Research Article

Grey Clustering Evaluation for the Cooperation Efficiency of PPP Project: Taking Beijing Metro Line 4 as an Example

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PPP model is an important model which provides public products or services based on the coordination between the public sector and private sector. The implementation of PPP model is helpful for relieving the stress of insufficient funding for public sector and improving the efficiency of resource allocation. Comparing with traditional infrastructure project, PPP project involves many stakeholders, and the cooperation efficiency during the different stakeholders impacts the results of the project directly. Thus, it is important to explore the cooperation efficiency of PPP project. Based on grey clustering model, this paper evaluates the cooperation efficiency of PPP project. An evaluation index system including 36 indexes is established based on the aims and objectives of three stakeholders (public sector, private sector, and passengers). A case study of Beijing Metro Line 4 PPP project is implemented to verify the validity and applicability of the evaluation model. And the results showed that the cooperation efficiency of Beijing Metro Line 4 PPP project is relatively high. The model also provided insights into the shortage of the cooperation efficiency of Beijing Metro Line 4 PPP project. As such, the results can assist all stakeholders in adjusting the cooperation efficiency.

1. Introduction

As the basement of the development for each career of national economy, national daily life and social production, public infrastructure, and services play important role for both improving the public living standards and enhancing the national economy development [1]. Therefore, the establishment and development of public infrastructure and services begin to get more attentions from government. The construction, operation, and maintenance of urban infrastructure require large funding investment [2]. For a long time, the construction of urban infrastructure in China is mainly based on the investment by government, which not only increases the financial pressure of the government, but also makes it difficult for public projects to keep high-quality construction and operation efficiency. To solve those problems, China begins the commercial exploration for both public products and services, aiming to attract public capital and alleviate financial pressure through applying PPP model [3].

PPP model is a type of systematic cooperation relationship for long-term mutual benefit, which is established

by the approach of signing the concession right agreement between the public sector and the private sector, including gain sharing, risk sharing, responsibility allocation among project financing, construction, and operation [4]. The major advantages of PPP project are fully applying the benefits of both public and private sectors, improving the construction and operation efficiency of public products and services, alleviating the financial pressure of government, and making the gain sharing through stakeholders as the core concept. The successful implementation of PPP model will enhance the total utility among government, private sector, and public [5]. Comparing the traditional government financial investment, PPP project involves many stakeholders, the value of the investment from investor can be reflected only through this specific trading relationship, and it is called as 'relationship specific investment' in contract economics [6]. PPP model changed the payment structure of cooperation between the two trading parties, which makes the project trading change from market-bidding 'preexisting majority' to interdependent 'postevent minority'. With the increase of the relationship specific investment, the level of the trading

parties locked in this specific trading relationship is also increased [7]. In this trading relationship with significant 'bilateral lock' characteristics, the success of the project depends to some extent on the cooperation efficiency of the project participants. Therefore, PPP project advocates a nonconfrontational working approach and aims to maximize the effect of the core stakeholders (government, private sector, and the public).

In Chinese construction practice, however, different trading parties of the PPP project often deviate from the goal of 'win-win', showing distinct barriers and strong confrontation. The government would like to gain more control to the project but not willing to provide adequate protection [8], private sector then presents the defenses against the government during the process of investment and operation, and the public often expresses dissatisfaction to the project price and service level. The three parties often fall into endless renegotiations to solve a great many disputes, eventually resulting in the high risk or even failure of the project [9]. Thus, it is required to commence from the basic objectives of the PPP project, recognise the expected objectives from PPP project of the different stakeholders, clarify the value orientation of the three parties, and then determine the key factors which effect the successful implementation of the PPP project. On this basis, different factors are integrated into a unified frame and are evaluated comprehensively, which makes the stakeholders of the PPP project own the ability to adjust the project schedule, seek the 'win-win' approach for the main contradictions and problems, improve the efficiency and cooperation level of the PPP project, eventually achieve the maximum of the total utility based on satisfaction of all stakeholders, and enhance the successful implementation of the PPP project.

The rest of this article is organized as follows: the second section summarizes the related literature of the cooperation efficiency of PPP project; the third section proposes the cooperation efficiency evaluation index system for PPP project; the fourth section introduces the grey clustering model; in the fifth section, a case study is provided to evaluate the PPP project cooperation efficiency; conclusions are drawn in the sixth section.

2. Literature Review

2.1. PPP Project Stakeholder Theory. The concept of stakeholder is mentioned by Dodd firstly; Mitchell et al. defined the 'stakeholder' as the groups without whose support to the organization would cease to exist [10]. Freeman (1984, 1994) considered the interaction between the organization and stakeholder, and he defined the concept of the stakeholder as any group or person which can interact with the organization [11, 12]. Clarkson emphasized the specific investment and stated that the stakeholders who own the direct impact to the enterprise must be considered. With the deepening of the research and practice, people realize that the survival and growth of the enterprises require the support of the stakeholders. But there are many stakeholders; the best strategy for the sustainable development of the

enterprise is to take different governance approaches based on different stakeholders. Thus, the approach to classify the stakeholders becomes the key point of the research. Frederick (1994) divided the stakeholders into direct stakeholders and indirect stakeholders based on impact level of stakeholders' behaviours affecting the enterprise [13]. Hill and Jones (1992) pointed out that the stakeholder as contractors in exchange relationships [14]. Ackermann and Eden (2011) improved the stakeholder management to strategy management level and present that the strategy objectives can be achieved through the stakeholder management [15]. Ranängen (2015) provides a management system approach for stakeholder management theory, and he considers that the manager should manage the potential of the profit based on the support or the opposition of the stakeholder [16]. In order to recognise the stakeholders, Banks et al. (2016) present that the stakeholder analysis should evaluate and understand the stakeholder from the group factor, considering the stakeholder's status, interest, impact, and so on and then defining the relevance between the stakeholder and the policy [17]. Bryson (2004) recommends that the interrelation between different stakeholders should be considered in the stakeholder analysis [18].

