

Research on Performance Evaluation of Sponge City PPP Projects in the Yangtze River Delta Region

Jingru Cao

Anhui University of Finance and Economics School of Management Science and Engineering,
Bengbu, China

ABSTRACT

In order to alleviate urban water ecological problems and promote sustainable urban development, many cities in my country are building sponge cities. At present, the country is vigorously promoting the application of the PPP model for project construction. The national government departments are actively preparing for the construction of sponge cities, promoting the construction of sponge cities in 30 pilot cities across the country, and encouraging sponge city construction projects using the PPP model, attracting a large amount of social capital to participate, and promoting The PPP model has been widely used in sponge city construction projects. This article takes the sponge city PPP project as the research object. In order to scientifically and rationally evaluate the construction performance of the sponge city PPP project, and on the basis of studying and summarizing the characteristics of the sponge city PPP project model and the development status of the performance evaluation system in my country, we conduct an analysis of the content of the performance evaluation. and research; establish and select a performance evaluation index system; conduct a comparative analysis of this model with other commonly used models, and build a PSIR-based PPP project performance evaluation model based on the design flaws of the existing performance evaluation system; and analyze and summarize the data. , clarifying its specific application and impact in practice; finally, a summary and outlook of the entire research are given.

KEYWORDS

Yangtze River Delta; Sponge City; PPP; Performance Evaluation

1. LITERATURE REVIEW

1.1. Current Status Of Foreign Research

Research and practice of PPP projects abroad show that different countries have adopted different management and supervision strategies based on their own national conditions and needs. As one of the pioneers of the PPP model, the UK's core concept is to achieve "value for money" (VFM), which is mainly reflected in providing continuous incentives for the entire life cycle of the project from design, construction to operation. In addition, the UK will develop industry-specific PPP contract templates based on the characteristics of different fields and industries, and unify them within the framework of PPP standardized contracts. This approach helps ensure the effectiveness and adaptability of PPP projects.

International experience in the supervision of PPP projects also shows that many countries implement industry-specific management and reflect industry characteristics in different contract documents and operating guidelines. For example, France is the first country in Europe to use public-private partnerships (PPP) to finance high-speed railway construction, and its PPP projects account for about

57% of high-speed railway PPP investments in all European countries. This shows that the application of the PPP model in the infrastructure field has extensive international influence.

In terms of literature research, Australia proposed "Water Sensitive Urban Design" (WSUD) in the 1990s, which systematically integrates urban planning, continuous water circulation management, and landscape design to protect and restore the urban water ecological environment [1][2]; New Zealand combines Low Impact Development (LID) and Urban Design (UD) on the basis of learning from Australia's WSUD, forming a unique Low Impact Urban Design (Low Impact Urban Design) system. and Development, LIUDD)[3][4].

In summary, the research progress of foreign PPP projects shows the positive role of these projects in promoting infrastructure construction and innovative financing methods, while also revealing challenges such as political risks and financing difficulties. These experiences and lessons have important reference value for other countries and regions when promoting PPP projects.

1.2. Domestic Research Status

Many domestic scholars have studied the traditional project performance evaluation system, but there are very few special studies on PPP projects, and the research results on PPP projects are almost all introduction and analysis of some typical foreign project theories and models. It can be seen that, The research on performance evaluation of public-private partnership projects in my country is still in its initial stage of exploration.

Currently, the PPP project (public-private partnership project) model is undergoing a series of developments and changes. From policy support, market development trends to specific implementation mechanisms, research in all aspects is continuously in-depth. Support for the PPP model at the policy level continues to increase. The "Guiding Opinions on Standardizing the Implementation of the New Mechanism for Government-Private Cooperation" issued by the Ministry of Finance clarified the adoption of the franchise model and proposed specific implementation methods, such as build-operate-transfer (BOT), transfer-operate-transfer (TOT) etc.[5][6]. This shows that while the government is promoting the development of the PPP model, it is also working hard to standardize its implementation process and ensure the healthy development of the project. In terms of market development, the market's interest in PPP projects continues to heat up. According to relevant reports, China's PPP project industry market development environment is good, and the market competition pattern is gradually taking shape [7]. At the same time, the in-depth analysis and development strategy research report of PPP project asset securitization also pointed out that the Ministry of Finance vigorously promotes the PPP model to help build a green The financial system stimulates the vitality of social capital [8]. These all reflect the activity and development potential of the PPP model in the market.

