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Analysis of Chinese sports industry listed company volatility based on the method of Copula-GARCH

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ABSTRACT

As one of the important reasons, the sports industry investment and financing mechanism is not sound, has been restricted the sports industry in China. This article chooses the two listed companies in mainland China in the stock exchange for the study, using Copula function method, through the build multivariate GARCH model, analyzes its stock return volatility correlation, which reflects the entire industry, the development situation of financing for the sports industry in China is the further development to have the important meaning.

KEYWORDS

Sports industry; Copula function; Kernel; Volatility.

INTRODUCTION

As an emerging industry of national economy, the sports industry is characterized by big potential demand, low resource consumption, wide coverage and high additional value. The sports industry is a general term for the industry which produces and provides sports-related material products and intellectual products, as well as relevant services. In western developed countries, the contribution of sports industry to GDP accounts for 10%. However, in China's GDP, the contribution rate of sports industry is only 0.1% to 0.3%. From an overall perspective, the development level of Chinese sports industry is still low. Sports industry is the pillar industry of national economy in the United States and has become a sunrise industry which stimulates national economic growth in many Western countries. Chinese sports industry is late in getting started. In 1980s, it was in an embryonic form and in the mid 1990s, it formed a preliminary industry scale and had a certain industrial formation. As one of the important reasons, the unsound investment and financing mechanism has been restricted the development of the sports industry in China. Along with the acceleration of Chinese economy internationalization, more and more companies seek for expansion and development by financing from stock market, which has become an important issue which has drew a common attention from every industry and has effectively promoted the expansion and prosperity of domestic capital market.

To expand financing by going public is of great importance to improve the brand value, enhance financial advantages, realize scale development for companies and so on. But compared with other industries, the predecessor of domestic sports industry companies are mostly private companies with a short entrepreneurial history, a small management scale and a low market share. Therefore, it is in a subordinate position in the while competitive link and its step towards going public is also very slow. The State Council passed *the Guidance to Accelerate the Development of Sports Industry* in March, 2010 and demonstrated its support for sports companies with complete conditions to enter financial market and raise development fund by equity financing, debt financing and capital operation. The sports goods companies can expand financing channels from various aspects, especially from outer-source channels and developing financial market. This significant strategic decision provides an important policy support for Chinese sports industry to go public and raise fund[1-3].

Compared with foreign countries, the scale of the sports industry in China is still smaller. But the development space is relatively bigger. In the relevant researches on the sports industry in China, the investment and financing has always been the weakest link. So far, the academic circle has profoundly explored such topics as the development state, restriction factors and industrial structure from system and mechanism levels. But there are few studies on the individual level of sports goods companies. This article chooses the two listed companies in mainland China in the stock exchange for the study, using Copula function method, through the build multivariate GARCH model, analyzes its stock return volatility correlation, which reflects the entire industry, the development situation of financing for the sports industry in China is the further development to have the important meaning[4].

LITERATURE REVIEW

The general studies on the sports industry are mainly from a macro level. Jianxin LONG (2010) pointed out that compared with foreign countries, despite of the significant development which has achieved since Chinese reform and opening up, there is still a wide gap in sports industry because of the insufficient investment and unsound financing system. Meanwhile, based on the experience from foreign countries and the actual situation in China, the government can arrange the subsides, improve the management system of sport lottery market, encourage the public to donate money and set up sports foundation to promote the investment and financing of Chinese sports industry. Ting Zhou (2010) stated that the GEM should encourage the innovative and growing companies to go public and give key support for high-tech sports industry. As for the current situation of the investment and financing of domestic and foreign sports industrial companies, he studied the feasibility of going public and raising fund in GEM for small and medium sports industrial companies by using the methods of capital investment and financing theory, expert interviews and literature data. Peigang ZHANG and Qidi ZHOU (2011) took LI-NING Company as an example. By analyzing the statistics of shareholder wealth, capital structure and financial performance and comparing the difference between the situations before and after financing via public placement, he concluded that the capital structure tends to be improved, the financial performance achieves a relatively greater growth and the management level is enhanced significantly. Its successful experience provides an investment and financing strategy for mainland sports industry to improve management level and wealth rapidly. Yanhong LUO(2010), by analyzing the investment and financing situation of mainland sports industry in recent five years, thought that as a sunrise industry, the sports industry has gradually become a new growth point of Chinese economy. The integration of sports industry and capital market is inevitable. Yunfeng JIE (2010) thought that due to its high relevance and high contribution rate, to develop sports industry can promote the economic growth, realize the optimization and upgrading of industrial structure and expand domestic demand by stimulating consumption. Therefore, the position of sports industry should be clear and definite, the sports running and management personnel should be cultivated energetically, the sports consumption market should be explored actively, the large scale development of sports industry should be promoted and the financing capacity of the whole industry should be improved[5-6].

