Along the "Belt and Road" based on Copula function Research on the Interdependence of Regional Financial Risks

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Abstract

Based on the GARCH-Copula-CoVaR model, this paper examines the stock market interdependence structure and risk spillover effects between China and the regions along the "Belt and Road", and analyzes the characteristics and evolution of risk correlations in normal and extreme situations. The research shows that there is a certain positive correlation between the stock markets of China and the regions along the " Belt and Road ", and among them, West Asia and Central Asia have a high risk dependence on China. The new crown pneumonia epidemic has exacerbated the possibility of contagion of stock market risks in the regions along the "Belt and Road", and the correlation of stock market returns has increased. From the perspective of risk spillover effects, the tail risk spillovers from the regions along the "Belt and Road" to the Chinese stock market have shown a slight upward trend of fluctuations. The conclusions of this paper provide a useful reference for preventing and resolving systemic financial risks along the " Belt and Road ".

Key words: *" One Belt, One Road " initiative; GARCH-Copula-CoVaR model; stock market linkage; risk contagion*

1. INTRODUCTION

Since the " Belt and Road " cooperation initiative was put forward, it has been widely recognized by the countries along the route. There are also new requirements for countries to participate in regional cooperation. In promoting this process, China has placed great emphasis on enhancing the financial services and support capabilities for the real economy. In 2019, the AIIB and the Asian Development Bank jointly signed a framework agreement on sovereign business co-financing. In this context, it is an important issue to deeply explore the path of financial services for the construction of the "Belt and Road", and to accurately grasp the linkage between China and other countries' markets, so as to better promote capital market cooperation and prevent and resolve systemic financial risks. [1]

The linkage effect of the financial market may lead to concerns about financial risks. At present, my country is in a period of economic structural transformation. In addition, the international capital market environment is not very optimistic. In particular, the frequent Sino-US trade frictions have a negative impact on economic growth.[2] How to measure the financial risk interdependence between my country and the countries along the "Belt and Road" and the risk contagion in extreme cases have important theoretical and practical value. Based on the Copula model, this paper tests the stock market correlations along the "Belt and Road" and analyzes the volatility spillover effects in extreme cases. The relevant conclusions provide empirical support for China's "Belt and Road" risk management and investment decisions.

2. MODEL STRUCTURES

The CoVaR method effectively solves this problem. It can measure the contribution of a single institution to the risk of other institutions when it falls into a crisis. Its mathematical expression is:

G. Vilas Bhau et al. (Eds.): MSEA 2022, ACSR 101, pp. 828–834, 2023.
https://doi.org/10.2991/978-94-6463-042-8_118

$$\Pr(R_t^j \le CoVar_t^{j|i} \mid R_t^i = Var_{\alpha,t}^{ji}) = q \quad (1)$$

Among them, and represent the rate of return of financial institution i and financial institution j at time t , respectively , indicating that when the rate of return of institution i at time t is less than the left-tail α quantile of its distribution, the condition of institution j at the q quantile is Value at risk, that is, CoVaR measures the maximum loss that other institutions may experience when an institution reaches its value at risk. R_t^i R_t^j $CoVar_t^{j|i}$ R_t^i

By definition, it can be found that CoVaR is the q quantile of the probability distribution of another variable when a variable is located at the quantile. The quantile can be calculated by integrating the probability density, so if the joint distribution function between the two variables can be known, CoVaR can be obtained.

3. EMPIRICAL ANALYSIS

In this paper, the T-GARCH method is used to describe the marginal distribution of each variable and estimate the parameters of the marginal distribution model. At the same time, in order to test the fitting effect of the model, KS test and quantiles are carried out on the fitting data based on the sequence probability density distribution. Graphical method (QQ map) analysis. The evaluation indicators all verify the fit of the model to the sample. [3]

In order to fully explore the correlation between China and the stock markets of countries and regions along the "Belt and Road", this paper selects four Copula functions to compare and analyze the correlation structure of stock index return series, and test the robustness of the results. In addition, a comparison between the sample period and the total sample before the outbreak of COVID-19 was constructed to examine the strength and changes of stock market linkages in countries and regions along the " Belt and Road " under the exogenous impact of the epidemic.

