Analysis and Research on the Synergism Between Financial Risks and Digital Finance--A Case Study of Wuhan

Jiahua Tian [1], Jing Xu [2], Zhitao Zhang [3,*]

[1] *School of Economics & Management Northwest University Xi'an，China*
[2] *School of Management Science and Engineering Dongbei University of Finance and Economics Dalian，China*
[3] *College of Science Yanbian University Yanbian University Yanji，China*
*Corresponding author: zhangzhitao0823@163.com

Abstract

Digital finance is the integration of Internet information technology and the traditional financial service industry, which has greatly changed the operation mode of traditional finance. However, it also brings a big challenge of financial risk. This paper starts from the two subsystems of regional financial risk and digital inclusive financial index, based on selected order parameters data of Wuhan from 2010 to 2020. Uses the Criteria Importance Through Intercriteria Correlation (CRITIC) weighting method to weight the order parameter order degree of the two subsystems, constructs the synergy degree evaluation model of regional financial risk and digital finance and hybrid system, explores its evolution law and development trend. The results show that the synergy degree of the composite system presents a W-shaped development trend, which is at a low level of synergism.

Keywords: Digital Finance; Financial Risk; Synergy; CRITIC

1. Introduction

With the rapid development of modern information technology, Internet digital technology has gradually penetrated and applied to all walks of life. Digital finance has emerged under the organic combination of the traditional financial industry and new digital technology. With advanced digital technologies such as artificial intelligence, big data, blockchain, and cloud computing, digital finance has low cost, high coverage, efficiency. Moreover, it injects strong impetus to the high-quality development of finance and even the economy. As an essential direction of financial development, digital finance is in continuous development and improvement. There will be many financial risks different from those generated by traditional finance as well. Therefore, to prevent the high contagion of these financial risks from leading to systemic financial risks, it is of great significance to always pay attention to and analyze digital financial risks.

At present, many scholars gradually turn their research horizons to digital finance, and the advantages of digital technology applications in the financial industry are generally shared by scholars. Classers and others [1] point out that digital finance has greatly influenced the structure and competitive model of the financial services industry, and reforms are needed from four perspectives: safety and soundness, competition policy, investor and consumer protection, and global public policy to reduce risks and reap benefits respectively. Lee [2] explores how digital finance has impacted financial services, products, operations. At the same time, he has increased the flexibility and efficiency of existing financial services.

The development of digital finance has brought about newer and more complex financial risks. Many scholars have researched the link between digital finance and financial risks, and the assessment system of financial risks brought by digital finance has been studied in different directions. Wang and others [3] argue that the development of digital finance has given rise to asymmetries in the size and quality of data, technology, management, utility, externalities, and regulation, also analyzes the characteristics of data asymmetry and its adverse consequences on the market, and puts forward suggestions for governance. Liu and Liu [4] uses factor analysis based on risk classification and generalization.

The factor analysis method is used to construct a comprehensive index model of digital financial risk and analyze the influencing factors. Tian [5] argues that digital technology plays an essential role in promoting commercial banks. While promoting the development of inclusive financial services of commercial banks, digital technology has also expanded the risk potential, such as the security of customer funds.

It can be seen from the above literature that many scholars have conducted extensive research on the field of regional financial risk and digital finance, but the relationship between the two remains to be addressed. The linkage between the two remains to be provided. Most of the current studies attribute the risks posed by digital finance to systemic financial risks and seldom clarify the link between the financial risks posed by digital technologies. The link between financial risks arising from digital technologies is rarely clarified. Therefore, this paper will consider two subsystems of regional financial risk and digital finance and consider the large-scale new coronary risk in Wuhan in 2020. Therefore, this paper will study the impact of external factors on financial risk from two subsystems: regional financial risk and digital finance, taking into account the economic impact of the large-scale outbreak of novel coronavirus in Wuhan in 2020. The CRITIC method derives the order degree of the two subsystems and constructs a synergy degree evaluation model of the regional financial risk and digital inclusive financial index complex system. Explore its evolution pattern and development trend.

