Study on Qualitative Evaluation Index System of VFM in PPP Project

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Abstract: With the vigorous development of PPP mode in China, the qualitative evaluation of value for money (VFM) has become an important support for the decision-making of PPP project. As the evaluation system of VFM is still not mature enough in China, it needs to be further improved. On the basis of the "Guide to VFM evaluation in PPP Project (trial)", to get further supplement and enrich the indicators of qualitative evaluation of PPP projects, and giving the specific judgment criterion, the expert investigation method and hierarchical analysis method are used to determine the weight of evaluation indexes, and then a qualitative evaluation model of VFM evaluation with strong operability and reasonable evaluation would be constructed. Finally, the model which is constructed in this paper would be tested by engineering projects so as to make the qualitative evaluation method scientific and feasible for PPP model.

1. Introduction
Public-private partnership (PPP) model is rapidly developing in China due to its ability to reduce the government's financial burden, reduce project risks and costs, and improve the efficiency of public project supply. However, not all of the infrastructure and public service construction projects are suitable for the PPP mode. If the project fails to implement\(^1\), it will not only cause waste of investment, but also harm the public interest and social welfare. Therefore, it requires the scientific and reasonable judgment methods and means. The VFM evaluation method is an important means for government departments to evaluate whether PPP mode can be adopted when purchasing public goods and service projects. It is an important way to judge which mode of PPP mode and traditional government procurement mode can have higher efficiency and value. In December 2015, the Ministry of Finance issued the "Guide to VFM evaluation in PPP Project (trial)" (hereinafter referred to as "Evaluation Guidelines"), which pointed out that in the PPP model, VFM evaluation played a very important role in the projects and summarized the qualitative evaluation and quantitative evaluation methods for VFM evaluation. At present, VFM evaluation is based on qualitative evaluation and encourages quantitative evaluation. The result of qualitative evaluation is the basis of decision-making. Only through the qualitative evaluation of VFM, can the project adopt the PPP mode. VFM qualitative evaluation plays an important role in PPP project decision-making.

At present, most of the VFM evaluations adopted in China refer to the steps and procedures of the “Evaluation Guidelines”. However, due to the unsound construction of China's current PPP project database and the few successful cases, VFM evaluation faces many difficulties. The “Evaluation Guidelines” stipulates six basic evaluation indexes and supplementary indexes for VFM qualitative
evaluation, including degree of integration, risk identification and distribution, potential competition, performance orientation and encouraging innovation, government capacity and feasibility of financing \[2\]. For the evaluation guidelines of VFM, the Ministry of Finance only gives a broad framework, the operability is weak, the connotation is not clear, and there is no specific judgment standard, so that different experts understand the indexes inconsistency and have large discretionary space when evaluating specific projects. Qualitative evaluation of VFM flows into form and does not reach the original purpose of the scientific decision-making \[3\], so it is necessary to study the VFM qualitative evaluation system in PPP mode.

Therefore, this paper further enriches and improves the evaluation indexes through the case project, uses the scientific methods to give weights, establishes a qualitative evaluation index system of VFM for PPP projects, and conducts further research and exploration on the qualitative evaluation methods in the Evaluation Guidelines.

2. Construct index system of VFM

2.1. Use expert survey method and analytic hierarchy process to determine index weights

The weight of the qualitative evaluation index of VFM is determined by the expert survey method and the analytic hierarchy process \[4\]. Firstly, it is necessary to establish the target layer, the criterion layer and the index layer of the index system with hierarchical structure. Secondly, through the expert survey method, the importance of the criterion layer related to the target layer and the index layer related to the criterion layer are compared pairwise. The weight of the indexes in the criterion layer and the indexes in the index layer related to the target layer.

2.2. Establish an evaluation index system of VFM

Combined with China's "Evaluation Guidelines" and relevant literature, the research includes six basic indexes, and considering the particularity of the project, on the basis of it, 11 additional indicators are extended on the basis of those indexes, for each index, factors affecting the indicators are summarized, establishing an evaluation index system for PPP projects, as shown in Figure 1.

3. Case analysis of qualitative evaluation of VFM for PPP project

The total length of the first-phase PPP project of Taizhou City Railway Line S1 is 52.396km. The line laying method is tight. Combined with the planning along the line and the current objective situation, the overhead bridge and underground line laying method is mainly adopted, and the bridge to tunnel ratio is 99.32%. There are 15 stations including Taizhou Central Station, Development Avenue, South Passenger Station and Wenling Stadium, including 7 underground stations and 8 elevated stations with an average distance of 3.5km. The total design budget approved by the project is 22.819 billion yuan, the capital accounted for 40% of the total project investment, and 60% was solved by external financing channels. The capital contribution of the government party is 20%, among which the Taizhou Municipal People's Government (the city level), the Jiaojiang District People's Government, Luqiao District People's Government, Taizhou Economic Development Zone Management Committee, and Wenling Municipal People's Government respectively contribute 15%, 24%, 24%, 1%, and 36% in the government's capital contribution; the social capital side's capital contribution is 80%.
3.1. Weight calculation of qualitative evaluation indicators of VFM

According to the VFM evaluation method, when evaluating the total level of VFM evaluation in Taizhou municipal railway line S1, three additional indexes are added: project scale and scope, clear and accurate output description and service, and stable and perfect laws and regulations [5]. The expert survey method and the analytic hierarchy process are used to calculate and determine the weight values of 25 indexes, as shown in Table 1.