The sustainable development of the stakeholder theory provides great research basis for the project stakeholder theory, and it begins to be implemented widely in the project management. The partnering relationship of the PPP project is established on the common interests of all stakeholders. As the PPP project involves many stakeholders and contains the interest from different stakeholders, the independence of different stakeholders will inevitably lead to many interest conflicts. Thus, the utilization of the stakeholder theory in the PPP project will be helpful to accurately analyze for the objective of the PPP project stakeholders, promote the successful implementation of the PPP project, improve the cooperation efficiency of the PPP project, reduce the cooperation dilemma, and maximize the social total utility. Yang and Zou (2014), Paletto et al. (2015), and some other scholars all apply social network model to analyze the interact relationship of stakeholders in the stakeholder analysis of the project or policy, to improve the identifying efficiency and accuracy of the stakeholders [19, 20]. Li et al. (2005) state that the risk of the PPP project should be shared among the public sector, private sector, and the final user, but it should mainly be between the public sector and the private sector. Ng and Loosemore (2007) present that risk sharing plan should be defined based on the risk identification capacity, risk sensitivity, and risk control capacity of the different stakeholders [21]. Similarly, Rutgers and Haley (1996) present that the risks of PPP project should be classified and allocated to the stakeholder who owns the better capacity to handle the specific type of risk [22]. For profit allocation of the project, Humphery et al. (2003) consider that the government should abandon the excess profit to promote the private sector to improve the operation efficiency of the project and fully reflect the public characteristic of the project [23]. El-Gohary et al. (2006) point out that the stakeholders should be involved in the PPP project from the early plan stage, to fully present the profit requirement and conduct the reasonable allocation [24].

2.2. Cooperation Efficiency of the PPP Project. The cooperation efficiency of the PPP project can be evaluated from the project performance and whether each stakeholder reaches the expected purpose. Lebas (1995) defined the performance evaluation as the process of quantifying and reporting the validity of the activities which are applied to achieve the organization objectives [25]. Mladenovic et al. (2013) point out that the performance evaluation and management of PPP project should surround the expected purpose of stakeholders, and they improve the performance evaluation approach of the PPP project [26]. Liu et al. (2015) put forward an index system to evaluate the PPP project performance through literature review. This index system does not only focus on the achievement of the project factor, but also focus on the cooperation process of the project [27]. Villalba-Romero and Liyanage (2016) propose that different indexes of the PPP project performance own different contributions for the success of the project; process management for key indexes is required [28]. Based on the expected purpose of the different stakeholders, Yuan et al. (2009) consider that public sector focuses on the overall strategy plan and task objective and private sector focuses on the long-term development of itself and financial strategy; the public then expects the application of the public facilities and services [29]. Xiong et al. (2015) use the satisfaction survey of the stakeholders as the method, recognizing that the government pay more attention to the cost saving and risk transfer, but private sector focuses more on gaining profit and government support [30]. Verweij (2015) proposes that the external-oriented management for PPP infrastructure project is more conducive to achieve the expected purpose of the project and considers the impact of social complexity on project cooperation efficiency [31]. Li et al. (2005) suggest that many factors may lead to the low-efficiency and inefficiency of the project, while some factors are being more critical to others for the success of the project, which are called the key factors for the success of the PPP project, such as the policy support, financial capacity of the enterprise, public suggestion, etc. [32]. Shi et al. (2016) compare the key factors for the success of the PPP project in both China and European, consider the interaction of different key factors, and then discover that in China, the key factors to improve the efficiency of PPP project are social culture, government support, services price, institutional environment, and appropriate risk allocation [33]. Ismail (2015) researches and finds that excellent government management, compliance with commitments for both public and private sectors, economic policy, and bankability are the key factors to improve the cooperation efficiency of PPP project in Malaysia [34]. Maskin and Tirole (2008) consider that the allocation of control right for PPP project is the key factor which affects the cooperation efficiency and then researches the impact and approach of the allocation of the PPP project control right for the cooperation efficiency through mathematical model [35]. Grimsey and Lewis (2002) organize systematically the risks of PPP project and think the optimal risk allocation is the key factor for the project success [36]. Zhang et al. (2010) study the impact of formal and informal contracts on the cooperation efficiency of the PPP project from the contract factor based on the equity

theory [37]. Klijn and Koppenjan (2016) study the impact from complexity and flexibility of contract and the possibility of the negotiation on PPP project performance through the contract factor [38]. Warsen et al. (2018) research and find that the trust between public and private sectors and good project management can promote the improvement of the cooperation efficiency through the relationship factor [39]. Leitch and Motion (2010) point out that the participation of the private sector in PPP project should be appropriate through case study; the deeper participation of the private sector can improve the cooperation efficiency [40].

In summary, many scholars have done a lot of research based on the impact of the input, output, and project management factors on PPP project cooperation efficiency. The results are abundant, but there are still some limitations. Firstly, the current studies mainly focus on the input, output, and capital benefit of the project itself for PPP project cooperation efficiency, but the comprehensive research for the value orientation of the stakeholders and project cooperation efficiency is very limited. Secondly, most studies utilize the game theory to analyze the cooperation efficiency of PPP project and focus on the control right to analyze the approach for improving cooperation efficiency, but the research from cooperation efficiency identification, evaluation, and dispose process is rare. As a result, applying the approach of reasonable control right allocation owns limited guiding and practical operability for improving cooperation efficiency. Therefore, based on the theories of PPP project cooperation efficiency, this paper starts with maximizing social total utility of the PPP project, defines the concession agreement period of PPP project as the evaluation scope, and purposes the PPP project cooperation efficiency evaluation model based on the grey clustering evaluation. Also, based on above model, this paper utilizes the relevant data of Beijing Metro Line 4 PPP project to research the cooperation efficiency in this case.

3. Evaluation Index for Cooperation Efficiency of PPP Project

PPP project cooperation efficiency influences the objective coordination of the stakeholder and requires combining the profit and objectives of different stakeholders. As the PPP project involves many stakeholders and the profit presents diversification, the public utility is incorporated into the context of cooperation efficiency. Drawing on the perspective of welfare economics, the PPP project cooperation efficiency is defined as total social utility, which is the maximum total utility of the government, private sector, and public.

3.1. Establish Index Concept Framework. Index logic framework of PPP project cooperation efficiency is established through the horizontal dimension of project cycle framework Input-Output-Outcome-Impact (IOOI) and the vertical dimension of government, private sector, and public. IOOI is purposed by European Environmental Protection Agency, which is used to establish the analysis framework of the project environmental index; four dimensions can present the characteristics of the project from the process of

approval, construction, and operation, and then the activities of the project whole life cycle can be presented completely [41]. 'Input' means the support from the project; PPP project contains financial cost, technical resources, and the policy support from the government; 'Output' means the final transferred products or services of the project through the input, such as the number of the completed buildings, the length of the metro line, and so on; 'Outcome' is the result which can be observed in short time, such as the safety during construction process, pricing of the public products/services, and so on; 'Impact' is the long-term result, such as the improvement of the traffic operation capacity, optimization of the urban traffic, promotion of the regional economy, and so on. 'Input' can be transferred to 'Output' through specific process. Comparing to 'Outcome', 'Impact' is affected by many factors and is more complex. 'Impact' dimension can measure the future growth of the project and present the achieving level of the project strategy objective. PPP project focuses on the profit of stakeholders, pays attention to balance the different objectives, and then maximizes the social total utility. Focusing only on the economic or social utility of the project cannot promote the application of the PPP project smoothly in public products/standard public products. Thus, it is inappropriate to only consider the profit of stakeholders when measuring the PPP project cooperation efficiency; it is necessary to focus on the long-term impact of the project on government, private sector, and public. Based on the satisfaction of the above three participants, the selection of PPP project cooperation efficiency indexes starts from the expected objectives of government, private sector, and public through PPP project and follows the logic of project input-output-outcome-impact.