2. Synergy degree analysis

Synergy refers to the nonlinear interaction between subsystems with common law, from disorder to orderly and benign development. It is understood that inclusive digital finance integrates traditional finance and digital science and technology within a specific range. Furthermore, regional financial risks are regional restrictions based on financial risks. This article regards regional financial risks and digital inclusive financial index as a hybrid system, and the synergism between the two is shown in Figure 1.
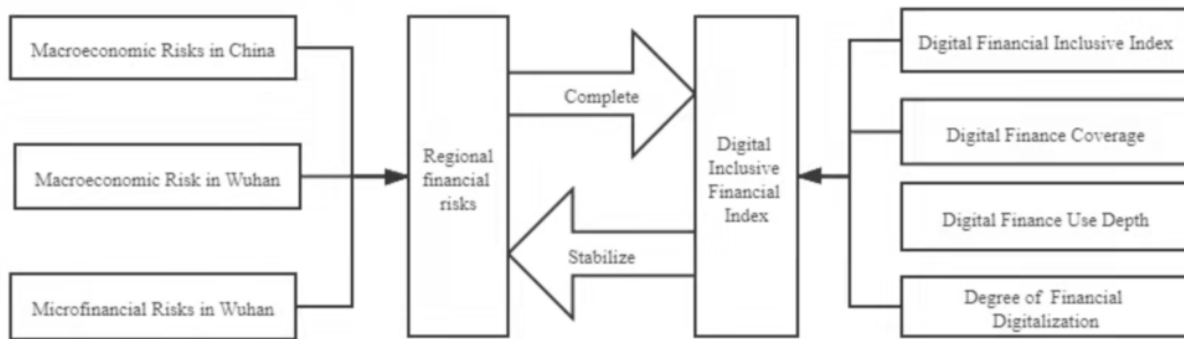

Figure 1 synergism between regional financial risk and digital inclusive financial index

3. Synergy degree evaluation model

3.1. Determine the order parameters

Synergetics believes that the order parameter describes the system order degree and represents the macroscopic state of the system during its movement and plays a decisive role in the final structure and order degree of the system. Therefore, the correct selection of order parameters is essential. Based on the principles of systematicity, scientificity, comparability, and availability of data based on synergy theory and methods, and consulting experts in the field of regional financial risk and digital inclusive financial index, setting up regional digital finance and regional financial risk subsystems. Order parameters and construct order parameters.

The regional financial risk subsystem determines ten order parameters from three aspects: Macroeconomic risk in China, regional macroeconomic risk, and regional micro-financial risk. The order parameters relied on in this paper are shown in Table 1. Where "+" indicates that the order parameter positively impacts regional financial risk, and "-" indicates a negative impact.

Table 1 Regional Financial Risk Subsystem

Subsystem	Order Parameters			Symbol	Relevance
	Primary Index	Secondary Index	Tertiary Index		
Regional Financial Risk	Macroeconomic Risks in China	Economic Development Level	Expenditure/GDP	X_1	+
		Monetary Policy	M2/GDP	X_2	-
	Macroeconomic	Economic	Regional Fiscal Expenditure	X_3	+

Risks in Wuhan	Development Level in Wuhan	/ Regional GDP			
		Investment Growth Rate	X_4	+	
		Total Import and Export	X_5	-	
		CPI Growth Rate	X_6	+	
Microfinance Risk in Wuhan	Banking Operations	Non-performing Loan Ratio	X_7	+	
		Domestic and Foreign Loan-to-deposit Ratio	X_8	+	
	Insurance Operations	Insurance Benefit Income Ratio	X_9	+	
	Securities Industry Operations	Securities Trading Volume	X_{10}	+	

The digital inclusive financial index data comes from the Peking University Digital Financial Index of Inclusion (PKU-DFIIC) 2011-2020 [6]. The data mainly includes the digital inclusive financial index, digital finance coverage, use depth, and degree of financial digitalization. The order parameters relied on in this paper are shown in Table 2.

Table 2 Digital Inclusive Financial Index Subsystem

Subsystem Name	Order Parameter	Symbol	Relevance
Digital Inclusive Financial Index	Digital Financial Inclusive Index	X_{11}	+
	Digital Finance Coverage	X_{12}	+
	Digital Finance Use Depth	X_{13}	+
	Degree of Financial Digitalization	X_{14}	+

3.2. Order degree model of the subsystem

3.2.1. Order degree of the order parameter

Consider the two subsystems as a composite system $S = \{S_1, S_2\}$, where S_1 is the digital financial inclusive index subsystem. S_2 is the regional financial risk subsystem. The order parameter is $X_i = (X_{i1}, X_{i2}, ..., X_{in})$, $\alpha_{ij} \leq X_{ij} \leq \beta_{ij}, n \geq 1; j = 1,2,\cdots n$, β_{ij}, α_{ij} are maximum value and minimum value respectively when the system is stable.

