Study on the key factors of the sustainable development of environmental protection PPP projects in China

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Abstract. With the progress of society and the building of a community with a Shared future for mankind, environmental protection has gradually become the top priority in China's infrastructure construction. The government and private capital jointly carry out the infrastructure construction of environmental protection PPP projects. In the construction of environmental protection PPP project, whether the sustainable development is the key to the success of the project. Therefore, it is of great significance to study the key factors of PPP project's sustainable development for the successful implementation of the project. By constructing the key factors of sustainable development of environmental protection PPP projects, the principal component analysis method is used to identify and classify the key factors of sustainable development. It is concluded that the key factors of the sustainable development of PPP projects include sustainable economic and social benefits, sustainable engineering, sustainable resources and environment, and sustainable project management. Through the implementation and construction of key factors of environmental protection PPP project, the sustainable development of the project can be improved, so that the ecological environment can be protected in the long run.

1. Introduction

Environmental protection PPP project is a cooperative mode of environmental protection construction by the government using the capital advantage of social capital. Hueskes believes that the concept of sustainable development should be integrated into PPP projects and actively promote the integration between the two. Based on the theory of fuzzy sets, Shen evaluates the indicators of the sustainable development of PPP projects from three aspects: economy, society and environment. Lenferink promotes the sustainable development of road infrastructure in the Netherlands through comprehensive contracts. Qing-hua Wu from the perspective of sustainable development to establish the environment, the main body, contracts and projects of infrastructure construction index system of the key factors. Huimin Li used the interval intuitionistic fuzzy set theory to analyze the evaluation system of the sustainable development of water environment governance PPP projects. Lunyan Wang and Shaofeng Yan evaluated the sustainability of PPP projects through cloud models based on specific water environment governance cases.

2. Methods

2.1. Participants

In this study, the questionnaire was made with the help of the questionnaire network, and distributed to the government, social capital parties, consulting companies and other groups. Questionnaires were
collected by means of "snowballing". It lasted for 2 months, and 200 questionnaires were collected, among which 2 were unqualified and were eliminated. A total of 198 valid questionnaires were obtained, with a recovery rate of 99%. The average number of years of working in PPP projects in the sample is 4.8 years, and the respondents have rich experience to ensure the accuracy of the data.

2.2. Measures
The sustainable development factors of environmental protection PPP projects were identified by principal component analysis. Principal component analysis (PCA) is the dimensionality reduction of a series of data, so that the relevant data can be recombined into several groups of data without correlation. The classified data can replace the original data and clearly reflect the indicators of the original data classification. Based on theoretical research and literature review, 16 key factors for the sustainable development of environmental protection PPP projects were constructed. Each index was given a score of 1, 2, 3, 4 and 5 in the form of likert scale, and the specific index system is shown in table 1.

| Key factor indicator | variable | Key factor indicator | variable |
|----------------------|----------|----------------------|----------|
| Comprehensive utilization of resources | X1 | Project facility renewal capability | X9 |
| Project management system | X2 | The development of regional economy | X10 |
| The rate of good quality | X3 | The fiscal solvency of the government | X11 |
| Public satisfaction | X4 | Residents' cognition of sustainable development has been improved | X12 |
| The adoption of advanced engineering technology | X5 | The relationship between the project company and the government | X13 |
| Biodiversity improvement index | X6 | Return on investment | X14 |
| Operation and maintenance capability | X7 | Energy conservation and the use of renewable energy | X15 |
| Project security | X8 | Compliance rate of resource and environment projects | X16 |

3. Results
3.1. Analysis procedure
Cronbach's Alpha was used for reliability analysis, and Cronbach's maximus value was 0.961, greater than 0.9, indicating a very good reliability and very reliable data. The KMO and bartlett tests showed that the KMO value was 0.846, the approximate chi-square was 3807.976, and the sig value of the significance test was 0.000. It shows that the validity of the questionnaire is very high, and the factor analysis is applicable.

