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Examination and Identification of Critical Success Factors (CSFs) and the Application of Three-Factor Effects in Construction Companies

Farhad. Eftekhari[1], Davod. Pouriyan[1*], Kambiz. Takeen[1]

[1] Department of Civil Engineering, ShQ.C., Islamic Azad University, Shahr-Qods, Iran

*** Corresponding author email address**: dr.dpouriyan@iau.ir

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ABSTRACT

The purpose of this study was to identify and analyze the Critical Success Factors (CSFs) and examine the application of three-factor effects in construction companies. To achieve this objective, a systematic review of the literature, extraction of key factors, expert surveys, and data analysis using Delphi, AHP, ANP, and DEMATEL methods were employed. The findings indicated that the success of construction projects is highly dependent on factors related to project planning, team management, and organizational structures. The DEMATEL analysis revealed the causal and effect relationships among the internal criteria, and the final model, using the ANP supermatrix, determined the final weights of the CSFs. Additionally, this research used factor analysis, which identified 10 variables representing the criteria. In order of priority, these include meeting the planned quality standards, cost transparency, selection through tendering, enhancing coordination among project phases, improving teamwork between project designers and contractors, attention to time criteria and reducing delays in project execution, the presence of enforcement guarantees to achieve commitments and increase credibility, user safety, noise pollution during construction, and environmental protection, all of which predict the likelihood of project success. These results can assist project managers in improving performance and reducing risk.

Keywords: *Project success, CSF, DEMATEL, ANP, Delphi, construction projects*

1. Introduction

The construction industry occupies a foundational role in national development, infrastructure expansion, and socio-economic progress, yet it remains one of the most risk-intensive and management-complex sectors worldwide. Increasing project size, dynamic environments, technological transformations, and rising sustainability expectations have intensified the need for more robust frameworks that explain why some construction projects succeed while many others underperform or fail. In recent years, research has emphasized that project success is no longer determined solely by traditional indices such as time, cost, and quality; instead, it is shaped by multidimensional organizational, technological, environmental, and human-centered factors that interact in complex ways. Within this evolving landscape, the identification of Critical Success Factors (CSFs) and the analysis of interdependent influences have become fundamental for advancing project performance, increasing resilience, and improving decision-making in construction projects (Wang & Wang, 2024).

As construction companies navigate heightened uncertainty, workforce transitions, and digital transformation, new paradigms in project governance and risk management are emerging. The need for improved behavioral, managerial, and structural capabilities has been emphasized across global studies. For example, analyses of project tasks and workforce capabilities reveal that employee resilience significantly enhances organizational resilience in construction environments, stressing the importance of adaptive and human-centered management practices (Wang & Wang, 2024). At the same time, the rapid expansion of digital ecosystems and integrated information platforms has altered traditional models of collaboration and communication. Research on digital ecosystems in construction development projects shows that transforming conventional project environments into integrated, data-driven systems can facilitate higher levels of coordination and performance consistency across phases (Bartko et al., 2024). Such insights indicate that CSFs are not static; they evolve in response to global technological and organizational shifts.

Parallel to these developments, the increasing integration of digital technologies such as Building Information Modeling (BIM), big data analytics, and smart contracts has profoundly reshaped planning, design, and execution processes. Studies examining the features of BIM for project-management knowledge areas demonstrate how advanced digital tools enable real-time collaboration, risk visualization, and streamlined decision cycles, improving both transparency and accountability (Raza et al., 2023). However, despite clear benefits, operational barriers still impede the adoption of smart contract technologies, including legal ambiguity, lack of stakeholder familiarity, and resistance to systemic change (Künkcü et al., 2023). The slow integration of digital tools is also evident in public-sector construction projects, where technologies remain underutilized due to financial, administrative, and capacity-building constraints (Camngca et al., 2024). Hence, a key CSF increasingly recognized is the organization’s ability to leverage engineering technologies and adapt to digital project environments.

