC-GARCH Model				
	CSI 300		Hang Seng	
	Parameters	t values	Parameters	t values
$\beta_{x,0}$	0.019	0.57	0.074**	2.38
γ_{xb}	-5.187	-0.77	11.19*	1.87
γ_{xa}	-1.610	-0.22	14.76	0.97
$\beta_{xx,1}$	-0.245	-3.14	-0.206*	-1.70
$\beta_{xx,2}$	-0.063	-0.90	-0.135	-1.20
$\beta_{xy,1}$	0.256***	3.40	0.208*	1.82
$\beta_{xy,2}$	0.05	0.73	0.118	1.09
$\beta_{y,0}$	0.021	0.66	0.053	1.60
γ_{yb}	-24.88***	-3.63	2.875	0.45
γ_{ya}	-14.70*	-1.76	3.195	0.19
$\beta_{yx,1}$	0.083	1.05	0.240*	1.85
$\beta_{yx,2}$	0.031	0.43	0.019	0.16
$\beta_{yy,1}$	-0.093	-1.20	-0.234*	-1.91
$\beta_{yy,2}$	-0.037	-0.53	-0.041	-0.35
Panel B: Variance equation of VECM-DCC-GARCH model				
	Parameters	t values	Parameters	t values
ω_x	0.051***	2.65	0.023***	2.97
$\delta_{x,1}$	0.919***	57.62	0.938***	77.05
$\delta_{x,2}$	0.074***	4.98	0.045***	4.89
ω_y	0.057***	3.20	0.021***	2.66
$\delta_{y,1}$	0.910***	61.73	0.948***	85.59
$\delta_{y,2}$	0.077***	5.74	0.039***	4.74
κ_1	0.112***	4.09	0.024	1.15
κ_2	0.639***	7.34	0.815***	2.27
Panel C: Ljung-Box Q Test				
	Statistics		Statistics	
Q(20) of Δx_t	17.5167		15.4813	
Q^2(20) of Δx_t	20.9305		12.8670	
Q(20) of Δy_t	23.5813		13.0579	
Q^2(20) of Δy_t	16.4871		11.2931	

Note: *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. Q(20) and Q^2(20) are the residuals and squared residuals of return. In panel A, the VECM models are $\Delta x_t = \beta_{x,0} + \gamma_{xb} ec_{t-1}(1 - D_{SHSCP}) + \gamma_{xa} ec_{t-1} D_{SHSCP} + \sum_{j=1}^{p} \beta_{xx,j} \Delta x_{t-j} + \sum_{j=1}^{p} \beta_{xy,j} \Delta y_{t-j} + \varepsilon_{x,t}$ and $\Delta y_t = \beta_{y,0} + \gamma_{yb} ec_{t-1}(1 - D_{SHSCP}) + \gamma_{ya} ec_{t-1} D_{SHSCP} + \sum_{j=1}^{p} \beta_{yx,j} \Delta x_{t-j} + \sum_{j=1}^{p} \beta_{yy,j} \Delta y_{t-j} + \varepsilon_{y,t}$. In panel B, the GARCH models are $h_{xx,t} = \omega_x + \delta_{x,1} h_{xx,t-1} + \delta_{x,2} \varepsilon_{x,t-1}^2$ and $h_{yy,t} = \omega_y + \delta_{y,1} h_{yy,t-1} + \delta_{y,2} \varepsilon_{y,t-1}^2$ DCC model is $Q_t=(1-\kappa_1-\kappa_2)\bar{Q}+\kappa_1 \mu_{t-1} \mu_{t-1}+\kappa_2 Q_{t-1}$. x and y are spot and futures markets.

3.3 Cross-Border Price Discovery between the Chinese and Hong Kong Markets

Since SHSCP connects China and Hong Kong together; these two markets will influence each other. Therefore, we investigate the cross-border price discovery ability between spot (futures) market for the Chinese and Hong Kong markets[16]. Table 5 shows the results of the long-term causality relationship between the Chinese and Hong Kong markets.[17] The results show that all the error correction terms γ_{xb} and γ_{xa} in Chinese markets are significant, but that the γ_{yb} and γ_{ya} in Hong Kong markets are not significant. Therefore, the unidirectional long-term causality relationship is from Hong Kong market to the Chinese market because Hong Kong's market was established earlier and has more international investors than the Chinese market. After SHSCP, this progress helps investors in Hong Kong's market to directly invest in the Chinese market, making the Chinese market more open. Due to the decreased barriers, more investors are investing in the Chinese market, and causing cash to flow from Hong Kong to China.

