The Influence of Multi-subject Collaboration Mechanism on the Performance of Municipal Engineering Project Management

Ziqing Bao

Anhui Shui'an Construction Group Co., Ltd., Hefei, Anhui, 230601, China

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Abstract: With the increase of the scale and complexity of municipal engineering projects, the disadvantages of traditional management mode are becoming more and more obvious. This article focuses on the influence of multi-agent cooperation mechanism on the management performance of municipal engineering projects. Through theoretical analysis and systematic exposition, this article deeply analyzes the respective roles and functions of multiple subjects in municipal engineering project management-government departments, construction units and construction enterprises; The connotation and operation of multi-agent cooperation mechanism and its influence on project schedule, quality, cost and safety management performance are also discussed. It is found that multi-agent cooperation mechanism can promote project progress, ensure quality, control cost and ensure safety. Based on this, this article puts forward multi-agent collaborative optimization strategies to improve management performance, such as strengthening information sharing, enhancing cooperation, improving benefit distribution and strengthening collaborative decision-making. This aims to provide scientific collaborative management methods for all participants in municipal engineering projects, improve project management performance and help urban construction and development.

1. Introduction

Municipal engineering projects are closely related to the life of urban residents, and their management performance directly affects the operational efficiency of the city, the quality of life of residents and the sustainable development of the city [1]. Under the traditional management mode of municipal engineering projects, the participants often go their own way and lack effective coordination and communication, which leads to many problems in the progress, quality, cost and safety of the project [2]. With the continuous advancement of urban construction, the scale of the project is getting larger and larger, and the technical complexity is increasing, so the traditional management mode has been difficult to meet the demand. In this context, the multi-agent cooperation mechanism came into being.

Multi-agent cooperation mechanism aims to integrate the resources, knowledge and abilities of different participants in municipal engineering projects, and through establishing effective communication, coordination and cooperation mechanisms, realize the complementary advantages of each subject, thus improving project management performance [3-4]. In recent years, although some research achievements have been made in related fields, systematic research on the influence of multi-agent coordination mechanism on municipal engineering project management performance is still relatively scarce [5]. Some studies only focus on a single subject or local links, and fail to fully consider the complex interaction between multiple subjects [6]. In practical projects, the application of multi-agent collaborative mechanism also faces many challenges, such as conflicts of interest, information barriers, unclear definition of responsibilities and other issues, which restrict the role of collaborative mechanism.

In view of this, it is of great significance to study the influence of multi-agent cooperation mechanism on the management performance of municipal engineering projects. It is helpful to enrich and improve the theoretical system of municipal engineering project management and

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provide a more comprehensive perspective and theoretical support for the follow-up research. It can also provide scientific collaborative management methods and strategies for all participants in municipal engineering projects, help them effectively deal with the problems in the collaborative process, and then improve the project management performance and ensure the smooth implementation of municipal engineering projects.

2. Multi-subjects in municipal engineering project management

Municipal engineering project management covers many subjects, and each subject plays a unique role in the project. Government departments are the initiators and supervisors of municipal engineering projects, and guide the project direction by formulating policies, regulations and providing financial support to ensure that the project conforms to urban development planning and public interests [7]. As the organizer of the project, the construction unit is responsible for the overall planning, fund raising and communication and coordination with all parties, and its decision-making and management ability is very important to the success or failure of the project. The construction enterprise undertakes the specific construction task of the project, and with the help of professional technology and construction ability, the design scheme is transformed into the actual project. Its construction quality and progress control directly affect the project delivery results. The supervision unit plays the role of supervisor, and strictly supervises the construction process according to the relevant standards and contract requirements to ensure the quality, progress and safety of the project meet the requirements [8]. Design units use professional knowledge to provide design solutions for the project, and suppliers are responsible for providing all kinds of materials and equipment needed for the project. Their work is also an indispensable part of the smooth progress of the project [9]. These multi-subjects are interrelated and influence each other, and together constitute an organic whole of municipal engineering project management.

