

Performance Evaluation of Sponge City PPP Project Based on PSIR Model

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Abstract

In order to scientifically and reasonably evaluate the construction performance of sponge city PPP projects, this study analyzes and studies the content of performance evaluation based on summarizing the characteristics of sponge city PPP project models and the current development status of performance evaluation systems in China; And based on the theoretical basis of performance evaluation and the characteristics of PPP projects, establish and screen a performance evaluation index system; Compare and analyze this model with other commonly used models, and construct a PPP project performance evaluation model based on PSIR to address the design deficiencies of the existing performance evaluation system; And take specific relevant case studies as examples to illustrate their specific applications in project practice; Finally, summarize and prospect the entire study.

Keywords

PSIR model; Sponge City; Performance evaluation.

1. Literature review

1.1. Current research status abroad

Gi Seog Kong and Katalin Tanczos used various financial evaluation methods (such as multi criteria analysis and cost-benefit analysis) in the evaluation of PPP projects, and compared and analyzed the advantages and disadvantages of each evaluation method. Pickets TA [1] analyzed the elastic capacity of sponge cities and used three cases to illustrate the design methods of rainwater and flood management at different scales from planning to design. Kumiawan and Fredy (2016) [2] used a balanced scorecard to study the performance evaluation of PPP projects, comprehensively evaluating them from financial dimensions, customer dimensions, internal process dimensions, and learning and growth dimensions. Solomon Olusola Babatunde, Srinath Perera, Lei Zhou and Chika Udejaja [3] regard the cost management level of PPP projects as the most important reference indicator for evaluating PPP project performance, and continuously adjust the cost management system to improve the PPP project performance evaluation system.

1.2. Domestic research status

Zhang Chen proposed a five system sponge city construction indicator system, which effectively guides the planning, construction, and management of Shanghai's sponge city. Cheng Hongqun et al. [5] studied the group consistency of indicator weights and performance assignment based on group evaluation theory. Zhou Jinjun et al. [6] aimed to analyze the expected effects of sponge city construction, taking Tianshui City as an example, using a multidimensional coupled rainfall runoff model to measure the effectiveness of sponge city construction. Jiang Wen et al. [7] used the Sponge City PPP project in Zhenjiang, Jiangsu Province as an example to establish a project performance evaluation system using the balanced scoring method. Liu Qiuchang et al. [8] proposed a sponge city performance evaluation model based on entropy weight and

TOPSIS method, and conducted a performance evaluation of the sponge city construction in Hebi City.

Based on the above literature, the theoretical research on performance evaluation of PPP projects in foreign countries is relatively in-depth, but the theoretical system related to performance management models is still incomplete, resulting in a lack of this evaluation method in performance evaluation. The direction of domestic research is more inclined towards the analysis of evaluation systems, initially exploring the performance evaluation system of PPP projects, but it is still not systematic and comprehensive enough.

2. Overview and data sources of the research area

2.1. Overview of the research area

Anhui Province is located in the middle east of China, with $114^{\circ} 54'$ - $119^{\circ} 37'$ east longitude and $29^{\circ} 41'$ - $34^{\circ} 38'$ north latitude. It has 16 prefecture level cities, nine county-level city, 50 counties and 45 municipal districts. The Yangtze River and Huaihe River run through the province, covering an area of 140100 square kilometers, and belongs to the economic zone of the middle east of China.

2.2. Data sources

The data used in this study mainly comes from the "China Statistical Yearbook 2010-2019".

3. Research significance and methods

3.1. Research significance

Sponge City PPP project refers to a type of project that utilizes social capital to achieve the construction and operation of sponge cities through cooperation between the government and enterprises. PPP project performance evaluation is a comprehensive and objective evaluation of the project from the perspectives of project investment, process control, results, impact, etc., starting from the interests of all project participants in the PPP project. It mainly starts from factors such as economic and social benefits, risk sharing, environment, and technology. Improving the performance evaluation of the Sponge City PPP project can not only supervise the implementation of national project documents, reveal problems in the project, regulate the use of project funds, but also implement a sponge city that meets the needs of the city and the ecological environment.

3.1.1. Theoretical significance

At present, there are very few research results applying performance management theory to PPP projects. This project studies the performance evaluation of PPP projects, which helps to improve the theoretical system of PPP project performance evaluation and therefore has certain theoretical significance.

