Research Article

Risk Evaluation of the New Fintech Institutions in China Based on Fuzzy Analytical Hierarchy Process

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The ongoing digital transformation is being undertaken by the financial institutions on the upgrade in China. The risks are accumulated synchronously in the middle of establishing differentiated competitive advantages through information technology innovations by the new fintech institutions. In this study, a fuzzy analytical hierarchy process is adopted to figure out the risk evaluation of the new fintech institutions in China, identifying those at risk as early as possible. Firstly, several level 1 indicators of the risk evaluation system of the new fintech institutions and corresponding subordinate level 2 indicators are determined, followed by rating the level 2 indicators of each new fintech institution ready for risk evaluation ranking, which leads to the risk evaluation matrix of each level 1 indicator. Secondly, the new fintech institutions are classified into the theoretically ideal “optimal,” “medium,” and “worst” categories by establishing the membership matrix of each level 1 indicator in the application of linear transformation formula. Thirdly, the degree of proximity is exploited in comparison of the fuzzy sets in pairs to form the fuzzy recognition model of each level 1 indicator in pursuit of the new fintech institutions least risky regarding each level 1 indicator. Finally, the fuzzy recognition models of each level 1 indicator are integrated into the construction of the fuzzy recognition model regarding the whole risk evaluation system to achieve the risk ranking of the new fintech institutions. This study aimed to provide a theoretical ground and an applied method for national regulators to monitor the fintech risks, which are prone to be avoided by the enterprises and individuals.

1. Introduction

Innovation is always supposed to be a progressive and very positive word in China. Everything that gets in the way of innovation should be rejected. Encouraging innovation has literally been an important principle for regulating the emerging industries such as fintech. The negative effect of scientific and technological innovation has begun to take shape in composition with the increasing influence of technology [1]. We have been educated by reality that being innovative is not always good or right. It is highlighted of “new technology application and its impact” by Chinese policy-makers on different occasions. Finance is all along in line with risk management and allocation [2]. It is clarified that big data cannot possibly entirely eliminate risk. On the contrary, the big scale of fintech institutions precisely contributes to accumulating risks [3]. Both academia and industry are calling for the constructing an evaluation indicator system of innovation supervision, improving the mechanism of innovation trial, error tolerance, and risk monitoring, and refining the relatively mature fintech innovation supervision tools in line with China’s national conditions. Based on the fuzzy analytic hierarchy process, in composition with the fuzzy mathematical analysis tools, this study aimed to establish the risk evaluation ranking model and risk evaluation system of new fintech institutions, providing the scientifically theoretical basis for constructing a new governance system of platform economy.

At present, a unified classification of the fintech risks still has not been approached in the academic area [4–6]. Financial risk indicators, especially those of new fintech institutions, are mostly evaluated by qualitative analysis [6, 7], or a combination of qualitative and quantitative analysis [4, 5]. The general analytic hierarchy process (AHP) can be
used to obtain the weight of risk indicators [4]. However, owing to the blurry bounded risk indicators of new fintech institutions featuring finance and technology spontaneously, analytic hierarchy process and fuzzy mathematical analysis tools are rather in need of quantitative and precise risk evaluation. Adopting the fuzzy analytic hierarchy process (FAHP), this study decomposes the problem into different component factors, which are gathered and combined in accordance with the interrelated influence and membership relationship among the factors to form a multilevel analysis structure model. Finally, the problem comes down to the determination of the importance of the weights of the lowest level (schemes and measures for decision-making, etc.) relative to the highest level (total goals). This determination is based on the approximate consistency fuzzy number relative to the highest level (total goals).

Based on the approximate consistency fuzzy number, the determination of the importance of the weight of the lowest level (schemes and measures for decision-making, etc.) relative to the highest level (total goals) is mathematically signified:

\[ S_k = \{ u_{1k}, u_{2k}, u_{3k}, u_{4k} \} \]

(1)

3. Establish the Membership Matrix of Each Level 1 Risk Evaluation Indicator

Suppose there are \( n \) new fintech institutions, marked as \( F_i, i = 1, 2, \ldots, n \), composing a ranking set as following, to be risk evaluated in rank.

\[ F = \{ F_1, F_2, \ldots, F_n \} \]

(2)

