The Construction of Financial Information Security Assessment Indicators based on Hierarchical Analysis Methods and Legal Regulation

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Abstract: -Along with the continuous development of information technology, the threat to the information security of financial enterprises is also increasing, and the financial information security assessment can help financial enterprises to fully understand the risk of information security, targeted to make the corresponding optimization recommendations. At the same time, it can also provide certain references for the improvement of laws and regulations in the financial information industry. Based on this, this paper proposes the construction of financial information security assessment indexes based on hierarchical analysis, by analyzing the fuzzy comprehensive evaluation result vector B_C of the C layer relative to the G layer, it can be found that the proportion of "three-star" and "four-star" is 0.0294 and 0.2903 respectively. According to the theory of degree of affiliation 31.97% of the assessment indicators can be improved. And accordingly puts forward the improvement strategy of legal regulation, to be able to provide certain references for the financial information security work.

Key-Words: - Financial information security, Hierarchical analysis, Security assessment, Legal regulation, Financial payment, payment risk, legal protection.

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1 Introduction

As the supervisor and main payment channel of network transactions, financial payment institutions provide convenient payment means and reliable service guarantee for active online transaction payment and promote the development of ecommerce, which is an important content of China's payment service system, and its own healthy and orderly development has gradually become one of the important factors affecting the national financial stability. Generally speaking, financial payment institutions generally have the risks brought by the operators' business ethics, anti-money laundering, credit card cash, network security of payment platforms and their systems, and the homogenization of competition and unknown profit models. Among them, the information security risk has become the core risk of non-financial payment institutions' daily business activities due to the fundamental support provided by information technology systems to their business development, [1]. It is very necessary and urgent to strengthen the information security risk prevention and control capacity building work of financial payment institutions. Literature [2], introduced a topic model based on Latent Dirichlet Allocation (LDA) to discover features from news articles and financial time series and applied LDA to data mining for financial time series forecasting, achieving better results than commonly used LDA, [2]. Literature [3], proposed the DeepClue system, which explains the key factors learned in the stock price prediction model through visualization and connects the text-based deep learning model with end users to predict stock prices through financial news and company-related tweets posted on social media, [3]. Literature [4], predict stock price movements based on financial news articles. Most of the other authors' studies focus on financial predictive data research, and there are relatively few studies related to financial information security. Based on this, this paper utilizes the hierarchical analysis method to construct a financial information security assessment index model and verifies the advantages of the model. At the same time, based on the results of the above model, it proposes legal regulation measures for financial information security, to provide certain references for the protection of financial information security.

2 Construction of Financial Information Security Assessment Index based on Hierarchical Analysis Method

2.1 Design of Indicator System

As shown in Table 1, based on the specific requirements of the Technical Guidelines, the indicator system is designed as 3 levels, and the evaluation of Internet financial information security is divided into 2 aspects: compliance security and dynamic security. The indicators are both independent of each other and related to each other, satisfying the components of the P2DR2 security model.

2.2 Construction of Indicator System

The hierarchical analysis method and fuzzy comprehensive evaluation method are used to construct the Internet financial information security evaluation index system.

2.2.1 Structure and Weights

The hierarchical analysis method (Analytic Hierarchy Process, AHP) is used to determine the structure and weight of the indicators, which includes the following four steps.

1) Establish a hierarchical structure. There are 3 levels in the indicator system. Goal level (G): the general goal of the assessment. Criteria layer (C): the criteria affecting the realization of the safety assessment. Indicator level (P): Specific indicators to be realized by the assessment. The order of the elements of each level and the affiliation between the elements are shown in Table 1.