Table 1 Descriptive statistics of stock market returns

	HS	SENSEX	RTS	STI	WIG	WHEREAS	BECAUSE
minimum	-9.154	-14.102	-18.240	-7.637	-13.527	-16.754	-13.818
maximum value	6.499	8.595	13.289	7.364	6.023	14.316	21.093
mean	0.046	0.052	0.027	0.006	0.011	0.937	1.438
standard deviation	1.491	1.101	1.806	0.882	1.087	6.348	5.474
Skewness	-0.909	-1.515	-0.782	-0.176	-1.444	-0.114	0.153
Kurtosis	6.015	24.995	13.590	12.563	17.755	-0.387	1.524

Different Copula functions represent different dependency structures between variables. Compared with the normal Copula function, the t-Copula function has a thicker tail, is more sensitive to the variation of the tail correlation between variables, and is more suitable for characterizing the variable " spike and thick tail ". The density of Gumbel Copula is in the shape of "J", that is, the upper tail is high and the lower tail is low, which is more suitable for capturing the upper tail correlation of variables. The corresponding Copula is more suitable for capturing the lower tail correlation of variables. [4] BB7 Copula is a kind of two-parameter Archimedes Copula, also known as Joe-Clayton Copula, which has the characteristics of flexible and diverse two-parameter modeling methods and simultaneously capturing the asymmetric correlation between the upper and lower tails of financial asset risks. Table 2 shows the estimation results of each parameter of market dependence under the Copula model.

Table 2 Parameter estimation results of different Copula models

	Copula type	Kendall rank correlation coefficient	parameter	log-likelihood estimate	AIC	BIC	Lower tail dependency coefficient	Top tail dependency coefficient
China - India	Gumbel Copula	0.13	1.15	42.01	-82.01	-76.52	0.00	0.17
	t-Coupula	0.14	0.22/9.11	58.03	-112.05	-101.06	0.03	0.03
	BB7 Copula	0.12	1.09/0.24	60.88	-117.75	-106.76	0.05	0.11
	Clayton 180° Copula	0.09	0.23	30.81	-59.62	-54.12	0.00	0.05
China - Russia	Gumbel Copula	0.09	1.10	19.73	-37.46	-31.96	0.00	0.12
	t-Coupula	0.10	0.16/27.01	25.58	-47.16	-36.17	0.00	0.00
	BB7 Copula	0.10	1.06/0.14	25.61	-47.22	-36.22	0.01	0.08
	Clayton 180° Copula	0.07	0.16	15.29	-28.59	-23.09	0.00	0.01
China -	Gumbel Copula	0.19	1.23	81.18	-160.35	-154.86	0.00	0.24

	Copula type	Kendall rank correlation coefficient	parameter	log-likelihood estimate	AIC	BIC	Lower tail dependency coefficient	Top tail dependency coefficient
Singapore	t-Coupula	0.21	0.32/9.48	113.46	-222.93	-211.93	0.04	0.04
	BB7 Copula	0.20	1.11/0.39	121.00	-238.01	-227.02	0.17	0.13
	Clayton 180° Copula	0.15	0.34	59.10	-116.20	-110.70	0.00	0.13
China - Poland	Gumbel Copula	0.11	1.13	28.83	-55.66	-50.17	0.00	0.15
	t-Coupula	0.13	0.21/27.70	41.91	-79.81	-68.82	0.00	0.00
	BB7 Copula	0.12	1.06/0.20	39.85	-75.71	-64.77	0.03	0.08
	Clayton 180° Copula	0.09	0.21	24.35	-46.70	-41.21	0.00	0.04
China - Turkey	Gumbel Copula	0.19	1.23	4.41	-6.82	-4.22	0.00	0.25
	t-Coupula	0.22	0.34/30.00	6.28	-8.57	-3.36	0.00	0.00
	BB7 Copula	0.21	1.05/0.46	6.55	-9.11	-3.90	0.22	0.07
	Clayton 180° Copula	0.15	0.36	3.51	-5.02	-2.42	0.00	0.15
China - Kazakhstan	Gumbel Copula	0.21	1.26	5.83	-9.67	-7.06	0.00	0.27
	t-Coupula	0.23	0.35/25.65	6.89	-9.78	-4.57	0.00	0.00
	BB7 Copula	0.21	1.15/0.36	6.88	-9.76	-4.55	0.15	0.18
	Clayton 180° Copula	0.16	0.39	3.84	-5.67	-3.07	0.00	0.17