Another major stream of research highlights the growing complexity of risk assessment and mitigation in construction projects. The frequency of project delays, budget overruns, and quality deviations in developing and developed countries alike has been attributed largely to insufficient identification of interdependent risks. For international and large-scale projects, risk networks are particularly intricate; studies applying DEMATEL show how causal relationships among risks can amplify uncertainties and trigger cascading failures (Zhu et al., 2022). Comprehensive risk identification is therefore essential for early detection of vulnerabilities and for establishing clear chains of accountability. In contexts such as Bangladesh, where construction projects face chronic managerial and logistical challenges, identifying critical project-management success factors has been shown to significantly reduce failure rates and improve contractor performance (Datta et al., 2023). Likewise, research in Iraq demonstrates that capturing and allocating significant risk factors in school construction projects improves project execution and resource allocation efficiency (Abed, 2023). Together, these studies underscore the vital role of risk sensitivity and proactive risk-management frameworks as dominant CSFs.

Growing attention has also been directed to human-resource and organizational competencies, especially in project-based firms. Ambidextrous leadership, characterized by the ability to balance flexibility with control, has been found to promote innovation via improved knowledge-sharing behaviors among employees (Haider et al., 2023). This is particularly relevant in construction settings where decentralized teams, multidisciplinary actors, and shifting project roles require managers to cultivate environments that support collaboration and collective problem-solving. Similarly, evidence shows that effective assessment of training needs significantly influences workforce capability, productivity, and error reduction in construction projects (Rasouli et al., 2024). Without systematic training, projects face skill gaps that can impede planning accuracy, coordination, safety enforcement, and project-phase integration. Thus, human-resource development remains one of the most frequently cited CSFs in global studies.

Alongside human-resource capacities, managerial competencies and strategic decision-making are crucial for reducing uncertainties and enhancing project outcomes. Project managers in the era of digitalization require new sets of competencies, including data literacy, digital communication skills, virtual collaboration management, and familiarity with automated tools for scheduling and monitoring (Kissi et al., 2024). Traditional supervisory models are insufficient for digitally intensive environments where complex information systems must be integrated into planning and execution. Research on social media use in construction teams shows that digital communication also contributes to improved feedback mechanisms and enhanced team performance, indicating that digital capabilities directly shape team dynamics and productivity (Karimi et al., 2024). The expansion of digital literacy and managerial digital competence has therefore emerged as a CSF with rising importance in contemporary construction practice.

A complementary dimension of success relates to project monitoring and performance evaluation. Earned Value Management (EVM), Earned Duration Management (EDM), and Earned Schedule Management (ESM) are widely recognized as critical tools for establishing performance benchmarks and controlling deviations. Analytical studies show that the integration of these project-control systems enhances accuracy in forecasting, clarifies work-progress assessments, and strengthens decision-making in schedule-driven environments (Andreas, 2023). Moreover, multi-objective optimization approaches for time-cost tradeoff modeling demonstrate that productivity improvement measures and optimization algorithms significantly contribute to success by helping managers resolve competing constraints across project modes (Mohammadjafari et al., 2024). These insights indicate that analytical modeling, monitoring tools, and optimization algorithms form a core category of CSFs related to performance control.

Concurrently, the increasing concentration on project ethics, stakeholder relations, and organizational behavior underscores the importance of social and behavioral variables in determining project outcomes. For instance, research on collective moral judgment shows that in infrastructure projects, unethical pro-organizational behaviors may emerge when teams prioritize organizational loyalty over ethical considerations, mediated by psychological traits such as Machiavellianism (Xiong et al., 2023). This highlights the need for projects to establish clear ethical guidelines, transparent communication practices, and well-balanced incentive systems to prevent ethical drift. Transparency also plays a crucial role in shaping trust and cooperation among contractors, clients, and regulatory entities. Studies examining smart-contract adoption show that lack of transparency, legal clarity, and stakeholder trust directly hampers implementation (Taleshalipour, 2024). Transparency, accountability, and stakeholder communication therefore remain critical behavioral and relational CSFs.