![Figure 1. Evaluation index system of VFM in PPP projects](image)

### Table 1. The weight map of factor layer

| Target layer $P$ | Index layer $U$ (weight $A$) | Criterion layer $a_i$ (weight $w_i$) |
|------------------|-------------------------------|-------------------------------------|
| Life cycle comprehensive potential (0.15) | Cost optimization (0.593) Investment arrangement and operation (0.407) | |
| Risk identification and allocation (0.15) | The ability to identify risks (0.163) The rationality of risk allocation (0.297) Effective risk management system (0.540) | |
| Performance-oriented and innovative encouragement (0.15) | Encouraging private sector innovation (0.140) Perfect performance evaluation mechanism (0.332) Reward-punishment and supervision mechanism (0.274) Environmental benefits (0.254) | |
| Degree of potential competition (0.15) | Attractiveness of the project (0.400) Number of potential bidders (0.200) Profitability of the project (0.400) | |
| Financial feasibility (0.1) | The rationality of financing cost (0.482) Diversification of capital channels (0.218) Attraction to institutions (0.183) Market financing capacity (0.117) | |
| Government capacity (0.1) | PPP project experience (0.167) Decision-making and management skill (0.521) Sector licensing and support (0.312) | |
| Project size and scope (0.05) | Project investment amount (0.667) Project asset value (0.333) | |
| clear and accurate output description and service (0.05) | Objectively and independently assess service quality (0.500) Whether the requirements can match the contractual agreements (0.500) | |
| stable and perfect laws and regulations (0.1) | Improvement of relevant legal policy system (0.250) Whether the implementation of the project conflicts with the relevant legal policy system (0.750) | |

3.2. Determine the evaluation level of VFM

Based on the weight of the VFM evaluation that affects the first-phase PPP mode of the Taizhou municipal railway line S1, the fuzzy comprehensive evaluation method is used to determine the evaluation level of VFM [6]. The specific steps are as follows.

1. Select the fuzzy synthesis operator
The calculation method of the fuzzy comprehensive evaluation method is based on the selection of the synthesis operator, and this part selects the operator \( M(\cdot, \oplus) \).

(2) Establish each matrix set

According to the definition of each matrix set, the evaluation sub-object set \( U \) from the target layer to the index layer, and the evaluation sub-object set \( u_i \) from the index layer to the criterion layer are respectively established; meanwhile, the index is established according to the weight vector obtained in the previous section. The weight distribution set \( A \) of the index layer, the weight distribution set \( w_i \) of each factor \( u_i \); finally, according to the situation of evaluation target, selecting \( V = \{ \text{excellent, good, medium, poor, extreme poor} \} \) to form an evaluation set, as shown in Table 1.

(3) Experts score to establish the first evaluation matrix

Under the premise of considering the cost, this case invites 15 authoritative experts in the relevant fields to score the factors \( u_i \) of the criterion layer according to the certain criterion, to count experts scoring results of each factor and classify them into the evaluation level corresponding to the score value, finally, the score ratio corresponding to each level is composed into a matrix as the first layer evaluation matrix \( R_i \). Table 2 takes the risk identification and sharing as an example, and lists the first-layer evaluation matrix \( R_2 \) of the first-phase project of the Taizhou municipal railway line S1:

| index | \( V_1 \) (excellent) | \( V_2 \) (good) | \( V_3 \) (medium) | \( V_4 \) (poor) | \( V_5 \) (extreme poor) |
|-------|-------------------|----------------|-----------------|-------------|------------------|
| \( u_1 \) is the ability to identify risks | 0.250 | 0.417 | 0.333 | 0.000 | 0.000 |
| \( u_2 \) is the rationality of risk allocation | 0.167 | 0.417 | 0.333 | 0.083 | 0.000 |
| \( u_3 \) is effective risk management system | 0.250 | 0.500 | 0.167 | 0.083 | 0.000 |

(4) Calculate the fuzzy comprehensive evaluation level of the first layer

Taking risk identification and sharing as an example, using the operator \( M(\cdot, \oplus) \), multiply \( R_i \) and weight matrix corresponding factor layer on the basis of the above first evaluation matrix, and normalizing the obtained product. After processing, the first-layer fuzzy comprehensive evaluation level \( B_1 \) is obtained, that is:

\[
B_1 = w_i \times R_1 = \begin{pmatrix}
0.163 \\
0.297 \\
0.540
\end{pmatrix}^T \times \begin{pmatrix}
0.250 & 0.417 & 0.333 & 0.000 & 0.000 \\
0.167 & 0.417 & 0.333 & 0.083 & 0.000 \\
0.250 & 0.500 & 0.167 & 0.083 & 0.000
\end{pmatrix}
\]

\[
= \begin{pmatrix}
0.225 \\
0.462 \\
0.243 \\
0.070 \\
0.000
\end{pmatrix}
\]