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[16] In particular, the China Financial Futures Exchange (CFFE) does not issue a futures contract on Shanghai stock index; thus, we use two spot indies (Shanghai composite index and CSI 300 index) to investigate the price discovery between Chinese and Hong Kong markets.

[17] From Granger causality, we can't reject the influence of Hang Seng on CSI 300 or the influence of CSI 300 on Hang Seng. Therefore, there is no lead-lag relationship between China and Hong Kong. In variance equations, as shown in panel C, all of the values of ω_x, ω_y, $\delta_{x,1}$, $\delta_{y,1}$, $\delta_{x,2}$ and $\delta_{y,2}$ are non-negative values and the sum of $\delta_{x,1}+\delta_{x,2}$ and $\delta_{y,1}+\delta_{y,2}$ are lower than 1. It means that the model is stationary and has volatility clustering. In the DCC equation, κ_1 and κ_2 are non-negative and the value of $\kappa_1 + \kappa_2$ is lower than 1. It means that the volatility will transform with time. We also applied the Ljung-Box Q test to investigate whether the residuals pf return have autocorrelation. As shown in panel D, the LB Q and LB Q^2 statistics for 20 lags are not significant for standard residuals and squared standard residuals; they are non-auto-correlated.

Table 5: Price Discovery between the Chinese and Hong Kong Markets

Panel A: Mean Equation of VECM-DCC-GARCH Model						
	Shanghai and Hang Seng Spot		**CSI300 and Hang Seng Spot**		**CSI300 and Hang Seng Futures**	
	Parameters	**t values**	**Parameters**	**t values**	**Parameters**	**t values**
$\boldsymbol{\beta_{x,0}}$	-1.338***	-2.68	-1.386***	-2.69	-1.229***	-2.58
$\boldsymbol{\gamma_{xb}}$	0.595***	2.69	0.635**	2.67	0.554**	2.52
$\boldsymbol{\gamma_{xa}}$	0.902***	3.43	0.945***	3.35	0.844***	3.22
$\boldsymbol{\beta_{xx,1}}$	0.043	1.42	0.029	0.95	-0.001	-0.03
$\boldsymbol{\beta_{xx,2}}$	0.002	0.07	-0.008	-0.25	0.011	0.39
$\boldsymbol{\beta_{xy,1}}$	-0.022	-0.68	-0.016	-0.45	-0.014	-0.44
$\boldsymbol{\beta_{xy,2}}$	-0.029	-0.87	-0.024	-0.63	-0.013	-0.40
$\boldsymbol{\beta_{y,0}}$	-0.136	-0.30	-0.131	-0.32	0.028	1.60
$\boldsymbol{\gamma_{yb}}$	0.080	0.41	0.079	0.42	0.006	0.003
$\boldsymbol{\gamma_{ya}}$	0.073	0.31	0.069	0.31	-0.029	-0.13
$\boldsymbol{\beta_{yx,1}}$	-0.044*	-1.92	-0.041*	-1.94	0.004	0.21
$\boldsymbol{\beta_{yx,2}}$	0.002	0.07	-0.006	-0.29	0.003	0.17
$\boldsymbol{\beta_{yy,1}}$	0.043	1.41	0.049	1.61	-0.022	-0.78
$\boldsymbol{\beta_{yy,2}}$	-0.010	-0.33	-0.006	-0.20	-0.005	-0.19
Panel B: Variance Equation of VECM-DCC-GARCH model						
$\boldsymbol{\omega_x}$	0.023***	2.4	0.034**	2.44	0.033***	2.59
$\boldsymbol{\delta_{x,1}}$	0.945***	82.14	0.943***	77.95	0.936***	78.79
$\boldsymbol{\delta_{x,2}}$	0.042***	4.63	0.042***	4.59	0.051***	5.09
$\boldsymbol{\omega_y}$	0.022**	2.05	0.03**	2.52	0.022**	2.05
$\boldsymbol{\delta_{y,1}}$	0.944***	66.35	0.926***	54.65	0.944***	66.35
$\boldsymbol{\delta_{y,2}}$	0.043***	3.88	0.052***	4.27	0.043***	3.88
$\boldsymbol{\kappa_1}$	0.001	0.28	0.001	0.24	0.001	0.41
$\boldsymbol{\kappa_2}$	0.995***	239.56	0.995***	205.88	0.995***	351.32
Panel C: Ljung-Box Q Test						
Q(20) of Δx_t	19.3792		15.4813		12.1256	
Q^2(20) of Δx_t	18.0682		12.8670		17.9852	
Q(20) of Δy_t	12.6299		13.0579		12.4468	
Q^2(20) of Δy_t	16.0174		11.2931		8.6931	

