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The Influence of Shanghai (Shenzhen)-Hongkong Stock Connect Program on the Dynamic Correlation between those Markets

-An Empirical Analysis Based on DCC-VaR-MVGARCH Model

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***Abstract*—This paper empirically analyzes the effect of Shanghai (Shenzhen)-Hongkong stock connect program on the dynamic correlation between those three markets based on the DCC-VaR-MVGARCH model. The results obtained show that: The volatility of Shanghai, Shenzhen and Hongkong stock markets has leverage effect. The opening of the Stock Connect Program between Shanghai and Hong Kong has improved the dynamic correlation coefficient between Shanghai and Hong Kong stock markets, reduced the dynamic correlation coefficient between Shenzhen and Hong Kong stock markets, and lowered the dynamic correlation coefficient between Shanghai and Shenzhen stock markets. The opening of Shenzhen-Hongkong Stock Connect Program has improved the dynamic correlation coefficient between Shenzhen and Hong Kong stock markets, decreased the dynamic correlation coefficient between Shanghai and Hong Kong stock markets, and lessened the dynamic correlation coefficient between Shanghai and Shenzhen stock markets. However, due to the leverage effect, the dynamic correlation between Shanghai and Hong Kong stock markets has gained some increments after the opening of Shenzhen-Hongkong Stock Connect Program. The program code of the model is invented by the author.**

Keywords—Shanghai (Shenzhen)-Hongkong Stock Connect Program; Dynamic correlation coefficient; Leverage effect

I INTRODUCTION

Shanghai-Hongkong Stock Connect Program was opened on November 17, 2014, which is conducive to promoting domestic markets' progress in the system and forces the mainland stock markets to reform in the fields of service and investor protection [7]. Hongkong capital and offshore capital inflowing into A shares will help to improve the capital side of A shares. After getting the experience of good operation of Shanghai-Hongkong Stock Connect Program, Shenzhen-Hongkong Stock Connect Program was opened on December 5, 2016.

From the point of view of basic factors, Shanghai-Hongkong Stock Connect Program and Shenzhen-Hongkong Stock Connect Program are funding channels that can bring incremental capital to the Shanghai and Shenzhen stock markets or the Hong Kong stock market, which will improve the linkage of the markets that is connected [5]. Besides, the programs accelerate the reform of the Shanghai and Shenzhen stock market system, such as price limits, trading time, delisting system, margin trading system, thus the mutual adjustment of the systems will also improve the linkage of the connected systems [1].

In terms of non-basic factors, the programs have increased the scope of assets that investors can choose, which leads investors to reclassify assets and then affects the investment decisions of the investors. From the mathematical point of view, the programs combine the assets of divided markets into the same selectable set, which will improve the linkage between the markets that is connected and reduce the linkage with other markets. In addition, the structure of investors in those three markets changed after the opening of the programs, and irrational factors, such as risk aversion, emotion and liquidity preference will also be transmitted to each markets that is connected, which will affect the decision of the investors and improve the linkage of the connected markets, but drop the linkage with other markets [6].

Therefore, this paper puts forward two hypotheses. First, after the opening of Shanghai-Hongkong Stock Connect Program, the dynamic correlation coefficient between Shanghai and Hong Kong stock markets increases, while the dynamic correlation coefficient between Shanghai and Hong Kong (Shenzhen) stock markets drops. Second, after the opening of Shenzhen-Hongkong Stock Connect Program, the dynamic correlation coefficient between Shenzhen and Hong Kong stock markets increases, while the dynamic correlation coefficient between Shanghai and Hong Kong (Shenzhen) stock markets drops.

II DATA SELECTION AND DESCRIPTION

In order to reflect the impact of programs on these three markets, I selects the most representative stock indexes of them, that is the daily closing price data of Shanghai Composite Index, Shenzhen stock index and Hongkong Hang Seng Index. And the date of the data is from September 17, 2011 to January 16, 2018. Besides, the data is derived from the flush iFinD financial data terminal. Because of the difference of trading time, I deletes the transaction data of the non-overlapping date to ensure the daily data correspond to each other. After deleting, 1493 data of each index are obtained.

I use simple rate of return as the rate of return, that is $r_i = \frac{r_i - r_{i-1}}{r_{i-1}}$. Among them, P_i represents the closing price of day i. The yield sequences of three markets are classified as $\{SH_t\}$, $\{SZ_t\}$ and $\{HK_t\}$.(t=1,2,…,T), T=1492.

The software used in this paper is R3.4.0.