Due to the limitation of multivariate GARCH model on the relevant researches on the profit rate of several markets and assets, it is necessary to introduce Copula function to describe the dependence structure among several random variables.

Yanhua WEI and Shutian QI (2008) made a research and stated that Copula function can help to seize asymmetric correlation and non-linearity. Thus the possibility misled by linearity-relevant coefficient can be greatly reduced. To analyze the fluctuation changes of marketing profit rate and the relevance between them is the basis of detecting the infection of financial crisis. These two scholars further integrated the Copula Theory, Z Test and Bayesian Sequential Diagnosis and chose the Vietnam financial market as the study object. They found out that it is not closely related with the financial markets in other major countries (or regions), that it will not cause crisis infection to other financial markets and that the possibility of stirring a larger-scale financial crisis is very small. Guotai CHI and other scholars(2008) used the Copula function method to fit the joint distribution functions of the profit rates of short-tern loan, medium and long-term loans, measure the VaR of joint distribution of loan combination, build a structural model of optimal time limit of loan combination based on Copula function, and solve the problems of banks' mobility risks and asset matching efficiency. Jinqing ZHANG and Xu LI (2008), on the basis of the empirical tests of Shanghai and Shenzhen financial market, pointed out that Clayton-Copula and Frank-Copula can relatively be applied to measure the VaR of the combination and integration of high reliability and low reliability. Through the comparative analysis of the Copula function of different species and kinds under their own reliability, they believed that these two calculation methods of Copula function is better than other functions and better than the traditional methods which uses multidimensional normal distribution multidimensional T distributio2.

THE MULTIVARIATE COPULA-GARCH MODEL

Actually, the relationship within the fluctuations of stock yield of listed companies is very complicate, covering tail correlation, asymmetric correlation and nonlinear correlation. Since the multivariate GARCH model frequently used in the study of multi-variable problems has certain limitation on the problem such as parameter estimation, and hypothesis of multivariate distribution, this paper tries to construct the multivariate Copula-GARCH model [7].

According to the Sklar theorem of multivariate distribution, if the marginal distribution of the variables of $x_1, x_2, \cdots, x_N$ respectively are $F_1(\cdot), F_2(\cdot), \cdots, F_N(\cdot)$, then there will be a Copula function C making:

$$\left(x_1, x_2, \cdots, x_N\right) \sim C\left(F_1\left(x_1\right), F_2\left(x_2\right), \cdots, F_N\left(x_N\right)\right)$$

Actually all Copula models are built on this basis. Given that $\{y_{1t}\}_{t=1}^{T}, \{y_{2t}\}_{t=1}^{T}, \cdots, \{y_{Nt}\}_{t=1}^{T}$ is N random processes complying with the GARCH process, then the N variables Copula-GARCH Model can be obtained combining with Copula and the GARCH model:

$$y_{nt} = \mu_{nt} + \varepsilon_{nt}, \quad n = 1, 2, \cdots, N, \quad t = 1, 2, \cdots, T \qquad (1)$$

$$\varepsilon_{nt} = h_{nt}^{1/2} \xi_{nt} \qquad (2)$$

$$h_{nt} = \omega_n + \sum_{i=1}^{q_n} \alpha_{ni} \varepsilon_{n,t-i}^2 + \sum_{i=1}^{p_n} \beta_{ni} h_{n,t-i} \qquad (3)$$

$$\left(\xi_{1t}, \xi_{2t}, \cdots, \xi_{Nt}\right) \sim C_t\left(\Phi\left(\xi_{1t}\right), \Phi\left(\xi_{2t}\right), \cdots, \Phi\left(\xi_{Nt}\right)\right) \qquad (4)$$

