A Study on Regional Financial Risks Based on CoCVaR Model

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Received 28 April 2021; Revised 17 May 2021; Accepted 22 May 2021; Published 27 May 2021

Academic Editor: Daqing Gong

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For the purpose of accurate measurement of regional systemic financial risks and prevention of regional economic turmoil, this paper proposes a new measure called the CoCVaR model, based on the tail mean loss, which is applied to measure the impact of stock returns of each listed company on the overall stock returns in Guangdong Province, China, from January 2010 to December 2020. It is found that there are significant CoVaR and CoCVaR for real estate, finance, utilities, and energy companies, while the risk spillover to the real economy market in Guangdong Province is more significant when companies in these industries are in extreme situations. There are insignificant CoCVaR for daily consumption, information technology, and health care. The risk spillover to the real economy market in Guangdong Province is smaller when companies in these industries are in crisis.

1. Introduction

In the current economic downturn, the impact of new industries, led by the Internet industry, on traditional sectors as well as overcapacity and other reasons, make China’s economic environment increasingly unstable. This has led to increased regional economic and financial risks, resulting in challenges of business operations and occasional defaults. It is noted that most of the loans led by emerging enterprises and private enterprises improve their credit ratings with mutual and joint guarantees. They gradually form industrial or regional guarantee chains and loops, featuring of large amount and extensive coverage. If their capital chains are broken, the risk of default will keep spreading through the guarantee loop [1].

If we want to prevent the outbreak of systemic financial risks, we should measure the systemic risks accurately and effectively. Prior to the U.S. subprime crisis, systemic risks were often evaluated with early warning indicators of risk from macroeconomic variables and balance sheet data, and single indicators were synthesized appropriately to reflect systemic risks as a whole (Calvo et al. [2], Frankel and Rose [3], Bordo et al. [4], Illing and Liu [5], and Vanaga and Sloka [6]). The financial crisis in the United States will lead to the economic downturn. Due to economic globalization, many foreign trade enterprises in China will be greatly affected and even form regional systemic financial risks.

If real-time regulation of key companies in the regional economy is achieved, it is necessary to implement the policies to each organization. Especially after the subprime crisis, countries worldwide have recognized the importance of preventing regional financial risks. What are the key companies in the regional economy? How can we identify them? These questions reflect that it is complex and challenging to identify key companies in the regional economy, and a lot of research on regional risks and regional importance has been conducted at home and abroad with many key results achieved. However, the CoVaR approach is more sophisticated to measure systemic financial risks, but more efforts should be made to measure the regional importance of listed companies.

Against this background, this paper proposes CoCVaR, an improved measure of CoVaR financial risks for listed companies in Guangdong Province, China, to enhance the prevention system of the regional financial risks. For listed companies, the business is multiple, the relationship between enterprises is complex, and the tail risk is more prominent. Our model can accurately measure the average
2. Literature Review

Scholars have explored financial risks. García-Herrero and Wooldridge focused on financial integration to explore the cross-border financial connections among different economic regions [7]. They argue that financial integration is related to the spreading of regional risks. It should be strengthened by monitoring the spreading channels associated with financial integration if the potential regional risks are to be reduced. Galesi and Sgherri characterized the financial spillover effects among 27 countries with a GVAR model [8]. They found that asset prices, stock prices, and credit growth can be important channels of risk spreading under certain circumstances. The study prudently showed the key elements and spreading methods that transform regional threats into systemic ones. Zhu et al. created a financial stress index for China with monetary and credit variables, asset price variables, macroeconomic variables, and other explanatory variables as fundamental and proposed an optimal forecasting equation to predict the systemic financial risks [9].

There have been increasing studies on regional financial risks in China in recent years. Wang et al. studied the potential regional financial risks arising from local government debts from an audit perspective and proposed methods to prevent and address regional financial risks arising from local government debts from an audit monitoring perspective [10]. Zhang and Yu argued that the prevention of regional financial risks focuses on local corporate financial institutions and nonbank financial institutions [11]. Gao and Zhang discussed the performance and the root causes of regional risks in China and proposed valuable conclusions for preventing regional risks in eight aspects, such as enhanced monitoring of the central bank and strengthened monitoring and alerting of regional financial risks [12].

