The Dependence Between Shanghai and Hongkong Stock Markets
Before and After the Connect Program

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Abstract. Based upon the Copula function, this paper investigates the time-varying dependence between Shanghai and Hongkong stock markets before and after the connect program. The author uses GARCH model to estimate the marginal distribution of returns, so as to setup the Copula models. According to the empirical analysis, it is found that the dependence between the two markets has been enhanced after the connect program. Besides, there exists asymmetric tail dependence between the two markets, and the dependence between lower tails is higher than upper tails, which means that investors are more sensitive to bad news in the markets rather than good news.

1. Introduction

On April 10, 2014, China Securities Regulatory Commission (CSRC) and Hongkong Securities and Futures Commission (SFC) issued a joint announcement, officially approved to carry out a pilot of connectivity mechanism between Shanghai Stock Exchange (SSE) and Hongkong Exchanges and Clearing Limited (HKEx). The Stock Connect Program (hereafter the program) was officially launched on Nov 17, 2014, it allowed the investors of the two sides trade eligible shares listed on the other market by local securities firms or brokers.

The starting point of this paper is to find out whether the dependence of Shanghai and Hongkong stock markets can be strengthened after the program, and what effects does the program brings to the tail dependence of the returns. The first part is introduction, which simply introduce the background of the program and the structure of this paper. The second part is related literature, which includes the analysis method of different market dependence by scholars. The third part states the source of the data and the preliminary processing. Then it is methodological and empirical analysis. The final part is the conclusion based on the empirical results.

2. Literature References

The research on the dependence of capital market has been going on for a long time, western scholars have already noticed about it. The existing literature generally holds that the dependence between western mature capital markets is quite significant. Among the econometric models, GARCH model is one of the most commonly used models to analyse dependence which derived from the ARCH model of Engle [1], and was first proposed by Bollerslev [2]. To better describe the dynamic and linear dependence among different financial assets, Engle [3] suggested using DCC-GARCH model, which could simplify the process of calculation but could not comprehensively describe the asymmetry of dynamic dependence caused by positive or negative spillover effects. Nowadays, Copula function has been widely used in market dependence measuring, which can not only capture the nonlinear and asymmetric dependency between markets but also catch the dependence of the tails. Jondeau and Rockinger [4] are the first to employ the Copula-GARCH model into the analysis of dependence. Laih [5] used Copula to study on the dependence among the stock markets of Four Asian Tigers.

At the meanwhile, the dependence between China and other capital markets worldwide has also arised the interest of scholars. For example Fei [6] and Fang et al. [7], had already studied on the dependence between China and its external markets. They found that the dependence between China
and America capital markets had been strengthened. Luo found that there was dependence between mainland and Hongkong markets [8].

In summary, researches on the effects that the program brings to the two markets are limited. Besides, the nonlinear and asymmetric tail dependence is neglected in most existing researches. With the consideration above, this paper aims to find out whether the dependence structure between the two markets has been changed after the program and what effects does the program brings to the tail dependence of the returns.

3. Data and preliminary statistics

The data sets are obtained from RESSET financial database. The whole sample covers the time period from Jan 01, 1997 to April 11, 2017. Data with different dates due to holidays are excluded, thus yielding 4746 observations for each market. Since the Connect program was published on Nov 17, 2014, we divide the whole sample into two sub-samples, namely pre-sample from Jan 01, 1997 to Nov 17, 2014 and after-sample from Nov 17, 2014 to April 11, 2017. We use the daily closing prices of SSE Composite Index and Hang Seng Index which both are the benchmark indices in Shanghai and Hongkong Stock markets respectively. We define \( P_t \) and \( P_{t-1} \) as the closing prices of an index at time \( t \) and time \( t-1 \), thus the return of index \( i \) at time \( t \) (\( R_{it} \)) is calculated as Eq. 1:

\[
R_{it} = \left( \ln P_t - \ln P_{t-1} \right) \times 100.
\]

RSH and RHK respectively represent the \( R_{it} \) of SSE Composite Index and Hang Seng Index.

Table 1. Summary statistics and diagnostic tests for daily stock returns.

