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Conceptual Framework of Mega Construction Project's Complexity: An Investigative Review

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Keywords:
Mega Construction; Mega Framework; Mega projects; Project complexity; Project Management.

Highlights:

- The article presents an excellent definition of the complexity concept, divided into several forms. These complexities are grouped together in order to enable one to decipher how diverse elements lead to the accumulation of large-scale construction projects.
- It covers a theoretical approach that intends to coordinate the challenges involved in mega-construction projects.
- The Study provides information about how to apply this framework in practice and avoid different risks or difficulties connected with project implementation.

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Abstract: Megaprojects are available as huge, long-lasting projects that involve many participants from different sectors (private and governmental). It's characterized by their impact on the economy and environment of the countries of construction. This study provides a tabulation of the characteristics and factors that increase megaprojects' complexity. This study analyzes previous studies concerned with diagnosing complexities in large projects, indicating the ways in which these complexities are evaluated to provide a table in which the most important complexities appear. Based on the list of complexities, a suitable framework will be presented to make it easy for decision-makers to manage complexity during the project life cycle. As far as the findings of the investigative review are concerned, it can be said that the most urgent concern is the application of a complex framework in designing the megaproject strategies and monitoring the project management practices by the model of conceptual frameworks. In this context, this review has drawn a multi-dimensional picture of complexity and tackled how to get around these challenges. This contribution is much needed in the era of global competition in which megaprojects are finally more a rule rather than an exception. It is concluded that qualitative analysis, Delphi study, and causal map methodology are the most effective tools for identifying significant complexity for effective farmwork.

مراجعة استقصائية للإطار المفاهيمي لتعقيد مشروع البناء الضخم

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الخلاصة

تتوفر المشاريع العملاقة كمشاريع ضخمة طويلة الأمد والتي يشارك فيها العديد من المشاركين من مختلف القطاعات (الخاصة والحكومية). وتتميز بتأثيرها على اقتصاد وبيئة بلدان البناء. توفر هذه الدراسة جدولاً للخصائص والعوامل التي تزيد من التعقيد في المشاريع الضخمة. تعتبر هذه الدراسة تحليلاً للدراسات السابقة التي اهتمت بتشخيص التعقيدات في المشاريع الكبيرة، مع بيان طرق تقييم هذه التعقيدات من أجل تقديم جدول تظهر فيه أهم التعقيدات. واستناداً إلى قائمة التعقيدات، سيتم تقديم إطار عمل مناسب لتسهيل إدارة التعقيد على صناع القرار خلال دورة حياة المشروع. ويمكن القول، فيما يتعلق بنتائج المراجعة الاستقصائية، أن الاهتمام الأكثر إلحاحا هو تطبيق إطار معقد في تصميم استراتيجيات المشاريع الكبرى ورصد ممارسات إدارة المشاريع من خلال نموذج الأطر المفاهيمية. وفي هذا السياق، رسمت هذه المراجعة صورة متعددة الأبعاد للتعقيد وتناولت كيفية التغلب على هذه التحديات. وهناك حاجة ماسة إلى هذه المساهمة في عصر المنافسة العالمية حيث أصبحت المشاريع الضخمة في نهاية المطاف قاعدة وليست استثناء. وخلصت الدراسة إلى أن التحليل النوعي ودراسة دلفي ومنهجية الخريطة السببية هي الأدوات الأكثر فعالية لتحديد التعقيدات المهمة اللازمة للعمل الزراعي الفعال.

الكلمات الدالة: الانشاءات الضخمة، الإطار الضخم، المشاريع الضخمة، تعقيد المشاريع، إدارة المشاريع.

1.INTRODUCTION

"giants" are named among projects [1]. Megaprojects are projects of a size and complexity typically costing more than one billion dollars and taking many years or decades to be completed. They involve multiple stakeholders and are transformational, affecting millions of people [2]. The main objective of such projects is to ensure national security, boost economic development, enhance human life, and promote social progress [2]. However, the size gives a share in complexity, but it is not the focal parameter to judge whether the project is complex or not [3]. Complexity can be caught on in several ways, not as it was in numerous areas, but as it has a distinctive concept inside the same field [4]. Mega construction projects are not subjected to traditional project management due to their dynamism. Their susceptibility to increasing unexpected possibilities is high due to instability, non-linearity, and degree of disorder [5]. Some researchers have shown that the complexity of a project is not only due to project size, duration, or scope, but it may also be due to the lack of experience of the project management team [6]. Despite the scarcity of sources related to complexities in large projects, this study worked to summarize the studies and provide a comprehensive picture of the factors that contribute to complexities directly or indirectly. To understand megaprojects well, Christian Brockmann [7] clarified various types of complexity: project complexity, social, task, and cultural. This article tried to review the concept of complexity in megaprojects and framed the factors and sub-factors that characterize megaprojects' complexity. The study focused on having a deep understanding of key factors that bring complexity to implementation megaprojects. For a better understanding of the purposive, two questions are formulated:

1) What is the concept of complexity of mega projects?