In general, the theories related to regional risks have become increasingly sophisticated and perfect. However, the measurement of regional financial risks based on CoVaR and its extended models is still a cutting-edge research. For example, the CoES model proposed by Zhang et al. focused on the tail mean losses to calculate the systemic risks of financial institutions more accurately [13]. Roengpitya and Rungcharoenkitkul measured the systemic risks of Thai banks and the external spillover effect of individual banks on the industry as a whole with CoVaR [14]. They concluded that the contribution of the banking industry to systemic risks had grown significantly after the Asian financial crisis. It is valuable and important to improve the CoVaR model and measure the regional risks from theoretical and practical perspectives. Due to multiple business operations, complex interenterprise relationships, and significant tail risks in listed companies, we have to look at their tail mean losses. Thus, this paper proposes CoCoVaR, a new model for measuring regional risk based on the CoVaR model, to study the mean losses suffered by the regional economy when an extreme risk occurs for a listed company.

3. Model and Methodology

3.1. CoVaR Model. VaR, known as “value at risk,” is a measure of the risk, which refers to the maximum possible loss of a financial asset (or portfolio) in a fixed time frame in the future at a certain confidence level [15].

With the practice of risk management, it is gradually found that VaR has specific limitations. Its biggest shortcoming is that it can only estimate the potential risk of a portfolio under “normal” market conditions but does not cover extreme market conditions [16]. To address the shortcomings of VaR, Adrian and Brunnermeier proposed Conditional Value at Risk or CoVaR based on the risk spillover perspective [17].

The mathematical expression of Conditional Value at Risk or CoVaR is as follows (note: in this paper, all calculations of the value at risk are performed at a confidence level of 95%):

\[
P\left(X_i^t \leq \text{CoVaR}^{|j|i}_q \mid X_i^t = \text{VaR}^{|i|}_q\right) = 1 - q, \tag{1}
\]

where CoVaR\(_q^{|j|i}\) denotes the maximum potential risk that financial market \(j\) faces when the risk of financial market \(i\) is at VaR\(_q^{|i|}\). It includes both unconditional and spillover value at risk. We define the spillover value at risk of \(i\) to \(j\) as Delta CoVaR\(_q^{|j|i}\) and describe the expression of the risk spillover effect through the numerical relationship of the sum and as follows:

\[
\Delta \text{CoVaR}^{|j|i}_q = \text{CoVaR}^{|j|i}_q - \text{VaR}^{|j|}_q. \tag{2}
\]

Since the unconditional value-at-risk varies widely across financial markets, Delta CoVaR\(_q^{|j|i}\) does not fully capture the intensity of risk spillovers, for which we normalize it as follows:

\[
\% \text{CoVaR}^{|j|i}_q = \left(\frac{\Delta \text{CoVaR}^{|j|i}_q}{\text{VaR}^{|j|}_q}\right) \times 100\%, \tag{3}
\]

where \%CoVaR\(_q^{|j|i}\) removes the effect of magnitude and more accurately captures the intensity of risk spillover to \(j\) from the maximum possible loss of \(i\).

The CoVaR model combines the risk spillover effect with the popular VaR, while Delta CoVaR\(_q^{|j|i}\) accurately and effectively reflects the influence and contribution of individual financial markets to systemic risks, with more accurate reflection of the true risk level. It is particularly significant for regulatory authorities concerned about the risk of the entire financial system to ensure a stable financial system by imposing severe regulation on financial markets with higher risk contribution.
3.2. Measure CoVaR Values with Quantile Regression. The quantile regression approach is an extension of the least squares method, which is based on the classical conditional mean model, and it estimates the overall model through multiple quantile functions [18]. Koenker and Bassett first introduced the idea of quantile regression in 1978, regressing each independent variable according to the conditional quantile set by the dependent variable [19]. It results in a quantile regression model with full quantile premise, which more comprehensively reflects some dependent variables influenced by the independent variable.

