Identifying driving factors of construction megaproject success based on three Chinese cases

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Abstract

This study focused on driving factors of construction megaproject success (CMS). To be specific, a mixed methodology, mainly including literature review, case study, and inductive method, was employed in this research to identify a total number of 12 driving factors based on three representative cases, namely Beijing-Shanghai high-speed rail, Three Gorges Dam and Hong Kong-Zhuhai-Macau Bridge. The 12 driving factors for CMS are as follows, including Political Environment, External Supervision, Corporate Reputation, Social Environment, Project Culture, Project Organization, Project Management System, Project Goals, Strategies of Participants, Leadership, Commitment and Devotion of Individuals, and Accumulation and Innovation of Technology.

This study contributes to the body of knowledge in three aspects. First, this study adopted an inductive method and events collection were from open resources, such as books, governmental reports, newspapers and official websites, which has been relatively used before. The research outcomes via such a method might be more comprehensive and objective. Second, this research identified 12 driving factors for CMS, and these findings can help industry professionals to manage megaprojects in a more effective way and improve the possibility of success. Third, this paper systematically reviewed and researched the driving factors of megaproject success, and research results could enrich existing theory of megaproject management and pave the way for further research on megaproject management in the construction industry.

Keywords: construction megaprojects, driving factors, project success, case study, China

1. Introduction

Construction megaprojects ("megaprojects" for short) are large-scale construction projects that typically cost a billion dollars or more, take many years to develop and build, involve multiple public and private stakeholders (Flyvbjerg, 2014), and have extensive impacts on the community, economy, technological development, and environment of the region or even the whole country (Flyvbjerg, 2017). Although a large number of megaprojects have been invested and built in recent decades worldwide, their performance is always poor, and with "over budget, over time, under benefits, over and over again" has already become the "iron law of megaprojects" (Flyvbjerg, 2017). For example, in terms of budget, nine out of ten megaprojects have cost overruns (Flyvbjerg, 2014). According to research results, the cost overruns are around 20% for road projects, 30% for bridge projects, 35% for tunnel projects, 40% for rail projects, and 96% for dams (Flyvbjerg, 2007, Flyvbjerg *et al.*, 2007, Flyvbjerg *et al.*, 2008). Similarly, a delay is also a severe problem for megaproject performance. For instance, a study undertaken by Oxford University suggested that delays on dams are 45% on average (Ansar *et al.*, 2014). Meanwhile, delays tend to contribute to the problem of cost overruns. A modeling analysis based on a large data set for major construction projects found that a one-year delay in the construction phase would contribute to a 4.64% increase in cost overrun (Flyvbjerg *et al.*, 2004). Therefore, researchers and practitioners in project management have attached great importance to improve megaproject performance and CMS finally.

The concept of driving forces was first applied in the physics area, which generally refers to periodic external forces. In the management field, driving forces specifically refer to the forces that drive an organization or system to approach a specific goal (Qin, 2006). Thus, "driving factors" can be explained as "elements that can drive an organization to achieve its goals". Currently, some studies were conducted on driving factors of construction project success. For example, Iyer and Jha (2006) found that the commitment of project participants, owner's competence, and conflict among project participants can enhance schedule performance level in Indian construction projects. Hu *et al.* (2015) identified 12 principal program organization factors (POFs) to determine megaproject organization success, such as contextual understanding, program strategy, program leadership, scope management, program governance, and matrix organizational structure. However, relevant studies are still very limited. Considering the political, economic and cultural environment in China, and characteristics of construction megaprojects, thus this study aims to explore key driving factors for CMS. To be specific, three typical Chinese megaprojects, namely the Three Gorges Dam, Beijing-Shanghai High-speed Railway and Hong Kong-Zhuhai-Macao Bridge, are comprehensively studied by induction to identify the driving factors of CMS in China. The research results of this paper can provide insights for megaproject managers, hopefully, improve the overall success of megaproject management, and increase the possibility of CMS.

