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# Deconstructing Organizational Capabilities of Megaproject Owners: Dimensions and Levels

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**Abstract:** Given that a strong owner has been identified as an important factor in the success of megaprojects, there has been a growing recognition of the importance of megaproject owner organizational capabilities. However, the questions of what organizational capabilities do owners need to foster successful megaprojects, and whether these capabilities are the stronger the better, have yet to be addressed. To answer these questions, this study identified the dimensions of owner organizational capabilities based on literature and interviews, and developed several sets of parallel hypotheses. Based on the 229 valid questionnaire data collected, the relationships between owner organizational capabilities and megaproject success were analyzed through hierarchical multiple regression, and the results were discussed through expert interviews. The findings show that owner coordination, dynamic, and system integration capabilities have positive impacts on megaproject success, with coordination capabilities being the most significant. While the impact of motivational capabilities on megaproject success is inverted U-shaped. This study provides an actionable dimensional framework for megaproject owner capabilities, moving the field of owner organizational capabilities beyond the conceptual level. This study provides empirical evidence for the importance of megaproject owner organizational capabilities and takes a more dialectical view of a strong owner. The empirical results can provide insights and guidance on the configuration and development of megaproject owner capabilities. **DOI: 10.1061/JCEMD4.COENG-13097.** 

**Author keywords:** Owner organizational capabilities; Megaproject success; System integration capabilities; Motivational capabilities; Coordination capabilities; Dynamic capabilities.



## Introduction

Many studies considered that megaproject owners essentially do two things: they are the investors in megaprojects and they are usually the operators of those megaprojects (Winch and Leiringer 2016; Winch and Cha 2020). However, the role of the owner in the project construction process seems to be ignored. Ever since Morris and Hough (1987) identified a "strong owner" as an important factor in the success of megaprojects, there has been a growing recognition of the importance of the organizational capabilities of megaproject owners. For instance, Merrow and Nandurdikar (2018) conducted a three-point measurement of life cycle benchmark data for 318 megaprojects, and they found that the key organizational practices that determine the success of megaprojects all related to the organizational capabilities of owners. In the research report of Samset et al. (2016) on megaprojects in several countries, the construction process of megaprojects in the UK, Norway, Denmark, Sweden, the Netherlands, and Canada was managed and governed by government owners. Similarly, in China, owner organizations need to manage the implementation of all key objectives, which puts forward certain requirements on owner organizational capabilities (Sheng 2018). Besides, the temporary nature of megaprojects, the uniqueness of tasks, and the diversity of participants increase the management difficulty and pressure of owner management (Li et al. 2019b).

Davies and Brady (2016) called for further research on the organizational capabilities of owners from the perspective of specific dimensions to further identify what organizational capabilities owners need to foster successful megaprojects. Some studies have responded to this call and focused on the organizational capabilities of owners in a certain dimension. For example, Davies et al. (2016) and Gulino et al. (2020) constructed the framework of dynamic capabilities of megaproject owners through semistructured interviews and case analysis of London's Heathrow Terminal 5, respectively. Hu et al. (2015) suggested in a case study that megaproject owners need coordination and motivational capabilities. There are also some studies that identified multiple dimensions of the organizational capabilities of megaproject owners. For example, Winch and Leiringer (2016) identified the capabilities (including strategic

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capabilities, commercial capabilities and governance capabilities) required by owners for the successful implementation of transportation infrastructure projects through a literature review and expert interviews.

These studies have noticed the contribution of owner organizational capabilities to megaproject performance (Winch and Leiringer 2016). The research of Winch and Leiringer (2016) is a great start, but they have not verified the impact of these owner capabilities on project performance or success through empirical studies. Similarly, perspectives on the dimensions of owner organizational capabilities are mostly conceptual and descriptive (Merrow 2011; Morris and Hough 1987; Winch 2014), rather than using a quantitative approach in a systematic manner to illustrate the multiple dimensions. Through a questionnaire survey, Wang et al. (2013) explored the impact of owner organizational capabilities on project performance of hydropower projects, revealing that several owner organizational capabilities have positive linear impacts on project performance. But in megaproject practice, are the owner organizational capabilities really the stronger the better? "Too much can be as bad as too little" (Haans et al. 2016). Many relationships in organizational management follow an inverted U-shaped pattern, where moderate levels lead to optimal performance (Haans et al. 2016). In megaproject practice, some of the owner organizational capabilities are too strong and may interfere too much with the various participants (Morris and Hough 1987), which is not conducive to megaproject success. Thus, this study holds that what organizational capabilities of the owner have what impact on the success of megaprojects have not been well addressed.

The discussion in the preceding paragraphs leads to the central research questions: What organizational capabilities do owners need to foster successful megaprojects? How do these capabilities impact the success of megaprojects? To address these research questions, this study firstly identified the dimensions of owner organizational capabilities based on the literature and interviews. Secondly, to explore which organizational capabilities are important and which capabilities are not the stronger the better, the relationships between owner organizational capabilities and megaproject success were analyzed through hierarchical multiple regression model. In this way, this study provides empirical evidence for the importance of megaproject owner organizational capabilities and provides a dimensional framework for megaproject owner capabilities, which provides a basis for further research. The empirical results on the relationships between the owner capabilities and megaproject success can also guide the practice of megaproject owner capability configuration and development.

## Theoretical Background and Research Hypotheses

### *Megaproject Success*

Megaprojects are generally defined as large-scale and complex architecture, engineering, and construction (AEC) projects with massive investment and extensive national political, social, and economic impact (Flyvbjerg 2014; Li et al. 2019b). There are two key characteristics that distinguish megaprojects from general projects. First, most megaprojects are public investment projects, and their owners are mostly governments (Samset et al. 2016; Sheng 2018). Second, in megaprojects, multiple organizations from different industries and institutional backgrounds work jointly on shared activities for years or even decades (Zhang et al. 2023). There is no clear definition of project success, but scholars generally agree that successful projects share some common characteristics, and these characteristics can be used as measurements of project success (Ika and Pinto 2022; Zwikael and Meredith 2019). Initially, project success was thought to depend on quality, schedule, and cost, which focused more on project delivery performance under temporary criteria (Chan and Chan 2004).

Different from general projects, megaprojects have a great comprehensive impact on society, politics, and the economy; therefore, in addition to delivery performance, the success of megaprojects should consider more comprehensive and long-term impacts. A typical example is the Sydney Opera House in Australia, a project that cost 14 times its original budget, yet today, it is considered an engineering masterpiece and a symbol of Sydney (Lim and Mohamed 1999). The realization of megaproject value is also increasingly recognized as a key to the success of megaprojects (Zerjav 2021). Sustainability of economic, environmental, and social dimensions (Hosseini et al. 2018) and stakeholder satisfaction (Mazur et al. 2014) have also been identified as important elements of megaproject success.

### *Owner Organizational Capabilities*

Organizational capability refers to "the capacity to perform a particular activity in a reliable and at least minimally satisfactory manner" (Helfat and Winter 2011). Such capabilities rely on stable, routinized, and collective activities of the organization members to allocate resources to produce certain outputs (Geleilate et al. 2021). In strategic management, organizational capabilities are described as key success factors, and almost every organization wants to be considered capable of doing things in an excellent way. In megaproject practice, organizational capabilities are also very important. On the one hand, megaprojects have long-term and cross-organizational characteristics; excellent organizational capabilities enhance cross-organizational collaboration and adaptability to deal with dynamic environments, thus contributing to the success of current projects (Davies and Brady 2016). On the other hand, projects are one-time unique endeavors, but at the same time, these temporary projects have joint participation by multiple permanent organizations. These permanent organizations can learn from the experience of the current project, cultivate organizational capabilities, and apply them to the next project to realize the learning from one project to the next (Davies and Brady 2000). In other words, although the project is temporary, organizational capabilities can be gradually accumulated (Brookes et al. 2017).

To further focus on the organizational capabilities of megaproject owners, there are huge challenges in the construction of megaprojects, including technical challenges, changes in design and operational requirements, liability disputes, and new regulations, and so on, all of which require owners to have appropriate organizational capabilities (Davies et al. 2017). Compared with normal construction projects, megaprojects have greater uncertainty and complexity, and therefore the organizational capabilities required by their owners may be more dynamic and systematic. Besides, megaprojects are large in scale, involve many participants, and are difficult to coordinate, which may require higher coordination capability for owners. Some studies have noticed the contribution of owner organizational capabilities to megaproject performance (Winch and Leiringer 2016). For example, Hu et al. (2015) suggested in a case study that megaproject owners need coordination and motivational capabilities. Wang et al. (2013) found the important role of the owner system integration capabilities on the performance of hydropower projects.