In addition to ethical behaviors, macro-environmental conditions, regulatory frameworks, and economic stability exert strong influence on project performance. Many construction projects operate within volatile economic systems where inflation, market instability, and rapid policy changes affect procurement, labor availability, material pricing, and contractor reliability. Empirical evidence confirms that macroeconomic stability is essential for ensuring continuity, reducing cost variability, and lowering systemic vulnerabilities in construction activities (Swetha et al., 2024). The external environment also includes technological, legal, political, and ecological conditions that shape expectations and constraints. For example, regulatory challenges and environmental compliance issues frequently determine the feasibility and time frameworks of construction projects (Zhu et al., 2022). In this context, CSFs increasingly incorporate external-environment elements such as permitting processes, environmental regulations, site access limitations, and community acceptance.

Moreover, sustainability and environmental responsibility have become indispensable elements of project success. The global mandate for carbon-reduction strategies, energy-efficient building designs, and environmentally responsible construction practices has intensified pressure on construction companies to adopt green standards and sustainable performance frameworks. Studies examining sustainability-related criteria highlight factors such as waste management, noise reduction, energy efficiency, and user safety as essential contributors to long-term project success and social acceptance (Zhu et al., 2022). Projects that integrate sustainability from early-stage planning through execution demonstrate higher operational efficiency, reduced rework, and improved stakeholder satisfaction.

Taken together, the existing body of literature illustrates that the success of construction projects is multi-dimensional, interdependent, and context-sensitive. CSFs span managerial, organizational, behavioral, technological, environmental, and sustainability-related domains. They form complex networks in which changes in one factor influence multiple others. As a result, recent studies emphasize the need to adopt analytical approaches that account for interrelationships, such as DEMATEL, ANP, and hybrid multi-criteria decision-making models. These methods capture causal pathways, feedback loops, and priority structures that conventional linear models cannot adequately represent. Such analytical integration is reflected in research across various countries and disciplines, acknowledging that CSFs must be identified, evaluated, and prioritized based on systemic relationships rather than isolated analysis.

Given the complexity of construction projects and the diverse set of factors influencing their outcomes, it is essential to develop a comprehensive model that identifies and prioritizes Critical Success Factors while analyzing their internal interactions through advanced multi-criteria decision-making techniques; therefore, the aim of this study is to identify and prioritize the Critical Success Factors (CSFs) in construction companies and analyze their interrelationships using Delphi, ANP, and DEMATEL methods.

2. Methods and Materials

The present study, based on its nature and methodology, is a descriptive–survey research and, in terms of purpose, falls within the category of applied studies. The target population consisted of experts and senior specialists in the field under investigation who had more than 10 years of work experience in stakeholder management within construction projects and were knowledgeable and experienced in this area. Given the importance of the topic and the collected opinions, the questionnaire was distributed among 10 experts and specialists in construction projects.

In this study, interviews and questionnaires were used as data collection tools. These questionnaires were designed based on a 9-point scale. The expert questionnaire was developed using Saaty's pairwise comparison model, through which the relative importance of the criteria was estimated using numerical values consistent with the principles of the Analytic Network Process (ANP).

The Delphi technique was used to screen the sub-criteria, while the Analytic Network Process (ANP) and DEMATEL techniques were applied to determine and prioritize the sub-criteria and to measure the internal relationships among the criteria. Accordingly, a pairwise comparison matrix was used to determine the weights of the criteria. The present study was conducted in several stages using multiple techniques. The computations related to the Delphi method and ANP were performed using Decision Super software.

Delphi Technique

In the first phase of this study, the Delphi technique was employed to refine and identify CSFs consistent with stakeholder management in construction projects. The expert panel was formed based on a combination of specialists with diverse areas of expertise, and a sample of 10 individuals was used.

Algorithm for Using ANP

In this study, the Analytic Network Process (ANP) was implemented to determine the priorities of criteria and sub-criteria through a matrix-based approach in five steps. First, using the research literature and expert opinions, the main criteria were identified and finalized through the Delphi method. Next, these criteria and alternatives were compared pairwise, and the initial weight vectors (W21 and W32) were computed. In the following step, the internal relationships among criteria and sub-criteria—representing the main advantage of ANP over AHP—were identified, and their weights were entered into the model as vector W22. After forming the initial (unnormalized) supermatrix, a weighted normalization process was conducted to generate the weighted supermatrix and subsequently the limit supermatrix, from which the final priorities of criteria and sub-criteria were extracted. Finally, the consistency of expert judgments was assessed through the calculation of the Consistency Ratio (CR), with comparisons having a CR below 0.1 considered acceptable.

