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Research Article

Evaluating Reputation of Internet Financial Platform: An Improved Fuzzy Evaluation Approach

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Recent frequent "thunderstorm incidents" of the internet financial platforms (IFPs) have caused the panic of investors. In order to measure and reduce the investment risk of IFPs, the focus of this study is to evaluate the reputation of IFPs regarding investment risk. First, the reputation evaluation indicator system of IFPs is constructed from two dimensions of direct and indirect reputations. Then, based on this system, an improved fuzzy evaluation approach (IFEA) integrating the method of fuzzy comprehensive evaluation (FCE), the analytic hierarchy process (AHP), and the factor analysis (FA) are proposed for evaluating the reputation of IFPs. Finally, a case study based on the data of 20 peer-to-peer (P2P) lending platforms from "Home of Online Loans" (HOL) in China is used to illustrate the IFEA. Results show that the IFEA can reduce uncertainty and randomness in the determination process of indicator weight and membership degree and therefore accurately obtain the reputation level of IFPs and help investors make better decisions. Meanwhile, the key factors in determining the reputation of IFPs are identified, thereby improving the reputation level of the IFPs.

1. Introduction

With the increasing application of emerging information technology such as cloud computing (CC), big data (BD), and artificial intelligence (AI) in the financial field, Internet financial platforms (IFPs) have rapidly spread around the world [1]. IFPs include platforms of peer-to-peer (P2P) lending, crowd-funding, online banking, and supply chain finance [2, 3]. The emergence of IFPs not only effectively broadens the business boundary of financial services but also promotes the effectiveness of optimal allocation of financial resources. However, the credit risk and liquidity risk are becoming more serious problems due to the cross-market operating characteristics of IFPs [4, 5]. For example, because of malicious fraud, improper operation, and loss of contact, more than 6000 P2P lending platforms have gone bankrupt in China by the beginning of 2021, which brought huge economic loss to investors [6]. Besides, frequent "thunderstorm incidents" of IFPs such as the "Ezubao" event in 2015, the "Tuandaiwang" event in 2019 exposed the huge investment risks of IFPs. In this context, investors often encounter great investment risk in the area of the Internet finance.

As an invisible contract, reputation plays a positive role in reducing the investment risk of IFPs [7]. Since a good reputation can attract more investors to invest [8, 9], IFPs often try their best to restrain their default behaviors for long-term benefits. It was proved that reputation had a positive impact on the establishment of the trust mechanism of the P2P lending market [10] and the reduction of the defaults of the P2P lending borrowers [11]. In addition, many third-party credit rating agencies have tried to measure the investment risk of IFPs from the aspects of reputation. For instance, the reputation indicator of P2P lending platforms created by "Home of Online Loans" (HOL), the credit reputation rating ranking list of the P2P lending platforms launched by "Wang Dai Tian Yan" (WDTY), and the reputation rating of the P2P lending platform proposed by "Rong 360" (R360). In practice, due to the information asymmetry between the IFPs and investors [12, 13], investors can only choose bidding projects based on the information disclosed by IFPs. Besides, IFPs usually disclose information that is good for enhancing their reputation. In this case, investors' role is ineffective in the transaction process, and they only can make investment decisions based on the reputation of IFPs. Thus, it is necessary to establish a scientific evaluation system and effective approach for evaluating the reputation levels of IFPs and to reduce the investment risks for investors.

In recent years, the reputation problem of IFPs has attracted growing attention, but it is still in its infancy. First, most of the existing literature mainly focuses on the reputation of borrowers and investors in the IFP. They pay more attention to the mechanism [14–19], influencing factors [20–22], and the measurement of reputation [23]. This study regarding with evaluating the reputation of the IFP itself has not been adequately presented in the available literature. Meanwhile, the reputation evaluation method concerning the ambiguity of evaluation results is relatively lacking. Second, the previous studies concentrate on constructing a reputation evaluation indicator system from the perspective of the direct reputation indicators [20–22]. The indirect reputation of IFPs has been ignored. However, because of the time lag characteristic of the direct reputation information [24], the current method based on direct reputation may delay the evaluation. The indirect reputation information, such as the real-time evaluation by stakeholders of IFPs, can make up the time lag limitation of the direct reputation. Thus, the evaluation system for the integration of direct reputation and indirect reputation elements should be constructed. Third, for improving the objectivity and credibility of the reputation evaluation results of IFPs, a multiple criteria decision-making (MCDM) approach applying for evaluation of multiple attributes is developed to handle uncertainty and subjective vagueness during the decision-making process. Recently, several studies have used MCDM approaches, including decision-making trial and evaluation laboratory (DEMATEL), analytic hierarchical process (AHP), technique for order performance by similarity to ideal solution (TOPSIS), and so on, either independently [25–27] or hybridization of two or more MCDM approaches [28, 29]. However, these MCDM methods ignored the comprehensive consideration of subjective and objective indicator weights. For example, in the TOPSIS, the weight is determined in advance, and its value is usually subjective. In the DEMATEL, the relative weight of the experts is usually not considered when summarizing the experts' subjective judgments into the group assessment. Therefore, addressing these research gaps inspired us to propose a comprehensive evaluation approach based on fuzzy MCDM considering the objective indicator weights.

To address these research gaps, this study focuses on the reputation evaluation problem of IFPs. A reputation evaluation indicator system including 6 criteria and 24 indicators is constructed from the two dimensions of direct and indirect reputations. Next, an improved fuzzy evaluation approach (IFEA) is designed for reputation evaluation. In this approach, fuzzy comprehensive evaluation (FCE), analytic hierarchy process (AHP), and factor analysis (FA) are integrated to evaluate the reputation level of IFPs. The case study based on the data of 20 P2P lending platforms in China has been carried out to verify the effectiveness and applicability of IFEA.

The contributions of this work include the following three points. (1) Direct and indirect reputations of IFPs are considered for constructing a reputation evaluation indicator system. The system not only fully considers the capability basis of IFPs (e.g., scale strength, financial performance, service quality, capital liquidity, and development potential) but also comprehensively examines the impact of the evaluation of stakeholders on the reputation of IFPs. (2) For evaluating the reputation of IFPs, IFEA is designed by the hybridization of three approaches (e.g. FCE, AHP, and FA), which expands the application of the traditional fuzzy MCDM approaches. Compared with other MCDM approaches (e.g., TOPSIS, DEMATEL, and AHP), the IFEA emphasizes the comprehensive consideration of subjective and objective indicator weights, which reduces uncertainty and randomness in the determination process of indicator weight and membership degree. (3) The reputation level and the impact of essential indicators on the reputation of IFPs are measured quantitatively. It is of great significance for investors to identify the platforms with high investment risks and to make better investment decisions. Moreover, it can also help managers to improve the reputation of IFPs by optimizing related factors.

The rest of this study is organized as follows: Section 2 reviews the existing literature, which concerns the mechanism and influencing factors of IFPs, the reputation evaluation problem, and the FCE method. Section 3 constructs the reputation evaluation indicator system of IFPs. In Section 4, IFEA proposes the reputation evaluation of IFPs. Section 5 presents the case study and discusses the results. Section 6 concludes and provides directions for future research.

2. Literature Review

Since the investment risk of the internet finance increases, many researchers have paid attention to the reputation evaluation problem of the IFPs. This study focuses on three research streams; the mechanism and influencing factors of the reputation of IFPs, the reputation evaluation problem, and the FCE method.

First, a significant issue of this work is the reputation of IFPs. Although this issue is significantly critical, it is still in its early stage. In terms of the reputation mechanism in IFPs, Yang and Lee found that the reputation can significantly affect the trust of lenders on the P2P lending platforms [14]. Kuwabara et al. pointed out that reputation had a curve effect on the success rate of the P2P lending [15]. Lin et al. found that the network reputation of the circle of friends can restrain the default behavior of the P2P lending borrowers

[16]. Ding et al. proved that there was an effective reputation mechanism in the P2P lending market by analyzing the transaction data of 78,000 borrowers in the P2P lending platform "renrendai.com" [17]. Shi et al. found that the reputation of the P2P lending platforms played a direct or indirect role in investors' investment choices [18]. Davies and Giovannetti pointed out that reputation played an important role in the success of crowd-funding projects [19]. In terms of influencing factors of reputation, the influencing factors of direct reputation are often only concerned. For example, third-party credit rating agencies, such as HOL [20], WDTY [21], and R360 [22], calculate the reputation level of IFPs based on indicators such as transaction volume per month, average rate of return, platform background, leverage ratio, net capital inflow, and loan dispersion. Moreover, some other factors, such as capital inflow [30], capital adequacy ratio [31], and information transparency [32], are considered to have a significant influence on the reputation of the IFPs.

Second, the reputation evaluation problem is another important stream in this study. Pang and Yang proposed a social reputation loss model for the disconnection of P2P platform borrowers and proved the disconnection proposition such as the gradual decline of the social reputation loss of borrowers with the delay of the disconnection time point [23]. Fang et al. proposed a beta-based trust and reputation evaluation system (BTRES) for the wireless sensor networks' node trust and reputation evaluation [33]. Panagopoulos et al. proposed a robust reputation system consisting of a new reputation measurement and attack prevention mechanism [34]. Feng et al. proposed a hierarchical and configurable reputation evaluation method based on collaborative filtering (CF) for evaluating the service reputation of the cloud manufacturing enterprises on CMFG service platform [35]. Zhang et al. proposed a novel and effective reputation evaluation method, which can calculate the global and dynamic reputation value of an enterprise by using a time-aware hyperlink-induced topic search algorithm [36]. Wang et al. proposed a reputation measurement method for cloud services based on feedback levels [37]. Dong et al. proposed a second-order reputation evaluation model [38].

Third, this study also contributes to the literature on the FCE method. The FCE method combines the fuzzy sets with the evaluation and converts the qualitative evaluation into a quantitative evaluation according to the membership theory of fuzzy mathematics [39, 40]. In recent years, the FCE method is widely used in the field of economics and finance [41]. For instance, Chen and Wang used the intuitive fuzzy number to evaluate the performance of the lending project of the international financial organizations [42]. Guo et al. constructed an evaluation model with multiple selection evaluation sets and proposed an FCE method based on the operations of the interval numbers for evaluating the laboratory performance in the university [43]. Cao and Xiong proposed a quantitative model of the credit evaluation index based on the fuzzy analytic hierarchy process (FAHP) [26]. Li et al. proposed an evaluation model of financing credit for scientific and technological small-medium enterprises (STSMEs), which improved the AHP and FCE by introducing a cloud model [44]. Zhong developed a financial investment risk comprehensive evaluation model combining the AHP and the FCE methods [45]. Yu and Li proposed a method of the importance of design factors of product innovation considering customer demands. In this method, the priority ranking of design factors of product innovation from the perspective of customer demand is calculated through the gray correlation method and fuzzy TOPSIS [25]. Sangaiah et al. integrated the fuzzy decision-making trial and evaluation laboratory (DEMATEL) model and TOPSIS approach for evaluating global software development project outcome factors [28]. Shaverdi et al. developed a new financial performance evaluation framework for ranking Iranian petrochemical companies based on the fuzzy AHP and fuzzy technique for order preference by similarity to the ideal solution (TOPSIS) [29].

