Research on Financing Risks of Low-Rent Housing Based on Fuzzy Quality Synthetic Evaluation

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Abstract—Financing risks of low-rent housing are influenced by many factors, and there are different levels of risk factors in different stages of development of the project. The index system of Financing risks of low-rent housing has been constructed in this paper where a index system of 5 criteria and 16 indicators has been proposed. Gray fuzzy comprehensive evaluation method has been elaborated and gray evaluation calculation process model is derived in detail. Finally, model is applied to the evaluation of the risk of low-rent housing project financing which makes it easy to prevent and control risk in each stages of the project.

Keywords—Low-rent housing; gray evaluation; index system; financing risks

I. INTRODUCTION

Some low-and middle-income families are unable to obtain housing through market means, so the government make effort to protect low-income families living in place through the construction of affordable housing. The low-cost housing is a very important part of China's housing security system as well as the most effective way to solve the most urgent need for housing by low-income populations. Currently, the construction of low-cost housing in China is relied on government investment which lead to a series of problems such as a shortage of funds for construction and lack of listings so that it can not meet the demand for housing for most low-and middle-income families^[1-2]. Financing for the construction of low-rent housing projects is essential in order to solve the problem of government funds and attract a large number of social funds for construction.

PPP (Public-Private Partnership) is a public infrastructure project financing mode^[3]. This mode encourages private enterprises to participate in the construction of low-rent housing and share low-rent housing finance risks with the government to mitigation government funding bottleneck problem. The financing of low-cost housing project time is relatively long, risky financing cause large amount of funds are needed for low-cost housing project and lots of parties should be involved in the construction of the project which has a direct impact on the feasibility of the project investment and construction. Evaluation study of low-rent housing PPP project financing risk is with practical significance which could make effective use of various types of social capital as well as

provide the conditions for the smooth implementation of low-cost housing project^[4].

II. CONSTRUCTION OF FINANCING RISK EVALUATION INDEX SYSTEM

There is no uniform standard for risk financing of low-rent housing projects in our allocation currently.^[5] The index system in this paper based on the construction of China's low-rent housing PPP project finance practice examples to analyze and identify the various participants in the risk factor and put forward 5 criteria and 16 indicators. The Hierarchical model index system will be identified with AHP [6] as follows:

Table.1 The risk of low-rent housing project financing

Destination Layer	Criterion Layer	Marker Bed
The risk of low-rent housing project financing A	Credit Risk A1	Contractor's Risk A11
		Government Risk A12
		Technical Risk A13
		Funding Ability Risk A14
		Management Level Risk A15
	Completion Risk A2	Risk of Cost Overruns A21
		Risk of Project Delay A22
		Quality Substandard Risk A23
	Management Risk A3	Business Cost Overruns Risk A31
		Operators Quality Risk A32
		Service Quality Risk A33
	Financial Risk A4	Exchange Rate Risk A41
		Interest Rate Risk A42
		Inflation Risk A43
	Natural, Environmental Risk A5	Earthquakes, Flood and Other Force Majeure Risk A51
		Environmental Risk A52

III. FINANCING RISK ASSESSMENT MODEL

Let A be the set of evaluation: $A = (A_1, A_2, \dots, A_i)$, (i

is the number of indicators, $i=1,2,\dots, n$), among them $A_i=(A_{i1}, A_{i2}, \dots, A_{im})$, m is the number of secondary indicators belongs to the i -th level indicators.

A. Determination of evaluation index weight

Let $B=(b_1, b_2, \dots, b_i)$ be the weight set of evaluation index, where $\sum_{i=1}^n b_i = 1$, b_i denotes the evaluation indicators of the weight; meanwhile set the secondary index weight set: $B_i=(b_{i1}, b_{i2}, \dots, b_{im})$, where b_{im} ($i=1,2,\dots, n$) represents the proportion of the index A_{im} in A , while $\sum_{i=1}^n b_{im} = 1$.

B. different levels of A_{im} determined according to the criteria for the classification

Table 2 Rating Standard

Standard	Implication
1	Effect is poorer
2	Results in general
3	Effect is more noticeable
4	Effect is very obvious
0.5、1.5、2.5、3.5	Between the two adjacent standard

C. Establishing the evaluation matrix D according to the expert scoring

R evaluators score to each evaluation based on scoring criteria A_{im} , the evaluator's serial number is set as k ($k=1,2,\dots, r$)

$$D = \begin{pmatrix} d_{111} & d_{112} & \dots & d_{11r} \\ d_{121} & d_{122} & \dots & d_{12r} \\ \dots & \dots & \dots & \dots \\ d_{211} & d_{212} & \dots & d_{21r} \\ \dots & \dots & \dots & \dots \\ d_{511} & d_{512} & \dots & d_{51r} \\ d_{521} & d_{522} & \dots & d_{52r} \end{pmatrix}$$

d_{imr} represents the r -th reviewer ratings evaluation criteria layer of the i -th.