\( k u_{ij} \) is corresponding to the level 2 risk evaluation indicator sequenced \( j \) subordinate to the level 1 risk evaluation indicator sequenced \( k \) regarding the new fintech institution sequenced \( i (i = 1, 2, \ldots, n) \). Each level 2 risk evaluation indicator \( k u_{ij} \) is about to be rated. The risk evaluation indicator is generally on 5 scales, “absolutely not severe, not severe, average, severe and very severe,” which can be scored 1, 2, 3, 4, and 5, respectively. A more meticulous 9 scales can be set as to put an extra level between each one above, respectively, scored 1, 2, 3, 4, 5, 6, 7, 8, and 9, a high score indicating a high risk. The scale of risk evaluation is determined by the business type and characteristics of the fintech institutions [7]. At present, the fintech enacts in three major representative forms (third-party payment, peer-to-peer, and equity-based crowdfunding) in China [7]. The new fintech institutions mainly feature platform size (transaction scale, number of R&D and business personnel, etc.), organizational structure (level of organizational hierarchies, employee turnover rate), and quality of employees (professional spirit, educational level, training and self-improvement, work experience of employees).

\( k V_i \) is named after rating the level 2 risk indicator sequenced \( j \), which is marked as \( k u_{ij} \), subordinate to the level 1 risk indicator sequenced \( k \) regarding the new fintech institution sequenced \( i \) ready for ranking. The row vectors \( k V_i \) in (2) represent the risk vector of the level 1 indicator sequenced \( k \), marked as \( S_k (k = 1, 2, 3, 4, 5, \ldots) \):
indicates the risk vector of the level 2 indicator sequenced j subordinate to the level 1 indicator sequenced k, marked as $S_k$ ($k = 1, 2, 3, 4, 5$) of the new fintech institutions ready for ranking. \( \mathbf{u}_j \) is elaborated in the following formula:

\[
\begin{pmatrix}
1_{V_1}^T
1_{V_2}^T
\vdots
1_{V_n}^T
\end{pmatrix}
\times
\begin{pmatrix}
1_{V_1}
1_{V_2}
\vdots
1_{V_n}
\end{pmatrix}
\triangleq
\begin{pmatrix}
1_{U_1,1,1,1,1}
1_{U_2,1,1,1,1}
\vdots
1_{U_n,1,1,1,1}
\end{pmatrix} = \left(v_{ij}\right)_{\text{new}}
\] (5)

Formula (4) is the comprehensive risk evaluation matrixes of the first level 1 risk indicator of credit moral risk regarding all the new fintech institutions ready for ranking.

\[
\begin{pmatrix}
2_{V_1}^T
2_{V_2}^T
\vdots
2_{V_n}^T
\end{pmatrix}
\times
\begin{pmatrix}
2_{V_1}
2_{V_2}
\vdots
2_{V_n}
\end{pmatrix}
\triangleq
\begin{pmatrix}
2_{U_1,1,1,1,1}
2_{U_2,1,1,1,1}
\vdots
2_{U_n,1,1,1,1}
\end{pmatrix} = \left(u_{ij}\right)_{\text{new}}
\] (6)

The matrices \( \left(u_{ij}\right)_{\text{new}} \), \( (k = 1, 2, 3, 4, 5) \) are about to be transferred into corresponding membership matrixes in the application of fuzzy mathematical analysis tools. It is known by rating each of the level 2 indicator that the lower the score, the better. Each k and corresponding j are processed by the linear transformation formula commonly used in fuzzy mathematics as shown in the following formula:

\[
\begin{pmatrix}
3_{V_1}^T
3_{V_2}^T
\vdots
3_{V_n}^T
\end{pmatrix}
\times
\begin{pmatrix}
3_{V_1}
3_{V_2}
\vdots
3_{V_n}
\end{pmatrix}
\triangleq
\begin{pmatrix}
3_{U_1,1,1,1,1}
3_{U_2,1,1,1,1}
\vdots
3_{U_n,1,1,1,1}
\end{pmatrix} = \left(u_{ij}\right)_{\text{new}}
\]
\[ k_{ij}^* = 1 - \frac{k_{ij} - \min_k U_j}{\max_k U_j - \min_k U_j}, \]

where \( \max_k U_j \) and \( \min_k U_j \), respectively, represent the maximum and minimum values of the elements in the column sequenced \( j \) in the matrix \( k \). In correspondence with the maximum and minimum risk evaluation on the level 2 indicator sequenced \( j \) subordinate to the level 1 risk indicator sequenced \( k \) regarding all the new fintech institutions ready for ranking, obviously \( 0 \leq k_{ij}^* \leq 1 \).

