Financial risk assessment of six regions in China under the TOPSIS model based on a coupling perspective

Yizhe Ding[1,*], Keyu Chen[2]

[1] Business School, Sichuan University, Sichuan, China

[2] School of Economics, Sichuan University, Sichuan, China

610000, Chengdu, China

xdixon@163.com

Abstract. As China's economy enters a new normal, the economy gradually changes from high speed to high quality, and the task of resolving various types of risks in each region becomes more arduous, while the prevention and control of regional financial risks will certainly become one of the severe challenges faced under the new economic normal. Based on the parallel data of six regions in China, this paper combines EWM subjective weights and AHP objective weights to construct EWM-AHP coupling weights. It also adopts the distance between ideal point superiority and inferiority solution (TOPSIS) ranking method to quantify the relative relationship between the sample and the evaluation criteria and establishes a differentiated financial risk indicator model for the six regions. The results show that the financial risk is lower in regions with a weaker economic base and lower level of financial development. Financial risk is higher in regions with a higher degree of financial openness. The integrated EWM-AHP and TOPSIS models can effectively reduce the financial risks in the development process of the six regions and improve the smoothness of economic operation, which has a particular application value. The results show that the financial risk is higher in regions with more backward economic development, and the financial risk index is lower in regions with sound capital market development.

Keywords: TOPSIS model; EWM-AHP model; regional financial risk.

1. Introduction

At present, China's economic development has entered a new normal stage, and changes in the situation at home and abroad have further intensified the downward pressure on the economy, making it more likely to cause a high level of risk. Among the major social risks faced by China, financial risks have become a key part of them due to their fast transmission, large impact, and destructive characteristics. Financial risks are cross-contagious between financial markets once the financial sector is at risk [1]. However, they can also quickly spill over to other industrial entities through the conduction mechanism, creating systemic and global major risks with severe consequences for China's economic security and social order. The key to precisely addressing regional financial risks is to grasp the heterogeneity of regional financial risks [2]. Therefore, constructing models through relevant theories and methods to quantitatively assess the financial risks of China's six regions will facilitate the formulation of relevant preventive policies by national and regional governments. With the in-depth development of mathematical estimation research, analytical tools such as AM-BPNN models, GARCH-CoVAR models, analysis of variance (ANOVA), and hybrid OLS estimation have been widely used in the assessment system of financial risks, enriching the methodological approaches for quantitative assessment of financial risks [3].

There are few studies in quantitative assessment of financial risks, which are technically and methodologically more reliable predictors of regional financial risks. Peng Huafei et al. [4] used data from 24 listed banks and 130 local legal person banks in China based on a contagion dynamics model, which is used to analyze the propagation of bank financial risks using a complex network contagion model. It can measure the current propagation trends and characteristics of systemic financial risks in China and to further analyze the variability and effectiveness of financial risk rescue strategies. Li Yongbo [5] et al. constructed an AHP-FUZZY model to rank the coupling of Internet finance's information technology, credit, operation, market, operation, liquidity, and legal policy indicators and found that credit, information technology, and legal policy risks are the main financial risks.

Although previous studies on financial risk assessment in China have yielded specific results, the resulting evaluation indicators still differ due to differences in research models and research directions, making it difficult to establish a set of assessment and forecasting systems on regional financial risks in China. On the other hand, previous studies have focused more on assessing specific risks in a particular area or region, making it difficult to evaluate the financial risks of the six regions in China from a macro perspective, which has certain limitations. In this paper, a multi-level regional financial risk assessment index system is constructed, and each index is weighted by applying the AHP method, while the EWM method relies on raw data to calculate the index weights and complements the AHP method. It is mainly based on the information entropy to measure the size of the information and to establish the indicator weights, which have strong objectivity. Finally, the TOPSIS model[6] is used to normalize the regional financial risk indicator matrix, find out the best and worst targets among multiple targets, calculate the distance between each evaluation target and the understood inverse ideal solution respectively, obtain the closeness of each target to the ideal solution, and rank them according to the closeness as the basis for evaluating the advantages and disadvantages of financial risk indicators.

