Identification and Analysis of Core Factors of Fintech Based on CRITIC-ANP

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ABSTRACT

Identifying the core factors of financial technology is of great significance to the research and development direction of financial technology. This paper selects the data of inclusive financial index of 21 indicators in China from 2011 to 2020 and divides them into three levels according to the correlation of indicators. Criteria Importance weights the above indicators through the Intercriteria Correlation (CRITIC) method and the Analytic Network Process (ANP) method. Combined with the minimum entropy theorem, the two methods are coupled to obtain the global weight of each indicator and then rank to obtain the core factors of financial science and technology. The study found that digitization has the largest coupling weight among all indicators, accounting for 14.62 %, followed by the five indicators: regional scientific research level, opening level, total index, China's debt service ratio, and regional urban registered unemployment rate. Based on the above research conclusions, this paper proposes policy recommendations for the core factors of integrated financial technology to China's economic development and the research and promotion of financial technology.

Keywords: *Fintech, CRITIC, ANP, The minimum entropy theorem*

1. INTRODUCTION

Under the impetus of fintech, the cross-border integration of finance and science and technology has produced revolutionary results, spawning new financial formats such as intelligent finance and providing future development directions for financial supply-side structural reform and financial risk prevention and resolution. Therefore, it is necessary to study financial science and technology. Identifying and analysing the core factors in fintech is of great significance to the future research and development direction of financial science and technology. At present, there are few studies on this aspect.

Liu, C et al.[1] proposed a synthetic algorithm RF-GA-DNN based on artificial intelligence, including Random Frog algorithm (RF), Genetic Algorithm (GA), and Deep Neural Networks (DNN). The proposed RF-GA-DNN prediction algorithm filters the key input variables and optimizes the DNN hyperparameters to predict the financial technology index. Deng, X et al.[2] proposed sustainability evaluation index system based on peer-to-peer (P2P) platform data of 31 provinces in China, analyzed the relationship between financial technology and sustainable development and analyzed the optimal index system of sustainable development. Emara, N et al.[3] assessed annual data for the period 2004-2018 using the Generalized System Method of Moments (GMM) panel estimation method, using a digital composite measure that includes Fintech agents commonly used. Coffie, C. P. K. et al.[4] studied the prominent role of mobile payment in promoting financial accessibility of sub-Saharan Africa by traditional banks through cross-sectional dependence (CD) tests, panel unit root test, panel cointegration test, and the fully modified ordinary least squares (FMOLS). This paper examines the impact of digitization as a proxy for financial technology on remittance inflows from 34 developed and developing country samples.

Many previous studies have achieved some results, but the core indicators of financial science and technology are not pointed out. Only some relevant indicators are selected for analysis, and there is no clear way to evaluate them. Criteria Importance Through Intercriteria Correlation (CRITIC) method is an objective weight weighting method, which considers the influence of index variation and its conflict on weight. Analytic Network Process (ANP) is a subjective weighting method formed by the gradual development of the Analytic Hierarchy Process (AHP). In this paper, CRITIC and ANP are coupled and weighted by the minimum entropy theorem, and the subjective weighting method and the objective weighting method are combined. Starting from the two methods, the structure is more complex, but the results are persuasive. Finally, combined with the data of the Digital Inclusive Financial Index (DIFI) of Peking University and the China National Bureau of Statistics, the core factors of financial science and technology are analyzed and identified to obtain the key core factors.

2. THE IMPORTANCE OF IDENTIFYING FINTECH FACTORS

Fintech refers to various scientific and technological means to innovate the products and services provided by the traditional financial industry, improve efficiency, and effectively reduce operating costs. The technologies involved have the characteristics of fast updating, cross-border, and mixed industry, which mainly include four core parts: big data finance, artificial intelligence finance, blockchain finance, and quantitative finance. Science and technology finance refers to the complementary relationship between science and technology and finance. Finance promotes the development of science and technology, and the progress of science and technology also increases the depth and breadth of finance. With the development of science and technology, the information age has come rapidly. The trading tools and trading methods of the financial industry have been greatly innovated. The speed of information circulation has also been accelerated due to the arrival of the network era. Securities trading is much more convenient, and securities trading is gradually moving towards globalization. At the same time, the financial system uses various financing channels to meet the needs of science and technology enterprises for funds. Its unique functions of providing liquidity, risk diversification, and price discovery are also beneficial to developing science and technology innovation.

