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The Impact of Design Team Characteristics on Construction Project Performance with the Mediating Role of Construction Project Costs

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Abstract: The aim of this research was to examine the impact of design team characteristics on construction project performance with the mediating role of construction project costs. A total of 212 project managers from construction projects participated in the study. Data were collected using a questionnaire and analyzed by PLS-SEM using SMARTPLS3 software. The results indicated that design team characteristics significantly and positively influence the performance of construction projects. Design team characteristics also have a significant and negative impact on construction project costs. The effect of construction project costs on construction project performance was found to be negative and significant. Furthermore, the mediating role of construction project costs in the relationship between design team characteristics and construction project performance was positive and significant. As a result, it can be inferred that the characteristics of the design team in construction projects lead to improved performance of these projects by reducing construction project costs.

Keywords: construction project costs; construction project performance; design team characteristics

1 INTRODUCTION

The construction industry, recognized for its complexity within project-oriented industries, has been the subject of extensive study by researchers in project management. This industry significantly contributes to development and the attainment of societal objectives. The construction industry represents a significant portion of the economy, accounting for around 10% of the gross national product in developed nations. This industry is characterized by its complexity, as it encompasses a variety of participants such as clients, contractors, consultants, stakeholders, and regulatory bodies. Additionally, the effectiveness of the construction sector is closely linked to the overall performance of the national economy. According to Yan [1], the contribution of the construction sector to the economy varies significantly, with advanced economies experiencing an added value between 7 and 10 percent, while developing nations see a contribution ranging from 3 to 6 percent. These figures highlight the crucial economic significance of the construction industry and its essential role in the growth and advancement of countries worldwide [2, 3]. Hence, enhancing processes and implementing effective project management strategies within this sector can lead to improved productivity, which in turn may positively influence the broader national economy.

Despite the significant contribution of the construction industry to the economies of developing countries and its crucial role in their development, the performance of this industry remains generally low. As Idoko and Ifediora [4] noted, many projects in developing countries face significant increases in time and costs, and may even become entirely abandoned either before or after completion, failing to achieve their intended benefits. Moreover, the growth of the construction sector in developing nations tends to be significantly slower than that of other industries within those nations, as well as in comparison to the construction sectors in more developed countries. Achieving success in construction projects is a key objective for project stakeholders, including both owners and contractors, which has led to considerable research focused on identifying the elements that contribute to project success. In addition, public project owners are exploring various delivery methods tailored to specific project characteristics to enhance the success rates of construction initiatives and are committed to selecting the most suitable contractor for each individual project [5]. Project success is an abstract concept, and no widely accepted general definition exists. Based on research literature, the following fundamental issues have been reported regarding construction project performance: low quality, budget overruns, lateness, unsafe construction, and customer dissatisfaction [6, 7]. Additionally, construction projects frequently encounter intricate issues involving various stakeholders. These challenges include disputes among team members, such as clients and contractors, as well as resistance from external groups like local communities affected by the projects [8]. In recent years, the landscape of construction projects has grown increasingly demanding for both contractors and clients due to stringent budgetary constraints and tight schedules. Consequently, to enhance the likelihood of successful project outcomes, it is essential to identify the factors that may contribute to either the success or failure of construction initiatives in order to optimize overall project performance.

The construction sector is characterized by its fragmented structure. Historically, the design phase has been viewed as a distinct entity, separate from the construction phase of a project. Construction teams typically start fresh for almost every new project. Research by Evbuomwan and Anumba [9] indicated that one of the contributing factors to subpar delivery outcomes within the construction industry is the lack of collaborative efforts among project stakeholders. The results of research studies highlight that effective process and team integration play a crucial role in facilitating the essential transformations needed for improved outcomes in the construction sector. Nonetheless, merely assembling individuals does not inherently result in effective teamwork. Teams in construction begin to form as they embark on new projects, aiming to showcase their worth through their performance and the strength of their collaborative dynamics. To achieve successful project outcomes, it is vital for

construction firms to focus on enhancing, assessing, and evaluating the efficiency of their teams [10].