2) Construct a judgment matrix and assign values. The expert constructs the judgment matrix of this level by taking the dominant elements of a certain level as the criterion, distinguishes the degree of importance of the elements of this level in comparison with each other, and assigns values concerning Table 2.

system					
Goal level G	Guideline level	Indicator level P			
		Safety Strategy P_1			
	Compliance Security C_1	Security			
		System P_2			
		Level Protection			
Internet financial information security		P_3			
		Personal Information			
		Protection P_4			
		Vulnerability			
	Dynamic	Scanning P_5			
		Threat Alert P_6			
assessment G		Online Monitoring			
		P_7			
		Vulnerability			
		Patching P_8			
	security C_2	Emergency			
		Response P_9			
		Disaster Recovery			
		P_{10}			
		Mobile APP			
		D Security Hardening			
		1 ₁₁			

Table 2.	Meaning	of importance	scales
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Scale	Materiality			
1	1 i and j are equally important			
3	3 i is slightly more important than j			
5	i is significantly more important than j			
7	i is more important than j			
9	i extremely important than j			
2, 4, 6, 8	Intermediate value			

Calculate the weights of the index items in a top-down order. Firstly, experts are invited to judge the importance of the elements in the layer C relative to the layer G. According to the quantitative assignment in Table 2, a judgment matrix of C-layer elements relative to G-layer is constructed (Eq. (1)).

$$A = \begin{pmatrix} 1 & 1/2 \\ 2 & 1 \end{pmatrix} \tag{1}$$

Calculate $\lambda_{max} = 2$, the corresponding maximum eigenvector is Eq. (2).

$$V = \begin{bmatrix} 0.4472, 0.8944 \end{bmatrix}^T$$
 (2)

$$w_i = \frac{v_i}{\sum_{i=1}^k v_i}$$
(3)

$$CR = 0 \text{ from Eqs. (4) and (5).}$$

$$CI = \frac{\left(\lambda_{\max} - n\right)}{\left(n - 1\right)}$$
(4)

$$CR = \frac{CI}{RI} \tag{5}$$

Next, experts are invited to judge the importance of the *P*-layer elements P_{1-4} relative to the *C*-layer element C_1 . According to the quantitative assignment in Table 2, a judgment matrix of *P*-layer elements P_{1-4} relative to *C*-layer element C_1 is constructed (Eq. (6)).

$$A = \begin{pmatrix} 1 & 2 & 3 & 3 \\ 1/2 & 1 & 2 & 2 \\ 1/3 & 1/2 & 1 & 1 \\ 1/3 & 1/2 & 1 & 1 \end{pmatrix}$$
(6)

Calculate $\lambda_{max} = 4.0104$, the corresponding maximum eigenvector is Eq. (7):

$$V = \begin{bmatrix} 0.8099, 0.4674, 0.2505, 0.2505 \end{bmatrix}^{T}$$
(7)

From Eq. (3), the weight vector of *P* layer element P_{1-4} with respect to *C* layer element C_1 is $W_{c_1} - {}_{P_{1-4}} = [0.4554, 0.2628, 0.1409, 0.1409]$. From Eq. (4) and Eq. (5), $CR = 0.0035/0.9 = 0.0039\langle 0.1 \rangle$, and it can be assumed that the constructed judgment matrix Eq. (6) has good consistency [5].

Similarly, experts are invited to judge the importance of the P-layer elements P_{5-11} relative to the *C*-layer element C_2 and construct the judgment matrix as Eq. (8).

$$A = \begin{pmatrix} 1 & 3 & 3 & 1 & 1/3 & 1/2 & 2 \\ 1/3 & 1 & 1/2 & 1/3 & 1/4 & 1/4 & 2 \\ 1/3 & 2 & 1 & 1/3 & 1/3 & 1/3 & 2 \\ 1 & 3 & 3 & 1 & 1/3 & 1/3 & 3 \\ 3 & 4 & 3 & 3 & 1 & 1 & 5 \\ 2 & 4 & 3 & 3 & 1 & 1 & 5 \\ 1/2 & 1/2 & 1/2 & 1/3 & 1/5 & 1/5 & 1 \end{pmatrix}$$
(8)

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Calculate $\lambda_{max} = 7.2373$, corresponding to the maximum eigenvector:

 $V = [0.3067, 0.1719, 0.3074, 0.6350, 0.5928, 0.1039]^{T}$ The weight vector $W_{c_2 - p_5} = [0.1365, 0.0572, 0.0765, 0.1369, 0.2827, 0.2639, 0.0462]$ is calculated from Eq. (3). Calculated by Eq. (4) and (5) $CR = 0.0456/1.32 = 0.0039 \langle 0.1, \text{ it can be}$ considered that the judgment matrix A has a good consistency. Next, it is necessary to determine the hierarchical total ordering of all indicator items relative to the overall goal of the assessment. In other words, it is necessary to calculate the total hierarchical ranking of all elements of *p* relative to the total objective of *G*. The weight vector of the total hierarchical ranking is calculated by Eq. (9) as follows:

$$W_{G-P_{l-11}} = \begin{bmatrix} 0.1518, 0.0876, 0.0470, 0.0470, 0.0910, \\ 0.0381, 0.0510, 0.0913, 0.01885, 0.1759, \\ 0.0308 \end{bmatrix}$$
$$\overline{W_i}^P = \sum_{j=1}^m \overline{W_{ij}}^P W_j^c, i = 1, 2, ..., n.$$
(9)

Then, the results of the hierarchical total ordering need to be tested for consistency. The values of the consistency test parameters for hierarchical total sorting are shown in Table 3.

Table 3.	Consistency	test	parameters	for	total
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ordering				
Parameter name	Parameter value			
Element weights W^{C}	$W_1^C = 0.3333$			
Element weights W_i	$W_2^C = 0.6667$			
Consistency indicators CI_i^P	$CI_1^P = 0.0035$			
	$CI_2^P = 0.0456$			
Consistency Ratio CR_i^P	$CR_1^P = 0.0039$			
	$CR_2^P = 0.0345$			
Stachastia Consistency Indicator <i>PI</i> ^P	$RI_1^P = 0.9$			
Stochastic Consistency Indicator KI _i	$RI_{2}^{P} = 1.32$			

According to Eq. (10), calculate $CI^{P} = \sum_{i=1}^{2} CI_{i}^{P}W_{i}^{c} = 0.0316$. According to Eq. (11), calculate $RI^{P} = \sum_{i=1}^{2} RI_{j}^{P}W_{j}^{c} = 1.1800$. According to Eq. (12), calculate the total sorting

$$CR^{P} = \frac{CI^{P}}{RI^{P}} = 0.0268 \langle 0.1, \text{ it can be considered} \rangle$$

that the results of the total hierarchical sorting have a better consistency, and the results of the total sorting weights are reasonable.

$$CI_{j}^{P} = \left(CI_{1}^{P}, CI_{2}^{P}, ..., CI_{m}^{P}\right) \bullet w^{C}$$

$$(10)$$

$$RI_{j}^{P} = \left(RI_{1}^{P}, RI_{2}^{P}, ..., RI_{m}^{P}\right) \bullet w^{C}$$

$$\tag{11}$$

$$CR^{P} = \frac{CI^{P}}{RI^{P}}$$
(12)

3 Analysis of Results

3.1 Qualitative and Quantitative Evaluation

Six professional evaluators are invited to conduct a comprehensive evaluation of the overall level of information security of a financial institution, and the summarized evaluation results are shown in Table 4.

 Table 4. Summary statistics of evaluator evaluation

 results

			counts		
	One	Two	Three	Four	Five
	star	stars	stars	stars	stars
P_1	0	0	0	1	5
P_2	0	0	0	1	5
P_3	0	0	0	2	4
P_4	0	0	1	3	2
P_5	0	0	1	2	3
P_6	0	0	1	3	2
P_7	0	0	0	2	4
P_8	0	0	0	1	5
P_9	0	0	0	1	5
P_{10}	0	0	0	3	3
P_{11}	0	0	0	2	4

$$B_{i} = W_{i} \bullet R_{i} = [b_{1}, b_{2}, ..., b_{m}]$$
(13)