The order degree calculation method of the order parameter is as equations (1) and (2). Equation (1) is for X_{ij} has a positive impact, and equation (2) is for X_{ij} has a negative impact.

$$\text{u}_i(X_{ij}) = \frac{X_{ij} - \alpha_{ij}}{\beta_{ij} - \alpha_{ij}} \quad (1)$$

$$\text{u}_i(X_{ij}) = \frac{\beta_{ij} - X_{ij}}{\beta_{ij} - \alpha_{ij}} \quad (2)$$

3.2.2. Order degree of subsystems

Based on synergetics, the order degree of regional financial risk and digital inclusive financial index subsystem is integrated by each order degree of the order parameter. This paper will use the linear weighted method to calculate the two subsystems' order degree, and the equation is as follows:

$$\text{u}_i(X_i) = \sum_{i=1}^{n} \text{u}_{ij}(X_{ij})\lambda_{ij} \quad (3)$$

λ_{ij} is order parameter weights for each parameter.

λ_{ij} is determined by the CRITIC weighting method. CRITIC is an objective weighting method that considers the index variation between the size and the indexes of conflicting effects on weight. It is a kind effective method to research objective weights are determined. Its basic principle is as follows:

Step1: Calculate the standard deviation.

$$\sigma_j = \sqrt{\frac{1}{\text{m}-1}\sum_{t=1}^{\text{m}}(X_{jt} - \overline{X_j})^2} \quad (4)$$

$\overline{X_j}$ is the average value of m data of order parameter index X_j. σ_j is the standard deviation of X_j.

Step2: Build correlation coefficient matrix.

$$r_{jk} = \frac{\sum(X_j - \overline{X_j})(X_k - \overline{X_k})}{\sqrt{\sum_{j=1}^{n}(X_j - \overline{X_j})^2(X_k - \overline{X_k})^2}} \quad (5)$$

$\overline{X_j}$ is the average value of all data in the order parameter X_j. $\overline{X_k}$ is the average value of all data in the order parameter X_k. r_{jk} is the correlation coefficient of order parameter X_j and X_k.

Step3: Determine the comprehensive information H_j of each indicator.

$$H_j = \sigma_j \sum_{k=1}^{n} (1 - r_{jk}) \quad j, k = 1, 2, ..., n \qquad (6)$$

Step4: Calculate the total weight λ_{ij} of each index.

$$\lambda_{ij} = \frac{H_j}{\sum_{j=1}^{n} H_j} \quad j, k = 1, 2, ..., n \qquad (7)$$

3.3. Composite system collaborative degree model

The collaborative degree of the synergy system composed of regional financial risk subsystem and digital inclusive financial index subsystem is the result of multiple factors, reflecting the two subsystems' integrated synergy degree. The following is a hybrid system synergy degree calculation method.

$$sig(\cdot) = \begin{cases} 1, & U_1(t) - U_1(t-1) \geq 0 \text{ and } U_2(t) - U \\ -1, & \text{else} \end{cases} \qquad (8)$$

$$U_{(t)} = sig(\cdot)\sqrt{|U_1(t) - U_1(t-1)| \cdot |U_2(t) - U|} \qquad (9)$$

$U_1(t)$ is at time t order degree of the former subsystem, $U_2(t)$ is at time t order degree of the latter subsystem, $U_{(t)} \in [-1, 1]$, the bigger $U_{(t)}$ is, the more considerable synergy degree is.

4. Research and analysis on the synergy degree

4.1. Research area

Wuhan is one of the megalopolises of central China. China's substantial industrial base is the scientific education base, comprehensive transportation hub, and logistic support troops compound. It is also a core city of the Yangtze River economic belt, the rise of central China strategy fulcrum, comprehensive innovation reform experimental area, and one of the three concentration areas of intelligence. The prosperity and development of Wuhan's economy and the degree of financial risks are of great significance to the development of China's central urban circle. Due to Wuhan, after more than ten years of the rapid development of digital financial and financial relations of permeability, the self-propagation characteristics and linkage of local financial risks are greatly enhanced. Individual or part of the institutions of the micro financial risk can dash forward show in a distribution and cumulative, spread, diffusion, and gradually form the regional financial risks. Wuhan is also vulnerable to the economic pro-cyclical effect as the centre city, which gradually accumulates the regional financial risk. Of course, the digital financial strong enhance the anti-risk ability of its economic and social development. In addition, Wuhan is the most affected by COVID-19 Research on the financial mechanism of China's cities of great significance to the development of Chinese cities.