In any construction project, it is essential to involve key stakeholders, which typically consist of the client, contractors, and the design team, including architects and engineers. Designers hold a pivotal position, as their responsibilities cover the entire project lifecycle, from inception to finalization [11] . Notably, critical decisions that influence overall costs are primarily made during the initial phases of the design process. Research studies have shown that key characteristics of design teams in construction projects are: procurement, skills, team experience, communication, collaboration, and motivation for innovation [12, 13]. Procurement encompasses the processes involved in selecting and engaging a team responsible for the design and construction of a project. It plays a critical role in shaping both the delivery and financing aspects of a project. Additionally, procurement impacts the level of trust among stakeholders, as well as facilitating open communication and interactions among team members [14, 15]. Furthermore, it significantly influences risk management strategies within construction projects. The term 'skills' pertains to the collective expertise possessed by the design team, with the exclusion of the client's abilities. Team experience pertains to the construction experience and overall project background of the team. Communication refers to the channels of communication during the project execution process. Collaboration pertains to the team members' feelings regarding teamwork and participation during the design phase. Motivation for innovation refers to the efforts of team members to introduce innovative ideas and solutions [12, 16, 17]. Research shows that the characteristics of the design team have an impact on project success [10, 18]. Some research studies highlight the necessity of integrating ecological considerations into the urban design process [19, 20] or municipal solid waste management [21] to foster sustainable development, thus underscoring the importance of stakeholder collaboration in achieving effective environmental outcomes within construction projects. Moreover, addressing the cognitive demands associated with urban design processes during construction projects could further mitigate risks and optimize performance across diverse stakeholder groups [22]. These findings suggest that augmenting these characteristics may facilitate the attainment of project objectives and enhance overall outcomes. Therefore, it is essential to conduct a comprehensive and earnest evaluation of these dimensions during the initial phases of design and planning for construction projects. Such an approach can lay a robust foundation for the future success of these endeavors.

As previously mentioned, the construction industry is a key factor in the development of any city and plays a significant role in job creation. However, it has often experienced stagnation due to various internal and external reasons. Among these, the most important issues are time delays and cost overruns, which severely impact construction project performance. Construction performance can be evaluated through completion scheduling, completion costs, productivity of completed tasks, and safety [23, 24]. This is the primary reason many projects remain unfinished, leading developers to move on to the next project. Understanding the impacts and factors influencing time delays and cost increases is crucial [25]. Research has also indicated that construction project costs significantly affect project success [23, 26]. In summary, the issue of construction project performance manifests itself in various ways. Many completed projects fail in terms of time performance, while others fail in cost performance or in other performance metrics. Projects have frequently faced setbacks throughout history, including client-related problems, material access issues, road closures, design modifications, added work, and delayed decisions. Consequently, examining the factors influencing the performance of construction projects has become a key issue in this field. A review of the research background indicates that, until now, no study has explored the impact of design team characteristics on the performance of construction projects with the mediating role of construction project costs within the framework of structural equation modeling (SEM). Hence, the fundamental objective of the present study is to investigate the effect of design team characteristics on the performance of construction projects, with construction project costs serving as a mediating variable. This aim is intended to enrich the research literature and empirical evidence in this area and to take a step towards improving the performance of construction projects. Drawing upon existing theoretical literature and the framework established through prior studies, the conceptual model for this research is illustrated in Fig. 1. As can be seen, the characteristics of the design team in construction projects are considered as the independent variable, construction project costs as the mediating variable, and construction project performance as the dependent variable.