3.1.1. Government Attention Indexes. Through PPP project, government plays many roles during the process of promoting the project. The government sometimes not only acts as the initiator or the leader of the project, but also serves as the profit and conflict adjuster between private sector and public. Therefore, from the IOOI aspect, the government mainly focuses on reducing financial input during the input stage and satisfying the public requirement in output stage, including whether the project owns reliable quality, satisfies public requirement and safety, and is of reasonable pricing. The government pays more attention to avoiding renegotiation and developing project smoothly in outcome stage. In impact aspect, the government takes main concern on promoting urban development, including the environmental influence of the project, promotion of the original economy development, and improvement of efficiency.

3.1.2. Private Sector Attention Indexes. In PPP project, private sector often stands in the first line during the construction and operation of the project; the final objective of the private sector is to gain the return of the project investment. Then, from the IOOI aspect, the private sector mainly focuses on the support from the government during input stage, including approving time, avoiding unreasonable intervention from the government, and gaining the government policy support (such as exclusive commitment and so on). In the

output stage, the private sector mainly focuses on project construction, including safe construction and operation, quality, and duration. The private sector pays more attention on project profit during outcome stage, including avoiding project overspend, low financial cost, reasonable pricing system, concession operation period, and users. In impact aspect, the private sector takes main concern on public relationship, including setting up long-term cooperation with the government and increasing corporate visibility.

3.1.3. Public Attention Indexes. The public is not only the main participant but also the main user of the PPP project. Most scholars consider that the concerns for PPP project of public contain operational reliability, including quality, environment, operational function, and so on. Besides, Liu presents that the public will be dissatisfied with the project due to the using price perception of the public for PPP project, especially the unreasonable project subsidy, low government subsidy, and high charge price and other problems which will damage the benefit for the public.

3.2. Establish Indexes System. According to the analysis of the factors affecting the cooperation efficiency in PPP projects from the perspective of government sector, private sector, and public, the evaluation index is set up as follows (Table 1). The main aim of this study starts from the expected objectives through PPP project of government, private sector, and public, to maximize the cooperation efficiency of the PPP project.

4. Methodology

The comprehensive evaluation of PPP project is a multilevel, multi-index, and multiattribute complex issue; its difficulty is that there are many indexes; it is also required to consider the fuzzy attributes of some indexes during the evaluation process. Therefore, it can be considered as a multiprinciple fuzzy evaluation issue. Many researchers began to use stochastic and fuzziness to describe the uncertainties. However, the probability distribution in stochastic optimization is usually hard to understand. The grey system theory is focused on the study of problems involving small samples and poor information, which provided an alternative method to deal with these problems. It processes uncertain systems with partially known information by generating, mining, and extracting useful information from the available information. So, the operating behavior of the system and its evolution can be correctly described and effectively monitored. Therefore, gray clustering evaluation is an effect way to describe the uncertainties. Comparing with fuzzy comprehensive evaluation method and weighted average method, gray clustering evaluation can fully utilize the known whitening information, research the relationship between the system internal action data, dilute the grayness of the system, and improve the accuracy of the evaluation.

4.1. Grey System Theory. The Grey System Theory is proposed by Julong Deng in 1982 [42]. This theory aims at

TABLE 1: PPP project cooperation efficiency index system.

Categories	Factors	Indexes	Definitions	Resources
Government	Satisfy Public Requirement	X1 Reliable quality	High quality of public product/service	Clarkson [47]; Li et al. [48]
		X2 Satisfied public product/service requirement	The new-built, renovated, and expanded public facilities need to satisfy the requirement of economic and social development	Bryson [18]
		X3 Safety construction and operation	Avoid safety accident during the construction and operation process of the project	Li et al. [32]; Shi et al. [23]
		X4 Reasonable pricing system	Define the price standards and adjust procedure based on the project investment and operational cost, and then control the services change of the franchise company	Zhan et al. [8]; Verweij [31]
	Avoid Renegotiation	X5 Avoid concession period extension	Avoid the renegotiation to extent concession period	Tiong [9]; Yang et al. [19]
		X6 Avoid increasing financial responsibility during concession period	Avoid the renegotiation to increase the financial expenditure	Tiong [9]; Osei-Kyei and Chan [49]
		X7 Avoid price increase during concession period	Avoid private sector increasing the price through renegotiation and then increasing the burden of the users	Yang and Zou [19]; Thomas et al. [50]
	Promote Urban Development	X8 Environmentally sustainable development	Sustainable utilization of resource and energy, sustainable maintenance of the ecosystem	Yang and Zou [19]; Villalba-Romero and Liyanage [28];
		X9 Promote regional economic development	Create job opportunities, increase local regional investment capacity, accelerate local economic development, guiding and radiation effects for the regional economic increase	Villalba-Romero and Liyanage [28]; Xiong et al. [30]
		X10 Improve the construction and operation efficiency of the public project	Introduce the advanced technology and management capacity of private sector, provide high quality public product/services with low cost	Li et al. [48]; Verweij [31]
	Successfully Develop Works	X11 Complete the project in time	Complete the construction of PPP project in time	Ng and Loosemor [21]; Rugters and Haley [22]
		X12 Transfer part of risks	Transfer part of the risks to private sector	Rugters and Haley [22]; Humpherys et al. [23]
		X13 Good condition of facilities after transfer	PPP project maintains good facility conditions after transfer	EI-Gohary et al. [24]; Yuan et al. [29]
	Reduce Financial Pressure	X14 Avoid high supervise cost	Due to the involvement of private capital, private sector owns some control for the project; it is difficult for government to supervise and the supervise cost will also increase	Liu et al. [27]; Villalba-Romero and Liyanage [28];
		X15 Reduce financial pressure	Reduce the financial pressure of the government to provide public product/service	Yuan et al. [29]; Maskin and Tirole [35]
Private Sector	Project Profit	Y1 Low Cost	Reduce project cost	Xiong et al. [30]
		Y2 Satisfy return on investment	The operation of the project can meet the requirement of return on investment	Li et al. [48]; Mladenovic et al. [26]
		Y3 Reasonable pricing principle	Stable income in long term and avoid the reduction of charge price	Yuan et al. [29]; Xiong et al. [30]
		Y4 Reasonable concession period	Reasonable concession period can guarantee the return of the project	EI-Gohary et al. [24]; Xiong et al. [30]
		Y5 Many users	The project can attract many users	Grimsey and Lewis [36]; Klijn and Koppenjan [38]

TABLE 1: Continued.