In conclusion, although the aforementioned literature discussed either reputation evaluation problem of IFPs or FCE method from different perspectives, there is still a limitation that needs to be addressed. The following conclusions can be summarized:

(1) The majority of the extant literature regarding reputation evaluation problem of the IFPs focuses on the reputation mechanism or influencing factors. Besides, establishing the reputation evaluation indicator system focuses only on the influencing factors of direct reputation. In this study, the influencing factors of the indirect reputation of the IFPs are still considered as reputation evaluation indicators of the IFPs by comparing them with the HOL [20], WDTY [21], and R360 [22]. Thus, we construct the reputation evaluation indicator system based on the direct and indirect reputations.

(2) An empirical or quantitative approach relying on only clear, transparent, and easily quantifiable data of individuals or enterprises as the basis for reputation evaluation is popular in the existing literature. However, the results of the aforementioned studies [23, 33–38] ignore the uncertainty and ambiguity in reputation evaluation. In this study, an improved fuzzy evaluation approach is developed to evaluate the reputation of the IFPs.

(3) In previous studies regarding the FCE method, the FCE method independently [42, 43], the method combining FCE and AHP [26, 44, 45], the method combining FCE and TOPSIS [25], the method combining FCE, TOPSIS and DEMATEL [28], and the method combining FCE, AHP, and TOPSIS [29] are often developed for evaluation, but the combined method rarely includes FA. In practice, the AHP, TOPSIS, and DEMATEL rely on the subjective judgment of experts regarding the indicator weights and ignore the consideration of objective indicator weights. The objective indicator weights calculated by FA should be concerned. Therefore, it is greatly beneficial to improve the evaluation method by integrating FCE, AHP, and FA.

3. Construction of the Reputation Evaluation Indicator System on IFPs

With the existence of the information asymmetry, investors tend to choose IFPs with a good reputation when making investment decisions. In order to attract more investors, IFPs often disclose information to enhance their reputation. Therefore, it is necessary to choose appropriate reputation indicators to quantify the reputation of IFPs.

Mohtashemi and Mui pointed out that reputation formation can be investigated from the two aspects of direct interaction experience and recommendation of other entities and, that is, direct and indirect reputations [24]. Based on a comprehensive analysis of studies on the impact of the basic information and transaction information on the reputation of IFPs, we divide the direct reputation evaluation indicators of IFPs into the following five categories. (i) Scale strength indicators, such as transaction volume per month, loan bid number, investment amount per capita, and loan balance. (ii) Financial performance indicators, such as total assets, asset-liability ratio, operating income, and registered capital. (iii) Service quality indicators, such as the average rate of return, information transparency, average loan term, full bidding period, and platform overdue loan rate. (iv) Capital liquidity indicators, such as the net capital inflow, capital adequacy ratio, loan dispersion. (v) Development potential indicators, such as the platform background, operating time, net profit growth rate, and operating revenue growth rate. However, since the direct reputation information is limited in terms of timeliness, feedback evaluation from other participants of Internet finance is often needed as the indirect reputation of the platform to make up for the lack of timeliness of the direct reputation information. The main participants of Internet finance include borrowers, investors, IFPs, and regulatory authorities. As such, the indirect reputation evaluation indicators of Internet financial platforms are as follows: (vi) Stakeholder evaluation for the platform, such as investors feedback score, regulatory authorities feedback score, borrowers feedback score, and peer platforms feedback score. Finally, the reputation evaluation indicator system including 6 criteria and 24 indicators was obtained.

Let variable X_i, $i = 1,2, \ldots, 24$ represent the above 24 reputation evaluation indicators, set $\Omega = \{x_{k1}, x_{k2}, x_{k3}, \ldots, x_{k24}\}$, $k = 1,2, \ldots, N$ represent the values of the 24 reputation evaluation indicators of IFPs. The reputation evaluation indicator system of IFPs is constructed, as given in Table 1.

4. IFEA for Evaluating Reputation of IFPs

In this study, IFEA integrating FCE and AHP with FA is developed for the reputation rating of IFPs. The combined method is based on the fuzzy comprehensive evaluation theory and comprehensive weighting method. The detailed steps of the evaluation process are shown in Figure 1. The multilevel decomposition to the evaluation question is carried on, and each level domain is established; the rating of reputation fuzzy evaluation is determined; the membership degree of each indicator to the corresponding comments is established and the fuzzy evaluation matrix is obtained; the group decision AHP method is used to determine the subjective weights of indicators; the method of FA is also used to determine the objective weights of indicators; the comprehensive weights of indicators are obtained according to the subjective and objective weights. The comprehensive evaluation value is obtained according to the indicator weight and the fuzzy evaluation vector.

4.1. Step 1: Establishing the Domain of Discourse for the Reputation Evaluation Factors.

4.1. Step 1: Establishing the Domain of Discourse for the Reputation Evaluation Factors. The dimensions of the reputation evaluation include direct and indirect reputations, which are expressed as $D = \{D_1, D_2\}$. The domain of the reputation evaluation target layer is expressed as $U = \{B_1, B_2, \ldots, B_m\}$, where m represents the number of criteria in the target layer. The domain of the reputation criterion layer i is expressed as $B_i = \{X_1, X_2, \ldots, X_n\}$, where n represents the number of indicators in the criterion layer (the reputation evaluation indicator system is given in Table 1). To solve the comparability problem of the different data, data standardization is usually required for indicators in the criterion layer i before data analysis.

The indicator original data should be transformed into standardized values between 0 and 1 to eliminate the effect of indicators' dimension. Let x_{ki} be the original value of the k^{th} sample in the i^{th} indicator, y_{ki} be the standardized value of the k^{th} sample in the i^{th} indicator, and N be the number of samples. The positive indicators mean that the higher original value of the indicator, the better reputation of the Internet financial platform is. Then, the data standardized value y_{ki} can be expressed by the following equation [48]:

$$y_{ki} = \frac{x_{ki} - \min x_{ki,1\leq k\leq N}}{\max x_{ki,1\leq k\leq N} - \min x_{ki,1\leq k\leq N}}. \quad (1)$$

The negative indicators mean that the higher original value of the indicator, the worse reputation of the Internet financial platform is. Then, the data standardized value y_{ki} can be expressed by the following equation [48]:

$$y_{ki} = \frac{\max x_{ki,1\leq k\leq N} - x_{ki}}{\max x_{ki,1\leq k\leq N} - \min x_{ki,1\leq k\leq N}}. \quad (2)$$

Standardize the qualitative indicators. According to the suggestion of senior managers and researchers familiar with reputation evaluation of Internet finance, the scoring criteria is formulated for qualitative indicators of IFPs, as given in Table 2.

4.2. Step 2: Determining the Rating of the Reputation Fuzzy Evaluation. According to Li et al. [44], this study takes the grades of the reputation evaluation on IFPs as the comment set, with five levels of "excellent," "good," "general," "bad," and "poor." The interval of the 5-level scale corresponding to each indicator will be divided by using the normal distribution of the 5-level interval method. As shown in Figure 2, (a) and (b) are the domain division diagrams of positive and negative indicators of the reputation evaluation, respectively.

Table 1: The reputation evaluation indicator system of IFPs.

Dimension	Criterion layer	Indicator layer	Indicator description	Types of indicators	Source of indicators
Direct reputation dimension D_1	Scale strength B_1	Transaction volume per month X_1	The total transaction amount that occurred on the IFPs this month	Positive	HOL [20], WDTY [21]
		Loan bid number X_2	The number of loans actually transacted	Positive	HOL [20], WDTY [21]
		Investment amount per capita X_3	Per capita investment amount of investors in the IFPs	Positive	HOL [20], WDTY [21]
		Loan balance X_4	The total amount of loans repayable in the IFPs	Positive	HOL [20], WDTY [21]
	Financial performance B_2	Total assets X_5	All assets owned or controlled by the IFPs	Positive	Literature [46, 47]
		Asset-liability ratio X_6	The ratio of total liabilities to total assets in these IFPs	Negative	Literature [46, 47]
		Operating income X_7	The income obtained from the operation of the IFPs	Positive	Literature [46, 47]
		Registered capital X_8	The total capital of the IFPs registered with the registration management agency	Positive	Literature [46, 47], HOL [20]
	Service quality B_3	Average rate of return X_9	The ratio of the average net income of Internet financial investment to the average investment amount	Positive	HOL [20], WDTY [21]
		Information transparency X_{10}	The degree of information disclosure on the IFPs	Qualitative	Literature [32], HOL [20]
		Average loan term X_{11}	The average time from borrowing to repayment in the IFPs	Negative	HOL [20], WDTY [21]
		Full bidding period X_{12}	The time for a loan target to raise all the funds required	Negative	HOL [20], WDTY [21]
	Capital liquidity B_4	Platform overdue loan rate X_{13}	The ratio of overdue loans to total loans in the IFPs	Negative	HOL [20], WDTY [21]
		Net capital inflow X_{14}	The net pending receipts of IFPs this month	Positive	Literature [30], WDTY [21]
		Capital adequacy ratio X_{15}	The ratio of capital adequacy of IFPs	Positive	Literature [31]
		Loan dispersion X_{16}	The degree of dispersion of loan business carried out by the IFPs	Positive	HOL [20], WDTY [21]
	Development potential B_5	Platform background X_{17}	Types of capital for investment and construction of the IFPs	Qualitative	Literature [46, 47], HOL [20]
		Operating time X_{18}	The time when the platform is still operating normally so far	Positive	HOL [20], WDTY [21]
		Net profit growth rate X_{19}	The ratio of the net profit of the current period to the net profit of the previous period	Positive	Literature [46, 47]
		Operating revenue growth rate X_{20}	The ratio of the increase in operating income of the current period to the total operating income of the previous period	Positive	Literature [46, 47]
Indirect reputation dimension D_2	Stakeholder evaluation for the platform B_6	Investors feedback score X_{21}	The evaluation score of investors for the IFPs	Qualitative	This study proposes
		Regulatory authorities feedback score X_{22}	The evaluation score of regulatory authorities for the IFPs	Qualitative	This study proposes
		Borrowers feedback score X_{23}	The evaluation score of borrowers for the IFPs	Qualitative	This study proposes
		Peer platforms feedback score X_{24}	The evaluation score of peer platforms for the IFPs	Qualitative	This study proposes

The critical value of the rating 1–5 scale of the reputation evaluation indicator will be calculated based on the sample data by using the normal distribution of the 5-level interval method. The detailed classification criteria of positive, negative, and qualitative indicators regarding "excellent," "good," "general," "bad," and "poor" ratings are given in Table 3, where μ and σ represent the mean value and standard deviation of the indicator X_i for all the IFPs in the sample data, respectively.