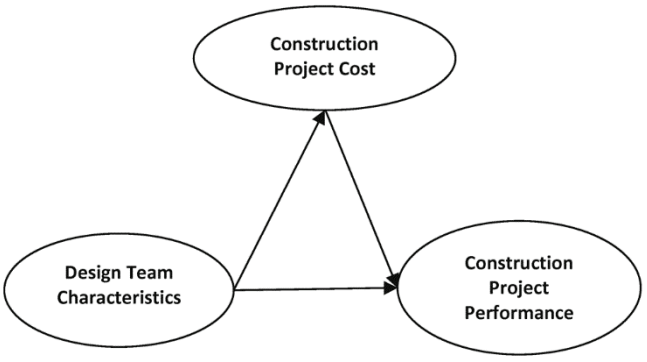

Figure 1 The conceptual model

Thus, the hypotheses of the research are as follows:

H1: The characteristics of the design team in construction projects influence the performance of construction projects.

H2: The characteristics of the design team in construction projects influence the costs of construction projects.

H3: The costs of construction projects influence the performance of construction projects.

H4: The costs of construction projects play a mediating role in the impact of the characteristics of the design team in construction projects on the performance of construction projects.

2 RESEARCH METHODOLOGY

This research employs a descriptive correlational design utilizing SEM with partial least squares (PLS) to investigate the intricate relationships between key variables. SEM is particularly advantageous in this study as it effectively captures complex interrelationships and assesses the impact of independent variables on dependent variables, even in the presence of small sample sizes and non-normally distributed data [13, 27]. By leveraging the strengths of SEM, this research provides a comprehensive and valid analysis of the relationships among the examined variables. This approach not only enriches our understanding of the underlying factors at play but also advances our knowledge of the social and economic phenomena being studied.

2.1 Population

The target population for this research consisted of construction project managers in Iran who possess at least five years of professional experience. To collect the requisite data, an initial phone contact was established to solicit participation, following which a questionnaire was distributed to 260 of these managers. A total of 212 questionnaires were completed and returned, yielding a response rate of 82%. This high level of participation underscores the willingness and commitment of project managers to contribute their insights and experiences, thereby enhancing the credibility of the findings derived from this research.

2.2 Measures

To measure the characteristics of the design team, the questionnaire developed by Hu & Skibniewski [12] was utilized. This questionnaire consists of 6 items. For assessing the performance of construction projects, the questionnaire by Nguyen and Watanabe [7] was employed, which contains 7 items. To measure the costs of construction projects, indicators introduced in the study by Olawale and Ming [28] were used with slight modifications. This questionnaire includes 6 items. The variables were assessed using a five-point Likert scale, with response options ranging from 1 (indicating a very low level) to 5 (indicating a very high level).

3 RESULTS

3.1 Measurement Model Test

To assess reliability, Cronbach's alpha and composite reliability were used, while validity was evaluated using factor loadings, average variance extracted (AVE), and the Fornell-Larcker criterion. The composite reliability index proposed by [29, 30] is superior to Cronbach's alpha because, in Cronbach's alpha, all observable variables in each measurement model have equal weights. This effectively equalizes their relative importance. In contrast, composite reliability does not make this assumption; it actually uses the factor loadings of the items during its calculation, thus making composite reliability values generally higher and more accurately reflective compared to Cronbach's alpha. The threshold for this index, similar to Cronbach's alpha, is a value of 0.7 or higher for internal consistency within the measurement model. Regarding the factor loading of each item, a factor loading of 0.6 or greater in confirmatory factor analysis indicates that the construct is well defined [31]. As shown in Tab. 1, the factor loadings for the research variables are above 0.6, thus confirming the factor loadings.

Table 1 Reliability

Variables	Item	Factor Loading	Cronbach's alpha	Composite reliability	AVE
Design Team Characteristics	1	0.826	0.918	0.936	0.710
	2	0.850			
	3	0.873			
	4	0.847			
	5	0.868			
	6	0.789			
Construction Project Cost	1	0.718	0.834	0.874	0.539
	2	0.823			
	3	0.818			
	4	0.678			
	5	0.675			
	6	0.677			
Construction Project Performance	1	0.746	0.880	0.907	0.582

A critical point here is that if, after calculating the factor loadings, we encounter values less than 0.6 between the construct and its indicators, we need to revise those indicators (questionnaire items) or remove them from our research model. To examine convergent validity, the AVE index was used. Alipour et al. [31] suggest that AVE values should reach at least 0.5, which signifies that a construct accounts for roughly 50% or more of the variance observed in its indicators [30]. In Tab. 1, the factor loadings, composite reliability, and AVE for the variables investigated in this study are displayed. The results presented in Tab. 1 demonstrate adequate and suitable reliability for the constructs examined.