Categories	Factors	Indexes	Definitions	Resources
Public	Government Support	Y6 Avoid project overspend	Avoid the project investment exceeding the planned investment	Xiong et al. [30]
		Y7 Avoid unreasonable intervention from the government	Avoid the illegal property requirement from the government through illegal influence, and result in costing increase in maintaining relationship.	Ismail [34]; Maskin and Tirole [35]
		Y8 Gain the policy support from the government sector	Own the guaranteed benefits, tax incentives, bundled development, logistics, and so on	Warsen et al. [39]; Leitch and Motion [40]
	Project Construction	Y9 Safe construction and operation	Avoid safety accident during the construction and operation process of the project	Li et al. [48]; Liu et al. [51]
		Y10 Standard quality	The quality of public product/service meets the expected standard	Lebas [25]; Mladenovic et al. [26]
		Y11 Complete the project in time	Complete the construction of PPP project in time	Tiong [9]; Paletto et al. [20]
	Public Relationship	Y12 Establish long-term cooperation relationship with the government	Establish good long-term cooperation relationship, increase mutual trust and the future cooperation opportunities, and also make the cooperation more successful.	Tiong [9]; Osei-Kyei and Chan [49]
		Y13 Improve the reputation and credibility of enterprise	Establish good social image, raise reputation, and achieve social responsibility of enterprise	Xiong et al. [30]
		Z1 Reliable construction quality	High level of public product/service quality	Villalba-Romero and Liyanage [28]; Yuan et al. [29]
	Operational Reliability	Z2 Good environment	Good and comfortable environment for public products	EI-Gohary et al. [24]
		Z3 Good operational function	Strong operational functions of public product, which can meet the client's requirements	Yuan et al. [29]
		Z4 Timely convenient service	Service in time, improve the convenience of the users	Mladenovic et al. [26]; Liu et al. [27]
	Operational Price	Z5 Safety operation	Safe services, low occurrence of malfunction	Mladenovic et al. [26]
		Z6 Low price	Low operational price	EI-Gohary et al. [24]
		Z7 User subsidy from the government	Avoid the decrease of the user subsidy standard from the government to private sector and resulting in the decrease of the public product or service quality provided from private sector	Maskin and Tirole [35]; Zhang et al. [37]
		Z8 Reasonable compensation	Fair and reasonable compensation for public during the process of land requisition and demolition	Liu et al. [51]

the ambiguity and incompleteness of the system internal information, understanding the entire system through the analysis of part known information, and then provides accurate control and description for the systematic operation and development principles. Based on establishing the grey model system of grey relevant space theory, through the relevant analysis of the system internal factors, established model, prediction, decision-making, evaluation, and control, combining qualitative analysis and quantitative calculation to analyse the system, new scientific approaches for systematic research are provided [43]. Currently, grey system theory has

been applied successfully in economic management, social system, ecosystem, construction, and other scientific areas.

Grey cluster approach can be separate as grey relational cluster and grey whitening weight function cluster [43]; the grey relational cluster is applied to merge the factors which own the same similar nature and simplify the complicated grey system; it can test whether there are some factors belonging to the same category among so many factors; then the comprehensive average index of these factors or one specific factor can be used to replace these factors and keep the original information as far as possible to avoid

FIGURE 1: Centre point triangular whitening weight function.

serious information loss. This is the deletion problem for systematic index. Grey whitening weight function cluster generally is applied to test whether the inspected objects belong to different categories; these categories or classes are defined in advance and the analysis is conducted based on different classified characteristics [44]. When evaluating the PPP project cooperation efficiency, the application of grey whitening weight function can analyse comprehensively the impact level of each index factor on cooperation efficiency and make the result of cooperation efficiency evaluation present the objective achieving level of stakeholders more accurately and reasonably.

4.2. Grey Cluster Evaluation Model. When applying the grey cluster method based on grey whitening weight function to conduct the evaluation of PPP project cooperation efficiency, firstly, determine the evaluation of cooperation efficiency and use the questionnaire survey method to score each index; establish the corresponding whitening weight function according to cooperation efficiency evaluation index system, and calculate whitening weight function according the index score; then, according to this information, AHP is used to determine the attribute weights. Finally, calculate the comprehensive clustering coefficient of cooperation efficiency and define the cooperation efficiency level of PPP project.

Suppose there are n clustering objects, m clustering indexes, and s grey clusters. According to the observed value x_{ij} on index j ($j = 1, 2, \dots, m$) of object i ($i = 1, 2, \dots, n$), classify clustering object i in the grey class k ($k \in \{1, 2, \dots, s\}$), which are grey clusters. The previous analysis can be summarized as the following steps [44–46].

Step 1 (define the number of grey clusters). Divide the indexes into s grey clusters according to the evaluation requirement, define the points which are the most possible belonging to each grey cluster $\lambda_1, \lambda_2, \dots, \lambda_s$, calling λ_k as centre point, according to the maximum possibility of whether it belongs to its grey cluster; divide the scope of index as s ranges $[a_1, a_2]$, $[a_2, a_3]$, ..., $[a_s, a_{s+1}]$. This paper divides the evaluation level of PPP project cooperation efficiency as 5 levels, which are very high, high, normal, low, and very low.

Step 2 (define the whitening weight function formula for k grey class of j index). Connect the point $(\lambda_k, 1)$ with the centre point $(\lambda_{k-1}, 0)$ of $(k-1)$ interval and the centre

point $(\lambda_{k+1}, 0)$ of $(k+1)$ interval, and then get the triangular whitening weight function $f_j^k(\cdot)$ for k grey classes of j index, $j = 1, 2, \dots, m$, $k = 1, 2, \dots, s$. For whitening weight function $f_j^1(\cdot)$ and $f_j^s(\cdot)$, prolong the value range of j index to λ_0, λ_{s+1} , shown in Figure 1.

Obtain the whitening weight function, presented in formula (1):

$$f_j^k(x) = \begin{cases} 0, & x \notin [\lambda_{k-1}, \lambda_{k+1}] \\ \frac{x - \lambda_{k-1}}{\lambda_{k+1} - \lambda_{k-1}}, & x \in (\lambda_{k-1}, \lambda_k] \\ \frac{\lambda_{k+1} - x}{\lambda_{k+1} - \lambda_k}, & x \in (\lambda_k, \lambda_{k+1}) \end{cases} \quad (1)$$

Step 3 (calculate the grey comprehensive clustering coefficient σ_i^k for clustering object i about grey class k). Apply x_{ij} to present the observation value of index value i with respect to index j , $f_j^k(\cdot)$ presents the whitening weight function of k th subclass of the j th index, and η_j is the weight of index j in the comprehensive clustering; we can obtain the weight vector of the attribute by AHP, then $\sigma_i^k = \sum_{j=1}^m f_j^k(x_{ij})\eta_j$.