The equation 4 also can be expressed as:

$$\left(\varepsilon_{1t}, \varepsilon_{2t}, \cdots, \varepsilon_{Nt}\right) \Big| I_{t-1} \sim C_t\left(\Phi\left(\frac{\varepsilon_{1t}}{h_{1t}} \Big| I_{t-1}\right), \Phi\left(\frac{\varepsilon_{2t}}{h_{2t}} \Big| I_{t-1}\right), \cdots, \Phi\left(\frac{\varepsilon_{Nt}}{h_{Nt}} \Big| I_{t-1}\right) \Big| I_{t-1}\right) \qquad (5)$$

The condition marginal distribution of the variables in the Copula-GARCH model can be described by anyone of the models including the GARCH model, the GARCH-t model and the GARCH-GED model which are under the normal distribution hypothesis. The condition marginal distribution of each variable in the Copula-GARCH model can either be the same, or be different. Since there is no limitation for the variables in the Copula-GARCH model to select condition marginal distribution, the model can be more flexible in practical application, and can get closer to the reality[8].

Unlike the multivariate GARCH model, the part of GARCH process in the multivariate Copulas-GARCH model only describes the condition marginal distribution of each variable, without reflecting the conditional correlation among variables. The conditional correlation among variables between is characterized by the Copula function, thus the conditional correlation among multiple variables can be studied without considering the condition marginal distribution of each variable, which also can make the model use the relatively simple two-stage estimation method so as to simplify the estimation of the model.

EMPIRICAL ANALYSIS

Descriptive statistics

The paper selects the data of the daily closing price of the two listed sports companies including China Sports Industry and Pathfinder company. The data ranges from October 2009 to January 2011, mainly coming from yahoo finance official website (www.yahoo.com). For the convenience of calculation and encoding, the variable U is used to represent the stock yield of China Sports Industry, and the variable V is used to represent the stock yield of Pathfinder. This paper adopts the software Matlab2009 to complete the whole modeling process. It can be seen that both of the frequency distribution of Figure 1 and Figure 2 and the specific value of the skewness and kurtosis of the variables in Table 1 show a preliminary conclusion: the random variables U, V are symmetrically distributed and have the outstanding characteristics of having "sharp peak and heavy tail". Since, the normal distribution generally has thin tail distribution, which can determine that the distribution of U, V are unlikely to belong to the normal type[9].

Table 1: The basic statistical data of the stock yield of China Sports Industry and Pathfinder

Variables	**Desired value**	**Median**	**maximum value**	**Minimum value**
U (China Sports Industry)	8.72	12.65	55.72	3.02
V (Pathfinder)	20.70	8.48	52.25	13.27
Variables	standard deviation	skewness	kurtosis	J-B(probability)
U (China Sports Industry)	9.79	1.53	6.04	176.66
V (Pathfinder)	112.78	4.74	33.19	9513.18

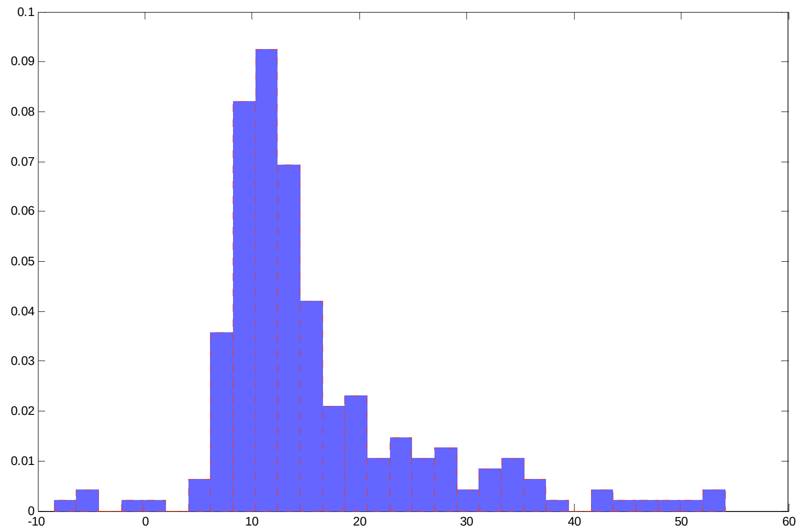

Figure 1: The frequency histogram of the stock yield (%) of China Sports Industry