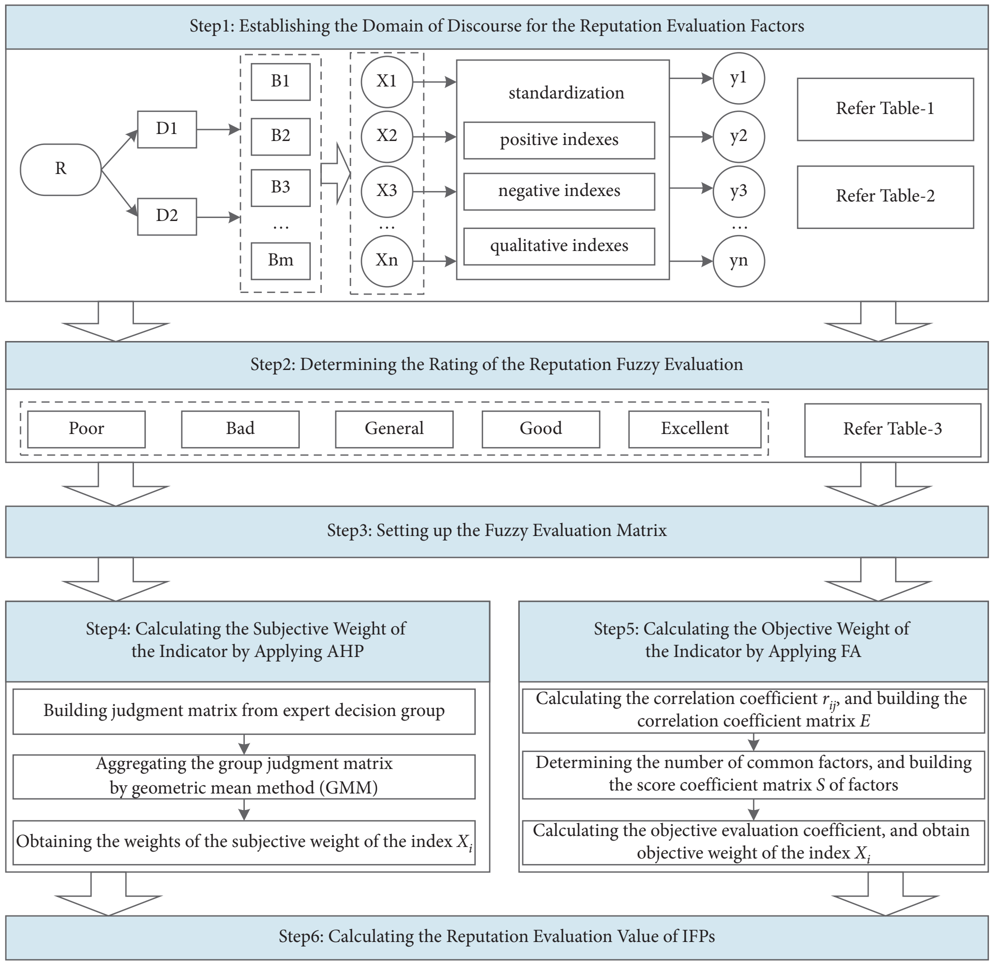

Figure 1: The framework of IFEA for evaluating reputation of IFPs.

Table 2: The scoring criteria for qualitative indicators.

Criterion layer	Indicator layer/qualitative	Grading rules
Service quality B_3	Information transparency X_{10}	Full disclosure is 1.00; basic disclosure is 0.75; partial disclosure is 0.50; less disclosure is 0.25; no disclosure is 0.00
Development potential B_5	Platform background X_{17}	State-owned sector is 1.00; banking sector is 0.75; listed sector is 0.50; venture capital sector is 0.25; private sector is 0.00
Stakeholder evaluation for the platform B_6	Investor feedback score X_{21} Regulatory feedback score X_{22} Borrower feedback score X_{23} Peer platform feedback score X_{24}	Excellent score is 1.00; good score is 0.75; general score is 0.50; low score is 0.25; poor score is 0.00

4.3. Step 3: Setting up the Fuzzy Evaluation Matrix. The membership relation of each indicator to the reputation alternative comment set is called the membership function $K(x)$. The closer $K(x)$ is to 1, the higher the membership of x to K. The closer $K(x)$ is to 0, the lower the membership of x to K.

For the positive indicators, the calculation formula of the membership degree of the rating j comment is by the following equation:

$$K(x) = \frac{x - x_{j+1}}{x_j - x_{j+1}}, \quad x_{j+1} < x < x_j. \tag{3}$$

For the negative indicators, the calculation formula of the membership degree of the rating j comment is by the following equation:

$$K(x) = \frac{x_{j+1} - x}{x_{j+1} - x_j}, \quad x_j < x < x_{j+1}. \tag{4}$$

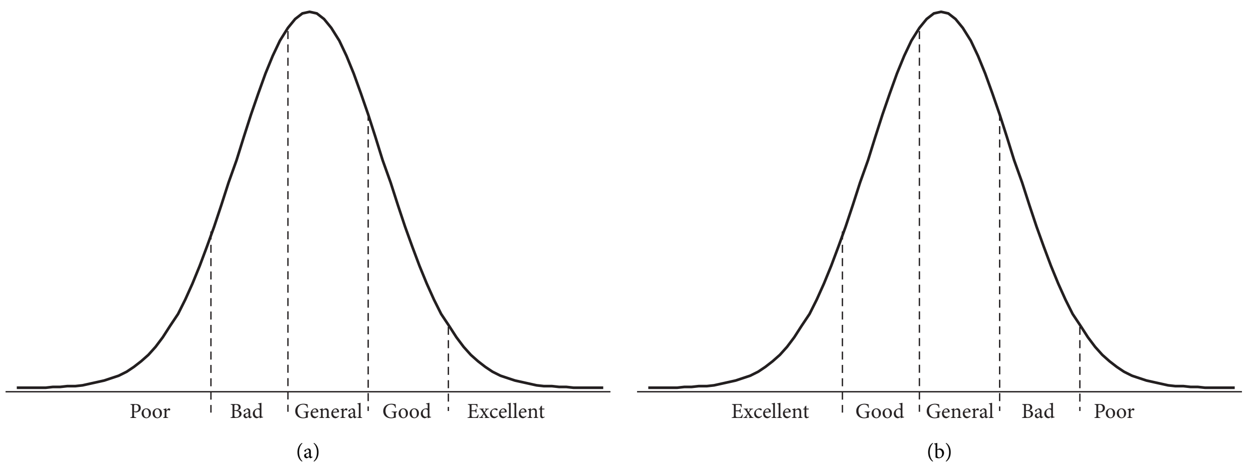

Figure 2: Fuzzy evaluation rating division of reputation evaluation indicators.

Table 3: The critical value of the rating 1–5 scale of the reputation evaluation indicator.

Reputation level	Positive indicators grade critical value	Negative indicators grade critical value	Qualitative indicators grade critical value
Excellent	$x_{ki} \geq \mu + 1.8\sigma$	$x_{ki} < \mu - 1.2\sigma$	1.00
Good	$\mu + 0.8\sigma \leq x_{ki} < \mu + 1.8\sigma$	$\mu - 1.2\sigma \leq x_{ki} < \mu - 0.2\sigma$	0.75
General	$\mu - 0.2\sigma \leq x_{ki} < \mu + 0.8\sigma$	$\mu - 0.2\sigma \leq x_{ki} < \mu + 0.8\sigma$	0.50
Bad	$\mu - 1.2\sigma \leq x_{ki} < \mu - 0.2\sigma$	$\mu + 0.8\sigma \leq x_{ki} < \mu + 1.8\sigma$	0.25
Poor	$x_{ki} < \mu - 1.2\sigma$	$x_{ki} \geq \mu + 1.8\sigma$	0.00

The membership degree of the rating j+1 comment is $1-K(x)$, where x represents the actual value of the indicators, and x_j and x_{j+1} are the critical values of the two reputation levels adjacent to the actual value of the indicator. After calculating the membership degree of the comments on level j and level j+1, the membership degree of the other three comments was 0.

The fuzzy evaluation matrix K formed by the membership degree is expressed by the following equation:

$$K = \begin{bmatrix} M_{X_1} \\ M_{X_2} \\ \vdots \\ M_{X_n} \end{bmatrix} = \begin{pmatrix} m_{11} & m_{12} & m_{13} & m_{14} & m_{15} \\ m_{21} & m_{22} & m_{23} & m_{24} & m_{25} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ m_{n1} & m_{n2} & m_{n3} & m_{n4} & m_{n5} \end{pmatrix}, \quad (5)$$

where m_{ij} represents the membership degree of indicator X_i in the reputation level L_j, and M_{X_i} represents the membership vector of the indicator X_i.

4.4. Step 4: Calculating the Subjective Weight of the Indicator by Applying AHP. The group decision AHP method is developed on the basis of traditional AHP [49]. The basic idea is to ask a group of experts to give a judgment matrix for the same indicator attribute based on the premise that the hierarchy structure has been established. Therefore, in order to avoid the subjective weight of indicators being influenced by the subjective assumption of a single expert, the group decision AHP is adopted to determine the subjective weight of each reputation evaluation indicator in this study.

Let $c_{ij}^1, c_{ij}^2, \ldots, c_{ij}^h$ be the different judgments of h experts in the group on the importance of indicator i and j of Internet financial platform. The 9-point scale method is adopted to form judgment matrix $C^k = (c_{ij}^k)_{n\times n}$, where $1 \leq k \leq h$. The valuation rule of expert k on the comparison scale c_{ij}^k between indicators X_i and X_j is given in Table 4.

In this study, the geometric mean method (GMM) is used to aggregate the group judgment matrix $C = (\overline{c_{ij}})_{n\times n}$. Each element $\overline{c_{ij}}$ is calculated by the following equation:

$$\overline{c_{ij}} = \left(\prod_{k=1}^{h} c_{ij}^k\right)^{1/h}. \quad (6)$$

According to the following equation, the maximum eigenvalue $\lambda_{\max}$ and the eigenvector W_s of the judgment matrix C are calculated:

$$C \times W_s = \lambda_{\max} \times W_s, \quad (7)$$

where $W_s = (\alpha_1, \alpha_2, \ldots, \alpha_i, \ldots, \alpha_n)$, and $\alpha_1, \alpha_2, \ldots, \alpha_i, \ldots, \alpha_n$ are the components of the eigenvector W_s.

To check the consistency of the judgment matrix C, CI is first calculated by the following equation.

$$\mathrm{CI} = \frac{\lambda_{\max} - h}{h - 1}. \quad (8)$$

CI is an indicator used to measure the amount (degree) of deviation from consistency in a judgment matrix. Then, the random consistency ratio CR is calculated by the following equation:

Table 4: Valuation of c_{ij}^k with a scale of 1–9.