There are also many studies that emphasize dynamic capabilities (Davies et al. 2016; Davies and Brady 2016). Scholars have different perspectives on organizational capabilities and have suggested different dimensions. In order to construct the initial library of

**Table 1.** Literature review of organizational capability dimensions

| References | Dimensions of organizational capabilities | Subjects and contexts |
|---|---|---|
| | Owner organizational capabilities | |
| Wang et al. (2013) | Capability of obtaining scarce and valued resources, interorganizational linking capability, information management capability, capability of integrating and managing resources | Owner organizational capabilities/ hydropower projects |
| Hu et al. (2015) | Coordination capability and motivational capability | Owner organizational capabilities/ Shanghai expo construction |
| Winch and Leiringer (2016) | Strategic capability, commercial capability, and governance capability | Owner capabilities/infrastructure projects |
| Gulino et al. (2020) | Dynamic capabilities | Owner organizational capabilities/ infrastructure projects |
| Davies et al. (2016) | Dynamic capabilities | Owner organizational capabilities/London Heathrow Terminal 5 |
| | Organizational capabilities of other organizations in the construction industry | |
| Zerjav et al. (2018) | Reconfiguring project capabilities, adapting project capabilities, and maintaining project capabilities | Interorganizational capabilities/London Heathrow Terminal 2 construction |
| Wethyavivorn et al. (2009) | Marketing capability, procurement capability, construction capability, financial capability, business management capability, learning, and innovation capability | Firm organizational capabilities/Thai construction firms |
| | Organizational capabilities of project managers | |
| Bentahar and Ika (2019) | Selecting the right people and building their capability, building trust with stakeholders, dealing with institutional power and politics effectively, and having the courage to innovate | Project manager capabilities/megaprojects |
| Zuo et al. (2018) | Communication skill, leadership skill, conflict management skill, achievement motivation skill, teamwork skill, cognitive skill | Skills of construction project management professionals/Vietnamese construction industry |
| | Organizational capabilities of other industry organizations | |
| Grewatsch and Kleindienst (2018) | Strategic planning capability, market sensing capability, stakeholder integration capability, and organizational learning capability | Firm organizational capabilities/Danish manufacturing firms |
| Ouakouak et al. (2014) | Ability to anticipate surprises and crises, ability to enhance the generation of new ideas, and ability to take fast strategic decisions | Firm organizational capabilities/European companies |

organizational capability dimensions, in addition to the literature on organizational capabilities of megaproject owners, we also sorted out the organizational capability dimensions of other organizations in the construction industry (Wethyavivorn et al. 2009; Zerjav et al. 2018), project managers (Bentahar and Ika 2019; Zuo et al. 2018), and other industries (Grewatsch and Kleindienst 2018; Ouakouak et al. 2014), as indicated in Table 1. After collating these organizational capability dimensions identified by the literature review, we further identified the capability dimensions required by megaproject owners through expert interviews (described in the "Method" section). Finally, we identified four organizational capabilities: system integration capabilities, motivational capabilities, coordination capabilities, and dynamic capabilities.

### *Owner System Integration Capabilities and Megaproject Success*

System integration is the process of ensuring that all elements of a system work together to achieve the system goals (Sheng 2018). The idea of system integration transforms management and governance from project-based to system-based, thereby increasing the likelihood of overall project success (Locatelli et al. 2014). The system integration capabilities of the owner are particularly important in megaprojects with the characteristics of one-time, numerous participants, and complexity (Kardes et al. 2013). On the one hand, owners outsource design and construction activities, rely on their own capabilities, or hire external project management consultants to integrate the various components. Strong owner system integration capabilities help integrate different construction stages and diversified participants, and deliver a fully functional system under time, cost, and quality objectives (Davies et al. 2009). On the other hand, accelerating changes in the construction industry are encouraging owners to turn to integrated teams comprised of existing supply chains. Once successfully formed, these teams move from one project to the next with their experience and a culture of continuous improvement (Gil and Beckman 2009).

To sum up, system integration capabilities can help owners ensure that megaprojects are managed and governed from a holistic perspective and systematic thinking, as well as help learning between projects, thereby promoting the success of megaprojects (Helfat and Campo-Rembado 2016; Mazur et al. 2014). However, stronger system integration capabilities may not be the better, because many owners in the architectural, engineering, and construction industry are laypersons (Sheng 2018). For example, energy utilities maintain operations by generating and distributing energy to customers. Although they are owners of projects to build power stations or transmission networks, these projects are not their core business and they do nott know much about how to build these projects (Engwall 2003). In such cases, it is good for the owners to have system integration capabilities, but too strong system integration capabilities may be a wrong intervention to professionals. Thus, we put forward the following two parallel hypotheses:

*H1a.* Owner system integration capabilities have a positive effect on megaproject success.

*H1b.* The relationship between owner system integration capabilities and megaproject success is inverted U-shaped.

### *Owner Motivational Capabilities and Megaproject Success*

In order to cope with the complex management situations faced by megaproject construction, owners need to build an organizational

structure suitable for such complex systems and improve project management techniques (Li et al. 2019b). In addition, it is also important to manage the motivation behind the organizational behaviors of all participants (Hu et al. 2012). As the internal driving force that stimulates organizational behaviors, motivation can profoundly affect the origin, direction, intensity, and continuity of organizational behavior, thereby affecting the outputs of megaprojects (Pinder 2014). In megaproject organizations, the relationship between the participants is temporary, and owner motivational capabilities play an important role in regulating the behaviors of all participants in such a temporary relationship (Zeng et al. 2018). Strong motivational capabilities of the owner help encourage all parties to give full play to their initiative, optimize design and construction plans, and optimize resource allocation, so as to better achieve the project objectives (Hu et al. 2012).

Several studies have emphasized the importance of owner motivational capabilities on project success. Meng and Gallagher (2012) verified through questionnaires that projects with higher owner motivational capabilities have better project performance. Through case studies of four megaprojects in Australia, Rose and Manley (2010) suggested that high owner motivational capabilities can help maximize the initiative of contractors under contract conditions. In a case study of the Shanghai Expo, Hu et al. (2012) found that owner motivational capabilities can help improve the quality and environmental performance of megaprojects.

However, another view claims that more incentives for owners are not always better, and the relationship between owner motivational capabilities and organizational outcomes may be an inverted U-shaped relationship (Gneezy et al. 2011). Owner motivational capabilities can guide the decisions and behaviors of each participant, but at the same time, the incentives require additional money or effort from the owner (Hu et al. 2015). The incentive cost is a concave function (Haans et al. 2016), that is, the influence of motivational capabilities on organizational outcomes will be optimal at a certain point, and the relationship between them may be an inverted U-shaped (Gneezy et al. 2011). Thus, we established two parallel hypotheses:

*H2a.* Owner motivational capabilities have a positive effect on megaproject success.

*H2b.* The relationship between owner motivational capabilities and megaproject success is an inverted U-shaped.

### Owner Coordination Capabilities and Megaproject Success

The megaproject organizations formed by all participants are open and complex interorganizational social network systems (Flyvbjerg 2014; Sheng 2018). As the complexity of organizational management increases, the requirements for owner coordination capabilities also increase (Hanisch and Wald 2014). Coordination in megaprojects requires the owner to establish clear mechanisms for task division, information sharing, and conflict resolution, which require specialized project management knowledge and resources (Helfat and Campo-Rembado 2016). Strong owner coordination enables the efficient and harmonious integration of project stakeholders and resources. Conversely, weak owner coordination capabilities make the interorganizational relationship fragmented, and each organization pursues the maximization of its own interests, which also leads to various conflicts and incoordinations among various participants (Wang et al. 2013; Zhang et al. 2021).

