

Analysis of regional financial risks in Shenzhen, China

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Abstract. Financial risks are characterized by complexity, concealment, abruptness, infectivity and harmfulness. In the 40 years since the establishment of China's Special Economic Zone, Shenzhen's financial industry has become the third largest financial center on the mainland. At present, the financial industry has developed into one of the four pillar industries in Shenzhen. The significance of this paper is to explore and evaluate the regional financial risks in Shenzhen, and put forward targeted suggestions for Shenzhen's banking, securities and insurance, and real estate markets according to the quantitative results. Based on the annual data of Shenzhen from 2000 to 2020, entropy weight method and CRITIC method are used to determine the weight of grading indicators. This paper proposes three innovative scenarios using Holt Winters three exponential smoothing method to predict data. Finally, the risk scoring system is constructed according to the scenario analysis results, and optimization suggestions are put forward according to the early warning results.

Keywords: Financial risk, CRITIC method, Scenario simulation method, Holt Winters Triple Exponential Smoothing.

1. Introduction

Finance is the core of modern economy, financial security is an important part of a national security, and preventing and defusing financial risks is the eternal theme of financial work. Systematic financial risk can be divided into time dimensions and space dimensions. The time dimension is mainly embodied in the inter-bank market and bond market, while the space dimension is embodied in key areas such as real estate bubbles and local debt problems.

Li and Lin studied the scale and structure of China's national debt by analyzing China's local government debt and non-performing loans of state-owned banks [1]. Taking Poland as an example, Galiński analyzed the economic and financial factors that affected the debt ratio growth of Polish local governments from 1995 to 2013 [2]. Xu Lei and Liu Xiaochuan evaluated the debt default risk of 31 provinces of China based on the KMV model [3]. Li Kaifeng and Li Xing used entropy weight method and comprehensive fuzzy evaluation method to measure the government debt risk of 30 provinces in China [4]. Chadwick and Ozturk selected 14 indicators to construct financial pressure indicators based on five different markets [5]. Guo Na et al. selected 23 indicators to build a financial early warning indicator system and calculated the financial risk [6]. Wang Qing and others built an indicator system for regional financial risk measurement on the basis of CAMELS rating indicators [7]. Caggiano and Greco believe that financial fluctuations have aggravated the impact on the financial situation [8]. Alter and Beyer used VAR model to quantitatively analyze the spillover effect between government debt risk and bank risk in euro countries [9]. Magkonis and Tsopanakis take the G5 economy as an example to evaluate the spillover effect [10].

Based on the annual data of Shenzhen from 2000 to 2020, this paper measures the financial risk of Shenzhen from four aspects: macroeconomic risk, banking risk, securities market risk and real estate market risk. Through scenario simulation analysis, it provides decision-making reference for preventing financial risk of Shenzhen under the impact of real estate market and banking industry.

The innovation of this paper is to combine different markets in Shenzhen and adopt corresponding models to build an evaluation system. The simulation will lead to a single or joint response when there are risks in individual markets. It will put solutions on the government and enterprises, and provide solutions based on the simulation results.

2. Construction of comprehensive evaluation model of financial risk in Shenzhen

2.1. Establishment of index system

Through the summary and induction of the existing literature, this paper intends to build a regional financial risk evaluation index system from the aspects of macro-economy, capital market, bank market and government debt. The macroeconomic indicators initially selected in this paper include GDP growth rate (X1), per capita GDP growth rate (X2), fixed asset investment growth rate/GDP growth rate (X3), CPI growth rate (X4), and industrial output growth rate (X5).

The banking market's business scope covers all levels of the economic and social fields. The bank market indicators initially selected in this paper include non-performing loan ratio (X6), loan balance/deposit balance (X7), and loan growth rate (X8).

The securities and insurance market has become an important area for financial risk transmission. The capital market variables selected in this paper include market value of listed companies/GDP (X9), premium income/GDP (X10), and insurance loss ratio (X11).

