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RESEARCH ARTICLE

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Organizational evolution of project management teams over the whole lifecycle of megaprojects: Case study of the Hong Kong–Zhuhai–Macao Bridge

Abstract Project management teams are critical in the implementation of megaprojects, but their evolution throughout the project lifecycle has not been clearly explained. This paper explores the organizational evolution of megaproject management teams through a longitudinal retrospective case study of the Hong Kong–Zhuhai–Macao Bridge (HZMB) project. The organizational evolution is examined in terms of management objectives, management content, and organizational structure. The organizational evolution of the HZMB project management team exhibits stage differentiation with the coexistence of turbulence and stability. Changes in the external environment are the driving force for organizational evolution, whereas a flexible organizational strategy is critical in promoting this evolution. Basing on the HZMB case study, this paper summarizes six critical measures that facilitate the organizational evolution of megaproject management teams. Our findings add value to megaproject management theory and provide a better understanding of the dynamics and complexity of megaproject organizational management.

Keywords megaproject, organizational evolution, whole lifecycle management, project management team

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1 Introduction

Megaprojects are large and complex projects that provide basic public services for social production, economic development, and people's livelihoods, such as large hydropower projects, high-speed railways, expressway networks, natural gas pipelines, and long-span bridges (Flyvbjerg, 2011; Kardes et al., 2013; Zeng et al., 2015). They are often characterized by huge investment scales, long implementation cycles, highly complex technology, numerous participants, and far-reaching social influence (Chapman, 2016; Kian Manesh Rad et al., 2017; Zhou and Mi, 2017). With an annual investment of $6–$9 trillion (equivalent to 8% of global GDP) on megaprojects (Flyvbjerg, 2014), large-scale infrastructure projects around the world have an upsurge (Denicol et al., 2020; Wang et al., 2020). As megaprojects are vital in social and economic development, promoting their success is becoming a common concern of governments, enterprises, the public, and other stakeholders (Davis, 2016; He et al., 2021).

The public nature and long-term effect of megaprojects (He et al., 2021) make their success transcend the time and space boundaries of traditional engineering projects. That is, the success of megaprojects goes beyond the successful implementation of the construction and encompasses the maximization of the social and economic benefits in the operation stage (Zhai et al., 2009; Laursen, 2018; Lehtinen et al., 2019). Undertaking megaprojects with traditional project management concepts often leads to difficulties such as lack of connection between different stages and problems with the overall planning and coordination of long-term project benefits due to the isolation of project management at each stage (Morris, 2011), which makes the comprehensive benefits of the project difficult to optimize. Whole lifecycle management is therefore urgently required for megaprojects because it can realize the overall

benefit increment of the project by coordinating the target planning and resource allocation of multiple stages of project planning, construction, and operation.

Megaprojects often adopt the agent construction system to implement their project management work, that is, the owner of megaprojects (usually the government) often entrusts a dedicated project management team to undertake organization coordination, task subcontracting, resource allocation, process control, safety supervision, and other project management work (Wu et al., 2014). Given the complexity and particularity of megaprojects, the specific form of the project management teams can be flexible and diverse. For example, a special project management company or a joint organization composed of multiple parties may be entrusted by the government or a project management team may be established by the government itself (Gatti et al., 2014). Although these project management teams differ in organizational composition, they are all fully responsible and highly involved in the implementation of megaprojects. The project management team is therefore better suited than any other participants to undertake the full lifecycle management of megaprojects. In some instances of megaprojects, such as the Three Gorges Dam and the Hong Kong–Zhuhai–Macao Bridge (HZMB), the project management team has extended its scope of work to the planning, operation, and maintenance stages of the project and promoted the success of the megaprojects by participating in their whole lifecycle management.

The long implementation cycle and multiple stages of megaprojects require the project management team to carry out organizational evolution during the whole lifecycle management. The project management team has to dynamically adjust its management objectives, organizational structure, and power allocation to match the dynamic management requirements of the megaproject (Daniel and Daniel, 2019). Analyzing the organizational evolution of the project management team in the lifecycle management of megaprojects is essential in furthering the understanding of how project management teams should evolve to improve the lifecycle management of megaprojects. However, research in this area remains lacking. Critical issues about the organizational evolution characteristics, driving factors, and management mechanism of the project management team of megaprojects must be addressed.

To fill this gap, this paper examines the newly completed HZMB project in China in terms of organizational evolutions of the project management team. We seek to reveal the organizational evolution and characteristics of the project management team through a retrospective study of this typical megaproject case. We also intend to interpret the organizational evolution mechanism of the project management team of megaprojects from two aspects: The driving role of the external environment of the project and the management strategy of organizational flexibility. Additionally, we try to extract practical knowledge of megaproject organizational management by summarizing key measures that promote the evolution of the project management team.

The remainder of this paper is organized as follows. Section 2 synopsizes the relevant research status, and Section 3 describes the research methods used in this paper. Section 4 traces the organizational evolution of the HZMB project management team. In Section 5, we analyze the organizational evolution characteristics and mechanism of the HZMB project management team. Section 6 summarizes the critical measures for promoting organizational evolution from the case study, and Section 7 presents the conclusions from this research.

2 Literature review

Organizational complexity is considered a key factor in the complexity of megaprojects (Bosch-Rekveldt et al., 2011; Lu et al., 2015b). Consequently, many scholars studied the organizational management of megaprojects, including the organizational design, operation, and behavior. Organizational design studies focus on how to design an effective organizational form for megaprojects. For example, Sun and Zhang (2011) studied the determinants and design methods of owner-oriented megaproject organization, Gil and Pinto (2018) studied the polycentric organization form of megaprojects in the project planning phase, and Eren (2019) analyzed the organizational design and management principles of megaprojects under complex socio-political environments. Organizational operation research mainly studies the influence factors and control methods of the organizational operation of megaprojects. For instance, Hu et al. (2015) identified key factors affecting the organizational operation of megaprojects, and developed a performance evaluation method for the organizational operation of megaprojects. Qiu et al. (2019) later explored suitable governance methods for the organizational operation of megaprojects. Organizational behavior research seeks to analyze and predict human behavior within an organization (Robbins and Judge, 2017). For example, Lin et al. (2018) examined how the personal traits of top managers can affect megaproject social responsibility. Yang et al. (2018) identified five critical organizational citizenship behaviors in megaprojects.