2) How did the researchers characterize and categorize the complexity of mega projects?

A framework of the study is shown in Fig. 1.

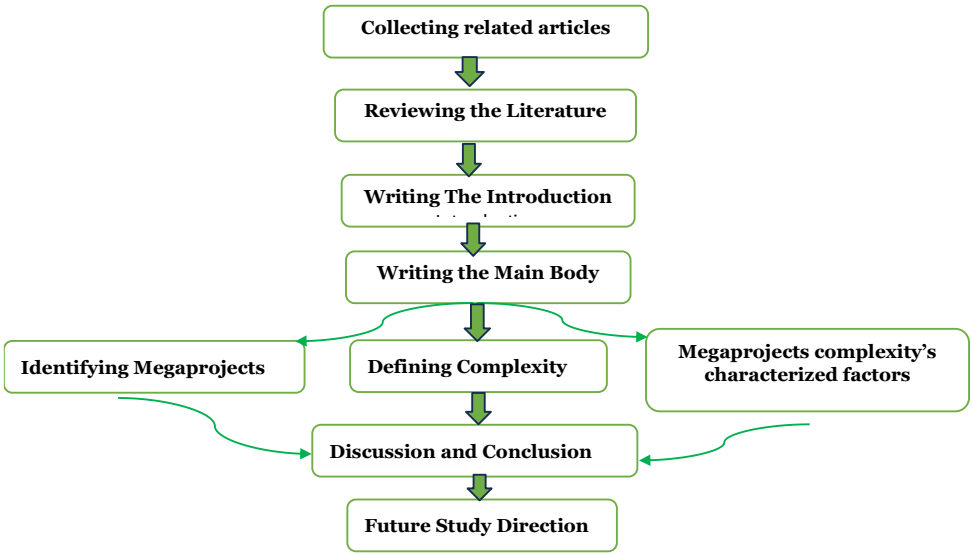

Fig. 1 Outline of the Study.

2.LITERATURE REVIEW

2.1.Complexity Definition

There are numerous ways to define complexity. In a very basic and straightforward one, complication is defined as the number of elements in a system and their potential relationships, while complexity is defined as the number of different components in a system alone [8]. According to the Association for Project Management (APM), a complicated project is one that usually calls for the application of a broad range of project management tools, techniques, and approaches [9], as well as the coordination of actions across multiple disciplines, interactions between multiple organizations, or different units within one organization [10]. Complexity is a project characteristic that results from the interdependence of several project elements, including tasks [11], parties, disciplines, and interfaces, making it challenging to comprehend, predict, and govern its behavior [12]. Due to interconnected operations, multiple stakeholders, multiple actors in the public and commercial sectors [4], and an unforeseen environment, uncertainties will increase during a significant project. Increasing the uncertainty ratio will make the project more challenging.[5]. Growing number of partners working together and the difficulty of overseeing such initiatives. However, considering their high failure rate [13]. Project uncertainty, which stems from inside the project itself, includes unclear objectives and scope, the use of cutting-edge technology, and the selection of organizational design, project management technique, and contracting approach. The way they are resolved will affect how well the project performs till then. Uncertainties arising from the specific context of interest encompass the changing expectations of external stakeholders, their respective definitions of project success, and their interrelationships. In particular, there will be uncertainty due to the way the representatives of the stakeholders behave and engage with the project team [14]. A spiral and quick increase in the complexity of construction processes has been caused by the ongoing demands for speed, cost and quality control, workplace safety, dispute avoidance, technological advancements, economic liberalization, the rise of globalization worries about the environment, and industry fragmentation [15].

2.2.Complexity Characteristics

According to population growth, the increase in construction projects, and their concern with the GDP, many countries are trying to improve their cooperation in order to evolve infrastructure projects, thereby improving life standards. Nevertheless, nowadays, Megaprojects with more than 1 Bn $ budget have a high probability of failure due to poor management and adopting new technology, which might bring challenges and complexity to complete mega projects. Brockmann and Girmscheid [16] addressed four complexity characteristics to have a clear sight of megaprojects. It is not only about taking tasks as a major source of project complexity but also diving into the overall project complexity: cultural and social complexity as shown in Fig. 2.