For examining the risk spillover effect of the risk generated by financial market j on financial market i, the following q-quantile regression model is created:

\[
R_{i}^{j} = \alpha + \beta X_{i} + \epsilon,
\]

where \( R_{i}^{j} \) and \( R_{i} \) represent the return series of i and j, respectively, and \( R_{i}^{j} \) reflects the estimated excess return i under the q quantile. According to the definition of value at risk, it can be defined as

\[
VaR_{i}^{q} = \tilde{\alpha} + \tilde{\beta} R_{i}^{j}.
\]

The above equation indicates that the value-at-risk estimate is obtained using quantile regression with series j as the predicted underlying return i with the existing condition \( R_{i}^{j} \), which yields \( \tilde{\alpha} \) and \( \tilde{\beta} \) of parameter estimates corresponding to quantile q. The value-at-risk estimate is

\[
\tilde{VaR}_{i}^{q} = \tilde{\alpha} + \tilde{\beta} R_{i}^{j}.
\]

According to the definition of CoVaR, CoVaR\(_{i}^{j} \) is expressed as the value at risk of i when return j is at its VaR\(_{i}^{j} \) level, and with quantile regression, our measure for CoVaR\(_{i}^{j} \) can be simply defined as

\[
CoVaR_{i}^{j} = VaR_{i}^{q}/VaR_{j} = \tilde{\alpha} + \tilde{\beta} VaR_{i}^{j}.
\]

In turn, we can get \( \Delta \) CoVaR\(_{i}^{j} \) and \( %CoVaR_{i}^{j} \).

3.3. CoCVaR and Its Measurements. CVaR (conditional value at risk) is a measure of investment risk developed by Rockafeller and Uryasev in 1999 to overcome the shortcomings of VaR, which is the average of the portfolio’s losses greater than a given VaR value, with its mathematical expression as follows [20]:

\[
CVaR_{a} = -E[Y|Y < -VaR_{a}].
\]

Compared to VaR, CVaR satisfies positive homogeneity, subadditivity, transfer invariance, and monotonicity, and it is a consistent risk measure optimized by linear programming algorithms noted by more organizational investors.

It is often assumed that the log returns of a portfolio will follow a normal distribution. However, scholars such as Rachev and Mittnik have shown that the log returns of financial assets do not obey a normal distribution in many cases with spikes and thick tails [21]. The Laplace distribution was fitted to the financial data to depict anomalous spikes in the vicinity of the mean. It is found that the individual order moments are finite and more relevant to the general financial theory. If the distribution density of the random variable \( X \) is

\[
LA(x, \mu, \sigma) = \frac{1}{2} \exp \left(-\frac{|x - \mu|}{\sigma}\right), \quad (-\infty < x < \infty).
\]

If \( x \) follows a Laplace distribution with parameters \( \mu \) (location parameter) and \( \sigma \) (scale parameter), it is denoted as \( x \sim LA(\mu, \sigma) \).

The distribution function is as follows:

\[
LA(x) = \begin{cases} 
\frac{1}{2} \exp \left(-\frac{x - \mu}{\sigma}\right), & x \leq \mu, \\
\frac{1}{2} \exp \left(-\frac{\mu - x}{\sigma}\right), & x \geq \mu.
\end{cases}
\]

Let \( x \) be a random variable of a financial asset gain or loss; following the distribution \( LA(\mu, \sigma) \), for a given confidence level, \( \alpha \) can be obtained as

\[
\begin{align*}
VaR_{a} &= F^{-1}(1 - \alpha), \\
CVaR_{a} &= \sigma \ln(2 - 2\alpha) + \mu,
\end{align*}
\]

Substitute \( VaR_{a} \) and \( CVaR_{a} \) (both less than \( \mu \)) into the distribution function of the gain or loss on financial assets \( x \), respectively, to obtain

\[
\begin{align*}
LA(VaR_{a}) &= 1 - \alpha, \\
LA(CVaR_{a}) &= 1 - \frac{\alpha}{e}.
\end{align*}
\]