III ECONOMETRIC MODEL

Assume the yield sequence of three markets is

$$r_t = [SH_t, SZ_t, HK_t]' \tag{1}$$

Rewrite the multiple yield sequence $\{r_t\}$ as

$$r_t = \mu_t + a_t \tag{2}$$

$\mu_t = E(r_t|F_{t-1})$ is the conditional expectation of r_t under the given information F_{t-1}. And $a_t = (a_{1t}, a_{2t}, a_{3t})'$ is the new information at time t. It is assumed that μ_t process obeys the conditional expectation process of multivariable time series models, then μ_t is a step forward prediction of the model. For a given F_{t-1}, the conditional variance matrix of a_t is a 3×3 positive definite matrix $\sum_t$, that is

$$\sum_t = \mathrm{Cov}(a_t|F_{t-1}) \tag{3}$$

Given a set of new information$F_{t-1} = \{a_1, \dots, a_{t-1}\}$, [4] the new unconditional covariance matrix can be estimated by the form as

$$\widehat{\sum} = \frac{1}{t-1}\sum_{j=1}^{t-1} a_j a_j' \tag{4}$$

Use the symmetry of $\sum_t$ to parameterize it, that is

$$\sum_t = [\sigma_{ij,t}] = D_t \rho_t D_t \tag{5}$$

Among them, ρ_t is the conditional correlation matrix of a_t, and D_t is a 3×3 diagonal matrix whose elements are the standard deviation of each component of a_t, that is $D_t = diag\{\sqrt{\sigma_{11,t}}, \dots, \sqrt{\sigma_{33,t}}\}$.

Tsay (2006) considered the leverage effect in the marginal volatility model and extended the DCC model proposed by Tse (2002) and Engle (2002) [3], that is

$$D_t = \wedge_0 + \wedge_1 D_{t-1}^2 + \wedge_2 A_{t-1}^2 + \wedge_3 L_{t-1}^2 \tag{9}$$

Among them, D_t is the diagonal matrix of fluctuation ratio, and $A_j = \mathrm{diag}\{a_{1j}, a_{2j}, a_{3j}\}$ and $\wedge_i = diag\{l_{1i}, l_{2i}, l_{3i}\}$ are 3×3 diagonal matrixes of parameters [2]. And the diagonal elements of $L_{t-1} = diag\{L_{1.t-1}, L_{2.t-1}, L_{3.t-1}\}$ are

$$L_{i.t-1} = \begin{cases} a_{i,t-1} & a_{i,t-1} < 0 \\ 0 & a_{i,t-1} \geq 0 \end{cases} \tag{10}$$

For i=1, 2, 3,$0 \leq \sum_{j=1}^{3} l_{ij} < 1$, $l_{i0} > 0$ and $l_{ij} \geq 0$. These constraints guarantee the existence of volatility. The leverage effect dose not exist when $\wedge_3 = 0$. The DCC model with leverage effect used in this paper is developed from Tsay's.

The correlation equation is

$$\rho_t = (1 - \theta_1 - \theta_2)\hat{\rho} + \theta_1 \psi_{t-1} + \theta_2 \rho_{t-1} \tag{11}$$

$\hat{\rho}$ is the sample correlation matrix of the rate of return. And $0 \leq \theta_1 + \theta_2 < 1, \theta_i \geq 0$ for i=1, 2.

IV EMPIRICAL ANALYSIS

TABLE I. DESCRIPTIVE STATISTICS OF SHANGHAI, SHENZHEN AND HONGKONG STOCK INDEX RETURN SERIES FROM SEPTEMBER 20,2011 TO JANUARY 22, 2018

Asset	Shanghai Composite Index	SZSE Component Index	Hang Seng Index
Mean	0.00035	0.00020	0.00049
SE	0.01448	0.01696	0.01630
Skewness	-0.891	-0.695	5.29
Excess Kurtosis	4	1.27	227
Box-Ljung Q(12)	57.3	33.7	101

As is shown in the table 1, the mean value of the yield sequence is 0, and three of the yield sequences have thick tails with excess kurtosis, which is consistent with expectation.

The stock index yield sequence of three markets have a certain degree of sequence correlation, but the correlation is at a low degree. Calculating the multivariate Ljung-Box statistics, we obtain Q (1) =130.86, and the p-value is less than 0.005; Q (2) =137.74, and the p-value is less than 0.005; Q (3) =139.60, and the p-value is less than 0.005; Q (5) =169.86, and the p-value is less than 0.005.

In order to simplify, we use the sample mean as the mean value equation, and use the proposed multivariate volatility model to process the mean corrected data. Then table 2 shows the results and p-values calculated at these estimated values.