3. Connotation and operation of multi-agent cooperation mechanism

Multi-agent cooperation mechanism in municipal project management refers to the integration of resources and capabilities of government, construction units, construction enterprises, supervision, design and suppliers, and the construction of cooperation mode to promote their cooperation to improve project management performance [10]. Its core lies in breaking down the barriers among the subjects and forming an organic whole of mutual cooperation and support. From the perspective of connotation, the multi-agent coordination mechanism emphasizes the consistency of goals. Although the participants have different functions, they all need to work around the overall goal of the municipal engineering project, that is, to ensure that the project is delivered with high quality, on time and within the budget, and meet the needs of urban development and the public [11]. It pays attention to resource sharing and complementary advantages. Different subjects have unique resources, such as the policy resources of government departments, the capital and organizational resources of construction units, the technology and manpower of construction enterprises, etc., and realize the rational flow and sharing of resources through the collaborative mechanism, giving full play to the maximum efficiency of all parties. In terms of operation, the multi-agent cooperation mechanism contains many key links. The key links of multi-subject collaborative operation of municipal engineering projects are shown in Table 1:

Table 1 Key Links in the Collaborative Operation of Multiple Entities in Municipal Engineering Projects

Collaborative Link	Government Departments	Construction Unit	Construction Enterprise	Supervision Unit	Design Unit	Supplier
Planning and Decision-Making	Lead in formulating project plans	Participate in planning discussions,	/	/	Provide design concepts and	/

	and approving proposals	provide funding and demand information			proposals	
Resource Allocation	Provide policy support and partial funding	Raise funds and coordinate resources among all parties	Provide construction resources and execute allocation instructions	Supervise the compliance of resource usage	Provide design resources as needed	Supply materials and equipment as required
Communication and Coordination	Establish a communication platform and coordinate major issues	Organize communication meetings among all parties to resolve daily coordination problems	Provide feedback on construction issues and cooperate in coordination	Convey supervision opinions and assist in coordination	Answer design queries and participate in coordination	Provide feedback on supply situations and participate in coordination
Supervision and Control	Develop supervision standards and conduct macro-level control	Supervise the work of all parties in accordance with contracts	Accept supervision and exercise self-control	Implement full-process supervision	Ensure design implementation and accept supervision	Guarantee supply quality and progress and accept supervision

In the planning decision-making, the government departments take the lead in project planning with their macro perspective, and approve relevant schemes, while the construction units participate in the discussion according to their own needs and financial conditions, providing reference for planning. In the resource allocation process, all parties integrate and allocate resources according to their own resource advantages under the overall collaborative framework. For example, construction enterprises allocate human and equipment resources into project construction according to the coordination instructions of the construction unit. Communication and coordination is the key to ensure smooth cooperation. All parties can exchange problems and resolve differences in time through the platform built by the government or the meeting organized by the construction unit. In the supervision and control link, each subject supervises and controls all aspects of the project according to different standards and requirements to ensure the smooth progress of the project. Through the close cooperation of these links, the multi-agent cooperation mechanism can operate effectively, laying the foundation for improving the management performance of municipal engineering projects.

4. The influence of multi-agent cooperation mechanism on management performance

The mechanism of multi-party collaboration is like a key engine for improving the performance of municipal engineering project management, which has a profound impact on various aspects of project progress, quality, cost, and safety management. In terms of project schedule management, the collaborative mechanism of multiple stakeholders plays a significant driving role. The government creates conditions for the rapid launch of projects through efficient approval processes. The construction unit should plan the construction period reasonably, coordinate resources from all parties, and avoid delays caused by resource shortages. Construction companies optimize construction organization design and improve construction efficiency based on collaborative arrangements. The supervisory unit shall monitor the progress in real-time, promptly identify and provide feedback on any issues. The design unit promptly resolves design changes during construction to ensure smooth progress of the project. Suppliers supply materials and equipment on time to ensure uninterrupted construction. Such close collaboration greatly reduces the waiting time

and poor connection in each link, effectively shortening the project duration.

The construction unit shall establish strict quality standards, the construction enterprise shall strictly follow the standards for construction, the supervision unit shall strictly supervise based on professional knowledge, and the design unit shall provide accurate and detailed design schemes and timely solve design questions during construction. Futhermore, government departments supervise the implementation of quality standards from a macro perspective, and suppliers provide materials and equipment that meet quality requirements. The construction unit conducts precise cost budgeting in the early stage of the project, the construction enterprise reduces costs by optimizing the construction plan, the supplier reduces supply costs by reasonable pricing and optimizing logistics, and the supervision unit strictly controls the cost increase caused by engineering changes. During the collaborative process, all parties should comprehensively and comprehensively control costs to avoid resource waste and unnecessary expenses.