The results of discriminant validity are reported in Tab. 2. It indicates that the square root of the AVE for each research variable exceeds their correlations with other variables. These findings indicate the appropriate validity of the measurement tools.

Table 2 Correlation Matrix and Square Root of AVE

Variables	Design Team Characteristics	Construction Project Cost	Construction Project Performance
Design Team Characteristics	0.84		
Construction Project Cost	–0.53**	0.73	
Construction Project Performance	0.59**	–0.63**	0.76
$^{**}p < 0.01$			

3.2 SEM Testing

To evaluate the performance of construction projects, a conceptual model was tested using PLS-SEM. The relationships among the research variables and the tested model are depicted in Fig. 2. It demonstrates that the

characteristics of the design team have a positive and significant effect on the performance of construction projects, whereas their influence on project costs is negative and significant. Additionally, the costs associated with construction projects have a negative and significant impact on overall project performance. The figures within the circles indicate the explained variances for each of the research variables. Tab. 3 presents the estimated path coefficients alongside the variance explained for the variables examined in the study.

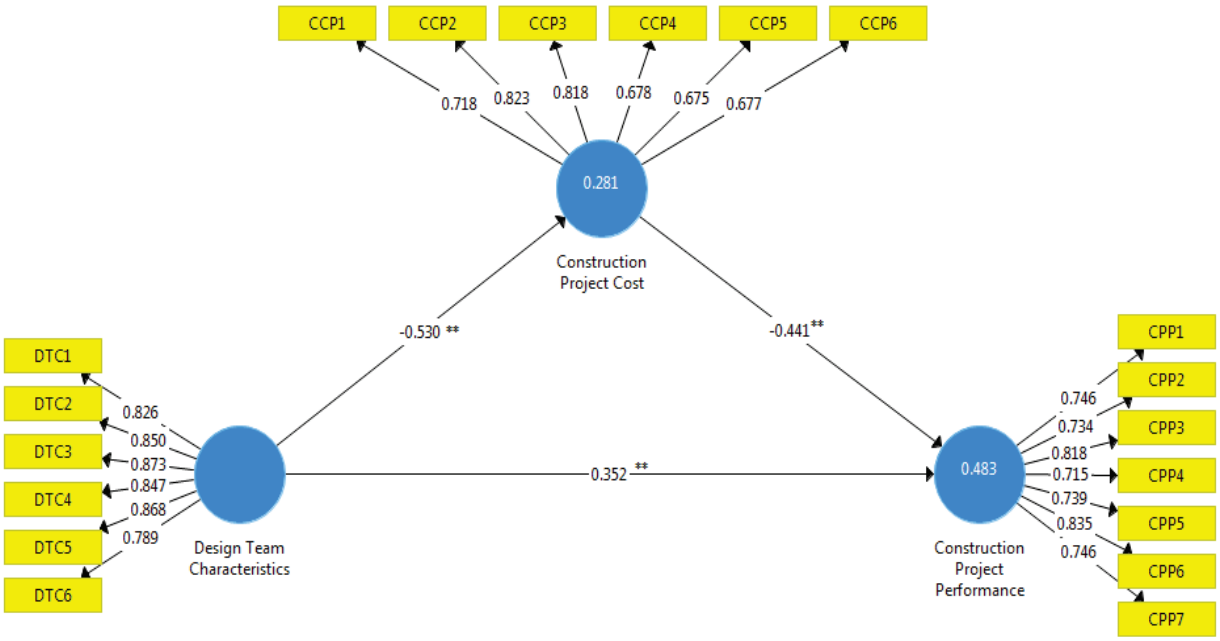

Figure 2 Tested model

Table 3 Path coefficients and explained variance

Variables	Path Coefficient	*t*-value	*p*-value	Explained Variance
On construction project performance via: Design team characteristics Construction project costs	 0.352** -0.441**	 4.135 6.389	 0.001 0.001	0.483
On construction project costs via: Design team characteristics	-0.53**	10.619	0.001	0.281
The mediating role of construction project costs	0.23**	5.711	0.001	-