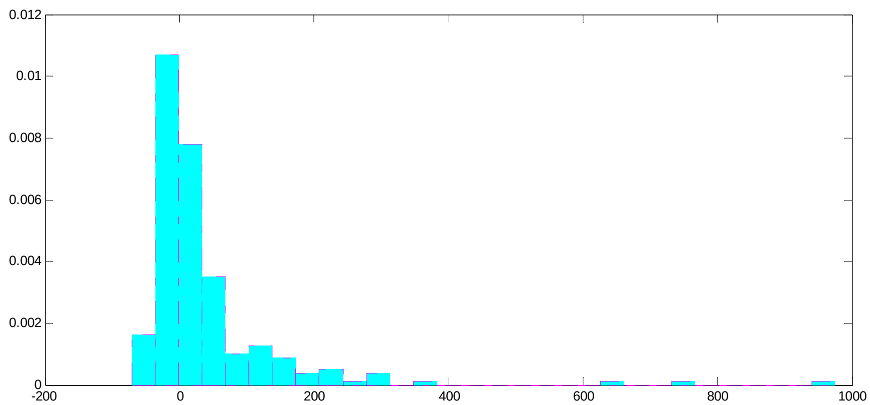

Figure 2: The frequency histogram of the stock yield (%) of Pathfinder

Non-parametric estmation

The distributions of U and V do not belong to the normal type, and they basically belong to a kind of symmetrical distribution with an obvious peak and fat tail. Unfortunately, since it is difficult to find the corresponding type of this kind of distribution in the common distributions, this paper uses the nonparametric method estimates to determine the distribution type of U, V. If the overall distribution is difficult to determine, the method of spline interpolation can be used to obtain the empirical distribution function of the study sample, which is usually achieved through the ecdf functions in the Matlab software. Treat as the approximation of the general distribution function , or use the ksdensity function, with the smooth kernel method to estimate the overall distribution.

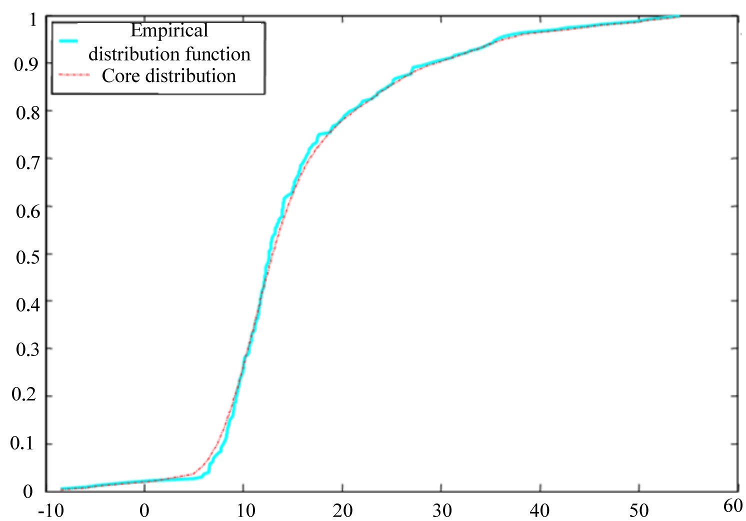

Figure 3: The graph of the empirical distribution function and kernel distribution estimation of the yield profits of China Sports Industry

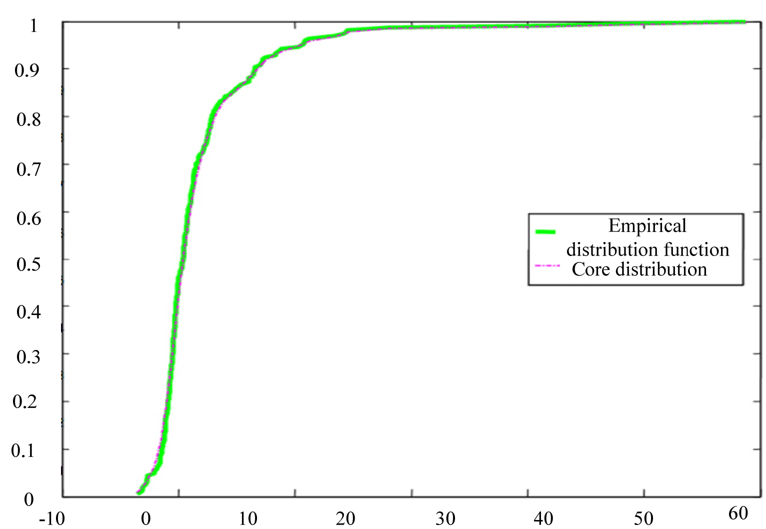

Figure 4: The graph of the empirical distribution function and kernel distribution estimation of the yield profits of Pathfinder

It can be seen from the results of figure 3 and figure 4 that, the empirical distribution function curve and the kernel estimation curve coincide with each other to a great extent in spite of the fact the estimation results of them may not be totally same, which shows that the difference between them is very small.