DEMATEL Technique

The DEMATEL technique, developed in the late 1980s based on the works of Gabus and Fontela (1976), is a powerful tool for analyzing complex issues and identifying interrelationships among factors. This method converts expert judgments into a direct-relation matrix and, after normalization and computation of the total relation matrix, enables the examination of the intensity and direction of influence among factors. DEMATEL not only structures a broad set of factors into causal and effect groups but also offers an important advantage by clarifying internal relationships and existing feedback among components. The resulting matrix is also used as a critical subsystem in forming the ANP supermatrix. By calculating the D (influence) and R (influenced) indices and deriving the values of R + D and R – D, the extent of interaction and the role of each factor can be determined; factors with a positive R – D are classified as causal, whereas those with a negative R – D fall into the effect group. Graphical representation of these values in a causal diagram provides a more precise understanding of the position and role of factors in the mutual influence process.

The factors contributing to the success of CSFs and the application of three-factor effects in construction companies are initially identified through previous studies in the field. Several leading databases, including Elsevier, Taylor &

Francis, ASCE, and Springer, will be searched using keywords such as “stakeholders,” “project partners,” and “project environment.” These journals will be reviewed to draw conclusions regarding CSFs in three-factor contractual models within construction companies. Based on the literature review, factors contributing to success in three-factor contractual arrangements will be proposed and formulated into hypotheses.

The questionnaire consists of four sections: respondents’ background, attitudes and reactions in stakeholder management, key issues related to stakeholders, and statements regarding the questionnaire. The target respondents are project managers from various organizations within the construction industry. The questionnaire will be emailed to potential respondents. They will be asked to indicate their level of agreement with each identified CSF on a scale of 1 to 5, citing the project in which they were involved. After several weeks, the completed responses will be returned. The return method includes email communication. The raw data obtained will be entered into SPSS and analyzed accordingly.

3. Findings and Results

According to the research technique, in the first stage a questionnaire containing the intended sub-criteria was provided to each member of the expert group. The selected experts—10 specialists familiar with all aspects of the subject—evaluated each sub-criterion individually using the Delphi method. For the initial screening of the identified sub-criteria, scores ranging from 1 to 10 were assigned, and sub-criteria with scores below 7 were removed. From the perspective of the experts, most of the eliminated sub-criteria had semantic overlap with other criteria. The Delphi technique continued for two rounds and was concluded in the second round after reaching final consensus. The results obtained from the Delphi technique are presented in the tables.

The results of the first round of the Delphi technique showed that nearly all sub-criteria in the five clusters—“Project and Planning,” “Project Team,” “Organization,” “External Environment,” and “Sustainability”—received acceptable mean values and high importance from experts for entering subsequent stages of analysis. In the project planning domain, components such as “urgency,” “agile processes,” and “quality standards” received the highest scores. In the project team domain, sub-criteria such as “team development and deployment of skilled labor” and “teamwork development” received the greatest attention. In the organizational dimension, criteria such as “continuous performance measurement” and “accurate technical understanding” received high averages. In the external environment, “stakeholder expectations,” “economic stability,” and “attention to time and delay reduction” were emphasized. Finally, in the sustainability cluster, “coordination among project phases,” “user safety,” and “environmental protection” received the highest scores. These results indicate that, from the experts’ viewpoint, a broad set of managerial, organizational, environmental, and sustainability-related factors are essential for the success of construction projects, and none of the domains can be excluded.

The results of the final round of the Delphi technique showed that almost all sub-criteria across the five main domains—“Project and Planning,” “Project Team,” “Organization,” “External Environment,” and “Sustainability”—received very high mean scores and full expert confirmation. In project planning, indicators such as “realistic objectives,” “selection through tendering,” “agile processes,” and “quality standards” obtained mean scores above 9, demonstrating their critical importance. In the project team domain, criteria such as “team development and deployment of skilled labor,” “training and awareness,” “fulfilling commitments,” “project life cycle,” and “adequate experience” received the highest scores. Within the organizational dimension, key factors included “organizational structure,” “continuous performance measurement,” “technology implementation,” “preservation of skills and personnel,” and “application of lessons learned.” In the external environment, “stakeholder expectations,” “macroeconomic stability,” and “cost transparency” achieved the highest consensus. Finally, in sustainability, sub-criteria such as “coordination among project phases,” “construction cost,” “noise pollution,” and “health and safety” received the strongest expert approval. These results demonstrate that the selected sub-criteria enjoy strong scientific validity and complete consensus, making them appropriate as final CSFs for subsequent analyses.