2. Driving factors of project success

Existing research focus on driving factors of project success is relatively limited. According to the study of Wang *et al.* (2001), factors of engineering project success were divided into four groups, namely characteristics of engineering projects, contract and agreements, participants, and coordination in organizations. Bredillet and Dwivedula (2008) pointed out that clear goals, training, feedback on performance, communication and top management support are significant factors of project success. Crosby (2012) found that good control system, clear project missions and goals, project communication, support from the top management team, project baseline, performance monitoring, and capabilities of project leaders are top-ranking success drivers in large high-technology projects. Jetu and Riedl (2012) concluded that working spirit, project team learning, and leadership are the three most important dimensions of project team success. Ndihokubwayo (2014) explored and compared monetary and non-monetary incentives to achieve project delivery success based on two models. Each model included four parts, namely project objectives, demographic information, short-run project-based interventions,

and long-run interventions. The research results showed that monetary incentives could be a useful project-based intervention mechanism in the short-run to achieve secondary project objectives, and non-monetary incentives could be more useful to achieve primary project objects, such as quality management. Additionally, some studies only focus on a specific aspect of project success. For example, Iyer and Jha (2006) only concentrated on schedule performance and found that inputs of project participators, owner's capabilities and conflict among project participants are three important success factors of schedule performance.

Megaprojects are generally critical to political and economic development, and very distinct from general projects (Shen and Shi, 2015). Currently, only a few studies focus on the research of driving factors in the context of megaprojects. Li *et al.* (2018) highlighted the important role of government and political impacts on successful decision making and construction of megaprojects. Marrewijk *et al.* (2008) pointed out that the project culture plays an essential role in how managers and partners cooperate to achieve project objectives successfully. Based on in-depth analysis of the case study of Shanghai EXPO, Hu *et al.* (2015) identified 12 principal program organization factors that are determinants of the program organization established by a client to manage a megaproject, namely contextual understanding, program strategy, program leadership, scope management, program governance, matrix organizational structure, program management office, use of project breakdown structure and work breakdown structure tools, partnering with key stakeholders, technology management, communication management and team building.

3. Research methodology

The case study is a very common and practical method in management. After selecting one or several scenarios as research objects, researchers collect and investigate systematical data to explore a phenomenon in real situations. Compared with other research methods, case study can provide a solid description and systematic understanding of the case, grasp the dynamic interaction process and its context, and obtain a more comprehensive point (Flyvbjerg, 2006). Considering the characteristics of megaprojects which are significantly different from general construction projects and the contextual environment in China, the relevant studies summarized in literature may not be suitable for CMS in China. Therefore, this paper explores driving factors for CMS with the assistance of the induction method based on three cases.

Three typical Chinese construction megaprojects, namely the Three Gorges Dam (T), Beijing-Shanghai High-speed Railway (B) and Hong Kong-Zhuhai-Macao Bridge (H), are selected as cases to be studied in this paper. Firstly, they are typical and representative megaprojects since the reform and opening up in China, which have a similar political and economic background. Secondly, the project teams of these megaprojects have shown a high level of project management in the implementation process, and their success has won extensive recognition from society and the public. For example, Beijing-Shanghai High-speed Railway has won the special award in National Award for Science and Technology Progress in 2015 and Excellence Award for outstanding major civil engineering projects in the past century by FIDIC. Finally, these three megaprojects have all attracted worldwide attention and have accumulated adequate and accessible data for this study.

In this paper, textual data which can directly show mega construction project success and its driving factors are selected from open resources, such as books and official websites. Books summarize all kinds of events, stories, experiences, and lessons in the process of construction, and contain comprehensive and systematic data about the cases. Official websites of megaprojects are established and maintained by developers or contractors to publish and update relevant notices, plans, reports, and events in the form of electronic periodicals, which make megaprojects under the supervision of the whole society. In addition, documentaries, news and other sources of data can be served as a supplement to the background and related information of the cases to get a more comprehensive understanding of collected data.

After collection, each textual material includes three elements: “driving force”, “driving result” and “driving relationship” were considered as criteria to analyze the effectiveness of the textual material. “Driving force" means a specific behavior or condition in the process of project construction, such as “coordination and support from government”. “Driving result” indicates that of the whole project or part of it (in a certain aspect/stage) has been successfully delivered, the description such as “the smooth progress in the project construction”, “the realization of project goals in each stage” and “the accomplishment of a first-class project”; “Driving relationship” refers to that there is a certain relationship between the behavior or condition and the success of the project, such as “promote”, “ensure” and “benefit”. In addition, textual materials that don’t contain all the three elements but convey similar relationships also collected as textual data. Eventually, a total of 492 textual materials on the driving factors of CMS in three cases have been collected after analysis and filtration. Table 1 shows the number of materials in each case.