The real estate market indicators initially selected in this paper include real estate investment growth rate/fixed asset investment growth rate (X12), real estate investment growth rate/GDP growth rate (X13), housing price growth rate/GDP growth rate (X14).

Table 1. Index System Construction

Primary indicators	Secondary indicators
Macroeconomic indicators	GDP growth rate (X1)
	GDP growth rate per capita (X2)
	Fixed investment growth rate/GDP growth rate (X3)
	CPI growth rate (X4)
	Growth rate of industrial output value (X5)
Banking indicators	Non performing loan ratio (X6)
	Loans/Deposits (X7)
	Loan growth rate (X8)
Securities insurance industry indicators	Market value of listed companies/GDP (X9)
	Premium income/GDP (X10)
	Insurance loss ratio (X11)
Real estate market indicators	Real estate investment growth rate/GDP growth rate (X12)
	Growth rate of real estate investment/Growth rate of fixed asset investment (X13)
	Housing price growth/GDP growth (X14)

2.2. Comprehensive evaluation method

2.2.1 CRITIC method and entropy weight method

CRITIC (Criteria Importance Through Intercriteria Correlation) method and entropy weight method are applicable to closely related indicator systems. Considering that the financial risk indicator system constructed in this paper is hierarchical, CRITIC method is used to determine the

weight of fourteen second level indicators, and entropy weight method is used to determine the weight of four first level indicators.

(1) A Method to Determine the Weights of Primary Indicators Based on Entropy Weight Method

1) Entropy weight method is a mathematical method used to judge the dispersion degree of an index. $p(x_i)$ is the probability of occurrence of each state. Formula (1) measures the degree of disorder of the system, while information entropy measures the degree of order of the system, the absolute values of the two are equal.

2) Quantify all indicators in the same degree, and calculate the proportion P of the i th unit index value under the j index P_{ij} .

3) Calculate the entropy value of index j .

4) Calculate the difference coefficient g of index g_j . Then, conduct normalization.

$$-\sum_{i=1}^n p(x_i) \text{Lnp}(x_i) \quad (1)$$

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^n x_{ij}} \quad (2)$$

$$e_j = -k \sum_{i=1}^n p_{ij} \text{Lnp}_{ij} \quad (3)$$

$$w_j = \frac{g_j}{\sum_{j=1}^m g_j} \quad (j = 1, 2, \dots, m) \quad (4)$$

$$g_j = 1 - e_j \quad (5)$$

(2) CRITIC method is to measure the objective weight of indicators based on the comparative strength of evaluation indicators and the conflict between indicators, taking into account the variability of indicators and the correlation between indicators.

1) Suppose there are n samples to be evaluated and p evaluation indicators to form the original indicator data matrix. Where X_{ij} represents the value of the j th evaluation index of the i th sample.

2) Index variability is expressed in the form of standard deviation. S_j represents the standard deviation of the j th index.

3) Conflict of indicators is expressed by correlation coefficient. r_{ij} represents the correlation coefficient between evaluation indexes i and j .

4) Information volume.

5) Objective weight

$$X = \begin{pmatrix} X_{11} & \cdots & X_{1p} \\ \vdots & \ddots & \vdots \\ X_{n1} & \cdots & X_{np} \end{pmatrix} \quad (6)$$

$$\begin{cases} \bar{x}_j = \frac{1}{n} \sum_{i=1}^n x_{ij} \\ S_j = \sqrt{\frac{\sum_{i=1}^n (x_{ij} - \bar{x}_j)^2}{n-1}} \end{cases} \quad (7)$$

$$R_j = \sum_{i=1}^p (1 - r_{ij}) \quad (8)$$

$$C_j = S_j \sum_{i=1}^p (1 - r_{ij}) = S_j \times R_j \quad (9)$$

$$W_j = \frac{C_j}{\sum_{j=1}^p C_j} \quad (10)$$

2.2.2 Determination of index weight

The weights of the primary and secondary indicators obtained by the CRITIC method and the entropy weighting method can be seen in Table 2.