D. Gray degree and calculation of evaluation [7-8].

I) Determine gray degree evaluation

Let gray degree $e=4,3,2,1$ representing the four evaluation gray class "poor", "medium", "good", "excellent". Each category albino function corresponding to the gray number as follows^[6]:

The first category($e=1$):gray degree $\otimes_1 \in [4, \infty]$, albino function is

$$f_1(d_{ijk}) = \begin{cases} 0 & x \notin [0, \infty] \\ \frac{d_{ijk}}{4} & x \in [0, 4] \\ 1 & x \in [4, \infty] \end{cases}$$

The second category($e=2$):gray degree $\otimes_2 \in [0,3,6]$, albino function is

$$f_2(d_{ijk}) = \begin{cases} 0 & x \notin [0, 6] \\ \frac{d_{ijk}}{3} & x \in [0, 3] \\ \frac{6-d_{ijk}}{3} & x \in [3, 6] \end{cases}$$

The third category($e=3$):gray degree $\otimes_3 \in [0,2,4]$, albino function is

$$f_3(d_{ijk}) = \begin{cases} 0 & x \notin [0, 4] \\ \frac{d_{ijk}}{2} & x \in [0, 2] \\ \frac{4-d_{ijk}}{2} & x \in [2, 4] \end{cases}$$

The fourth category($e=4$):gray degree $\otimes_4 \in [0,1,2]$, albino function is

$$f_4(d_{ijk}) = \begin{cases} 0 & x \notin [0, 2] \\ 1 & x \in [0, 1] \\ 2-d_{ijk} & x \in [1, 2] \end{cases}$$

II) Gray evaluation coefficient Calculation

The gray evaluation coefficient which A_{im} belongs to the e -th evaluation gray class denoted as x_{im}^e , where $x_{ije} = \sum_{k=1}^r f(d_{ijk})$. The total gray evaluation coefficient which A_{im} belongs to each evaluation gray class denoted as x_{im} , where $X_{ij} = \sum_{e=1}^4 x_{ije}$.

III) Gray evaluation weight vector and weight matrix calculating

The gray evaluation weight of the e -th advocates in A_{im} proposals by all the experts denoted as y_{im}^e ,

$$y_{ije} = \frac{x_{ijk}}{x_{ij}}$$

Consider that there are 4 gray evaluation classes, the gray evaluation weight vector of different gray evaluation classes by A_{im} donated as $y_{ij} = (y_{ij1}, y_{ij2}, y_{ij3}, y_{ij4})$. At this point that we can get the gray evaluation weight matrix for each evaluation gray class z_j by the respective indicator A_{im} from A_i :

$$Y_i = \begin{Bmatrix} y_{i1} \\ y_{i2} \\ \vdots \\ y_{im} \end{Bmatrix} = \begin{Bmatrix} y_{i11} & y_{i12} & y_{i13} & y_{i14} \\ y_{i21} & y_{i22} & y_{i23} & y_{i24} \\ \vdots & \vdots & \vdots & \vdots \\ y_{ij1} & y_{ij2} & y_{ij3} & y_{ij4} \end{Bmatrix}$$

IV) Make comprehensive evaluation on A and A_i

Make comprehensive evaluation on A_i , let the evaluation result as Z_i , so $Z_i = A_i \bullet Y_i = (z_{i1}, z_{i2}, z_{i3}, z_{i4})$, The gray evaluation weight of the e -th advocates in A_i proposals by evaluator denoted as z_{ie} .