*$p < 0.05$, **$p < 0.01$

Table 4 Hypotheses Results

Hypotheses	Results
H1: The characteristics of the design team in construction projects influence the performance of construction projects.	Confirmed
H2: The characteristics of the design team in construction projects influence the costs of construction projects.	Confirmed
H3: The costs of construction projects influence the performance of construction projects.	Confirmed
H4: The costs of construction projects play a mediating role in the impact of the characteristics of the design team in construction projects on the performance of construction projects.	Confirmed

According to Tab. 3, the mediating role of construction project costs in the relationship between design team characteristics and construction project performance is positive and significant. Furthermore, 48% of the variance in construction project performance and 28% of the variance in construction project costs can be explained by the variables in the research model. The results of the hypothesis testing are presented in Tab. 4.

The goodness-of-fit index (GOF) measures the model's predictive ability, particularly in relation to the endogenous latent variables. In this study, the calculated absolute GOF for the proposed model was 0.48, suggesting that the model demonstrates a good fit. A GOF value exceeding 0.36 is considered indicative of satisfactory model quality.

4 DISCUSSION

This research sought to establish a model that examines how the characteristics of design teams influence the performance of construction projects, considering project costs as a mediating factor through SEM. Findings revealed that the model aligns well with the collected data, accounting for 48% of the variability in construction project performance and 28% of the variability in project costs.

The results indicated that design team characteristics have a significant positive impact on the performance of construction projects; however, their impact on construction project costs is significant and negative. Therefore, design team characteristics lead to a reduction in construction project costs and, consequently, improve the performance of construction projects. This finding is consistent with the results of the research conducted by Radhakrishnan et al. [18] and Azmy [10]. To explain this finding, it can be stated that

if the selection and hiring process for the design team of a construction project is based on competency and capability, several key factors come into play. When the design team possesses both collective and specialized skills, has relevant construction and project experience, maintains essential communication channels, fosters collaboration and participation among team members, and is motivated to generate innovative ideas and solutions, it ultimately leads to a reduction in construction project costs. Consequently, this approach significantly improves the overall performance of the construction project. Teamwork is defined as "a group of individuals who are mutually dependent on each other to achieve a common goal." It encompasses commitment, collaboration, clear objectives, and goals. Commitment, accountability, and the skills of team members are some of the essential characteristics required for team members to reach their common goals. Therefore, for effective teamwork, it is essential for team members to establish a shared understanding of behavioral standards, project planning, role allocation, and task management, including scheduling and decision-making processes. Addressing these aspects is crucial for minimizing misunderstandings throughout the design phase of construction projects.

Teamwork is also important due to the increased efficiency it can provide, and since it resembles a structure where members work in a planned manner through both collaboration and communication, it is well-organized, and there is regular information exchange about ideas and products. For this reason, projects that aim to reduce costs and increase effectiveness prefer to utilize teamwork.

The findings demonstrate that construction costs have a notable adverse impact on the performance of construction projects, suggesting that higher expenses are linked to reduced effectiveness in project outcomes. This finding is consistent with the results of studies by Molavi and Barral [23]; and Trach et al. [26]. To explain this finding, it can be said that increasing costs in projects results in dissatisfaction with project quality, project schedules, project costs, reduced productivity, and lack of progress in the projects, ultimately leading to a decline in the performance of projects [32]. Furthermore, as the findings indicate, the characteristics of the design team have an impactful role in reducing construction costs, thereby improving construction project performance. A team operates with shared goals and objectives, enabling members to build strong, collaborative relationships aimed at achieving these goals. Effective teamwork involves individuals working together in a cooperative setting, where knowledge and skills are exchanged to reach common objectives. Research highlights that a primary characteristic of successful teams is their commitment to a clear, collective purpose. Teams play a crucial role in numerous projects, with successful collaboration depending on the synergy among participants. This collaborative spirit fosters a positive environment, encouraging all members to contribute actively to the team's success and effectiveness. Team members must exhibit the flexibility to thrive in collaborative settings where success is attained through cooperation and shared goals, rather than through competition and individual aims [33]. Consequently, the attributes of a construction project design team can be viewed as a vital factor in achieving competitive advantage within the construction industry.