Table 2. Weighting of risk indicators

	Primary indicators	Weight	Secondary indicators	Weight
Financial Risk Measurement Indicators	Macroeconomic indicators	29.42%	GDP growth rate (X1)	12.84%
			GDP growth rate per capita (X2)	19.41%
			Fixed investment growth rate/GDP growth rate (X3)	33.64%
			CPI growth rate (X4)	12.00%
			Growth rate of industrial output value (X5)	22.11%
	Banking indicators	24.36%	Non performing loan ratio (X6)	53.85%
			Loans/Deposits (X7)	12.97%
			Loan growth rate (X8)	33.19%
	Securities insurance industry indicators	29.60%	Market value of listed companies/GDP (X9)	29.62%
			Premium income/GDP (X10)	58.38%
			Insurance loss ratio (X11)	12.00%
	Real estate market indicators	16.62%	Real estate investment growth rate/GDP growth rate (X12)	32.03%
			Growth rate of real estate investment/Growth rate of fixed asset investment (X13)	46.16%
			Housing price growth/GDP growth (X14)	21.82%

2.2.3 Shenzhen Regional Financial Risk Index Calculation Methodology

Regional financial will accumulate and lead to systemic imbalances in the financial system within the region and gives rise to risks that are typical of the region, bringing about greater regional systemic risks. In simple terms, regional systemic financial risk = financial risk (endogenous) + systemic + regional.

Construct risk indices for each level of indicator.

1) Macroeconomics Risk Index (MRI)

$$MRI_t = \omega_{X1}X1_t + \omega_{X2}X2_t + \omega_{X3}X3_t + \omega_{X4}X4_t + \omega_{X5}X5_t \tag{11}$$

MRI is a risk index that integrates GDP growth rate, GDP per capita growth rate, fixed investment growth rate/GDP growth rate, CPI growth rate and industrial output growth rate. ω_{X1} , ω_{X2} , ω_{X3} , ω_{X4} , ω_{X5} represent the relative weights of each of the five components in the formula.

2) Bank Risk Index (BRI)

$$BRI_t = \omega_{X6}X6_t + \omega_{X7}X7_t + \omega_{X8}X8_t \tag{12}$$

The BRI is a composite risk index reflecting the non-performing loan ratio, loans/deposits and loan growth rate. ω_{X6} , ω_{X7} and ω_{X8} represent the respective weights of the three components in the formula.

3) Securities and insurance Risk Index (SIRI)

$$SIRI_t = \omega_{X9}X9_t + \omega_{X10}X10_t + \omega_{X11}X11_t \tag{13}$$

SIRI is a risk index that combines the market capitalisation of listed companies/GDP, premium income/GDP and insurance payout ratio. ω_{X9} , ω_{X10} , ω_{X11} denote the weights of the three individual characters in the formula.

4) Real Estate Market Risk Index (REMRI)

$$REMRI_t = \omega_{X12}X12_t + \omega_{X13}X13_t + \omega_{X14}X14_t \tag{14}$$

REMRI is a risk index that integrates the growth rate of real estate investment/GDP, the growth rate of real estate investment/fixed asset investment and the growth rate of housing sales price/GDP. ω_{X12} , ω_{X13} and ω_{X14} represent the respective weights of the three components in the formula.

In summary, the Financial Risk Index (FRI) for Shenzhen is constructed using the formula:

$$FRI_t = W_1MRI_t + W_2BRI_t + W_3SIRI_t + W_4REMRI_t \quad (15)$$

FRI is a risk index that integrates macroeconomic risk, banking sector risk, securities and insurance sector risk and real estate market risk. W_1 , W_2 , W_3 and W_4 represent the respective weights of the three components in the formula.

3. Results

3.1. Shenzhen Regional Financial Risk Evaluation Index Calculation Results

To evaluate financial risks in Shenzhen in a more comprehensive and objective manner, it is necessary to judge the financial risk situation of each influencing segment. Table 3 shows the financial risk indices of each market and the comprehensive financial risk index.