3.1.2. Practical significance

The research on the performance evaluation of PPP projects in this project will help provide theoretical guidance for government departments to monitor project performance and output under the PPP model in practice, and also provide important reference indicators for the private sector to improve its own performance.

3.2. Research Methods

3.2.1. Literature research and comparative analysis method

On the premise of reading a large number of literature, first, conduct a reading and analysis of domestic and foreign literature related to PPP project performance evaluation, and focus on the selection of evaluation indicators and the evaluation methods used. By comparing and

analyzing the models proposed by some scholars, select the determined indicator weights to build a PSIR performance evaluation model.

3.2.2. PSIR model method

By relying on the PSIR model, a new chain based closed-loop evaluation index system framework can be established based on the dispersed and isolated performance evaluation index system in the past. Under this framework, the performance indicators of sponge city PPP projects form an elastic relationship chain based on the logic of pressure status impact response. When a single indicator changes, the correlation indicators will also dynamically adjust, which is conducive to the implementation of dynamic monitoring of the performance evaluation index system.

3.2.3. Qualitative analysis and quantitative research

Qualitative analysis is mainly reflected in: ① proposing initial evaluation indicators through studying relevant literature on evaluation indicators; ② Based on the evaluation results of Anhui Province, propose countermeasures and suggestions for improving the level of sponge city construction in Anhui Province; ③ Based on empirical analysis, propose the unique advantages of building sponge cities in Anhui Province. Quantitative research is manifested as: in the process of establishing indicators, the weights of indicators are determined through range standardization and entropy weight methods, and the performance evaluation model of sponge city PPP projects designed is applied to the case of sponge city PPP projects in Anhui Province to obtain the sponge city construction degree score of Anhui Province.

4. Research content

4.1. Construction of Performance Evaluation Index System for Sponge City PPP Project

Deeply analyze the characteristics of performance evaluation for Sponge City PPP projects, refer to existing research, design preliminary indicators for performance evaluation of Sponge City PPP projects, screen preliminary indicators based on expert evaluation and suggestions, and obtain a reasonable performance evaluation index system for Sponge City PPP projects. Using methods such as range standardization to comprehensively determine the weights of each evaluation indicator factor.

To eliminate the impact of indicator dimensions on the original data, the range standard method is used to process the data. The coefficient of variation method is used to determine the weights of each indicator in the data. During the calculation process, there may be situations where logarithms cannot be taken. To avoid this situation, the range standardization formula needs to be processed. The specific processing form is as follows: the formula is shown in equations (1) and (2).

Standardization of positive indicators

$$Z_{ij} = \frac{(X_{ij} - X_{ijmin})}{(X_{jmax} - X_{jmin})} \quad (1)$$

Standardization of negative indicators:

$$Z_{ij} = \frac{(X_{ijmax} - X_{ij})}{(X_{jmax} - X_{jmin})} \quad (2)$$

Due to the fact that the entropy weight method can determine objective weights based on the variation size of indicators and eliminate indicators with low contribution rates, this article first uses the entropy weight method to calculate indicator weights.

4.2. Construction of Performance Evaluation Model Based on PSIR Model

At present, the main methods for evaluating the performance of sponge city construction include system dynamics method, cloud model method, interval intuitionistic fuzzy set method, grey fuzzy comprehensive evaluation method, etc. Due to the particularity of sponge city construction projects, these evaluation methods are difficult to objectively and accurately reflect the performance level of sponge city projects.

This project introduces the PSIR framework as the basic support, and forms a network of correlation between indicators through the PSIR framework (pressure state impact response). A performance evaluation model is constructed, which can effectively control and guide the mode of sponge city planning, implementation, and evaluation, and promote the synergy between environmental performance and economic performance.

4.3. Empirical Analysis on Performance Evaluation of Sponge City PPP Project

Taking Anhui Province as the object of empirical research, this paper conducts a macro analysis of the sponge cities in Anhui Province from three aspects: physical geography overview, economic and social overview, and the current situation of water resources development and utilization, collects data, uses the established sponge city evaluation index system and performance evaluation model to evaluate the performance of the sponge city PPP construction projects, and further analyzes the main influencing factors of the performance of the sponge city PPP construction projects.