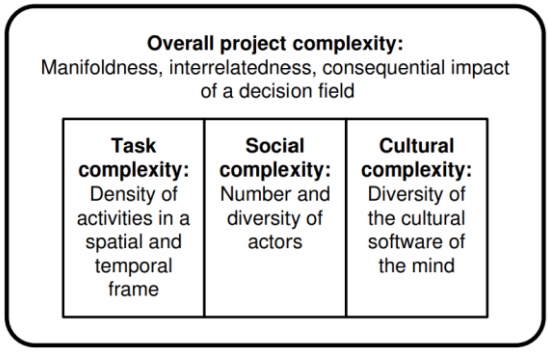

Fig. 2 Overall, Task, Social and Cultural Complexity [7].

Since it is easier to control project complexity rather than process complexity, managing and controlling task complexity by functional organization is a good choice. This will lead to minimizing the task complexity by ensuring well-allocating resources, deep communication, and good coordination. Cultural and social are processes that can not easily make it zero at the end of the project. The complexity process increases the overall project complexity if it cannot be understood and well-measured. The study presented a method for process complexity reduction through trust, commitment, and cultural sense-making. Figure 3 explains the overall complexity of project curves. It shows three scenarios with different environmental conditions. The first scenario presents smooth project processing within the planned scheduled time. While the second one shows a degree of complexity with important changes, the project is still delivered within a certain time. Finally, the curve shows extend out of schedule due to the settled disputes. Yumin Qiu et al. [17] illustrated that the megaproject organization stems from institutional and business logic they have to ensure their profitability. Institutional complexity is derived from macro and micro circumstance actors. The institutional complexity dimensions consist of rational, cultural, social, developments, and political complexity. At variance to traditional research that stems institutional complexity to institutional arrangements and participants' experience, this study provided the construction professionals with four mechanisms for efficient megaproject

organization to handle the institutional complexity. Figure 4 explains how the institutional complexity forms and works over the project life-cycle.

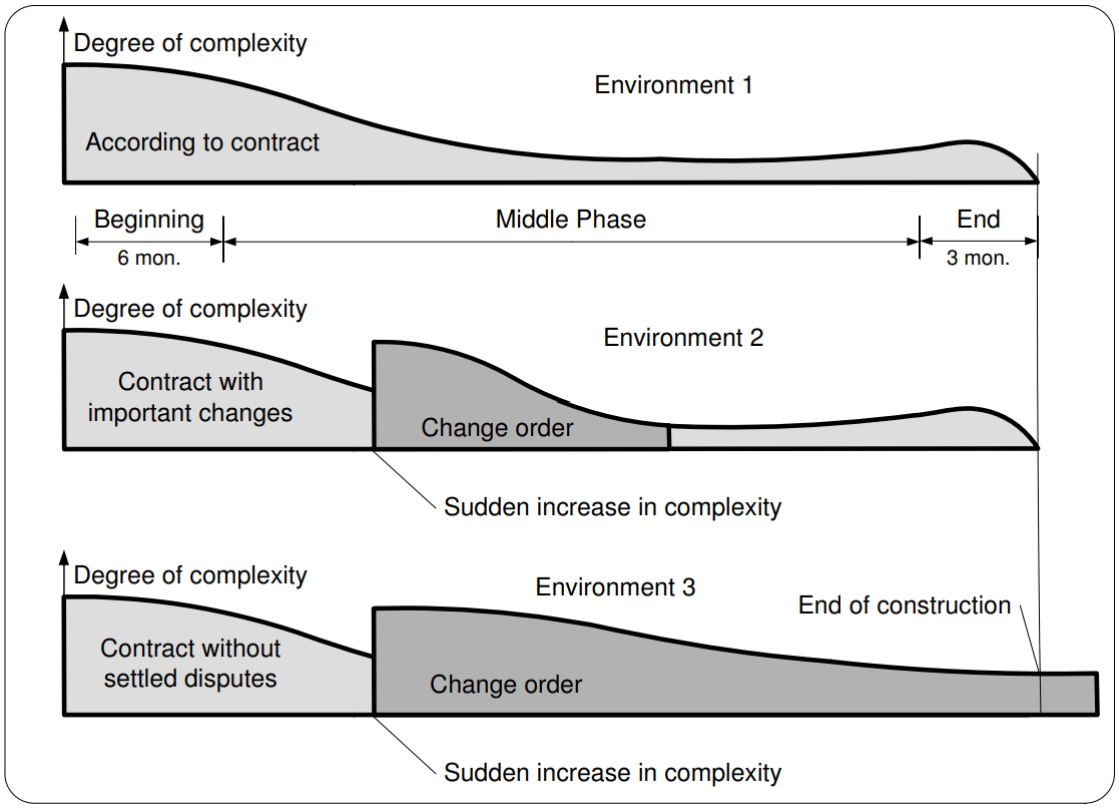

Fig. 3 Overall Complexity Curves [7].