Table 3. Risk index measurement results

Year	Macroeconomic Risk Index (MRI)	Macroeconomic Risk Index (MRI)	Macroeconomic Risk Index (MRI)	Macroeconomic Risk Index (MRI)	Macroeconomic Risk Index (MRI)
2001	1.575131684	5.773764246	4.883920562	7.406068808	4.546421834
2002	2.991659015	4.999512079	5.023925796	1.094107879	3.76694999
2003	3.149152043	3.927990575	5.239330365	0.326066881	3.488373139
2004	3.002118304	4.016809409	4.708109326	0.344674102	3.312603173
2005	2.46589511	3.394039542	4.645833934	-0.009423826	2.925854978
2006	2.732149071	2.884665089	4.868981886	1.021845394	3.117552015
2007	2.797705136	2.096233572	6.459974464	0.712392013	3.364279343
2008	2.851636693	0.681706561	5.525141186	0.501152761	2.557165436
2009	1.544291741	0.619300989	5.85085345	0.241413529	2.377167901
2010	3.088739175	0.501664156	5.232486114	0.797460224	2.712266232
2011	3.182899001	0.469269227	5.055295516	1.406087362	2.780782062
2012	2.372010236	0.568734104	5.39488832	2.486926586	2.846603181
2013	2.212893477	0.610405382	5.438616723	2.131421831	2.76380087
2014	1.879016764	0.700360209	5.94867961	1.839050268	2.789873798
2015	2.278348877	0.962655364	6.142276047	2.233272353	3.094076661
2016	2.533430711	1.110862492	6.190787776	2.240504569	3.22078646
2017	2.451232578	1.01472426	6.361004207	1.125644149	3.038278757
2018	2.261485156	0.972947247	7.048587263	1.784433325	3.285293531
2019	2.224633356	0.897899516	7.027216009	1.239475661	3.159272249
2020	1.699587948	0.73533334	7.247805848	3.154553286	3.348783263

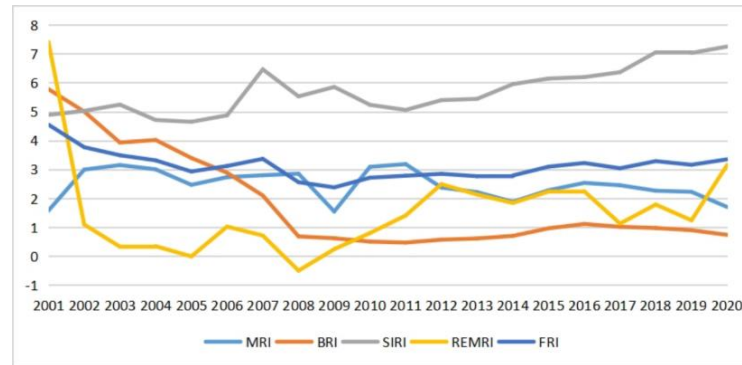


Figure 1. Trend forecasts for the Sector Risk Index and the Financial Risk Composite Index

Figure 1 shows that securities and insurance risks have been at a high level, while macroeconomic risks and banking risks are on a downward path, and real estate market risks began to gradually rise after 2008, overall financial risks are in a more stable range.

3.2. Multi-scenario-based forecasting of the Shenzhen Financial Risk Index

3.2.1 Scenario setting

Based on the multiple possibilities of financial risk formation, this paper has designed different scenarios for financial risk early warning, namely the smooth running, real estate market risk shock and banking sector risk shock scenarios.

Scenario 1: Smooth running of the economy. Assuming that the economy is not affected by any "black rhinoceros" or "black swan" events in the future, the financial risk profile of Shenzhen is simulated for the next ten years based on the existing economic conditions and the degree of influence of risk factors.