A megaproject management team is considered a temporary organization, but it differs from other temporary organizations in that it usually lasts longer than the so-called stable and permanent organizations (Brookes et al., 2017). Many scholars investigated the uniqueness of megaproject management teams, but most of them focused on the multi-agent coordination of the project management team. For example, Jia et al. (2011) developed

an organizational maturity measurement model to improve the efficiency and capability of the temporary large project management team composed of the owner, general design contractor, and general construction contractor. Pauget and Wald (2013) explored the roles of different participants in the relational network of megaproject management teams by analyzing their relational competence. Lu et al. (2015a) used social network analysis to study the evolution of network relations among various participants in megaprojects, and they proposed several corresponding governance strategies. Zheng et al. (2018) identified the key factors in cultivating relationship behaviors and improving the relationship quality among participants in megaproject management teams.

Regarding whole lifecycle management of megaprojects, Priemus (2010) pointed out that the complexity and far-reaching influence of megaprojects make the span of their whole lifecycle broader than that of traditional projects. That is, the whole lifecycle of megaprojects should cover multiple stages of project planning and approval, design and construction, and operation and maintenance. Subsequently, a number of studies try to explore the governance strategy of megaprojects from the perspective of lifecycle management. For example, Zeng et al. (2015) sorted out the social responsibility of each stage of the whole lifecycle of megaprojects. Ma et al. (2017) explored the lifecycle governance methods of megaproject social responsibility to realize the sustainable development of megaprojects. Li et al. (2018) summarized the dynamic governance strategy of the whole lifecycle of megaprojects by studying the lifecycle evolutionary governance of the 2010 World Expo project.

With the deepening of the understanding of the complexity and dynamics of megaprojects, some studies have emerged in recent years to explore the evolution and adaptability of organizations in megaprojects. For example, Lu et al. (2015a) explored the evolution of organizational network of megaprojects and offered effective strategies for governing megaproject organizations. Daniel and Daniel (2019) applied the theory of complex adaptive systems to examine and simulate the dynamic evolution of megaproject management. Xue et al. (2022) evaluated the dynamic relationship performance between stakeholders in the development of megaprojects. Although these studies recognize the importance of organizational evolution research of megaprojects, they do not fully answered classic research questions in organizational evolution research, such as the competitive relationship between organization and external environment, the key driving forces of organizational evolution, and the implementation strategies of organizational evolution (Abatecola, 2014).

Overall, research on the organizational management of megaprojects is flourishing, but most studies are from the static or stage-based perspective. Few studies adopt longitudinal dynamic research methods to examine the organizational evolution issues that generally exist throughout the lifecycle management of megaprojects. For the project management team, which plays a key role as organizer, supervisor, and controller during the implementation of megaprojects, existing studies focus mostly on its multi-agent coordination issues during the construction stage. Research on the dynamic evolution and mechanisms of the project management team in the whole lifecycle management of megaprojects is lacking.

3 Research methodology

We adopt a longitudinal case analysis methodology (Stake, 1995; Yin, 2013) to examine the organizational evolution and rules of a megaproject management team. The case study method is very suitable because the uniqueness of megaproject makes it difficult to abstract and separate the organizational evolution of its project management team from its context (Flyvbjerg, 2006). Specifically, a retrospective study of the evolution of the project management team involved in the newly completed HZMB project in China is conducted. The evolution mechanism of the HZMB project management team is revealed by investigating its organizational evolution. The data used in this study are mainly derived from literature analysis, semi-structured interviews, and non-participatory observation, as shown in Table 1. The specific research process is as follows.

We first used content analysis to analyze the management document compilation, including important meetings, decisions, and regulations, to restore the organizational evolution of the HZMB project management team from three aspects of management objectives, organizational structure, and management content. On this basis, we formed a preliminary outline of expert interview around the core issues of organizational evolution, such as when the team will adjust, why the team will adjust, and how to achieve organizational adjustment. We then selected 15 senior members of the HZMB project management team for semi-structured interviews through the snowball sampling method, as shown in Table 2. The content of

Table 1 Summary of data sources

Source	Numbers
Literature (document) analysis	
Decision-making stage document	4 volumes
Implementation stage (design and construction) document	10 volumes
Operation stage document	2 volumes
Related books	5 books
Semi-structured interviews	15 people
Non-participatory observation (field study)	95 days

Table 2 Detailed information of interviewees

No.	Positions	Work experience in HZMB
1	Department Director	13 years
2	Chief Engineer	13 years
3	Department Director	11 years
4	Department Director	11 years
5	Department Assistant Director	9 years
6	Safety Supervisor	9 years
7	Structural Engineer	8 years
8	Procurement Supervisor	8 years
9	Civil Engineer	6 years
10	Commercial Supervisor	5 years
11	Operation Supervisor	5 years
12	Maintenance Supervisor	5 years
13	Cost Engineer	5 years
14	Legal Affair Supervisor	5 years
15	Sustainability Supervisor	5 years

the interview included the reasons that triggered the organizational evolution of the HZMB project management team and the management mechanisms and methods that ensured the smooth realization of the organizational evolution. The time of each interview was controlled within 1 to 1.5 hours, and the interview questions were constantly optimized with the increase of the number of interviewees. After the interview, we compiled the interview content into written data. We used the manual multilevel coding and comparison method in grounded theory (Strauss and Corbin, 1997) to analyze the interview data. Subsequently, we summarized the mechanism of the organizational evolution of the HZMB project management team and the key measures to achieve its efficient organizational evolution. In addition, we conducted a 95-day non-participatory observation to examine the organizational evolution of the HZMB project management team and verify our conclusions.

4 Organizational evolution of the HZMB project management team

4.1 Project overview

The HZMB project is a 55-kilometer bridge-tunnel system consisting of a series of three cable-stayed bridges, an immersed tunnel, and four artificial islands. As the longest sea-crossing and open-sea fixed link in the world, and with a total investment of $19 billion, the HZMB project took 15 years to prepare and build and has a design life of 120 years. The HZMB spans the Lingding and Jiuzhou channels and is a mega-scale transport infrastructure that connects Hong Kong, Zhuhai, and Macao, the three major places in the Guangdong–Hong Kong–Macao Greater Bay Area. The project is designed to promote the economic, cultural, and social integration and development of the region.