Table 1: Various data

Criterion layer	Indicator layer	Indicator attribute
Pressure indicators Status indicators	Urban population density/(person/km ²)	negative
	Total per capita industrial wastewater discharge (tons/person)	negative
Impact indicators Criterion layer	The proportion of total wetland area to national land area (%)	just
	Green coverage rate in built-up areas/%	just
	Forest coverage rate (%)	just
Pressure indicators Status indicators	Urban waterlogging days (days)	negative
	Residential water supply price growth rate (%)	negative
Impact indicators	Water consumption savings (10000 cubic meters)	just
	Daily sewage treatment capacity (10000 cubic meters)	just
	Average number of students in higher education institutions per 100000 population (person)	just

4.3.1. Pressure Analysis

According to data from the National Bureau of Statistics, the environmental impact of the ecosystem in the research area in the past 30 years has mainly been caused by human activities. The urban population density has been increasing year by year, resulting in an increasing impact of human factors on the ecological environment. When human impacts exceed the adjustable capacity of the ecosystem, the ecosystem will deteriorate. The total amount of

industrial wastewater discharge per capita is also increasing year by year, which also damages the ecological environment.

4.3.2. State analysis

State indicators reflect the natural health status of ecosystems under ecological pressure. From the indicator data, it can be seen that due to China's strong promotion of ecological civilization and environmental protection, consideration of regional ecological environmental carrying capacity, protection of ecological barriers and water source protection areas, various indicators are showing an increasing trend year by year. At the same time, the promulgation and implementation of relevant policies and regulations have promoted the ecological protection and construction of the region, resulting in an improvement in the natural health status of the region.

4.3.3. Impact indicators

The impact indicator refers to the impact of the system's state on socio-economic, public life, and population health. Including: the number of days of urban waterlogging, and the growth rate of residents' water supply prices.

4.3.4. Response indicators

Response indicators represent the response of ecosystems to human activities and the response of humans to ecosystem responses. Based on data analysis, the indicators of water conservation and daily sewage treatment capacity indicate that humans have to some extent become aware of changes in the ecological environment, are responding to the protection of the ecological environment, actively restoring ecosystem vitality, and effectively promoting the sustainable development of the region.

5. Conclusion and Discussion

This article takes sponge cities in Anhui Province as the research area and constructs an evaluation index system using the PSIR model to analyze the changes in ecological environment health in Anhui Province. Due to the rapid development of society and economy, human activities in the ecological environment are becoming more and more frequent, resulting in an increasing impact on the ecological system in the research area. The comprehensive index of ecological health is continuously decreasing, the ecological environment is deteriorating, and the ecological continuity is decreasing. From the current development trend, the country pays more and more attention to the ecological environment benefits. It is helpful for us to better carry out the construction of ecological engineering by establishing an evaluation model to analyze the sponge project.

Acknowledgements

Anhui University of Finance and Economics undergraduate scientific research innovation fund project support (XSKY22143)

Reference

- [1] Picketts T A, Cadenasso M L, Mcgrath B. Resilience in Ecology and Urban design: Linking theory and practice for sustainable cities[J]. 2013.
- [2] Liu Jiahuan Research on Performance Evaluation of Sponge City PPP Project [D]. Jilin University of Finance and Economics, 2021 (7).
- [3] Solomon Olusola Babatunde, Srinath Perera, Lei Zhou and Chika Udeaja. Stakeholder perceptions on critical success factors for public-private partnership projects in Nigeria [J]. Built Environment Project and Asset Management, 2016, (1):74-91.

- [4] Zhang Chen. Research on the Index System of Sponge City Construction in Shanghai [J]. Water Supply and Drainage, 2016 (6): 52-56.
- [5] Cheng Hongqun, She Jiaxue, Ji Rui, et al. Research on Performance Evaluation of Sponge City Construction Based on Group Evaluation [J]. Science and Technology Management Research, 2016 (24): 43-47.
- [6] Zhou Jinjun, Liu Jiahong, Jin Sheng, et al. Analysis of Sponge City Construction Effect Based on HydroInfo - Taking Tianshui City as an Example [J]. Water Resources and Hydropower Technology, 2017, 48 (5): 14-19.
- [7] Jiang Wen, Shen Jiaheng, Li Qindui. Research on the Performance Evaluation System of PPP Projects Based on the Balanced Scorecard: Taking the Sponge City Construction Project in Zhenjiang City as an Example [J]. China Business Review, 2017 (25): 152-153.
- [8] Liu Qiuchang, Han Han, Li Huimin, et al. Performance Evaluation of Sponge City Construction Based on Entropy Weighted TOPSIS Method: A Case Study of Hebi City, Henan Province [J]. People's Yangtze River, 2017, 48 (14): 24-26.