To measure the consistency of expert opinions, the Kendall coefficient of concordance for the Delphi sub-criteria was calculated:

Table 1

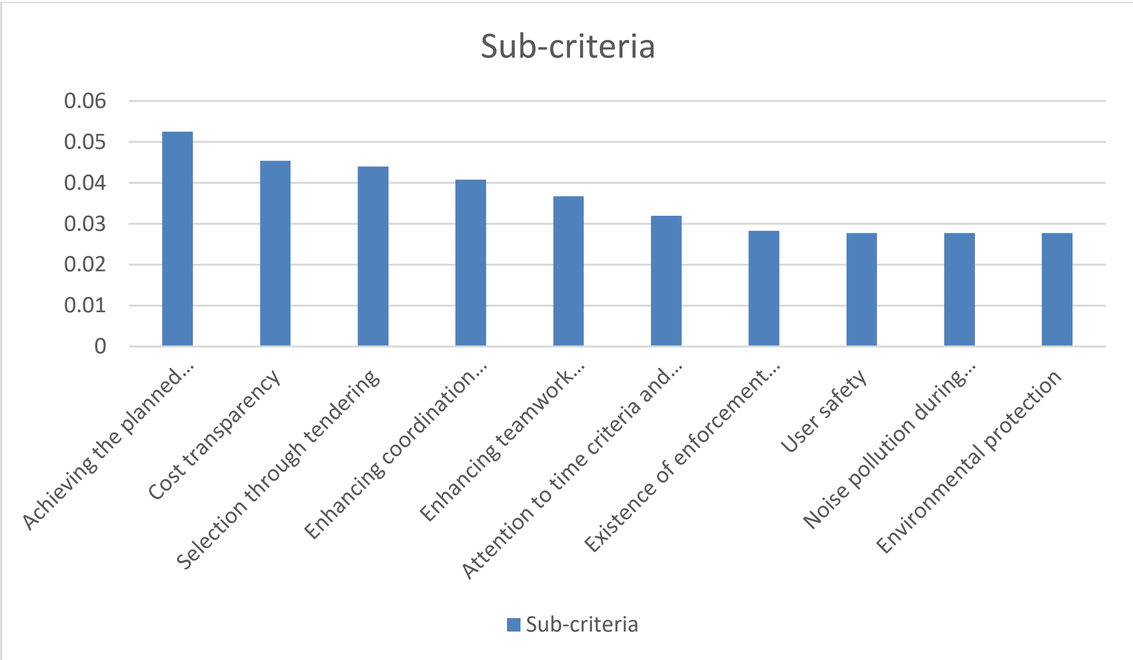
Kendall's Coefficient of Concordance for Delphi Sub-Criteria

Round	Number of Sub-Criteria	Number of Experts	Degrees of Freedom	Kendall's W	Significance
First Round	51	10	50	0.315	0.000
Second Round	44	10	43	0.321	0.000

According to the objective of the study, and based on the identified criteria and sub-criteria, an appropriate Analytic Network Process model was designed in Super Decisions software. Based on this model, the ANP analysis process diagram is presented.

Figure 1

ANP diagram of sub-criteria prioritization in Super Decisions



To determine the priorities of the main criteria in accordance with the objective of the study, pairwise comparisons were conducted with the participation of the expert group. Their judgments were aggregated using the geometric mean and then normalized to compute the eigenvector and final weight of each criterion. The resulting inconsistency ratio was 0.085, which is below the acceptable threshold of 0.1; therefore, the pairwise comparisons demonstrated acceptable consistency and the results are reliable.