There have been some studies that have stressed the important role of owner coordination capabilities for megaproject success. Li et al. (2019a) identified the positive impact of owner coordination capabilities on megaproject performance through a case study of Nanning Transportation Hub in China. Hu et al. (2016) emphasized that improving owner coordination capabilities is a key approach to improve megaproject performance. These studies suggested that owner coordination capabilities help create effective communication, build good partnerships, and thus contribute to megaproject success (Gil and Beckman 2009; Kardes et al. 2013).

However, coordination in megaprojects requires the owner to establish clear mechanisms for task division, information sharing, and conflict resolution, which require specialized project management knowledge and resources (Helfat and Campo-Rembado 2016). With the gradual improvement of the owner coordination capabilities, the marginal cost paid for the establishment of more perfect mechanisms increases (Haans et al. 2016), and thus the impact of owner coordination capabilities on megaproject success is likely to be inverted U-shaped. Therefore, we established two parallel hypotheses:

*H3a.* Owner coordination capabilities have a positive effect on megaproject success.

*H3b.* The relationship between owner coordination capabilities and megaproject success is inverted U-shaped.

### Owner Dynamic Capabilities and Megaproject Success

Dynamic capabilities refer to the strategic innovation process of adapting, integrating, and reconfiguring the organizations' internal and external capabilities, resources, and routines to respond to a rapidly changing internal and external environments (Teece et al. 2016). The interaction of numerous participants, intersecting interfaces, and changes in the external environments make the construction environment more dynamic and uncertain. Strong owner dynamic capabilities enable project participants to flexibly adapt to the owner's requirements and change the design or construction process and management routines to adapt to the dynamic and complex environments (Brady and Davies 2014; Gulino et al. 2020). In addition, owner dynamic capabilities can help handle unexpected, emergent, and improvised situations and flexibly adapt and respond to rapidly changing environments (Kardes et al. 2013).

Many studies have emphasized the importance of owner dynamic capabilities. For example, the case study of London Heathrow Terminal 5 emphasized the important role of owner dynamic capabilities in supporting the strategic management of megaprojects (Davies et al. 2016). These studies hold that when owners have strong dynamic capabilities, they can coordinate all participants and integrate internal and external resources to meet the challenges of the dynamic environments and increase the success rate of the project (Davies and Brady 2016). Meanwhile, dynamic capabilities theory states that even though dynamic capabilities enable organizations to adapt to rapidly changing environments, the cost of developing dynamic capabilities is high, and an optimal solution needs to be found that weighs dynamic capabilities against their development costs (Eisenhardt and Martin 2000; Teece 2007).

In megaprojects, owner dynamic capabilities depend on "having enough excellent people with a real attitude of rapid assessment and decision-making to be able to see issues, discuss them, make decisions, and move on" (Davies et al. 2017). The project benefits of higher dynamic capabilities are a convex function and the costs are a concave function, which leads to a possible inverted U-shaped relationship between owner dynamic capabilities and megaproject success. Thus, we established two parallel hypotheses:

*H4a.* Owner dynamic capabilities have a positive effect on megaproject success.

*H4b.* The relationship between owner dynamic capabilities and megaproject success is inverted U-shaped.

## Method

As shown in Fig. 1, this study followed five steps:

1. We reviewed the literature on organizational capability and initially identified owner organizational capability dimensions and measurement items.
2. Through interviews with 10 senior experts (profiles of experts are given in Table 2), we determined the owner organizational capability dimensions and measurement items for this study.
3. We distributed and collected questionnaires through onsite and online approaches.
4. We performed hierarchical multiple regressions for each capability and megaproject success and validated the inverted U-shaped relationships.
5. After finishing the data analysis, we conducted return interviews with these 10 experts. We presented the quantitative results to the experts, inviting them to interpret our empirical findings through their practical experience or to propose discussions on the empirical results that contradict their practical experience.

### *Identification of the Four Owner Organizational Capabilities*

After collecting organizational capability dimensions from the literature (Table 1), we initially reviewed and integrated some dimensions. For example, "interorganizational linking capability," "stakeholder integration capability," "building trust with stakeholders," "communication skill," "conflict management skill," and "teamwork skill" were integrated into "coordination capabilities." Furthermore, "ability to anticipate surprises and crises," "ability to take fast strategic decisions," "reconfiguring project capabilities," "adapting project capabilities," and "maintaining project capabilities" were integrated as "dynamic capabilities." Next, "capability of integrating and managing resources" and "information management capability" were integrated into "integrative capabilities." However, motivational capabilities, strategic capabilities, business capabilities, governance capabilities, innovation capabilities, and organizational learning capabilities cannot be integrated, and more expert opinions need to be elicited.

We then invited 10 experts who have been involved in 10 different megaprojects (Table 2) to participate in the interviews and help us continue to refine and modify the dimensions of owner organizational capabilities. These experts covered different participants such as owners, consultants, contractors, and academics with rich practical experience in megaprojects. Experts affirmed our preliminary framework and believed that integrative capabilities, coordination capabilities, and dynamic capabilities can be used as the dimensions of owner organizational capabilities. Experts suggested deleting innovation capabilities; they argued that the most important thing in megaprojects is to meet engineering targets, rather than being innovative. They argued that strategic capabilities and business capabilities are required for the project planning stage,

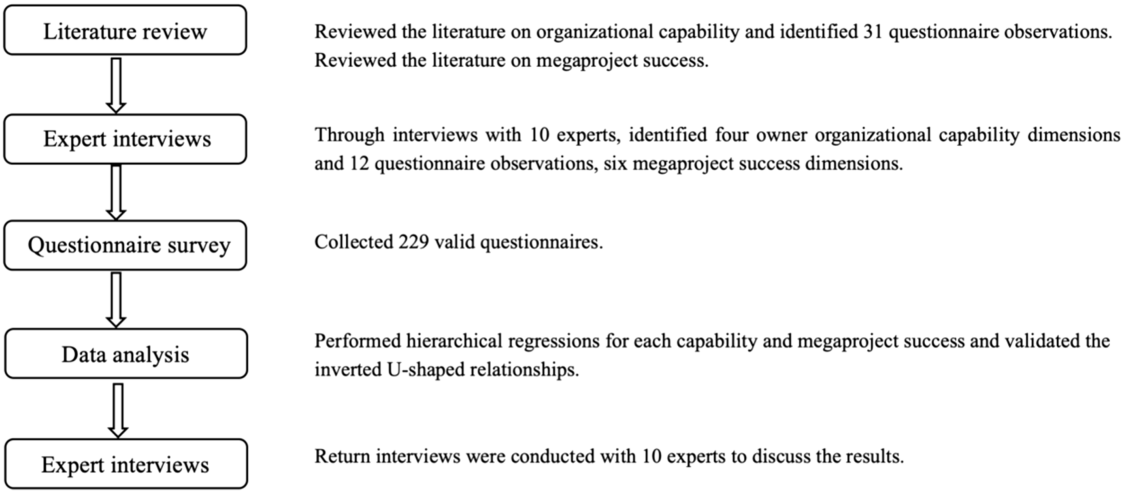


**Fig. 1.** Methodological framework.

**Table 2.** Profiles of interviewees

| No. | Participant | Position | Education | Experience in projects [megaprojects (years)] | Involved megaprojects |
|---|---|---|---|---|---|
| 1 | Scholar | Professor | Doctor | 27 (20) | Shanghai Expo, Shanghai Disneyland |
| 2 | Consultant | Project manager | Doctor | 13 (10) | Shanghai Expo, Nanning High Speed Railway Station |
| 3 | Contractor | Project manager | Master | 27 (10) | Beijing Daxing International Airport |
| 4 | Scholar | Associate professor | Doctor | 18 (10) | Guangzhou Baiyun International Airport |
| 5 | Consultant | Project manager | Master | 15 (10) | Shanghai West Bund Media Port |
| 6 | Consultant | Project manager | Doctor | 15 (10) | Shanghai Disneyland |
| 7 | Scholar | Lecturer | Doctor | 13 (5) | Beijing Daxing International Airport, Shanghai Pudong International Airport |
| 8 | Owner | Project manager | Master | 15 (15) | Many large hospitals in Shanghai |
| 9 | Owner | Middle manager | Master | 18 (15) | Hong Kong–Zhuhai–Macao Bridge |
| 10 | Owner | Middle manager | Doctor | 15 (15) | Shanghai Hongqiao Hub |



J. Constr. Eng. Manage., 2023, 149(7): 04023055

whereas organizational capabilities are required for the project construction stage, and governance capabilities are too general, so these three capabilities should not be used as organizational capability dimensions. They considered that motivational capabilities fit well with megaproject practices and could be retained. They argued that organizational learning capability can be integrated into integrative capabilities, and suggested that integrative capabilities should be renamed as system integration capabilities. Ultimately, we identified four dimensions of owner organizational capabilities of megaprojects, including system integration capabilities, motivational capabilities, coordination capabilities, and dynamic capabilities.