According to Eq. (13), the total hierarchical ranking weights $W_{G-P_{1-4}}$ of the index layer elements P_{1-4} relative to the target layer *G* obtained through hierarchical analysis and the single-factor fuzzy relationship matrix R_{C_1} are synthesized to obtain the single-factor evaluation result vector (Eq. (14)).

$$B_{C_i} = W_{C-P_{i\rightarrow}} \bullet R_{C_i} = \begin{bmatrix} 0.1518\\ 0.0876\\ 0.0470\\ 0.0470 \end{bmatrix} \bullet \begin{bmatrix} 0 & 0 & 0 & 0.1667 & 0.8333\\ 0 & 0 & 0 & 0.1667 & 0.8333\\ 0 & 0 & 0 & 0.3333 & 0.6667\\ 0 & 0 & 0.1667 & 0.5000 & 0.3333 \end{bmatrix}$$
$$= \begin{bmatrix} 0 & 0 & 0.0235 & 0.2372 & 0.7393 \end{bmatrix}$$

(14)

Similarly, the total hierarchical ranking weights $W_{G-P_{5-11}}$ of the indicator layer elements P_{5-11} relative to the target layer *G* obtained by hierarchical analysis are synthesized with the single-factor fuzzy relationship matrix R_{C_2} to obtain B_{C_2} as follows Eq. (15), [6].

$$B_{C_2} = W_{G-P_{5-11}} \bullet R_{C_2} = \begin{bmatrix} 0.0910\\ 0.0381\\ 0.0510\\ 0.0913\\ 0.1885\\ 0.1759\\ 0.0308 \end{bmatrix} \bullet \begin{bmatrix} 0 & 0 & 0.1667 & 0.3333 & 0.5000\\ 0 & 0 & 0.1667 & 0.5000 & 0.3333\\ 0 & 0 & 0 & 0.1667 & 0.8333\\ 0 & 0 & 0 & 0.1667 & 0.8333\\ 0 & 0 & 0 & 0.1667 & 0.8333\\ 0 & 0 & 0 & 0.1667 & 0.8333\\ 0 & 0 & 0 & 0.5000 & 0.5000\\ 0 & 0 & 0 & 0.3333 & 0.6667 \end{bmatrix}$$
$$= \begin{bmatrix} 0 & 0 & 0.0323 & 0.3169 & 0.6508 \end{bmatrix}$$

From B_{C_1} and B_{C_2} , we get the fuzzy relationship matrix of *C* layer with respect to *G* layer (Eq. (16)).

$$R_{C} = \begin{bmatrix} B_{C_{1}} \\ B_{C_{2}} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0.0235 & 0.2372 & 0.7393 \\ 0 & 0 & 0.0323 & 0.3169 & 0.6508 \end{bmatrix}$$
(16)

According to the hierarchical structure of the indicator system, the fuzzy comprehensive evaluation result vector of layer C relative to layer G is finally obtained as Eq. (17).

 $B_{c} = W_{G-C} \bullet R_{c} = \begin{bmatrix} 0.3333\\ 0.6667 \end{bmatrix} \bullet \begin{bmatrix} 0 & 0 & 0.0235 & 0.2372 & 0.7393\\ 0 & 0 & 0.0323 & 0.3169 & 0.6508 \end{bmatrix}$ $= \begin{bmatrix} 0 & 0 & 0.0294 & 0.2903 & 0.6803 \end{bmatrix}$

Finally, calculates the comprehensive evaluation value of Internet financial information security as Eq. (18):

$$S = B_C \bullet \overline{V} = \begin{bmatrix} 0 \\ 0 \\ 0.0294 \\ 0.2903 \\ 0.6803 \end{bmatrix} \bullet \begin{bmatrix} 20 \\ 40 \\ 60 \\ 80 \\ 100 \end{bmatrix} = 93.0180 \quad (18)$$

3.2 Related Discussion

It can be found that the $S \in (81,100], S \in V'_5$ corresponding rating is "five stars", which reflects that the overall information security level of an Internet financial institution is high, [7]. The index system proposed in this paper enables evaluators to analyze the specific problems of security more precisely. For example, by analyzing the fuzzy comprehensive evaluation result vector B_C of the *C* layer relative to the *G* layer, it can be found that the proportion of "three-star" and "four-star" is 0.0294 and 0.2903 respectively. According to the theory of degree of affiliation 31.97% of the assessment indicators can be improved.