2. Financial risk indicator system construction

To select systemic regional financial risk early warning indicators, it is considered the influence of economic environment, banking environment and securities market environment on regional financial risk, this paper will select indicators from local finance, local economy, and macroeconomic and financial levels[7].

2.1 Basic regional economic indicators

Based on the analysis and summary of existing literature, this study will construct a regional financial risk evaluation indicator system from the capital market, banking sector, macroeconomy, insurance market, and government debt [8].

Macroeconomics includes the total national economy of a country, the composition of the national economy (mainly divided into GDP sectors and non-GDP sectors), the stage of industrial development and industrial structure, and the degree of economic development, which are important indicators for regional financial risk assessment and early warning. The macroeconomic indicators to be selected for this study are GDP growth rate (X1), GDP per capita growth rate (X2), fixed asset investment growth rate (X3), industrial output growth rate (X4), consumer price index (X5) and producer price index (X6).

The banking market is an essential part of the regional financial market, and its business scope covers all areas of the economy and society. The health of its operation directly determines the outbreak of risks in the financial market. The banking market indicators initially selected for this paper are the non-performing loan ratio (X7), capital adequacy ratio (X8), M2 / GDP (X9), and loan balance/deposit balance (X10).

As the largest financial market in terms of capital flows, the capital market has become a trigger for regional financial risk contagion, and the degree of its perfect development determines the probability of a financial risk outbreak. The capital market variables initially selected in this paper are stock market capitalization / GDP (X11), stock market capitalization in circulation / GDP (X12), and stock trading turnover rate (X13).

The insurance market is the financial market where the most significant number of residents, enterprises, and other individuals participate. It is an essential contributor to capital in the financial sector. Its existence also protects against regional financial risks for other investment institutions. The insurance market indicators initially selected for this paper are insurance density (X14), insurance depth (X15), and premium income growth rate (X16).

Government debt is an essential variable in measuring regional financial risk, where the problem of local government debt risk is an important causal factor of local and regional financial risk. The primary government debt indicators selected in this paper are government debt service / fiscal revenue (X17), government bond issuance revenue / fiscal revenue (X18), and government fiscal revenue / fiscal expenditure (X19).

The initial selection of regional financial risk indicators was screened for significance, and GDP growth rate (X1), consumer price index (X2), regional GDP (X4), market value, market value/GDP (X5), local general budget revenue (X6), local general budget expenditure (X7), fiscal revenue/fiscal expenditure (X8), depth of insurance All business (X9), Non-performing loan ratio (X10)

3. Construction of coupled model based on AHP-EWM

3.1 Hierarchical analysis method

Hierarchical analysis (AHP) was proposed by Professor T. L. Saaty, an American operations researcher. AHP is a practical and straightforward multi-criteria decision-making method for quantitative analysis of qualitative problems [9]. It organizes the various factors in a complex problem by dividing them into interrelated ordered levels and quantifies the importance of the elements of a level by comparing them two by two bn. The weights reflecting the relative order of importance of the elements of each level are then calculated mathematically, and the relative weights of all elements are calculated and ranked by the total ranking among all levels. This study uses a combination of subjective and objective methods to determine the indicator weights of the evaluation system. The specific steps are as follows

STEP1: Firstly, we use the AHP and entropy methods to calculate the index weights.

STEP2:Then the weights of the two methods are combined to calculate the combined weights using the principle of minimum information entropy. The AHP method establishes a structured and systematic indicator evaluation system. For each indicator of the same level, two comparisons are made between the upper-level indicators as a criterion, a two-comparison judgment matrix is constructed, and a consistency test is conducted to determine the indicator weights. Then use the weight values of all the corresponding subordinate indicators in the same level, as well as the weights of all the indicators in the upper level, and carry out weighting to calculate the weight values of all the indicators in this level to the highest level, and finally arrive at the comprehensive weights of the six regional financial risks.