The development direction of the PPP model is also being continuously explored by the research community. Some studies have proposed that the new PPP mechanism should focus on user-pay projects and clarify charging channels and methods to ensure the sustainability of the project [9]. In addition, there are also studies that emphasize the five development directions of returning to the original intention of the PPP model, eliminating the need to eat what is needed, unifying conceptual understanding, strengthening project feasibility, and respecting market laws [10].

Although the PPP model is currently highly anticipated, it also faces some challenges and difficulties in actual operation. For example, how to effectively avoid over-reliance on government subsidies and ensure project quality and efficiency are key issues that need to be resolved. Therefore, the future development of the PPP model will require comprehensive consideration and optimization adjustments in policy guidance, market demand, technological innovation and other aspects.

Cheng Hongqun et al. [11] studied the group consistency of indicator weight and performance assignment based on group evaluation theory. Jiang Wen et al. [12] took the sponge city PPP project

in Zhenjiang City, Jiangsu Province as an example to establish a project performance evaluation system based on the balanced scoring method. Liu Qiuchang et al. [13] proposed a sponge city performance evaluation model based on entropy weight and TOPSIS method to evaluate the performance of sponge city construction in Hebi City. Through literature research, it can be seen that in the face of urban water ecological problems, active response measures have been taken at home and abroad. Whether it is foreign advanced stormwater management models or the growing domestic sponge city construction, they are playing an important role in improving urban water ecology and human settlement environment. However, as a systematic project, sponge cities have only begun to emerge in my country in recent years. The construction content of sponge city projects is complex and the investment amount is huge. Compared with other traditional infrastructure projects, the application of the government-social capital cooperation model to sponge city construction has made Projects face more complex risks. In addition, the PPP model is still in its initial development stage when applied to sponge city construction, so there are many problems that need to be solved during the application process. At present, academic research on sponge city PPP projects mainly focuses on theoretical concepts, operational technologies, etc., while there is relatively little research on issues such as project risk identification and evaluation, and determination of sharing entities and proportions.

In summary, the current research status of PPP projects in China shows its wide application and importance in many fields, and it also faces a series of challenges and problems. Through policy guidance and the optimization of market mechanisms, the PPP model is expected to achieve more healthy and sustainable development.

2. OVERVIEW OF THE STUDY AREA AND DATA SOURCES

2.1. Overview Of The Study Area

The Yangtze River Delta region, as one of the regions with the most active economic development, the highest degree of openness, and the strongest innovation capabilities in China, plays a pivotal strategic role in the overall situation of national modernization and all-round opening up. Including Shanghai City, Jiangsu Province, Zhejiang Province, and Anhui Province, a total of 41 cities; located in the lower reaches of the Yangtze River in China, close to the Yellow Sea and the East China Sea, at the intersection of the river and the sea, with many coastal ports along the river, and is an alluvial plain formed before the Yangtze River enters the sea.

2.2. Data Sources

The data used in this study mainly come from the "China Statistical Yearbook 2013-2023".

3. RESEARCH SIGNIFICANCE AND RESEARCH METHODS

3.1. Research Significance

Sponge city PPP projects refer to the type of project that uses social capital to realize the construction and operation of sponge cities through cooperation between the government and enterprises. PPP project performance evaluation mainly starts from factors such as economic benefits, social benefits, risk sharing, environment and technology, and conducts a comprehensive and objective evaluation of the project.

At present, the PPP model has been widely used in urban infrastructure construction in my country. However, relevant departments in my country do not pay attention to the management of PPP projects and performance evaluation during operation. Due to the large differences between traditional

projects and PPP projects, the traditional performance evaluation model is not suitable for the evaluation of PPP projects. Improving the performance evaluation of sponge city PPP projects can not only supervise the implementation of national project documents, reveal existing problems in the project, standardize the use of project funds, and promote the optimization of financial resource allocation, but also implement sponge cities that meet urban needs and ecological environment needs. Further promote the standardized and orderly development of PPP projects and achieve stable and long-term development.