Scale	Importance level
1	Reputation indicator X_i is as important as X_j
3	Reputation indicator X_i is slightly more important than X_j
5	Reputation indicator X_i is obviously more important than X_j
7	Reputation indicator X_i is strongly more important than X_j
9	Reputation indicator X_i is far more important than X_j
2, 4, 6, 8	Between two importance levels
Reciprocal	If indicator X_i compares with X_j, the scale $a_{ij} = 1/a_{ji}$

$$CR = \frac{CI}{RI}, \tag{9}$$

where RI is called the random indicator and is used to reconcile the different requirements of related CI. In this study, if $CR < 0.1$, the judgment matrix satisfies the requirement of consistency, and the component α_i of the eigenvector W_s is the subjective weight of the indicator X_i. Otherwise, the judgment matrix should be modified.

4.5. Step 5: Calculating the Objective Weight of the Indicator by Applying FA. The FA is to reduce the variables with complicated relations into a few comprehensive factors by studying the dependence relation inside the correlation matrix and adopting the idea of dimensionality reduction [50]. In this study, the collected data were processed by FA to obtain the objective weight of each indicator.

r_{ij} is the correlation coefficient between indicator X_i and X_j; x_{ki} is the value of indicator X_i of Internet financial platform k; $\overline{x}_i$ is the mean of the indicator X_i; x_{kj} is the value of indicator X_j of Internet financial platform k; $\overline{x}_j$ is the mean of the indicator X_j; and r_{ij} is calculated by the following equation:

$$r_{ij} = \frac{\sum_{i=1}^{n} \left(x_{ki} - \overline{x}_i\right)\left(x_{kj} - \overline{x}_j\right)}{\sqrt{\sum_{i=1}^{n} \left(x_{ki} - \overline{x}_i\right)^2 \sum_{i=1}^{n} \left(x_{kj} - \overline{x}_j\right)^2}}. \tag{10}$$

The correlation coefficient matrix E is calculated by the following equation:

$$E = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{bmatrix}. \tag{11}$$

The eigenvalues of the matrix E are $\lambda_1, \lambda_2, \ldots, \lambda_n$, and the eigenvectors of the matrix E are $\mu_1, \mu_2, \ldots, \mu_n$. So, the load matrix A of the factor is expressed by the following equation:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} = \begin{bmatrix} \mu_{11}\sqrt{\lambda_1} & \mu_{12}\sqrt{\lambda_2} & \cdots & \mu_{1n}\sqrt{\lambda_n} \\ \mu_{21}\sqrt{\lambda_1} & \mu_{22}\sqrt{\lambda_2} & \cdots & \mu_{2n}\sqrt{\lambda_n} \\ \vdots & \vdots & \vdots & \vdots \\ \mu_{n1}\sqrt{\lambda_1} & \mu_{n2}\sqrt{\lambda_2} & \cdots & \mu_{nn}\sqrt{\lambda_n} \end{bmatrix}. \tag{12}$$

The variance contribution rate of the factor j is g_j; then, $g_j = \sum_{i=1}^{n} a_{ij}^2$, $j = 1, 2, \ldots, n$.

When $\sum_{j=1}^{p} g_j / \sum_{j=1}^{n} g_j \geq 85\%$, that is, the cumulative variance contribution rate was more than 85%; then, the number of eigenvalues is selected as the number p of common factors. Next, the score function of each factor is obtained by the regression method. Finally, the score coefficient matrix S of factors is expressed by the following equation:

$$S = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1p} \\ s_{21} & s_{22} & \cdots & s_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ s_{n1} & s_{n2} & \cdots & s_{np} \end{bmatrix}. \tag{13}$$

The objective evaluation coefficient of each indicator is calculated by the following equation:

$$e_i = \frac{\sum_{j=1}^{p} g_j s_{ij}}{\sum_{j=1}^{p} g_j} = \frac{g_1 s_{i1} + g_2 s_{i2} + \cdots + g_p s_{ip}}{g_1 + g_2 + \cdots + g_p}, \tag{14}$$

where e_i represents the objective evaluation coefficient of indicator X_i; and S_{ij} represents the score coefficient of the indicator X_i with respect to factor j. Next, the objective evaluation coefficients of each indicator are normalized, as shown in the following equation.

$$\beta_i = \frac{e_i}{\sum_{i=1}^{n} e_i}, \tag{15}$$

where β_i is the objective weight value of the indicator X_i.

4.6. Step 6: Calculating the Reputation Evaluation Value of IFPs. The subjective weight α_i is obtained by the group decision AHP method in Section 4.4, and the objective weight β_i is obtained by FA in Section 4.5. The normalized formula of multiplication is used to determine the comprehensive weight of each indicator. The comprehensive weight w_i of indicator X_i is expressed by the following equation:

$$w_i = \frac{\alpha_i \cdot \beta_i}{\sum_{i=1}^{n} \alpha_i \cdot \beta_i}, \tag{16}$$

where n is the number of indicators.

The fuzzy comprehensive evaluation vector P is obtained by the indicator weight w_i and the fuzzy evaluation matrix K, where $P = (p_1, p_2, p_3, p_4, p_5)$. Based on the aforementioned "five levels" of reputation, the score set D for reputation evaluation is obtained. In this study, we set $D = (100, 80, 60, 40, 20)^T$, and the reputation evaluation value R of the Internet financial platform is expressed by the following equation:

$$R = P \times D = (p_1, p_2, \ldots, p_7) \times (100, 80, 60, 40, 20)^T = 100p_1 + 80p_2 + \cdots + 20p_5. \tag{17}$$

We determine the reputation level of IFPs according to the calculation of the reputation evaluation value. The detailed rating rules are given in Table 5.

Table 5: The reputation levels and scores.

Reputation level	Excellent	Good	General	Bad	Poor
Score	80–100	60–80	40–60	20–40	0–20

5. Case Study

5.1. Data Sample. In this study, the transaction data of the P2P lending platforms are selected as samples to verify the performance of IFEA. The octopus data collector was used to capture (obtain) the monthly transaction data of 20 P2P lending platforms during the period from January to June 2019 (data capture time: July 24, 2019) from HOL [20]. Data include net capital inflow, transaction volume per month, loan amount per capita, borrower per month, operating time, loan balance, registered capital, investment amount per capita, platform background, platform rate of return, average loan term, and other information. By querying the financial reports of 20 P2P lending platforms in 2018, we can obtain data such as total assets, asset-liability ratio, operating income, registered capital, net profit growth rate, and operating income growth rate. From the interactive community of HOL, the qualitative evaluations of the P2P lending platform from participants of the Internet finance are obtained.

The positive and negative indicator data are standardized according to equations (1) and (2); for qualitative indicator data, it is standardized according to the scoring rules of qualitative indicators in Table 2. The standardized result of the reputation evaluation indicators data of the P2P lending platforms is given in Table 6. Due to space limitation, only the processing results of some indicators of some platforms are given.

5.2. Calculating the Critical Value of the Rating and Membership Degree of Indicators. According to Tables 6 and 3, each reputation evaluation indicator of IFPs is divided into five ratings: "excellent," "good," "general," "bad," and "poor," and it calculates the critical value of each rating of the indicator. The following examples will demonstrate the calculation process of the critical value of the rating 1–5 scale of positive, negative, and qualitative indicators.

The critical values of the rating 1–5 scale of positive indicators are divided as follows: take transaction volume per month X_1 for example. The mean value of indicator X_1 of 20 P2P lending platforms is 1201222.3, and the standard deviation is 952327.0. According to the calculation formula of the critical value of the positive indicator rating in Table 3, excellent value $= 1201222.3 + 1.8 \times 952327.0 = 2915410.9$, good value $= 120122.23 + 0.8 \times 952327.0 = 1963083.9$, general value $= 120122.23 – 0.2 \times 952327.0 = 1010756.9$, bad value $= 120122.23 – 1.2 \times 952327.0 = 58429.9$, and poor value $= \min\{X_1\} = 45768.1$.

The critical values of the rating 1–5 scale of the negative indicators are divided as follows: for asset-liability ratio X_6, the mean value of indicator X_6 of 20 P2P lending platforms is 0.499, and the standard deviation is 0.297. According to the calculation formula of the critical value of negative indicator rating in Table 3, excellent value $= 0.499 – 1.2 \times 0.297 = 14.36\%$, good value $= 0.499 – 0.2 \times 0.297 = 44.01\%$, general value $= 0.499 + 0.8 \times 0.297 = 73.65\%$, bad value $= 0.499 + 1.8 \times 0.297 = 103.30\%$, and poor value $= \max\{X_6\} = 108.22\%$.

The critical value of the rating 1–5 scale of the qualitative indicator is divided as follows: the excellent value = 1.00, good value = 0.75, general value = 0.50, bad value = 0.25, and poor value = 0.00.

By analogy, the critical value of other indicators is calculated according to the above rules. The critical values of the rating 1–5 scale for all 24 indicators are given in Table 7.

According to the critical value of the rating 1–5 scale of each indicator in Table 7 and the membership function equations (3) and (4), take the internet financial platform PF1 as an example to calculate the membership degree.

For the membership degree of the positive indicator, the value of the indicator X_1 of PF1 is 2007634.4 thousand yuan, so the indicator rating is between "excellent" and "good." Thus, according to equation (3), the membership degree of an "excellent" rating of this indicator is $K_{x_1} = ((2007634.4 - 1963083.9)/(2915410.9 - 1963083.9)) = 0.047$, and its membership degree of the "good" rating of this indicator is $1 - K_{x_1} = 0.953$. The membership vector of the indicator X_1 of PF1 is $M_{X_1} = (0.047, 0.953, 0, 0, 0)$. The membership vector of other positive indicators of PF1 can be obtained similarly.

For the membership degree of a negative indicator, in the case of X_6 of PF1, the value of the indicator is 44.57%, which is less than the critical value of the "general" level 73.65% and more than the critical value of "good" level 44.01%. According to equation (4), the membership degree of "good" rating of this indicator is $K_{x_6} = ((73.65\% - 44.57\%)/(73.65\% - 44.01\%)) = 0.981$, and the membership degree of "general" rating of this indicator is $1 - K_{x_6} = 0.019$. The membership vector of the indicator X_6 of PF1 is $M_{X_6} = (0, 0.981, 0.019, 0, 0)$. The membership vector of other negative indicators of PF1 can be obtained in the same way.

For the membership degree of the qualitative indicator, when the indicator value is 1, then the membership degree of "excellent" rating of this indicator is 1, and the membership vector of the qualitative indicator of PF1 is $M_{X_i} = (1, 0, 0, 0, 0)$. Similarly, the membership vector of the qualitative indicator of platform PF1 is $M_{X_i} = (0, 1, 0, 0, 0)$, $M_{X_i} = (0, 0, 1, 0, 0)$, $M_{X_i} = (0, 0, 0, 1, 0)$, and $M_{X_i} = (0, 0, 0, 0, 1)$ when the indicator value is 0.75, 0.50, 0.25, and 0.00, respectively.