3.2 Entropy weighting method

Entropy weighting method (EWM) physics term, originally derived from the concept of thermodynamics in physics [10]. Based on the explanation of the basic principles of information theory, information is a measure of the degree of order of the system. Entropy is a measure of the degree of disorder of the system. Based on the definition of information entropy, for a particular indicator, the entropy value can be used to determine the discrete degree of a specific indicator, and the tool of information entropy can be used to calculate the weight of each indicator, which provides a basis for the comprehensive evaluation of multiple indicators. The specific steps are as follows:

With m evaluation indicators and n evaluation objects, the original data matrix $R=\left(r_{ij}\right)_{m\times n}$ is formed. The entropy for the first indicator is defined as:

$$H_i=-k\sum_{j=1}^{n}f_{ij}\ln f_{ij} \tag{1}$$

Where: $f_{ij}=f_{ij}/\sum_{j=1}^{n}r_{ij}, k=1/\ln n$, when $f_{ij}=0$, let $f_{ij}\ln f_{ij}=0$. f_{ij} is the i th indicator under the j th indicator.

3.3 Coupling weights

After obtaining the subjective weights W_{AHM} and objective weights W_{CRI}, the multiplier synthesis normalization method can effectively reflect the relative weight relationship of each indicator and its weight share on the whole.

$$W = \frac{W_{\mathrm{AHM}} W_{CRI}}{\sum_{j=1}^{n} W_{\mathrm{AHM}} W_{CRI}} \tag{2}$$

4. TOPSIS ranking

The TOPSIS method, first proposed by C.L. Hwang and K. Yoon in 1981, is a method of ranking a limited number of evaluation objects according to their proximity to an idealized target and evaluating the relative merits of the existing objects. The core of TOPSIS is the determination of positive and negative ideal solutions, which in this study is to determine the best and worst values of each indicator and to rank them by comparing the Euclidean distance between different evaluation objects and the ideal solution in order to make a superior or inferior judgment. The specific steps are as follows.

STEP1:Construct the standardized weighting matrix Y. The standard weighting matrix $Z = \left(z_{ij}\right)_{m\times n}$ is constructed by coupling the weights with the standardized matrix, $z_{ij} = W_j y_{ij}\left(i = 1, 2, \cdots, m; j = 1, 2, \cdots, n\right)$ where W_j is the coupling weight of each indicator y_{ij} is the standardized value of the j th evaluation indicator factor of the i th evaluation object in the standardized matrix Y.

STEP2: Determine the positive and negative ideal solutions of each indicator. The solution set of positive ideal solution of the indicator is $K^+ = \left(k_1^+, k_2^+, \cdots, k_n^+\right)$, the larger the value, the better; the solution set of a negative ideal solution is $K^- = \left(k_1^-, k_2^-, \cdots, k_n^-\right)$, the smaller the value, the better.

STEP3:Calculate the distance. Here the Euclidean distance formula (3) is adopted to determine the distance D_i^+ D_i^- between the evaluation object and the positive and negative ideal solutions, as follows:

$$\begin{cases} D_i^+ = \sqrt{\sum_{j=1}^{n}\left(z_{ij} - z_j^+\right)^2} \\ D_i^- = \sqrt{\sum_{j=1}^{n}\left(z_{ij} - z_j^-\right)^2} \end{cases} \tag{3}$$

STEP4:Calculate the closeness. The following formula is used to determine the closeness of each evaluation object to the ideal solution. If the closeness C_i is greater, the better the solution is, which determines the relative merits of the risk indicators.

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{4}$$

The weight of the evaluation object to the indicator n is the number of evaluation objects; H_i is the entropy of the i th indicator. After defining the entropy of the i th indicator, the entropy weight of the i th indicator is defined as:

$$w_{2i} = \frac{1 - H_i}{n - \sum_{i=1}^{m} H_i} \tag{5}$$

Where: $0 \le w_{2i} \le 1$, $\sum_{i=1}^{m} = 1$. H_i is the entropy of the i th indicator and m is the number of evaluation indicators; w_{2i} is the entropy weight of the i th indicator.