Scenario 2: Real estate market risk shock scenario. Shenzhen has a large number of foreign immigrants and a large population, resulting in a high demand for housing and a tight supply of real estate. Therefore, commercial banks will naturally enter the real estate sector and try to put in more financing funds.

Scenario 3: Banking sector risk shock scenario. Banking risks have a "transmission effect". Commercial banks are particularly important in Shenzhen's financial sector, so banking sector risk is one of the key influencing factors of financial risk in Shenzhen.

3.2.2 Multi-scenario Shenzhen Financial Risk Forecasting

(1) Smooth running scenario

Using the Holt-Winters triple exponential smoothing technique, an Excel forecast worksheet with a confidence level of 95%, a forecast timeline starting in 2020 and a forecast end date of 2030, the forecast results can be obtained as shown in Figure 5.

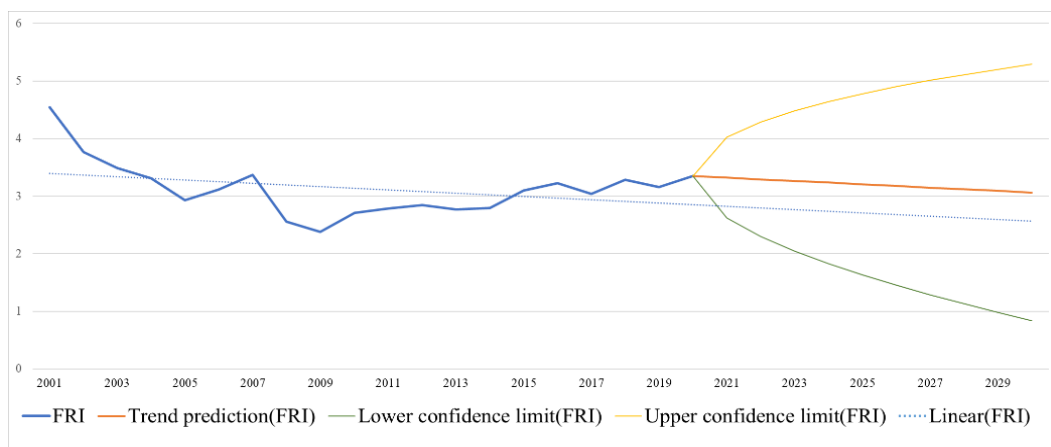


Figure 2. Forecast results under smooth running

From Figure 2, Shenzhen's overall financial risk is in a more stable range, and the trend line shows that Shenzhen's overall financial risk is in a slow declining process over the next 10 years.

(2) Real estate market risk shocks

Risk shock approach: house price growth is much greater than GDP growth high house prices bring asset appreciation faster than wage growth; real estate investment growth is much greater than GDP on other industries causing crowding out effect. The REMRI was forecasted and the upper limit of its confidence interval, and the simulation forecast results are shown in Figures 8 and 9 below.

(3) Banking sector risk shocks

Risk shock approach: A high loan-to-deposit ratio implies insufficient bank reserves; a high non-performing loan ratio will result in increased bank losses. The banking sector risk shock simulations were using the same methodology, with the BRI forecasted and the upper limit of its confidence interval, and the simulation forecasts are shown in Figure 3 and Figure 4 below.

