OPEN ACCESS

Kashf Journal of Multidisciplinary Research
Vol: 02 - Issue 11 (2025)
P-ISSN: 3007-1992 E-ISSN: 3007-200X
https://kjmr.com.pk

EVALUATING THE ADVANCED MANAGEMENT PRACTICES IN THE CONSTRUCTION INDUSTRY USING FUZZY-LOGICS BASED FTOPSIS TECHNIQUE: ENHANCING ORGANIZATIONAL PERFORMANCE

Moaaz Munir[1], *Akmal Shahzad[2], Muneeb Ahmed[3], Muhammad Shahoon Iqbal[4], Zaryab Riaz[5]

[1]Assistant Professor, Department of Civil Engineering, The University of Lahore, Pakistan.

[2, 4, 5]Post-Graduate Student, Department of Civil Engineering, University of Engineering and Technology Lahore, Pakistan.

[3]Site Engineer, Highways and Transportation Engineering Division - NESPAK, Pakistan.

***Corresponding Author:** 2019civ18@student.uet.edu.pk*

Article Info

Abstract

Construction industry plays an important part in the economic growth of countries, especially developing counties. It was observed that the construction industry faces many problems which hinders its growth. Despite an adequate emphasis on project management, the construction firms less focus on advance management domains, like strategic management, operational management, and decision making which are vital for ensuring effective organizational performance. Hence the current study was planned to establish the implementation level of advance management domains in the construction industry. A questionnaire, comprising of five sections, was prepared and distributed among 100 participants. By analyzing the responses, it was seen that about 90% of the construction firms had defined their vision, mission and long-term goals. About 80% of the firms considered the factors of risk management, team building and leadership as important for long-term success, and almost all of the firms were equipped a quality management system. Further, a fuzzy-logics based technique, known as FTOPSIS, was applied to rank different types of firms in terms of their implementation level of advance management domains. It was found that Mega Firms ranked first with closeness coefficient (CC) value of 0.599, followed by Scaled firms and Emerging Firms.

Keywords:

Strategic Management, Operational Management, Decision Making, Fuzzy Logics, FTOPSIS, Construction Management, Project Management.

INTRODUCTION

The construction industry possesses a significant share in the economy of any country around the world, especially developing countries [1]. According to the statistics issued by Pakistan Credit Rating Agency (PCRA) for the calendar year 2022, the global construction industry contributed 11% share in global Gross Domestic Product (GDP) with the employment of 7% global workforce, while for Pakistan, the construction industry direct share in GDP was estimated at about 2.75%, exclusive of the 42 ancillary sectors [2]. It was also reported that the local construction industry was found to be second largest employer, and employed about 30-35% of the local workforce, either directly or indirectly [3], while the global construction industry accounts for 7% workforce. Given that the construction industry's major role in the economy of developing economies, it becomes very crucial to employ advance management techniques to expedite its growth process for the economic development of the country.

It is frequently observed that the organizations put a great emphasis on ensuring the success of an undertaken project, by optimizing the planning and execution activities [4], however the process of strategic management is often neglected. Strategic management is a very broad and coherent approach which involves defining such underlying concepts, or strategies, which are intended to develop long-term goals to achieve the organization's mission and vision. Further it also includes implementing and evaluating the strategies, rather not confining to defining only [5]. Hence it can be termed as the highest level of management domain which compels the top-level executives to formulate and implement such strategies that define the organization's future direction which is compatible with the firm's vision and mission. The process of strategic management may be distributed down into, but not limited to, the following five distinct steps [6]:

1) **Define the direction**: This step involves defining the vision, mission, and goals. This step is crucial in determining the organization's direction for the future.
2) **Analyze the current situation**: This step involves the up-to-date analysis of organization's resources, limitations, and performance. Different analysis tools may be used for this purpose, i.e. SWOT analysis [7].
3) **Outline the strategy**: This step involves crafting an effective strategy to achieve the organization's goals, which are compatible with its capacity.
4) **Execute the plan**: This step involves the execution of the strategic plan, and monitoring its progress.
5) **Evaluate the plan**: This step involves the assessment of the effectiveness of strategic plan. If found ineffective, then backup plan may be executed.

Although the domain of strategic management is indispensable for adhering to the long-term goals of the organization, the process of operational management is vital for ensuring the maximum efficiency of regular tasks. It involves meeting the customer's expectations, optimal use of resources and timely turnover of the projects, while adhering to the long-term strategy of the organization [8]. It also puts a great emphasis on continuous improvement and innovation, hence ensuring that the organization's strategies remain up-to-date, while catering for the shifting market demands and user's better experience [9]. Hence the domains of operational management and strategic management are closely inter-linked. Thus, it can be stipulated that the operational management is an effective tool for ensuring the adherence

to the long-term strategic goals [10]. Further an efficient integration between strategic goals and daily operations are one of key factors for an organization's competitive advantage and its long-term success [11].

Decision making is a very important process for ensuring the optimal performance of an organization as it involves the analysis and selection of the best choice, or an action, among the available multiple options. The importance of decision-making lies in its fundamental aspect of management, which is necessary to acquire competitive advantage, and adaptability to the external factors [12]. It interlinks the domains of strategic management and operational management in a very unique way. As the long-terms goals, defined under the umbrella of strategic management, provide a direction for the organization's course of action, the operational decisions make sure that the same direction has been followed in routine matters, so that the organization's strategic goals may be successfully achieved [10]. Hence by aligning the regular tasks with long-term strategy, the overall productivity is greatly enhanced [13]. Therefore, it can be said that the effective decision-making plays a vital role in ensuring the long-term success of an organization.

The concept of organizational performance is comparative in nature, as it measures how well an organization performs to achieve its strategic goals, by considering various matrices, like financial performance, market share, stakeholder satisfaction [14]. It shows an organization's ability to generate profit, while meeting its strategic goals in parallel. The concepts of strategic management, operational management, and decision making have a direct influence on determining the organizational performance. The domain of strategic management deals with defining strategic goals to gain a competitive advantage, while the operational management focuses on optimizing regular task to meet customers' expectations. Further the process of decision-making acts as major element in both of the aforementioned domains, as it enables organizations to deal with shifting market demands, resource allocation, capacity building, and implementing new ideas [12]. Hence, it is evident that different management domains are vital to ensure and sustain a good organizational performance [15].

The construction industry is generally known for its conservative approaches, and is mainly focused on individual projects, rather than strategic goals [16]. However, when complex projects are undertaken, the concepts of advanced management, like strategic management, operational management, etc., become very important. When uncertainties arise, strategic management provide a way forward to reduce risks, allocate resources and develop skilled workforce. To achieve monetary benefits, operational management provides a blueprint to efficiently conduct the routine tasks, while the decision making helps in making informed and calculated choices to ensure project success [17]. It is also observed that the geographical region somehow affects the performance of construction firms. It was reported that the North American construction firms were more efficient than their European and Asian peers [18]. As the construction industry accounts for about 5-9% of the gross domestic product (GDP) for the developing countries [19], hence it becomes very important to employ advanced management techniques for sustainable growth of industry. It is frequently observed that the construction firms, in most of the developing countries, mainly focus on project management, rather than strategic and operational management, due to which many problems arise like lack of skilled labor, substandard quality of work, poor management etc. [20]. Hence, in the current study, an attempt was made to evaluate the implementation level of various advanced construction management techniques in the construction industry. Below is the summary of different

research projects intended to study the impacts of different advanced management domains on the organizational performance.