3. INTRODUCTION OF FINTECH INDEX SYSTEM

This paper selects the data of the Digital Inclusive Financial Index (DIFI) of Peking University and China National Bureau of Statistics for analysis. China's digital inclusive finance index can effectively reflect the development of inclusive digital finance in various regions. The development index system of inclusive digital finance in China was developed by the Digital Finance Research Center of Peking University, Shanghai New Finance Research Institute, and the Joint Research Group of Ant Financial Services Group. Using the microdata of inclusive digital finance from Ant Financial Services, a representative Internet financial institution in China, the digital inclusive finance index system covering 31 provinces, 337 prefecture-level cities, and about 2800 counties in mainland China was obtained[5].

According to the summary of related research on Inclusive Finance, its concept can be defined from two levels.

1) At the basic concept level, in 2015, the State Council of China issued the “Plan for Promoting the Development of Inclusive Finance (2016 – 2020)”, pointing out that inclusive finance refers to providing appropriate and effective financial services for all sectors and groups of society with financial services needs at affordable costs based on the requirements of equal opportunities and the principle of commercial sustainability. On this basis, Xing Yan proposed the '5 + 1 definition method', which summarized inclusive finance as one of the five core elements to meet availability, comprehensiveness, convenience, security and price rationality, and financial services for specific service objects.

2) At the theoretical concept level, the theoretical concept of inclusive finance is the extension and deepening of the basic concepts. Inclusive finance is an economic theory that studies financial development and the distribution of financial well-being. It jumps out of the limitation of the basic concept that only focuses on financial services. From the perspective of fair distribution of financial products and financial well-being, it takes a variety of financial theories such as financial structure and financial repression as theoretical sources. It takes the rationality of the distribution of financial well-being as the core indicator to analyze and evaluate the evolution path of financial development and its “advantages and disadvantages”[6].