TABLE II. ESTIMATED RESULTS OF DCC MODEL WITH LEVERAGE EFFECT

$\wedge_0 (l_{10}, l_{20}, l_{30})$	$\wedge_1 (l_{11}, l_{21}, l_{31})$	$\wedge_2 (l_{12}, l_{22}, l_{32})$	$\wedge_3 (l_{13}, l_{23}, l_{33})$
4.16E-08(0.7480)	0.999531 (0.0000)	0.000324 (0.0052)	-3.17E-05 (0.8050)
1.16E-07 (0.6226)	0.999289 (0.0000)	0.000283 (0.0273)	-8.21E-06 (0.9538)
1.32E-06(0.0000)	0.990821(0.0000)	0.000337(0.0000)	-0.000328(0.0000)

Use following formula to calculate the standardized residuals.

$$\hat{\varepsilon}_t = \hat{\sum}^{-1/2} a_t \quad (14)$$

$\hat{\sum}^{-1/2}$ is the symmetric square root matrix of the estimated volatility matrix $\hat{\sum}_t$. And we use the Ljung-Box statistics on the standard deviation $\hat{e}_t$ and its square process $\hat{\varepsilon}_t^2$ to test the adequacy of model. Then we obtain Q (10) = 47.424, and the p-value is 0.0000; Q (10) = 29.664, and the p-value is 0.001; Q (10) = 20.181, and the p-value is 0.028. The results show that the model can describe the mean and volatility of the yield series.

Besides, we obtain $\wedge_3 = diag\{0,0,-0.000328\}$, which is statistically significant, although the value of leverage parameter is small.

What's more, we study the volatility sequences of three stock indexes and separately calculate the sum of the GARCH parameters. We obtain 0.750000(0.150000+0.600000), 0.750000(0.150000+0.600000) and 0.750000(0.150000+0.600000), and all of them is less than one, thus all of the three sequences have IGARCH characteristics.

We use scroll estimation in the time window length of 70 and get a time dependent correlation coefficient diagram among three simple return rates of indexes, as follows:

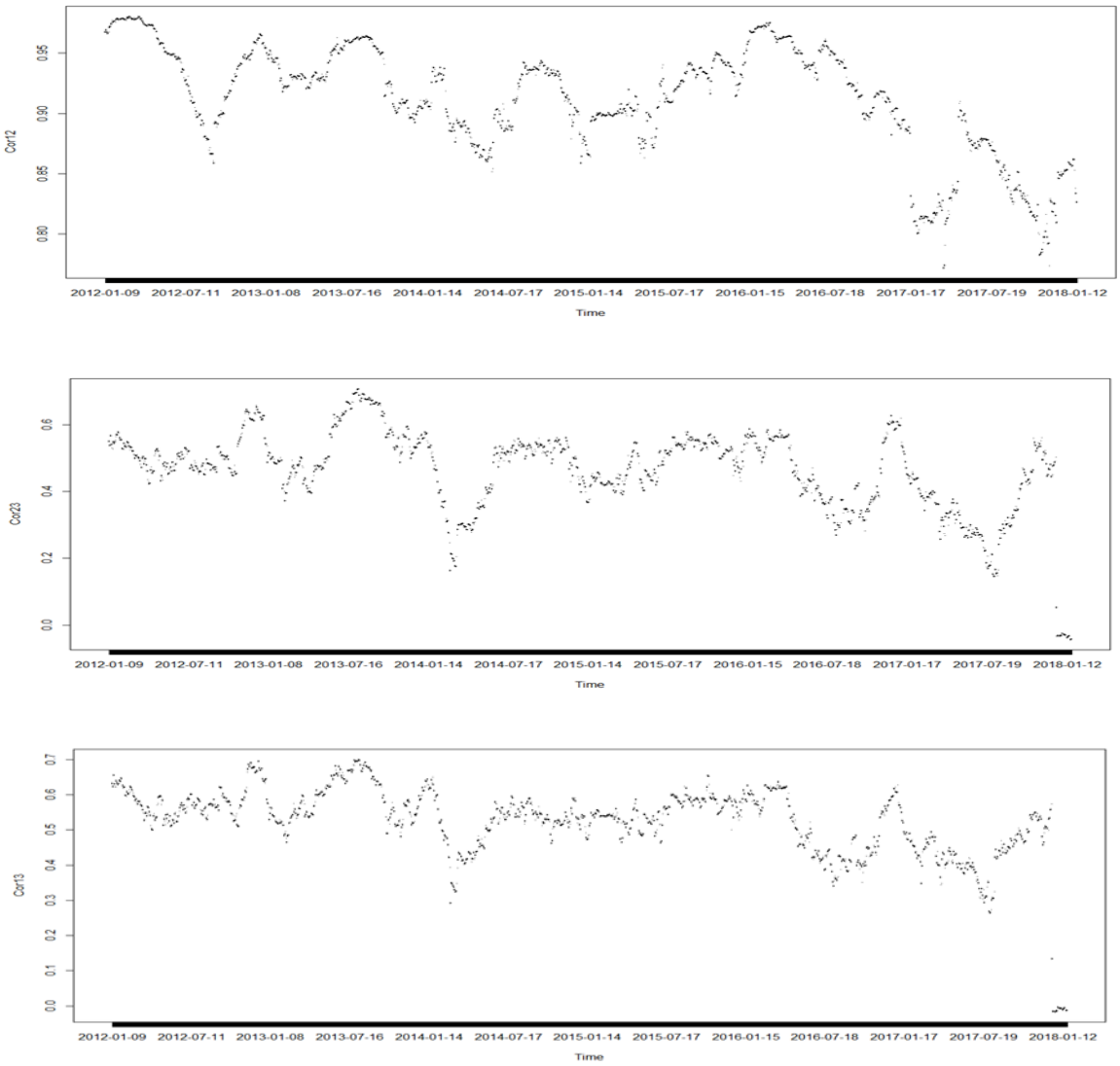

Fig. 1. Time dependent correlation coefficient of Shanghai, Shenzhen and Hong Kong stock index yield rate from January 9, 2012 to January 12, 2018

Cor12 represents the dynamic correlation coefficient between Shanghai and Shenzhen stock markets, and Cor23 represents the dynamic correlation coefficient between Shenzhen and Hong Kong stock markets, and Cor13 represents the dynamic correlation coefficient between Shanghai and Hong Kong stock markets.

As is shown in the figure one, after the opening of Shanghai-Hongkong Stock Connect Program on November 17, 2014, the dynamic correlation between Shanghai and Shenzhen stock markets continued to fall in the next one month until January 2015, and the dynamic correlation between Shenzhen and Hong Kong stock markets continued to fall in the next one month until January 2015, While the dynamic correlation between Shanghai and Hong Kong stock markets rose rapidly in the next half month.

After the opening of Shenzhen-Hongkong Stock Connect Program on September 5, 2016, the dynamic correlation between Shanghai and Shenzhen stock markets accelerated down in the next 2 months, and the dynamic correlation between Shenzhen and Hong Kong stock markets maintained a stable level of 0.6 in the next 1 month, While the dynamic correlation between Shanghai and Hong Kong stock markets increased from 0.55 to 0.60 in the next 1 month.

V THE CONCLUSION OF EMPIRICAL ANALYSIS

The results of DCC model show that the fluctuation of Shanghai, Shenzhen and Hong Kong stock markets has leverage effect. Besides, the dynamic correlation coefficient diagrams show that the opening of Shanghai-Hongkong Stock Connect Program has led to decline in the dynamic relevance between Shanghai and Shenzhen stock markets and between Shenzhen and Hong Kong stock markets, while the dynamic correlation between Shanghai and Hong Kong has risen. The opening of Shenzhen-Hongkong Stock Connect Program has led to decline in the dynamic relevance between Shanghai and Shenzhen stock markets. The dynamic correlation between Shenzhen and Hong Kong stock markets maintains at the highest level of 0.60, and it can be observed that there is a rapid rise from 0.30 to 0.60 in the two months before the opening of the program, which means the expectation on the dynamic correlation between Shenzhen

and Hong Kong has been realized before the policy is officially opened.

The above conclusions are basically consistent with the hypothesis. The only exception is that after the opening of Shenzhen-Hongkong Stock Connect Program, the dynamic correlation coefficient between Shanghai and Hong Kong is still increasing, because both of Shanghai and Hong Kong stock markets are in bear market from December 2016 to January 2017, and the leverage effect has led to the increase of the dynamic correlation coefficient.

Therefore, the opening of Shanghai-Hongkong Stock Connect Program has led to decline in the dynamic relevance between Shanghai and Shenzhen stock markets and between Shenzhen and Hong Kong stock markets, while the dynamic correlation between Shanghai and Hong Kong stock markets has risen. And the opening of Shenzhen-Hongkong Stock Connect Program has led to decline in the dynamic relevance between Shanghai and Shenzhen stock markets and between Shanghai and Hong Kong stock markets, while the dynamic correlation between Shenzhen and Hong Kong stock markets has risen.

VI POLICY SUGGESTIONS

First, the government's macro control of Shanghai and Shenzhen stock markets should consider the reaction of Hong Kong stock market, especially when all of three markets are in bear market.

Second, after the opening of the programs, the degree of segmentation among those stock markets has declined significantly so that the portfolio dispersedly invested in these stock markets needs to be vigilant to the rise of the non-systematic risk and make adjustments.

Third, the supervision of these three stock markets should be coordinated to prevent cross market violations, and relevant legislation should be promoted.

Forth, the function of "two-way investment in both domestic and foreign capital" first tried in the Shanghai free trade area is similar to the programs'. In the future, with the opening of more free trade areas, the increase in channels will further enlarge the risk of capital flow, so the management departments should arrange those channels as a whole to prevent the overall risk.

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