The preparation, construction, operation, and maintenance of the HZMB has a high degree of complexity and uncertainty due to the huge volume of construction work, highly complex construction environment, and stringent construction and maintenance standards, making the project management task extremely difficult. To meet this challenge, the Chinese government set up a professional project management team, namely, the HZMB Office of Preliminary Work Coordination in the early stage and the HZMB Authority in the later stage. The team participated in the planning and design of the HZMB and was fully responsible for the construction and operation of the project. Through effective organizational management, the HZMB project management team undertook project management functions such as coordination, supervision, and control during project implementation, leading to the success of the project. Looking back on the implementation of the HZMB, its project management team exhibited features such as full lifecycle coverage of the project and dynamic organizational evolution. Therefore, tracing the organizational evolution of the HZMB project management team and revealing its organizational evolution rules through a case study effectively allow us to understand the management of megaprojects and promote the success of future megaprojects.

4.2 Evolution of HZMB project management team

As shown in Table 3, the whole lifecycle of HZMB consisted of three main stages. The first stage was the decision-making stage, which occurred before the project was approved. The second stage was the implementation stage, including design, construction, and operation preparatory work. The third stage was the operation stage, that is, after the bridge had officially opened to traffic, including trial and formal operations. Based on these

Table 3 Stage information of HZMB

Stage	Duration	Major work
Decision-making stage	August 5, 2003 – October 28, 2009	Project approval
Implementation stage	October 28, 2009 – October 24, 2018	Project design, construction, and operation preparation
Operation stage	October 24, 2018 – Now	Project trial operation and formal operation

three stages, this study reproduced the organizational evolution of the HZMB project management team in terms of settings of management objectives, changes in management content, and adjustments of organizational structure.

4.2.1 Management objective settings

Organizational management objectives are the basis for guiding the project management team to build an organizational structure and develop work plans. This study describes the evolution of the HZMB project management team's management objectives from two dimensions: Macro-management vision and micro-management objective system. As shown in Table 4, the HZMB project management team proposed different project strategic visions at each stage of the project, reflecting the management priorities in each stage. For example, the strategic vision in the decision-making stage emphasizes the social function and strategic position of the project, whereas that in the implementation stage focuses on the construction quality of the project, and that in the operation stage emphasizes the quality of the operation and the social and economic services of the project.

According to the strategic vision at each stage, the HZMB project management team formulated the corresponding management objective system in terms of quality, progress, efficiency, safety, and environmental protection. Table 5 presents the composition of the management objective system of the HZMB project management team at different stages. The management objective system has considerable differences at different stages in terms of objective composition and specific content. At the decision-making stage, for example, there are no safety and environmental management objectives because construction has not yet begun. Additionally, the specific management content of the same management objective may vary at different stages. For example, the quality objectives in the decision-making stage mainly concern the quality control of project evaluation activities, whereas in the implementation stage, they are mainly for the quality control of project subcontracting, procurement, and construction activities. In the operation stage, they mainly focus on quality control of the maintenance and service activities. Therefore, the management objective system of the HZMB project management team was formulated in accordance with the main work tasks in each stage of the project and was constantly adjusted as

Table 4 Strategic visions of HZMB at different stages

Stage	Strategic vision
Decision-making stage	To build an economic, cultural, and psychological bridge for Lingding channel of "one country, two systems, three places", which will make Guangdong–Hong Kong–Macao a world-class regional center
Implementation stage	To build a world-class cross-sea passageway, provide quality services for users, and become a landmark building
Operation stage	To provide customers with quality services, operate a world-class brand, and create social and economic value

Table 5 Management objectives of HZMB project team at different stages

Management objective	Decision-making stage	Implementation stage (design and construction)	Operation stage
Quality	·Feasibility study quality ·Project evaluation and decision quality ·Project planning quality ·Data management quality ·Organization coordination quality	·Exploration quality ·Design quality ·Bidding quality ·Procurement quality ·Civil construction quality ·Mechanical, Electrical and Plumbing (MEP) installation quality ·Contract management quality ·Data management quality ·Organization coordination quality ·Operation planning quality ·Operation bidding quality ·Operation emergency planning quality	·Operation planning quality ·Bidding quality ·Civil maintenance quality ·MEP maintenance quality ·Service quality ·Emergency planning quality ·Research quality ·Contract management quality ·Data management quality ·Organization coordination quality
Schedule	·Feasibility study schedule ·Evaluation and decision schedule	·Design schedule ·Construction schedule ·Construction–operation transition schedule	·Construction–operation transition schedule
Cost	·Feasibility study cost ·Financing cost ·Management cost	·Procurement cost ·Construction cost ·Management cost ·Ecological compensation cost	·Operation cost ·Operation income ·Social benefit ·Ecological compensation cost
Safety	N/A	·Construction safety ·Aircraft route safety ·Ship channel safety	·Operation safety ·Aircraft route safety ·Ship channel safety ·Structure safety ·Political (Legal) security
Environmental protection	N/A	·Construction physical pollution control ·Construction noise control ·Marine life protection	·Operation waste management ·Marine life protection

the project advanced. The expert interviews indicate that the importance of different management objectives also changed dynamically. For example, schedule management objectives are crucial in the decision-making and implementation stages but are less important in the operation stage due to the reduction of schedule control work. The safety management objective becomes the first priority in the operation stage with the completion and operation of the HZMB.

4.2.2 Changes of management content

Management content is the specific work undertaken by the project management team in managing megaprojects. The summary of the specific work undertaken by the HZMB project management team at different stages of the project (as shown in Table 6) reveals that the evolution of the management content has the dual characteristics of coherence and differentiation. The management content undertaken by the project management team at different stages of the HZMB has a certain degree of coherence because it has a high degree of relevance, especially in the decision-making and implementation stages. Many major issues managed in the decision-making stage, such as the determination of bridge location and landing place, project investment and financing, port mode, and the Chinese White Dolphin protection plan, directly affected the formulation of a project design and construction plan in the implementation stage. Similarly, the operation preparation and connection work undertaken at the end of the implementation stage had a significant effect on the opening of the bridge in the operation stage. Moreover, the management content undertaken by the project management team significantly varies at different stages of the project. In the decision-making stage, the project management team was mainly responsible for organizing the feasibility study of critical technical issues and participating in the formulation of major decision-making issues. In the implementation stage, the project management team was responsible for organizing, coordinating, supervising, and managing various participants involved in the design and construction of the project. In the operation phase, the project management team was the main body of operation and took charge of the overall project operation. The differences in management content reflect the evolution of the role and function of the project management team at different stages of the project.