4.2. Data processing

4.2.1. Data sources

Wuhan regional financial risk data from *2010-2020 in Wuhan statistical yearbook* and *The national economic and social development in Wuhan statistical bulletin.* In this paper, the referenced order parameter is not the optimal evaluation index. The availability of data ignores some regional financial risk indicators. Wuhan's digital inclusive financial index comes from *Beijing University Digital Inclusive Financial Index (PKU-DFIIC) 2011-2020.* Specific data as shown in Figure 2 and Figure 3:
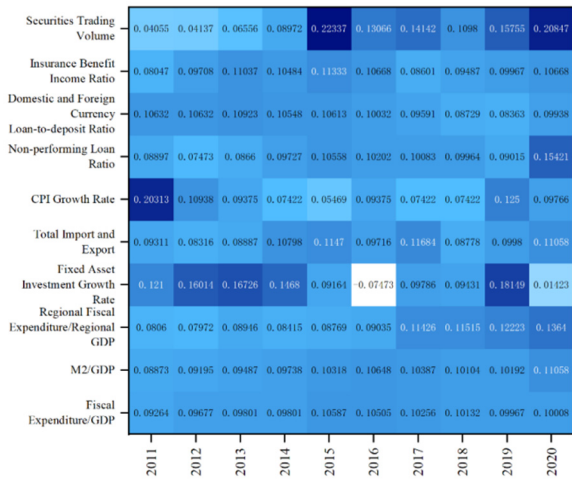
Figure 2 Regional financial risk data in Wuhan

Figure 3 Digital inclusive financial index data in Wuhan

It can be found to the thermodynamic diagram, Wuhan, the overall economic situation and the development of financial figures belong to a more steady development, which is more favourable in all aspects. The number of factors related to financial risk gradually decline, but there has been part of the trend rebound in 2020.
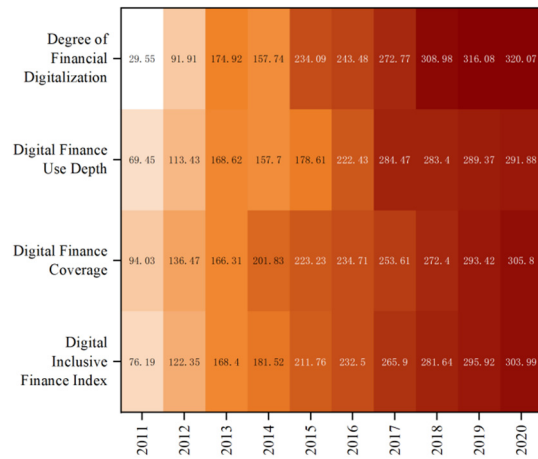
4.2.2. Data processing results

Based on standardizing the order parameter data of Wuhan regional financial risk and digital inclusive financial index. Uses the above equation to calculate the standard deviation, correlation coefficient matrix, and the total weight of each index W, V for each index. The results are shown in figure 4 and figure 5.
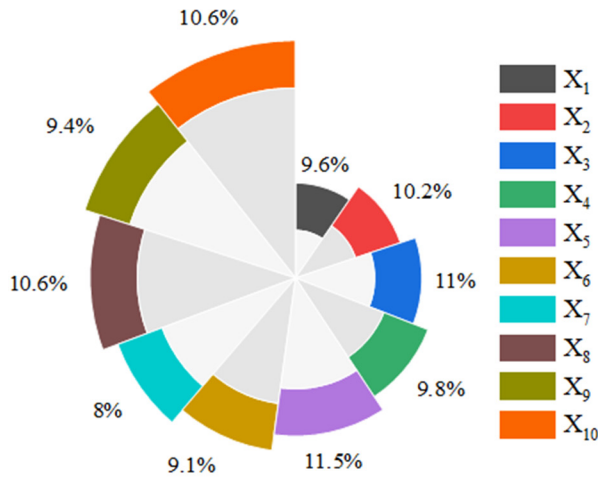