Step 4 (judge the grey classes of the clustering objects). When $\sigma_i^{k^*} = \max_{1 \leq k \leq s} \{\sigma_i^k\}$, clustering object i belongs to grey class k^* .

5. Case Study

5.1. Project Overview. The total length of Beijing Metro Line 4 is 28.65 kilometers; the south of this metro line is from Beijing Gongyixiqiao Station in Fengtai District and north to the Anheqiao North station in Haidian District. There are 24 stations in total across this metro line. The total investment of this project is about 15.3 billion Yuan. The construction of this project started from the end of 2003, and this project was completed and put into operation in 2009. At present, the average daily passenger flow has reached 700,000.

This project has been separated into two independent parts: A and B. Part A contains tunnels, stations, and some other civil works. The investment of part A is about 10.7 billion Yuan, which occupies the 70% of the total project investment. The wholly owned subsidiary of Beijing Infrastructure Investment Company (government state-owned company) is

FIGURE 2: PPP model operation of Beijing Metro Line 4.

TABLE 2: Distribution of questionnaire.

Stakeholders category	Number	Percentage
Public sector	21	20.5%
Private sector	48	47.7%
Public	32	31.8%
Total	101	100%

responsible for the construction and investment of the part A. Part B includes vehicles and signals and other equipment assets. The investment amount of Part B is 4.6 billion Yuan, accounting for 30% of the project total investment. The PPP project company (franchise company), which is established through market-based methods, takes the responsibility of the investment, construction, operation, management, and conducting franchise. The PPP model of Beijing Metro Line 4 is presented in Figure 2.

5.2. Project Evaluation. The samples for this investigation are the staff of franchise company who take part in the implementation of Beijing Metro Line 4 PPP project, government staff, and the public. Out of 140 questionnaires sent out, 120 are received. After checking, inspecting, and eliminating the invalid data, 101 valid questionnaires remain with 72% valid response rate. The statistics criteria are presented in Tables 2 and 3.

Determine the evaluation language description set U for each qualitative index of Beijing Metro Line 4 PPP project cooperation efficiency evaluation model as $U = (\text{extremely low, very low, low, relevantly low, moderately low, moderately high, relevantly high, high, very high, extremely$

high) = (1, 2, 3, 4, 5, 6, 7, 8, 9, 10). When combining the grey clustering evaluation, these indexes will be considered as clustering object. The relative change threshold is used as the corresponding value after the dimensionlessness of the index. This value not only emphasizes the direct comparison between the actual data and the planned data, but also measures the rate of change and converts the relative threshold to a positive value according to the change of the data. The processing method is as follows.

For benefit index,

$$x_{prj} = \begin{cases} \frac{x_r - x_p}{x_p} \times 100, & x_r > x_p \\ \frac{x_p}{|x_r - x_p|}, & x_r < x_p \end{cases} \quad (2)$$

For cost index,

$$x_{prj} = \begin{cases} \frac{|x_r - x_p|}{x_p} \times 100, & x_r < x_p \\ \frac{x_p}{x_r - x_p}, & x_r > x_p \end{cases} \quad (3)$$

x_{prj} is relative change threshold, x_p is planned value, and x_r is actual value.

5.2.1. Divide Grey Classes. The index level is divided into 5 evaluation grey classes which present the cooperation efficiency level as very low, low, moderate, high, and very high separately. According to the lowest and highest evaluation score for the evaluation language set, considering the divide requirement of grey classes, the very low, low, moderate, high,

TABLE 3: Percentage distribution of the respondents' profile.

Index	Range	Public sector	Private sector	Public
Age	18-30	2	11	9
	31-50	14	30	16
	50+	5	7	7
Education level	High school graduation	-	-	9
	Post high school	21	48	23
	<3 years	2	7	-
Years of PPP project experience	3~5 years	5	23	-
	6~10 years	11	14	-
	>10 years	2	5	-

TABLE 4: Divide qualitative index level.

Grey class	I	II	III	IV	V
Cooperation efficiency level	Very low	Low	Moderate	High	Very high
Score	[0, 2]	[2, 4]	[4, 6]	[6, 8]	[8, 10]

and very high points in set $[0, 10]$ are selected as $\lambda_1 = 1$, $\lambda_2 = 3$, $\lambda_3 = 5$, $\lambda_4 = 7$, $\lambda_5 = 9$. Thus, the sets of 5 grey classes are $[0, 2]$, $[2, 4]$, $[4, 6]$, $[6, 8]$, $[8, 10]$. The corresponding value is shown in Table 4.

5.2.2. Define the Whitening Weight Function. The whitening weight function value of λ_k is 1, belonging to grey class k . Connect the point $(\lambda_k, 1)$ with the centre point $(\lambda_{k-1}, 0)$ of $(k-1)$ interval and the centre point $(\lambda_{k+1}, 0)$ of $(k+1)$ interval, and then get the triangular whitening weight function $f_j^k(\cdot)$ for k grey classes of j index, $j = 1, 2, \dots, m$, $k = 1, 2, \dots, s$. The triangular whitening weight function for cooperation efficiency evaluation value x_{ij} can be established according to formula (1).

5.2.3. Calculate Grey Comprehensive Clustering Coefficient. Take the corresponding value of each index into the above formula, and then calculate the corresponding grey whitening weight function value for each index. Finally, the whitening weight function value is managed as Table 5.

5.2.4. Judge the Grey Classes of the Clustering Objects. Based on the expert survey to weight of public sector, private sector, and public through AHP approach, comprehensive weight of each index can be obtained. According to the formula $\sigma_j^k = \sum_{i=1}^m f_j^k(x_{ij})\eta_j^k$, the corresponding comprehensive clustering coefficient σ_j^k of grey class for Beijing Metro Line 4 project can be calculated. The results are presented in Table 5.

5.3. Results and Discussion. According to $\max_{1 \leq k \leq 5} \{\sigma_j^k\} = \sigma_j^4$ and the grey classes of cooperation efficiency evaluation, the cooperation evaluation of Beijing Metro Line 4 PPP project belongs to the forth grey class; from Table 4 we can see that the cooperation efficiency level is 'high' level.