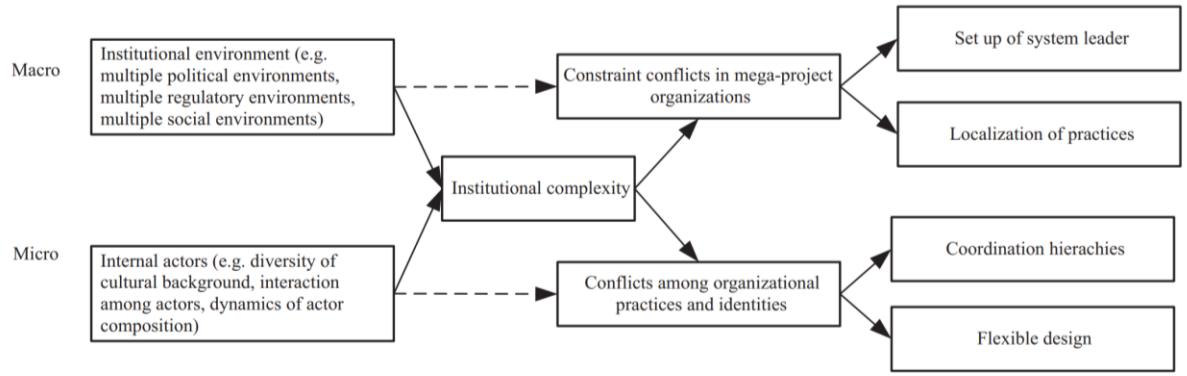

Fig. 4 Institutional Complexity Forms and Works Over Project Life-Cycle [17].

Gransberg [5] clarified the importance of adding two more dimensions to the traditional life cycle approach: cost, quality, and design. Financial arrangement and political/social context were added to the 3DPM in order to provide a base for the project manager to recognize controlled factors from uncontrollable factors. Applying 5DPM enhanced the project delivery and made complexity management more valuable. Qinghua He et al. [18] divided the complexity categories into six groups with a total of 28 subfactors. The groups, namely technological factors, goal complexity, culture complexity, environment complexity, organizational complexity, and information complexity, are shown in Fig. 5. The reason for aggregating the factors and subfactors was to prepare a suitable and effective complexity framework to measure the complexity of megaprojects. Table 1 shows the ranking of the 28's subfactors.

Table 1 Ranking of Complexity Measures [18].

Sub-factors	Mean Value	Ranking
Number of Organizational units and departments	3.90	1
Cross-organizational interdependence	3.85	2
Multiple Participating Countries	3.80	3
Multiple Stakeholders	3.75	4
Project team's trust	3.70	5
Sense of cooperation	3.70	6
Risk of using highly difficult technology	3.45	7
Cultural differences	3.40	8
Degree of Obtaining Information	3.40	9
Experience and Social Background of Organization Members	3.30	10
Dependence of relationship among tasks	3.30	11
Environment of changing policy and regulation	3.30	12
Interaction between the technology system and the external environment	3.20	13
Integration of more than one system or platform	3.20	14
Dynamics of task activities	3.15	15
Environment of changing technology	3.15	16
Information uncertainty	3.15	17
Dependence of technological processes	3.10	18
Uncertainty of goals	3.10	19
Uncertainty of project management methods and tools	3.10	20
Availability of resources and skills	3.10	21
Environment of changing economy	3.10	22
Capacity of transferring information	3.10	23
Diversity of technology in projects	3.05	24
Diversity of tasks	3.05	25
Level of processing information	3.05	26
No. of Organizational structure hierarchies	3.00	27
Environment of changing nature	2.95	28