In the field of safety management, government departments are responsible for formulating safety regulations and supervising their implementation. The construction unit actively supervises all parties to implement safety responsibilities. Construction companies are focusing on strengthening safety management at construction sites. The supervisory unit shall supervise the implementation of safety measures. The design unit fully considers safety factors during the design phase. All parties work together to create a safe construction environment. The impact of the multi subject collaborative mechanism on the performance of municipal engineering project management is shown in Figure 1:

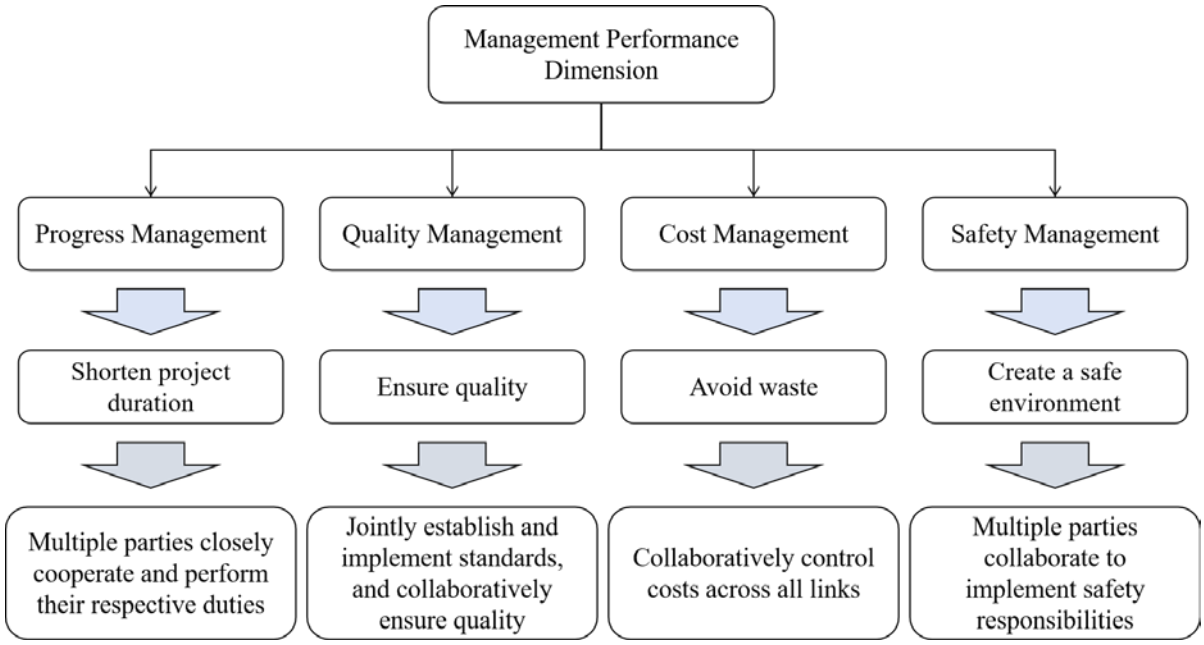

Figure 1 Influence of multi-party cooperation mechanism on management performance of municipal engineering projects

Through the multi-agent cooperation mechanism, the performance of municipal engineering projects in terms of progress, quality, cost and safety management has been comprehensively improved, providing better, more efficient and safer infrastructure projects for urban construction.

5. Multi-agent collaborative optimization strategy to improve management performance

In order to further improve the performance of municipal engineering project management, it is necessary to optimize the multi-agent cooperation mechanism. This involves many aspects, from information sharing to cooperation strengthening, from benefit distribution to collaborative decision-making, each link is crucial. Build a unified information management platform, so that government departments, construction units, construction enterprises, supervision units, design units and suppliers can upload and obtain project-related information in real time. Such as

construction progress, quality inspection data, design change notice, material supply, etc. By breaking the information barrier, all subjects can adjust their work arrangements in time to avoid mistakes and delays caused by poor information. It is also indispensable to enhance cooperation among multiple subjects. Departments can regularly organize project coordination meetings with the participation of all parties to strengthen face-to-face communication and enhance mutual understanding and trust. In the early stage of the project, carry out joint training and exchange activities to familiarize each subject with each other's work processes and requirements, and lay the foundation for subsequent cooperation.