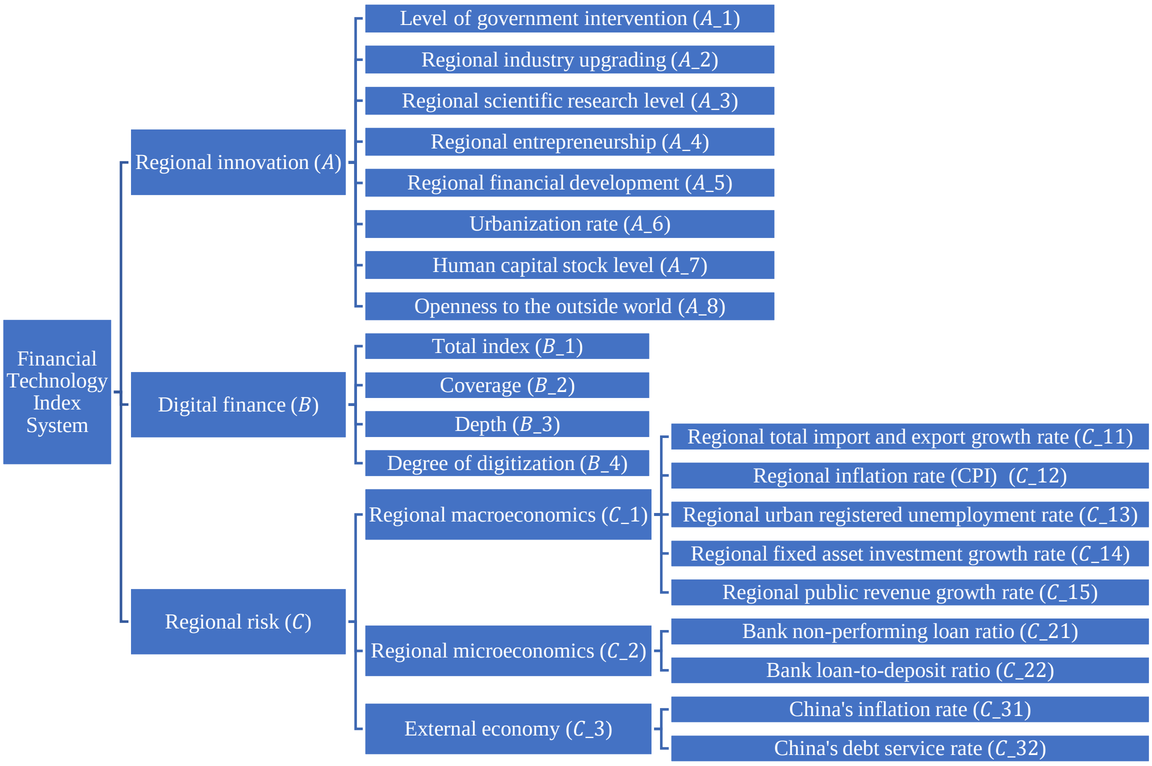

Figure 1 Fintech index system framework

4. CONSTRUCTION OF CRITIC-ANP WEIGHTING METHOD

4.1 Construction of CRITIC Weighting Method

Criteria Importance Through Intercriteria Correlation (CRITIC)is an objective weighting method proposed by Diakoulaki. Its basic idea is to determine the objective weight of the index based on two basic concepts. One is the contrast strength. It represents the size of the value gap of each evaluation scheme in the same index, in the form of standard deviation, that is, the size of the standardization difference shows the size of the value gap of each scheme in the same index, the greater the standard deviation, the greater the value gap of each scheme. Second, the conflict between evaluation indicators, the conflict between indicators is based on the correlation between indicators, such as the strong positive correlation between the two indicators, indicating that the conflict between the two indicators is low. The general process is as follows:

Step1: Normalization

$$A=\frac{a_{ij}}{\sqrt{\sum_{i=1}^{m}a_{ij}^{2}}} \qquad (1)$$

$$\sigma_j=\sqrt{\frac{1}{m}\sum_{i=1}^{m}\left(a_{ij}-\overline{a}_j\right)} \qquad (2)$$

$$\rho_{ij}=\frac{cov\left(A_i,A_j\right)}{\sigma_i\sigma_j} \qquad (3)$$

Formula (1-3): σ_j is the standard deviation of the j^{th} evaluation index; $\overline{a_j}$ is the mean of the j^{th} evaluation index; ρ_{ij} is the correlation coefficient between the i^{th} evaluation index and the j^{th} evaluation index; $cov\left(A_i,A_j\right)$ is the covariance of a column i^{th} and j^{th} a standard matrix A.

Step2: The calculation of information quantity

Information content of each index

$$I_j=\sigma_j\sum_{i=1}^{n}\left(1-\rho_{ij}\right) \qquad (4)$$

Step3: Calculation of weight coefficient

$$w_{CRI}=w_j=\frac{I_j}{\sum_{j=1}^{n}I_j} \qquad (5)$$

4.2 Construction of ANP Weighting Method

Step1: Construct the ANP network structure, and compare the importance of each element under this criterion by the Saaty Scaling Law according to the given criterion.

Table 1 Saaty Scaling Law

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and judgment slightly favour one over the other.
5	Much more important	Experience and judgment strongly favour one over the other.
7	Very much more important	Experience and judgment very strongly favour one over the other.
9	Absolutely more important	The evidence favouring one over the other is one of the highest possible validities.
2,4,6,8	Intermediate values	When compromise is needed.

Step2: Construct a supermatrix whose role is to determine the degree of interaction between elements under the sub-criteria. The normalized feature vector is calculated and tested for consistency, and finally, a supermatrix W is obtained.

$$W=\begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ w_{21} & w_{22} & \cdots & w_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ w_{n1} & w_{n2} & \cdots & w_{nn} \end{bmatrix} \quad (6)$$

Step3: Construct a weight matrix whose role is to determine the degree of influence between element sets.

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (7)$$

Step4: Construction of weighted supermatrix $\bar{W}$

$$\bar{W}=\begin{bmatrix} a_{11}w_{11} & a_{12}w_{12} & \cdots & a_{1n}w_{1n} \\ a_{21}w_{21} & a_{22}w_{22} & \cdots & a_{2n}w_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1}w_{n1} & a_{n2}w_{n2} & \cdots & a_{nn}w_{nn} \end{bmatrix} \quad (8)$$

Step5: Finally, the global weight vector Q of each index is obtained

$$w_{ANP}=Q=q_1,q_2,\cdots,q_n \quad (9)$$

4.3 Coupling Weights

After obtaining subjective weight w_{CRI} and objective weight, the minimum entropy theorem is used to combine them.