Selection of the Copula function

After determining the marginal distribution $U = F(x)$ of variable U and the marginal distribution $V = G(x)$ of variable V, the Copula function can be correctly selected according to the shape of the bi-histogram of $(U_i, V_i)(i = 1, 2, \cdots, n)$.

It can be seen figure 5 that, both the tails in the bivariate frequency histogram of variable U and variable V are basically symmetrical. In other words, the tails of the joint density function (U,V) are basically symmetrical, which shows the characteristic of the Copula density function. Based on this, the bivariate t-Copula function or the bivariate normal Copula function can be used to correctly and appropriately describe the relational structure of the original data.

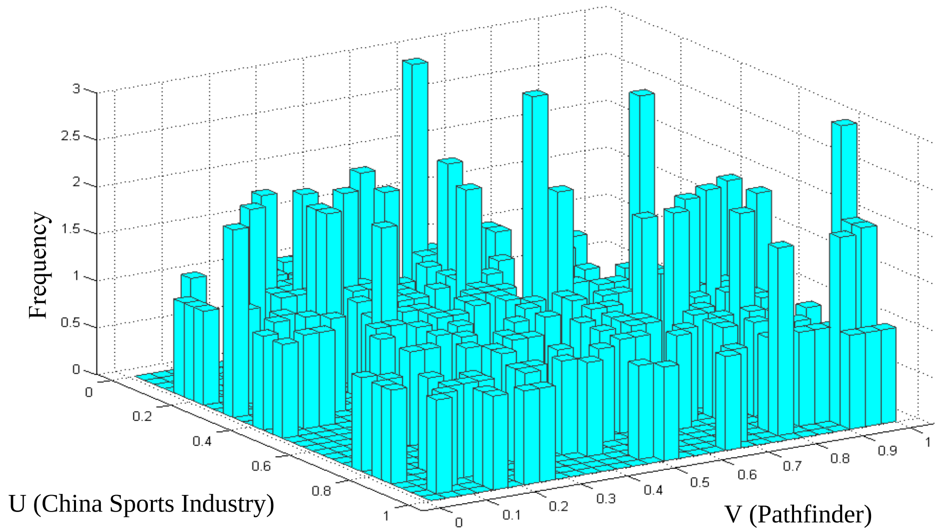

Figure 5: The bivariate frequency histogram of the marginal distribution of the stock yields of China Sports Industry and Pathfinder

Parameter estimation

As for the corresponding bivariate t-Copulas function and bivariate normal Copulas function, the marginal distribution of random variables can be calculated through the kernel estimation method, and the relevant parameters of the bivariate Copula function can be calculated by using the copulafit function in the Matlab software.

The estimated value ρ of the linear correlation parameters in the bivariate normal Copula function is calculated as:

$$\hat{\rho}_{norm} = \begin{pmatrix} 1.0000 & 0.2790 \\ 0.2790 & 1.0000 \end{pmatrix}$$

The obtained expression of the estimated bivariate normal Copula function is:

$$\hat{C}^{Ca}\left(\hat{u},\hat{v}\right) = \int_{-\infty}^{\Phi^{-1}(\hat{u})}\int_{-\infty}^{\Phi^{-1}(\hat{v})} \frac{1}{2\pi\sqrt{1-0.2790^2}} \exp\left[-\frac{s^2-2\times 0.2790st+t^2}{2\times\left(1-0.2790^2\right)}\right] dsdt$$

The estimated value of the linear correlation parameter ρ and variance k in the bivariate t-Copula respectively are:

$$\hat{\rho}_t = \begin{pmatrix} 1.0000 & 0.3328 \\ 0.3328 & 1.0000 \end{pmatrix},\ \hat{k} = 8.2921 \approx 8$$

The expression of the estimated t-Copula function is:

$$\hat{C}^{t}\left(\hat{u},\hat{v}\right) = \int_{-\infty}^{t_8^{-1}(\hat{u})}\int_{-\infty}^{t_8^{-1}(v)} \frac{1}{2\pi\sqrt{1-0.3328^2}} \left[1+\frac{s^2-2\times 0.3328st+t^2}{8\times\left(1-0.3328^2\right)}\right]^{-1(4+2)/2} dsdt$$

After estimation of the parameters of Copula, the density function value and distribution function value of Copula are respectively calculated and are drew into graph.