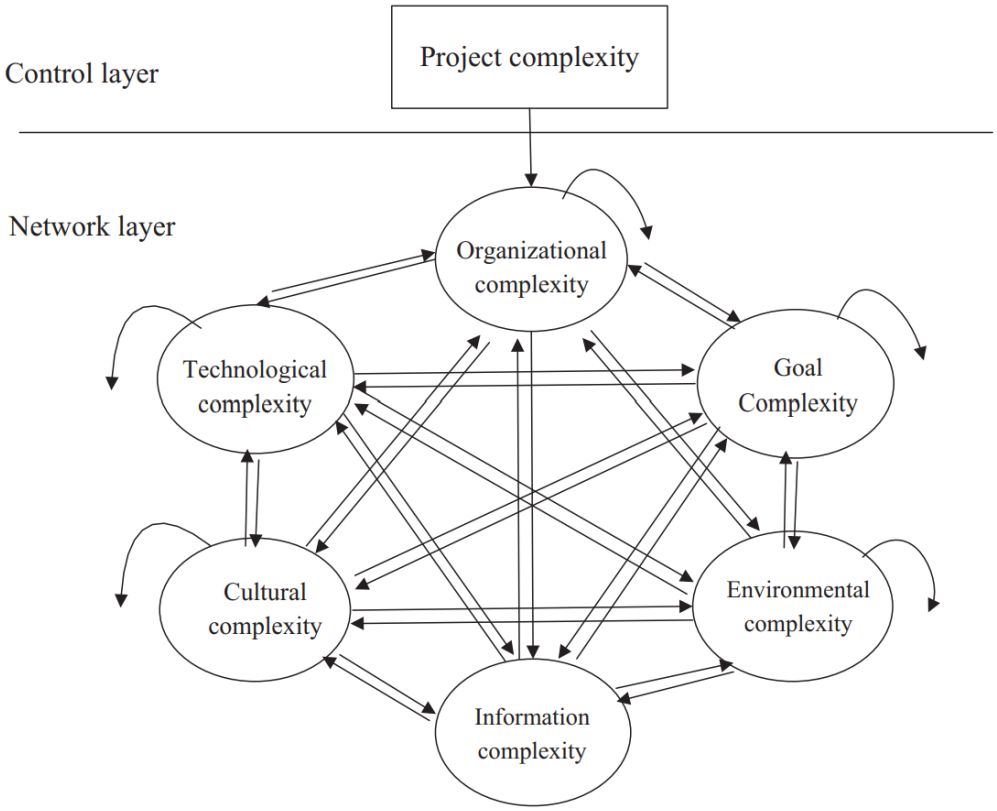

Fig. 5 ANP Structure for Project Complexity [18].

Ludovic-Alexandre Vidal et al. [19] proposed a systematic complexity framework. It consisted of more than 18 criteria related to the four main families: Project size, system dependencies, project system variety, and environmental and cultural context. The importance of Vidal's study was in making the user confident with the measurement and ensuring the users can easily understand the purpose of evaluating complexity. The Delphi process was used to correlate the six complexity dimensions. Table 2 illustrates that only 11.2% were technological complexity. The most complexity drives went into the organization complexity families. 61% of complexity drives went to project system interdependencies, 16.7% to variety, 16.7 context -dependence, and 5.6% to project size.

Table 2 Refined Project Complexity Framework [19].

Family	Organizational Complexity	Technological Complexity
Project system size	Number of stakeholders	
Project system Variety	Variety of information systems to be combined	
	Geographic location of the stakeholders and their mutual disaffection	
	Variety of the interests of the stakeholders	
Project system Variety	Dependencies on the Environment	Specifications interdependences
	Availability of people, material, and any of the resources due to share	
	Interdependence between site, departments, and companies	
	Interconnectivity and feedback loop in the task and project networks	
	Team cooperation and communication	
	Dependencies between schedules	
	Interdependence of information systems	
	Interdependence of objectives	
	Level of interrelation between phases	
	Processes interdependence	
Project System Interdependencies	Cultural configuration and variety	Environmental complexity (networked environment)
Project System Context-dependence	Environment complexity (networked environment)	

Table 2 examined these six complexities by analyzing six highly complicated megaprojects. The most complicated factors were cultural complexity, followed by organization and technology complexity. Finnally, the complexities were environmental and information complexity. Chapman [14] considered six main complexity dimensions. The dimensions were finance, context, management, site, task, and delivery. Figure 6 shows the suitable framework applied among the literature frameworks. Each of these main complexity factors consisted of some sub-factors: Context complexity branched to legal issues, technological complications, economic, political, social, developmental, financial, and cultural [20, 21].