Table 3 The optimal Copula rank correlation coefficient and tail dependency coefficient before and after the epidemic

		HS-SENSEX	HS-RTS	HS-STI	HS-WIG	HS-ISE	HS-KASE
Before the epidemic	τ	0.02	0.01	0.02	0.00	0.18	0.14
total sample	τ	0.12	0.10	0.20	0.13	0.21	0.23
Before the epidemic	λ_U	0.02	0.02	0.00	0.00	0.00	0.19
	λ_L	0.00	0.00	0.00	0.00	0.00	0.00
total sample	λ_U	0.17	0.12	0.24	0.15	0.25	0.27
	λ_L	0.00	0.00	0.00	0.00	0.00	0.00

Note : The sample period before the epidemic was from January 2 , 2014 to December 31 , 2019.

Observing Table 2, we can see that there is a certain correlation between China and the stock market returns of countries and regions along the “Belt and Road” , and the countries with greater correlation are mainly Kazakhstan, Turkey and Singapore. The level of connectivity between China and the countries along the “Belt and Road” is strengthening. The reasons for this phenomenon may be the expansion of trade cooperation and the support of relevant national policies. From the tail risk dependence coefficient, we can see that there are also different degrees of tail risk dependence between China and the countries and regions along the “Belt and Road”. Comparing the upper-tail and lower-tail dependency coefficients, it is found that, relative to the effect of extreme losses on the correlation effect, the impact of extreme returns on the correlation degree of the stock market is stronger, which implies that the stock markets of countries and regions along the “Belt and Road” have inconsistencies in the extreme transmission effect of the Chinese stock market. Symmetrically, the risk spillover effect of bull markets is higher than that of bear markets. [5]

According to the principle of the largest log-likelihood value, the smallest AIC criterion and the smallest BIC criterion, this paper obtains the optimal Copula function, determines the rank correlation coefficient under the optimal Copula function, and then analyzes the linkage effect between two-way stock markets. Based on the above criteria, it is found that the binary BB7 Copula fits the relevant structures better among the four joint distributions. It can be seen from Table 3 that although Poland is relatively independent from the Chinese stock market in a certain period of time, on the whole, the kendall's τ corresponding to the optimal Copula function between different markets is almost all greater than 0, indicating that each sample

country has There is a positive correlation with the Chinese stock market. Comparing the market dependency structure of the pre-pandemic samples and the total samples in each region, it is found that the correlation between the stock markets after adding the epidemic samples has increased significantly, indicating that the new crown pneumonia epidemic has exacerbated the possibility of risk contagion in the stock markets of various countries, and the linkage of capital markets has increased.

A horizontal comparison of the differences in stock market correlations shows that currently the countries with high correlations with China's stock markets are Turkey and Kazakhstan, while India and Russia have relatively weak correlations. Before the outbreak, the rank correlation coefficient between China and Turkey and Kazakhstan was relatively high (0.18 and 0.14 , respectively), and the rank correlation coefficient with other regions was between 0.00 and 0.02 , and the correlation was very weak, indicating that Central Asia and West Asia The changes in the capital market in China will have a larger volatility spillover in China, and the market changes in more “Belt and Road” regions show a state that is relatively independent from the fluctuations in the Chinese market (such as Southeast Asia, South Asia, North Asia, and Central and Eastern Europe).

In order to explore the correlation of the market in extreme cases, this paper draws on the method of Huang Zaixin and Qin Zheng (2012) to analyze the tail correlation of the stock market return series, using the Gumbel Copula function, which is easier to capture the upper tail change, and the lower tail change. The Clayton Copula function measures the correlation of the upper and lower tails respectively.