Previous Studies

Many researchers have attempted to study the positive impacts of employing best management practices in the organizations. Chinowsky and Meredith studied the strategic management practices in the construction sector [13]. The concept of strategic management was studied comprehensively in the context of rapidly changing social and technological factors, and recommendations were given to increase the competence of construction sector globally. Naaranoga et.al. presented a case study of a construction project to show the use of strategic management tools [21]. It was observed that the organizational vision proved to be helpful in meeting the customer's expectations, and for the prioritization of different choices. Puspa Mali et. al. evaluated the impact of reverse logistics in construction supply chains, and suggested that effective reverse logistics approaches like reuse and remanufacturing should also be adopted, in addition to material recycling [22]. Arif et. al. studies the practices of strategic management in the construction sector of Pakistan, and observed that the industry was found to be lacking in the use of strategic management tools [23]. Tetik et. al. introduced a novel operational management practice, i.e. Direct Digital Construction, and it was found that the quality and efficiency was enhanced by automation and reusability [24]. Kumaraswamy et. al. studied the feasibility of integrating the novel strategies of procurement and operations for research and development in the field of construction [25]. Ibrahim et. al. evaluated the performance of lean manufacturing in achieving the optimal operational efficiency, in the context of Malaysian construction industry [26]. A positive coefficient of correlation was observed between lean manufacturing concepts and organizational performance, hence authenticating the hypothesis. Tan et. al. combined the MCDM and BIM techniques for better decision making in the construction industry, and different strategies were proposed for this purpose [27]. Yang et. al. studied different attributes, i.e. power, urgency, and proximity, and behaviors, i.e. cooperative potential, competitive threat, opposite position, and neutral attitude, of stakeholders on the strategic decision making in construction projects, and proposed few recommendations for managers [28]. Cristobal and Chai et. al. used various Multi Criteria Decision Making techniques for choosing the best contractor and supplier for effective project management, respectively [29, 30]. Zang et. al. considered the effect of Corporate Social Responsibility (CSR) approach on optimizing the performance of construction related organizations, and stipulated that various strategies exhibited a strong relationship with the performance [31]. Assad et. al. formulated a comprehensive approach to check the overall project progress and forecast the performance by considering a range of input collectively [32]. Further, Aftab et. al. studied the role of performance management in the relationship between management innovation and organizational performance in the construction industry of Pakistan [33]. However, there still remained a gap about finding the implementation level of different advanced management domains, like strategic management, operational management and decision making, combinedly in the context of organizational performance, which becomes the goal of this undertaken research.

With an increase in the popularity of various Artificial Intelligence (AI) and Machine Learning (ML) techniques, many researchers have started to utilize these techniques for research purpose. Its application can be found in many research domains related to civil engineering, like material sciences, structural

dynamics, etc. Saif et. al. applied AI and ML techniques for sustainable production of ceramic tiles using industrial coal ashes, and ceramic waste [34, 35]. Further Abbas et. al. formulated an AI based predictive model for the heavy metals in agricultural waste ashes [36]. Many researchers have utilized the ML techniques in the domain of project management as well. Buch and Pokiya explored the potential benefits of utilizing machine learning techniques for improving the project planning effectiveness [37]. Hence in the current study, a fuzzy logics-based technique, called FTOPSIS, was applied to rank different types of construction firms according to the implementation level of strategic management, operational management, and decision making in the construction industry.

Research Methodology

This study utilized a mix of qualitative and quantitative techniques to check the implementation level of advanced management domains in the construction industry. For this purpose, a thorough survey was conducted. The questionnaire contained four sections; each aimed at a particular management domain. The responses were recorded by visiting and interviewing the concerned professionals from the construction firms. Following this step, the responses were analyzed to establish the implementation level of strategic management, operational management, and decision making as a tool for achieving best organizational performance. After this, a fuzzy-logics based Multi-Criteria Decision Making (MCDM) technique, called FTOPSIS, was applied on the recorded data to rank different types of construction firms in terms of the implementation level of advanced management domains for an effective organizational performance.

Population, Sample and Response Rate

For this study, a population of 10,000 construction firms was considered. The required number of sample size **SS** for 10,000 firms was calculated using the equations (i) and (ii), [38].

$$SS' = \frac{z^2 \times p \times (1-p)}{C^2} \quad \textbf{(i)}$$

$$SS = \frac{SS'}{1 + \frac{SS'}{P}} \quad \textbf{(ii)}$$

Where $\boldsymbol{SS'}$ shows an intermediate value for sample size of infinite population. For this study, the population **P** supposed to be 1000 with a percentage of 10% (**p**), i.e. total population equals 10,000. The confidence level **C** was taken as 95%, with a corresponding **z**-score of 1.67 [39]. Hence by plugging in all the values in eq (i) and (ii), the sample size was calculated to be 92. Hence to be on a safer side, a sample size of 100 was used to conduct the study.

Questionnaire Preparation

For this study, a detailed questionnaire was prepared by literature review, to find the implementation level of advanced management domains in the construction industry. The questionnaire contained 36 questions in total. First three questions were related to the respondent's profile, while the remaining questions were distributed into four sections, as given in Table 1.

Table 1 Details of questionnaire sections

Sections	Purpose	No of Questions
1	Strategic Management	17
2	Operational Management	5
3	Decision Making	5
4	Organizational Performance	6

Survey Response

The questionnaire was distributed among different construction firms. For the sake of analysis, the construction firms were defined as Emerging, Scaled, and Mega Firms, depending upon their annual revenue. The annual revenue, in US Dollars, of the firms is given in table 2. As stated earlier, a sample size of 100 was selected for this study. Out of 100 requests, 91 firms agreed to respond. Hence a response rate of 91% was achieved, which is quite suitable for analysis [40]. Table 3 gives A detailed analysis about the profiles of the respondents. It can be observed from Table 3 that the majority of the participating firms belonged to mega firms. Further it was also seen that the majority of the respondents held Bachelor's degree in engineering, while very few respondents had acquired a PhD degree. Almost one fifth of the respondents had an experience of more than 15 years in the local construction industry.