4 Suggestions for Improving the Legal Protection of Internet Financial Information Security in China

4.1 Improve the Legal System of Internet Financial Information Security Protection

China's Internet finance is in a period of rapid development, Internet financial regulation involves a very wide range of levels, the main body of supervision is also more, including the People's Bank of China, the CBIRC, but also includes the Ministry of Industry and Information Technology, the Ministry of Public Security and other ministries and commissions. The original model of separate regulation can no longer be well adapted to the current development of Internet finance, and needs urgent adjustment.

Firstly, the scope of application of the law should be revised to cover the aspects of construction, operation, maintenance, and safe behavior of network operation, as well as the supervision and management of network security, [8]. In addition, the first and second chapters of the original text of the law are some appealing provisions, which need to be changed and deleted if they are incorrect or unnecessary, and the provisions of Articles 18 and 19 need to be regularly updated, which is the responsibility of the national net information department or relevant departments, based on the catalog of national and industry standards, to regulate key equipment and network security products.

Emphasize the protection of personal information, and regulate the sharing of personal information by improving the terms and conditions.

If a network operator wants to share personal information with a third party, he or she must have the permission of the individual and abide by a confidentiality agreement, and if personal information is leaked and sold by a third party, the third-party responsible for the leakage will be held liable accordingly, [9].

4.2 Building a Coordinated Regulatory System

Firstly, we should mobilize the positive role of social regulatory resources, and based on existing regulatory resources, adopt various ways to create a reasonable and perfect Internet financial governance platform. Driven by Internet technology, there are more modes of Internet financial industry, and the convenience of Internet financial transactions makes Internet financial transactions present crossregional, cross-time, and space characteristics, so the Internet financial governance system is a more complex systematic project, which requires social regulatory resources to collaborate in governance. Secondly, the responsibilities and tasks of each regulatory department should be clarified. Because the current Internet financial business model is diverse, so in the process of improving the system, it is necessary to clarify the responsibilities of various departments and regulators to avoid regulatory gaps or over-regulation of the problem. We can first identify the advantages of each regulatory body, and then give the corresponding rights according to these characteristics. For example, the government can regulate the whole industry and field, so it can plan and develop the policies and principles of the industry as a whole. Industry associations are mainly responsible for infrastructure work in the field such as industry access, exit criteria, and credit evaluation, so they can be given the right to build the infrastructure; thirdly, we have to realize that the current focus is to solve the information security problems encountered in the field of Internet finance, and to formulate corresponding security mechanisms according to these problems, [10]. However, there are many subjects involved in Internet finance, and the risks are transmissible and difficult to control, so the primary goal is to reduce the risks of Internet finance development and improve the risk prevention mechanism of Internet finance.

In the Internet regulatory system, the government occupies a central position, so it must accelerate the construction of laws and regulations in the financial field, constantly improve China's financial legal system, change the previous nothreshold entry rules of the Internet financial industry, and truly implement the policy that there is a law to be complied with in the Internet financial industry. In the coordinated supervision system, the role played by social supervision cannot be ignored, such as the establishment of the Internet financial social credibility evaluation system, exposing the true face of Internet financial enterprises with extremely low credibility, and supervising the healthy operation of the industry through social public opinion. The association's service quality should also be upgraded, opening two-way service channels, and forming a service system based on market demand, emergency response mechanism, and sharing mechanism as a whole, [11]. In addition, the industry's self-regulation policy is also indispensable, as it can control whether and to what extent personal data are disclosed, and protect people's privacy. Enterprise platforms should consciously abide by laws and regulations and establish information security prevention and early warning mechanisms to maximize the protection of information security of Internet financial users when risks arise. Strengthen the supervision between Internet financial enterprise platforms to avoid vicious competition among peers.