From Table 5, the level of some indexes is lower than others; for example, index X14 (avoid high supervise cost) corresponds to the whitening weight function value being 0.75, and the grey class is 'moderate', which means the achieved results of this objective are general. The fundamental cause is the establishment of the supervise system and the high cost of strict enforcement. The stakeholders of the project contain private sector, the private sector has self-interest characteristics, and the project has great impact on the public. Thus, the government supervision is strict and the system is more comprehensive. The scope includes the whole process of investment, construction, and operation. The sequence contains three supervise stages which are prestage, interstage, and poststage. Besides, the maintenance of the equipment is also one of the important focuses of the government supervision; then the cost of total supervision is high. The corresponding grey classes 'moderate', 'high', and 'very high' of the whitening weight function value for index X15 are 0.39, 0.39, and 0.61, respectively, which are relatively average. The government's objective of solving financial problems through PPP projects has not been achieved completely. As the public nature of public projects determines its low return rate, the government has to subsidize the private sector. The subsidy for Beijing Metro Line 4 is based on two prices: the actual fare paid by the citizens and the settlement price agreed by the government and Beijing MTR cooperation limited company. The settlement price is higher than the actual fare and the difference is the subsidy which the government should provide. The settlement price will change according to the change of the annual cost measurement, and the cost measurement will be adjusted based on the CPI of the current year and some other factors. According to relevant information, Beijing MTR cooperation limited company received the government financial subsidy for about 150 million Yuan in 2009 and 640 million Yuan in 2010. The corresponding grey classes 'low' and 'moderate' of the whitening weight function value for index Y1 (low cost) are 0.2 and 0.8 separately. As the construction and operation

TABLE 5: Comprehensive clustering coefficient for Beijing metro line 4 PPP project cooperation efficiency index.

Cooperation efficiency index	Comprehensive weight ω_i		$f_j^1(\cdot)$	$f_j^2(\cdot)$	$f_j^3(\cdot)$	$f_j^4(\cdot)$	$f_j^5(\cdot)$
X1 Reliable quality	ω_1	0.0061	0	0	0	0.9	0.1
X2 Satisfied public product/service requirement	ω_2	0.0257	0	0	0	0.3	0.7
X3 Safety construction and operation	ω_3	0.0068	0	0	0	0.95	0.05
X4 Reasonable pricing system	ω_4	0.0078	0	0	0.4	0.6	0
X5 Avoid concession period extension	ω_5	0.0091	0	0	0	0.55	0.45
X6 Avoid increasing financial responsibility during concession period	ω_6	0.0099	0	0	0.15	0.85	0
X7 Avoid price increase during concession period	ω_7	0.0125	0	0	0	0	0.95
X8 Environmentally sustainable development	ω_8	0.0170	0	0	0.1	0.9	0
X9 Promote regional economic development	ω_9	0.0151	0	0	0	0.95	0.05
X10 Improve the construction and operation efficiency of the public project	ω_{10}	0.0204	0	0	0	0.65	0.35
X11 Complete the project in time	ω_{11}	0.0039	0	0	0	0	0.9
X12 Transfer part of risks	ω_{12}	0.0057	0	0	0	0.75	0.25
X13 Good condition of facilities after transfer	ω_{13}	0.0033	0	0	0	0.95	0.05
X14 Avoid high supervise cost	ω_{14}	0.0162	0	0	0.75	0.25	0
X15 Reduce financial pressure	ω_{15}	0.0403	0	0	0.39	0.39	0.61
Y1 Low Cost	ω_{16}	0.0299	0	0.2	0.8	0	0
Y2 Satisfy return on investment	ω_{17}	0.0215	0	0	0.5	0.5	0
Y3 Reasonable pricing principle	ω_{18}	0.0189	0	0	0	0.9	0.1
Y4 Reasonable concession period	ω_{19}	0.0083	0	0	0	0.45	0.55
Y5 Many users	ω_{20}	0.0357	0	0	0	0.35	0.65
Y6 Avoid project overspend	ω_{21}	0.0278	0.89	0.11	0.11	0	0
Y7 Avoid unreasonable intervention from the government	ω_{22}	0.0099	0	0	0	0.6	0.4
Y8 Gain the policy support from the government sector	ω_{23}	0.0672	0	0	0	0.75	0.25
Y9 Safe construction and operation	ω_{24}	0.1662	0	0	0	0.35	0.65
Y10 Standard quality	ω_{25}	0.0145	0	0	0	0.6	0.4
Y11 Complete the project in time	ω_{26}	0.0165	0	0	0	0.3	0.7
Y12 Establish long-term cooperation relationship with the government	ω_{27}	0.0145	0	0	0	0	0.75
Y13 Improve the reputation and credibility of enterprise	ω_{28}	0.0118	0	0	0	0.45	0.55
Z1 Reliable construction quality	ω_{29}	0.0073	0	0	0	0.9	0.1
Z2 Good environment	ω_{30}	0.1956	0	0	0.05	0.95	0
Z3 Good operational function	ω_{31}	0.0427	0	0	0.45	0.55	0
Z4 Timely convenient service	ω_{32}	0.0354	0	0	0	0.2	0.8
Z5 Safety operation	ω_{33}	0.0271	0	0	0.04	0.04	0.96
Z6 Low price	ω_{34}	0.0206	0	0	0	0	0.5
Z7 User subsidy from the government	ω_{35}	0.0171	0	0	0	0.95	0.05
Z8 Reasonable compensation	ω_{36}	0.0114	0	0	0	0.6	0.4
$\sigma_j^k = \sum_{i=1}^{36} f_j^k(x_{ij})\omega_i$			0.0248	0.0090	0.1020	0.5326	0.3365

cost of line 4 is quite high for Beijing MTR cooperation limited company, the construction investment is about 4.6 billion Yuan, *Analysis of the Cost Composition of Urban Rail Transit* combining the exiting date, considering the Beijing's per capita wage growth rate, asset depreciation rate, and

loan interest rate, and calculating the total operation cost of 30 years for Beijing MTR cooperation limited company is about 18.58 billion Yuan. External costs, which are the cost brought by accident loss, noise pollution, air pollution, and so on, are calculated as 1.37 billion Yuan for 30 years.

The total cost is about 24.55 billion Yuan. The corresponding grey classes ‘very low’, ‘low’, and ‘moderate’ of the whitening weight function value for index Y6 (avoid project overspend) are 0.89, 0.11, and 0.11 separately, which means the result of avoiding project overspend amount is poor. The planned investment of the project is 4.58 billion Yuan, and actual investment is 4.67 billion Yuan. The overspend amount of the project is 90 million Yuan. The corresponding grey classes ‘moderate’ and ‘high’ of the whitening weight function value for index Y2 (satisfy return on investment) are both 0.5, which presents that the profit expected of private sector has not been satisfied enough. Metro Line 4 owns large passenger flow and the government provides subsidy based on the concession agreement; the Beijing MTR cooperation limited company can obtain basic profit. However, the profit model ‘railway + property’ has not played its role; the profit model should be applied to satisfy the expected return on investment with the profit of the comprehensive development of railway property, which means achieving earnings without any subsidy. Beijing line 4 owns no opportunity to conduct commercial development, any commercial retail facilities are forbidden in the stations. Then Beijing MTR cooperation limited company can only develop advertisement, communication, and some other aspects, as well as shared revenue of the passenger flow.