$$W=\frac{w_{CRI}w_{ANP}}{\sum w_{CRI}w_{ANP}} \quad (10)$$

5. AUTHENTIC PROOF ANALYSIS

5.1 Overview of Research Indicators

This paper selects the data of the Digital Inclusive Financial Index (DIFI) of Peking University and China National Bureau of Statistics for analysis. Respectively statistics the level of government intervention, regional industry upgrading, regional scientific research level, regional entrepreneurship, regional financial development, urbanization rate, human capital stock level, openness to the outside world, total index, coverage, Depth, degree of digitization, regional total import and export growth rate, regional inflation rate (CPI), regional urban registered unemployment rate, regional fixed asset investment growth rate, regional public revenue growth rate, bank non-performing loan ratio, bank loan-to-deposit ratio, China's inflation rate, and China's debt service rate of 21 indicators from 2011 to 2020 is nearly a decade of data analysis. The thermal diagram is displayed after the dimensionless of some data.

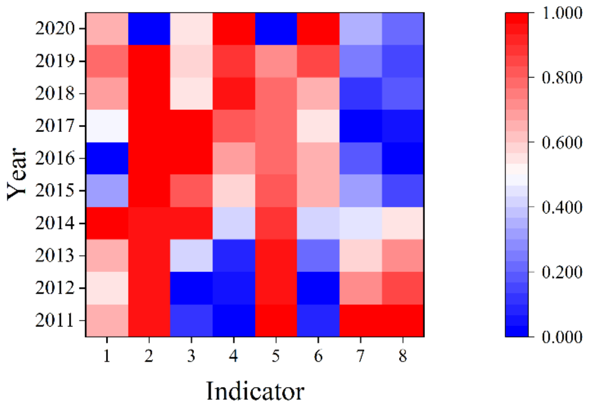

Figure 2 Thermal diagram after dimensionless data

5.2 Core Factor Identification

According to the classification of each index in Section 3 and the importance of each factor given by experts, the ANP network structure is determined.

Table 2 ANP Network Structure

(a)

A	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8
A_1	1	3	5/11	5/4	4	5	3	1/2
A_2	1/3	1	1/7	1/6	4/3	5/3	2	1/5
A_3	11/5	7	1	7/2	9	7	4	7/3
A_4	5/4	6	2/7	1	5	3	1/3	1/2
A_5	1/4	3/4	1/9	1/5	1	5/4	3/4	1/8
A_6	1/5	3/5	1/7	1/3	4/5	1	1/3	1/5
A_7	1/3	1/2	1/4	3	4/3	3	1	1/2
A_8	2	5	3/7	2	8	5	2	1

(b)

B	B_1	B_2	B_3	B_4
B_1	1	2	3	1/2
B_2	1/2	1	2	1/4
B_3	1/3	1/2	1	1/4
B_4	2	4	4	1

(c)

C	C_1	C_2	C_3
C_1	1	3	2
C_2	1/3	1	2/3
C_3	1/2	3/2	1

(d)

C_1	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_{11}	1	1/2	1/3	2	3
C_{12}	2	1	2/3	4	5
C_{13}	3	3/2	1	5	6
C_{14}	1/2	1/4	1/5	1	3/2
C_{15}	1/3	1/5	1/6	2/3	1

(e)

C_2	C_{21}	C_{22}
C_{21}	1	2
C_{22}	1/2	1

(f)

C_3	C_{31}	C_{32}
C_{31}	1	1/2
C_{32}	2	1

According to the above weighting method, the correlation coefficient matrix is constructed to obtain the weight w_{CRI} of each index, which is coupled with w_{ANP} to obtain the coupling weight of CRITIC-ANP, as shown in Table 3 and Figure 3 (a) – (e).

Table 3 CRITIC-ANP coupling weight

1st-level indicator	2nd-level indicator	3rd-level indicator	CRITIC	ANP	CRITIC-ANP
A	A_1		0.043	0.048	0.044
	A_2		0.056	0.019	0.022
	A_3		0.049	0.105	0.109
	A_4		0.048	0.042	0.042
	A_5		0.055	0.011	0.013
	A_6		0.039	0.010	0.009
	A_7		0.057	0.032	0.039
	A_8		0.070	0.066	0.098
B	B_1		0.039	0.090	0.075
	B_2		0.040	0.049	0.041
	B_3		0.039	0.031	0.026
	B_4		0.042	0.164	0.146
C	C_1	C_{11}	0.044	0.028	0.026
		C_{12}	0.054	0.054	0.061
		C_{13}	0.041	0.075	0.065
		C_{14}	0.053	0.015	0.016
		C_{15}	0.033	0.011	0.007
	C_2	C_{21}	0.048	0.040	0.041
		C_{22}	0.049	0.020	0.021
	C_3	C_{31}	0.050	0.030	0.032
		C_{32}	0.052	0.061	0.066