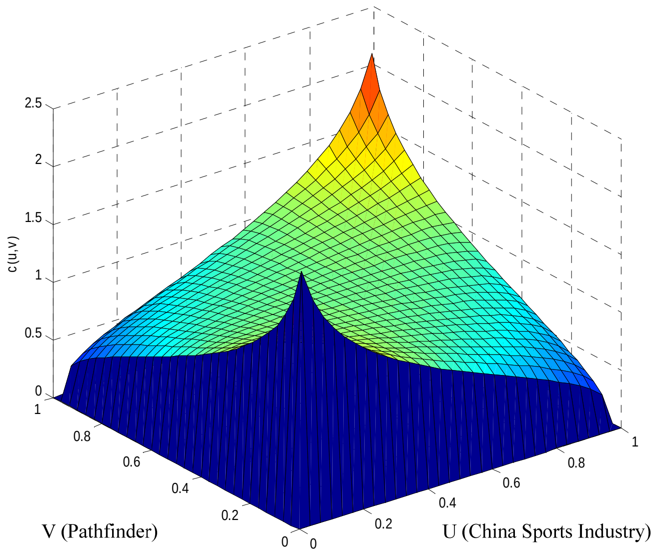

Figure 6: Diagram of bivariate normal Copula density function

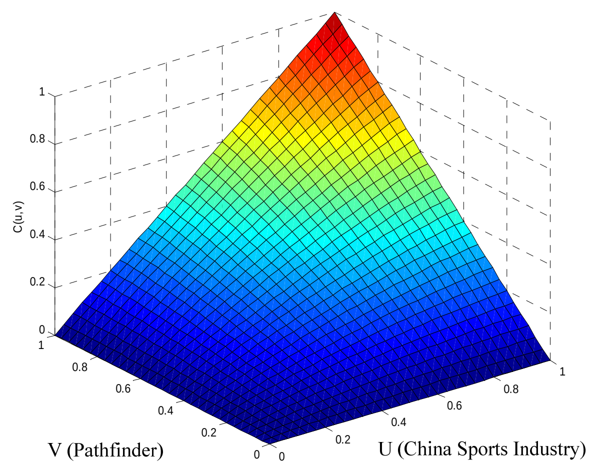

Figure 7: Diagram of bivariate normal Copula distribution function

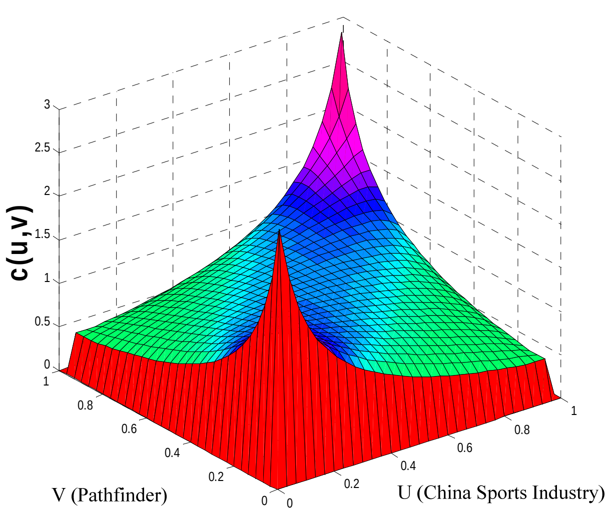

Figure 8: Diagram of bivariate t-Copula density function

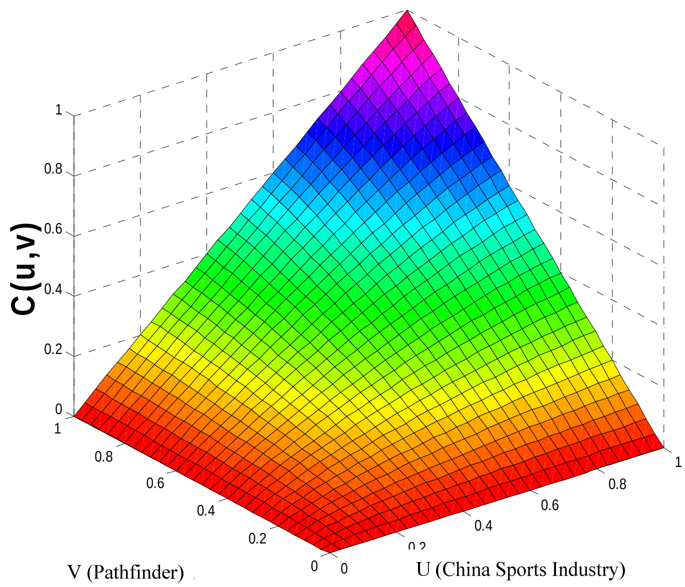

Figure 9: Diagram of bivariate t-Copula distribution function

It can be seen from figure 6 ,figure 7,figure 8 and figure 9 that the linear correlation parameter $\hat{\rho}$ of the bivariate Copula is 0.2790. Correspondingly , the variance $\hat{k}$ of the density function of the bivariate t-Copula is 8, and the linear correlation $\hat{\rho}$ is 0.3328. Since it has a thicker tail, the tail correlation among variables can be better reflected. Then it can be seen from the comparison of figure 5, figure 2, and figure 8 that the bivariate t-Copula with a linear correlation parameter $\hat{\rho}$ of 0.3328 and a variance of 8 can better reflect the tail correlation between the stock yields of China Sports Industry and the stock yields of Pathfinder. The tail correlation coefficient can be calculated through corresponding software:

$$\hat{\lambda}^{up} = \hat{\lambda}^{la} = 2 - 2t_{\hat{k}+1}\left[\frac{\sqrt{\hat{k}+1}\sqrt{1-\hat{\rho}}}{\sqrt{1+\hat{\rho}}}\right] = 0.6277$$

But the linear correlation coefficient between variable U and variable V is 0.7421.

Model evaluation

Based on thesample observation value of the stock yields of China Sports Industry and Pathfinder, the paper constructs the bivariate t-Copula model and the bivariate normal Copula model, at the same time it introduces into the concept of experience Copulas to evaluate the advantages and disadvantages of the two models.