### Sample and Data Collection

To ensure data quality, we selected the respondents based on two criteria (Sepasgozar et al. 2016): on the one hand, they should be participants who have worked in megaprojects; on the other hand, it is desirable that the respondents have a senior position in the project and have a clear understanding of the overall project profile. In order to improve the representativeness of the sample, the survey was conducted on different types of megaprojects in different regions. In addition, different participants in megaprojects, such as contractors, designers, and consultants, were involved in the survey so that a fair evaluation of owner organizational capabilities could be obtained. Specifically, we distributed and collected questionnaires on-site in two ways: at project sites (the Research Institute of Complex Engineering and Management, where the first, third, and sixth authors work, has provided consulting services for over 50 megaprojects), and at megaproject management workshops (four times, organized by our institute). We distributed online questionnaires to members of the China Association of Engineering Consultants (the third author is the director of the association). Finally, the response rates of the onsite (150) and online (261) questionnaires were 88% and 49.04%, respectively, with a total of 229 valid questionnaires collected.

To meet the sample size requirement (Lakens 2022) for the data analysis method (hierarchical multiple regression) of this study, a sample size greater than five times (Bentler and Chou 1987) or 10 times (Nunnally 1967) the independent variable needs to be collected. The number of valid samples we collected far exceeded the sample size required for data analysis. The profiles of the surveyed megaprojects and respondents are given in Table 3.

**Table 3.** Profiles of megaprojects and respondents

| Profiles of megaprojects | | Profiles of respondents | |
|---|---|---|---|
| Variable | Value (%) | Variable | Value (%) |
| Type | | Participant | |
| Program (e.g., large-scale event exhibition center) | 30.1 | Owner | 33.2 |
| Environmental and public facilities | 23.6 | Consultant | 30.5 |
| Transportation infrastructures | 22.3 | Contractor | 18.8 |
| Skyscrapers | 14.4 | Designer | 17.5 |
| Energy and hydropower facilities | 9.6 | — | — |
| Region | | Position | |
| East China | 44.1 | Senior manager | 34.1 |
| Western China | 22.6 | Middle manager | 55.0 |
| Central China | 16.2 | Professional | 10.9 |
| North China | 11.4 | — | — |
| South China | 5.7 | — | — |

The final questionnaire included three parts: Part A is the basic information of the megaproject, including project name, investment, region, and type. Part B measured owner organizational capabilities and megaproject success using a five-point Likert scale, where 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; and 5 = strongly agree. Part C asks for demographic information about the respondents.

### Measures

To generate the organizational capabilities scale for megaproject owners, we first drew on related studies and initially developed 31 measures. The 10 experts were informed of the purpose of our study and background knowledge related to owner organizational capabilities. They were first asked to filter the measurements from these 31 items by deleting, merging, and modifying them. In addition, we asked them to assess whether these measures were well-worded and interpreted in the context of megaprojects to ensure the content validity of the measures. Based on their feedback, we finalized 12 items to measure owner organizational capabilities in the formal survey. Confirmatory Factor Analysis was adopt to evaluate the model fit (AMOS version 24.0 software was employed), as detailed in Table 4. The absolute fit indices, incremental fit indices, and parsimonious fit indices indicate that the measurement items we developed have a good model fit.

#### Owner System Integration Capabilities

Hall et al. (2018) held that system integration capabilities include three dimensions: horizontal (from the perspective of construction elements); vertical (from the perspective of the construction stage); and longitudinal (from the perspective of the cross-organizational management). Following Hall et al.'s (2018) ideas, the measurement items of system integration capabilities in this study included

**Table 4.** Overall goodness-of-fit statistics of confirmatory factor analyses performed

| Categories of statistics | Statistics | Fitness criteria | Values |
|---|---|---|---|
| Absolute fit indices | $\chi^2$/DF | $1.00 < \chi^2/DF < 3.00$ | 1.867 |
| | RMR | <0.05 | 0.037 |
| | RMSEA | <0.08 | 0.062 |
| | GFI | >0.90 | 0.942 |
| | AGFI | >0.90 | 0.903 |
| Incremental fit indices | NFI | >0.90 | 0.944 |
| | RFI | >0.90 | 0.921 |
| | IFI | >0.90 | 0.973 |
| | TLI | >0.90 | 0.962 |
| | CFI | >0.90 | 0.973 |
| Parsimonious fit indices | PGFI | >0.50 | 0.567 |
| | PNFI | >0.50 | 0.672 |
| | PCFI | >0.50 | 0.693 |
| | AIC | Values of default model < values of saturated model and independent model | 149.772 < 156.000<br>149.772 < 1,581.340 |
| | CAIC | | 287.217 < 501.830<br>287.217 < 1,634.545 |

Note: $\chi^2$/DF = chi-square/degrees of freedom; RMR = root-mean square residual; RMSEA = root-mean square error of approximation; GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; NFI = normed fit index; RFI = relative fit index; IFI = incremental fit index; TLI = Tacker-Lewis index; CFI = comparative fit index; PGFI = parsimony goodness-of-fit index; PNFI = parsimony-adjusted normed fit index; PCFI = parsimony comparative fit index; AIC = Akaike information criteria; and CAIC = consistent Akaike information criteria.

the following "The owner can well integrate construction elements, such as cost, quality, and schedule, etc.," "The owner can well integrate the different construction stages," and "The owner can implement certain standardized management methods."

### Owner Motivational Capabilities

In this study, the measurement of owner motivational capabilities included the following: "The owner has established a reasonable performance evaluation system for the project" (Meng and Gallagher 2012), "The owner can identify problems and put penalties when participants act contrary to project goals£ (Meng and Gallagher 2012), and "The owner has established monetary, or administrative, or honorary incentives" (Hu et al. 2012; Rose and Manley 2010; Sheng 2018).

### Owner Coordination Capabilities

Based on the studies of Zhang et al. (2018) and Szentes and Eriksson (2016), three items were adopted to measure coordination capabilities, including the following: "The owner has established a clear task division mechanism," "The owner has established an information sharing mechanism," and "The owner can resolve conflicts between project participants in time."

### Owner Dynamic Capabilities

In this study, the measurement of owner dynamic capabilities includes the following: "Facing the challenges of project management in a complex and changing environment, the owner can integrate internal and external resources" (Teece 2018), "The owner can discover problems in time, quickly evaluate and make decisions, and take measures to respond to changes in the internal and external environments" (Davies et al. 2017), and "The owner can handle unexpected, emergent and improvised situations" (Kardes et al. 2013).

### Megaproject Success

The megaproject success dimensions in this study were integrated from the classic literature on project success dimensions (Chan and Chan 2004; Lim and Mohamed 1999), and incorporated special dimensions related to the success of megaprojects (Turner and Xue 2018). Then, according to the criteria for judging megaproject success in practice emphasized in expert interviews, the dimensions integrated from the literature were added and deleted. Finally, this study measured megaproject success from the following aspects: schedule, quality, cost, realization of project value, sustainability, and satisfaction of project stakeholders. In the questionnaire, we presented statements such as "The project cost is well controlled as expected" (Table 5), and respondents select their perceived options on a five-point scale (strongly disagree=1; disagree=2; neither agree nor disagree=3; agree=4; and strongly agree=5).

### Control Variables

A number of other factors have the potential to impact megaproject success, but are not variables of interest in this study. The control variables in this study include the type of megaproject and the region in which it is located.

## Results

First, we assessed the validity and reliability of the measures. Second, we analyzed the structural model through hierarchical multiple regression analysis (Aiken et al. 1991). Specifically, we implemented it through STATA version 15.1, and measured the curve relationships by constructing quadratic terms (Haans et al. 2016).