3.1.1. Theoretical significance

At present, there are very few research results that apply performance management theory to PPP projects. This project builds a performance evaluation model for sponge city PPP projects based on the PSIR model. Based on the analysis of the shortcomings of existing sponge city performance indicators, this project explores the sponge city PPP. The construction of the project performance evaluation system will help improve the theoretical system of PPP project performance evaluation, and therefore has certain theoretical significance.

3.1.2. Practical significance

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

Second, it helps reduce project risks and improve project decision-making and management levels. Through reasonable risk allocation, PPP projects can effectively control the overall project risks and achieve the purpose of reducing project risks. This project studies the decision-making principles and methods of all parties involved in the project under the PPP model, aiming to improve the coordination efficiency between units. It analyzes the comprehensive performance level and indicators through the PSIR model to provide reference for improving project decision-making and management levels.

Third, taking the Yangtze River Delta region as a research case for investigation and analysis, the adoption of the PPP model is conducive to promoting the sustainable development of sponge city construction in terms of both organizational structure and operating mechanism. Based on the characteristics of partnership, benefit sharing, and risk sharing, the PPP model has efficient resource integration capabilities and effectively guarantees the smooth implementation of the project.

Fourth, provide a theoretical basis for PPP legislation. Our country has not yet formulated PPP laws, which is not conducive to the sustainable development of PPP in our country. This research on the PPP model and its performance evaluation system hopes to promote the promulgation of PPP laws in my country to guide the standardized operation of PPP projects and mobilize the enthusiasm of social capital to participate in infrastructure construction.

3.2. Research Methods

3.2.1. Literature research and comparative analysis method

Use CNKI, VIP and other data resource systems as well as through network search and other methods to conduct literature searches, study theoretical knowledge related to sponge cities, PPP models and risk sharing research, and sort out the current research status at home and abroad to determine the research content and methods of this article wait.

3.2.2. PSIR model method

A new chain-type closed-loop evaluation index system framework is established based on the PSIR model. Under this framework, sponge city PPP project performance indicators form an elastic

relationship chain based on the logic of pressure-status-influence-response. When a single indicator changes, the correlation indicator also changes. Adjustments will occur to facilitate dynamic monitoring of the system.

4. RESEARCH CONTENT

4.1. Construction Of Performance Evaluation Index System For Sponge City PPP Projects

In-depth analysis of the characteristics of sponge city PPP project performance evaluation, referring to existing relevant research, designing preliminary indicators for sponge city PPP project performance evaluation, screening the preliminary indicators based on expert evaluation and suggestions, and obtaining a reasonable sponge city PPP project performance evaluation indicator system. Use methods such as the analytic hierarchy process to comprehensively determine the weight of each evaluation index factor.

In order to eliminate the impact of the index dimension on the original data, the data is first processed. During the calculation process, it may be impossible to take the logarithm. To avoid this situation, the range standardization formula needs to be processed. The specific processing form is as follows: The formula is as follows: As shown in formula (1) and formula (2).

Positive indicator normalization

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

Negative indicator normalization:

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

Since the entropy weight method can determine the objective weight based on the size of the indicator variation and can eliminate indicators with small contribution rates, this paper first uses the entropy weight method to calculate the indicator weight.

4.2. Construction Of Performance Evaluation Model Based On PSIR Model

This project introduces the PSIR framework as a basic support, and uses the PSIR framework (pressure-state-impact-response) to form a network of associations between indicators and build a set of performance evaluation models that can effectively control and guide the preparation, implementation and evaluation of sponge city planning. model to promote synergy between environmental performance and economic performance.

4.3. Empirical Analysis Of Sponge City PPP Project Performance Evaluation

Taking the Yangtze River Delta region as the object of empirical research, we conduct a macro analysis of the Yangtze River Delta region from three aspects: physical geography overview, economic and social overview, and water resources development and utilization status, collect data, and use the established sponge city evaluation index system and performance The evaluation model evaluates the performance of sponge city PPP construction projects and further analyzes the main influencing factors of sponge city PPP construction project performance.