Note: *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. Q(20) and Q^2(20) are the residuals and squared residuals of return. In panel A, the VECM models are $\Delta x_t = \beta_{x,0} + \gamma_{xb} ec_{t-1}(1 - D_{SHSCP}) + \gamma_{xa} ec_{t-1} D_{SHSCP} + \sum_{j=1}^{p} \beta_{xx,j} \Delta x_{t-j} + \sum_{j=1}^{p} \beta_{xy,j} \Delta y_{t-j} + \varepsilon_{x,t}$ and $\Delta y_t = \beta_{y,0} + \gamma_{yb} ec_{t-1}(1 - D_{SHSCP}) + \gamma_{ya} ec_{t-1} D_{SHSCP} + \sum_{j=1}^{p} \beta_{yx,j} \Delta x_{t-j} + \sum_{j=1}^{p} \beta_{yy,j} \Delta y_{t-j} + \varepsilon_{y,t}$. In panel B, the GARCH models are $h_{xx,t} = \omega_x + \delta_{x,1} h_{xx,t-1} + \delta_{x,2} \varepsilon_{x,t-1}^2$ and $h_{yy,t} = \omega_y + \delta_{y,1} h_{yy,t-1} + \delta_{y,2} \varepsilon_{y,t-1}^2$ DCC model is $Q_t = (1 - \kappa_1 - \kappa_2)\bar{Q} + \kappa_1 \mu_{t-1} \mu_{t-1} + \kappa_2 Q_{t-1}$. x and y are Chinese and Hong Kong markets. We use two spot indies (Shanghai composite index and CSI 300 index) and CSI 300 index futures in Chinese markets, and the we use the Hang Seng spot index and Hang Seng index futures in Hong Kong markets.

From the common factor weight measures, θ_{yb} are 0.881, 0.889 and 0.989 and θ_{ya} are 0.925, 0.932 and 0.967, signifying that the cross-border price discovery mainly happens in the Hong Kong market. Hong Kong market is a mature and international capital market with more information, thus, it contribute more to the cross-border price discovery process to adjust less to a deviation from the equilibrium.

After SHSCP, θ_{ya} values increase (decrease) cross-border price discovery process from Hong Kong market to Chinese market in the spot (futures) markets. SHSCP allows investors to trade stocks between the Shanghai and Hong Kong stock markets, but not the trade futures. Figure 1 shows the daily volume from the Hong Kong to Shanghai market and Shanghai to Hong Kong market after SHSCP.[18] It shows that the transaction volume from the Hong Kong to the Shanghai stock market is higher than the volume from the Shanghai stock market to the Hong Kong stock market. This result shows that most of the investors on Hong Kong with more information enter the Shanghai stock market so that the Shanghai stock market with a large speed adjustment coefficient; thus, the SHSCP increases cross-border price discovery from Hong Kong to Shanghai stock market in the spot market in China. However, the SHSCP did not major allow trading futures and the CSI 300 futures market has high trading barriers; therefore, the trading futures investors of Hong Kong no enter the futures market in China, so that the SHSCP had a limited impact the speed adjustment coefficient in the Chinese futures market. This finding indexed the SHSCP decreases cross-border price discovery from Hong Kong to Shanghai stock market in the futures market in China.