### *Measurement Model*

As indicated in Table 5, the validity and reliability of the measurement model are satisfactory both for individual items and constructs. The reliability of individual items was evaluated by standardized indicator loadings. The standardized loadings of 18 items were higher than the 0.7 (Bagozzi and Yi 1988). The

**Table 5.** Measurement model evaluation

| Construct/item | Loading | Cronbach's $\alpha$ | CR | AVE |
|---|---|---|---|---|
| System integration capabilities (SIC) | — | 0.838 | 0.903 | 0.757 |
| SIC1: The owner can well integrate the different construction stages. | 0.899 | — | — | — |
| SIC2: The owner can well integrate construction elements, such as cost, quality, and schedule, and so on. | 0.907 | — | — | — |
| SIC3: The owner can implement certain standardized management methods. | 0.801 | — | — | — |
| Motivational capabilities (MC) | — | 0.725 | 0.842 | 0.640 |
| MC1: The owner has established a reasonable performance evaluation system for the project. | 0.730 | — | — | — |
| MC2: The owner can identify problems and put penalties when participants act contrary to project goals. | 0.785 | — | — | — |
| MC3: The owner has established monetary, or administrative, or honorary incentives. | 0.879 | — | — | — |
| Coordination capabilities (CC) | — | 0.764 | 0.864 | 0.680 |
| CC1: The owner has established a clear task division mechanism. | 0.850 | — | — | — |
| CC2: The owner has established an information sharing mechanism. | 0.782 | — | — | — |
| CC3: The owner can resolve conflicts between project participants in time. | 0.840 | — | — | — |
| Dynamic capabilities (DC) | — | 0.898 | 0.936 | 0.831 |
| DC1: Facing the challenges of project management in a complex and changing environment, the owner can integrate internal and external resources. | 0.914 | — | — | — |
| DC2: The owner can discover problems in time, quickly evaluate and make decisions, and take measures to respond to changes in the internal and external environments. | 0.928 | — | — | — |
| DC3: The owner can handle unexpected, emergent and improvised situations. | 0.893 | — | — | — |
| Megaproject success (MS) | — | 0.871 | 0.903 | 0.608 |
| MS1: The project schedule is well controlled as expected. | 0.769 | — | — | — |
| MS2: The project quality is evaluated as good. | 0.777 | — | — | — |
| MS3: The project cost is well controlled as expected. | 0.746 | — | — | — |
| MS4: The project achieves the intended construction goals and is successfully delivered, and the project value can be realized. | 0.804 | — | — | — |
| MS5: The assets of the project achieve sustainability in operations. | 0.773 | — | — | — |
| MS6: The project stakeholders (participants, government, users, and so on) are satisfied with the project. | 0.810 | — | — | — |

construct reliability was evaluated by composite reliability (CR). The CR scores of each construct exceeded the 0.7 thresholds, which indicate acceptable reliability (Bagozzi and Yi 1988). Moreover, the average variance extracted (AVE) values exceeded the 0.5 thresholds, which indicated good convergent validity (Fornell and Larcker 1981).

### *Hierarchical Multiple Regression Model*

Hierarchical multiple regression allows the comparison of two or more regression models and is widely used in management research to test parallel hypotheses, especially when the parallel hypotheses include inverted U-shaped relationships (e.g., Janssen 2001; Kim and Choi 2018; Salamin and Hom 2005). In hierarchical multiple regressions, the different models developed are compared according to the differences in the variance explained by the different regression models. The more variance explained by a model, the better it fits the data. The differences between the variance amounts explained by different models can be estimated and tested using statistical significance.

The way to test whether a predictor variable is significant is to compare two models where the former model does not include this predictor variable and the latter model includes it. If the predictor variable explains significant additional variation, then the latter model significantly explains more variation than the former model (Aiken et al. 1991). This study used hierarchical multiple regression to analyze whether progressively increasing the control variables (region and type of megaproject), owner organizational capabilities (system integration, motivational, coordination, and dynamic capabilities), and the squared terms of the organizational capabilities can improve the prediction of megaproject success. Such hierarchical regression models enabled us to visualize whether the curvilinear relationship explains the data better than the linear relationship.

As indicated in Table 6, Model 1 includes control variables, neither region nor type has a significant effect on megaproject success. Model 2 adds four organizational capabilities to Model 1, and all four organizational capabilities have significant impacts on megaproject success. The effects of system integration capabilities, motivational capabilities, coordination capabilities, and dynamic capabilities on the success of megaprojects are 0.136 ($p < 0.05$), 0.109 ($p < 0.01$), 0.283 ($p < 0.001$), and 0.160 ($p < 0.01$), respectively. Among them, coordination capabilities can best predict the success of megaprojects. Then, the squared terms of these capabilities were added to Model 3, 4, 5, and 6, respectively. The square term of motivational capabilities was added to Model 4, which can also predict megaproject success well ($\beta = -0.275$ and $p < 0.01$).

The predictive ability of the model can also be discerned by observing the significance of the change in adjusted $R^2$ and $F$. Compared with Model 1, Model 2 significantly enhanced its ability to predict the success of megaprojects. In Model 2, the adjusted $R^2$ was 0.511, the change in adjusted $R^2$ was 0.502, and the change in $F$ was 58.516 ($p < 0.001$), which is statistically significant. Similarly, Model 4 has significantly greater predictive power for megaproject success compared with Model 3. In Model 4, the adjusted $R^2$ was 0.607, the change in adjusted $R^2$ was 0.095, and the change in $F$ as 55.178 ($p < 0.001$). In contrast, the inclusion of control variables in Model 1, the squared term of integrative capabilities in Model 3, the squared term of coordination capabilities in Model 5, and the squared term of dynamic capabilities in Model 6 were not statistically significant in predicting the success of megaprojects.

**Table 6.** Results of hierarchical multiple regression analysis for megaproject success

| Variables | Model 1 | | Model 2 | | Model 3 | | Model 4 | | Model 5 | | Model 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta$ | $b$ | $\beta$ | $b$ | $\beta$ | $b$ | $\beta$ | $b$ | $\beta$ | $b$ | $\beta$ | $b$ |
| Region | 0.046 | 0.104 | 0.031 | 0.069 | 0.028 | 0.062 | 0.027 | 0.06 | 0.029 | 0.065 | 0.028 | 0.063 |
| Type | 0.029 | 0.096 | 0.019 | 0.062 | 0.017 | 0.057 | 0.019 | 0.061 | 0.018 | 0.06 | 0.016 | 0.051 |
| System integration capabilities | — | — | 0.136$^{*}$ | 0.173$^{*}$ | −0.072 | −0.092 | −0.400 | −0.507 | −0.26 | −0.33 | −0.123 | −0.157 |
| Motivational capabilities | — | — | 0.109$^{**}$ | 0.141$^{**}$ | 0.117$^{**}$ | 0.151$^{**}$ | 1.855$^{***}$ | 2.394$^{***}$ | 1.867$^{***}$ | 2.41$^{***}$ | 1.870$^{***}$ | 2.414$^{***}$ |
| Coordination capabilities | — | — | 0.283$^{***}$ | 0.325$^{***}$ | 0.28$^{***}$ | 0.322$^{***}$ | 0.222$^{***}$ | 0.255$^{***}$ | −0.201 | −0.231 | 0.118 | 0.136 |
| Dynamic capabilities | — | — | 0.160$^{**}$ | 0.212$^{**}$ | 0.153$^{**}$ | 0.203$^{**}$ | 0.161$^{**}$ | 0.213$^{**}$ | 0.165$^{**}$ | 0.218$^{**}$ | −0.252 | −0.333 |
| System integration capabilities$^2$ | — | — | — | — | 0.03 | 0.273 | 0.079$^{**}$ | 0.711$^{**}$ | 0.058$^{***}$ | 0.525$^{***}$ | 0.040$^{***}$ | 0.359$^{***}$ |
| Motivational capabilities$^2$ | — | — | — | — | — | — | −0.275$^{***}$ | −2.242$^{***}$ | −0.276 | −2.250 | −0.276 | −2.250 |
| Coordination capabilities$^2$ | — | — | — | — | — | — | — | — | 0.057 | 0.490 | 0.014 | 0.124 |
| Dynamic capabilities$^2$ | — | — | — | — | — | — | — | — | — | — | 0.059 | 0.549 |
| Adjusted $R^2$ | 0.013 | | 0.511 | | 0.511 | | 0.607 | | 0.609 | | 0.612 | |
| Change in adjusted $R^2$ | 0.021 | | 0.502 | | 0.002 | | 0.095 | | 0.004 | | 0.004 | |
| Change in $F$ | 2.469 | | 58.516$^{***}$ | | 0.899 | | 55.178$^{***}$ | | 2.355 | | 2.530 | |

Note: $^{*}p < 0.05$; $^{**}p < 0.01$; and $^{***}p < 0.001$.