Given that $(x_i, y_i)(i = 1, 2, \cdots, n)$ is a sample coming from the bivariate generality(X,Y), the empirical distribution function of X,Y are respectively denoted as $F_n(x)$ and $G_n(y)$, and the empirical Copula of the sample can be defined as follows:

$$\hat{C}_n(u,v) = \frac{1}{n}\sum_{i=1}^{n} I_{[F_n(x_i)\le u]} I_{[G_n(y_i)\le v]}, \quad u,v \in [0,1]$$

Among it, $I_{[\cdot]}$ is indicative function and when $F_n(x_i) \le u$, $I_{[F_n(x_i)\le u]} = 1$, otherwise $I_{[F_n(x_i)\le u]} = 0$.

After obtaining the Copula function $\hat{C}_n(u,v)$, the squared euclidean distance between the empirical Copula function $\hat{C}_n(u,v)$ and the bivariate normal Copula function $\hat{C}^{Ca}(\hat{u},\hat{v})$ as well as the bivariate t-Copula function $\hat{C}^{t}(\hat{u},\hat{v})$ can be obtained:

$$d_{Ca}^2 = \sum_{i=1}^{n} \left|\hat{C}_n(u_i,v_i) - \hat{C}^{Ca}(u_i,v_i)\right|^2$$

$$d_t^2 = \sum_{i=1}^{n} \left| \hat{C}_n(u_i, v_i) - \hat{C}^t(u_i, v_i) \right|^2$$

Among it, $u_i = F_n(x_i)$, $v_i = G_n(y_i)(i = 1, 2, \cdots, n)$. The d_{Ca}^2 and d_t^2 respectively show the situation of fitting the original data in the bivariate normal Copula function $\hat{C}^{Ca}(\hat{u}, \hat{v})$ and bivariate t-Copula function $\hat{C}^t(\hat{u}, \hat{v})$. If $d_{Ca}^2 \prec d_t^2$, then it shows that the bivariate normal Copula function $\hat{C}^{Ca}(\hat{u}, \hat{v})$ can better fit the original data, otherwise the bivariate t-Copula function can better fit the original data.