In summary, according to aforementioned rules, the membership degrees of all the 24 indicators of the PF1 are given in Table 8.

Table 6: The original and standardized data of 24 indicators of P2P lending platform.

Platform	Transaction volume per month		⋯	Total assets		Asset-liability ratio		⋯	Peer platforms feedback score	
	Original value	Standardized value	⋯	Original value	Standardized value	Original value	Standardized value	⋯	Original value	Standardized value
PF1	2007634.4	0.5125	⋯	389065.1	0.0456	44.57%	0.5923	⋯	Good	0.75
PF2	2140942.1	0.5473	⋯	1471955.3	0.1863	71.56%	0.3411	⋯	Good	0.75
PF3	2055776.6	0.5251	⋯	4554000.0	0.5868	64.89%	0.4032	⋯	Good	0.75
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋯	⋮	⋮
PF9	592942.1	0.1429	⋯	220764.3	0.0238	88.46%	0.2304	⋯	Low	0.50
PF10	482487.7	0.1141	⋯	1174026.8	0.1476	101.59%	0.0617	⋯	Low	0.25
PF11	410774.8	0.0954	⋯	75403.8	0.0049	43.47%	0.6025	⋯	Low	0.50
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋯	⋮	⋮
PF18	45768.1	0.0000	⋯	71686.1	0.0044	40.74%	0.6280	⋯	Low	0.25
PF19	254442.5	0.0545	⋯	330475.6	0.0380	45.18%	0.5866	⋯	General	0.50
PF20	300803.2	0.0666	⋯	117878.8	0.0104	0.75%	1.0000	⋯	Low	0.25

Table 7: The critical value of the rating 1–5 scale of 24 indicators.

Indicator	Excellent value	Good value	General value	Bad value	Poor value
X_1 (1000 yuan)	2915410.9	1963083.9	1010756.9	58429.9	45748.1
X_2 (number)	1012435	676653	340870	5088	3063
X_3 (1000 yuan)	140.9	95.7	50.4	05.2	00.0
X_4 (1000 yuan)	54252230.8	32065237.5	9878244.2	892512.0	600318.2
X_5 (1000 yuan)	4585112.1	2690059.4	795006.7	55936.1	37880.0
X_6 (%)	14.36	44.01	73.65	103.30	108.22
X_7 (1000 yuan)	4799375.0	2797328.4	795281.7	34503.9	23000.0
X_8 (1000 yuan)	1180843.5	696214.9	211586.3	17734.8	6550.0
X_9 (%)	11.93	10.56	9.18	7.81	7.08
X_{10} (score)	1.00	0.75	0.50	0.25	0.00
X_{11} (month)	4.16	9.81	15.45	21.09	27.69
X_{12} (minute)	111.29	67.57	23.85	6.36	0.10
X_{13} (%)	0.79	1.97	4.90	7.84	10.68
X_{14} (1000 yuan)	1015677.2	264802.6	−486072.0	−1236946.7	−3411750.4
X_{15} (%)	68.86	57.94	47.01	36.08	12.90
X_{16} (degree)	3.02	1.85	0.68	0.21	0.05
X_{17} (%)	1.00	0.75	0.50	0.25	0.00
X_{18} (month)	111.37	87.30	63.24	39.17	0.00
X_{19} (%)	249.00	133.78	18.55	−62.11	−72.17
X_{20} (%)	272.48	158.65	44.82	−69.01	—
X_{21} (score)	1.00	0.75	0.50	0.25	0.00
X_{22} (score)	1.00	0.75	0.50	0.25	0.00
X_{23} (score)	1.00	0.75	0.50	0.25	0.00
X_{24} (score)	1.00	0.75	0.50	0.25	0.00

Table 8: The membership degrees of all 24 indicators of platform PF1.

Indicator	Excellent	Good	General	Bad	Poor	Indicator	Excellent	Good	General	Bad	Poor
X_1	0.047	0.953	0	0	0	X_{13}	0	0.648	0.352	0	0
X_2	0.391	0.609	0	0	0	X_{14}	0	0.255	0.745	0	0
X_3	0	0.203	0.797	0	0	X_{15}	0	0.381	0.619	0	0
X_4	0	0.216	0.784	0	0	X_{16}	0	0.487	0.513	0	0
X_5	0	0	0.451	0.549	0	X_{17}	1	0	0	0	0
X_6	0	0.981	0.019	0	0	X_{18}	0	0	0.616	0.384	0
X_7	0	0	0.769	0.231	0	X_{19}	0	0.615	0.385	0	0
X_8	0	0	0.476	0.524	0	X_{20}	0	0.696	0.304	0	0
X_9	1	0	0	0	0	X_{21}	0	1	0	0	0
X_{10}	0	0	1	0	0	X_{22}	0	0	1	0	0
X_{11}	0	0	0.929	0.071	0	X_{23}	0	1	0	0	0
X_{12}	0	0	0	0.176	0.824	X_{24}	0	1	0	0	0

5.3. Calculating the Subjective Weight of Indicators. In order to achieve the reputation evaluation indicator system in Table 1, 10 experts including 3 associate professors and 7 doctoral candidates in the field of Internet finance are selected to score the importance of each reputation evaluation indicator according to the 1–9 scale method in Table 4. The comparative judgment matrix of the 10 experts was obtained. According to equation (6), the indicator comparison judgment matrix of the 10 experts was assembled.

The judgment matrix and weights of the criterion layer indices are given in Table 9.

The judgment matrix and weights of the indicator layer indices are given in Tables 10–15.

Whereas, Tables 10–15 are the judgment matrices and weights of indicator layer indices in criterion B_1, B_2, B_3, B_4, B_5, and B_6, respectively. The subjective weight of indicator X_1 is $\alpha_1 = 0.2502 \times 0.3626 = 0.0907$, the subjective weight of X_2 is $\alpha_2 = 0.2502 \times 0.2382 = 0.0596$, and the subjective weight of X_5 is $\alpha_5 = 0.2578 \times 0.2650 = 0.0683$. All the subjective weights of the 24 indicators are given in Table 16.

5.4. Calculating the Objective Weight of Indicators. According to the data of the 24 indicators of the 20 P2P lending platforms, Bartlett sphericity and the KMO test in SPSS20.0 statistical analysis software are used to verify whether the original variables are suitable for the factor analysis. Then, 8 common factors are extracted according to the gravel analysis diagram, as given in Table 17.

The score coefficient matrix of the 8 factors is obtained by regression calculation by the SPSS software. The results are given in Table 18.

According to equation (14), the score coefficient matrix of the factors is calculated to obtain the objective evaluation coefficient of the indicator. In case of X_1, the detailed steps of the objective weight calculation process of this indicator are demonstrated as follows.

The objective evaluation coefficient of the indicator X_1 is

$$\frac{23.042\% \times 0.106 + 12.628\% \times 0.045 - 10.559\% \times 0.018 + \cdots + 6.085\% \times 0.155 - 4.451\% \times 0.115}{23.042\% + 12.628\% + 10.559\% + 9.362\% + 7.521\% + 6.432\% + 6.085\% + 4.451\%} = 0.0417. \tag{18}$$

Similarly, the objective evaluation coefficient of the other indicators can be obtained.

Meanwhile, the objective weight of the indicator is obtained by normalizing the objective evaluation coefficient according to equation (16). The objective weight of indicator X_1 is $\beta_1 = 0.0453$. The objective weights of other indicators are given in Table 16.

5.5. Fuzzy Comprehensive Evaluation. According to equation (16), the comprehensive weights of indicators are obtained. As given in Table 16, the higher the comprehensive weight values of the reputation evaluation indicators such as the "asset-liability ratio," the "transaction volume per month," the "operating income," and the "total assets rank," the greater their impact on the reputation of IFPs.

According to Table 16, the weight of the criterion scale strength B_1 is $w_{B_1} = 0.0961 + 0.0626 + 0.0723 + 0.0383 = 0.2693$. Similarly, the weights of criteria B_2, B_3, B_4, B_5, and B_6 are 0.3507, 0.1303, 0.1065, 0.0750, and 0.0681, respectively. So, the weight vector of the criterion layer B_1 is $W_1 = ((0.0961/0.2693), (0.0626/0.2693), (0.0723/0.2693), (0.0383/0.2693)) = (0.3569, 0.2324, 0.2685, 0.1422)$. Correspondingly, the weight vector of indicators in the criterion financial performance B_2 is $W_2 = (0.2207, 0.3456, 0.2640, 0.1697)$, the weight vector of indicators in the criterion service quality B_3 is $W_3 = (0.2452, 0.2058, 0.0854, 0.2301, 0.2335)$, the weight vector of indicators in the criterion capital liquidity B_4 is $W_4 = (0.3299, 0.3736, 0.2965)$, the weight vector of indicators in the criterion development potential B_5 is $W_5 = (0.2328, 0.1042, 0.3462, 0.3168)$, and the weight vector of indicators in the criterion stakeholder evaluation for platform B_6 is $W_6 = (0.5165, 0.1445, 0.0317, 0.3073)$.

The first-order fuzzy synthesis vector from the indicators layer to the criterion layer is calculated. Taking PF1, for example, the first-order fuzzy synthesis vector of the scale strength is as follows:

$$\begin{aligned} P_1 = W_1 \times \begin{pmatrix} M_{X_1} \\ M_{X_2} \\ M_{X_3} \\ M_{X_4} \end{pmatrix} &= (0.3569, 0.2324, 0.2685, 0.1422) \times \begin{pmatrix} 0.047 & 0.953 & 0 & 0 & 0 \\ 0.391 & 0.609 & 0 & 0 & 0 \\ 0 & 0.203 & 0.797 & 0 & 0 \\ 0 & 0.216 & 0.784 & 0 & 0 \end{pmatrix} \\ &= (0.1075, 0.5670, 0.3255, 0, 0). \end{aligned} \tag{19}$$

Table 9: Judgment matrix and weights of criterion layer indices.

Criterion layer	B_1	B_2	B_3	B_4	B_5	B_6	Maximum eigenvalue	Relative weight	CR
B_1	1	1.7118	1.8760	1.4727	1.5683	2.7742	6.3024	0.2502	0.0504
B_2	0.5842	1	2.3191	2.5779	2.2179	3.0837		0.2578	
B_3	0.5330	0.4313	1	1.4767	1.7617	2.3522		0.1566	
B_4	0.6790	0.3879	0.6771	1	2.6360	2.2036		0.1551	
B_5	0.6376	0.4508	0.5676	0.3794	1	2.7019		0.1138	
B_6	0.3604	0.3243	0.4251	0.4538	0.3701	1		0.0665	

Table 10: Judgment matrix and weights of indicator layer indices in criterion B_1.