Table 1 The Numbers of Textual Data in Three Megaprojects

Megaprojects	Resources of Data	Total number
Three Gorges Hydroelectric Power Station (T)	“Opinions on the Three Gorges Project by Li Peng” “The Success of China Three Gorges Cooperation”	64
Beijing-Shanghai High-speed Railway (B)	“Review on the Construction of Beijing-Shanghai High-speed Railway (Construction Phase)” “Review on the Construction of Beijing-Shanghai High-speed Railway (Operation Phase)” “Innovation and Practice in Construction Management of Railways” “Reports on Beijing-Shanghai High-speed Railway” “Chinese Speed: The Development of High-speed Railway in China”	168
Hong Kong -Zhuhai-Macao Bridge (H)	“Hong Kong-Zhuhai-Macao Bridge” (electronic periodicals, Issue 1-41) “Hong Kong-Zhuhai-Macao Bridge by Joint Venture of China Communications Construction Co., Ltd” (electronic periodicals, Issue 1-75) “Reports on Island and Tunnel Project of Hong Kong-Zhuhai-Macao Bridge” (electronic periodicals, Issue 1-83)	260

4. Results and discussions

Based on the research results of three case studies, a total of 12 key driving factors for CMS were summarized, including Political Environment, External Supervision, Corporate Reputation, Social Environment, Project Culture, Project Organization, Project Management System, Project Goals, Strategies of Participants, Leadership, Commitment and Devotion of Individuals, and Accumulation and Innovation of Technology. Meanwhile, political environment, accumulation and innovation of technology, project organization and project culture are the top four factors.

The political environment, especially the support from the government was identified as the leading factor for CMS according to research results. The reason could be that megaprojects are generally landmarks, then central and local governments always attach great importance to the construction of them. The role of government cannot be replaced in the decision-making and construction of megaprojects, especially infrastructure megaprojects and mega event projects (Li *et al.*, 2018). In China, the owners are usually special purpose vehicles (SPVs) organized by their host government (Hu *et al.*,

2015), and meanwhile, many participants either are state-owned companies or connect closely with the government (Chi *et al.*, 2011). At times, this kind of situation indeed contributes to successful project outcomes, such as the case of the Bird's Nest project built for the Beijing 2008 Olympic Games (Manzenreiter, 2010). Additionally, the government often acts as both the regulator and an active coordinator in the projects. For example, without the strong support and cooperation of local governments involved in the Beijing-Shanghai High-speed railway, the work of land acquisition could not be smoothly carried on and delivery on time would not be achieved.

Technological challenges have been recognized as an important issue which cannot be ignored in megaprojects (Kipp *et al.*, 2008). New technologies and operating procedures can be explored, identified, selected and experimented by project organization to support improvements in megaproject processes (Davies *et al.*, 2009). For example, the idea of industrial lean manufacturing has been pioneered to ensure the quality and duration of the construction of the Hong Kong-Zhuhai-Macau Bridge. Compared with the traditional process, the production efficiency has increased by more than 300% and the quality has also been significantly improved (Gao *et al.*, 2018). Additionally, technological experience, managerial experience, and professionals accumulated and cultivated in previous project practices or relevant academic programs can provide valuable experience and technologies for similar megaprojects. As stated by Davies *et al.* (2009), learning from past experience can improve performance by adopting project processes, ideas, and developed technologies, and aided the project success further.

Project organization was one of the most important factors for CMS. Many existing studies indicated the important role of organizational mode and structure in the megaproject performance and megaproject success (Lundrigan *et al.*, 2015, Hu *et al.*, 2015). Organizational structure, such as project breakdown structure and work breakdown structure, and organizational mode, such as construction headquarter mode and project corporation liability system, both play a significant role especially in the coordination within or between project teams in megaprojects (Le *et al.*, 2014). For instance, a three-level organizational structure of "task force–three prefectural party committee–project legal person" was adopted in the construction management in the Hong Kong–Zhuhai–Macao Bridge. This kind of structure provided strong support to project construction and effectively ensured the implementation of the project goals (Gao *et al.*, 2018).