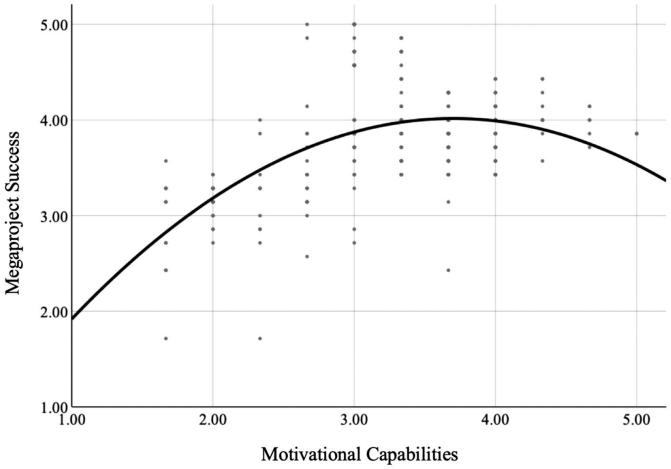


**Fig. 2.** Impact of owner motivational capabilities on megaproject success.

Interestingly, in Model 2, motivational capabilities can predict megaproject success; that is, motivational capabilities have a positive linear effect on megaproject success; In Model 4, the quadratic term of motivational capabilities can also predict megaproject success, and its coefficient is negative; that is, the influence of motivational capabilities on megaproject success is inverted U-shaped. To check robustness, referring to the U-shaped relationship validation procedure (Lind and Mehlum 2010), we found that the curve turning point is within the data range, and it is indeed an inverted U-shaped relationship. Furthermore, as shown in Fig. 2, we performed quadratic curve regressions, again verifying that the relationship between motivational capabilities and megaproject success is inverted U-shaped.

Given that organizational capabilities may have different impacts on different success factors, we further conducted hierarchical regressions on the impact of each capability on each success factor. The first model of the hierarchical regression is a linear relationship and the second model is a quadratic relationship. As indicated in Table 7, the quadratic relationships of motivational capabilities with quality and cost are significant, and the quadratic relationships of coordination and dynamic capabilities with cost are significant. However, the linear relationships between these capabilities and the corresponding success factors are also significant and need to be further tested for the inverted U-shaped relationships. As shown in Fig. 3, we plotted the fitted lines for the linear and quadratic relationships. Based on the validation method (the curve turning point is within the data range), we found that only the motivational capability has inverted U-shaped relationships with quality and cost.

## Discussion

### *Most Important: Owner Coordination Capabilities*

The empirical results showed that owner coordination capabilities have the most significant impact on megaproject success. An important reason why the project management of megaprojects is difficult and complicated is that there are many construction entities, including design companies, construction companies, consultants, suppliers, government, and many others (Bahadorestani et al. 2020; Patanakul et al. 2016). During the construction of the project, these entities need to collaborate well with each other in order to support the construction of the project, but the different objectives of these entities directly lead to the conflict of interests (Mazur et al. 2014). When project objectives conflict with the interests of these entities, the entities generally consider protecting their own interests first, thus splitting the project objectives (Sheng 2018). However, in a general project, the owner contracts the project to a general contractor and can easily wait for the turnkey. It can be seen that, unlike general projects, the success of megaprojects depends very much on the coordination capabilities of the owner.

The result that owner coordination capabilities have the most significant impact on megaproject success may be related to the specific characteristics of megaproject management in the Chinese context. In China, the majority of megaprojects are owned by the government or state-owned enterprises (Hu et al. 2012). In such a context, owner coordination capabilities stem from a centralized organizational model. Resolving conflicts of interest among entities requires a construction management entity with strong resource integration and coordination capabilities. In many megaprojects in China, such as Beijing Daxing International Airport and Hong Kong–Zhuhai–Macao Bridge, the owners of these projects are the government and have established construction headquarters to manage the project and coordinate various entities (Sheng 2018). Such model of establishing project construction headquarters is the basis for effective allocation of resources and coordination of various participants for megaprojects in China. It is worth noting that the construction headquarters of these projects are headed by senior government officials, and these officials often work part-time in megaprojects while serving in the government (Zhai et al. 2017). They can rely on their administrative positions in the government to coordinate different participants of megaprojects (Zheng et al. 2018).

There are many different participants in a megaproject, and the tasks and procedures of different participants are intersected and overlapped, and owner coordination capabilities can ensure the smooth progress of the megaproject (Mazur et al. 2014). In general, the government, as the owner of megaprojects, establishes the construction headquarters led by senior government officials to improve owner coordination capabilities and thus promote the success of the megaproject. This is considered fundamental for China to achieve the miracle of building one megaproject after another (Sheng 2018).

Several other studies also support our findings. Zhang et al. (2018) identified good relationships among participants as an important factor in infrastructure management in China. Zheng et al. (2018) argued that in megaprojects with high owner coordination capabilities, they often establish a collaborative culture and strengthen the information sharing between different parties, which have positive impacts on megaproject performance. Yan et al. (2019) argued that if relationships can be improved and managed, participant satisfaction can increase motivation and cooperation, thereby promoting project success. Furthermore, during the interviews, one expert also emphasized the importance of owner coordination capabilities:

> The Hong Kong–Zhuhai–Macao Bridge is a cross-sea bridge spanning two social systems and three geographical boundaries. The laws, regulations, and working procedures of the three regions should be taken into account in communication, coordination, and decision-making. The coordination capabilities of the owner have the greatest impact on the outcome of this project (Interviewee 9).

### *More Is Not Better: Owner Motivational Capabilities*

Economists often stress that "incentives matter," where higher incentives lead to more effort and higher performance (Gneezy et al.