Table 2 Details of annual revenue of the construction firms

Revenue (USD)	
Emerging Firms	<2M
Scaled Firms	2M-15M
Mega Firms	>15M

Table 3 Details of respondent's profile

	Category	Frequency	Percentage
Type of Firm	Emerging Firms	26/28	92.8%
	Scaled Firms	25/27	92.6%
	Mega Firms	41/45	91.1%
		Average=	91%
Industry Experience	1-5 years	42	46.1%
	6-15 years	31	34.1%
	16 and above	18	19.8%
Qualification	Associate Diploma	26	28.6%
	Bachelors	38	41.8%
	Masters	24	26.4%
	PhD	3	3.3%

Results and Discussion

Strategic Management

To find the implementation level of strategic management in various construction firms, the section of strategic management was further divided into five sub-sections, each aimed at assessing a particular factor. Table 4 gives a detailed analysis about the responses for the strategic management by the participating firms. It can be seen that about 90% of the firms had defined vision, and mission statements which form the backbone of the strategic management domain [41]. It can also be assessed that majority of the firms, 83 respondents, defined their long-term goals, while less importance was given to middle-term and short-term goals, respectively. The results revealed that the 86% of the firms had defined short-term goals, while 80% of the respondents reported the establishment of middle-term goals, which is 11% lesser than the reported frequency of long-term goals. As the exclusive focus on short-term goal achievement may affect the organization's future competitiveness and earning potential [42], hence there is more focus on long-term strategic goals, rather than short-term efficiency [43]. It was also observed that the critical factors for determining the time schedule of organizations included the capacity of the labor, the possibility of changes and the availability of the equipment. However most of the construction firms avoided the possibility of overlapping of work, hence this factor exerted the least influence on the time schedule. By overlapping various sequential activities in a project, early completion can be achieved [44], however cost is increased in this fast-track mechanism due to the risk of rework, hence many construction firms tend to avoid it [45]. It was interesting to note that financial capacity of the client and the project time schedule were considered to be most important factors for determining the cost of project by most of the construction firms, while possibility of changes was given lesser importance, i.e., 83%. It is generally observed that changes made in the design at the early stage in the project result in lesser cost overrun, as compared to when made at the later stages in the project [46]. Further with the utilization of advanced modeling techniques, like Building Information Module (BIM), the efficiency of design process is greatly increased and hence lesser changes are expected in the design of a project [47]. Hence lesser focus on the possibility of changes for determining the cost of project by construction firms can be justified. It was also evaluated that most of the respondents focused on risk management, team building, and leadership, i.e., 88, 85, and 81, respectively, while less interest was taken in staff training and change management. When an excess of unskilled or unemployed labor is readily available, the organizations tend to spend less on human resources [48]. Further with the use of advanced and efficient design methodologies, there is always less chances of changes in the design, and hence construction firms tend to give lesser importance to change management [49].

Table 4 Analysis of strategic management assessment section

Sub-Section	Components	Frequency	Percentage
1. Firm Vision and Mission	Firm vision	82	90.1%
	Firm mission	83	91.2%
2. Firm's Goals	Short term goals	78	85.7%
	Middle term goals	73	80.2%
	Long term goals	83	91.2%

3. Firm Time Schedule consideration Factors	Capacity of labour	84	92.3%
	Overlapping of work	72	79.1%
	Possibility of changes	82	90.1%
	Equipment availability and performance	85	93.4%
4. Project Cost consideration Factors	Financial capacity of client	88	96.7%
	Time schedule	83	91.2%
	Possibility of changes	76	83.5%
5. Management System	Risk management	88	96.7%
	Change management	69	75.8%
	Leadership	81	89.0%
	Team building	85	93.4%
	Staff recruitment and training	72	79.1%

Operational Management

The second section of the questionnaire was analyzed in detail to study the effectiveness of operational management practices to ensure smooth organizational performance. It was seen that most of the construction firms, 74 respondents, employed about 11 to 200 employees, while some of the firms, 15 respondents, had more than 200 high-skilled employees. The results revealed that the resources allocation was identified as the key operational management challenge, followed by cost management, while quality control and communication had the least impact on operational management process. As resource allocation is a complex process which contains various trade-offs between quality, performance, cost, revenue and project constraints, hence it was identified as the biggest challenge to achieve operational efficiency for construction firms [50]. Further the cost management directly affects the operational efficiency of any organization, hence many firms are forced to optimize the process of cost management by various techniques, like effective resource utilization, targeted improvements, etc. Hence cost management can also be termed as an important factor for efficient organizational performance [51]. By analyzing the responses in Figure 01, it was revealed that the operational management practices proved to be significant for improving project efficiency and the subsequent cost savings. Further almost 70% of the respondents rated the effectiveness of their organization's planning and operational practices as highly effective. Akinsulire et.al. reported that the optimization of operational management by effective resource allocation and utilization within the stipulated budget, the construction projects become cost-efficient [52]. Hence it can be said that the operational management plays an important role ensuring the success of an organization.