This yields that \( VaR_{a} \) corresponds to the \( 1 - \alpha \) quantile of the distribution and \( CVaR_{a} \) corresponds to the quantile of the distribution \( 1 - \alpha/e \). The conclusions obtained in the \( VaR \) and \( CVaR \) measures with the Laplace distribution show that \( CVaR \) can be converted to a quantile of the return distribution concerning an ex-ante set confidence level, while CoCVaR is essentially a conditional \( CVaR \). As a result, CoCVaR\(_{a}^{j} \) can be measured with quantile regression.

\[\text{CoCVaR}_{a}^{j} \] represents the extreme risk faced by financial market \( j \) at confidence level \( q \), with the risk level of financial market \( i \) under the \( CVaR \) condition. It is defined as

\[
\text{CoCVaR}_{a}^{j} = CVaR_{a}(j) \mid CVaR_{a}(i) = E[X_{i}' \mid (X_{i}' < VaR_{a}(i) \cap X_{j}' = VaR_{a}(j))].
\]

In summary, under the condition that the risk level is at \( CVaR \) and the confidence level is \( \alpha \) (0 < \( \alpha \) < 1), CoCVaR\(_{a}^{j} \) is calculated as

\[
\text{CoCVaR}_{a}^{j} = \tilde{\alpha} + \tilde{\beta}(XI_{i} = CVaR_{a}(i)),
\]

where the estimated \( \tilde{\alpha} \) and \( \tilde{\beta} \) of the regression coefficients can be obtained by quantile regression.
4. Empirical Analysis

4.1. Data and Processing. In this paper, the daily closing prices of stocks of 500 listed companies in Guangdong Province are selected as the research object, and the data of 358 stocks are sampled from January 4, 2010, to December 31, 2020. The data include two recessions (September 2011 and December 2014) and one financial crisis (European Debt Crisis in 2011). Extreme risks exist in the region during this timeline, and the observation sample is very representative and valuable for research. Adopt the arithmetic average of the closing price of each stock as the overall closing price of Guangdong. There are 1,702 observations of trading days in the sample with all data from the Wind database, which covers stocks, funds, bonds, foreign exchange, insurance, futures, financial derivatives, spot trading, macroeconomic, financial news, and other fields.

To make the data representative, delete the data of listed stocks with less than 200 observations, and normalize the closing price data of the remaining 329 stocks with log returns \( R_t = 100 \times (\ln P_t - \ln P_{t-1}) \).

From the above, the logarithmic return of financial assets is distributed by Laplace and has the characteristics of peak and tail. So it includes basic descriptive statistics, smoothness test, spike test, and thick-tail test.

4.1.1. Basic Descriptive Statistics. The histograms of the minimum, maximum, and mean log returns for each listed company are shown in Figure 1.

The histogram made by the average log return of each listed company tends to be the standard normal distribution, with more values greater than 0, indicating that the province is generally in stable profitable development.

4.1.2. Data Smoothing Test. The data smoothness is the basis and prerequisite for time series analysis. The most popular method for the smoothing test of the series is the graphical method, the unit root test, and the autocorrelation coefficient test. The above two methods are preliminary and intuitive judgments on the smoothness of the time series, which are highly subjective and generally used as auxiliary methods. The most popular test today is the unit root test. At a significance level of 0.05, the results show that the kurtosis coefficients of all stock log return series are greater than zero, indicating that the log return data are spiky distributed.

4.1.3. Spike Test. Let the mathematical expectation of the function \( (X - E(X))^k \), \( k = 1, 2, \ldots, \) of the random variable \( X \) exist, and it is called \( E(X - E(X))^k \) as the \( k \)th-order central distance of \( X \), noted as \( \mu_k(X) = E(X - E(X))^k \), \( k = 1, 2, \ldots \). The ratio of the fourth-order central distance of the random variable \( X \) to the squared second-order central distance is defined as the kurtosis coefficient, denoted as \( K \), and its expression is

\[
K = \frac{\mu_2}{\mu_4} = \frac{E(X - E(X))^4}{D(X)^2}. \tag{16}
\]