4.2.3 Adjustments of organizational structure

Organizational structure involves the division of labor and the grouping and coordination of management tasks, which reflect the scope of duties, responsibilities, and rights of organization members in management activities (Andrews, 2010). By tracking the evolution of the organizational structure of the HZMB project management team, we found great differences in the structure and stability of the organizational structure at different stages of the project lifecycle, as shown in Fig. 1. The difference is first reflected in the number of functional departments. In the decision-making stage, the project management team consists of only two functional departments, whereas in the implementation and operation stages, the project management team has as many as seven and eight functional departments, respectively. This reflects the complexity and diversity of the tasks faced by project management team at different stages. The difference is also reflected in the composition of functional departments. In the implementation stage, the project management team set up functional departments that were closely related to the project construction work, including the Engineering Management Department, Traffic Engineering Department, Safety Department, and Environmental Protection Department. In the operation stage, however, functional departments closely related to the operation of the project were set up, including the Maintenance Department, Safety and Emergency Department, and Operation Development Department. This reflects the different natures of the work undertaken by the project management team at different stages of the project.

In addition, through the analysis of the dynamic adjustment of the organizational structure of the HZMB project management team, we found that the stability of the organizational structure varies greatly at different stages. The organizational structure is stable in the decision-making and operation stages but is unstable in the implementation stage, with frequent department adjustments. For example, in July 2011, the Steel Structure Engineering Management Office was disbursed from the Engineering Management Department to cope with the huge demand of steel beam engineering work. Then, the office was reincorporated into the Engineering Management Department in February 2014 following the completion of this work. Similarly, the Bridge Deck Pavement Management Office was established in September 2013 and then incorporated into the Engineering Management Department in January

Table 6 Management content of HZMB project management team at different stages

Stage	Management content
Decision-making stage	Technical feasibility study and coordination among the three governments on key issues
Implementation stage	Management of the project construction and the preparation and connection before the project is put into operation
Operation stage	Finishing off project construction activities and project operation and development

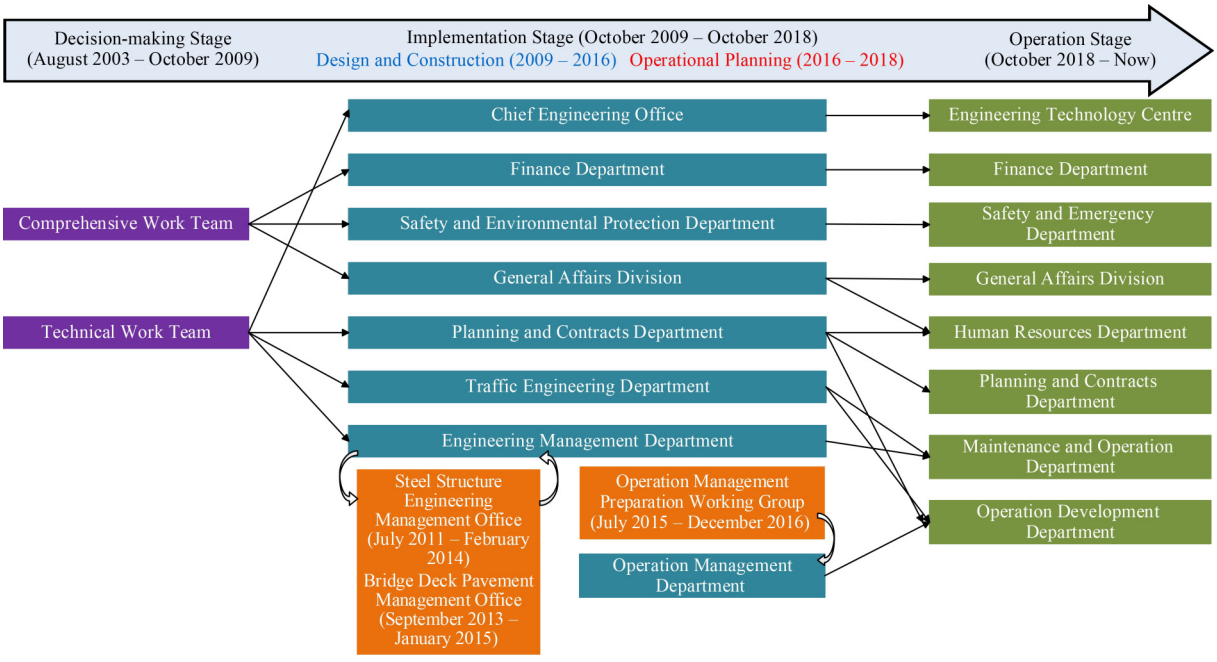

Fig. 1 Organizational structure of the HZMB project management team at different project stages.

2015. The Operation Management Preparation Working Group was established in July 2015 and officially transformed into the formal Operation Management Department in December 2016. The difference in organizational structure stability reflects the distinction between the management strategy and engineering environment of the HZMB project management team at different stages of the project. In the project planning and operation stages, due to the relatively fixed work content, the management strategy of the HZMB project management team emphasizes the accuracy of work decomposition and stability of organizational design. In the project implementation stage, due to the complexity and variability of the work content, the management strategy of the HZMB project management team emphasizes the timely perception of environmental changes and dynamic adjustment of organizational arrangements.

5 Evolution characteristics and mechanism of the HZMB project management team

This section interprets the organizational evolution of the HZMB project management team from two aspects: External organizational evolution characteristics and internal organizational evolution mechanism.

5.1 Organizational evolution characteristics

5.1.1 Stage differentiation

Analysis of the organizational evolution shows that the organizational evolution of the HZMB project management team presents the characteristics of stage differentiation. In other words, the evolution of the organizational structure at each stage is different and has its own characteristics (as shown in Fig. 2). The characteristics of organizational evolution in the decision-making stage can be summarized as the creation and stability of the organization. The decision-making stage mainly covers the creation of the project management team, including the selection of the core team members and construction of the organizational structure to deal with the management tasks of this stage. Owing to the fixed tasks at the decision-making stage, the organization remained stable without major adjustments to personnel and organizational structure.

The characteristics of organizational evolution in the

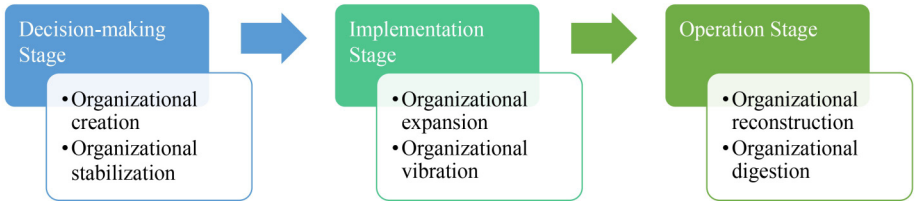

Fig. 2 Organizational evolution characteristics of the HZMB project management team at different stages.

implementation stage can be summarized as organizational expansion and vibration. Early in the implementation stage, according to the task decomposition of design and construction work, the project management team rapidly expanded the original two functional departments into seven functional departments, which undertook the work of contracting, civil engineering, traffic engineering, financing, safety and environmental protection, and so on. In the middle and late periods of the implementation stage, the organizational structure of the project management team "vibrated" with the arrival of steel structure engineering, bridge deck pavement, operation preparation work, and other professional engineering work. The project management team dynamically adjusted its organizational structure to match the task requirements of the project.