The row vectors \( kV_j^* \) and the column vectors \( kU_i^* \) are caused by replacing the element \( k_{ij} \) with \( k_{ij}^* \), respectively, which are demonstrated as follows:

\[
\begin{align*}
1V_i &= (v_{i1}, v_{i2}, v_{i3}, v_{i4}), \quad i = 1, 2, \ldots, n, \\
2V_i &= (v_{i1}, v_{i2}, v_{i3}, v_{i4}), \quad i = 1, 2, \ldots, n, \\
3V_i &= (v_{i1}, v_{i2}, v_{i3}, v_{i4}), \quad i = 1, 2, \ldots, n, \\
4V_i &= (v_{i1}, v_{i2}, v_{i3}, v_{i4}), \quad i = 1, 2, \ldots, n, \\
5V_i &= (v_{i1}, v_{i2}, v_{i3}, v_{i4}), \quad i = 1, 2, \ldots, n, \\
1U_j^* &= \begin{pmatrix} v_{1j}^* \\ v_{2j}^* \\ \vdots \\ v_{nj}^* \end{pmatrix}, \quad j = 1, 2, 3, 4, \\
2U_j^* &= \begin{pmatrix} v_{1j}^* \\ v_{2j}^* \\ \vdots \\ v_{nj}^* \end{pmatrix}, \quad j = 1, 2, 3, \\
3U_j^* &= \begin{pmatrix} v_{1j}^* \\ v_{2j}^* \\ \vdots \\ v_{nj}^* \end{pmatrix}, \quad j = 1, 2, 3, \\
4U_j^* &= \begin{pmatrix} v_{1j}^* \\ v_{2j}^* \\ \vdots \\ v_{nj}^* \end{pmatrix}, \quad j = 1, 2, 3, 4, \\
5U_j^* &= \begin{pmatrix} v_{1j}^* \\ v_{2j}^* \\ \vdots \\ v_{nj}^* \end{pmatrix}, \quad j = 1, 2.
\end{align*}
\]

It can be seen that all the new fintech institutions ready for ranking sequenced \( i \), the row vectors \( kV_i^* \) show the membership vectors of the comprehensive risk evaluation on the level 1 risk indicator sequenced \( k \), marked as \( S_k (k = 1, 2, 3, 4, 5) \). The column vectors \( kU_i^* \) imply the membership vectors of the comprehensive risk evaluation on the level 2 risk indicator sequenced \( j \) subordinate to the level 1 risk indicator sequenced \( k \), marked as \( S_k (k = 1, 2, 3, 4, 5) \). Known from the definition of fuzzy set \([13]\), \( kV_i^* \) and \( kU_i^* \) are actually vector-formulated fuzzy sets.

Here comes the membership matrix of the comprehensive risk evaluation on each of the five level 1 indicators.

\[
\begin{pmatrix}
1v_{11}^* & 1v_{12}^* & 1v_{13}^* & 1v_{14}^* \\
1v_{21}^* & 1v_{22}^* & 1v_{23}^* & 1v_{24}^* \\
1v_{31}^* & 1v_{32}^* & 1v_{33}^* & 1v_{34}^* \\
1v_{41}^* & 1v_{42}^* & 1v_{43}^* & 1v_{44}^* \\
1v_{51}^* & 1v_{52}^* & 1v_{53}^* & 1v_{54}^*
\end{pmatrix}
\]

\[
\begin{pmatrix}
v_{11}^* \\
v_{12}^* \\
v_{13}^* \\
v_{14}^*
\end{pmatrix}
\]

\[
\begin{pmatrix}
v_{21}^* \\
v_{22}^* \\
v_{23}^* \\
v_{24}^*
\end{pmatrix}
\]

\[
\begin{pmatrix}
v_{31}^* \\
v_{32}^* \\
v_{33}^* \\
v_{34}^*
\end{pmatrix}
\]

\[
\begin{pmatrix}
v_{41}^* \\
v_{42}^* \\
v_{43}^* \\
v_{44}^*
\end{pmatrix}
\]

\[
\begin{pmatrix}
v_{51}^* \\
v_{52}^* \\
v_{53}^* \\
v_{54}^*
\end{pmatrix}
\]