Reasonable benefit distribution mechanism is an important guarantee for coordination. According to the investment, risk bearing and contribution degree of each subject in the project, a fair and reasonable benefit distribution plan is formulated. Give appropriate rewards to the subjects who have made outstanding achievements in project progress, quality and cost control, and stimulate their enthusiasm. When making major project decisions, invite all relevant subjects to participate together and fully listen to the opinions and suggestions of all parties. Comprehensively consider the professional perspectives and interests of different subjects, and formulate scientific and reasonable decision-making plans. See Figure 2 for the multi-agent collaborative optimization strategy to improve management performance:

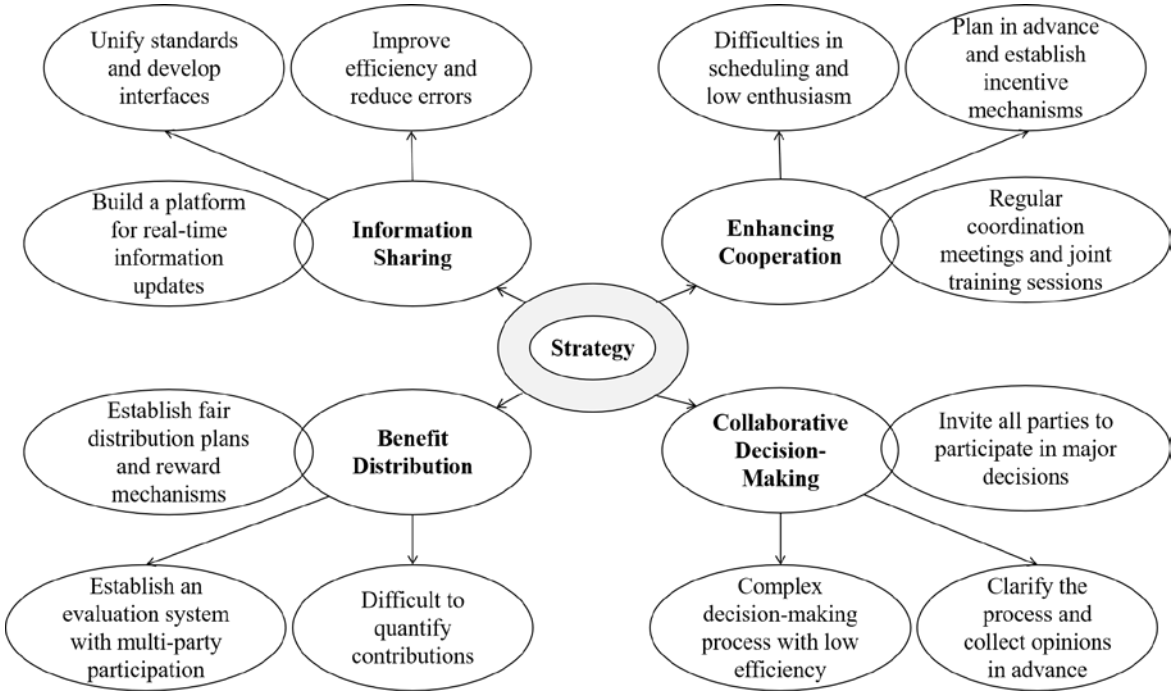

Figure 2 Multi-agent collaborative optimization strategy to improve management performance

Through the above multi-agent collaborative optimization strategy, the management performance of municipal engineering projects can be further improved. On the basis of strengthening information sharing, all subjects should enhance cooperation, take reasonable interest distribution as a link, and solve key problems in the project through collaborative decision-making, so as to ensure the efficient and high-quality completion of municipal engineering projects and better meet urban development and public needs.

6. Conclusions

This article focuses on the influence of multi-agent cooperation mechanism on the management performance of municipal engineering projects, and the research results are of great significance. It enriches the theoretical system of municipal engineering project management in theory, provides a new perspective for the research in this field, and further clarifies the relationship and synergistic mechanism of multiple subjects in project management. From a practical point of view, by analyzing the role of multi-agents in municipal engineering projects, the operation principle of

collaborative mechanism and its influence on management performance are revealed, which provides theoretical guidance for actual project operation. This article clarifies the positive role of multi-agent cooperation mechanism in project progress, quality, cost and safety management, such as the close cooperation of all agents can shorten the construction period and jointly guarantee the project quality. The collaborative optimization strategies such as strengthening information sharing and enhancing cooperation put forward in the study have strong pertinence and maneuverability, which are helpful to solve the problems of interest conflicts and information barriers faced by multi-subject collaboration in practical projects.

In the future, municipal engineering project management should further strengthen the application and improvement of multi-agent coordination mechanism. With the development of science and technology, digital and intelligent means can be used to improve the efficiency of information sharing and the scientificity of collaborative decision-making. We should continue to pay attention to the dynamic changes of each subject in the collaborative process and adjust the optimization strategy in time to better adapt to the increasingly complex development needs of municipal engineering projects and promote the high-quality development of urban construction.

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