As a result, combined with the actual situation and operability, the directions for this project to improve cooperation efficiency in future operation process are as follows.

(1) *Reduce the Cost of Government Supervision.* The government has paid a large amount of cost in the early stage to establish a comprehensive supervision system, so the implementation of this system should be deepened at current stage. First at all, the law enforcement responsibility system should be improved; the law enforcement cost should be contained in the index of evaluating the law enforcement level of supervisors. Secondly, diligence and thrift should be advocated and the cost consciousness of law enforcement for all stakeholders should be established. Thirdly, cost supervision system which is conducted by supervisor should be improved. Besides, the e-government should be promoted actively to reduce the human resource costs. Finally, law-abiding cost for the private sector should be reduced, that is, reducing some of the nonessential procedures when cooperating with the supervision; then the inspection efficiency can be improved and the delays for private sector operations caused by supervision can be reduced.

(2) *Explore New Type of ‘Subsidy Model’ Actively.* There are contradictions between the government financial pressure and return on investment of private sector. On one hand, private sector expects to obtain income through the operation of the project, but the public nature of the project makes it nonprofitable. Then the government generally will provide financial subsidy, which violates the original intention of easing financial pressure. Therefore, it is necessary to seek other approaches to subsidize private sector, or improve increase of the preferential level, to achieve satisfied investment

returns for private sector without increasing the government financial pressure and finally achieve a win-win situation.

6. Conclusion

The PPP model is widely used worldwide now and has played an integral role in China’s infrastructure sector. However, at the same time of development, many PPP projects failed to achieve the expected results, and the construction and operation results of the PPP projects were totally different; a large number of projects were even in a state of loss, leading to the cooperation degree not meeting the expected objective. This paper evaluates the PPP projects through establishing cooperation efficiency evaluation model. Based on the recognizing the key factors for impacting the cooperation level of stakeholders and resulting in low benefits for PPP projects; this paper conducts the grey clustering model to research the cooperation efficiency of PPP project. The results show that the total cooperation efficiency of Beijing Metro Line 4 PPP project is high. But the objects for reducing the government supervise cost, alleviating government financial pressure, and satisfying the return on investment for private sector have not been achieved comprehensively. It is necessary to reduce the government supervision cost in the following operation process of the project and explore the new type of ‘subsidy model’ actively and then maximize the cooperation efficiency among all stakeholders and achieve the success following execution of the PPP project.

Data Availability

The numerical application data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no competing interests.

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References

- [1] J. Adams, A. Young, and W. Zhihong, “Public private partnerships in China: system, constraints and future prospects,” *International Journal of Public Sector Management*, vol. 19, no. 4, pp. 384–396, 2006.
- [2] M. J. Garvin and C. Y. J. Cheah, “Valuation techniques for infrastructure investment decisions,” *Construction Management and Economics*, vol. 22, no. 4, pp. 373–383, 2004.
- [3] Z. J. Zhao, G. Su, and D. Li, “The rise of public-private partnerships in China,” *Journal of Chinese Governance*, vol. 3, no. 2, pp. 158–176, 2018.
- [4] Z. Liu, “Application and analysis of PPP mode in the public service field,” *Construction Economy*, vol. 273, pp. 13–18, 2005.