4. Construct the Fuzzy Recognition Models of Risk Evaluation System

The first level 1 indicator of credit moral risk is to be discussed. For all the new fintech institutions ready for ranking,
The four level 2 risk indicators, which are in line with the four known as head order. Due to the degrees of membership of the minimum value, and it turns out \( \succ \) for medium value, and \( \prec \) for maximum value regarding all the \( n \) new fintech institutions ready for ranking. Thereafter, the head order \( B_1 \), in the name of “the optimal-ranking fintech institution,” is theoretically ideal and potentially the least risky one regarding the first level 1 indicator. It is noted that this institution is just theoretically ideal, not a really authentic one.

The vector \( B_2 \) in formula (91) is called second order, also known as medium order. Due to the degrees of membership of the four level 2 risk indicators, which are in line with the four components of the second order, subordinate to the first level 1 risk indicator hitting the medium value regarding all the \( n \) new fintech institutions ready for ranking, the medium order \( B_2 \), in the name of “the mediocre-ranking fintech institution,” is consequently less risky in the theoretically ideal sense.

The vector \( B_3 \) in formula (91) is called third order, also known as tail order. Due to the degrees of membership of the four level 2 risk indicators, which are in line with the four components of the third order, subordinate to the first level 1 risk indicator hitting the maximum value regarding all the \( n \) new fintech institutions ready for ranking, that is to say, all the four level 2 indicators subordinate to the first level indicator get least desirable. Therefore, the tail order \( B_3 \), in the name of “the worst-ranking fintech institution,” is potentially the most risky and most undesirable involving the first level 1 indicator.

Similarly, here follows the elaborations on the second to the fifth level 1 risk indicators:

\[
B_2 = (b_{11}, b_{12}, b_{13}, b_{14})
\]

\[
B_3 = (b_{21}, b_{22}, b_{23}, b_{24})
\]

\[
B_4 = (b_{31}, b_{32}, b_{33}, b_{34})
\]

\[
B_5 = (b_{41}, b_{42}, b_{43}, b_{44})
\]

\[
B_6 = (b_{51}, b_{52})
\]

\[
B_7 = (b_{61}, b_{62})
\]

\[
B_8 = (b_{71}, b_{72})
\]

It is deduced from (91) \( \sim (95) \) that \( B_q (k = 1, 2, \ldots, 5; q = 1, 2, 3) \) is entirely fuzzy sets formulated by vectors.

For the \( n \) new fintech institutions ready for ranking, the theoretically ideal “optimal,” “mediocre,” and “worst” institutions come up with the above operations regarding the five level 1 risk indicators. The purpose of this study was to authentically filter the institutions most optimally evaluated related to the five level 1 risk indicators among the \( n \) new

| Table 1: Fintech risk evaluation indicator system. |
|--------------------------------|-----------------|-----------------|
| Level 1 indicator           | Level 2 indicator | Denoted          |
| 1. Credit moral risk [8]    |                  |                 |
| (i) Fintech fraud risk      | \( u_1 \)        |                 |
| (ii) Fund embezzlement risk | \( u_2 \)        |                 |
| (iii) Illegal fund-raising  | \( u_3 \)        |                 |
| (iv) Default risk           | \( u_4 \)        |                 |
| 2. Credit information      |                  |                 |
| (i) Information asymmetry   | \( u_5 \)        |                 |
| (ii) Information theft and  |                 |                 |
| tampering risk              | \( u_6 \)        |                 |
| (iii) Information abuse     | \( u_7 \)        |                 |
| risk                       |                 |                 |
| 3. Operating risk [10]      |                  |                 |
| (i) Exchange rate risk      | \( u_8 \)        |                 |
| (ii) Interest rate risk     | \( u_9 \)        |                 |
| (iii) Market selection      | \( u_{10} \)     |                 |
| risk                       |                 |                 |
| (iv) Liquidity risk         | \( u_{11} \)     |                 |
| 4. Network security        |                  |                 |
| (i) Technical support risk  | \( u_{12} \)     |                 |
| (ii) Virus infection risk   | \( u_{13} \)     |                 |
| (iii) Technical disclosure  | \( u_{14} \)     |                 |
| risk                       |                 |                 |
| (iv) Data transmission risk | \( u_{15} \)     |                 |
| 5. Legal risk [12]          |                  |                 |
| (i) Vague or lack of       | \( u_{16} \)     |                 |
| supporting legal norms     |                 |                 |
| (ii) High uncertainty of    | \( u_{17} \)     |                 |
| policies                   |                 |                 |
Table 2: Rating of the level 2 risk indicators for the 10 new fintech institutions.