**Table 7.** Development of owner organizational capabilities scale for megaprojects

| Item | Model MS1a | Model MS1b | Model MS2a | Model MS2b | Model MS3a | Model MS3b | Model MS4a | Model MS4b | Model MS5a | Model MS5b | Model MS6a | Model MS6b |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Model SIC-MS | | | | | | |
| SIC | $0.619^{***}$ | 0.161 | $0.587^{***}$ | 0.233 | $0.662^{***}$ | $0.673^{*}$ | $0.681^{***}$ | $0.604^{*}$ | $0.633^{***}$ | 0.361 | $0.63^{***}$ | 0.569 |
| $SIC^2$ | — | 0.464 | — | 0.36 | — | −0.012 | — | 0.078 | — | 0.276 | — | 0.062 |
| Adjusted $R^2$ | 0.38 | 0.383 | 0.342 | 0.343 | 0.435 | 0.433 | 0.461 | 0.459 | 0.398 | 0.397 | 0.395 | 0.392 |
| Change in Adjusted $R^2$ | 0.383 | 0.006 | 0.345 | 0.004 | 0.438 | 0 | 0.463 | 0 | 0.4 | 0.002 | 0.397 | 0 |
| Change in $F$ | $140.779^{***}$ | 2.255 | $119.501^{***}$ | 1.27 | $176.787^{***}$ | 0.002 | $195.868^{***}$ | 0.073 | $151.518^{***}$ | 0.816 | $149.549^{***}$ | 0.041 |
| | | | | | | Model MC-MS | | | | | | |
| MC | $0.362^{***}$ | $1.006^{*}$ | $0.284^{***}$ | $1.127^{*}$ | $0.331^{***}$ | $1.833^{***}$ | $0.269^{***}$ | 0.797 | $0.333^{***}$ | 0.469 | $0.285^{***}$ | 0.565 |
| $MC^2$ | — | −0.651 | — | $-0.852^{*}$ | — | $-1.518^{***}$ | — | −0.534 | — | −0.137 | — | −0.283 |
| Adjusted $R^2$ | 0.127 | 0.132 | 0.077 | 0.087 | 0.105 | 0.149 | 0.068 | 0.07 | 0.107 | 0.104 | 0.077 | 0.075 |
| Change in Adjusted $R^2$ | 0.131 | 0.009 | 0.081 | 0.015 | 0.109 | 0.047 | 0.072 | 0.006 | 0.111 | 0 | 0.081 | 0.002 |
| Change in $F$ | $34.229^{***}$ | 2.254 | $19.924^{***}$ | $3.67^{*}$ | $27.89^{***}$ | $12.49^{***}$ | $17.665^{***}$ | 1.413 | $28.391^{***}$ | 0.097 | $20.101^{***}$ | 0.4 |
| | | | | | | Model CC-MS | | | | | | |
| CC | $0.686^{***}$ | $1.091^{***}$ | $0.666^{***}$ | 0.276 | $0.762^{***}$ | $1.851^{***}$ | $0.684^{***}$ | $1.014^{**}$ | $0.727^{***}$ | 0.448 | $0.698^{***}$ | $1.314^{***}$ |
| $CC^2$ | — | −0.409 | — | 0.394 | — | $-1.101^{***}$ | — | −0.333 | — | 0.282 | — | −0.623 |
| Adjusted $R^2$ | 0.468 | 0.469 | 0.441 | 0.442 | 0.578 | 0.602 | 0.466 | 0.466 | 0.526 | 0.526 | 0.486 | 0.492 |
| Change in Adjusted $R^2$ | 0.47 | 0.004 | 0.443 | 0.003 | 0.58 | 0.026 | 0.468 | 0.002 | 0.528 | 0.002 | 0.488 | 0.008 |
| Change in $F$ | $201.492^{***}$ | 1.53 | $180.805^{***}$ | 1.348 | $313.648^{***}$ | $14.781^{***}$ | $199.908^{***}$ | 1.004 | $254.38^{***}$ | 0.815 | $216.229^{***}$ | 3.694 |
| | | | | | | Model DC-MS | | | | | | |
| DC | $0.652^{***}$ | $0.826^{**}$ | $0.574^{***}$ | 0.489 | $0.648^{***}$ | $1.366^{***}$ | $0.652^{***}$ | $1.172^{***}$ | $0.59^{***}$ | 0.32 | $0.626^{***}$ | $1.085^{***}$ |
| $DC^2$ | — | −0.177 | — | 0.086 | — | $-0.73^{**}$ | — | −0.528 | — | 0.274 | — | −0.467 |
| Adjusted $R^2$ | 0.422 | 0.421 | 0.326 | 0.324 | 0.417 | 0.432 | 0.423 | 0.429 | 0.345 | 0.344 | 0.389 | 0.394 |
| Change in Adjusted $R^2$ | 0.425 | 0.001 | 0.329 | 0 | 0.42 | 0.017 | 0.425 | 0.009 | 0.348 | 0.002 | 0.392 | 0.007 |
| Change in $F$ | $167.67^{***}$ | 0.392 | $111.413^{***}$ | 0.08 | $164.156^{***}$ | $6.817^{**}$ | $167.904^{***}$ | 3.554 | $121.048^{***}$ | 0.834 | $146.341^{***}$ | 2.609 |

Note: $^{*}< 0.05$; $^{**}< 0.01$; and $^{***}< 0.001$.

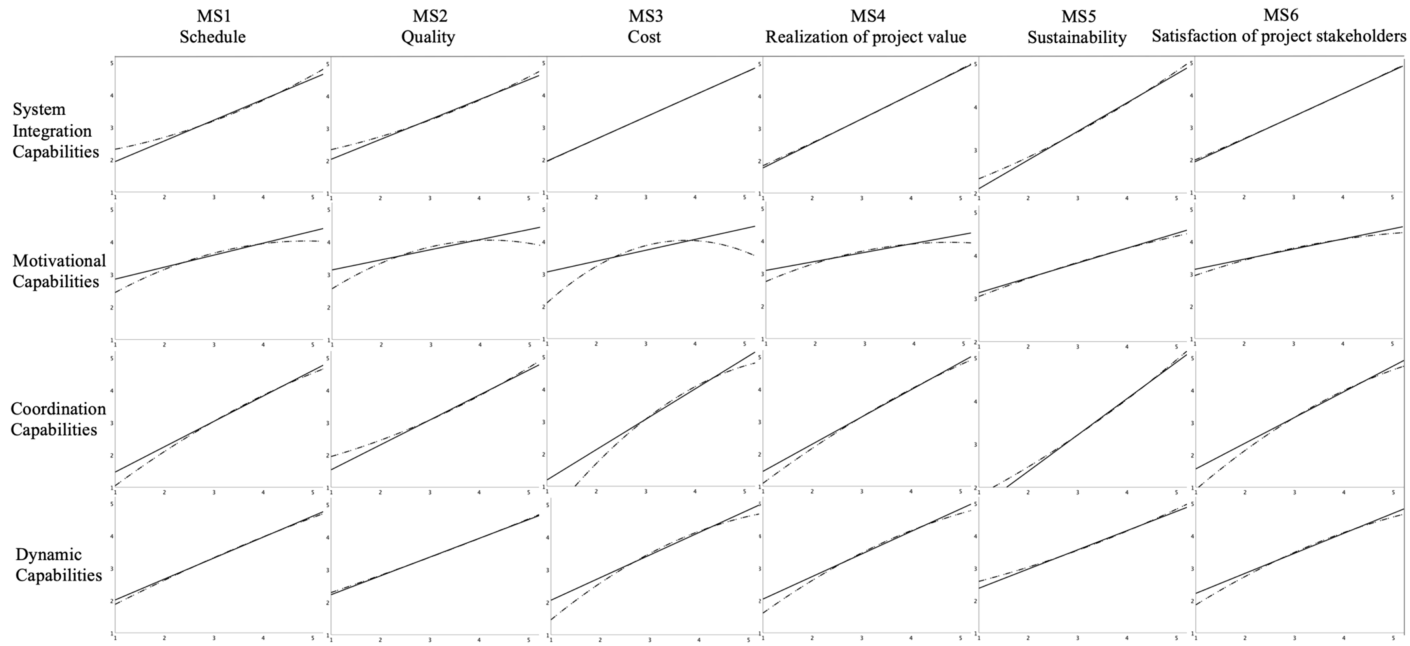


**Fig. 3.** Linear and quadratic curve fitting for the effect of each organizational capability on megaproject success.

2011). However, our findings in megaprojects indicate that the relationship between owner motivational capabilities and megaproject success has an inverted U-shape, that is, as motivational capabilities continue to increase, the impact on megaproject success is positive in the first stage and negative in the second stage. Zhu et al. (2020a) constructed a mathematical model in the context of megaprojects and concluded that megaproject owners should establish incentive mechanisms. Scholars also emphasized the importance of monetary rewards in their study of the success factors of megaprojects (Zhu et al. 2020b). These are consistent with the positive relationship we obtained between owner motivation capabilities and megaproject success in the first stage. In the interview, an expert introduced us a megaproject incentive system with Chinese characteristics:

> In China, labor competitions were held in the construction of the Three Gorges Project, the Qinghai–Tibet Railway, the Hangzhou Bay Bridge, the Beijing Olympic Games, the Shanghai World Expo, etc. Such competitions cover various construction companies, design companies, project management companies, supporting service companies, and research teams involved in engineering construction. This honor incentive system of holding labor competitions is common in megaproject construction, as it is closely related to the honor and future development of the enterprise, and thus greatly mobilizes the motivation and enthusiasm of all participants (Interviewee 1).

Some scholars have offered some explanations for situations where incentives do not work or are counterproductive. Fuster and Meier (2010) argued that incentives guide behaviors and thus may lead to adverse effects on the implementation of norms, which is a hidden cost, especially when incentives are high enough that they may stimulate opportunistic behavior, and this is not conducive to the overall optimization. Ariely et al. (2009) also found that monetary incentives are more likely to be counterproductive in promoting public pro-social activities. Incentives naturally entail costs, and Frey and Oberholzer-Gee (1997) argued that the cost of incentives is a concave function; that is, when the incentives are sufficiently attractive, the costs will increase rapidly. Therefore, compared with the high incentive cost, the additional organizational outputs brought by incentives are insignificant, and the total organizational benefit from the incentive may be reduced in this stage (Gneezy et al. 2011). This result was also discussed by the experts during the interviews:

> Overly attractive incentives may not lead to good results. For example, if the owner offers an attractive incentive for completing the construction ahead of schedule, in order to receive the incentive, some participants are likely to cut corners and sacrifice the quality of work in pursuit of a quick completion. Because the progress is visible to the naked eye, while the quality problems may not be revealed until the operational phase (Interviewee 7).