The culture in a construction project has a significant influence on the behavior of participating entities and employees, thus promoting the improvement of performance in the project (Zuo and Zillante, 2011). Megaprojects encompass multi-stakeholders, mainly including the government, owners, constructors, sub-constructors, designers, supervisors, consultants, suppliers, and monetary institutes (Flyvbjerg, 2014, Hu *et al.*, 2015). Existing studies have demonstrated that project culture effectively facilitates the governance, reduces conflicts, improves the employees' work enthusiasm and maintains the harmonious atmosphere within or between organizations in megaprojects (Jia *et al.*, 2011, Yang *et al.*, 2018, Zhai *et al.*, 2017). It is interesting to note that in China, project goals or spirits are usually transformed into brief slogans and posted in the construction sites to motivate all the employees (e.g. "Building a world-class bridge across the sea channel, providing the high-quality services to the users and becoming landmark buildings", in the case of Hong Kong–Zhuhai–Macao Bridge) (Gao *et al.*, 2018), and beneficial to establish a close partnership between participating entities in megaprojects, which contributes to improving work efficiency and achieving project goals.

Table 1 Identified driving factors for CMS based on the case study

Driving Factors	Sub-factors	Explanations & implications
Political Environment	Guide from Government	Megaprojects are included in national construction plan, and their implementation is guided by relevant policies and guidelines from the government.
	Support from Government	Government departments at different levels and in different areas provide strong cooperation and assistance for the construction of megaprojects to help solve problems.
	Political Institutions	The whole country participates in the construction of megaprojects under the socialist system

		in China
External Supervision	Regulations and Supervisions from Government	Supervision departments at all levels oversee and inspect the legality and compliance of megaproject construction.
	Restriction from Laws and Regulations	National laws and regulations place limitations to the construction of megaprojects.
Corporate Reputation	Maintaining Corporate Reputation	Enterprises as participants in megaprojects try their best to avoid problems about quality, safety and time in the construction process so as to prevent their reputation from being damaged.
	Improving Corporate Reputation	Enterprises as participants in megaprojects strive to improve their work efficiency and performance to enhance their reputation.
Social Environment	Public Opinions	The public show understanding and support for megaprojects in their comments and behavior.
	Demands of Stakeholders	Measures are taken in the construction of megaprojects to avoid damaging the interests of the public and other stakeholders when residents are immigrating and housed are being demolished.
	Information Disclosure	By publicizing data and information of megaprojects, the public can know and monitor their construction process.
Project Culture	Project Spirit	Ideas and spirit of megaprojects are concluded to guide the working attitude and thinking mode of participating employees.
	Labor Competition	Labor competitions and award ceremonies are held to improve the enthusiasm of participating employees in megaprojects.
	Harmonious Relationship	Activities and meetings are held to form a positive and harmonious atmosphere in or between participants of megaprojects.
Project Organization	Structure of the Organization	The organizational structure and mode of megaprojects are designed Reasonably and improved by adjusting or adding structural units.
	Development of Organization	Trainings are conducted to improve the awareness, technical level and moral qualities of participating employees.
Project Management System	Project Management System	Management systems are adopted or established to guide, standardize, and control the work of participants in megaprojects.
Project Goals	Restriction from Goals	Clear goals about the overall construction tasks are made to restrict the work of the participants in megaprojects.
	Guide from Goals	Construction goals of megaprojects are deeply explained and published to guide the thoughts and actions of participants.
Strategies of Participants	Strategies of Participants	Decision-making mode and guidelines for action are made by participants in megaprojects from the perspective of overall development and long-term interests.
Leadership	Leaders' Capabilities	Leaders at different levels in megaprojects have the capabilities and skills to make important decisions and control the construction work.
	Leaders' Awareness	Leaders at different levels in participants give significant attention and support to the construction of megaprojects.
Commitment and Devotion of Individuals	Dedication and Hard Work	Participating employees concentrate on the construction of megaprojects. with dedication and strong will.
	The sense of Mission and Responsibility	Participating employees are fully aware of the significance and function of megaprojects for the whole country and have a sense of mission and responsibility to work for the construction according to their positions.
	Qualities and Virtues	Participating employees have personal qualities and virtues, such as honesty and integrity.
	The pursuit of Life Value	Participating employees pursue the improvement of capabilities and the realization of personal value in their lives.
Accumulation and Innovation of Technology	Accumulation and Application of Technology	Technology and experience in researches and practices of previous megaprojects are adopted to improve the management level of current megaprojects.
	Development and	Experiments and practices in megaprojects are analyzed to realize the development and

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