4.3 Improve Internet Financial Information Security Dispute Resolution Mechanism

First of all, improve the means of infringement relief. Due to the asymmetry of information, the information security of Internet financial users is often infringed upon, so the public interest litigation system can be established to give Internet financial consumers the qualification for litigation, [12]. Moreover, in the process of formulating the litigation system, the binding force of individual cases should not be ignored. The judiciary or social organizations in charge of this area are responsible for protecting the rights and obligations of citizens. For citizens to have a place to go to and exercise their rights, it is necessary to have a corresponding early warning system and a platform for handling complaints, set up specialized departments, establish personnel and improve the industry's self-regulatory norms, which requires the role and function of Internet financial institutions to be brought into full play. Secondly, the current legal liability for invasion of privacy cannot meet the demand and needs to be further strengthened. In the Internet financial industry, once there is an infringement of customers' privacy information, it is necessary to assume corresponding legal responsibility. For more serious cases, severe penalties should be imposed and the cost of violating the law should be increased to protect users' right to privacy relief. In addition,

to protect users' privacy, a fair and efficient online dispute resolution platform with a relatively low cost can be established to provide users with various privacy protection services.

Second, establish a specialized arbitration system. First, set up a specialized Internet financial arbitration tribunal. At present, many Internet financial disputes in China have special characteristics and need to be resolved by specialized Internet financial arbitration tribunals. Nowadays, some regions have also set up financial arbitration courts or financial arbitration tribunals. but the number is far from enough and needs to be strengthened. Secondly, a separate roster of Internet financial arbitrators should be set up, and a team of professional arbitrators should be established, which can be composed of people from Internet financial companies. lawyers, members of industry associations, etc., as long as they have professional knowledge and are highly specialized, they can join the team, but they must undergo regular training and examination of arbitrators, and can only take up the post after passing the examination, [13]. Third, differentiated management of cases. Financial or commercial disputes and Internet financial disputes are different concepts, so the arbitral tribunal must make a clear distinction when handling these disputes, and make rulings that are truly in line with the special characteristics of these disputes. Fourthly, the flexibility of Internet financial arbitration should be fully mobilized, and the arbitrators' decisions should refer to the value of dispute resolution and ensure fairness and reasonableness, as well as innovate the content of consumer protection and financial protection. As an emerging industry, the relevant policies and regulations of the Internet financial industry cannot be made loophole-free immediately, so the arbitrators need to take into account the loose and flexible characteristics of arbitration, combine the new laws and professional characteristics of the financial industry, and make a decision that is more in line with the actual needs.

5 Conclusion

Accompanied by the continuous development of modern information technology, financial information system risk assessment and security assessment can also be based on quantitative analysis models to obtain more accurate assessment results, which can provide mathematical model support for revenue maximization decision-making and cost minimization decision-making, and assist in realizing the assessment of financial information security and decision-making support. Based on this, the construction of financial information security assessment indexes based on hierarchical analysis proposed in this paper assesses the overall information security level of an Internet financial institution, and the results show that its information security level is high. At the same time, based on the above analysis, this paper puts forward suggestions to improve the legal protection of China's Internet financial information security from three aspects, to be able to provide certain references for China's financial information security protection. However, the scope of the research data in the article is relatively narrow, which may be mixed with human subjective factors affecting the results of the analysis, the next step will be to improve the assessment model to minimize the impact of human subjectivity in the assessment process on the final assessment results.

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- Yingli Wang conducted the writing, survey and data analysis.
- Yinglong Zheng provided methodological guidance for the study.

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The authors have no conflicts of interest to declare.

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