5. Empirical analysis

5.1 Data collection

Considering the availability and reference of data, this paper selected provincial and municipal panel data between 2014 and 2020. The six administrative regions of the People's Republic of China refer to the six administrative regions of Northeast, North, East, Central and South, Northwest, and Southwest China, established at the early stage of the establishment of the People's Republic of China North China: Beijing, Tianjin, Hebei, Shanxi and Inner Mongolia. Northeast China includes Heilongjiang, Jilin, and Liaoning Provinces. East China Region includes Shanghai, Shandong Province, Jiangsu Province, Zhejiang Province, Anhui Province, Jiangxi Province, and Fujian Province. South Central Region includes Henan Province, Hubei Province, Hunan Province, Guangdong Province, Guangxi Zhuang Autonomous Region, and Hainan Province. The Southwest Region includes Chongqing, Sichuan, Guizhou, Yunnan, and Tibet Autonomous Region. The Northwest region includes Shaanxi Province, Gansu Province, Qinghai Province, Ningxia Hui Autonomous Region, Xinjiang Autonomous Region

Due to the high similarity between indicators of the same category, too many of them may easily lead to dilution of the weight coefficients of the indicator variables. Ten indicators were selected from the alternative indicators in this paper to reflect regional financial risks, which are somewhat representative. The initial sample data of non-performing loans, insurance depth of all business, and fiscal revenue/fiscal expenditure were obtained from the CNRDS database, while other data were obtained from the WIND database and the China Urban Statistical Yearbook. Combining the above data, the mean matrix of panel data for the six regions in China was obtained, and the specific results are shown in Table 1.

Table 1 Six Regional Financial Indicators Matrix

Indicator	X1	X2	X3	X4	X5
North China	6.23	101.85	20459.31	37674.91	1.42
North East	3.32	101.91	15266.00	5102.77	0.33
East China	8.38	102.11	45390.00	27211.92	0.62
Central South	8.41	102.13	44951.00	26877.73	0.41
South West	10.69	102.00	18408.31	7993.55	0.56
Northwest	7.43	101.87	9255.82	3578.14	0.40
Indicator	X6	X7	X8	X9	X10
North China	2927.43	5046.63	0.58	4.34	2.06
North East	1654.5	4422.35	0.36	4.45	2.38
East China	4907.51	7320.33	0.65	3.47	1.79
Central South	4361.8	8264.13	0.47	3.98	1.59
South West	1904.79	5055.78	0.34	3.20	1.50
Northwest	994.69	3159.41	0.29	3.77	2.24

5.2 Calculation of weights

Combining formula (1) and formula (2) can determine the weight of each indicator in the six regional financial risk evaluation systems in China under different methods. While the comprehensive evaluation of each regional financial risk is carried out, the entropy weight method is used to evaluate the regional financial risk. The system layer indicator weights are obtained by adding up the indicator layer weights. When the quality of the system layer indicators is evaluated alone, the system does not contain the target layer, but only the system and indicator layers. The indicator weights of the indicator layer are obtained by the ratio of the indicator layer weights to the corresponding system layer weights. The results are shown in Table 2

To address the current situation, the weight of indicators is difficult to measure, and the traditional weighting methods are unable to achieve the organic unity of subjectivity and objectivity. The assignment rules described in this paper are introduced, and the traditional assignment models are organically synthesized by constructing a coupled model. The results were obtained to satisfy the objectivity of indicators and reflect the subjective preference of decision-makers, which avoids the influence of a single weight.

Table 2 Weight calculation formula

Indicator	X1	X2	X3	X4	X5
AHP	5.84%	8.23%	8.01%	10.26%	6.97%
EWM	5.88%	0.00%	17.28%	32.42%	16.42%
AHP-EWM	0.04	0	0.15	0.36	0.12
Indicator	X6	X7	X8	X9	X10
AHP	9.85%	11.36%	11.79%	13.96%	13.72%
EWM	15.26%	5.55%	4.71%	0.84%	1.63%
AHP-EWM	0.16	0.07	0.06	0.01	0.03

5.3 Ranking calculation

The TOPSIS scores and rankings of the six major regional financial risks are obtained according to equations (3-5). The relative proximity C is used to reflect regional financial risk indicators, with a higher ranking representing lower regional financial risk. The specific results are shown in Table 2.