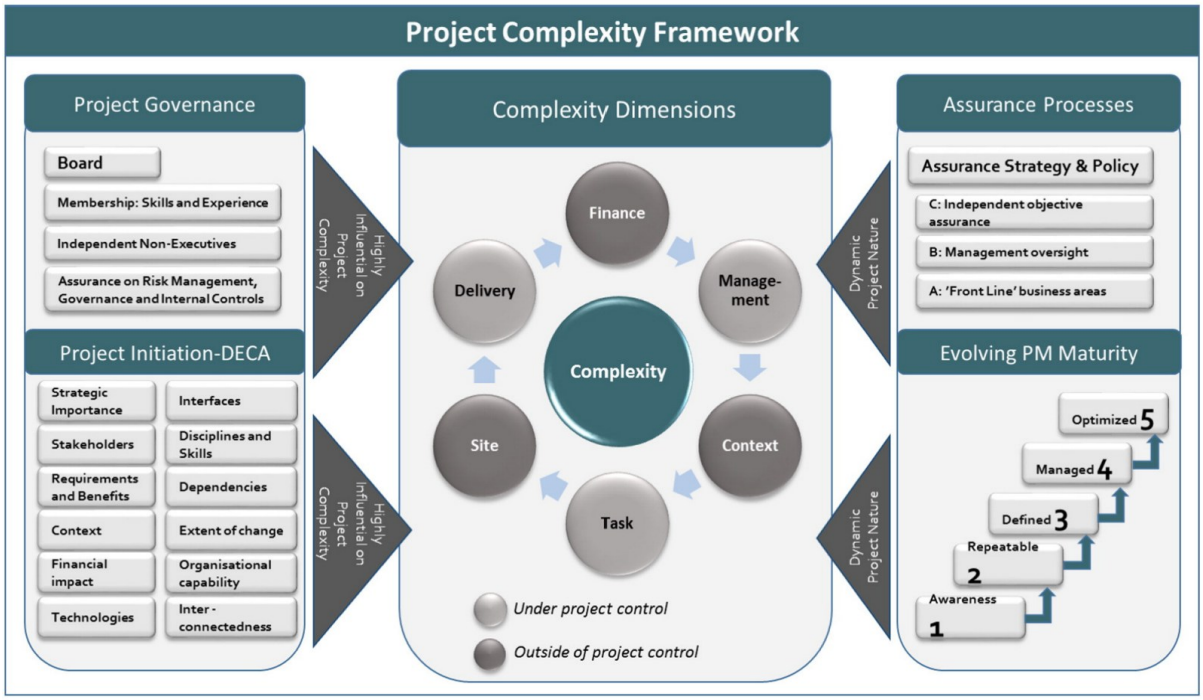

Fig. 6 Framework of the Sources of Project Complexity [14].

Based on the reviewed articles, the research's contributions to a megaprojects complexity, including the methodology they adopted to identify and asses complexity factors in mega projects, are shown in Table 3 below.

Table 3 Classifying Megaprojects Complexity According to Researchers.

Refs.	Methodology	Area of Study (complexity factors)
[22]	Delphi study for constructing framework The Analytic Hierarchy Process (AHP) builds the complexity index.	Employed resources Environmental Complexity Level of Scientific and technological knowledge Number of interactions in different parts of the workflow
[4]	Complex systems theory (CST) applications Computer simulations for phenomena analysis	Organizational evolution and social complexity
[23]	Qualitative Analysis is used to stimulate debate on project complexity.	Technological Complexity Organizational Complexity Organizational Complexity Goal Complexity Environmental Complexity Cultural and Information Complexity
[24]	Qualitative analysis, which accommodateddifferent epistemologies and conceptualizations.	Communication Complexity within the project Stakeholders and communication management
[25]	Delphi Study for constructing framework Platform Environment Control Interface (PECI) tools to compute complexity through case studies	Task Complexity Social Complexity Cultural Complexity
[5]	Graphically displays project complexity, complexity Mapping	Project Management complexity, which consisted of cost, schedule, technical, financial, social and political
[16]	Qualitative Analysis Micro-analysis and grounded theory coding	Task, social, and cultural complexity.
[12]	Qualitative Analysis using NVivo software Causal map to visualize interrelations between complexities	Communication complexity
[26]	Qualitative analysis approach	Institutional Complexity Regulatory complexity political complexity Cultural and Social complexity Relational Complexity
[11]	Delphi method Statistical analysis	Complexity in construction projects from the perspectives of owners, contractors, and consultants
[27]	Simulation model	Project complexity (Project Uncertainty, Infrastructure Newness, Interconnectivity, and Size)
[28]	Complexity measurement model (ANP) Fuzzy analytic network process (FANP) Delphi survey	Technological Complexity Organizational Complexity Goal Complexity Environmental Complexity Cultural and Information complexity