If \( X \sim N(\mu, \sigma^2) \), its kurtosis coefficient is given by

\[
K = \frac{\mu_4}{\mu_2^2} = \frac{3\sigma^4}{(\sigma^2)^2} = 3. \tag{17}
\]

In general, the kurtosis coefficient of a normal distribution is subtracted by 3 for the convenience of comparing its spike. \( K = 0 \) signifies that the kurtosis of the distribution is the same as that of the normal distribution with no spiking issue; \( K > 0 \) suggests that the distribution has a higher kurtosis than the normal distribution. Then, the kurtosis coefficient of the financial asset return series is

\[
K = \frac{n\sum_{t=1}^{n} (x_t - \bar{x})^4}{\left(\sum_{t=1}^{n} (x_t - \bar{x})^2\right)^2} - 3. \tag{18}
\]

At the 0.05 significance level, the results show that the kurtosis coefficients of all stock log return series are greater than zero, indicating that the log return data are spiky distributed.

4.1.4. Thick-Tailed Test. If the distribution function \( F(x) \) of the random variable \( X \) satisfies \( \lim_{x \to -\infty} 1 - F(tx)/1 - F(t) = x^{-2r} \), \( r > 0, x > 1 \), then \( X \) is an upper “thick-tailed” distribution and \( r \) is the upper-tailed extreme index. When \( r = 0 \) given \( x > 1 \), the distribution follows the normal distribution (also known as the thin-tailed distribution) and vice versa \( r > 0 \) for the thick-tailed distribution.

Let the sequence \( X_1, X_2, \ldots, X_n \) of financial asset returns be independently distributed \( X_{1,m} \leq X_{2,m} \leq \ldots \leq X_{n,m} \) as its statistic; then, the moment-type estimate formula is

\[
\hat{r} = M_n^1 + 1 - \frac{1}{2} \left( 1 - \frac{M_n^2}{M_n^1} \right)^{-1}. \tag{19}
\]

Considering the tail exponent only, when \( \sqrt{m \hat{r}_n} \sim \mu \), the random variable is in a thick-tailed distribution; conversely, it is a thin-tailed distribution, where \( \mu \) is the one-sided critical value of the standard normal distribution, i.e., \( P(X > \mu) = a \), \( X \sim N(0, 1) \). \( m = [n/m] \) is always thought to be the best choice.

At a significance level of 0.05, the results show that the tail extreme values of the log-return series for all stocks \( \sqrt{m \hat{r}_n} \sim \mu_{0.05} = 1.64 \). Therefore, log-return sequences are in thick-tailed distribution.

4.2. Specific Measurement of Regional Risks

4.2.1. Regional Risk Measurement Based on CoVaR. At a significance level of 5%, solving the original data with Laplace hypothetical distribution yields

\[ VaR_{\alpha} = \partial \ln (2 - 2\alpha) + \bar{\mu}. \tag{20} \]

Calculate the VaR of log returns of all stocks, and the smallest 10 stock names and their corresponding VaR are given in Table 1.
The financial crisis in 2011 had a significant impact on our economy. The VaR value of each stock dropped significantly, and the VaR risk increased rapidly. Since 2012, the government increased its focus on risk, and the risk gradually decreased.

The CoVaR measures the risk spillover to be exposed as a whole in the event of a maximum possible risk loss for a listed company. $\text{CoVaR}_{ij}$ denotes the maximum possible risk of institution $j$ under the maximum possible risk for institution $i$. $\Delta \text{CoVaR}_{ij}$ quantifies the difference between the systematic risks when institution $i$ is in crisis and stable, which act as the risk premium of each listed company. The histogram of $\Delta \text{CoVaR}$ for log returns of the sampled stock is given in Figure 2.

As shown in the histogram, the $\Delta \text{CoVaR}$ of the log returns of each stock tends to be $[2.0, 2.5]$ in distribution which are all less than zero, i.e., all listed companies increase the overall systematic risk of the province when they are in crisis.

The 10 listed companies with the smallest $\Delta \text{CoVaR}$ and their corresponding $\Delta \text{CoVaR}$ are shown in Table 2.