Figrue 10 shows the Copula distribution function formed through encoding program. According to the calculating result of the final squared euclidean distance, the variance of the bivariate t-Copula function is 8, the linear correlation parameter is 0.3328, the squared euclidean distance with the empirical function Copula $d_t^2 = 0.0709$, while the linear correlation parameter of the bivariate normal Copula function is 0.2790, the squared euclidean distance with the empirical function Copula $d_{Ca}^2 = 0.0740$. Thus, it can be seen that the bivariate t-Copula model has a better effect, namely that it can better fit the observation data of the fluctuations of stock yields of China Sports Industry and Pathfinder.

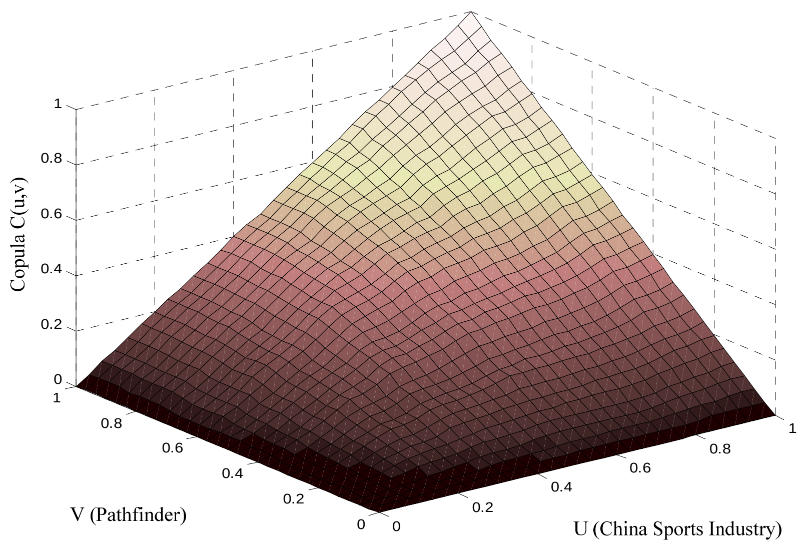

Figure 10: The distribution function diagram of the empirical Copula

CONCLUSIONS AND ADVISES

This article chooses the stock yield of two listed companies in Mainland China in the stock exchange for study. By using Copula multivariate function method and GARCH model to analyse the dichotomy static and conditional correlation between them, as well as their time-varying correlation. According to the analysis result of this example, it can tell that there is a positive correlation between the share prices of these two companies. The linear correlation coefficient is 0.7421 by general calculating, while tail correlation coefficient is 0.6277 by Copula function. If the calculation were only done according linear correlation, the tail correlation would be over estimated. Thus the investment risk would be increased. No matter from the marginal distribution of multiple frequency histogram or comparison of density function diagram, the degree of freedom of multivariate t-Copula function is $\hat{k} = 8$. And the linear correlation coefficient is $\hat{\rho} = 0.3328$. Investors will have more important reference value in the asset allocation with better showing the tail correlation. The suggestions are as following.

(1) The Nation should support Sports Industry more with policies to make more sports companies become public financing.

Under the existing supports, National policies should reduce restrictions on small and medium private enterprises in the sports industry, and increase financial and tax preferential policies instead. Under the same conditions, sports listed companies with growth potential should have the priority approve to raise funds to achieve the purpose of high-growth.

(2) Release sports industry regulation and further improve the corporate governance mechanism.

As a competitive coexistence with the non-profit sector, the Government should release industrial control, breaking industry barriers to entry. Through improving the legal system to achieve the goal of a series of behavioural constraints relevant stakeholders. It is necessary to innovate state-owned sports enterprise management mechanisms and enhance the joint-stock reform efforts to further improve the corporate governance mechanism. The establishment of investment diversification and the development of mechanisms for the sports industry output efficiency of a virtuous cycle should be done.

(3) As for the investors, the time-varying correlations among the sports industry stocks should be taken into consideration.

In the investment, the investors need to consider the conditional tail correlations among sports stock yields, which will can effectively spread risk , and at the same time timely and dynamically adjust the head parts according to time variation so as to achieve the goal of avoiding risk.

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