Gray evaluation weight matrix S is available on A_i :

$$S = \begin{Bmatrix} Z_1 \\ Z_2 \\ \vdots \\ Z_i \end{Bmatrix} = \begin{Bmatrix} z_{11} & z_{12} & z_{13} & z_{14} \\ z_{21} & z_{22} & z_{23} & z_{24} \\ \vdots & \vdots & \vdots & \vdots \\ z_{i1} & z_{i2} & z_{i3} & z_{i4} \end{Bmatrix}$$

Make comprehensive evaluation on A , the evaluation result as follows:

$$S = B \bullet Z = (b_1, b_2, \dots, b_i) \bullet \begin{Bmatrix} z_{11} & z_{12} & z_{13} & z_{14} \\ z_{21} & z_{22} & z_{23} & z_{24} \\ \vdots & \vdots & \vdots & \vdots \\ z_{i1} & z_{i2} & z_{i3} & z_{i4} \end{Bmatrix} = (s_1, s_2, s_3, s_4)$$

V) Calculate the value of comprehensive evaluation

Assignment each evaluation gray degree grade is based on the "gray level", then we can get the vector of Each evaluation gray class level value $C = (4, 3, 2, 1)$. Comprehensive evaluation value is calculated as follows: $W = S \bullet C^T$, where C^T means the transpose of each evaluation gray class rank value vector. Obtained the value of W so we can evaluate the pros and cons of internal control by control the levels described above.

IV. CASE ANALYSIS

The government of City S proposed a low-cost housing project. In order to measure the risk of the project financing, gray evaluation model is set up to evaluate the low-rent housing project financing risks. In order to assess the risks, university professors, government officials and engineering experts who participated in the construction of low-rent housing investment research were invited to made up a judge group to scoring the rates of risk indicators in risk subsets of low-cost financing housing based on their wealthy experience.

The weight of first grade assessment indicator A_i and A_{im} are evaluated by method AHP, get the results as follows: $B = (0.3, 0.2, 0.2, 0.2, 0.1)$ is the weight vector of level indicators A_i ($i = 1, 2, 3, 4, 5$)

The secondary indicators corresponding to the weight vector can be learned respectively through the calculation:

$$B_1 = (0.4, 0.2, 0.1, 0.2, 0.1) \quad B_2 = (0.4, 0.3, 0.3)$$

$$B_3 = (0.3, 0.3, 0.4) \quad B_4 = (0.2, 0.4, 0.4)$$

$$B_5 = (0.6, 0.4)$$

A. The establishment of the evaluation matrix

Senior experts were invited to evaluate the project risk, the evaluation matrix made up by specific scoring criteria are as the following table:

Index Number s	1	2	3	4	5	6	7	8
Expert scoring	2.5	3	2.5	4	2.5	3	3	2.5
	3	3	2.5	3.5	4	4	4	3
	2.5	2.5	3	3	4	3	3.5	3
	4	3	2.5	4	3	3	2.5	3
Expert scoring	3	2.5	3	3	3	2.5	4	3
Index Number s	9	10	11	12	13	14	15	16
Expert scoring	3	3.5	3.5	3	2.5	3	3.5	3.5
	2.5	3	2.5	3	3	3.5	3	3
	3	3	3	3	3	2.5	3	3
	3	3	4	3	3	2.5	3	3
	3	2.5	3	3	3.5	3	3	3

B. Determine the evaluation gray degree

The gray type evaluation is divided into four standards and set the serial number represent the "poor", "medium", "good", "excellent" level. Detail relation of whitening weight and gray degree in evaluation was introduced before.

C. Calculating the gray evaluation coefficient

x_{11}^e represents the e -th evaluation coefficient in secondary index A_{11} as follows:

$$e=1, x_{11}^1 = f_1(d_{111}) + f_1(d_{112}) + f_1(d_{113}) + f_1(d_{114}) + f_1(d_{115}) = 3.75$$

$$x_{11} = x_{11}^1 + x_{11}^2 + x_{11}^3 + x_{11}^4 = 11.583$$

x_{11} : The total number of gray degree evaluation

D. Weight vector and weight matrix

The gray evaluation weight of the e -th advocates in A_{11} by experts denoted as y_{11}^e :

$$e=1, y_{111} = \frac{x_{111}}{x_{11}} = 0.354$$

$y_{112}, y_{113}, y_{114}$ can be calculated by the same method.

So $y_{11} = (0.354, 0.410, 0.236, 0)$ is the evaluation weight vector corresponding to evaluation price A_{11} .