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<td>j</td>
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Table 3: Five membership matrices.

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<td>j</td>
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Table 4: Three vectors.

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<tr>
<td>j</td>
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Table 5: Degrees of proximity of $k_{w_1}$, $k_{w_2}$, and $k_{w_3}$.

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</tbody>
</table>
fintech institutions ready for ranking. Firstly, the new fintech institution best performing on each of the five level 1 indicator is pointed out. Therefore, the degree of proximity is referenced to form the fuzzy recognition models. Finally, the fuzzy recognition model of the entire risk evaluation indicator system, so to speak, the risk evaluation ranking model of the entire risk evaluation indicator is manifested as fuzzy subsets between which the degree of proximity is iterated as follows:

\[
k_i w_{i1} = C(\mathbf{k}V_i^*, \mathbf{k}B_{1})_k w_{i2} = C(\mathbf{k}V_i^*, \mathbf{k}B_{2})_k w_{i3} = C(\mathbf{k}V_i^*, \mathbf{k}B_{j})_k, \quad i = 1, 2, \ldots, n.
\]

Apparently, the degree of proximity \( k_i w_{i1}/k_i w_{i2}/k_i w_{i3} \) reiterates the extent of proximity between the new fintech institution ready for ranking sequenced \((i = 1, 2, \ldots, n)\) and the so-called optimal/mediocre/worst-ranking fintech institution in regard to the comprehensive evaluation on the level 1 risk indicator sequenced \( k(k = 1, 2, 3, 4, 5) \).

For each \( k(k = 1, 2, 3, 4, 5) \), the row vectors \( \mathbf{V}_i^* (i = 1, 2, 3, 4, 5) \) ascertainment by formula (6) and the three row vectors \( \mathbf{B}_1, \mathbf{B}_2, \text{and} \mathbf{B}_3 \) ascertainment by formula (9) are viewed as fuzzy subsets. In regard to each \( i(i = 1, 2, \ldots, n) \), based on formula (10), the degrees of proximity between \( \mathbf{k}V_i^* \) and \( \mathbf{k}B_{1}, \mathbf{k}B_{2}, \text{and} \mathbf{k}B_{3} \) can be manifested as follows:

\[
C(A, B) = \frac{A \otimes B + A \odot B}{2}.
\]

\( \prec \) and \( \succ \) in the inner product \( A \otimes B = \sum_{j=1}^{p} (a_j \prec b_j) \) and outer product \( A \odot B = \sum_{j=1}^{p} (a_j \succ b_j) \) represent minimum processing and maximum processing involved as stated before. The degree of proximity can be phrased straightforward but not strictly as in comparison of the elements of subsets \( A \) and \( B \) in pairs, the inner product \( A \otimes B \) referring to taking “the biggest of the smallest (the worst of the best)” and the outer product \( A \odot B \) referring to taking “the smallest of the biggest (the best of the worst).” The arithmetic mean of the inner product \( A \otimes B \) and the outer product \( A \odot B \) accounts for the degree of proximity \( C(A, B) \) between the fuzzy subsets \( A \) and \( B \). Apparently, the more proximal the two fuzzy subsets \( A \) and \( B \) get, the closer the degree of proximity \( C(A, B) \) gets to 1; otherwise, the further the two fuzzy subsets get, the closer the degree of proximity \( C(A, B) \) gets to 0.

<table>
<thead>
<tr>
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<th>1</th>
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<th>Weighted average</th>
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Table 6: Results in the application of the fuzzy recognition model of the level 1 risk indicators.

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<td>0.11</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>10</td>
<td>0.08</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Table 7: Comprehensive risk evaluations of the 10 new fintech institutions.