Indicator layer	X_1	X_2	X_3	X_4	Maximum eigenvalue	Relative weight	CR
X_1	1	2.3097	1.5971	1.335	4.1258	0.3626	0.0338
X_2	0.4330	1	1.8564	1.1161		0.2382	
X_3	0.6261	0.5387	1	1.1822		0.1920	
X_4	0.7490	0.8960	0.8459	1		0.2071	

Table 11: Judgment matrix and weights of indicator layer indices in criterion B_2.

Indicator layer	X_5	X_6	X_7	X_8	Maximum eigenvalue	Relative weight	CR
X_5	1	4.8225	4.8638	5.6992	4.8966	0.2650	0.0922
X_6	0.2074	1	6.5041	6.3374		0.3489	
X_7	0.2056	0.1537	1	6.9599		0.2474	
X_8	0.1764	0.1578	0.1437	1		0.1388	

Table 12: Judgment matrix and weights of indicator layer indices in criterion B_3.

Indicator layer	X_9	X_{10}	X_{11}	X_{12}	X_{13}	Maximum eigenvalue	Relative weight	CR
X_9	1	1.4727	2.0476	1.6141	0.9895	5.1772	0.2613	0.0357
X_{10}	0.6790	1	2.6052	2.4307	1.3110		0.2681	
X_{11}	0.4884	0.3839	1	2.1074	0.6520		0.1475	
X_{12}	0.6196	0.4114	0.4745	1	0.7892		0.1202	
X_{13}	1.0106	0.7628	1.5337	1.2671	1		0.2028	

Table 13: Judgment matrix and weights of indicator layer indices in criterion B_4.

Indicator layer	X_{14}	X_{15}	X_{16}	Maximum eigenvalue	Relative weight	CR
X_{14}	1	2.2442	1.6141	3.1108	0.4842	0.0447
X_{15}	0.4456	1	1.9433		0.3005	
X_{16}	0.6196	0.5146	1		0.2154	

Table 14: Judgment matrix and weights of indicator layer indices in criterion B_5.

Indicator layer	X_{17}	X_{18}	X_{19}	X_{20}	Maximum eigenvalue	Relative weight	CR
X_{17}	1	1.6438	0.9819	0.9704	4.0058	0.2772	0.0016
X_{18}	0.5179	1	0.9330	0.6711		0.1909	
X_{19}	1.0184	1.1487	1	1.3493		0.2800	
X_{20}	1.0537	1.4902	0.6452	1		0.2519	

Table 15: Judgment matrix and weights of indicator layer indices in criterion B_6.

Indicator layer	X_{21}	X_{22}	X_{23}	X_{24}	Maximum eigenvalue	Relative weight	CR
X_{21}	1	1.8882	1.5971	1.5060	4.1225	0.3533	0.0329
X_{22}	0.5296	1	1.6438	2.5048		0.2907	
X_{23}	0.6261	0.6084	1	1.4142		0.1987	
X_{24}	0.6640	0.3992	0.7071	1		0.1573	

Table 16: The weights of reputation evaluation indicators of IFPs.

Indicator	Subjective weight	Objective weight	Comprehensive weight	Importance rank	Indicator	Subjective weight	Objective weight	Comprehensive weight	Importance rank
X_1	0.0907	0.0453	0.0961	2	X_{13}	0.0318	0.0409	0.0304	14
X_2	0.0596	0.0449	0.0626	6	X_{14}	0.0751	0.0200	0.0351	11
X_3	0.0480	0.0644	0.0723	5	X_{15}	0.0466	0.0365	0.0398	8
X_4	0.0518	0.0316	0.0383	9	X_{16}	0.0334	0.0404	0.0316	13
X_5	0.0683	0.0484	0.0774	4	X_{17}	0.0315	0.0237	0.0175	20
X_6	0.0899	0.0576	0.1212	1	X_{18}	0.0217	0.0154	0.0078	23
X_7	0.0638	0.0620	0.0926	3	X_{19}	0.0319	0.0348	0.0260	17
X_8	0.0358	0.0710	0.0595	7	X_{20}	0.0287	0.0354	0.0238	18
X_9	0.0409	0.0334	0.0320	12	X_{21}	0.0235	0.0640	0.0352	10
X_{10}	0.0420	0.0273	0.0268	16	X_{22}	0.0193	0.0218	0.0098	22
X_{11}	0.0231	0.0206	0.0111	21	X_{23}	0.0132	0.0070	0.0022	24
X_{12}	0.0188	0.0682	0.0300	15	X_{24}	0.0105	0.0852	0.0209	19

Table 17: Total variance of factor analysis.

Factor	Initial eigenvalue		
	Eigenvalue	Variance contribution rate (%)	Cumulative variance contribution (%)
1	5.530	23.042	23.042
2	3.031	12.628	35.670
3	2.534	10.559	46.229
4	2.247	9.362	55.592
5	1.805	7.521	63.113
6	1.544	6.432	69.545
7	1.460	6.085	75.630
8	1.068	4.451	80.081

Table 18: The score coefficient matrix of the 8 factors.

Indicator	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
X_1	0.106	0.045	−0.018	0.113	−0.177	0.056	0.155	−0.115
X_2	−0.018	0.078	0.248	−0.092	−0.044	−0.056	0.177	0.136
X_3	0.273	−0.161	−0.125	0.076	0.079	−0.011	0.065	0.043
X_4	−0.040	0.291	0.009	−0.053	0.007	−0.049	−0.012	0.071
X_5	0.186	0.109	−0.075	0.086	−0.092	−0.120	−0.074	−0.044
X_6	0.013	−0.028	0.045	−0.379	−0.001	−0.079	−0.055	−0.060
X_7	0.104	0.108	0.059	0.009	0.062	−0.054	0.002	−0.007
X_8	0.232	−0.098	0.062	−0.079	0.097	0.021	−0.059	0.159
X_9	0.034	0.002	0.327	−0.075	0.131	0.038	−0.371	−0.017
X_{10}	−0.016	0.131	−0.236	−0.056	−0.067	0.127	−0.206	0.149
X_{11}	0.144	−0.054	−0.333	−0.043	−0.003	−0.132	0.022	0.115
X_{12}	0.103	−0.066	0.045	0.271	−0.117	−0.072	0.109	0.262
X_{13}	−0.044	−0.040	−0.047	0.054	0.050	0.481	0.189	−0.021
X_{14}	0.085	−0.334	0.008	0.035	−0.007	0.087	0.034	−0.081
X_{15}	0.056	−0.049	−0.011	0.387	0.017	−0.045	−0.127	−0.124
X_{16}	−0.064	0.110	−0.020	0.000	0.111	0.047	−0.050	0.553
X_{17}	−0.012	0.082	−0.073	0.026	0.394	−0.009	−0.187	−0.055
X_{18}	0.210	−0.017	−0.054	−0.068	−0.142	−0.031	−0.066	−0.133
X_{19}	−0.017	0.108	−0.084	0.036	−0.019	−0.537	0.151	−0.067
X_{20}	0.013	−0.093	−0.045	0.181	0.137	−0.080	0.239	0.068
X_{21}	0.053	−0.047	0.113	−0.108	0.446	0.066	−0.073	0.131
X_{22}	−0.004	0.005	−0.001	−0.079	−0.098	0.010	0.532	−0.040
X_{23}	−0.140	0.186	0.075	0.065	0.178	0.016	0.010	−0.335
X_{24}	0.135	0.058	0.017	0.090	0.118	0.098	−0.001	−0.015

Similarly, the first-order fuzzy synthesis vector of the financial performance is $P_2 = (0, 0.3391, 0.3896, 0.2713, 0)$, the first-order fuzzy synthesis vector of the service quality is $P_3 = (0.2452, 0.1514, 0.3672, 0.0465, 0.1897)$, the first-order fuzzy synthesis vector of the capital liquidity is $P_4 = (0, 0.3708, 0.6292, 0, 0)$, the first-order fuzzy synthesis vector of the development potential is $P_5 = (0.2328, 0.4332, 0.2940, 0.0400, 0)$, and the first-order fuzzy synthesis vector of the stakeholder evaluation for the platform is $P_6 = (0, 0.8555, 0.1445, 0, 0)$.

Next, the second-order fuzzy synthesis vector from the criterion layer to the target layer is calculated as follows:

$$P = W \times \begin{pmatrix} P_1 \\ P_2 \\ P_3 \\ P_4 \\ P_5 \\ P_6 \end{pmatrix} = (0.2693, 0.3507, 0.1303, 0.1065, 0.0750, 0.0681) \times \begin{pmatrix} 0.1075 & 0.5670 & 0.3255 & 0 & 0 \\ 0 & 0.3391 & 0.3896 & 0.2713 & 0 \\ 0.2452 & 0.1514 & 0.3672 & 0.0465 & 0.1897 \\ 0 & 0.3708 & 0.6292 & 0 & 0 \\ 0.2328 & 0.4332 & 0.2940 & 0.0400 & 0 \\ 0 & 0.8555 & 0.1445 & 0 & 0 \end{pmatrix} = (0.0784, 0.4216, 0.3710, 0.1042, 0.0247). \tag{20}$$

Therefore, the reputation level of the platform PF1 belongs to the "excellent" rating with a membership degree of 0.0784, the membership in the "good" rating is 0.4216, the membership in the "general" rating is 0.3710, the membership in the "bad" rating is 0.1042, and the membership in the "poor" rating is 0.0247. According to equation (17), the final reputation comprehensive evaluation value of PF1 is obtained.

$$R = P \times D = (0.0784, 0.4216, 0.3710, 0.1042, 0.0247) \times (100, 80, 60, 40, 20)^T = 68.49. \tag{21}$$

According to the rating rules of the reputation level in Table 5, it can be determined that the reputation level of the Internet financial platform PF1 is "good." The reputation levels of the other 19 IFPs are given in Table 19.

The results in Table 19 provide that the reputation level of the 20 IFPs is between "good" and "low." Six platforms are in the reputation rating of "good," 11 platforms are in the reputation rating of "general," and 3 platforms are in the reputation rating of "bad," and it has good rating differentiation. The three IFPs with the "bad" reputation level (PF9, PF18, and PF20) are consistent with the reputation status quo of the platforms, respectively. For example, according to the financial report of the platform PF9 in 2018, it is found that the scale strength of the platform is relatively weak. The total assets and operating income are relatively low compared with other platforms. The asset-liability ratio is relatively high, and the profit growth rate is negative. In terms of capital liquidity, the net capital inflow is negative, and the capital adequacy ratio is lower than other platforms. In addition, the existing online information media disclosed that PF9 had been investigated in March 2020 due to the illegal fund-raising, which further verified the effectiveness and adaptability of the evaluation results of the IFEA.

To further explore the impact of various reputation evaluation indicators on the reputation of the PF9, the impact of each reputation indicators on the reputation evaluation value of PF9 is calculated. As shown in Figure 3, the order of factors of reputation of PF9 is the indicators X_6, X_1, X_7, and X_5. Therefore, if managers want to improve the reputation of the PF9, the "asset-liability ratio" of PF9 should be reduced, and the "transaction volume per month," "operating income," and "total assets" of the PF9 should be enhanced.