2.DISCUSSION AND COMPARISON

The complexity dimension is a core issue in megaprojects. Their most included dimensions in consideration of the clearest vision for the participants. Most of the literature's research aimed to provide an effective complexity framework based on the adaptive and essential complexity criteria and dimensions. Comprehensive and integrated factors make the task easier for decision-makers. Chapman categorized complexity as those that can be controlled under project management and others that are out of project management control [21]. All the reviewed research addressed the significance of project management to ensure the project scope and delivery. Vidal explained the significant managerial approach to simplifying and easily managing the project's complexity. The Shanghai Expo project is one of the most complicated megaprojects, and it wasfinished 11 days earlier than the contractual project completion. It attained the goal, quality, and safety environment requirements within the project budget due to applying good program management strategies [19]. Complexity changes over time. It must be considered and measured during the overall project life cycle. Chapman [14] explained that due to the most interest in the organization and technological factors in the earliest age of megaprojects, he neglected the overall project's complexity. So, he focused on finance and context complexity in his study. Christian Brockmann [7] supported Chapman's idea about the comprehensive project's complexity. He classified the mega projects into three stages. The first was where there was a mess, managers did not know each other, novel technologies may be used, all the participants wanted to show and implement their points of view, the designs were in their beginning, and all the activities interacted and showed as an urgent task. Decision-making during this stage was critical because a lot of decisions must be taken, and familiarity with the project was weak. Normally, it took about 6 months of the project duration to start the second stage with less complexity, but still, some complexity dimensions remain, such as cultural and social. Complexity returned at the last stage as an activity required an evaluation and work on it. The organization's complexity is

a significant factor in the project outcomes and shows the stakeholders' behaviors toward the project process. Qinghua He et al. [18] mentioned in their study that the key to success in organization complexity was the project breakdown structure (PBS). One solution to such complexity is hiring an expert consultant, which in turn establishes a client-led program. The program breaks the project into sub-projects, which are managed by an equally sub-project management team. Yumin et al. [17] provided some strategies to balance institutional complexity within the organization. Installing a leader system is effective in megaprojects as it solves conflicts with government, political, regulatory, and social issues. The leader system can be considered as a link between the organization and government's decisions to balance institutional complexity, and it supports the project teams in being efficient and creative. Megaproject complexity dimensions are important for the researcher to develop and provide a suitable framework. Frameworks provide a comprehensive and well-examined project's complexity dimensions, but there is still a gap compared with the project's complexity during the whole project life. Each framework provides a new vision or may add some other complexity dimensions. Chapman [14] suggested, in his study, that "for rail projects, they have added dimension of the impact of complexity on passenger safety during both trails and operation." Usually, this is reflected by the multidimensional approach with which the mega project issues can be addressed along the technical, organizational, and contextual aspects. Technical complexities comprise the obstacles with engineering, design, and construction techniques, frequently striving to improve technologies and implement innovative approaches. Organizational complexity is the main issue associated with coordinating different models of stakeholders, leveraging complex contracts, and integrating multidisciplinary teams situated in different locations. Contextual complexity, as such, denotes a continuous and dynamic exchange of relations of a project. Its external surroundings are regulatory frameworks, community socio-political, economic conditions, and environment.

4.NEW FINDINGS

Through improving knowledge and comprehensiveness in mega construction projects, the parties involved in those projects will be able to enhance the planning, implementation, and delivery of those projects in order to achieve much higher and sustainable heights in construction projects. This success can be achieved by:

- Improving communication management: communicating among the stakeholders and through the organizations is a focal point to smash the mystery and make the complexities much easier to accept and contain.
- Simulating and analyzing the emergence of new technologies before project performance may reduce the likelihood of complexity risks and improve risk management.
- Organizational regulations should be regulated and reorganized to adapt to multicultural work since they significantly influence the complexity of the framework in mega construction projects.
- All the previous megaproject frameworks will be more valuable and considerable if accompanied by a quantitative analysis of all the factors contributing to increasing the project's complexity.

5.CONCLUSIONS

Knowing the megaproject complexity characteristics and categories makes it much easier for decision-makers to provide a suitable framework and complexity dimensions. Traditional project management fundamentals may not be adapted to large-scale projects. Consequently, considering the overall dimensions of the megaproject complexity and passing through all layers and environments (micro and macro) of megaprojects will increase its success. Despite the lack of research on mega-construction complexity, some provide an effective framework to measure the megaproject complexity. Qualitative analysis and Delphi study are effective in simulating debate and identifying project complexity. Causal map methodology is also influenced to visualize the interrelation between the project's complexity. Still, more improvements are required because of facing a changeable environment. Multi institutions in the megaprojects made each institution follow their national regulation and rules since there is no general complexity framework to evaluate and measure the complexity of such projects. In developed countries, some complexity factors may be less focused than in developing countries.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

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REFERENCES

[1] Grun O. **Taming Giant Projects: Management of Multi-Organization Enterprises**. Berlin: Springer; 2004.

[2] Flyvbjerg B. **What You Should Know About Megaprojects, and Why: An Overview**. *Project Management Journal* 2014; **45**(2): 6–11.

[3] Lopez del Puerto C, Gransberg DD. **Measuring Complexity for Small Highway Projects**. Transportation Research Board Annual Meeting; 2015.