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degrees of proximity (or processed by normalization [15]) as follows:

$$\frac{k w_{i1}}{k w_{i1} + k w_{i2} + k w_{i3}} \quad i = 1, 2, \ldots, n,$$

which is seen to be the fuzzy recognition model of the level 1 risk indicator sequenced $k$.

For each $k (k = 1, 2, 3, 4, 5)$, the $n$ ratios resulted from $(k w_{i1}/k w_{i1} + k w_{i2} + k w_{i3}), i = 1, 2, \ldots, n$ are sequenced from biggest to smallest in unveiling the risk evaluation ranking regarding the level 1 indicator sequenced $k$ of the new fintech institutions. The more leading in the ranking, the more adjacent to "the optimal-ranking fintech institution" features less risk. It is noted that the resulted ranking is with respect to the authentic new fintech institutions. It is necessary to explicitly draw out the meaning of the fuzzy recognition model $(k w_{i1}/k w_{i1} + k w_{i2} + k w_{i3}), i = 1, 2, \ldots, n$, in regard to the level 1 indicator sequenced $k$. On condition that for the new fintech institution sequenced $i$ ready for ranking, $k w_{i1}$ accounts for the largest percentage of the sum of $k w_{i1}$, $k w_{i2}$, and $k w_{i3}$, implying that $k V^*_i$ is the most proximal to $k B_1$, which cooperates that the new fintech institution sequenced $i$ is deemed to be the most ideal one in regard to the evaluation on the level 1 indicator sequenced $k$.

The fuzzy recognition model of the whole risk evaluation system regarding the new fintech institutions [15] is generated as follows (13) in result of integrating the fuzzy recognition models of the five level 1 risk indicators as long as $t_1, t_2, t_3, t_4$, and $t_5$ [7] are, respectively, weighed for each of the five level 1 indicators:

$$\sum_{k=1}^{5} \left( t_k \cdot \frac{k w_{i1}}{k w_{i1} + k w_{i2} + k w_{i3}} \right), \quad i = 1, 2, \ldots, n.$$

The overall risk evaluations on all the level 1 risk indicators related to the $n$ new fintech institutions ready for ranking are caused by sequencing the values of the $n$ weighted sums produced by (13), among which the top one is tended to be least risky. This conclusion provides an instrumentally decision-making basis for the relevant national authorities to regulate fintech innovations, as well as the enterprises or individuals to consciously avoid the fintech risks.

5. Case of Application

Hypothetically, there are 10 new fintech institutions in a certain area. The results $k V^*_j$ regarding rating (5 scales) of the level 2 risk evaluation indicators $k u_{ij}$ for each institution are detailed in Table 2 (bigger value going with bigger risk). Note: $k$ stands for the level 1 indicators. $i$ stands for the new fintech institutions ready for ranking. $j$ stands for the level 2 indicators.

$k V^*_j$ is named after $k V^*_j$ getting conducted by the linear transformation formula. Here come forward the five membership matrixes in Table 3.

Implementing the operations of taking "the maximum," "the medium," and "the minimum" on the column vectors of the membership matrixes leads to the three vectors $k B_{11}, k B_{12},$ and $k B_{13}$ as shown in Table 4.

$k w_{i1}, k w_{i2},$ and $k w_{i3}$ in the exhibition of Table 5 describe to what extent the row vectors, respectively, are proximal to the vectors $k B_{11}, k B_{12},$ and $k B_{13}$.

$k w_{i1}, k w_{i2},$ and $k w_{i3}$ in Table 5 are input into the fuzzy recognition model $k w_{i1}/k w_{i1} + k w_{i2} + k w_{i3}, \quad i = 1, 2, \ldots, n$. The results are viewed in Table 6.

In regard to the first level 1 indicator, the institutions numbered 1, 6, and 7 would be considered best-operated. Similarly, the institutions numbered 6 and 8 would be considered most excellent on the second level 1 indicator, while the numbered 5 best qualified on the third level 1 indicator. The institutions numbered 3 and 6 are excelling at the fourth level 1 indicator. The institution numbered 2 would be suggested with respect to the fifth level 1 indicator.