The financial crisis caused serious damage to the stable Guangdong economy and significantly expanded the overall systemic risk in the province, with a large trough in 2010-2011. After the financial crisis, the government focused on risk regulation and improved the relevant system, and the $\Delta \text{CoVaR}$ gradually increased in 2013–2015, and the impact of systemic risk decreased step by step. With the speedup of the interest rate and exchange rate market reform, the state guides private capital to enter the financial industry. Due to awash interbank tractions, liquidity tension, and explosive growth of shadow banking, a small trough occurred in 2011–2013, when a crisis in listed companies expanded the overall systemic risks in the province to some extent.

Box-and-line diagrams of $\Delta \text{CoVaR}$ and its industry categories are made for $\Delta \text{CoVaR}$ measurement in Figure 3.

The scatter plot of $\Delta \text{CoVaR}$ and time to market of companies is made for the measurement of $\Delta \text{CoVaR}$ in Figure 4.

From the scatter plot of listing time, it can be seen that, for listed companies before 2011, $\Delta \text{CoVaR}$ is discrete with a small value, and the impact caused by a crisis is significant; for companies listed around 2014, $\Delta \text{CoVaR}$ is more concentrated with a large value, and the impact caused by a crisis is relatively small.

- The 10 listed companies with the smallest $\Delta \text{CoVaR}$ and their corresponding $\Delta \text{CoVaR}$ are shown in Table 2.

Table 1: The 10 stocks with the smallest VaR values.

<table>
<thead>
<tr>
<th>Stock name</th>
<th>VaR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guanhao Bio</td>
<td>6.870</td>
</tr>
<tr>
<td>Youngy Co., Ltd.</td>
<td>6.197</td>
</tr>
<tr>
<td>NASDA</td>
<td>6.163</td>
</tr>
<tr>
<td>Macsun Solar Energy Technology</td>
<td>5.941</td>
</tr>
<tr>
<td>Biolight</td>
<td>5.913</td>
</tr>
<tr>
<td>Shenzhen Hifuture Information Technology</td>
<td>5.900</td>
</tr>
<tr>
<td>Guangdong Shirong Zhaoye</td>
<td>5.740</td>
</tr>
<tr>
<td>Sunway Communication</td>
<td>5.734</td>
</tr>
<tr>
<td>AVIT</td>
<td>5.732</td>
</tr>
<tr>
<td>Guangzhou Yuetai Group</td>
<td>6.124</td>
</tr>
</tbody>
</table>

Figure 1: Descriptive statistics of return.
2.0 2.5 3.0
1.0 1.5
0
10
20
30
40
50
60
70
ΔCoVaR
Figure 2: Histogram of ΔCoVaR.

Table 2: 10 stocks with the smallest ΔCoVaR.

<table>
<thead>
<tr>
<th>Stock name</th>
<th>ΔCoVaR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunlord Electronics</td>
<td>2.565</td>
</tr>
<tr>
<td>Shenzhen Laibao Hi-Tech Co., Ltd.</td>
<td>2.538</td>
</tr>
<tr>
<td>Shenzhen Topband Co., Ltd.</td>
<td>2.484</td>
</tr>
<tr>
<td>SG Holding A</td>
<td>2.473</td>
</tr>
<tr>
<td>Shenzhen Jinjia Group Co., Ltd.</td>
<td>2.465</td>
</tr>
<tr>
<td>Shenzhen Zhongji Lingnan Nonfemet Co., Ltd.</td>
<td>2.445</td>
</tr>
<tr>
<td>Shenzhen Batian Ecotypic Engineering Co., Ltd.</td>
<td>2.419</td>
</tr>
<tr>
<td>Shenzhen Hifuture Information Technology</td>
<td>2.436</td>
</tr>
<tr>
<td>YGSOFT Inc.</td>
<td>2.495</td>
</tr>
<tr>
<td>Gree Electric Appliances Inc.</td>
<td>2.427</td>
</tr>
</tbody>
</table>

4.2.2. Regional Risk Measurement Based on CoCVaR. Calculate the CVaR of log returns of the stocks. And, the stock names and their corresponding CVaR are given as follows. The names of the 10 stocks with the smallest CVaR values and the corresponding CVaR are shown in Table 3.