Based on the eigenvector, the criterion "Organization" with a weight of 0.417 was identified as the most important factor in project success. This was followed by "External Environment" (0.264) and "Sustainability" (0.181) in second and third place, respectively. "Project Team" (0.071) and "Project and Planning" (0.066) ranked lowest. These findings indicate that organizational structure and maturity, macro-environmental conditions, and sustainability factors exert greater influence on the success of construction projects.

1. Priority of Sub-Criteria in "Project and Planning"

The results of the pairwise comparisons for the "Project and Planning" cluster show that experts assign the greatest importance to design quality and contractor selection structure. The sub-criterion "Achieving planned quality standards" ranked first with a weight of 0.262. It was followed by "Selection through tendering" (0.220) and "Agile project processes" (0.127). Other sub-criteria in descending order include "urgency" (0.108), "realistic objectives" (0.085), "cost-effectiveness and cash flow planning" (0.070), "alignment of the project with corporate strategy" (0.068), and "minimum project scope change" (0.059). The inconsistency ratio was 0.068, indicating acceptable precision in expert judgments.

2. Priority of 11 Sub-Criteria Related to "Project Team"

Based on 55 pairwise comparisons, the results showed that human resource empowerment plays the greatest role in project team performance. The sub-criterion "Training, development, and awareness of human resources" ranked first with a weight of 0.125. It was followed by "Planning and good planning methods" (0.123) and "Team development and deployment of skilled labor" (0.121). "Teamwork development" ranked fourth with a weight of 0.117, highlighting the importance of cooperation and internal synergy.

In middle ranks, sub-criteria such as "competent management," "risk management," "stakeholder consultation," and "fulfilling commitments" play supportive roles in team performance. The lowest-ranked items included "project life-cycle management processes," "adequate experience," and "information sharing." The inconsistency ratio was 0.073, below 0.1, confirming acceptable reliability.

3. Priority of Sub-Criteria Related to "Organization"

In the organizational cluster, the most important sub-criterion was "Application of lessons learned from previous projects" with a weight of 0.190, indicating the importance of organizational learning and error prevention. The second and third ranks were assigned to "Enhancing teamwork between designers and contractors" (0.152) and "Good stakeholder relations" (0.117).

Subsequent priorities included "organizational maturity level" (0.107), "performance measurement" (0.089), and "adequate managerial support" (0.088). The lower-ranked sub-criteria included "availability of adequate resources" (0.084), "technical understanding" (0.066), "implementation of appropriate technology" (0.056), and "organizational project structure" (0.050). The inconsistency ratio was 0.043, demonstrating strong accuracy.

4. Priority of Sub-Criteria for "External Environment"

The results indicate that economic and regulatory factors play the greatest role in the project's external environment. The sub-criterion "Cost transparency" ranked first with a weight of 0.226, highlighting the essential role of financial clarity. It was followed by "Attention to time and delay reduction" (0.159) and "Awareness of environmental issues and regulations" (0.129).

Additionally, "macroeconomic stability" (0.125) and "construction permitting" (0.120) represented mid-level priorities. "End-user constraints" (0.092), "stakeholder expectations" (0.077), and "compliance with national specifications" (0.071) ranked lowest. The inconsistency ratio of 0.072 confirms the reliability of the analysis.

5. Priority of Sub-Criteria in "Sustainability"

The results of 21 pairwise comparisons indicated that "energy consumption" held the highest importance with a weight of 0.187. It was followed by "recycling and waste management" (0.180) and "construction cost" (0.165).

Subsequent priorities included "public comfort, health, and safety" (0.139), "noise pollution during construction" (0.126), and "user safety" (0.112). "Environmental protection" ranked lowest with a weight of 0.090. The inconsistency ratio of 0.046 confirms the high consistency of judgments.

