Guest editorial

Complex system management in mega infrastructure projects

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Mega infrastructure projects are distinguished by their extensive scale, intricate environments, advanced technological requirements and prolonged construction and lifecycle durations. These projects are of critical importance to the political, economic, social and environmental landscapes of a nation or region, significantly influencing public safety, environmental protection and societal welfare. Representative examples include large-scale transportation systems, water management infrastructure, environmental remediation initiatives and major sports complexes. Current management of mega infrastructure projects faces numerous challenges, including increased environmental uncertainties, negotiations and conflicts among management entities, dynamic changes in management organizations and the diversification of management objectives. These complexities have led to a series of management difficulties, such as decision-making in the initial stages, financing models, schedule coordination, technological innovation and sustainable development. In recent years, the management issues associated with mega infrastructure projects have garnered significant attention, being fervently discussed across various media platforms, including traditional media, social media, blogs and forums. This topic has also sparked considerable academic research and debate, particularly concerning decision-making errors, cost overruns and project delays. It is an indisputable fact that traditional project management theories, despite their long-term development and increasing refinement, remain inadequate in addressing the myriad issues that arise in the management of mega infrastructure projects. Consequently, there is a need for the development of specialized management theories tailored specifically to this unique field.

The complexity of mega infrastructure projects has been widely recognized and extensively studied. This complexity is not only an apparent characteristic but also an intrinsic essence of such projects. The preliminary decision-making process for mega infrastructure projects is not merely a compromise among current diverse demands. It must consider the coupling of the project with its surrounding environment throughout its entire lifecycle and the effective realization of its functions. This represents a quintessential example of a complex holistic problem. Mega infrastructure projects represent a typical example of complex systems. In managing these projects, it is crucial to focus on their dynamism, adaptability and emergence throughout their entire lifecycle. The application and promotion of complex systems management in the context of mega project management not only hold significant academic research value but also offer important practical guidance. Based on this, the special issue initiated the topic "Complex System Management in Mega Infrastructure Projects." We are fortunate that this special issue received a wide response from scholars worldwide, with 106 submissions from 23 countries or regions. Due to the limitations of the special issue's capacity and focus, 16 papers were selected for publication. The editors of the special issue extend their heartfelt gratitude to all authors who submitted their manuscripts and hope that researchers will continue to engage with and contribute to this field of study.

The research in this special issue mainly focuses on the following three aspects:

The first seven papers primarily focus on management methods for mega infrastructure projects, including risk assessment and safety management. Nezami *et al.* introduced a tool

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for evaluating inter-organizational collaboration in interconnected infrastructure projects, comprising 12 criteria and 36 sub-criteria, providing a systematic approach to collaboration assessment in infrastructure construction. Lu *et al.* investigated the design for fire emergency evacuation in metro stations. Through simulation modeling, they proposed strategies to optimize evacuation design, thereby enhancing emergency response capabilities. Deng *et al.* identified the causative factors of metro construction safety accidents, analyzed the correlation between accidents and causative factors and assisted in developing safety management strategies for improving safety performance in the context of the Chinese construction industry. Wu *et al.* employed the fuzzy-set qualitative comparative analysis (fsQCA) method to study complexity governance strategies in megaprojects, offering new perspectives for project management. Zeng *et al.* introduced the "Auto-Scan-To-BIM (ASTB)" system, which can enhance the efficiency of infrastructure management by automatically generating a complete industry foundation classes (IFC) model consisting of the 3D building elements for the given building based on its point cloud without requiring additional modeling tools. Malek and Bhatt. explored the management methods and risk factors of mega infrastructure project (MIP), using structural equation model and artificial neural network approach to derive the importance of factors affecting the success of MIPs. Liu *et al.* studied the management system of mega railway infrastructure project from the perspective of dissipative structure, proposing pathways to enhance management efficiency.

The next four papers focus on the sustainability and environmental protection of mega infrastructure projects. Zhao *et al.* studied the vulnerabilities of sustainable infrastructure, combining interpretive structural modeling (ISM) and matrix cross-impact multiplication applied to classification (MICMAC). They identified 18 representative factors and proposed corresponding countermeasures. Song *et al.* developed an ecological restoration decision-making model based on multi-source heterogeneous data, providing decision support for the ecological restoration of mega-infrastructure projects. Zhang *et al.* focused on the supportability evaluation of cross-regional mega infrastructure projects, emphasizing identification of evaluation indicators from a complexity perspective. They developed an evaluation model using qualitative and quantitative methods that supports the sustainable development of these projects. Li *et al.* proposed a risk assessment model for spoil grounds in mega transportation infrastructure projects, based on improved projection pursuit clustering (PPC) methods and K-means clustering algorithm. This model effectively classifies and evaluates the ecological environmental risks of spoil grounds.

The final five papers focus on organizational behavior and strategies in mega infrastructure projects, exploring topics such as organizational behavior, leadership styles, coopetition strategies and their impact on project success. Zhai *et al.* designed and tested a model to boost stakeholders' intention to take socially responsible collective action in the context of mega water transfer projects in China. Using the belief-desire-intention model and social influence theory, they analyzed the roles of subjective norms, group norms, social identity and desire in enhancing stakeholders' participation in socially responsible collective action. Niu *et al.* focused on the dynamics of coopetition in international joint ventures for high-speed rail projects. This study analyzes the impact of different coopetition constructs, including coopetition relationship, coopetition capability and coopetition strategy, on firm performance. Yang *et al.* analyzed abnormal organizational behaviors (AOBs) in complex projects and proposed countermeasures based on network attack theory. The study emphasizes the management and control of abnormal behaviors by specific organizations. Yunpeng and Zaman explored mega-construction projects within the Belt and Road Initiative, examining the roles of paternalistic leadership (PL), team members' voice (TMV) and team resilience (TR) in project success. They found that benevolent leadership and moral leadership styles have a positive impact on project success, while authoritarian leadership has a negative effect. Zaman *et al.* investigated the impact of paradoxical leadership on

project agility and success, highlighting the importance of leadership styles in complex project management. Using empirical data from the China–Pakistan Economic Corridor (CPEC) megaproject, they validated the mediating role of project agility in achieving megaproject success.

The development of complex systems management theory in mega infrastructure project management is still nascent. Researchers, including the authors of this special issue, hold diverse perspectives that benefit the theory's growth. We hope this special issue will catalyze the advancement of this theoretical framework.

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