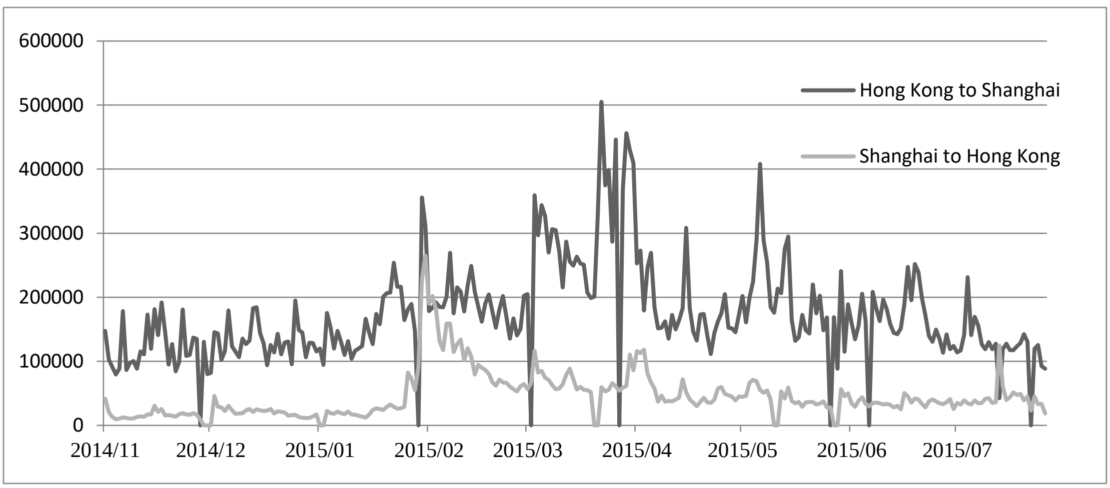

Figure 1: Daily Volume of Buying between Hong Kong and Shanghai

[18] Shanghai-Hong Kong Stock Connect will also help promote the internationalization of the RMB and development of Hong Kong as an offshore RMB business center by enabling Mainland investors to directly participate in the Hong Kong stock market using RMB.

4. Conclusion

In this paper, we address the issue of the price discovery for spot and futures markets and for Chinese and Hong Kong markets. We used CSI 300 index and Hang Seng index daily closing prices and stock index futures daily settlement prices and Shanghai Composite index daily closing prices from April 16, 2010 to December 31, 2015 with the VECM-DCC-GARCH model to test the changes in price discovery before and after the Shanghai-Hong Kong Stock Connect entered the markets. There are two topics; therefore, we first investigated the price discovery relationships between the spot and futures markets in Chinese or Hong Kong markets and we second investigated the cross-border price discovery relationships between the Chinese and Hong Kong markets based on spot or futures markets

The research first finds the empirical results for the Chinese (Hong Kong) market show the price discovery happens in the spot (futures) market before SHSCP. The different is the CSI 300 futures market has high trading barriers; therefore, the result of price discovery happening in the spot markets in China. After SHSCP, we find this programme deepens price discovery process form stock (futures) market to futures (stock) market in Chinese (Hong Kong).

Second, the common factor weight in Chinese spot markets including Shanghai Composite index are lower than in the Hang Seng spot market; therefore, the cross-border price discovery happens from the Hang Seng spot (futures) market to Chinese stock markets (futures market). Hong Kong market is a mature and international capital market with more information, thus, it contribute more to the cross-border price discovery process to adjust less to a deviation from the equilibrium. After SHSCP, this programme allows investors to trade stocks between the Shanghai and Hong Kong stock markets, but not the trade futures. Therefore, the cross-border price discovery increases (decreases) from the Hang Seng spot (futures) market to Chinese stock markets (futures market).

Summing up, because Hong Kong is a mature financial center in Asia, most of the institutional investors like to invest in Hong Kong. Therefore, price discovery happens in both Hang Seng spots and futures markets. This program also increased the speed of adjustment from long-term equilibrium in the Chinese spot and futures market, implying that the Chinese market has higher trading volume than before. Therefore, this progress not only enhances Hong Kong’s but also Chinese spot and futures markets to become more international and to enjoy greater liquidity.

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