In summary, incentives, as external drivers that stimulate the way organizations behave, can profoundly affect the genesis, direction, intensity, and persistence of their behaviors and thus the outputs of the organization (Pinder 2014). Too few incentives cannot drive the enthusiasm of participants, and too many incentives may bring high costs and opportunism. It is of great significance to set up a reasonable incentive system to stimulate the motivation of all participants.

### *Impact of Owner Dynamic Capabilities on Megaproject Success*

Owner dynamic capabilities are the second important factor affecting megaproject success. Dealing with uncertainty is an urgent and persistent challenge in megaproject management (Flyvbjerg 2017). At the macro level, megaproject organizations operate in an increasingly challenging business environment due to globalization, privatization, and deregulation, so owners need to develop dynamic capabilities to survive and thrive in changing conditions (Too 2012). At the micro level, due to changes in the natural, technological, market, financial, and other environments, the original planning and design may face adjustments or some urgent situations need to be addressed (Brady and Davies 2014). In order

to improve the dynamic capabilities of owners, megaproject owners in China usually have departments responsible for safety and risk management in their organizations. They organize experts to conduct construction risk analysis, provide construction risk analysis checklists to contractors, and supervise contractors' risk management efforts, as well as conduct a series of risk management training (Sheng 2018).

Numerous studies have highlighted the important impact of owner dynamic capabilities on megaproject success. Kardes et al. (2013) confirmed through a case study of eight megaprojects around the world that owner dynamic capabilities can help the project conduct better risk management and improve the success rate and productivity of the megaproject. Brady and Davies (2014) found in the case study of London's Heathrow Terminal 5 and the London 2012 Olympics that owner dynamic capabilities helped to manage the complexity of the megaproject, thus promoting megaproject success. In the interviews, one expert also shared with us the relevant practices:

> The construction of the underground pipeline network in Beijing Daxing International Airport made full use of BIM and the Internet of Things to build a smart management platform, which realized real-time monitoring of the operational status of various pipelines and provided auxiliary decision-making in case of accidents, which enhanced the dynamic capability of the owner (Interviewee 3).

### *Impact of Owner System Integration Capabilities on Megaproject Success*

Owner system integration capabilities also have a positive impact on megaproject success. System integration capability is a holistic capability that includes not only cross-phase integration and cross-objective integration, but even cross-project integration. Megaprojects are not only the integration of physical resources such as materials, equipment, and technology, but also the integration of management resources such as information and organization. These resources have complex associations and interactions, and integrating them requires system integration capabilities (Sheng 2018). Besides, the value of megaprojects is diversified, including engineering value, economic value, social value, ecological value, and so on. The integration of these values requires system integration capabilities (Bahadorestani et al. 2020). Furthermore, as Egan (1998) emphasized, although buildings are unique, the project management follows certain routines, and achieving interproject learning relies on owner system integration capabilities.

A number of studies have also demonstrated the positive impact of owner system integration capabilities on megaproject success. Helfat and Campo-Rembado (2016) argued that integrative capabilities provide the ability for effective internal communication and coordination of activities, investments, and goals across production stages within an organization. Flyvbjerg (2017) argued that one of the ambitious challenges of megaproject research is to further extend the research scope to the project life cycle to cover the operations and maintenance phases in order to realize the economic, environmental, and social dimensions of the project value. Therefore the owners' capabilities to integrate different time dimensions and management content dimensions are important for the success of megaprojects. In the interviews, one expert also emphasized the importance of the owner system integration capabilities:

> Capital Airport Holdings (the owner of Beijing Daxing International Airport) has developed an information platform for comprehensive management of the project progress. This platform enables real-time information sharing among all entities and also has system integration functions such as overall progress analysis, which has greatly enhanced the owner system integration capabilities and contributed to the eventual six-month early commissioning of the airport (Interviewee 7).

## Conclusions

Based on the literature and interviews, this study identified the dimensions of the organizational capabilities of megaproject owner. Further based on the questionnaire survey data in China, the relationship between owner organizational capabilities and megaproject success was analyzed through a hierarchical multiple regression model. In this way, this study explores in megaprojects, which organizational capabilities are important and which are not the stronger the better. The findings showed that coordination, dynamic, and system integration capabilities have positive impacts on megaproject success, and coordination capabilities are the most critical antecedents of megaproject success. Meanwhile the relationship between owner motivational capabilities and megaproject success is inverted U-shaped.

### *Theoretical Contributions*

This study makes three contributions to the owner capabilities and megaproject success literature. First, this study provides a framework for the organizational capabilities of megaproject owners, deconstructing the concept of "strong owner" proposed by Morris and Hough (1987). Existing studies on owner organizational capability have been limited to the conceptual level (Winch and Leiringer 2016); this owner organizational capability framework moves beyond the conceptual level to a more implementable capability dimension level and deconstructs the specific path to improve the organizational capability of megaproject owners.

Second, this study enriches the people-related factors of megaproject success with empirical evidence. Studies have been conducted to discuss the impact of project manager capabilities (e.g., Bentahar and Ika 2019) and contractor capabilities (e.g., Liu et al. 2016) on project success, but the owner, as the principal and organizer of the megaproject implementation, has been studied only from the conceptual perspective (Winch 2014; Winch and Leiringer 2016). Through a mixed quantitative and qualitative approach, this study makes a complementary contribution to the knowledge field of the relationship between owner capabilities and megaproject success.

Third, this study examines the curvilinear relationship between owner capabilities and megaproject success by establishing several sets of parallel hypotheses. Compared with previous studies that simply emphasized the importance of owner capabilities (Wang et al. 2013), this study takes a more dialectical view of the strong owner concept, and provides inspiration for related discussions.

### *Practical Implications*

Our findings also have some practical implications for megaproject practice. The identified owner organizational capability dimensions and the results of the empirical study on the relationship between owner organizational capabilities and megaproject success can guide owner team formation and capability development. The results emphasize the importance of the owner coordination, dynamic and system integration capabilities, and the ways in which the owner can enhance these capabilities are through the formation of

the owner team on the one hand, and the development of owner capabilities on the other.

First, regarding the formation of owner teams, Chinese megaproject practices have done a good job in establishing owner teams with strong coordination capabilities. Owner teams often include government officials who serve part-time in megaprojects and can borrow their administrative power in the government to coordinate the relationship between megaproject participants. In forming an owner team with dynamic capabilities and system integration capabilities, the team is required to include professionals who are familiar with various stages of the construction project, as well as in different aspects such as cost, schedule, and quality, and so on, and have a keen eye for environmental changes and the ability to solve them, but doing so is extremely costly. It is also a good choice to hire professional consultants to help the owner carry out project management.

Second, in terms of developing owner organizational capabilities, establishing clear mechanisms for task division, knowledge sharing, and conflict resolution are effective ways to improve owner coordination capabilities. The identification and rapid response to environmental changes or emergencies are effective ways to improve owner dynamic capabilities. Integrating different phases and project objectives, and establishing management standards are the keys to improve owner system integration capabilities. Third, our findings alert practices to consider more of owner motivational capabilities, which are not the stronger the better. Establishing an appropriate incentive mechanism can promote the initiative and enthusiasm of the participants, thereby promoting the success of megaprojects. Nonetheless, more attractive incentive mechanisms do not promote the success of megaprojects, but rather impose excessive incentive costs and induce participants' opportunistic behaviors.

Some limitations suggest directions for future research. First, based on the literature and interviews, this study identified the dimensions of organizational capabilities of megaproject owners. These dimensions are not exhaustive and may have richer dimensions as relevant knowledge fields develop. Second, because most owners of megaprojects in China are the government, the findings on the relationship between owner organizational capabilities and megaproject success may have limitations in extending to other cultural contexts, but these findings can also shed some light on other institutional settings. Third, this study concluded that there is an inverted U-shaped relationship between owner motivational capabilities and megaproject success, and some interviews have been conducted, but this is far from sufficient. A more in-depth case study would be beneficial to the understanding of this result.

## Data Availability Statement

Data generated or analyzed during the study are available from the corresponding author by request.

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