The characteristics of organizational evolution in the operation stage can be summarized as restructuring and digestion of the organization. After entering the project operation stage, the project management team made major adjustments to the existing organizational structure according to the work content of this stage. The original functional departments related to design and construction work were disbanded or integrated, and functional departments related to operation work were set up, such as the Maintenance and Operation Department, Safety and Emergency Department, and Operation Development Department. To complete some of the work left over from the implementation stage, such as project completion acceptance, contract payment, and project audit, subdepartments such as the Project Settlement Office and the Project Audit Office were retained. With the end of the associated work, their corresponding departments or functions were gradually adjusted or eliminated from the project management team.

5.1.2 Coexistence of turbulence and stability

Although the HZMB project management team experienced several major organizational adjustments in the whole lifecycle of the project, its organizational evolution was not completely turbulent but instead combined turbulence and stability. In other words, the HZMB project management team exhibited both dynamic adjustment and static stability in its organizational evolution. Figure 3 shows the turbulent and stable factors in the organizational evolution of the HZMB project management team.

The organizational turbulence of the HZMB project management team included work content, professional personnel, organizational structure, power allocation, and cooperation network. As mentioned, the work content undertaken by the project management team was constantly changing as the project progressed. In terms of professional personnel, the project management team enhanced the organization's adaptability to professional work by dynamically supplementing professionals.

Fig. 3 Unification of turbulence and stability in the organizational evolution of the HZMB project management team.

During the transition from decision-making stage to implementation stage, engineering and technical experts were recruited to form a core technical team. During the transition from the implementation stage to the operation stage, professional operation management personnel and engineering maintenance personnel were absorbed to meet the coming operation and maintenance needs of the HZMB project. For short-term professional work, such as steel beam engineering and road pavement construction, some professionals were even hired temporarily. In terms of organizational structure, the functional department composition of the project management team was dynamically adjusted according to the needs of the project. In terms of power allocation, the project management team adjusted its power allocation by establishing temporary cross-department organizations to solve the mismatch between the original power allocation and the new work content. In terms of cooperation network, the external cooperation network of the project management team was dynamically adjusted in the matters of member composition and cooperation relations according to the needs of the project. The project management team adjusted the partners according to the needs of the project and established formal and informal cooperative relationships with different types of partners, such as contractors, suppliers, and government agencies.

Organizational stability is reflected in strategic objectives, core members, principal–agent relationship, and organizational adjustment mechanism. As mentioned, the HZMB project management team put forward strategic visions at different stages of the project. These strategic objectives remained stable in their respective stages, with a certain degree of continuity among them. In terms of core members, the HZMB project management team maintained the stability of the core members, including leadership, technical, and department directors, for 15 years from project decision-making to project trial operation. In terms of the principal–agent relationship, the project management team and the government maintained a stable principal–agent relationship with clear powers and responsibilities, smooth communication, full trust,

and consistent interests. In terms of organizational adjustment mechanism, the project management team developed a stable and effective organizational adjustment mechanism, which defined the process and administration regulations of organizational adjustment.

In general, this coexistence of turbulence and stability ran through the entire organizational evolution of the HZMB project management team. Organizational turbulence was a key factor in the project management team effectively dealing with the complex uncertainties of the HZMB project, whereas organizational stability ensured the orderly operation and stable development of the project management team.

5.2 Organizational evolution mechanism

By tracing the evolution of the HZMB project management team, we found that the mechanism of its evolution can be explained by contingency theory. That is, the essence of the HZMB project management team evolution is the dynamic interaction between organizational design and organizational environment (especially the external environment), as shown in Fig. 4. The evolution mechanism can be explained as follows. After the existing organizational design was stimulated by the dynamic external organizational environment, adjusts were made to the organizational design through flexible organizational management strategy and finally a new one was formed that can match the dynamic external organizational environment. This cyclic interaction and re-matching relationship between organizational design and organizational environment appears iteratively in the whole lifecycle of megaprojects with changes in the external organizational environment. The rest of this section attempts to explain

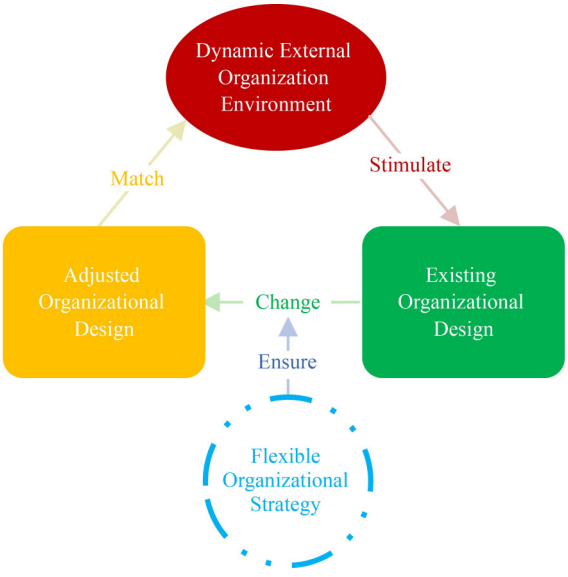

Fig. 4 Organizational evolution mechanism of the HZMB project management team.

the decisive role played by the external environment and the supportive role played by flexible organizational management strategy in the organizational evolution of the HZMB project management team.