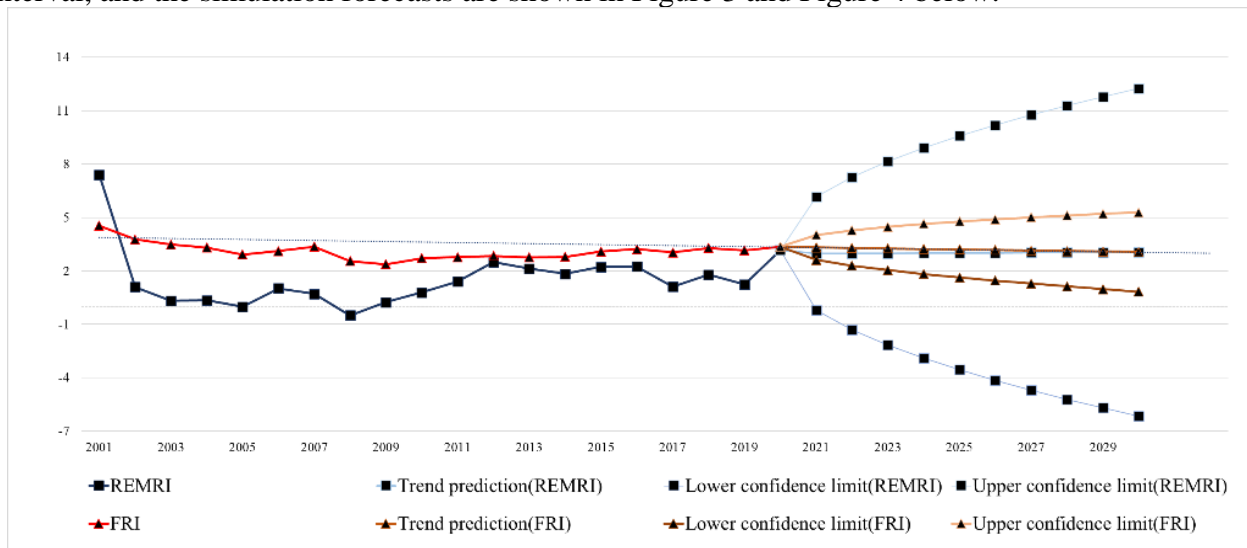


Figure 3. Results of REMR and BRI analysis

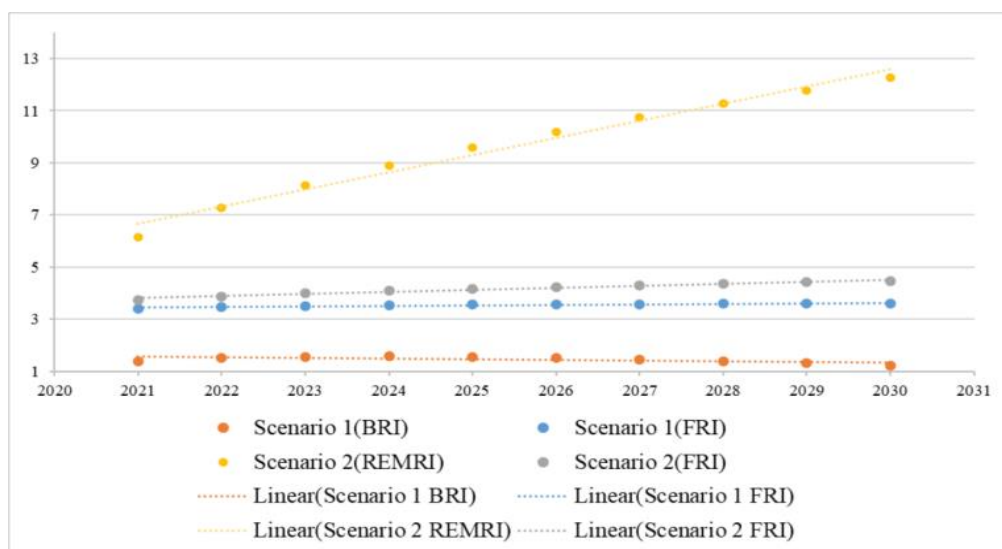


Figure 4. Linear relationship between FRI and REMRI under real estate market and banking sector risk shocks

3.2.3 Policy suggestions on risk prediction results in Shenzhen

Based on the results of the calculations, the financial risk measurements for the different scenarios are shown in Figure 5.