In this work, Table 16 provides that the weights of "asset-liability ratio," "operating income," and "total assets" are the highest in direct reputation evaluation indicators, which indicates that the financial performance is crucial for direct reputation of the IFPs. Besides, the weight of "investors feedback score" is the highest in indirect reputation evaluation indicators, which indicates that the evaluation of investors is attached more important for indirect reputation of the IFPs.

Moreover, the reputation level of the entire Internet finance industry can be obtained by appropriately expanding the sample based on IFEA. Besides, the results can provide decision-making references on the investment of Internet finance for the investors. Meanwhile, the results of the IFEA can also help the managers find ways to improve the reputation of the platform. In detail, the financial performance and evaluation of investors have a great influence on the direct and indirect reputations of the IFPs. Thus, the managers can improve the reputation level of the platform by optimizing these factors.

5.6. Discussion regarding the Results of IFEA, TOPSIS, and DEMATEL. In this study, IFEA-integrated FCE, AHP, and FA is designed for evaluating the reputation of the IFPs. In this subsection, IFEA is compared with TOPSIS [29] and DEMATEL [28] to validate its performance in terms of the comparative analysis of the 24 reputation indicators.

The overall importance weights and ranking of the reputation indicators among the IFPs obtained by applying TOPSIS, DEMATEL, and IFEA are given in Table 20. The results of the IFEA show that the weights and ranking of the reputation indicators $X_6 > X_1 > X_7 > X_5 > X_3 > X_2$ are the highest-ranking among the 24 indicators. Similarly, the results of TOPSIS show that $X_1 > X_5 > X_3 > X_{12} > X_2 > X_{17}$ are highly significant indicators. The results of DEMATEL show $X_6 > X_{12} > X_3 > X_2 > X_5 > X_4$ as the highest priority reputation indicators. Subsequently, the relative weights obtained by IFEA are compared with TOPSIS and DEMATEL. We can

Table 19: The reputation level of IFPs.

Platform	Reputation evaluation value	Reputation level	Platform	Reputation evaluation value	Reputation level
PF1	68.49	Good	PF11	57.36	General
PF2	69.13	Good	PF12	47.84	General
PF3	70.20	Good	PF13	55.62	General
PF4	53.50	General	PF14	77.91	Good
PF5	55.99	General	PF15	43.30	General
PF6	54.85	General	PF16	75.33	Good
PF7	54.83	General	PF17	71.61	Good
PF8	53.22	General	PF18	32.74	Bad
PF9	39.31	Bad	PF19	44.31	General
PF10	53.41	General	PF20	31.68	Bad

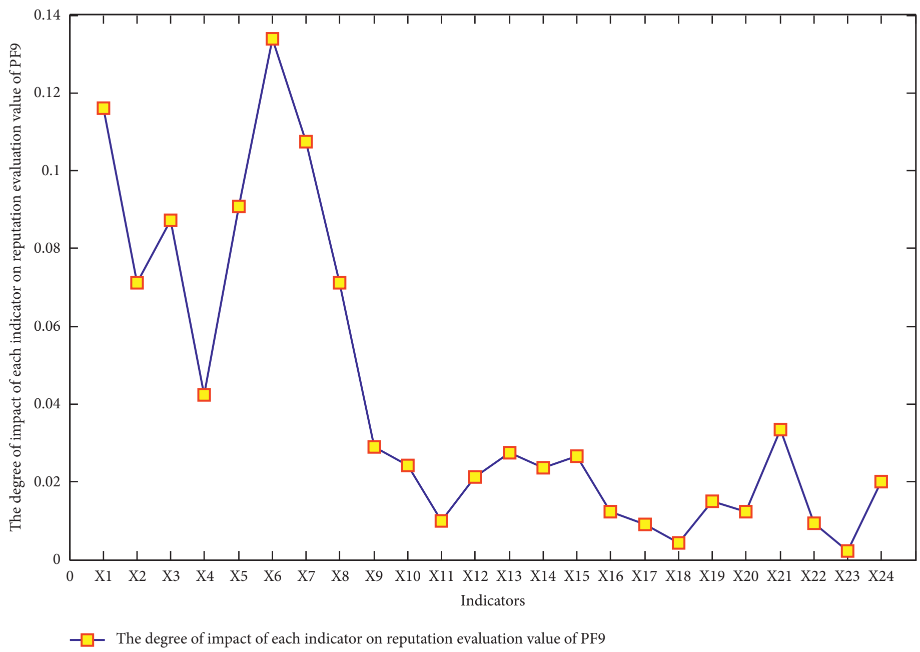

Figure 3: The degree of impact of each indicator on reputation evaluation value of PF9.

Table 20: Fuzzy importance weights and ranking of reputation indicators, as obtained by TOPSIS, DEMATEL, and IFEA.

Reputation indicator	Results of TOPSIS [29]		Results of DEMATEL [28]		Results of this work	
	Weights (W_i)	Rank	Weights (W_i)	Rank	Weights (W_i)	Rank
X_1	0.0513	1	0.0464	7	0.0961	2
X_2	0.0471	5	0.0508	4	0.0626	6
X_3	0.0495	3	0.0533	3	0.0723	5
X_4	0.0462	7	0.0489	6	0.0383	9
X_5	0.0502	2	0.0495	5	0.0774	4
X_6	0.0455	9	0.0584	1	0.1212	1
X_7	0.0461	8	0.0325	23	0.0926	3
X_8	0.0363	20	0.0374	16	0.0595	7
X_9	0.0385	18	0.0357	19	0.0320	12
X_{10}	0.0406	16	0.0348	21	0.0268	16
X_{11}	0.0406	17	0.0397	12	0.0111	21
X_{12}	0.0477	4	0.0579	2	0.0300	15
X_{13}	0.0414	14	0.0384	14	0.0304	14
X_{14}	0.0452	10	0.0409	10	0.0351	11
X_{15}	0.0451	11	0.0366	17	0.0398	8
X_{16}	0.0347	21	0.0399	11	0.0316	13
X_{17}	0.0470	6	0.0448	8	0.0175	20
X_{18}	0.0416	13	0.0411	9	0.0078	23

Table 20: Continued.

Reputation indicator	Results of TOPSIS [29]		Results of DEMATEL [28]		Results of this work	
	Weights (W_i)	Rank	Weights (W_i)	Rank	Weights (W_i)	Rank
X_{19}	0.0433	12	0.0385	13	0.0260	17
X_{20}	0.0366	19	0.0381	15	0.0238	18
X_{21}	0.0409	15	0.0339	22	0.0352	10
X_{22}	0.0326	22	0.0360	18	0.0098	22
X_{23}	0.0300	23	0.0356	20	0.0022	24
X_{24}	0.0219	24	0.0312	24	0.0209	19

find that the indicators $X_1 > X_5 > X_3 > X_2$ have a significant impact, and they are consistent with TOPSIS, the indicators $X_6 > X_3 > X_2$ have significant impact, and they are consistent with DEMATEL too. In other words, the highly significant indicators obtained from the IFEA are almost consistent with the TOPSIS and DEMATEL, which indicates that IFEA has a great performance for displaying the effectiveness of the reputation indicators. Moreover, Kendall's coefficient of concordance computed for TOPSIS, DEMATEL, and IFEA rankings is 0.673, which indicates a very high correlation among rankings.

Therefore, we can conclude that the IFEA is a robust and efficient approach for evaluating the reputation of IFPs. The evaluation results of IFPs improved by the IFEA comprehensively consider the objectiveness and fuzziness of the results, which can reduce uncertainty and randomness in the determination process of the indicator weight and membership degree. By emphasizing these reputation indicators, the managers can obtain the key factors in determining the reputation of IFPs.

6. Conclusions and Future Research

The focus of this study is to design a reputation evaluation approach for IFPs. Since the credit challenge of IFPs commonly exposed in China recently, it is urgent and beneficial to construct a reputation evaluation system for the Chinese IFPs to reduce the investment risk and to help investors make better decisions. The research results are shown as follows:

(1) The reputation evaluation indicator system of the IFPs, which includes 6 criteria (e.g., scale strength, financial performance, service quality, capital liquidity, development potential, and stakeholder evaluation for the platform) and 24 indicators, is constructed from the two dimensions of direct and indirect reputations. The results of the case study show that this system can more comprehensively reflect the reputation levels of the IFPs, and the financial performance and evaluation of investors have a great influence on the direct and indirect reputation of the IFPs, respectively.

(2) The methods of FCE, AHP, and FA are integrated to develop an improved fuzzy evaluation approach (IFEA) for evaluating the reputation of IFPs. Results of the case study are presented to show that IFEA can significantly distinguish the reputation level of the IFPs and effectively identify the IFPs with high investment risks. The reputation evaluation results of IFPs improved by the IFEA comprehensively consider the objectiveness and fuzziness of the results compared with other MCDM approaches (e.g., TOPSIS and DEMATEL), which can improve the robustness and closeness with the reality of the evaluation results.

(3) The reputation levels of the IFPs can be calculated by the transaction data extracted during the period of June 2019. The results of the case study are consistent with the actual reputation level of the IFPs in China. With the reputation evaluation results of IFPs, which is more objective and reliable, the investors can make the correct investing decisions and reduce the investment risk of Internet finance. Moreover, it can also help managers to find out the key factors of reputation in determining the reputation of IFPs, such as asset-liability ratio, operating income, total assets, and investors feedback score, thereby improving the reputation level of IFPs by optimizing these factors.

This study makes several contributions to the field of the MCDM approach and its applications. First, the IFEA is designed for evaluating the reputation level of IFPs, which is easy to operate and can help investors make the better investing decisions. Second, the IFEA considers the uncertainty of a complex large group decision-making and combines the subjective weighting method and objective weighting method during the indicator weight in decision-making problems. It not only overcomes the shortcomings of the traditional subjective factors' empowerment method but also takes full account of objective factors. Third, the IFEA expands the application of the traditional fuzzy MCDM approaches. It can not only evaluate the reputation of IFPs but also apply to reputation evaluation of other industry platforms (e.g., e-commerce platform and logistics information platform).

This study can be further extended. The reputation evaluation indicators are summarized based on literature and the related reputation evaluation indicator system of the third-party credit rating agencies in this work. Since the factors influencing the reputation of IFPs varies with the change of external environments, it is recommended that big data can be used to discover the potential factors. Besides, the method of artificial intelligence, such as the support vector machine (SVM) and neural network (NN), can also be incorporated into FCE to further improve the effectiveness of the fuzzy evaluation method.

Data Availability

The data used to support this research article are available from the first author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

[1] P. Xie, C. Zou, and H. Liu, "The fundamentals of internet finance and its policy implications in China," *China Economic Journal*, vol. 9, no. 3, pp. 240–252, 2016.

[2] Z. Chen, Y. Li, Y. Wu, and J. Luo, "The transition from traditional banking to mobile internet finance: an organizational innovation perspective-a comparative study of Citibank and ICBC," *Financial Innovation*, vol. 3, no. 1, 2017.