Table 3 TOPSISI ranking results

Item	Positive ideal solution distance D+	Negative ideal solution distance D-	Relative proximity C	Ranking results
North China	9726.8	20942	0.683	3
North East China	22829	2537.3	0.1	5
East China	6285.2	20021	0.761	1
Central South China	6486.9	19759	0.753	2
Southwest China	20708	4469.3	0.178	4
Northwest China	24881	0.804	0	6

5.4 Analysis of results

As can be seen from the above Table 3, 10 indicators (GDP growth rate (%), consumer price index (previous year = 100), gross regional product (billion yuan), market value (billion yuan), market value/GDP, local fiscal general budget revenue (billion yuan), local fiscal general budget expenditure (billion yuan), fiscal revenue / fiscal expenditure, insurance depth all business (%), non-performing loan rate (%)), the TOPSIS evaluation, while the evaluation objects are 6 (the number of sample size is the number of evaluation objects); TOPSIS method firstly finds out the positive and negative ideal solutions (A+ and A-) of the evaluation indicators, and then calculates the distance values D+ and D- of each evaluation object from the positive and negative ideal solutions respectively. Based on the

D+ and D- values, the degree of proximity of each evaluation object to the optimal solution (C-value) is finally calculated and can be ranked against the C-value. From the ranking results, it can be concluded that there are significant geographical differences in financial risk among the six regions of China between 2014 and 2020.

Eastern China has the lowest financial risk, with the relative proximity of 0.761, which is much lower than the average financial risk index of China over the same period. South Central, North China, and Southwest China rank second, third and fourth, respectively, in terms of overall regional financial risk, with evaluated risk indices reaching 0.753, 0.683, and 0.178, respectively. Northwest China has the highest financial risk index, with proximity of 0.000.

The difference in economic growth between provinces is noticeable. Since 1978 China's rapid economic development, the national economy has been greatly enhanced. The economic growth rate is ahead, in the overall development of a good environment, the development gap between China's provinces gradually expanded, and the economic development level of the eastern provinces and cities is much higher than the western region. Due to the coastal areas, convenient transportation conditions, superior natural resources, and external development. The most developed of these is Shenzhen, the first city to open up. In the central and western regions, especially the western inland, the economic development is slow due to the transportation conditions and natural environment. The Western Development Strategy is a guiding policy to help the west based on its slow development.

The widening income gap between regions is brought about by economic growth and rapid economic development. Meanwhile, the income gap between regions of China's residents is growing. According to the World Bank, China's income distribution is highly unfair, and the Gini coefficient is currently used to measure income distribution. China's Gini coefficient is fast approaching 0.5. The widening of the per capita income gap has triggered conflicts and had an impact on social stability, while the uneven development across the country has led to people migrating to areas with better economic development, adding pressure to cities. For example, Yunnan province, which was a veritable poor province at the beginning of the new China, has seen significant economic growth with the support of the state. In 2019, with a per capita income of over 4,000 yuan, qualitative development had been achieved, but vertically, this is a very unsatisfactory result compared to the Jiangsu, Zhejiang, and Shanghai regions. The income gap between regions is also a sign of uncoordinated economic development.

6. Conclusion

This paper assessed and analyzed the financial risk of six regions in China (excluding Hong Kong, Macao, and Taiwan) by constructing regional financial risk indices. The subjective weights were first calculated using the hierarchical analysis method (AHP), and then the objective weights of the indexes were calculated using the entropy weight method (EWM). The two weights were then coupled using the principle of minimum information entropy to calculate the combined weights of each indicator. Using the combination weights of each risk indicator, the six regional financial risk indicators are ranked close to the ideal solution (TOPSIS) to determine the optimal and worst values of each indicator, and then compare the distance between each indicator and the ideal solution to obtain the ranking of the six regional financial risk indicators. The following main conclusions are drawn.