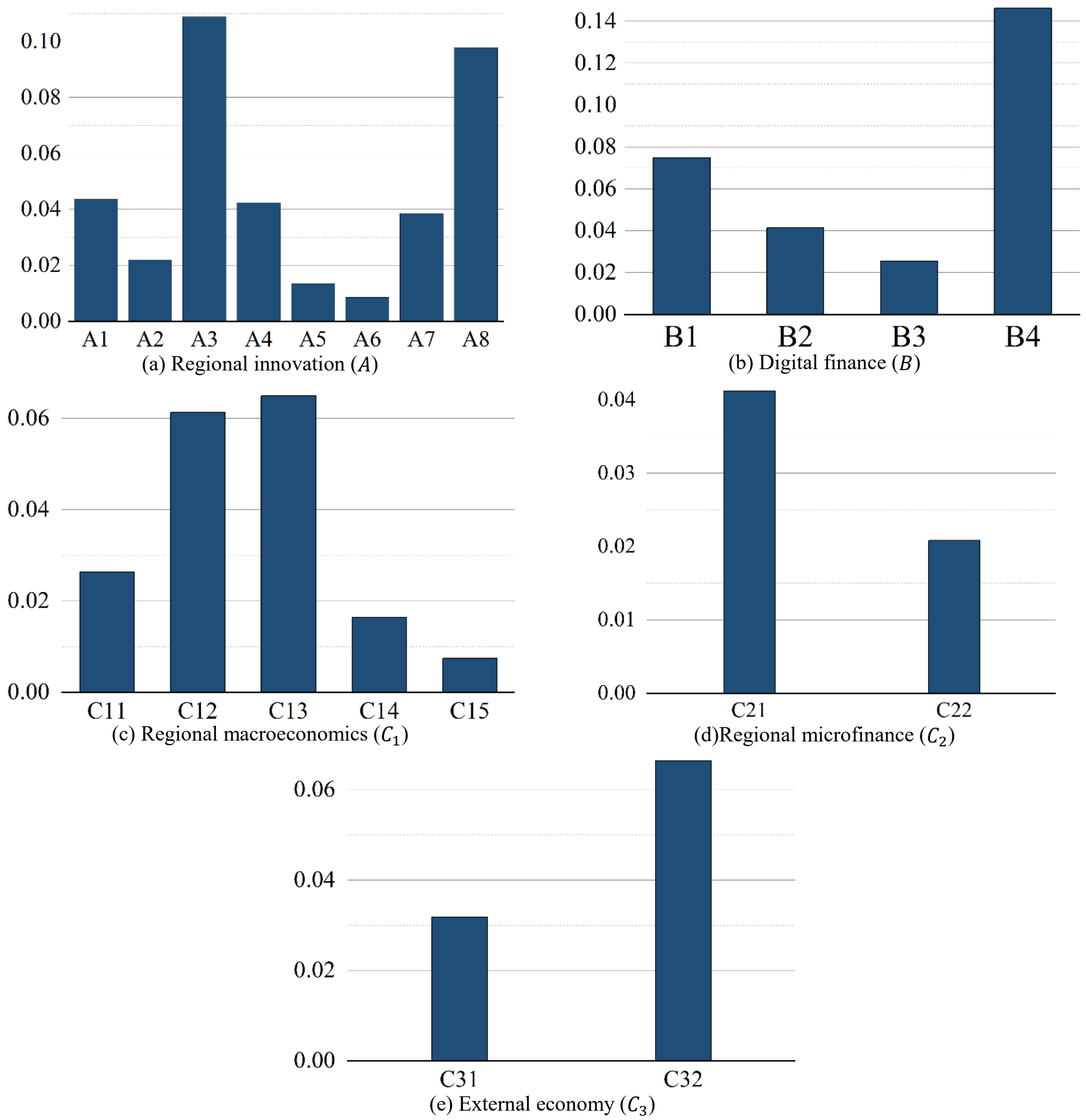

Figure 3 CRITIC-ANP coupling weight

In Table 3, the degree of digitization (B_4) has the largest coupling weight among all indicators, accounting for 14.62%. Similarly, the following five indicators are: the regional scientific research level (A_3), the openness to the outside world (A_8), the total index (B_1), China's debt service rate (C_{32}), and regional urban registered unemployment rate (C_{13}), and their weights are 10.89 %, 9.78 %, 7.49 %, 6.64 %, and 6.49 %, respectively. It can be seen from Figure 3 that among regional innovation (A), regional scientific research level (A_3) is the highest; in digital finance (B), the degree of digitalization (B_4) is the highest; regional urban registered unemployment rate (C_{13}) is the highest among regional macroeconomics (C_1); in the regional microeconomics (C_2), the bank non-performing loan ratio (C_{21}) is the highest; in the external economy (C_3), China's debt service rate (C_{32}) is the highest.

The weight of degree of digitization ranks first, which shows that digitization plays a vital role for both Chinese residents and Chinese enterprises. The regional scientific research level has the greatest impact on regional innovation, indicating that the development of a region's scientific research level will improve the innovation ability of the region. In the regional risk sector, China's debt service rate is the most important. The debt service rate is an important indicator to analyze and measure the scale of foreign debt and a country's solvency. The debt service rate is related to the countries and closely related to the individual residents.

5.3 Conclusion and Future Work

a) Due to the highest proportion of the degree of digitization, it is necessary to improve the construction of digital information infrastructure, continuously narrow the information availability gap and gradually narrow the digital divide. Meanwhile, it is used to strengthen the dissemination of the new consumption concept of elderly residents and accelerate their acceptance of new ideas and new technologies. Internet platform institutions are encouraged to participate in digital financial innovation, provide more high-quality financial services and products for residents, and promote a substantial increase in household consumption.

b) Strengthen the combination of digital finance and the real economy, accelerate the process of digital finance from virtual to real, and promote the development of digital finance to serve the real economy. Only with the high-quality and rapid development of the real economy can digital finance achieve long-term and stable development.

c) Digital finance has the economic effect of reducing corporate leverage, enriching current policy tools for steady growth, and deleveraging. We should increase investment in digital network hardware facilities, promote the construction of digital China, and then reduce the leverage ratio of enterprises through digital finance as an alternative to traditional credit.