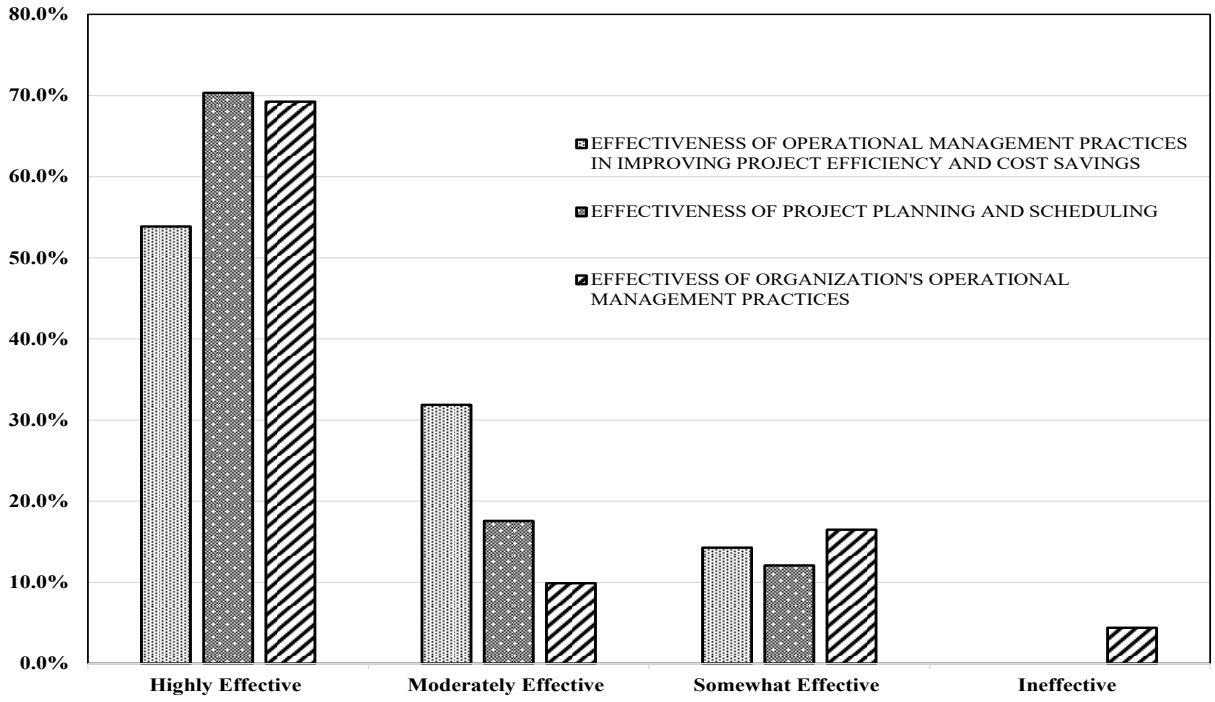

Figure 1 Effectiveness of various operational management processes

Decision Making

The analysis of response to the third section of the questionnaire was performed to establish the implementation level of decision making in the construction firms. It was observed that almost 99% of the firms, i.e., 90 respondents, had developed a quality management system in place. Further almost three-fourth of the respondents reported that the management team organized regular meetings to discuss the project progress and the challenges. The quality management can be termed as a continuous process which is intended to establish requirements and Key Performance Indicators (KPIs) at each project milestone [53]; hence the project team requires proper communication among all members to work efficiently. It also requires the top managements to possess the vital characteristics of leadership, and human resource management skills, so that each personnel may contribute efficiently towards the success of project [54]. Further the next three questions about decision-making were assessed by means of a Likert scale, as presented in Figure 2. Likert scale is a type of rating scale which is used to assess the degree of agreement or disagreement with an argument [55]. It was found that the 69% of the respondents termed the coordination between various departments of their organization as satisfactory, while 61% reported that the access to the relevant information was up to the mark. However only 53% of the respondents were satisfied with the effectiveness of decision-making process within the organization, whereas 24% remained neutral on this argument. The process of decision-making can become a challenging task for management sometimes, due to various reasons like failure to consensus, uncertain outcome, conflict of interest, etc. [56]. Hence to optimize the decision-making process in various aspects of management, many organizations opt for deep learning algorithms [57]. Further, many algorithms are being developed by researchers globally to optimize this process for specific tasks [58].

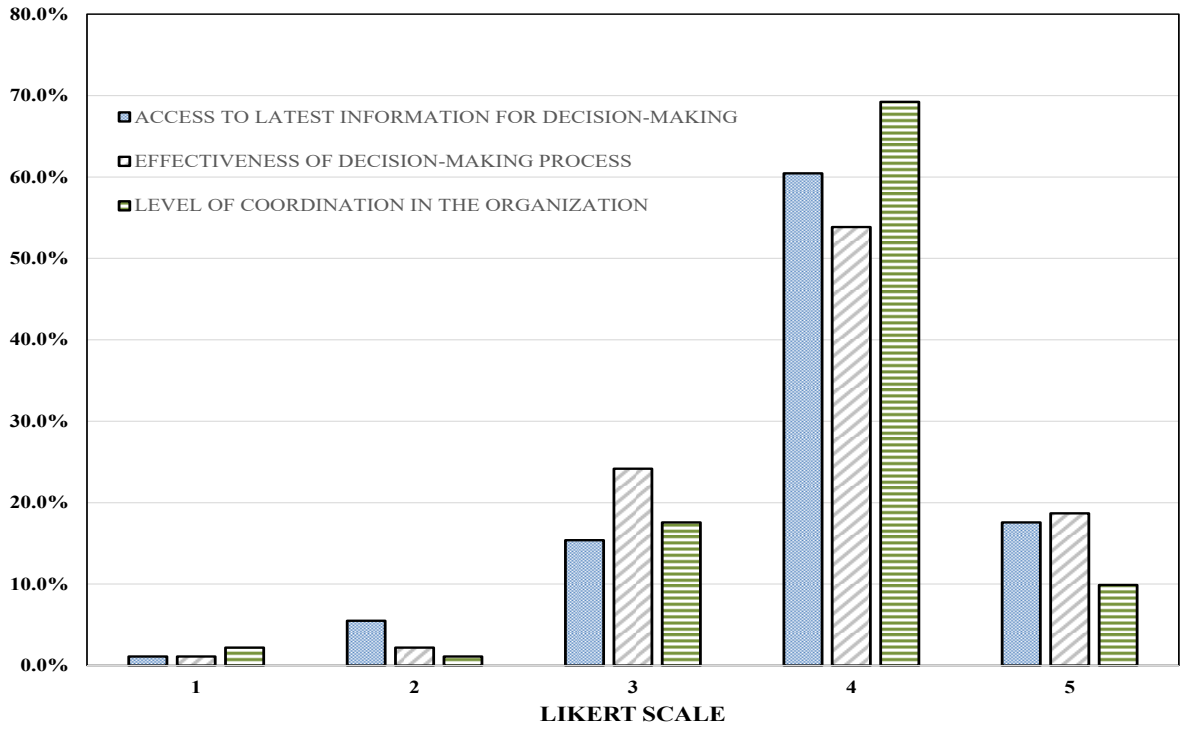

Figure 2 Assessment of the effectiveness of decision-making process using Likert scale

Organizational Performance

The responses to the last section of the questionnaire were comprehensively investigated to evaluate the organizational performance from the perspective of management team. It was found that 70 respondents rated the internal communication of the organization as effective, while 76 respondents termed the process of monitoring and cost control as satisfactory. Effective communication is regarded as an important tool for ensuring valuable performance of any organization [59]. Further, many researchers have also established the fact the process of monitoring and control exerts a positive influence on project management and its subsequent success [60]. Hence these factors play an important role in increasing the productivity of organizations. As illustrated in Figure 3, responses were recorded using Likert scale to study different organizational performance indicators. It was observed that 82% of the respondents termed their work ethics and organizational culture as satisfactory, while 78% strongly agreed that their organization performed efficiently to ensure project success. It was also reported that the 76% of the responses stipulated the adoption of innovative technologies in the construction work, while an overwhelming majority, i.e., 87% respondents, reported the influence of advanced management domains, like strategic management and operational management, in their regular tasks. Research reveals that a safe work environment results in employee's commitment towards the organizational goals, which greatly enhances the performance of the organization as a whole [61]. Further, it is also important to note that the advanced management domains, like strategic management, not only ensure the long-term success and competitiveness of an organization, but also bring about productive changes in work environment, which fosters the employee's confidence and commitment. Hence these techniques are vital for sustained and efficient organizational performance [62].