- [5] L. Kumar, A. Jindal, and N. R. Velaga, "Financial risk assessment and modelling of PPP based Indian highway infrastructure projects," *Transport Policy*, vol. 62, pp. 2–11, 2018.
- [6] S. J. Grossman and O. D. Hart, "The costs and benefits of ownership: a theory of Vertical and Lateral Integration," *Journal of Political Economy*, vol. 94, no. 4, pp. 691–719, 1986.
- [7] O. Hart and J. Moore, "Property rights and the nature of the firm," *Journal of Political Economy*, vol. 98, no. 6, pp. 1119–1158, 1990.
- [8] C. Zhan, M. de Jong, and H. de Bruijn, "Path dependence in financing urban infrastructure development in China: 1949–2016," *Journal of Urban Technology*, vol. 24, no. 4, pp. 73–93, 2017.
- [9] R. L. K. Tiong, "Csfs in competitive tendering and negotiation model for BOT projects," *Journal of Construction Engineering and Management*, vol. 122, no. 3, pp. 205–211, 1996.
- [10] R. K. Mitchell, B. R. Agle, and D. J. Wood, "Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts," *Academy of Management Review* (AMR), vol. 22, no. 4, pp. 853–886, 1997.
- [11] R. E. Freeman, *Strategic Management: A Stakeholder Approach*, Pitman, Boston, Mass, USA, 1984.
- [12] R. E. Freeman, "The politics of stakeholder theory: some future directions," *Business Ethics Quarterly*, vol. 4, pp. 409–421, 1994.
- [13] W. C. Frederick, "From CSR1 to CSR2: the maturing of business-and-society thought," *Business & Society*, vol. 33, no. 2, pp. 150–164, 1994.
- [14] C. W. L. Hill and T. M. Jones, "Stakeholder-agency theory," *Journal of Management Studies*, vol. 29, no. 2, pp. 131–154, 1992.
- [15] F. Ackermann and C. Eden, "Strategic management of stakeholders: theory and practice," *Long Range Planning*, vol. 44, no. 3, pp. 179–196, 2011.
- [16] H. Ranängen, "Stakeholder management in reality: moving from conceptual frameworks to operational strategies and interactions," *Sustainable Production and Consumption*, vol. 3, pp. 21–33, 2015.
- [17] M. A. Banks, D. Vera, S. Pathak, and K. Ballard, "Stakeholder management as a source of competitive advantage. A relationship and portfolio perspective," *Organizational Dynamics*, vol. 45, no. 1, pp. 18–27, 2016.
- [18] J. M. Bryson, "What to do when stakeholders matter: stakeholder identification and analysis techniques," *Public Management Review*, vol. 6, no. 1, pp. 9–11, 2004.
- [19] R. J. Yang and P. X. W. Zou, "Stakeholder-associated risks and their interactions in complex green building projects: a social network model," *Building and Environment*, vol. 73, no. 1, pp. 208–222, 2014.
- [20] A. Paletto, K. Hamunen, and I. De Meo, "Social network analysis to support stakeholder analysis in participatory forest planning," *Society & Natural Resources*, vol. 28, no. 10, pp. 1–18, 2015.
- [21] A. Ng and M. Loosemore, "Risk allocation in the private provision of public infrastructure," *International Journal of Project Management*, vol. 25, no. 1, pp. 66–76, 2007.
- [22] J. A. Rugters and H. D. Haley, "Project risks and risk allocation," *Cost Engineering Journal*, vol. 38, no. 9, pp. 27–30, 1996.
- [23] I. Humphreys, G. Francis, and S. Ison, "An examination of risk transference in air transport privatization," *Transportation Quarterly*, vol. 57, no. 4, pp. 31–37, 2003.
- [24] N. M. El-Gohary, H. Osman, and T. E. El-Diraby, "Stakeholder management for public private partnerships," *International Journal of Project Management*, vol. 24, no. 7, pp. 595–604, 2006.
- [25] M. J. Lebas, "Performance measurement and performance management," *International Journal of Production Economics*, vol. 41, no. 1–3, pp. 23–35, 1995.
- [26] G. Mladenovic, N. Vajdic, B. Wüdsch, and A. Temeljotov-Salaj, "Use of key performance indicators for PPP transport projects to meet stakeholders' performance objectives," *Built Environment Project and Asset Management*, vol. 3, no. 2, pp. 228–249, 2013.
- [27] J. Liu, P. E. D. Love, J. Smith, M. Regan, and E. Palaneeswaran, "Review of performance measurement: implications for public-private partnerships," *Built Environment Project and Asset Management*, vol. 5, no. 1, pp. 35–51, 2015.
- [28] F. Villalba-Romero and C. Liyanage, "Evaluating success in PPP road projects in Europe: a comparison of performance measurement approaches," *Transportation Research Procedia*, vol. 14, pp. 372–381, 2016.
- [29] J. Yuan, A. Y. Zeng, M. J. Skibniewski, and Q. Li, "Selection of performance objectives and key performance indicators in public-private partnership projects to achieve value for money," *Construction Management and Economics*, vol. 27, no. 3, pp. 253–270, 2009.
- [30] W. Xiong, J. Yuan, Q. Li, and M. J. Skibniewski, "Performance objective-based dynamic adjustment model to balance the stakeholders' satisfaction in PPP projects," *Journal of Civil Engineering and Management*, vol. 21, no. 5, pp. 539–547, 2015.
- [31] S. Verweij, "Achieving satisfaction when implementing PPP transportation infrastructure projects: a qualitative comparative analysis of the A15 highway DBFM project," *International Journal of Project Management*, vol. 33, no. 1, pp. 189–200, 2015.
- [32] B. Li, A. Akintoye, P. J. Edwards, and C. Hardcastle, "Critical success factors for PPP/PFI projects in the UK construction industry," *Construction Management and Economics*, vol. 23, no. 5, pp. 459–471, 2005.
- [33] S. Shi, H.-Y. Chong, L. Liu, and X. Ye, "Examining the inter-relationship among critical success factors of public private partnership infrastructure projects," *Sustainability*, vol. 8, no. 12, p. 1313, 2016.
- [34] S. Ismail, "Critical success factors of public private partnership (PPP) implementation in Malaysia," *Asia-Pacific Journal of Business Administration*, vol. 5, no. 1, pp. 6–19, 2013.
- [35] E. Maskin and J. Tirole, "Public-private partnerships and government spending limits," *International Journal of Industrial Organization*, vol. 26, no. 2, pp. 412–420, 2008.
- [36] D. Grimsey and M. K. Lewis, "Evaluating the risks of public private partnerships for infrastructure projects," *International Journal of Project Management*, vol. 20, no. 2, pp. 107–118, 2002.
- [37] Z. Zhang and M. Jia, "Procedural fairness and cooperation in public-private partnerships in China," *Journal of Managerial Psychology*, vol. 25, no. 5, pp. 513–538, 2010.
- [38] E. H. Klijn and J. Koppenjan, "The impact of contract characteristics on the performance of public-private partnerships (PPPs)," *Public Money & Management*, vol. 36, no. 6, pp. 455–462, 2016.
- [39] R. Warsen, J. Nederhand, E. H. Klijn, S. Grotenbreg, and J. Koppenjan, "What makes public-private partnerships work? Survey research into the outcomes and the quality of cooperation in PPPs," *Public Management Review*, vol. 20, no. 8, pp. 1165–1185, 2018.
- [40] S. Leitch and J. Motion, "Public-private partnerships: consultation, cooperation and collusion," *Journal of Public Affairs*, vol. 3, no. 3, pp. 273–277, 2010.

- [41] L. Segnestam, *Environmental Performance Indicators*, World Bank, Washington, DC, USA, 1999.
- [42] J. L. Deng, "Control problems of grey systems," *Systems & Control Letters*, vol. 1, no. 5, pp. 288–294, 1982.
- [43] C. Yuan, B. Guo, and H. Liu, "Assessment and classification of China's provincial regional innovation system based on grey fixed weight clustering," *Grey Systems: Theory and Application*, vol. 3, no. 3, pp. 316–337, 2013.
- [44] T. Li, E. Qi, and Y. Huang, "Grey clustering evaluation based on triangular whitenization weight function of enterprise's management innovation performance," *Grey Systems: Theory and Application*, vol. 4, no. 3, pp. 436–446, 2014.
- [45] J. Guo, X. Zhao, and Y. Huang, "Grey clustering evaluation of urban low-carbon transport development based on triangular whitenization weight function," *Grey Systems: Theory and Application*, vol. 5, no. 3, pp. 278–289, 2015.
- [46] J. Xin, "Evaluation of auto parts remanufacturing by grey cluster model," *Grey Systems: Theory and Application*, vol. 6, no. 3, pp. 296–308, 2016.
- [47] M. E. Clarkson, "A stakeholder framework for analyzing and evaluating corporate social performance," *Academy of Management Review (AMR)*, vol. 20, no. 1, pp. 92–117, 1995.
- [48] L. Bing, A. Akintoye, P. J. Edwards, and C. Hardcastle, "The allocation of risk in PPP/PFI construction projects in the UK," *International Journal of Project Management*, vol. 23, no. 1, pp. 25–35, 2005.
- [49] R. Osei-Kyei and A. P. C. Chan, "Risk assessment in public-private partnership infrastructure projects: Empirical comparison between Ghana and Hong Kong," *Construction Innovation*, vol. 17, no. 2, pp. 204–223, 2017.
- [50] A. V. Thomas, S. N. Kalidindi, and K. Ananthanarayanan, "Risk perception analysis of BOT road project participants in India," *Construction Management and Economics*, vol. 21, no. 4, pp. 393–407, 2003.
- [51] B. Liu, Y. Li, B. Xue, Q. Li, P. X. W. Zou, and L. Li, "Why do individuals engage in collective actions against major construction projects? —An empirical analysis based on Chinese data," *International Journal of Project Management*, vol. 36, no. 4, pp. 612–626, 2018.

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