[3] C.-C. Liang and N. L. Nguyen, "Marketing strategy of internet-banking service based on perceptions of service quality in Vietnam," *Electronic Commerce Research*, vol. 18, no. 3, pp. 629–646, 2017.

[4] P. Xia, Z. Ni, X. Zhu, and L. Ni, "A novel key influencing factors selection approach of P2P lending investment risk," *Mathematical Problems in Engineering*, vol. 2019, no. 12, Article ID 6086089, 2019.

[5] Y. Guo, W. Zhou, C. Luo, C. Liu, and H. Xiong, "Instance-based credit risk assessment for investment decisions in P2P lending," *European Journal of Operational Research*, vol. 249, no. 2, pp. 417–426, 2016.

[6] G. You, H. Guo, A. Dagestani, and S. Deng, "Evolutionary game analysis of three players on behavioural strategy of P2P lending participants: a sustainable operations perspective," *Complexity*, vol. 2021, Article ID 7795016, 2021.

[7] G. Bolton, B. Greiner, and A. Ockenfels, "Engineering trust: reciprocity in the production of reputation information," *Management Science*, vol. 59, no. 2, pp. 265–285, 2013.

[8] X. Chen, X. Hu, and S. Ben, "How do reputation, structure design and FinTech ecosystem affect the net cash inflow of P2P lending platforms? Evidence from China," *Electronic Commerce Research*, 2020, In press.

[9] Z. Wang, Y. Liu, S.-B. Tsai et al., "A research on effect of response to internet financing reputation evaluation on achievement - from the perspective of social network theory," *IEEE Access*, vol. 7, pp. 39352–39361, 2019.

[10] M. E. Greiner and H. Wang, "Building consumer-to-consumer trust in E-finance marketplaces: an empirical analysis," *International Journal of Electronic Commerce*, vol. 15, no. 2, pp. 105–136, 2010.

[11] H. Yum, B. Lee, and M. Chae, "From the wisdom of crowds to my own judgment in microfinance through online peer-to-peer lending platforms," *Electronic Commerce Research and Applications*, vol. 11, no. 5, pp. 469–483, 2012.

[12] W. Liu and L. Q. Xia, "An evolutionary behavior forecasting model for online lenders and borrowers in peer-to-peer lending," *Asia Pacific Journal of Operational Research*, vol. 34, no. 1, Article ID 1740008, 2017.

[13] Q. Wei and Q. Zhang, "P2P lending risk contagion analysis based on a complex network model," *Discrete Dynamics in Nature and Society*, vol. 2016, Article ID 5013954, 2016.

[14] Q. Yang and Y.-C. Lee, "Influencing factors on the lending intention of online peer-to-peer lending: lessons from renrendai.com," *Journal of Information Systems*, vol. 25, no. 2, pp. 79–110, 2016.

[15] K. Kuwabara, D. Anthony, and C. Horne, "In the shade of a forest status, reputation, and ambiguity in an online micro-credit market," *Social Science Research*, vol. 64, pp. 96–118, 2017.

[16] M. Lin, N. R. Prabhala, and S. Viswanathan, "Judging borrowers by the company they keep: friendship networks and information asymmetry in online peer-to-peer lending," *Management Science*, vol. 59, no. 1, pp. 17–35, 2013.

[17] J. Ding, J. Huang, Y. Li, and M. Meng, "Is there an effective reputation mechanism in peer-to-peer lending? Evidence from China," *Finance Research Letters*, vol. 30, no. 1, pp. 208–215, 2019.

[18] X. Shi, J. Wu, and J. Hollingsworth, "How does P2P lending platform reputation affect lenders' decision in China?" *International Journal of Bank Marketing*, vol. 37, no. 7, pp. 1566–1589, 2019.

[19] W. E. Davies and E. Giovannetti, "Signalling experience and reciprocity to temper asymmetric information in crowdfunding evidence from 10,000 projects," *Technological Forecasting and Social Change*, vol. 133, pp. 118–131, 2018.

[20] "Home of Online Loans" (HOL) 12 March 2020, https://shuju.wdzj.com/.

[21] "Wang Dai Tian Yan" (WDTY) 13 March 2020, https://www.p2peye.com/shuju/ptsj/.

[22] "Rong 360" (R360) 13 March 2020, https://www.r360insights.com/.

[23] S. Pang and J. Yang, "Social reputation loss model and application to lost-linking borrowers in a internet financial platform," *Peer-to-Peer Networking and Applications*, vol. 13, no. 4, pp. 1193–1203, 2020.

[24] M. Mohtashemi and L. Mui, "Evolution of indirect reciprocity by social information: the role of trust and reputation in evolution of altruism," *Journal of Theoretical Biology*, vol. 223, no. 4, pp. 523–531, 2003.

[25] Y. Yu and C. Li, "Evaluate the priority of product design factors in the process of complex product innovation," *Complex and Intelligent Systems*, 2021, In press.

[26] Y. Cao and S. Xiong, "A sustainable financing credit rating model for China's small- and medium-sized enterprises," *Mathematical Problems in Engineering*, vol. 2014, Article ID 861085, 5 pages, 2014.

[27] Y. Yu, C. Li, W. Yang, and W. Xu, "Determining the critical factors of air-conditioning innovation using an integrated model of fuzzy Kano-QFD during the COVID-19 pandemic: the perspective of air purification," *PLoS One*, vol. 16, no. 7, Article ID e0255051, 2021.

[28] A. K. Sangaiah, P. R. Subramaniam, and X. Zheng, "A combined fuzzy DEMATEL and fuzzy TOPSIS approach for

evaluating GSD project outcome factors," *Neural Computing & Applications*, vol. 26, no. 5, pp. 1025–1040, 2015.

[29] M. Shaverdi, I. Ramezani, R. Tahmasebi, and A. A. A. Rostamy, "Combining fuzzy AHP and fuzzy TOPSIS with financial ratios to design a novel performance evaluation model," *International Journal of Fuzzy Systems*, vol. 18, no. 2, pp. 248–262, 2016.

[30] T. Teubner, M. T. P. Adam, and F. Hawlitschek, "Unlocking online reputation," *Business & Information Systems Engineering*, vol. 62, no. 6, pp. 501–513, 2019.

[31] P. Bond and A. S. Rai, "Borrower runs," *Journal of Development Economics*, vol. 88, no. 2, pp. 185–191, 2009.

[32] P. Song, Y. Chen, Z. Zhou, and H. Wu, "Performance analysis of peer-to-peer online lending platforms in China," *Sustainability*, vol. 10, no. 9, Article ID 2987, 2018.

[33] W. Fang, C. Zhang, Z. Shi, Q. Zhao, and L. Shan, "BTRES: beta-based trust and reputation evaluation system for wireless sensor networks," *Journal of Network and Computer Applications*, vol. 59, pp. 88–94, 2016.

[34] A. Panagopoulos, E. Koutrouli, and A. Tsalgatidou, "Modeling and evaluating a robust feedback-based reputation system for e-commerce platforms," *ACM Transactions on the Web*, vol. 11, no. 3, 2017.

[35] Y. Feng and B. Huang, "A hierarchical and configurable reputation evaluation model for cloud manufacturing services based on collaborative filtering," *International Journal of Advanced Manufacturing Technology*, vol. 94, no. 9-12, pp. 3327–3343, 2018.

[36] S. Zhang, S. Xu, W. Zhang, and D. Yu, "A time-aware hyperlink-induced topic search-based reputation evaluation method for optimal manufacturing service recommendation in distributed peer-to-peer networks," *Journal of Algorithms and Computational Technology*, vol. 11, no. 1, pp. 13–22, 2017.

[37] S. Wang, L. Sun, Q. Sun, J. Wei, and F. Yang, "Reputation measurement of cloud services based on unstable feedback ratings," *International Journal of Web and Grid Services*, vol. 11, no. 4, pp. 362–376, 2015.

[38] Y. Dong, G. Hao, J. Wang, C. Liu, and C. Xia, "Cooperation in the spatial public goods game with the second-order reputation evaluation," *Physics Letters A*, vol. 383, no. 11, pp. 1157–1166, 2019.

[39] L. A. Zadeh, "Fuzzy sets," *Information and Control*, vol. 8, no. 3, pp. 338–353, 1965.

[40] L. Ma, Y. Xu, J. Zheng, and X. Dai, "Reconfigurability evaluation of multifunctional intelligent boom sprayer based on fuzzy comprehensive evaluation," *Mathematical Problems in Engineering*, vol. 2020, Article ID 7167193, 2020.

[41] M. Sanchez-Roger, M. Oliver-Alfonso, and C. Sanchis-Pedregosa, "Fuzzy logic and its uses in finance: a systematic review exploring its potential to deal with banking crises," *Mathematics*, vol. 7, no. 11, Article ID 1091, 2019.

[42] K. Chen and M. Wang, "Research on performance evaluation of projects loaned by international financial organizations with fuzzy number intuitionistic fuzzy information," *Journal of Intelligent and Fuzzy Systems*, vol. 33, no. 6, pp. 3505–3514, 2017.

[43] H. Guo, C. Zheng, X. Yang, H. Lin, and X. Yang, "Fuzzy comprehensive evaluation for the laboratory performance in the university under multi-judgments situation," *Journal of Liaocheng University*, vol. 33, no. 1, pp. 10–16, 2020.

[44] J. Li, Q. Zhang, F. Yan, and M. Zhong, "A cloud model-based multi-level fuzzy comprehensive evaluation approach for financing credit of scientific & technological small-medium enterprises," *Journal of Difference Equations and Applications*, vol. 23, no. 1-2, pp. 443–456, 2017.

[45] Y. Zhong, "Financial risk investment decision based on fuzzy logic theory model," *Journal of Discrete Mathematical Sciences and Cryptography*, vol. 21, no. 6, pp. 1419–1424, 2018.

[46] E. A. G. Groenland, "Qualitative research to validate the RQ-dimensions," *Corporate Reputation Review*, vol. 4, no. 4, pp. 308–315, 2002.

[47] F. Thevissen, "Belgium: corporate reputation in the eye of the beholder," *Corporate Reputation Review*, vol. 4, no. 4, pp. 318–326, 2002.

[48] S. Yu, G. Chi, and X. Jiang, "Credit rating system for small businesses using the K-S test to select an indicator system," *Management Decision*, vol. 57, no. 1, pp. 229–247, 2019.

[49] Y. Hong and Q. Zhang, "Indicator selection for topic popularity definition based on AHP and deep learning models," *Discrete Dynamics in Nature and Society*, vol. 2020, Article ID 9634308, 11 pages, 2020.

[50] G. Luo, Y. Liu, and X. Mo, "Factor Analysis model based on the theory of the TOPSIS in the application research," *Discrete Dynamics in Nature and Society*, vol. 2017, Article ID 9173460, 8 pages, 2017.