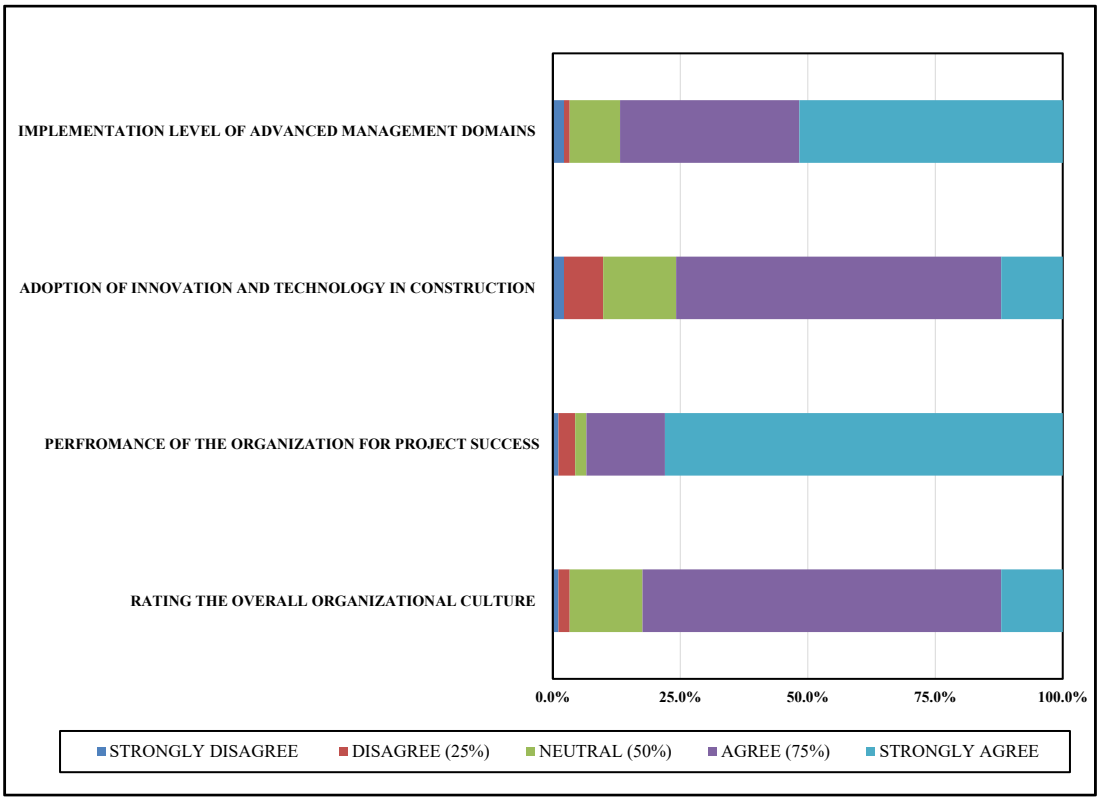

Figure 3 Assessment of various organizational performance parameters using Likert scale

FUZZY TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO THE IDEAL SOLUTION (FTOPSIS)

After conducting a comprehensive analysis of all the sections of the questionnaire individually, the recorded responses were analyzed considering the scale of construction firms, i.e., Emerging firms, Scaled firms, and Mega firms. Further, a data analysis technique, incorporating fuzzy logics [63], was applied to the data for finding the order of preference among the data. The data analysis technique, known as Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS), was employed to prioritize the construction firms considering the implementation level of strategic management, operational management and decision making to ensure the optimal performance of the respective organization. There steps involved in performing FTOPSIS analysis are shown in Figure 4.

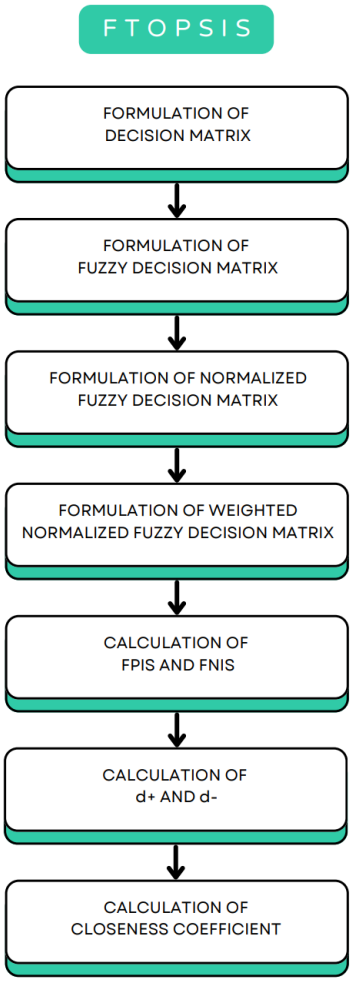

Figure 4 Steps for performing FTOPSIS analysis

By calculating the weighted mean of the responses to the individual sections of the questionnaire by the respective firms' representative, a decision matrix was formulated. The decision matrix, given in Table 5, shows the implementation level of strategic management, operational management, and decision making in different types of construction firms, i.e. Emerging firms, Scaled firms and Mega firms.

Table 5 Decision Matrix

	Strategic Management	**Operational Management**	**Decision Making**
Emerging Firms	87.6	86.8	68.6
Scaled Firms	90.4	83.4	68.5
Mega Firms	92	83.4	68.4
Average Implementation Level (%)	90	84.5	68.5

After formulating the decision matrix, a fuzzy decision matrix was formulated by converting the data into Triangular Fuzzy Numbers (TFN). Triangular fuzzy numbers are the most common method to represent the fuzzy data [64]. These numbers are generally represented by the relation expressed in eq(iii).

$$x_{ij} = (a_{ij},\ b_{ij},\ c_{ij}) \quad \textbf{(iii)}$$

Where a_{ij} represents the smallest expected value, b_{ij} represents the average value, and c_{ij} represents the largest expected value. Using this guideline, the fuzzy decision matrix was formulated, and is given in Table 6.

Table 6 Fuzzy Decision Matrix

	Strategic Management	Operational Management	Decision Making
Emerging Firms	(84.6, 87.6, 90.6)	(81.8, 86.8, 91.8)	(60.6, 68.6, 76.6)
Scaled Firms	(87.4, 90.4, 93.4)	(78.4, 83.4, 88.4)	(60.5, 68.5, 76.5)
Mega Firms	(89, 92, 95)	(78.4, 83.4, 88.4)	(60.4, 68.4, 76.4)

In the next step, the fuzzy decision matrix was normalized in the range of 0 to 1. The process of normalization is very important in data pre-processing, as it provides a same scale of comparison for all the input parameters [65-68]. The fuzzy data was normalized using the relation given in eq(iv).

$$\tilde{x_{ij}} = \left(\frac{a_{ij}}{\sqrt{\sum_{i=1}^{n} a_{ij}^2}}, \frac{b_{ij}}{\sqrt{\sum_{i=1}^{n} b_{ij}^2}}, \frac{c_{ij}}{\sqrt{\sum_{i=1}^{n} c_{ij}^2}}\right) \quad \textbf{(iv)}$$

The normalized fuzzy decision matrix is given in Table 7.

Table 7 Normalized Fuzzy Decision Matrix

	Strategic Management	Operational Management	Decision Making
Emerging Firms	(0.561, 0.562, 0.562)	(0.592, 0.593, 0.594)	(0.578, 0.579, 0.579)
Scaled Firms	(0.579, 0.580, 0.581)	(0.569, 0.569, 0.570)	(0.577, 0.578, 0.578)
Mega Firms	(0.589, 0.590, 0.590)	(0.569, 0.569, 0.570)	(0.576, 0.577, 0.577)

After this step, weighted normalized fuzzy decision matrix was formulated by multiplying the corresponding fuzzy numbers with their weight, as expressed by eq(v). To find out the weightage of strategic management, operational management and decision making for an effective organizational performance, literature was consulted. As it was reported that the strategic management acts like a back bone for optimal organizational performance [66], hence strategic management was given more weightage, as compared to operational management and decision making. Following the computation of weighted normalized fuzzy decision matrix, Fuzzy Positive Ideal Solution (FPIS), and Fuzzy Negative Ideal Solution (FNIS) was determined. As all the three criteria, i.e., strategic management, operational management, and decision making are vital for optimal organizational performance, hence their maximum values were termed as FPIS (A^+), while their minimum values were termed as FNIS (A^-), as given in eq(vi) and eq(vii).

$$x_{ij}^{*} = \tilde{x_{ij}} \times w_j \quad \textbf{(v)}$$

$$FPIS\ (A^{+}) = max\ (a_{ij}^{*}), max\ (b_{ij}^{*}), max\ (c_{ij}^{*}) \quad \textbf{(vi)}$$

$$FNIS\ (A^{-}) = min\ (a_{ij}^{*}), min\ (b_{ij}^{*}), min\ (c_{ij}^{*}) \quad \textbf{(vii)}$$

The weighted normalized fuzzy decision matrix is given in Table 8, along with the values for FPIS and FNIS.