Generally speaking, there is no one institution good enough matching up all the level 1 indicators. The fuzzy recognition model regarding the comprehensive risk evaluation system is involved to make a thorough evaluation of the institutions. The weight is given to each of the five level 1 indicators $(t_1 = 0.33, \ t_2 = 0.06, \ t_3 = 0.04, \ t_4 = 0.46, \ t_5 = 0.11 [4])$. For simplicity, 2 digits after the decimal point are reserved, and the weighted averages are reserved to 4 digits after the decimal point (see Table 7).

Table 7 shows the risk evaluation ranking of the 10 new fintech institutions as follows: 6 3 7 2 8 5 10 1 9.

As a whole, among the 10 institutions, the least risky one numbered 6, which is not the one ranking in rating (the one numbered 1 is roughly compared more superior to the one numbered 6). Given by the weight of each five level 1 indicator, the one numbered 6 tops among the 10 institutions in terms of the comprehensive evaluation.

6. Conclusions and Limitations

The risk evaluation indicator system of the new fintech institutions is sorted into five level 1 and seventeen level 2 indicators in reference to the literature review. The matrixes regarding the five level 1 risk evaluation indicators $(4_j) (k = 1, 2, \ldots, 5)$ occur in rating the seventeen level 2 indicators of the $n$ new fintech institutions ready for ranking. Adopting the linear transformation formula generally used in mathematics, it comes in handy in the membership matrixes of the five level 1 risk evaluation indicators $(8_k) (k = 1, 2, \ldots, 5)$, in which the row vectors $k V^*_i$ are exactly the membership vectors, in form of the fuzzy sets signified by vectors. The column vectors of the membership matrixes with regard to the level-1 indicator sequenced are, as a matter of fact, the membership vectors of the level-2 risk evaluation indicators as well as inherently fuzzy sets represented by vectors. The three vectors $k B_{q}(q = 1, 2, 3)$, corresponding to the three risk evaluation vectors regarding the level 1 indicator sequenced $k$, stand for the theoretically ideal "optimal," "mediocre," and "worst" ranking new fintech institutions, as a result of implementing three operations of taking "the minimum," "the medium," and "the maximum" value on the column vectors. The degree of proximity is introduced to make
comparison in pairs of the fuzzy sets composed of vectors \( k B_q (q=1, 2, 3, k=1, 2, \ldots, 5, ) \), \( k w_{12} \), \( k w_{13} \), and \( k w_{13} \) delegated to the degrees of proximity between \( V_i \) and \( B_1, B_2, \) and \( B_3 \) in relation to the level 1 indicator sequenced \( k (k=1, 2, \ldots, 5) \) are, respectively, declaring the degrees of proximity between the one sequenced \( i \) among the \( n \) new fintech institutions ready for ranking and the theoretically ideal “optimal,” “mediocre,” and “worst” ranking new fintech institutions. As a result of making each \( k \) processed in the model \( \phi_{kwi} \), \( i = 1, 2, \ldots, n \), which is the fuzzy recognition model of the level 1 indicator sequenced \( k (k=1, 2, \ldots, 5) \) in regard to the risk evaluation indicator system of the new fintech institutions, the \( n \) values sorted from biggest to smallest can be output to obtain the performance ranking of the level 1 evaluation indicator sequenced \( k \) in relation to the \( n \) new fintech institutions ready for ranking. The one most leading on the ranking is supposedly closest to “the optimal” quality new fintech institution. Assumedly, the weight of each five level 1 indicator is, respectively, set as \( t_1, t_2, \ldots, t_5 \) for the risk evaluation system of new fintech institutions, which would propose the fuzzy recognition model of the whole risk evaluation system \( \sum_{k=1} (t_k \cdot (k w_{12} + k w_{13})), i = 1, 2, \ldots, n \). Making the \( n \) values in sequence from big to small would lead to the integral performance on the overall level 1 indicators involving the \( n \) new fintech institutions ready for ranking. The more leading on the ranking, the less risky the new fintech institution is evaluated. The results of this study are obviously theoretically and pragmatically meaningful.

The limitations of this research method lie in the rating of the seventeen level 2 risk evaluation indicators in terms of preciseness and quality, which is considered to be a factor determining the credibility of study and the basis for the subsequent operations. This could supposedly be a potential limitation of the research method.

**Data Availability**

The data used to support the findings of this study are included within the article.

**Conflicts of Interest**

The authors declare that they have no conflicts of interest.

**References**