5 PRACTICAL IMPLICATIONS

The results of this research offer substantial insights that can significantly enhance the performance of construction projects. The following key findings highlight practical applications that stakeholders may consider implementing:

The study underscores the importance of design team attributes—specifically competence, skill, and experience—as critical factors in minimizing project costs and improving overall performance. Consequently, it is advisable for organizations to prioritize these characteristics as essential criteria during the selection and recruitment process for design team members. Evidence suggests that robust communication channels within design teams facilitate enhanced collaboration and engagement. It is imperative for organizations to establish conducive platforms for the exchange of ideas and perspectives among team members, as this can lead to improved cooperation and cost efficiency.

The research highlights the value of fostering an environment that motivates team members to propose innovative solutions. By nurturing a culture that encourages the free sharing of ideas, organizations can significantly elevate project performance outcomes. The findings emphasize that successful construction projects hinge on effective teamwork. It is crucial for organizations to cultivate a collaborative culture and enhance teamwork competencies among design team members, thereby reinforcing the collective skill set necessary for project success. The study demonstrates that reducing costs not only improves project performance but also heightens customer satisfaction and ensures timely delivery. Therefore, prioritizing comprehensive cost management strategies throughout all phases of construction projects is essential. Clarifying and establishing shared objectives among design team members can foster synergy and enhance collaborative efforts. By promoting a collective understanding of project aims, team members are more likely to work cohesively toward achieving the overall objectives. By implementing these findings, stakeholders in construction management can significantly improve project outcomes, fostering higher efficiency, satisfaction, and success rates in construction endeavors.

6 CONCLUSION

This study provides strong evidence that the costs associated with construction projects play a crucial role as a mediator between the characteristics of design teams and the overall performance of construction projects. Our results suggest that positive attributes of design teams not only improve project performance but also help in reducing costs, resulting in more favorable project outcomes. By recognizing and nurturing key traits such as collective expertise, effective communication, teamwork, and a unified commitment to objectives, stakeholders can enhance the process of selecting design teams and create an atmosphere that values efficiency and innovation. These traits align well with the project life cycle and significantly boost the likelihood of team success.

Additionally, comprehending the relationship between the qualities of design teams and team dynamics is essential for advancing project management methodologies. Our research highlights the need to cultivate an environment that promotes collaboration and problem-solving, which can lessen the time needed for conflict resolution and improve the quality of ideas exchanged, thereby influencing project schedules and results. However, this study is limited by its focus on project managers from construction projects in Iran, which may restrict the applicability of the findings. Future studies should aim to include a wider range of geographical locations and project settings to gain a comprehensive understanding of the results' relevance. In conclusion, our findings emphasize the importance of investing in the development of design teams as a strategic method to enhance construction project performance. We urge industry professionals and researchers to delve deeper into the intricate characteristics of design teams and their effects on project success, thereby enriching the field and promoting improved practices in construction management globally. In future research, it would be beneficial to include qualitative studies such as Ghorashi et al. [34] and Darvishinia [35] that explore people's experiences and opinions about design teams. Additionally, using data mining such as Bevilacqua et al. [36], deep learning such as Tashakkori et al. [37] and artificial intelligence techniques such as Espahbod et al. [27], Metaheuristics algorithms such as Bahadoran Baghbadorani et al. [38] can help analyze data more effectively and provide deeper insights into team performance and project outcomes.

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