5.2.1 Environmental changes driving organizational evolution

As an open system (Ruuska et al., 2011), a project management team evolves due to the internal and external needs of the system (Alexander and Price, 2012). The internal needs include the self-realization needs of organizational members and the self-improvement needs of the organization, whereas the external needs mainly refer to changes in the external environment of the organization, including market demand, competitor pressure, and government policies (Kozlowski and Ilgen, 2006; Abatecola, 2014). Through the expert interview, we found that changes in the external environment were the key driving force for the organizational evolution of the HZMB project management team because some interviewees claimed the following:

"We do not actively seek organizational change because the organizational change itself is risky and uncertain, which may lead to management failure and responsibility vacuum. We prefer the HZMB project management team to be relatively stable." (Interviewee 1, department director)

"Only when we realize that the existing organizational structure and power allocation cannot adapt to the new work requirements will we start organizational adjustment." (Interviewee 3, department director)

The organizational structure change of the HZMB project management team also reflects the causal relationship between environmental changes and organizational evolution. For example, to meet the needs of tasks at different stages, the project management team carried out a major organizational structure adjustment when entering a new stage. Several temporary and specialized management departments were set up to cope with new project tasks during construction. These examples reflect that the organizational evolution of the HZMB project management team is mainly driven by the change of external work tasks rather than the external competition emphasized in the traditional evolution research (Hodgson, 2013). The "passive" organizational evolution reflects the essence and key characteristics of megaproject management. That is, megaproject management is a process in which project management team members continuously adapt to and match the dynamic, changeable, and complex engineering environment by coordinating their cognitions, motivations/emotions, and behaviors. Owing to the one-off and complex large-scale systematic characteristics of megaprojects, their management presents significant risk-aversion characteristics.

5.2.2 Flexible organizational strategy ensuring organizational evolution

The HZMB project management team adopted a flexible organizational management strategy, which can be summarized as promoting and ensuring the flexible adjustment of organizational composition and power allocation through the establishment of flexible management system so as to realize the dynamic matching between organizational design and project situation. Specifically, the HZMB project management team used a number of flexible organizational management measures, including periodically combing and decomposing the work content, regularly holding cross departmental work meetings, and establishing the management system for flexible organization. The feedback from the interviewees proves that these measures effectively ensured that the HZMB project management team could realize organizational evolution.

"The implementation process of HZMB is a dynamic process. We ensure that our project management can always match the needs of the project by regularly analyzing the work content we need to complete." (Interviewee 5, department assistant director)

"We continuously optimize our organizational structure and power allocation through regular cross departmental coordination meetings, so that our team can dynamically match the changing project needs." (Interviewee 2, chief engineer)

"We have built a series of flexible organization management regulations including cross organization cooperation rules, temporary department rules, and department adjustment rules to ensure that our organization adjustment can be carried out in a standardized and stable manner." (Interviewee 6, safety supervisor)

The flexible organization strategy adopted by the HZMB project management team makes their organization flexible in organizational structure, power allocation, human resources, and inter-organizational relationships, as shown in Fig. 5. In terms of organizational structure, the project management team maintained the dynamic adaptability of the department settings to the project management goals and task requirements. The project management team established temporary departments, either separated from a single department or formed across departments, to solve any failures of the original organizational structure with respect to newly emerging tasks. The existence of these temporary departments was then modified according to the project requirements. Once the project requirements were met, the department was dissolved (e.g., Steel Structure Engineering Management Office), and when the project requirements were ongoing, the department was transformed into a formal department (e.g., Operation Management Preparation Working Group). In terms of power allocation, the project management team emphasized horizontal departmental

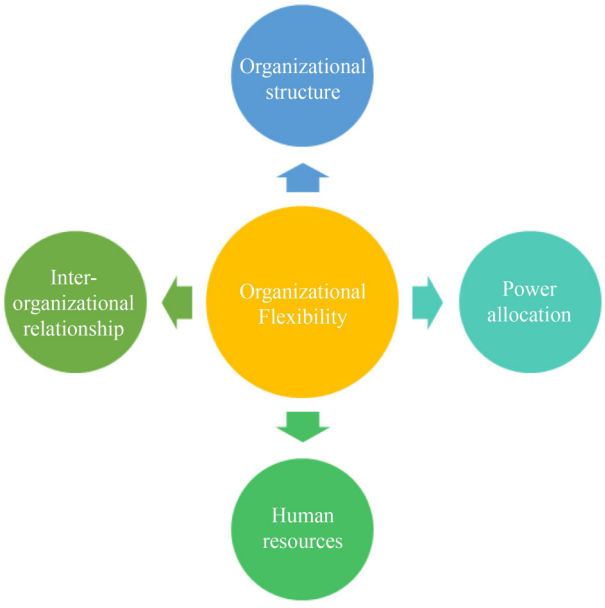

Fig. 5 Organizational flexibility of the HZMB project management team.

communication and power coordination. The project management team realized efficient communication and power coordination among departments by relying on temporary cross-department working groups. In terms of human resources, the project management team pursued the adaptability and mobility of team members in terms of knowledge composition and personnel composition. Through the study of typical projects, the introduction of an advisory team, and regular training, the level of recognition and adaptability to the project of existing personnel was continuously improved. Similarly, through a mobile employment strategy, the problem of redundancy or insufficiency of the original personnel was solved. In terms of inter-organizational relationships, the project management team adopted flexible and diverse inter-organizational cooperative relationships, including formal relationships, informal relationships, and partnerships, to improve the adaptability and collaboration ability of the project management team's organizational network. This practice proves that a flexible organizational management strategy, which emphasizes the dynamic adaptability of the organization, ensures effective organizational evolution by enhancing the rapid response and flexible adjustment abilities.

6 Measures to promote organizational evolution

This section discusses six key measures for promoting the efficient organizational evolution of the project management team in the whole lifecycle of megaprojects based on the case study of the HZMB project.

6.1 Develop clear and accurate phased strategic management goals

In the practice of megaproject management, the strategic management goal is the long-term goal that the project management team is attempting to achieve (Shenhar and Holzmann, 2017), which reflects the team's understanding of the core goal and task of project management activities (Lewis and Clark, 2020). The interviewees' feedback indicates that the clear strategic management objectives formulated by the HZMB project management team at each stage not only defined the project management team's physical expectations (e.g., quality standards) and social benefit expectations (e.g., socioeconomic functions) of the project but also strongly guided the project management team in arranging its core business segments and building effective organization structures at different stages.

"All of our organizational designs and work arrangements are carried out according to phased strategic management goals." (Interviewee 2, chief engineer)

"Phased strategic management goals largely determine our definition of work scope and content, which is the basis of organizational arrangement." (Interviewee 4, department director)

The organizational change of the HZMB project management team also indicates that strategic management goals greatly affect organizational evolution. The organizational structure is designed to match the needs of strategic management goals, and major adjustments of organizational structure always appear as the strategic management goals are adjusted. Therefore, accurate strategic management goals are crucial to the effectiveness of the organizational evolution of the megaproject management teams. Only when the project management team can accurately recognize the core and long-term goals of its management activities can it form a matching and effective organizational form, ultimately making its organizational management activities successful.