$y_{12}, \dots, y_{15}, y_{21}, y_{22}, \dots, y_{52}$ can be calculated by the same method and then primary index weight matrix Y_i that corresponding to all the secondary indexes can be calculated as follows:

$$Y_i = \begin{pmatrix} 0.354 & 0.410 & 0.236 & 0 \\ 0.313 & 0.418 & 0.269 & 0 \\ 0.303 & 0.292 & 0.405 & 0 \\ 0.447 & 0.426 & 0.127 & 0 \\ 0.411 & 0.415 & 0.174 & 0 \end{pmatrix} \dots Y_5 = \begin{pmatrix} 0.375 & 0.438 & 0.187 & 0 \\ 0.361 & 0.436 & 0.203 & 0 \end{pmatrix}$$

Making an comprehensive evaluation to primary index weight matrix A_i and the result is $Z_i = B_i \bullet Y_i = (0.365, 0.404, 0.231, 0)$

Z_2, Z_3, Z_4, Z_5 can be calculated by the same method.

Then the total gray evaluation weight matrix in project

$$\text{risk is } Z = \begin{bmatrix} 0.365 & 0.404 & 0.231 & 0 \\ 0.365 & 0.424 & 0.211 & 0 \\ 0.353 & 0.431 & 0.216 & 0 \\ 0.350 & 0.413 & 0.237 & 0 \\ 0.369 & 0.437 & 0.194 & 0 \end{bmatrix}$$

The financing risk evaluation results is $S = B \bullet Z = (0.354, 0.420, 0.226, 0)$

E. Calculate the value of comprehensive evaluation

Assignment each evaluation gray class grade based on the "gray level" as $C = (4, 3, 2, 1)$. Then the value of comprehensive evaluation can be calculated as: $W = S \bullet C^T = 3.128$

F. Conclusion analysis

These calculations indicate that the score of low-rent housing PPP project financing risk is 3.128 while 3 is good according to the scoring criteria which suggesting that this project financing risk in good condition and this project is feasible, governments and investors could participate in the construction of this project. However there is still room for improvement, the government should take appropriate measures to control and prevent the risk of low-rent housing project and the share of credit risk weights most according to the index weights. So government should particularly concern about the credit risk, and reasonable policy should be implemented accordingly, so that the impact of the credit risk can be reduced. Government should ensure that the profits returns to investors to make more social capital into the construction of low-rent housing projects and to ensure the smooth implementation of low-cost housing project.

V.CONCLUSION

The construction of low-rent housing is a welfare undertakings as well as an effective way to solve the housing difficulties of low-income families. The most

important issues in the construction of low-rent housing is funds bottlenecks and PPP financing is an effective solution for low-rent housing projects. However, there has been a lot of risk factors inevitably when using PPP financing means. The gray evaluation method is used in this paper to analysis the size of the risk and distinguish whether the project is feasible. This method also provides a theoretical basis for effective decision making by the Government as well as provide new ideas to protect the sustainability for the development of low-cost housing. For the Sustainable development of low-rent housing, the government should also broaden the financing channels, pay attention to learn from foreign experience, improve housing security laws and regulations, and clear the responsibilities and obligations of the government and developers in the process of moving. The limitations of this paper are there is a great initiative of the expert's scoring because the experience of experts is not quite the same and personal feelings are usually putting into the scoring. Further research should be focused on exchanges with more experts and scholars to actively looking for subjective and objective methods and deeper discussion should be taken on the two fronts.

REFERENCES

- [1] Wang Ying. The problems and countermeasures of China's low-rent housing construction under the new situation [J]. Charming China, 2010(04): 31-32
- [2] Liu Yachen, Jin Ying. The countermeasures and suggestions of vigorously promoting the housing security work in Liaoning Province [J]. Liaoning Economic, 2011(12): 32-35.
- [3] Wang Qiankun, Wang Shuqiang. PPP mode in the low-rent housing project [J]. Construction Economic, 2007 (10) 27-30.
- [4] Qiu Yuanhua. The management methods of modern project risk [M]. Bei Jing: Science Press. 2003 .7-10.
- [5] Ding Wenjie. The risk allocation strategy of PPP project about the low-rent housing [J]. Technology Market Economy, 2007(4): 17-19
- [6] Wang Kaifeng, Zhang Xiedong. The evaluation system of production safety based on AHP's construction enterprise [J]. Technology of Wuhan University, 2009 (1) :169-171.
- [7] Deng Xiaopeng, Yuan Jingfeng, Li Qiming. The value stream analysis of PPP project about indemnificatory housing [J]. Construction Economic, 2012, (12): 35-39.
- [8] Hu Shenghuang. The multi-level gray evaluation method of Subjective indicators evaluation [J]. Theory and Practice of Systems Engineering, 1996, 22(1) : 36-41.
- [9] Deng Julong. Grey System Theory [M]. Wu Han: Huazhong University of Science and Technology Press. 1990: 3-6.