[4] Morel B, Ramanujam R. **Through the Looking Glass of Complexity: The Dynamics of Organizations as Adaptive and Evolving Systems**. *Organization Science* 1999; **10**(3): 278–293.

[5] Gransberg DD, Shane JS. **Managing Mega-Project Complexity in Five Dimensions**. The 6th International Conference on Construction Engineering and Project Management; 2015.

[6] Owens J, Shane J, Strong KC, Ahn J, Gransberg D. **Resource Allocation for Complex Highway Projects**. Transportation Research Board 90th Annual Meeting; 2011.

[7] Brockmann C, Girmscheid G. **Complexity of Megaprojects**. CIB World Building Congress; 2007; Cape Town, South Africa; pp. 219–230.

[8] Simon HA. **The Architecture of Complexity**. *Proceedings of the American Philosophical Society* 1962; **106**(6): 467–482.

[9] Baccarini D. **The Concept of Project Complexity—a Review**. *International Journal of Project Management* 1996; **14**(4): 201–204.

[10] Association for Project Management (APM). **Competence Framework**. Association for Project Management: Bucks, UK; 2008.

[11] Kermanshachi S, Rouhanizadeh B. **Identification and Quantification of Project Complexity from Perspective of Primary Stakeholders in US Construction Projects**. *Journal of Civil Engineering and Management* 2019; **25**(4): 298–311.

[12] Cakir H, Dikmen I, Atasoy G, Birgonul MT. **An Exploratory Study on Communication Complexity in Mega Construction Projects**. World Building Congress 2022; 2022.

[13] Kardes I, Ozturk A, Cavusgil ST, Cavusgil E. **Managing Global Megaprojects: Complexity and Risk Management**. *International Business Review* 2013; **22**(6): 905–917.

[14] Chapman RJ. **A Framework for Examining the Dimensions and Characteristics of Complexity Inherent within Rail Megaprojects**. *International Journal of Project Management* 2016; **34**(6): 937–956.

[15] Gidado KI. **Project Complexity: The Focal Point of Construction Production Planning**. *Construction Management and Economics* 1996; **14**(3): 213–225.

[16] Brockmann C, Girmscheid G. **Complexity of Megaprojects**. CIB World Building Congress: Construction for Development; 2007; Cape Town, South Africa; pp. 219–230.

[17] Qiu Y, Chen H, Sheng Z, Cheng S. **Governance of Institutional Complexity in Megaproject Organizations**. *International Journal of Project Management* 2019; **37**(3): 425–443.

[18] He Q, Luo L, Hu Y, Chan APC. **Measuring the Complexity of Mega Construction Projects in China—a Fuzzy Analytic Network Process Analysis**. *International Journal of Project Management* 2015; **33**(3): 549–563.

[19] Vidal L-A, Marle F, Bocquet J-C. **Measuring Project Complexity Using the Analytic Hierarchy Process**. *International Journal of Project Management* 2011; **29**(6): 718–727.

[20] Chapman RJ. **The Rules of Project Risk Management: Implementation Guidelines for Major Projects**. Gower Publishing; 2014.

[21] Chapman RJ. **The Commercial Imperative: Why Knowledge and Experience of Leading Risk Management Practices Makes Project Management Organizations More Competitive in the Market Place**. *PM World Journal* 2016; **V**(III): 1–10.

[22] Vidal L-A, Marle F, Bocquet J-C. **Measuring Project Complexity Using the Analytic Hierarchy Process**. *International Journal of Project Management* 2011; **29**(6): 718–727.

[23] Baccarini D. **The Concept of Project Complexity—a Review**. *International Journal of Project Management* 1996; **14**(4): 201–204.

[24] Geraldi J, Maylor H, Williams T. **Now, Let's Make It Really Complex (Complicated): A Systematic Review of the Complexities of Projects**. *International Journal of Operations & Production Management* 2011; **31**(9): 966–990.

[25] Mirza E, Ehsan N. **Quantification of Project Execution Complexity and Its Effect on Performance of Infrastructure Development**

Projects. *Engineering Management Journal* 2017; **29**(2): 108–123.

[26] Qiu Y, Chen H, Sheng Z, Cheng S. **Governance of Institutional Complexity in Megaproject Organizations**. *International Journal of Project Management* 2019; **37**(3): 425–443.

[27] Lebcir RM, Choudrie J. **A Dynamic Model of the Effects of Project Complexity on Time to Complete Construction Projects**. *International Journal of Innovation, Management and Technology* 2011; **2**(6): 477–482.

[28] He Q, Luo L, Hu Y, Chan APC. **Measuring the Complexity of Mega Construction Projects in China—a Fuzzy Analytic Network Process Analysis**. *International Journal of Project Management* 2015; **33**(3): 549–563.