d) From the perspective of regional economics, against the background of the current global economic downturn, the ongoing epidemic of COVID-19, and the continuous occurrence of corporate defaults, we should strengthen regional market-oriented construction, increase investment in network hardware, improve the digital network environment, promote financial development, and joint development of the digital economy and Fintech, thereby reducing the risk of corporate debt default and promoting high-quality economic development.

6. CONCLUSIONS

In this paper, the core factors of Fintech are studied. The minimum entropy theorem couples the CRITIC objective weighting method and ANP subjective weighting method to obtain a recognition method of the core factors of Fintech. The CRITIC weight is obtained by using the regional financial index as the data, and then a supermatrix is constructed by sorting out the relative importance of each index by the collected experts to obtain the ANP weight. Finally, the minimum entropy theorem combines the two to obtain the final weight and sort them to identify the core factors. The conclusions are as follows:

(1) The model is applied to China, and 21 indicators are selected, including the level of government intervention, regional industry upgrading, regional scientific research level, regional entrepreneurship, regional financial development, urbanization rate, human capital stock level, openness to the outside world, total index, coverage, Depth, degree of digitization, regional total import and export growth rate, regional inflation rate (CPI), regional urban registered unemployment rate, regional fixed asset investment growth rate, regional public revenue growth rate, bank non-performing loan ratio, bank loan-to-deposit ratio, China's inflation rate, and China’s debt service rate. The core factors of the data from 2011 to 2020 are identified. The results show that the degree of digitization, the regional scientific research level, the openness to the outside world, the total index, China’s debt service rate, and the regional urban registered unemployment rate are relatively high.

(2) At the same time, CRITIC and ANP are used to identify the core factors, and it can be obtained that subjective weighting (ANP) is susceptible to the overall influence, showing the subjective extremum phenomenon; objective weighting (CRITIC) may lead to conservative evaluation results and insensitive response to various indicators; the coupling weight can effectively combine the subjective and objective weighting and avoid weaknesses, and has more reasonable evaluation results for different regions.

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