3.2. Data analysis
3.2.1. Preliminary statistical analysis. Through SPSS24.0 software, the score data of the key factors of the sustainable development of environmental protection PPP projects are calculated, as shown in table 2. The sample size was 198, and the mean value was between "3.87-4.54", with a small difference. Except that the standard deviation of X7 and X16 is slightly greater than 1, the standard deviation of other factors is less than 1. That suggests the respondents are less divided.
Table 2. Descriptive statistics on key factors of sustainable development

| Var | N   | Min | Max | Mean  | S.D  | Var | N   | Min | Max | Mean  | S.D  |
|-----|-----|-----|-----|-------|------|-----|-----|-----|-----|-------|------|
| X1  | 198 | 2   | 5   | 4.22  | 0.93 | X9  | 198 | 2   | 5   | 4.31  | 0.86 |
| X2  | 198 | 2   | 5   | 4.02  | 0.93 | X10 | 198 | 2   | 5   | 4.47  | 0.82 |
| X3  | 198 | 2   | 5   | 4.15  | 0.93 | X11 | 198 | 2   | 5   | 4.41  | 0.8  |
| X4  | 198 | 1   | 5   | 4.43  | 0.95 | X12 | 198 | 1   | 5   | 4.35  | 0.94 |
| X5  | 198 | 2   | 5   | 4.27  | 0.78 | X13 | 198 | 2   | 5   | 4.54  | 0.72 |
| X6  | 198 | 2   | 5   | 4.19  | 0.91 | X14 | 198 | 1   | 5   | 4.44  | 0.95 |
| X7  | 198 | 1   | 5   | 3.87  | 1.09 | X15 | 198 | 2   | 5   | 4.37  | 0.87 |
| X8  | 198 | 2   | 5   | 4.3   | 0.86 | X16 | 198 | 2   | 5   | 4.11  | 1.06 |

3.2.2. Extraction and interpretation of principal components of key factors of sustainable development. Through SPSS24.0 software, dimension reduction was carried out on the data of key factors of sustainable development of environmental protection PPP projects. According to the standard that the eigenvalue is greater than 1, four components are extracted. The eigenvalues are 8.563, 1.039, 1.022 and 1.010 respectively, as shown in Table 3. The cumulative contribution rate of the four components reached 88.707%, more than 85%, indicating that the information of the four components could represent the information of the original data. Therefore, the 16 factors are divided into four categories, namely, the four major principal components.

Table 3. Total variance interpretation

| Component | Initial Eigenvalues | Extract the sums of squared loadings | Rotation sums of the squared loadings |
|-----------|---------------------|-------------------------------------|-------------------------------------|
|           | Total               | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1         | 8.563               | 65.293        | 65.293       | 8.563 | 65.293        | 65.293       | 3.239 | 24.697        | 24.697       |
| 2         | 1.039               | 7.920         | 73.214       | 1.039 | 7.920         | 73.214       | 2.946 | 22.460        | 47.157       |
| 3         | 1.022               | 7.793         | 81.006       | 1.022 | 7.793         | 81.006       | 2.788 | 21.260        | 68.418       |
| 4         | 1.010               | 7.701         | 88.707       | 1.010 | 7.701         | 88.707       | 2.661 | 20.289        | 88.707       |
| 5         | 0.269               | 2.049         | 90.756       |        |                |              |       |                |              |
| 6         | 0.205               | 1.561         | 92.317       |        |                |              |       |                |              |
| ...       | ...                 | ...           | ...          | ...   | ...           | ...          | ...   | ...           | ...          |
| 15        | 0.040               | 0.304         | 99.844       |        |                |              |       |                |              |
| 16        | 0.020               | 0.156         | 100.000      |        |                |              |       |                |              |

3.2.3. Classification of key factors for sustainable development. SPSS24.0 software was used to rotate the data to obtain the rotation component matrix. As shown in Table 4. In order to ensure the intuitive effect of the data, the values with absolute values less than 0.4 are eliminated. After the elimination of the data, it is found that among the principal component 1, the correlation coefficients are X14, X10, X4 and X12, with the coefficients of 0.844, 0.625, 0.695 and 0.687, respectively. Among the principal component 2, the correlation coefficients are X3, X5, X7, X9 and X8, with coefficients of 0.783, 0.546, 0.708, 0.467 and 0.442, respectively. Among principal component 3, the ones with large correlation coefficients are X15, X1, X16 and X6, with coefficients of 0.769, 0.755, 0.616 and 0.461, respectively. Among the four principal components, the correlation coefficients are X13, X2 and X11, with the coefficients of 0.568, 0.696 and 0.422, respectively.
Table 4. Rotation component matrix