The CoCVaR is able to measure the extreme risk loss that could occur as a whole in the event of an extreme risk loss for a listed company. The ΔCoCVaR for the log returns of each stock tend to be [1.8, 2.7] in distribution, i.e., all listed companies in an extreme crisis will increase the systemic extreme risks in aggregate in the province. Thirty listed companies with the smallest ΔCoCVaR and the corresponding ΔCoCVaR are shown in Table 4, and the histograms are given in Figure 5.

Figures 6–8 show that there are large CoVaR and CoCVaR for real estate, finance, utilities, and energy companies, and the risk spillover to the entire real economy market in Guangdong Province is significant when companies in these sectors are under extreme conditions; there are smaller CoCVaR for daily consumption, information technology, and healthcare, and the risk spillover to the entire real economy market in Guangdong Province is insignificant when companies in these sectors are in crisis.

4.3. Analysis of CoVaR vs. CoCVaR. The CoVaR and CoCVaR methods both measure the risk of one institution when another institution is at risk.

The scatter plots of VaR and CVaR are made through the closing price data of listed companies in Guangdong Province in Figure 9. They have a strong positive correlation, and the correlation coefficient is close to 1. Figure 10 shows a strong positive correlation between ΔCoVaR and ΔCoCVaR, and the listed companies above the fitted line are those with significant ΔCoVaR at the same ΔCoCVaR level, which have less impact on the overall systemic extreme risk in the province when an extreme risk occurs in this category.

5. Summary

This paper verifies the feasible CoCVaR through empirical analysis, and the model can measure the extreme risks of the whole financial conditions under the premise of extreme risks generated by financial institutions (or financial markets) and propose a new measurement model for preventing financial risks. Comparison with the traditional CoVaR model reveals that the model can better measure the comprehensive risks. Although the chances of extreme risk generation are low, it may bring enormous damages in an unignorable way for regulators. It possible to measure financial risks more comprehensively by combining the model with other risk measurement models (e.g., CoVaR model) and provide a strong guarantee against the financial risks.

Different industries have various impacts on the collective systemic risk of the state’s stock market under risks,
which means that different sectors differ in importance to the stock market of the province [22]. When monitoring the systemic risk of the stock market in the province, we should focus on industries that have a high impact on the systemic risk, such as information technology and industrial and real estate.

There are significant CoVaR and CoCVaR for real estate, finance, and energy and utility companies, and the risk spillover to the real economy market in Guangdong Province is more significant when companies in these industries are in extreme situations. There are insignificant CoCVaR for daily consumption, information technology, and health care. The risk spillover to the real economy market in Guangdong Province is smaller when companies in these industries are in crisis.

The analysis of VaR, CVaR, CoVaR, and CoCVaR indicators of individual enterprises shows that large enterprises (e.g., Ping An China Merchants Bank, Poly, ZTE, Gree, and Shenzhen) have significant CoCVaR with low CVaR values. For example, they are more resilient to risks.
but with a more significant regional systemic risk spillover for Guangdong Province. Some small manufacturing (materials) and information technology companies, which have lower CoCVaR and significant CVaR values, are less resilient to risks but have less impact on the regional or systemic economy.
It is necessary to focus on the impact of China’s real economic operation on the systemic risk in the securities market and real-time monitoring of the trading process, with a sound early warning system established. The state should fully consider the possible impact of its issuance and application on the securities market when formulating macroeconomic policies. Analysis is given to the systemic risks of the securities market and the systemic risk that existed in practice, and a pool of systemic risk scenarios is created via imitating various possible scenarios in the virtual market with the state-of-the-art computer technology.

**Data Availability**

The WIND database used to support the findings of this study is included within the article.

**Conflicts of Interest**

The authors declare that they have no conflicts of interest.

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**Figure 10:** Scatter plot of ΔCoVaR and ΔCoCVaR.