<table>
<thead>
<tr>
<th></th>
<th>Whole sample</th>
<th>Pre-sample</th>
<th>After-sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSH</td>
<td>Mean</td>
<td>0.029</td>
<td>-0.0068</td>
</tr>
<tr>
<td></td>
<td>Std dev.</td>
<td>1.6549</td>
<td>1.6617</td>
</tr>
<tr>
<td></td>
<td>Skewness</td>
<td>-0.3801</td>
<td>0.0039</td>
</tr>
<tr>
<td></td>
<td>Kurtosis</td>
<td>7.6959</td>
<td>12.8225</td>
</tr>
<tr>
<td></td>
<td>JB test</td>
<td>4474.961***</td>
<td>19079.33***</td>
</tr>
<tr>
<td></td>
<td>Q(5)</td>
<td>16.564***</td>
<td>17.672***</td>
</tr>
<tr>
<td></td>
<td>ADF</td>
<td>-68.1777***</td>
<td>-69.4865***</td>
</tr>
</tbody>
</table>

Table 1 shows basic descriptive statistics and diagnostic tests for the returns. All the average returns are close to zero. The average of RHK is lower than that of RSH, which means that Hongkong stock market has lower return compared with Shanghai stock market. The two returns show the nonzero skewness and high excess kurtosis (over 3) for the whole sample and the sub-samples, which reveals that RSH and RHK are inconsistent with normal distributions. As for diagnostic tests, RSH and RHK reveal similar results. The Jarque-Bera statistics for the two returns both reject the null hypothesis of normality at the 1% significance level. The Ljung-Box tests of RSH in the whole, pre- and after-sample rejected the null hypothesis of no auto-correlation for 5 and 10 lags, but no auto-correlation is accepted for RHK in the pre-sample. ADF test statistics show that RSH and RHK are stationary series.

4. Methodology

4.1 Estimation of the marginal distribution

Although there exists GARCH(p,q), GARCH(1,1) can greatly capture the volatility of most time-varying series in a dynamic process according to the research of many scholars. Consequently,
this paper uses GARCH(1,1) to estimate the marginal distribution, there are the estimated equations below:

\[
\begin{align*}
  r_t &= \phi_0 + \phi r_{t-1} + \mu_t \\
  \sigma_t^2 &= \alpha_0 + \alpha \mu_{t-1}^2 + \beta \sigma_{t-1}^2.
\end{align*}
\]

(2)

For Eq. 2, \(\alpha_0 \geq 0, \alpha \geq 0, \beta \geq 0\). Among these variables, \(r_t\) represents the return at time \(t\), \(\alpha_0\) stands for the original uncertainty in the system, \(\alpha\) is defined as the coefficient of the square of the lagged residual. The higher the value of \(\alpha\) is, the faster the speed is to transfer the market information into the future volatility; \(\beta\) is defined as the coefficient of the lagged conditional heteroskedasticity. The higher the value of \(\beta\) is, the more persistent the interference factor is.

### 4.2 Estimation of the dependence between the two markets

Among all the Copulas, Joe-Clayton Copula is always a better choice in application as it can well describe the asymmetry and tail dependence. There exists one-to-one relationship between the parameters of Joe-Clayton Copula and the coefficients of tail dependence, the unconditional form of it is shown as Eq. 3 and Eq. 4:

\[
C(u, v, \kappa, \gamma) = 1 - \left\{ \left[ 1 - (1-u)^{\kappa} \right] \left[ 1 - (1-v)^{\gamma} \right] - 1 \right\}^{1/\gamma}, \quad \kappa \geq 1, \quad \gamma > 0.
\]

(3)

\[
\lambda^U = 2 - 2^{-1/\kappa}, \quad \lambda^L = 2^{-1/\gamma}.
\]

(4)

As it shows, the upper tail dependence coefficient is determined by \(\kappa\) while the lower tail dependence coefficient is determined by \(\gamma\). The crucial part of the estimation of time-varying parameters lies in the definition of exogenous variables in the evolution equations. Using the one-to-one relationship, Patton defined the dynamic evolution process of the parameters in Joe-Clayton Copula function:

\[
\lambda^U = \tilde{\Lambda} \left\{ \omega_U + \beta_U \lambda^U_{t-1} + \alpha_U \cdot \frac{1}{10} \sum_{j=1}^{10} |u_{t-j} - v_{t-j}| \right\},
\]

(5)

\[
\lambda^L = \tilde{\Lambda} \left\{ \omega_L + \beta_L \lambda^L_{t-1} + \alpha_L \cdot \frac{1}{10} \sum_{j=1}^{10} |u_{t-j} - v_{t-j}| \right\}.
\]

(6)

In the functions above, \(\tilde{\Lambda} \equiv \frac{1}{1 + e^{-s}}\), the application of \(\Lambda\) is to ensure that the upper and the lower tail dependence coefficient belong to \((0,1)\). Eq. 5 and Eq. 6 are also similar to the ARMA(1,10) model, the right side of the equations both contain an auto-regressive term and an exogenous variable. We use \(\frac{1}{10} \sum_{j=1}^{10} |u_{t-j} - v_{t-j}|\) as a measure of the distance between the estimated dependence and full positive dependence.