Table 8 Weighted Normalized Fuzzy Decision Matrix, along with FPIS and FNIS

Weights	0.35	0.4	0.45	0.25	0.3	0.35	0.25	0.3	0.35
	Strategic Management			**Operational Management**			**Decision Making**		
Emerging Firms	0.1965	0.2247	0.2531	0.1480	0.1778	0.2078	0.1445	0.1735	0.2024
Scaled Firms	0.2029	0.2319	0.2609	0.1423	0.1709	0.1995	0.1443	0.1732	0.2021
Mega Firms	0.2064	0.2360	0.2657	0.1423	0.1709	0.1995	0.1441	0.1730	0.2018
FPIS	0.2064	0.2360	0.2657	0.1480	0.1778	0.2078	0.1445	0.1735	0.2024
FNIS	0.1965	0.2247	0.2531	0.1423	0.1709	0.1995	0.1441	0.1730	0.2018

In the next step, the distance of each fuzzy point to FPIS and FNIS was calculated using distance formula for three dimensional coordinates, as given by eq(viii) and eq(ix). The parameters d^{+} and d^{-} were also calculated for each of the alternative, by summing the distance from fuzzy point to FPIS and FNIS respectively. The equation to calculate d^{+} and d^{-} is given by eq(x), and eq(xi) respectively.

$$d_{ij}^{+} = \sqrt{\frac{(a_{ij}^{*} - A_{ij}^{+})^2 + (b_{ij}^{*} - A_{ij}^{+})^2 + (c_{ij}^{*} - A_{ij}^{+})^2}{3}} \quad \textbf{(viii)}$$

$$d_{ij}^{-} = \sqrt{\frac{(a_{ij}^{*} - A_{ij}^{-})^2 + (b_{ij}^{*} - A_{ij}^{-})^2 + (c_{ij}^{*} - A_{ij}^{-})^2}{3}} \quad \textbf{(ix)}$$

$$d^{+} = \sum_{j=1}^{n} d_{ij}^{+} \quad \textbf{(x)}$$

$$d^{-} = \sum_{j=1}^{n} d_{ij}^{-} \quad \textbf{(xi)}$$

The calculation of distance from FPIS, and d^{+} is given in Table 9, while Table 10 gives the distance form FNIS and d^{-}.

Table 9 Distance from FPIS and d^{+}

	Distance from FPIS			
	Strategic Management	**Operational Management**	**Decision Making**	**d^{+}**
Emerging Firms	0.01185	0.00000	0.00000	0.01185
Scaled Firms	0.00415	0.00708	0.00027	0.01149
Mega Firms	0.00000	0.00708	0.00052	0.00759

Table 10 Distance from FNIS and d^-

	Distance from FNIS			
	Strategic Management	**Operational Management**	**Decision Making**	**d^-**
Emerging Firms	0.00000	0.00708	0.00052	0.00759
Scaled Firms	0.00720	0.00000	0.00025	0.00745
Mega Firms	0.01135	0.00000	0.00000	0.01135

In the last step, the Closeness Coefficient (CC) was calculated using the formula given in eq(xii), and the alternates were ranked, or prioritized, according to their increasing closeness coefficient. The closeness coefficient is a measure of how much the alternate is close to its positive ideal solution [67]. Table 11 gives the closeness coefficient for all the three categories of construction firms, while Figure 5 shows a graphical illustration of closeness coefficient of various alternatives.

Table 11 Closeness Coefficient for various categories of construction firms

	Closeness Coefficient	**Rank / Priority**
Emerging Firms	0.39048	3
Scaled Firms	0.39327	2
Mega Firms	0.59921	1

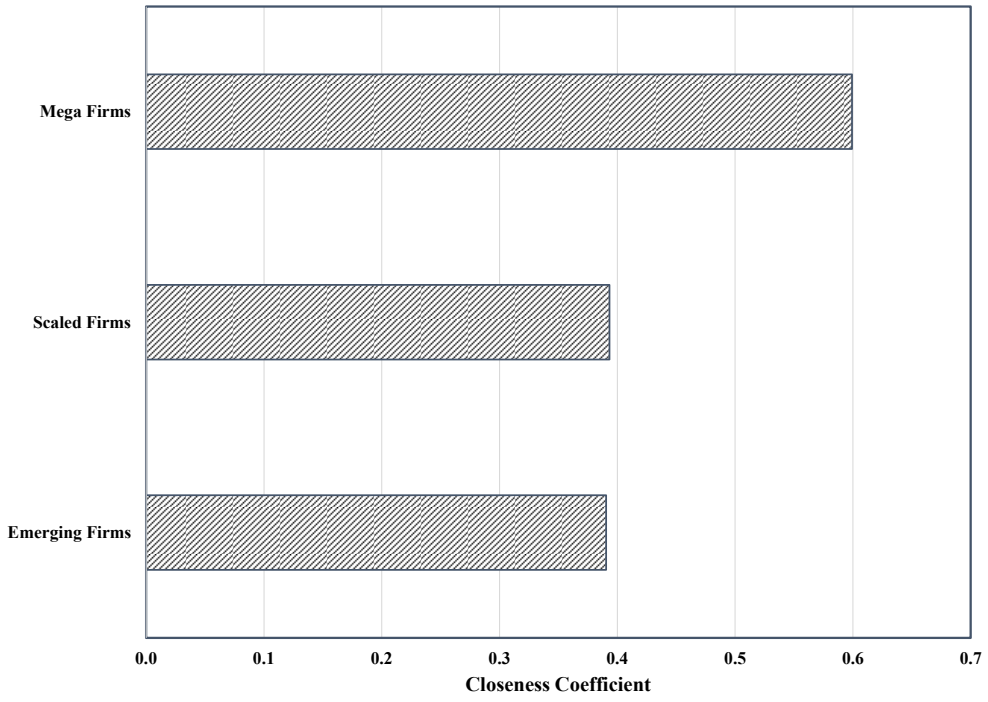

Figure 5 Ranks of construction firms according to their closeness coefficient

It can be seen from Figure 5 that the Mega Firms performed the best in terms of application of strategic management, operational management, and decision making to achieve the optimal organizational performance, however the Scaled and Emerging firms were found to be lagging in the implementation level. Further it is important to note that the closeness coefficient of scaled and emerging firms was found to be approximately equal, hence presenting the opportunity to employ advanced management domain for achieving an optimal organizational performance in the construction industry.

CONCLUSIONS

The current study was designed to check the implementation level of strategic management, operational management, and decision making for effective organizational performance of the construction firms. The survey questionnaire was distributed to the representatives of 100 construction firms having different amount of annual revenue. Their response was analyzed and following conclusion were made.