6.2 Improve the absorptive capacity of the project management team

Absorptive capacity is the key to an organization being able to constantly adapt to changes in the external environment, and it refers to the ability to recognize and assimilate new knowledge and apply it for commercial ends (Cohen and Levinthal, 1990). The HZMB project fully reflects the complexity and uncertainty of megaprojects, with new and unpredictable situations constantly emerging during its implementation. Some respondents pointed out that in this complex and changeable environment, the efficiency and effectiveness of the organizational evolution of the project management team greatly depends on its absorptive capacity.

"The effect of our organizational adjustment largely depends on the speed and degree of our cognition of the dynamic changes of the project." (Interviewee 8, procurement supervisor)

"We continuously improve the knowledge reserve and management ability of the team through expert consultation, training, and investigation, so as to ensure that we can cope with the changes of HZMB." (Interviewee 14, legal affair supervisor)

The organizational evolution of the HZMB project management team shows that the evolution of management objectives, management content, and organizational structure is essentially the organization's learning and adaptation to the outside environment. In other words, organizational evolution is the behavior whereby an organization readjusts its organizational arrangements by acquiring, assimilating, and applying new information and knowledge on the basis of accurately identifying changes in the external environment. Therefore, improving the absorptive capacity of the organization effectively allows the project management team to recognize and deal with the complex and changeable external environment, and doing so is the key to achieving rapid and effective organizational evolution.

6.3 Maintain stable core management personnel

The core management personnel of the project management team include decision makers and middle-level managers. The former are responsible for the organization's strategic planning, management system design, and cultural construction. Middle-level managers are responsible for implementing the organization's decisions and enabling the functional departments to carry out management activities. The interview reveals that the HZMB project management team tried to maintain the stability of its core management personnel during the long process of project planning, design, construction, and trial operation, which ultimately played a positive role in the organizational evolution.

"We tried to keep our core management personnel as stable as possible. This stability enables our team to form a unified team recognition and stable organizational culture during the long implementation process of the HZMB." (Interviewee 1, department director)

"The stability of the core people makes us more tacit understanding of each other, which allows us to make efficient adjustments to changes and emergencies in the HZMB." (Interviewee 2, chief engineer)

As mentioned before, the organizational evolution of the HZMB project management team included turbulence and stability, that is, evolution was realized based on the partial adjustment and overall stability of the organization. The stability of the core management personnel is an important prerequisite for the overall stability of the project management team. Stable core management personnel is conducive to the formation of stable knowledge

accumulation, management systems, relationship networks, and organizational culture, which are crucial in the project management team forming a strong absorptive capacity and achieving a smooth transition in the organizational evolution.

6.4 Construct a flexible organizational management mechanism

A flexible organizational management mechanism refers to the structure, principles, policies, and methods of organizational management that emphasize organizational flexibility and adaptability. The HZMB project management team developed a set of scientific and standardized flexible management mechanisms to ensure the implementation of a flexible organization strategy, as mentioned by some interviewees.

"We put a lot of energy into design of the management system during the team formation period. We have developed a series of management regulations to guide the operation, adjustment, and change of the team." (Interviewee 2, chief engineer)

"Whether it is the construction of a temporary interdepartmental working group or the creation of a new department, we have a set of corresponding management regulations to guide us how to carry out efficient and orderly transfer of personnel, distribution of power, and assignment of responsibilities." (Interviewee 9, civil engineer)

As shown in Table 7, the HZMB project management team set up temporary departments or working groups through flexible organization management mechanisms such as holding cross-department consultation meetings and promulgating temporary management methods. Effective flexible organization management mechanisms enabled the HZMB project management team to quickly integrate its resources and adjust its organizational arrangement according to changes in the external environment. In addition, this flexible organizational management mechanism promoted learning initiatives among the HZMB project management team members and enhanced their sensitivity to changes in the external environment.

Table 7 Temporary organizations of the HZMB project management team

Organization type	Organization name	Holding department	Main work	Management system
Inter-departmental collaborative organizations	Quality Management Committee	Engineering Management Department, Traffic Engineering Department, Chief Engineering Office	Quality management	Quality Management Outline for the Main Construction Project of the HZMB
	Health, Safety and Environment (HSE) Management Committee	Safety and Environmental Protection Department	HSE management system development	HSE Management Outline and Control Measures for the Main Construction Project of the HZMB
	Informatization Leading Group	Traffic Engineering Department	Integrated management information system development	Information System Management Outline for the Main Construction Project of the HZMB; Measures for the Implementation, Operation, and Maintenance of the Integrated Management Information System for the Main Construction Project of the HZMB
	Credit Evaluation Leading Group	Planning and Contracts Department	Credit evaluation of contractors	Contractors' Credit Evaluation Management Measures for the Main Construction Project of the HZMB
	Tendering and Bidding Work Leading Group	Planning and Contracts Department	Bidding management	Tendering and Bidding Management Measures for the Main Construction Project of the HZMB
	Completion Acceptance Committee	Engineering Management Department	Completion acceptance	Quality Acceptance Management Measures for the Main Construction Project of the HZMB
	Operation Management Preparation Working Group	Operation Management Department	Operation preparation management	Operation Management Outline for the Main Construction Project of the HZMB
Temporary dedicated organizations	Chinese White Dolphin Conservation Special Working Group	Safety and Environmental Protection Department	Chinese White Dolphin conservation	Chinese White Dolphin Protection Measures for the Main Construction Project of the HZMB
	Cross-boundary Traffic Policy Working Group	Finance Department	Traffic policy research	Working Outline and Management Measures for Cross-border Traffic Policy Research of the HZMB
	Steel Structure Procurement and Manufacturing Bidding Working Group	Planning and Contracts Department	Steel structure procurement	Steel Structure Procurement and Manufacturing Management Measures for the Main Construction Project of the HZMB
	Bridge Trial Pile Engineering Working Group	Chief Engineering Office	Trial pile engineering	Bridge Trial Pile Engineering Management System for the Main Construction Project of the HZMB
	Steel Structure Engineering Management Office	Steel Structure Engineering Management Office	Steel structure engineering	Steel Structure Procurement and Manufacturing Management System for the Main Construction Project of the HZMB
	Bridge Deck Pavement Management Office	Bridge Deck Pavement Management Office	Bridge road pavement	Bridge Deck Pavement Management System for the Main Construction Project of the HZMB
	Archives Management Working Group	General Affairs Division	Archives management	Archives Management Measures for the Main Construction Project of the HZMB

Both are important factors in enabling an organization to realize effective evolution. In general, the case of the HZMB project indicates that the construction of flexible organization management mechanisms is an institutional guarantee of organizational flexibility and improved adaptability to the external environment for megaproject management teams.