### 5. Empirical results

There are two steps to estimate the dependence in this paper: first, setup the GARCH(1,1) model to estimate the marginal distribution of each variate, according to which can we make a cumulative transform to get a new series that consistent with uniformly distributions; second, using Copula function to measure the overall dependence and the dependence of the tails between two markets.
5.1 Estimation of the marginal distribution

Table 2. GARCH(1,1) results.

<table>
<thead>
<tr>
<th></th>
<th>$\Phi_0$</th>
<th>$\Phi_1$</th>
<th>$\alpha_0$</th>
<th>$\alpha$</th>
<th>$\beta$</th>
<th>K-S TEST</th>
<th>P-Value</th>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-sample</td>
<td>RSH</td>
<td>Coeff 0.0287 -0.0012 0.0416*** 0.0851*** 0.9013*** 0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S.E</td>
<td>-0.0250 -0.0155 -0.0052 -0.0049 -0.0051</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RHK</td>
<td>Coeff -0.0062 -0.0109 0.0158*** 0.0732*** 0.9219*** 0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S.E</td>
<td>-0.0263 -0.0155 -0.0032 -0.0053 -0.0058</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After-sample</td>
<td>RSH</td>
<td>Coeff 0.0372 0.069 0.0033*** 0.07726*** 0.9276*** 0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S.E</td>
<td>-0.0865 -0.042 -0.0041 -0.0093 -0.0066</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RHK</td>
<td>Coeff -0.0079 0.0244 0.0758*** 0.09946*** 0.8467*** 0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S.E</td>
<td>-0.0508 -0.042 -0.0276 -0.0208 -0.0353</td>
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</table>

The choice of marginal distribution determines the validity of the dependence structure that Copula function describes and K-S test is a method that can estimated the goodness of fit based on the standard residual of the model. The K-S statistic is calculated from the series after integral transformation. Table 2 shows the estimated results of marginal distribution: we follow the common suggestion that a GARCH(1,1) specification is appropriate for conditional variances of most financial series. Most of the parameters are significant for each sub-sample. The model fits well according to the K-S test results.

5.2 Estimation of the dependence between the two markets

Fig. 1 shows the upper and lower tail dependence between the two markets before and after the connect program. The coefficient of constant upper tail dependence was 0.11 before the program and increased to 0.17 in the after-sample period. The dependence coefficient of lower tail was higher compared with the upper tail, which fluctuated from 0.14 to 0.38. It indicates that lower tail dependence is stronger than upper between Shanghai and Hongkong stock markets, which means that
the dependence is stronger when any one of the markets is booming rather than crashed. Besides, whether for upper or lower tail, the dependence is increased after the connect program.

6. Summary

This paper applies GARCH and Copula models to investigate the dependence between Shanghai and Hongkong stock markets. The main conclusions are as follows:

The dependence between Shanghai and Hongkong markets has been increased after the program. It reflects that inter-market information transmission is faster after the program; the results also imply that the dependence of lower tail is stronger than upper tail, which indicates that the dependence are stronger when the market is depressed as bad news is more easily to be transformed at that time. According to the theory of market contagion, when the market is booming or depressed, the irrational behaviors of investors are more likely to produce herd effects, thus resulting in the share prices go up and down at the same time in different financial markets.

With the launch of the Connect program, the integration process of mainland and Hongkong will be strengthened. To weaken the effects of spillover between the two markets, supporting measures should be taken when promoting the integration process: first, speed up the marketization of interest rates and exchange rates in China, which can prevent the massive cross-border flow of funds caused by arbitrage opportunities; second, sound stock system is needed. Imperfect system easily leads to disorderly flow of cross market funds such as the free suspension of stocks for mainland enterprises.

References