1) It was reported that 90% of the construction firms had defined vision and mission statement, while about 91% of the firms had long-term goals. It was also seen that for determining the project cost, the construction firms considered the financial capacity of the client and the project's time schedule. Further, more than 80% of the firms considered the factors of risk management, team building, and leadership for long-term success.

2) It was observed that the process of resource allocation was determined as the biggest challenge for ensuring the operational efficiency of the organizations. Further 70% of the respondents termed the process of project planning and scheduling as highly effective, while 69% considered the same for their organization's operational management practices.

3) It was reported that 99% of the construction firms had a quality management system in place. However, only 53% of the respondents were found to be satisfied with the decision-making practices of their organization. It was also observed that 82% of the respondents considered their organizational culture as satisfactory, while 87% agreed with the influence of advanced management domains in their regular tasks.

4) After comprehensively analyzing the responses, a fuzzy-logics based FTOPSIS technique was applied to the data to find the rank of various types of organizations in terms of their implementation level of advanced management domains for better organizational performance. It was found that Mega Firms performed the best with a closeness coefficient value of 0.599, followed by Scaled Firms and Emerging Firms with approximately same values, i.e., 0.393 and 0.390 respectively.

LIMITATIONS AND RECOMMENDATIONS

Although the current study provides valuable insights about the construction industry, however there a few limitations of this study. A population size of 10,000 was considered was considered for this study. Further, the analysis was performed on the self-reported data only, which may induce some bias in the

findings. For future research, the authors recommend following points which may prove to be useful for stakeholders.

1. Future research should consider more factors, like risk management, human resource development, etc. for an effective organizational performance.
2. Future research should utilize more sample size for evaluating the trends in the construction industry, and analyze data from diverse sources to generalize the results.
3. Future research should study the long-term effects of employing advanced management techniques on the organizational performance.
4. For more comprehensive data analysis, future research should utilize advanced data analysis in combination with artificial intelligence and building information module.

ACKNOWLEDGEMENT

The authors would like to acknowledge the support provided by the construction industry professional in the form of prompt responses. The authors express their thankfulness to all the respondents.

REFERENCES

1. M. A. Musarat, W. S. Alaloul, and Liew, "Impact of inflation rate on construction projects budget: A review," *Ain Shams Engineering Journal*, vol. 12, no. 1, pp. 407–414, Mar. 2021, doi: 10.1016/j.asej.2020.04.009.

2. The Pakistan Credit Rating Agency Limited, "Construction sector study," Feb. 2023. [Online]. Available: https://www.pacra.com/sector_research/Construction%20-%20PACRA%20Research%20-%20Mar'23_1680249473.pdf

3. Trade Development Authority of Pakistan, Ministry of Commerce, "Pakistan Construction." [Online]. Available: https://www.gcci.org.pk/data/PakistanExports/35.pdf

4. G. Fuertes, M. Alfaro, M. Vargas, S. Gutierrez, R. Ternero, and J. Sabattin, "Conceptual Framework for the Strategic Management: A Literature Review—Descriptive," *Journal of Engineering*, vol. 2020, pp. 1–21, Jan. 2020, doi: 10.1155/2020/6253013.

5. F. R. David and M. E. David, *Strategic Management: A Competitive Advantage Approach, Concepts and Cases*.

6. C. Staff, "What is strategic management? Benefits, process, and careers," *Coursera*, Apr. 03, 2024. https://www.coursera.org/articles/strategic-management

7. W. Kenton, "How to perform a SWOT Analysis," *Investopedia*, Jun. 29, 2024. https://www.investopedia.com/terms/s/swot.asp

8. J. Heizer, B. Render, and C. Munson, *Operations Management: Sustainability and Supply Chain Management, Global Edition*. Pearson, 2023.

9. N. Slack and A. Brandon-Jones, *Operations Management (9th edition)*. 2019. [Online]. Available: https://researchportal.bath.ac.uk/en/publications/operations-management-9th-edition

10.Kaplan, Robert S., and D. P. Norton. The Strategy-Focused Organization: How Balanced Scorecard Companies Thrive in the New Business Environment. Boston, MA: Harvard Business School Press, 2000.

11. M. E. Porter, *Competitive Advantage: Creating and Sustaining Superior Performance*. 1985. [Online]. Available: http://ci.nii.ac.jp/ncid/BA00852365

12. K. M. Eisenhardt and M. J. Zbaracki, "Strategic decision making," *Strategic Management Journal*, vol. 13, no. S2, pp. 17–37, Jan. 1992, doi: 10.1002/smj.4250130904.

13. P. S. Chinowsky and J. E. Meredith, "Strategic Management in construction," *Journal of Construction Engineering and Management*, Jan. 2000, doi: 10.1061/(ASCE)0733-9364(2000)126:1(1.

14. P. J. Richard, T. M. Devinney, G. S. Yip, and G. Johnson, "Measuring organizational performance: towards methodological best practice," *Journal of Management*, vol. 35, no. 3, pp. 718–804, Feb. 2009, doi: 10.1177/0149206308330560.

15. S. Elbanna and J. Child, “The influence of decision, environmental and firm characteristics on the rationality of strategic Decision-Making*,” *Journal of Management Studies*, vol. 44, no. 4, pp. 561–591, Feb. 2007, doi: 10.1111/j.1467-6486.2006.00670. x.

16. X. Xue, R. Zhang, R. Yang, and J. Dai, “Innovation in Construction: a critical review and future research,” *International Journal of Innovation Science*, vol. 6, no. 2, pp. 111–126, Jun. 2014, doi: 10.1260/1757-2223.6.2.111.

17. R. Ansari, S. A. Banihashemi, R. Taherkhani, and S. Moradi, “Decision support System for analyzing key performance indicators in construction projects management,” *International Journal of Engineering. Transactions B: Applications*, vol. 35, no. 5, pp. 865–874, Jan. 2022, doi: 10.5829/ije.2022.35.05b.03.

18. I. M. Horta, A. S. Camanho, J. Johnes, and G. Johnes, “Performance trends in the construction industry worldwide: an overview of the turn of the century,” *Journal of Productivity Analysis*, vol. 39, no. 1, pp. 89–99, Mar. 2012, doi: 10.1007/s11123-012-0276-0.

19. M. A. Musarat, W. S. Alaloul, and Liew, “Impact of inflation rate on construction projects budget: A review,” *Ain Shams Engineering Journal*, vol. 12, no. 1, pp. 407–414, Mar. 2021, doi: 10.1016/j.asej.2020.04.009.

20. E. F. Boadu, C. C. Wang, and R. Y. Sunindijo, “Characteristics of the construction industry in developing countries and its implications for health and safety: an exploratory study in Ghana,” *International Journal of Environmental Research and Public Health*, vol. 17, no. 11, p. 4110, Jun. 2020, doi: 10.3390/ijerph17114110.

21. M. Naaranoja, P. Haapalainen, and H. Lonka, “Strategic management tools in projects case construction project,” *International Journal of Project Management*, vol. 25, no. 7, pp. 659–665, May 2007, doi: 10.1016/j.ijproman.2007.04.002.