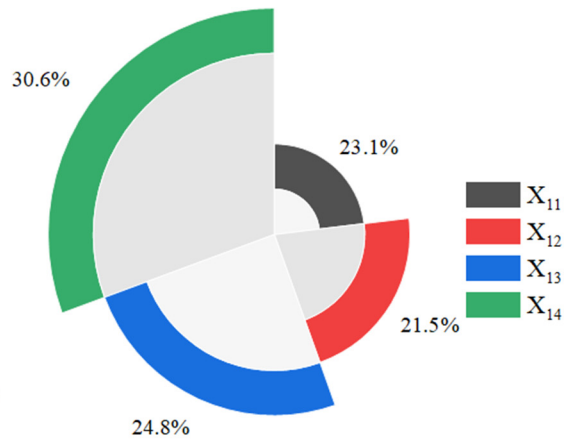**Figure 4** Regional financial risk weight in Wuhan

Figure 5 Digital inclusive financial index weight in Wuhan

It uses the above equation to calculate the order degree of the two subsystems, respectively. Based on this, calculates the hybrid system on the synergy degree.

Results as table 3. Note: Some data that cannot be calculated, and it is expressed as "-".
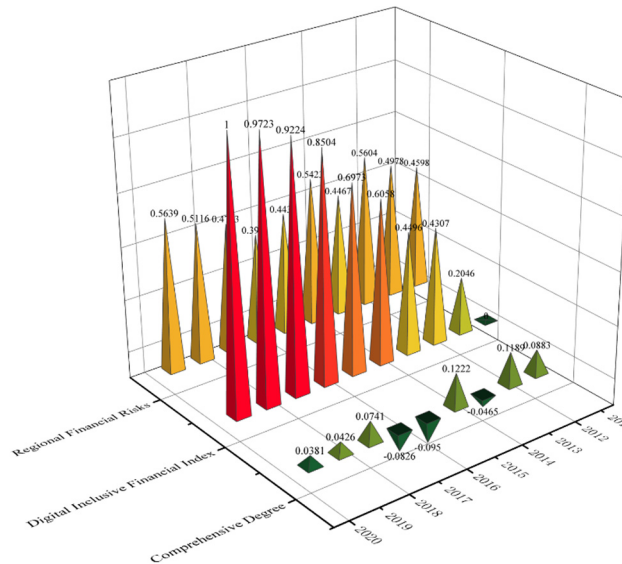
Table 3 Order degree and synergy degree between regional financial risk and digital inclusive financial index

	Regional Financial Risk Order Degree	Digital Inclusive Financial Index Order Degree	Synergy Degree
2011	0.46	0.00	-
2012	0.50	0.20	0.09
2013	0.56	0.43	0.12
2014	0.45	0.45	-0.05
2015	0.54	0.61	0.12
2016	0.44	0.70	-0.10
2017	0.40	0.85	-0.08
2018	0.48	0.92	0.07

| 2019 | 0.51 | 0.97 | 0.04 |
| 2020 | 0.56 | 1.00 | 0.04 |

4.3. Synergism analysis

4.3.1. Results visualization

Figure 6 2010-2020 order degree and synergy degree of regional financial risk and digital inclusive financial index in Wuhan

4.3.2. Subsystem order degree analysis

As shown in Figure 6, the order degree of the digital inclusive financial index subsystem in Wuhan shows a monotonically increasing trend, from 0 in 2011 to 1 in 2020. The order degree increases rapidly. The regional financial risk subsystem generally presents a stable fluctuation trend, with a small change between 0.4 and 0.6. By comparing the order degree of the two subsystems, it can be seen that from 2011 to 2014, the order degree of the former is significantly higher than the latter, indicating that the popularity of the digital inclusive finance index is low and the impact of digital finance on another is low, too. In 2014, the order degree of regional financial risk subsystem caught up with the order degree of the digital inclusive financial system.

From 2015 to 2017, the order degree of the regional financial risk subsystem showed a downward trend, while the digital inclusive financial subsystem showed rapid growth. The two subsystems ran at opposite speeds, showing the characteristics of a weak correlation between the two subsystems. Likely, digital finance is still not developing on a large enough scale to influence and increase local financial risks. However, from 2017 to 2020, the order degree of regional financial risk subsystem showed a gradual upward trend, and the contribution degree of the two subsystems to the hybrid

system maintained a positive synergy level. It is speculated that the development of digital finance has begun to take shape and has impacted financial activities in Wuhan.