It can be observed from Table 3 that the correlation coefficients of the upper and lower tails show significant asymmetric characteristics, and the upper-tail correlation coefficients of stock market returns in various countries are larger than the lower-tail correlation coefficients. This shows that the stock markets of China and the countries along the "Belt and Road" will rise and fall differently in extreme cases. When the stock markets of other countries rise sharply, the Chinese stock market will also rise sharply; when the stock markets of other countries fall sharply, the Chinese stock market will rise sharply. It will not fall sharply, which is a good signal. It is worth noting that after 2020, the upper tail correlation coefficient of each country has increased, which means that the market is more sensitive to changes in the bull market, and the stock market of China and the countries along the “Belt and Road” is increasing.

The above content mainly studies the stock market linkage under normal and extreme conditions, and does not specifically measure the risk spillover effect. Therefore, this paper adopts the CoVaR method to draw the CoVaR time series diagram of the dynamic risk spillover value between the “Belt and Road” markets, and uses the CoVaR method to draw the CoVaR time series diagram. Characterize the evolution of risk transmission (see Figure 1).

Figure 1 shows the maximum possible losses faced by the Chinese stock market when the regions along the “Belt and Road” reach the extreme loss VaR value at the 1% significance level. On the whole, different countries and regions have risk spillover effects on China's stock market, but there are certain differences in risk spillover effects between different markets. On average, the conditional value-at-risk CoVaR in the markets of China and countries along the “Belt and Road” is in descending order: Turkey, Kazakhstan, Poland, Singapore, India, and Russia, indicating that the stock price crash in Turkey is a risk contagion to China. The impact is greater, and the risk contagion to China is less affected when the Russian market is in crisis.