4. Discussion and Conclusion

The findings of this study provide a comprehensive and structured understanding of the Critical Success Factors (CSFs) that shape the performance and success of construction projects. By applying Delphi, ANP, and DEMATEL techniques, the results highlight the multidimensional and interconnected nature of project success and emphasize that no single domain—organizational, environmental, team-based, planning-related, or sustainability-related—can independently ensure positive outcomes. Instead, these domains collectively form an integrated ecosystem that determines project performance. The prominence of "achieving planned quality standards," "cost transparency," "selection through tendering," "coordination between project phases," and "teamwork enhancement between designers and contractors" demonstrates that construction projects succeed when both technical and relational dimensions of project design and execution are synchronously optimized. This aligns with existing global research which similarly argues that project success arises from balanced integration of technical efficiency, managerial capacity, and stakeholder-centered collaboration (Datta et al., 2023).

The emerged dominance of organizational factors—including the highest weighting of organizational maturity, performance measurement, and the application of lessons learned—supports the argument that construction project outcomes are heavily dependent on the internal structures, governance systems, and managerial processes of the executing organization. This is consistent with previous studies that emphasize organizational resilience as a key determinant of project success, with resilient organizations demonstrating greater capacity to navigate uncertainty, manage risks, and maintain continuity in complex environments (Wang & Wang, 2024). The strong effect of organizational maturity and internal capability also corresponds with studies highlighting project-manager competencies in the digital age, particularly the ability to manage information, coordinate stakeholders, and use digital tools for performance monitoring (Kissi et al., 2024).

Furthermore, the findings identify the external environment—especially cost transparency, regulatory compliance, macroeconomic stability, and timely permitting—as the second-most influential cluster. This outcome aligns with research emphasizing that external macroeconomic and regulatory conditions shape the feasibility, schedule, and cost outcomes of construction activities (Swetha et al., 2024). Construction projects often operate within volatile contexts, and changes in financial conditions, regulatory standards, or environmental requirements can introduce unexpected complexities. Studies on international construction risk have similarly shown that interdependent risk categories often create cascading impacts that alter schedule, quality, and cost outcomes (Zhu et al., 2022). The DEMATEL results in the present study confirm these interdependencies by demonstrating that external factors frequently act as receivers in causal structures, absorbing impacts from internal management systems and project-planning processes.

The team-related findings emphasize the importance of human-resource empowerment, training, and professional development, which aligns with available literature on knowledge-sharing and innovation in project-based firms. Research on ambidextrous leadership shows that collaborative, flexible, and knowledge-centered team environments enhance innovation outputs and problem-solving capacity (Haider et al., 2023). Similarly, systematic training-needs assessment contributes to improved performance, reduced errors, and more effective alignment of worker capabilities with project requirements (Rasouli et al., 2024). In this study, expert consensus also highlighted that the capacity of project teams to collaborate, manage risks, and fulfill commitments constitutes an essential CSF, reflecting findings from international studies that stress the centrality of human capital and team dynamics in construction performance (Raza et al., 2023).

The results further highlight digital transformation as a rising influence on CSFs. The emphasis on cost transparency, agile processes, and performance measurement aligns with research showing that digital tools—such as BIM, social media communication platforms, and digital ecosystems—improve project oversight, inter-team coordination, and decision-making (Camngca et al., 2024). Moreover, studies exploring social media use in construction teams suggest that digital communication strengthens feedback cycles and improves overall team performance (Karimi et al., 2024). This confirms that digital literacy and the ability to utilize modern communication and monitoring tools have become integral success factors in contemporary construction management.

In addition to team and organizational capabilities, the prioritization of planning-related CSFs—specifically achieving planned quality standards, tender-based selection, and the use of agile project-management processes—reveals that technical efficiency remains foundational to project performance. This corresponds to studies showing that structured monitoring techniques such as Earned Value Management (EVM), Earned Duration Management (EDM), and Earned Schedule Management (ESM) greatly improve accuracy in forecasting and controlling project deviations (Andreas, 2023). Moreover, multi-objective optimization models support the view that project managers must increasingly rely on quantitative modeling to balance time, cost, and quality considerations under varying productivity constraints (Mohammadjafari et al., 2024). These findings reinforce the conclusion that effective planning is inseparable from analytical rigor and that a scientifically grounded planning process is a core CSF for project success.