6.5 Maintain a stable and effective principal–agent relationship

The HZMB project management team established a stable principal–agent relationship with the government throughout the whole lifecycle of the project, including a stable legal and contractual relationship, clear power boundaries, smooth communication, and full trust between the two parties. This stable principal–agent management is considered by some respondents an important basis for obtaining external resource support in the organizational evolution.

"We have maintained a stable relationship and smooth communication with government authorities. We regularly communicate with them about the implementation progress, existing problems and work plans of HZMB, which makes our work match the government's goals and allows us to obtain full trust and necessary support." (Interviewee 1, department director)

"Our major deployments and adjustments are carried out on the basis of full communication with the government, because these changes often require the government to provide certain help and support." (Interviewee 3, department director)

In the implementation of the HZMB, such a stable principal–agent relationship enables the project management team and the government to form a good tacit understanding and consistent goals, which provide the necessary political, social, and financial resources for the project management team to carry out their activities and realize the organizational evolution. For example, the project management team established a multi-level decision-making system to coordinate the decision-making differences between the three local governments (Zhu et al., 2018). The Chinese government supported the construction of the submerged tube tunnel by controlling dredging and shipping activities in the area where the project was to be implemented. The project management team regularly communicated with the government to ensure that its management objectives and organizational arrangement adjustments were consistent with the government's requirements. In general, a stable and effective principal–agent relationship is the key external basis for the survival and evolution of megaproject management teams. It helps the project management team to obtain the necessary external support and resources and ensure that the organizational evolution is consistent with the government's goals.

6.6 Build an efficient information management system

The complex and large-scale systemic characteristics of megaprojects lead to the generation of a large amount of engineering information during their implementation, including contracts, survey documents, design drawings, construction records, inspection reports, and meeting minutes. During the implementation of the HZMB, the application of information technologies such as digital design, assembly construction, and intelligent operation and maintenance (Zhou et al., 2018; Gao et al., 2020) generated a vast amount of information in the project management. To effectively manage these information during the long process of project implementation, the HZMB project management team especially developed an integrated information management platform. This practice proves that such platforms greatly promote the efficient organizational evolution of the project management team in terms of both information retention and information transfer. As mentioned by Interviewee 5, the platform enables project information to be retained and continued in the long process of project implementation, which ensures the continuity of the organizational evolution of the project management team.

"The scale and complexity of HZMB far exceeds that of ordinary transportation projects. The information management platform we established in the early stage effectively helps us save and transfer the key information of the project, which is very important for our project management in the long project implementation cycle." (Interviewee 5, department assistant director)

Moreover, some interviewees reported that the platform enables the smooth flow of engineering information, which was of great importance for the HZMB project management team in extracting and integrating engineering information in the context of organizational structure adjustments or cross-departmental temporary working groups.

"We rely on the information management system to realize the exchange and extraction of HZMB technical information, which is an important prerequisite for us to quickly realize cross-departmental cooperation and departmental adjustment." (Interviewee 11, operation supervisor)

Today, with the continuous improvement of engineering digitization, the information management system plays an increasingly important role in the efficient and orderly evolution of megaproject management teams.

7 Conclusions

This paper has reported the results of a case study on a typical megaproject, namely, the HZMB. The aim of this research is to explore the process and rules of organizational evolution of the project management team across

the whole lifecycle of megaprojects. Based on longitudinal research ideas, we conducted literature analysis, non-participatory observations, and expert interviews to trace the organizational evolution of the HZMB project management team in terms of management objectives, work content, and organizational structure.

The organizational evolution of the HZMB project management team presents the characteristics of stage differentiation, that is, the creation and stability of the organization in the decision-making stage, the expansion and vibration of the organization in the implementation stage, and the restructuring and digestion of the organization in the operation stage. Additionally, the organizational evolution of the HZMB project management team exhibits the coexistence of turbulence and stability. During the evolution, the project management team displayed turbulence in the aspects of work content, personnel composition, organizational structure, power allocation, and cooperation network, while it remained stable in terms of strategic objectives, core members, principal–agent relationship, and flexible organizational management mechanism. This organizational evolution mode of maintaining stability at the strategic level and making adjustments at the implementation level was evident throughout the organizational evolution of the HZMB project management team.

The case of the HZMB project shows that the organizational evolution of megaproject management teams is driven by changes in the external environment. The project management team will only make adjustments when the existing organizational arrangements cannot adapt to changes in the external environment (e.g., new engineering tasks, emergencies, etc.). This "passive" organizational evolution reflects the essence and characteristics of the organizational evolution of megaproject management teams. That is, organizational evolution is a process in which the project management team continuously adapts to a complex and changeable external engineering environment, and the complexity and risk of megaprojects make the project management team relatively conservative and unwilling to seek change actively. In addition, the flexible organization strategy ensured the rapid and effective organizational evolution of the HZMB project management team. The HZMB project management team rapidly adjusted to new or changing external environments by improving the flexibility of the organizational structure, power allocation, human resources, and inter-organizational relationships. This flexible organization strategy greatly enhanced the adaptability of the HZMB project management team. Based on our analysis of the organizational evolution of the HZMB project management team, this paper has summarized six key measures for promoting the organizational evolution of megaproject management teams: 1) develop clear and accurate phased strategic management goals, 2) improve the organization's absorptive capacity, 3) maintain stable core management personnel, 4) construct a flexible organizational management mechanism, 5) maintain a stable and effective principal–agent relationship, and 6) build an efficient information management system.

The findings of this exploratory study should be applied with caution. Especially considering the uniqueness of megaprojects, the background of the project should be taken into account when applying the findings of this research. Furthermore, the retrospective study adopted in this paper potentially suffers from missing and inaccurate information. Although the study attempted to restore the organizational evolution of the project management team to the maximum extent, tracing some documents and project participants is difficult due to the long backtracking period, which is bound to cause potential flaws. Finally, this paper is a summary based on the results of organizational evolution and fails to effectively observe the process of organizational evolution. Future research can pay more attention to the organizational evolution process of project management team of megaprojects. Some key issues in organizational evolution, such as the key factors affecting the stability and adaptability of the organization, the key dilemmas that hinder the evolution, and the evaluation of the compatibility between the organization and the engineering environment, need to be answered urgently.

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