Table 1. Descriptions of indicators

Criterion layer	indicator layer	Indicator properties
stress indicator	Urban population density/(person/km ²)	-
	Per capita water consumption (cubic meters/person)	-
	Total industrial wastewater discharge per capita (tons/person)	-
status indicator	Proportion of total wetland area to land area (%)	+
	Green coverage rate of built-up areas/%	+
	Forest cover rate(%)	+
Impact indicators	Number of days with urban flooding (days)	-
	Residential water supply price growth rate (%)	-
response metrics	Water consumption saved (10,000 cubic meters)	+
	Daily sewage treatment capacity (10,000 cubic meters)	+
	Personnel employed in water conservancy, environment and public facilities management urban units (10,000 people)	+
	Average number of students enrolled in higher education institutions per 100,000 population (person)	+

4.3.1. Pressure analysis

According to the data, the urban population density in the study area has increased year by year in the past 30 years, and the impact on the ecosystem is mainly caused by human activities. It can be concluded that the impact of human factors on the ecological environment is increasing year by year. When the influence of human factors exceeds When the pressure that a natural ecosystem can withstand, that is, the adjustability of the ecosystem, is exceeded, the ecosystem will degrade.

4.3.2. Status analysis

Status indicators reflect the natural health of an ecosystem in the face of ecological stress. Judging from the indicator data, since our country currently vigorously advocates environmental protection and sustainable development, advocates green waters and lush mountains, which are valuable assets, advocates ecological civilization and environmental protection, and protects ecological barriers and water source protection areas, various indicators show an increasing trend year by year. . At the same time, the relevant policies and regulations promulgated by the state and the promulgation and implementation of various regulations have promoted ecological protection and construction in the Yangtze River Delta region, and improved the natural health status of the region.

4.3.3. Impact indicators

Impact indicators are the impact of system status on social economy, public life and population health. Including: the number of urban flooding days and the growth rate of residential water supply prices.

4.3.4. Response indicators

Response indicators represent the response of the ecosystem to the impacts of human activities and the response of humans to the response of the ecosystem. At present, according to national policies, my country's water conservation and sewage treatment have been effectively improved. According

to data analysis, the water conservation and daily sewage treatment capacity indicators have improved. Human beings are making active efforts to protect the ecological environment. In response, we strive to create new vitality for the ecosystem and effectively promote the sustainable development of the region.

5. RESEARCH INNOVATION POINTS

This article combs the current index system construction methods, selects a framework that meets the requirements of sponge cities and combines it with sponge city construction content, proposes methods and ideas for constructing sponge city index systems, and improves the operation mode of the existing index system. By constructing evaluation indicators based on the PSIR model The system evaluates the Yangtze River Delta region in time series and spatial two-dimensional scales, and analyzes the status and existing problems of sponge city PPP projects in the Yangtze River Delta region based on this. The innovation is as follows.

- (1) Study the development status of sponge cities in the Yangtze River Delta region, and build a PSIR model suitable for the Yangtze River Delta region by analyzing existing system evaluation methods. On this basis, through scientific screening methods, a four-dimensional integrated index evaluation system was formed to conduct an empirical analysis of the Yangtze River Delta region in the spatial and temporal dimensions.
- (2) Research the performance evaluation literature of sponge city PPP projects, analyze the criterion layer and indicator layer in different indicator systems, build an indicator system through the PSIR model, and determine the indicator weight from both qualitative and quantitative aspects, so that the comprehensive weight The value is more in line with the actual value.
- (3) Through comprehensive comparative analysis of vertical (time series) and horizontal (spatial) dimensions, a three-dimensional understanding of the status of sponge cities in the Yangtze River Delta region can be formed. From the time evolution, factors that are not conducive to urban ecological security can be discovered; by comparing and referring to various cities, we can discover the laws of urban development and common problems.

6. CONCLUSION AND DISCUSSION

This paper takes the sponge city in the Yangtze River Delta region as the research area, uses the PSIR model to construct an evaluation index system, and analyzes the changes in ecological environment health in the Yangtze River Delta region. Due to the rapid development of social economy, human activities in the ecological environment are becoming more and more frequent. As a result, the impact on the ecosystem of the study area is also increasing, the comprehensive ecological health index continues to decline, the ecological environment deteriorates, and ecological continuity decreases. Judging from the current development trend, the interaction intensity and coordinated development degree of the regional ecological environment status, pressure and response in the Yangtze River Economic Belt from 2013 to 2023 generally show a positive trend. The country is paying more and more attention to ecological and environmental benefits. Through Establishing an evaluation model to analyze sponge projects will help us better construct ecological projects.

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