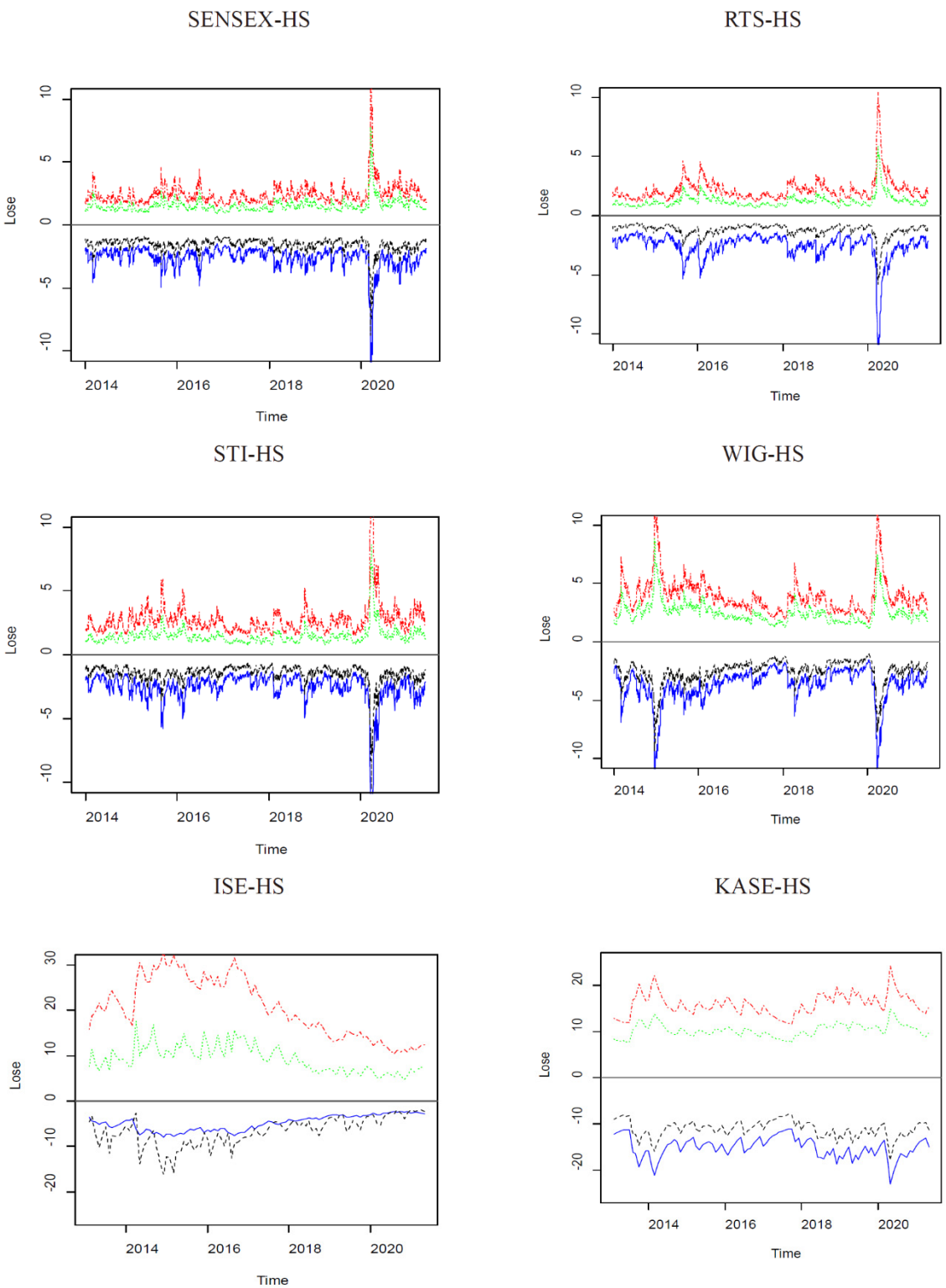

Figure 1 The dynamic risk spillover value CoVaR among the various markets of the "Belt and Road"

Note: The red curve represents the upper tail CoVaRup , the blue curve represents the lower tail CoVaRdown , the green curve represents the upper tail VaRup , and the black curve represents the lower tail VaRdown.

Judging from the trend of risk spillover intensity, excluding most time periods except the 2015 stock market crash and the 2020 COVID -19 epidemic, the tail risk spillover from market changes in countries and regions along the "Belt and Road" to China's stock market has basically maintained a slight fluctuation. The only ones with a clear downward trend are China and Turkey. Overall, the tail risk spillovers from the regions along the "Belt and Road" to the Chinese stock market have shown a slight upward trend with market

conditions, indicating that since the initiative was proposed, the risk transmission between the stock markets in most regions and the Chinese stock market has increased with market fluctuations. increased. In terms of the intensity and frequency of risk spillover effects, the tail losses of Chinese stock markets caused by stock market risk spillovers in Poland, Turkey and Kazakhstan are significantly higher than those in other countries, and the dynamic differences in risk contagion are more obvious. To sum up, the “Belt and Road” construction not only promotes the linkage of the capital market, but also enhances the risk contagion effect of the stock market.

4. CONCLUSION

Since its inception, the Belt and Road Initiative has made outstanding contributions to the development of global value chains and capital markets, injected strong vitality into the building of a community with a shared future for mankind, and will enter a new stage of "going deeper and more solid". With the strengthening of the financial correlation of countries along the route, it is also necessary to analyze and grasp the correlation of various capital markets. In view of this, based on the GARCH-Copula-CoVaR model, this paper tests the stock market correlations of countries and regions along the “Belt and Road”, and analyzes the risk spillover effect in extreme cases.

ACKNOWLEDGEMENT

Research on Rural Revitalization and regional brand collaborative construction mechanism (Heilongjiang Social Sciences Federation, Project number: 20412)

Feasibility study on the application of block link technologyin Daqing Industrial Transformation (Daqing Philosophy and Social Science Planning Research Project, DSGB2022043)

Training project of innovation plan for college students in Heilongjiang Province "Exploration on the targeted poverty alleviation mode of higher education in Heilongjiang Province -- Taking Heilongjiang Bayi Agricultural Reclamation University" (Project number: 201910223054)

A Study on the Financing Predicament and Solution Approach of Small and Medium-sized Enterprises in Daqing County under High Quality Development (Daqing Philosophy and Social Science Planning Research Project, DSGB2022131)

Research on the Financial Support Path for Rural Infrastructure Construction in the Countryside Revitalization Strategy - Taking Heilongjiang as an Example (Youth Innovative Talents Project of Heilongjiang Provincial Department of Education, UNPYSCT 2018088）

A Probe into the Fiscal and Financial Policies of Daqing Economic Transformation(Cultivation topic of Heilongjiang Bayi Agricultural University, XRW2015－10)

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