Firstly, the extreme difference in the average financial risk index of the six major regions in China from 2014 to 2020 is large, which is shown that the financial risk index of Eastern China, Northern China, and Central and Southern China is much lower than that of the rest of the regions and much lower than the national average during the same period. It is fully reflected in the current uneven level of regional economic development in China and the large gap in the level of regional financial risk prevention and control.

Secondly, the overall financial risk level is higher in regions with a sluggish level of economic development, with the overall financial risk index in Northwest China, Southwest China, and

Northeast China being higher than that of East China, North China, and South Central China during the same period from 2014 to 2020. In terms of the provinces and autonomous regions included in the six regions, the provinces and autonomous regions with higher regional systemic financial risks have a lower level of economic development. On the other hand, although the financial risk indices of some provinces in North, East, and South China are higher than the average level of the corresponding regions, they are generally lower than the financial risk indices of the vast majority of provinces in the Northwest, Northeast and Southwest regions.

On the whole, China's regional financial risks are markedly differentiated, which requires financial regulators to provide differentiated policy guidance to enterprises in different regions and to develop region-specific financial risk prevention measures. For the eastern regions with a high level of economic development, where the financial transaction market is more complete and enterprises are more aware of and capable of preventing and controlling risks, the government can focus its policies on financial innovation, so that enterprises can actively integrate into the international financial market and enhance their international competitiveness; for the less economically developed regions, due to the incomplete development of their capital markets and the small number and scattered distribution of leading enterprises in the industry, enterprises' financing capacity is weak, resulting in the release of risks concentrated in the For less developed regions, due to their poorly developed capital markets, fewer and more scattered industry-leading enterprises, resulting in weak corporate financing capacity, making risks concentrated in the banking market and generally higher non-performing loan ratios of banks; at the same time, the lower average income level of residents in less developed regions, low financial market activity and scattered hotspots, making government revenues sluggish with limited sources and rising debt risks. In response to the differences in financial risks in regional capital markets, capital can be targeted to flow to less developed regions to enhance capital market activity in less developed regions. It provides more vital capital liquidity to diversify risks, thereby maintaining the stability of China's regional economic development and balancing financial risks in the six regions.

References

[1] Wang, Y. & Cao, T. K.. (2017). Spatial correlation of regional financial risk and its contagion effect in China - Based on social network analysis method. Studies in Financial Economics (03), 46-55.

[2] Zhao, Wenju & Zhang, Zenglian. (2022). A study on the dynamics, spatial differences and convergence of regional financial risk distribution in eight integrated economic zones in China. Operations Research and Management (03), 199-206.

[3] Wang, Q., Liu, J. & Jin, Z. Wen. (2018). Correlation analysis of regional financial risk and regional economic growth. Reform(05),66-75.

[4] People's Bank of China Guangzhou Branch Research Group & Peng Huafei. (2021). Research on financial risk prevention and control based on complex network contagion model. Southern Finance (07), 29-39.

[5] Li Yongbo & Wang Xianghong. (2019). Research on risk assessment and prevention of Internet finance based on AHP-FUZZY. Journal of Shanghai Lixin College of Accounting and Finance (01), 42-54. doi:10.13230/j.cnki.jrsh.2019.01.005.

[6] Han, Yang & Zhao, Xinyi. (2021). Research on the dynamic evaluation system of regional coordinated financial development in China - based on factor analysis method and TOPSIS evaluation method. Journal of Shanxi College of Finance and Taxation (04), 19-24.

[7] Qu Jianfeng. (2020). Measurement of financial systemic risk based on comprehensive index method. Friends of Accounting (02), 105-110.

[8] Zhang Shuai. (2021). Evaluation and forecasting of regional financial risks in China based on index method. Friends of Accounting (06), 24-32.

[9] Wu, Kaiya & Jin, Ju-Liang. (2008). An entropy combination weight attribute identification model for regional ecological security evaluation. Geoscience (06), 754-758.

[10] Wang Fuxi, et al. "Measurements of urbanization quality and analysis of spatial differences in Shandong Province based on entropy method." Geographical Sciences 33.11 (2013): 1323-1329. doi:10.13249/j.cnki.sgs.2013.11.006.