The sustainability-related findings—particularly the importance of energy consumption, waste management, noise reduction, user safety, and environmental protection—reflect the global shift toward sustainable development. Existing research has shown that environmental compliance, safety standards, and community acceptance increasingly influence project continuity and organizational reputation (Zhu et al., 2022). Furthermore, studies examining the digital transformation of construction ecosystems argue that the integration of sustainability data, monitoring technologies, and environmental dashboards strengthens the capacity of construction organizations to meet regulatory and societal expectations (Bartko et al., 2024). The high prioritization of sustainability in this study therefore confirms that modern CSFs must extend beyond operational concerns to include the long-term ecological and social impact of construction activities.

Notably, the DEMATEL causal analysis in this study provides deeper insights into the relational dynamics of project success. The identification of the organizational domain as the strongest causal factor, and the project team and external environment as key effect factors, aligns with systems-based interpretations of the construction project ecosystem, where organizational leadership, resource allocation, and governance mechanisms create ripple effects that shape project outcomes. This is supported by the literature arguing that ethical behaviors, stakeholder expectations, and managerial decisions propagate through the project system with significant effects on team behavior and project transparency (Xiong et al., 2023). Similarly, research on smart contract adoption indicates that organizational clarity, trust, and stakeholder communication strongly affect the implementation of technological innovations (Taleshalipour, 2024). The present findings reinforce the idea that robust organizational systems must precede technological or procedural improvements to ensure project-wide impact.

The strong performance of criteria such as “selection through tendering,” “cost transparency,” and “user safety” also highlights the importance of accountability and regulatory robustness. This aligns with the existing body of literature which emphasizes that transparent procurement processes, regulatory compliance, and adherence to safety standards are essential in preventing corruption, minimizing project disputes, and enhancing stakeholder trust (Almutahir, 2024). Clear procurement structures also reduce uncertainty and promote competitive bidding, contributing to higher-quality contractor selection and improved project outcomes (Abed, 2023). The confirmation of these factors in this study suggests that accountability remains a universal CSF across diverse construction contexts.

Overall, the results of this study strongly align with the current body of international research on CSFs in construction management. They support the idea that organizational maturity, digital capability, team competence, sustainability integration, planning accuracy, and external-environment management are interconnected determinants of project success. By integrating Delphi, ANP, and DEMATEL, the study offers a holistic model that captures the complexity of these interactions and provides a structured prioritization of CSFs for construction companies and policymakers.

This study, despite its methodological rigor, is constrained by several limitations. First, the sample size of experts, although consistent with Delphi-based methodologies, reflects a relatively small representation of the broader construction industry and may limit generalizability to other regions or sectors with different regulatory, economic, or cultural conditions. Second, the use of expert judgment may inherently introduce subjective biases, especially in pairwise comparisons required for ANP, which depend on the consistency and accuracy of participant evaluations. Third, the study’s focus on a specific set of CSFs may overlook contextual factors such as regional political stability, contractor availability, or supply-chain disruptions that were not explicitly included in the analysis. Finally, the cross-sectional nature of data collection prevents the examination of how CSFs evolve during different stages of the project lifecycle.

Future studies should consider expanding the expert panel to include international participants in order to enhance cross-cultural validity and increase the generalizability of results. Longitudinal research would also be beneficial to explore how CSFs shift during various phases of construction projects, particularly in response to digital transformation and emerging regulatory frameworks. Further research may employ hybrid multi-criteria methods or machine-learning models to compare the predictive power of different techniques in identifying CSFs. Additionally, examining CSFs across different project types—such as residential, industrial, and mega-infrastructure projects—could refine factor prioritization for specialized construction environments. Finally, integrating sustainability performance metrics and digital traceability tools into CSF frameworks may reveal new insights into environmental and technological readiness in construction projects.

Practitioners should strengthen organizational maturity by institutionalizing continuous learning, performance measurement, and managerial accountability mechanisms. Construction firms are encouraged to invest in digital capabilities, including BIM, collaborative platforms, and project-monitoring tools, to enhance coordination and reduce uncertainty. Emphasis should be placed on structured procurement processes, transparent financial reporting, and early-stage risk identification to improve trust and decision-making. Project managers should focus on building competent, well-trained teams through systematic capacity-building initiatives. Finally, integrating sustainability principles into all project stages—including planning, execution, and post-construction—can improve long-term value and stakeholder satisfaction.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

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