4.3.3. Synergy degree analysis of composite system

As shown from Figure 6, the synergy degree of the composite system development in Wuhan shows a W-shaped development trend of alternating increase and decrease and is generally in a state of low-level coordination. The overall variation trend of the synergy degree of the composite system can be divided into three stages:

First stage: from 2011 to 2013, the regional financial risk system gradually increases, while the digital inclusive financial subsystem rapidly increases, and the latter quickly caught up with the regional financial risk system. At this time, the synergy degree of the composite system is positive. The two subsystems reflected the synergetic phenomenon. The possible reason for this is that the imperfection of inclusive digital finance has had a weak impact on the social credit system.

Second stage: from 2013 to 2017, the two curves, on the whole, showed an opposite trend of change, and the coordination degree of the hybrid system was negative in this stage (only in 2015 it suddenly became positive, and

the high probability was a coincidence problem after excluding extraordinary circumstances). It is indicated that the two subsystems are always in a non-cooperative state. It should be a transitional period when the digital inclusive financial system impacts local financial risks.

Third stage: from 2017 to 2020, the order degree of the regional financial risk subsystem showed a gradual upward trend, and the order degree of the digital inclusive financial subsystem also slowed down. The digital inclusive financial subsystem was far ahead of the regional financial risk subsystem. The synergy degree of the composite system is positive, the two subsystems are in a low level of synergy state, and visible synergistic effect is produced, and the development trend is usual.

In addition, the COVID-19 outbreak and lockdown in Wuhan in 2020 should have caused a substantial impact on the local economy and a significant increase in financial risks. However, the research results show that the level of local financial risks only slightly increased, and the process of financial digitalization is still progressing steadily. It can be seen that the epidemic did not have a profound impact on financial risks in Wuhan. On the one hand, this result shows that the gradual and perfect development and broad application of inclusive digital finance in recent years have had a great positive effect on avoiding financial risks.

4.4. Problem Analysis and Suggestions

A) Improve the development system of inclusive digital finance and strengthen supervision and management.

Although relevant departments have put forward some relatively straightforward requirements for developing digital financial inclusion, they are still not specific enough. Industry standards and self-regulatory rules are not yet clear, which leads to the possibility that the application of emerging technologies may be uncontrolled, underpowered, or abused to create financial risks. In this regard, we should abide by the supervision and management principles of inclusive digital finance, explore a set of innovative management mechanisms applicable to banks and other financial institutions, leave some space for trial and error in innovative products, strengthen supervision and management, and define the development requirements and direction while encouraging the development of innovative science and technology.

C) The banking industry should strengthen its digital transformation, improve its ideological understanding, and optimize its products and services.

Compared with banks, inclusive digital finance has more significant information advantages due to the combination of big data, artificial intelligence, and other technologies. It can target customers more accurately and provide more diversified services than banks. Through digital transformation, combined with the development of big data and artificial intelligence, banks can learn the advantages of inclusive digital finance, strengthen online business ability, reduce the pressure of digital inclusive financial diversion, accurately identify the repayment ability of lenders, and reduce liquidity risk and credit risk.

D) Public sector cooperation builds all-around guarantee financial institutions to increase capital investment.

The public sector also needs to work together to improve the inclusive financial infrastructure construction, actively and effectively promote the combination of traditional financial institutions and digital inclusive financial, constantly promote the development of digital inclusive financial let inclusive financial can touch more user groups. Moreover, accelerate the construction of a credit system, provide a multi-level guarantee for the security of inclusive digital finance, and make a more outstanding contribution to the take-off of China's economy.

5. Conclusion

A) From the perspective of system analysis, ten sub-system order parameters representing regional financial risks reflecting national macroeconomic risks, regional macroeconomic risks, and regional micro-financial risks, and four order parameters representing regional financial risks are selected to evaluate the risk level of regional digital inclusive finance and regional finance.

B) The building principles of regional digital inclusive finance and regional financial risk system order parameters determine the order parameters of regional digital inclusive finance and regional financial risk system. The evaluation model of the synergy degree of regional digital inclusive finance and regional financial risk is established and determines the measurement method of the synergy level of regional digital inclusive finance and regional financial risk.

Taking "new first-tier city" Wuhan as an example, the model is applied to evaluate inclusive digital finance and financial risk synergy degree in more developed regions. The results show that the coordination degree of regional digital inclusive finance and regional financial risk system in Wuhan presents a W-shaped development trend of alternating increase and decrease and is generally in the stage of low-level coordination.

Acknowledgments

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