The same reason can be obtained:

\[\begin{align*}
B_2 &= \begin{pmatrix}
0.272 \\
0.582 \\
0.173 \\
0.028 \\
0.000
\end{pmatrix} & B_3 &= \begin{pmatrix}
0.188 \\
0.413 \\
0.317 \\
0.055 \\
0.028
\end{pmatrix} \\
B_4 &= \begin{pmatrix}
0.467 \\
0.450 \\
0.083 \\
0.000 \\
0.000
\end{pmatrix} & B_5 &= \begin{pmatrix}
0.158 \\
0.510 \\
0.259 \\
0.074 \\
0.000
\end{pmatrix} \\
B_6 &= \begin{pmatrix}
0.000 \\
0.347 \\
0.319 \\
0.334 \\
0.000
\end{pmatrix} & B_7 &= \begin{pmatrix}
0.889 \\
0.111 \\
0.000 \\
0.000 \\
0.000
\end{pmatrix} \\
B_8 &= \begin{pmatrix}
0.500 \\
0.292 \\
0.167 \\
0.042 \\
0.000
\end{pmatrix} & B_9 &= \begin{pmatrix}
0.146 \\
0.396 \\
0.375 \\
0.083 \\
0.000
\end{pmatrix}
\end{align*}\]

(5) Calculate the second-layer fuzzy comprehensive evaluation level

The \( B_i \) obtained in the previous step is composed of the second-layer evaluation matrix:

\[
B = (B_1, B_2, B_3, B_4, B_5, B_6, B_7, B_8, B_9)^T
\]

Then, \( B \) is multiplied by the weight \( A \) of the corresponding index layer \( U \), to obtain the fuzzy comprehensive evaluation level \( P \) of the second-layer (Target layer), that is:
\[ P = A \times B = \begin{pmatrix} 0.150 & 0.150 & 0.150 & 0.150 & 0.150 & 0.100 \\ 0.150 & 0.188 & 0.413 & 0.317 & 0.055 & 0.028 \\ 0.150 & 0.467 & 0.450 & 0.083 & 0.000 & 0.000 \\ 0.100 & 0.158 & 0.510 & 0.259 & 0.074 & 0.000 \\ 0.100 & 0.000 & 0.347 & 0.319 & 0.334 & 0.000 \\ 0.050 & 0.889 & 0.111 & 0.000 & 0.000 & 0.000 \\ 0.050 & 0.500 & 0.292 & 0.167 & 0.042 & 0.000 \\ 0.100 & 0.146 & 0.396 & 0.375 & 0.083 & 0.000 \end{pmatrix} = \begin{pmatrix} 0.273 \\ 0.423 \\ 0.426 \\ 0.074 \\ 0.004 \end{pmatrix}^T \]

(6) Find the final evaluation level of the overall target

According to the obtained fuzzy comprehensive evaluation level \( P \) of the target layer, the maximum membership level is taken, that is, "good" is the final evaluation level of the VFM evaluation level of the first-phase PPP project of the Taizhou municipal railway line S1.

(7) Verify the final evaluation level

From the final evaluation results, the largest component \( \beta=0.423 \), the second largest component \( \gamma=0.273, \alpha=0.511>0.5 \). Corresponding to the table of the relationship between \( \alpha \) value and the validity of the maximum membership principle, the conclusion is more effective.

4. Conclusion

According to the evaluation framework and index system, this study designs the evaluation rules, uses the analytic hierarchy process to determine the weight of each evaluation index, and improves the accuracy of the evaluation results. The fuzzy comprehensive evaluation method is used to make corresponding judgments and evaluations on the evaluation index, reduces the subjectivity of the expert scoring and makes the evaluation result more effective; using the actual case to simulate the qualitative evaluation, the evaluation system proposed in this research is presented and its operability and effectiveness are tested.

References

[1] World Bank Group. (2014) Public Private Partnerships Reference Guide Version 2.0. R. Public Private Partnership in Infrastructure Resource Center.
[2] National Development and Reform Commission. (2015) Guidance on promoting government and social capital cooperation models in the public service sector.
[3] Wu H W, Yuan J F, Du J. (2017) Qualitative evaluation of international PPP project value and its enlightenment to China. J. Building economy, 38(03):38-42.
[4] Pan P C, Wang H Q. (2018) Value-for-money evaluation of highway PPP project based on intuitionistic fuzzy set. J. Highway transportation and technology, 35(05):142-150.
[5] Su W, Hu F J. (2017) Research on Quantitative VFM Evaluation Method for Infrastructure PPP Project--Taking Beijing Metro Line 4 as an Example. J. Macroeconomic Research, (05):74-79+133.
[6] Liu H H, Sun J, Li F F. (2016) VFM Evaluation of PPP Mode in Urban Underground Integrated Pipe Gallery. J. Journal of Civil Engineering and Management, 33(04):122-126.