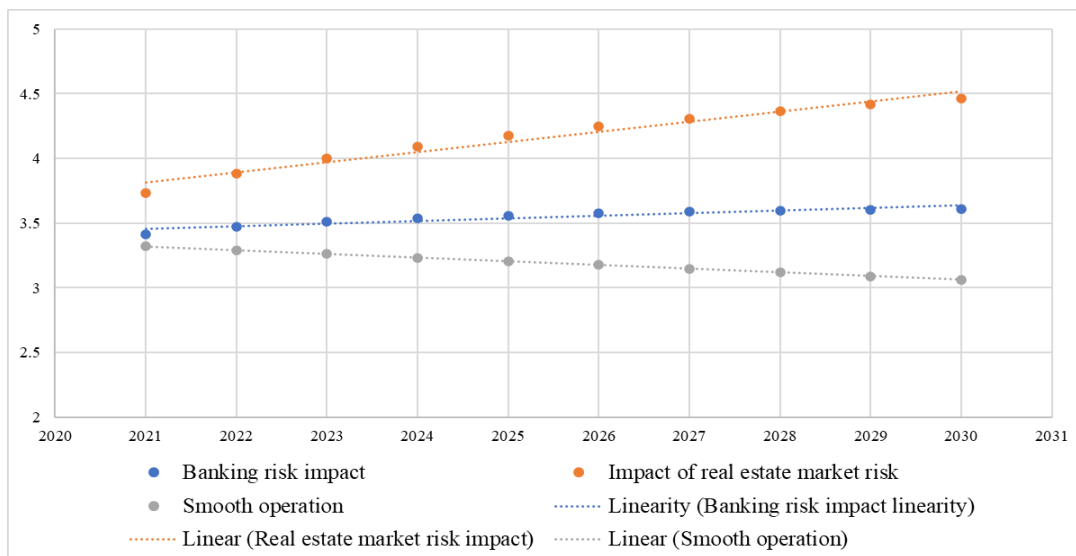


Figure 5. FRI scenarios under three scenarios

Recommendation one, verify and properly deal with the debts of financing platform companies, delineate the functions of financing platforms, conduct ex-ante review of the departments; conduct strict review of the financing practices of local financing platforms and outlaw irregular capital injections.

Recommendation two, local governments should establish criteria to receive fiscal reserves; strengthen the supervision of financial institutions and judge; improve their fiscal strength to delay the best period of bailout for financial institutions, which in turn may cause systemic financial risks.

Recommendation three, local governments should control the scale and intensity of investment in the real estate sector, cultivate new economic growth points and encourage the housing rental market; financial institutions should prudently examine the flow of funds to real estate and strictly control the scale of credit.

Recommendation four, enterprises can borrow from banks, and to raise funds from society. In addition, state-owned enterprises should be required to provide information on their operating conditions, solvency and profitability when taking out loans from banks, in order to defuse the risks arising from information asymmetry.

4. Conclusions

This paper summarizes and combs the relevant research results of systematic financial risk monitoring and early warning. From four aspects of the banking market, the real estate market, the stock market and the macro market, an evaluation system of 14 indicators was established. The entropy weight method and CRITIC method were used to determine the indicators and market weights, and the comprehensive index evaluation system of Shenzhen's systemic financial risk from 2000 to 2020 was calculated. According to the demand of systematic financial risk early warning, analyze the systematic financial risk early warning mechanism in different scenarios. Based on the three scenarios set in this paper, the suggestions are as follows:

(1) Rectify local financing platforms. At present, China has not yet formed an effective local financing platform specification and management system. Once insolvent, debt risk will be transferred to the financial field. Therefore, local financing platforms must be standardized and rectified.

(2) Establish a financial reserve system. When financial risks occur, local governments will provide financial support to financial institutions that are about to go bankrupt or close down, which will expand the government's fiscal gap, thus causing debt risks.

(3) Prevent real estate bubbles. The real estate bubble is the inducement of regional financial risks. In order to ensure economic development, local governments also need to maintain the healthy development of the real estate industry.

(4) Standardize the relationship between banks and enterprises. Enterprises are the main credit objects of banks. We should build a hard constraint mechanism for debt and creditor's rights between banks and enterprises, and broaden the financing channels of enterprises.

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