| Var  | Component 1 | Component 3 | Var  | Component 2 | Component 4 |
|------|-------------|-------------|------|-------------|-------------|
| X14  | 0.844       |             | X3   | 0.783       |             |
| X10  | 0.625       |             | X5   | 0.546       |             |
| X4   | 0.695       |             | X7   | 0.708       |             |
| X12  | 0.687       | 0.769       | X8   | 0.442       |             |
| X15  |             | 0.755       | X13  |             | 0.568       |
| X1   | 0.616       |             | X2   | 0.696       |             |
| X6   |             | 0.461       | X11  |             | 0.422       |

4. Discussion

Combined with the classification of key factors of sustainable development after rotation, it can be obtained from table 5.

Principal component 1 can be classified as the key factor of sustainable development of economic and social benefits. It includes the rate of return on investment (0.844), regional economic development (0.625), public satisfaction (0.695) and residents' cognition (0.687).

Principal component 2 can be classified as the key factor for the sustainable development of engineering construction. It includes the good and good rate of engineering quality (0.783), the adoption of advanced engineering technology (0.546), operation and maintenance support capacity (0.708), project facility renewal capacity (0.467), and project safety (0.442).

Principal component 3 is classified as the key factor of sustainable development of resources and environment. It includes the use of energy conservation and renewable energy (0.769), the comprehensive utilization rate of resources (0.755), the compliance rate of resources and environment projects (0.616), and the biodiversity improvement index (0.687).

Principal component 4 is classified as the key factor for sustainable development of project management. It includes the relationship between the project company and the government (0.568), the project management system (0.696), and the government's financial solvency (0.422).

Table 5. Classification results of key factors for sustainable development of environmental protection PPP projects

| Category                                      | Principal component | Variable | Factors of sustainable development                                      | Coefficient of components |
|-----------------------------------------------|---------------------|----------|--------------------------------------------------------------------------|---------------------------|
| Key factors for sustainable development of    | 1                   | X14      | Return on investment                                                     | 0.844                     |
| economic and social benefits                  |                     |          | The development of regional economy                                      | 0.625                     |
|                                               | 1                   | X10      | Public satisfaction                                                      | 0.695                     |
|                                               | 1                   | X4       | Residents' cognitive level                                               | 0.687                     |
|                                               | 1                   | X12      | The rate of good quality                                                | 0.783                     |
| Key factors for sustainable development of    | 2                   | X3       | The adoption of advanced engineering technology                          | 0.546                     |
| engineering construction                      |                     |          | Operation and maintenance capability                                      | 0.708                     |
|                                               | 2                   | X5       | Project facility renewal capability                                       | 0.467                     |
|                                               |                     |          | Project security                                                         | 0.442                     |
| Key factors of sustainable                    | 3                   | X15      | Energy conservation and the use of renewable energy                      | 0.769                     |
| projects                                      |                     |          |                                                                          |                           |
development of resources and environment

|   |   |                                                                                       |
|---|---|----------------------------------------------------------------------------------------|
|   | 3 | X1 Comprehensive utilization of resources                                              |
|   | 3 | X16 Compliance rate of resource and environment projects                                |
|   | 3 | X6 Biodiversity improvement index                                                       |

Project management key factors for sustainable development

|   |   |                                                                                       |
|---|---|----------------------------------------------------------------------------------------|
|   | 4 | X13 The relationship between the project company and the government                    |
|   | 4 | X2 Project management system                                                            |
|   | 4 | X11 The fiscal solvency of the government                                               |

5. Conclusion

The purpose of this study is to explore the key factors of the sustainable development of environmental protection PPP projects in China, and to fill the literature on the key factors of the sustainable development of environmental protection PPP projects. The key factors for the sustainable development of environmental protection PPP projects are sustainable economic and social benefits, sustainable engineering, sustainable resources and environment, and sustainable project management. In this study, the principal component analysis method was used to identify the key factors for the sustainable development of PPP projects, which can be extended to other PPP projects in other industries.

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