22. N. Pushpamali, D. Agdas, and T. M. Rose, “Strategic Decision making in construction Supply Chains: A comparison of reverse logistics strategies,” *Frontiers in Built Environment*, vol. 6, Dec. 2020, doi: 10.3389/fbuil.2020.593372.

23. F. Arif, N. Azhar, and M. E. Bayraktar, “Strategic Management Concepts and Practices in Pakistan: a Construction Industry perspective,” *Construction Research Congress 2012*, May 2012, doi: 10.1061/9780784412329.154.

24. M. Tetik, A. Peltokorpi, O. Seppänen, and J. Holmström, “Direct digital construction: Technology-based operations management practice for continuous improvement of construction industry performance,” *Automation in Construction*, vol. 107, p. 102910, Sep. 2019, doi: 10.1016/j.autcon.2019.102910.

25. M. Kumaraswamy, P. E. D. Love, M. Dulaimi, and M. Rahman, “Integrating procurement and operational innovations for construction industry development,” *Engineering Construction & Architectural Management*, vol. 11, no. 5, pp. 323–334, Sep. 2004, doi: 10.1108/09699980410558511.

26. A. R. Ibrahim, G. Imtiaz, B. Mujtaba, X. V. Vo, and Z. U. Ahmed, “Operational excellence through lean manufacturing: Considerations for productivity management in Malaysia’s construction industry,” *Journal of Transnational Management*, vol. 25, no. 3, pp. 225–256, May 2020, doi: 10.1080/15475778.2020.1749809.

27. T. Tan, G. Mills, E. Papadonikolaki, and Z. Liu, "Combining multi-criteria decision making (MCDM) methods with building information modelling (BIM): A review," *Automation in Construction*, vol. 121, p. 103451, Nov. 2020, doi: 10.1016/j.autcon.2020.103451.

28. R. J. Yang, Y. Wang, and X.-H. Jin, "Stakeholders' Attributes, Behaviors, and Decision-Making Strategies in Construction Projects: Importance and correlations in practice," *Project Management Journal*, vol. 45, no. 3, pp. 74–90, Jun. 2014, doi: 10.1002/pmj.21412.

29. J. R. S. Cristóbal, "Contractor selection using multicriteria Decision-Making methods," *Journal of Construction Engineering and Management*, vol. 138, no. 6, pp. 751–758, Sep. 2011, doi: 10.1061/(asce)co.1943-7862.0000488.

30. J. Chai, J. N. K. Liu, and E. W. T. Ngai, "Application of decision-making techniques in supplier selection: A systematic review of literature," *Expert Systems With Applications*, vol. 40, no. 10, pp. 3872–3885, Dec. 2012, doi: 10.1016/j.eswa.2012.12.040.

31. Q. Zhang, B. L. Oo, and B. T. H. Lim, "Linking corporate social responsibility (CSR) practices and organizational performance in the construction industry: A resource collaboration network," *Resources Conservation and Recycling*, vol. 179, p. 106113, Dec. 2021, doi: 10.1016/j.resconrec.2021.106113.

32. R. Assaad, I. H. El-Adaway, and I. S. Abotaleb, "Predicting project performance in the construction industry," *Journal of Construction Engineering and Management*, vol. 146, no. 5, Feb. 2020, doi: 10.1061/(asce)co.1943-7862.0001797.

33. "The nexus of management innovation, performance management, and organizational performance in the Pakistani construction industry," *Questa Soft*, 2022. https://www.ceeol.com/search/article-detail?id=1091795

34. S. Saif, W. Abbass, S. Mubin, F. Aslam, and R. Alyousef, "Artificial intelligence-based predictive model for utilization of industrial coal ash in the production of sustainable ceramic tiles," *Archives of Civil and Mechanical Engineering*, vol. 24, no. 4, Aug. 2024, doi: 10.1007/s43452-024-01020-6.

35. S. Saif, S. Mubin, W. Abbass, F. Aslam, and R. Alyousef, "Utilizing machine learning to integrate silica-based production waste material in ceramic tile manufacturing: Progressing toward sustainable solutions," *Ceramics International*, Mar. 2024, doi: 10.1016/j.ceramint.2024.02.377.

36. W. Abbass, M. Ahmed, A. Ahmed, F. Aslam, I. Aziz, and A. Mohamed, "AI based model for prediction of heavy metals using Physio-Chemical characterization of agricultural waste ashes," *Research Square (Research Square)*, Jan. 2024, doi: 10.21203/rs.3.rs-3865940/v1.

37. "Project Management using Machine Learning," *ResearchGate*. https://www.researchgate.net/publication/348327272_Project_Management_using_Machine_Learning

38. "Sample Size Formula: meaning, formulas, solved examples," *Toppr-guides*, Mar. 26, 2020. https://www.toppr.com/guides/maths-formulas/sample-size-formula/

39. Admin, "Z-Score Table | Formula, Distribution Table, Chart & Example," *BYJUS*, Jul. 06, 2022. https://byjus.com/maths/z-score-table/

40. A. Kashif, M. Sajjad, and G. Ekatrina, "Evaluating quality management system of construction projects," *International Journal of Performability Engineering*, vol. 18, no. 7, p. 492, Jan. 2022, doi: 10.23940/ijpe.22.07. p4.492-501.

41. "Vision and Mission: The Backbone of Strategic Planning | LinkedIn," Jun. 24, 2024. https://www.linkedin.com/pulse/vision-mission-backbone-strategic-planning-eric-mcconaty-u9i3e/

42. C. P. Mayer, *Prosperity: Better Business Makes the Greater Good*. Oxford University Press, USA, 2018.

43. L. Kurznack, D. Schoenmaker, and W. Schramade, "A model of long-term value creation," *Journal of Sustainable Finance & Investment*, pp. 1–19, May 2021, doi: 10.1080/20430795.2021.1920231.

44. D. Gour and B. P. Mudgal, "Activity overlapping technique for early completion of construction project," *International Journal for Research in Applied Science and Engineering Technology*, vol. 10, no. 6, pp. 1517–1525, Jun. 2022, doi: 10.22214/ijraset.2022.44091.

45. R. Dehghan and J. Y. Ruwanpura, "The mechanism of design activity overlapping in construction projects and the Time-Cost trade off function," *Procedia Engineering*, vol. 14, pp. 1959–1965, Jan. 2011, doi: 10.1016/j.proeng.2011.07.246.

46.. "UNCERTAINTY ANALYSIS IN CONSTRUCTION PROJECT'S APPRAISAL PHASE," *ResearchGate*, Jun. 01, 2018. https://www.researchgate.net/publication/267679969_UNCERTAINTY_ANALYSIS_IN_CONSTRUCTION_PROJECT'S_APPRAISAL_PHASE/citations

47. S. M. Paik, P. Leviakangas, and J. Choi, "Making most of BIM in design: analysis of the importance of design coordination," *International Journal of Construction Management*, vol. 22, no. 12, pp. 2225–2233, Jun. 2020, doi: 10.1080/15623599.2020.1774837.

48. E. F. Boadu, C. C. Wang, and R. Y. Sunindijo, "Characteristics of the construction industry in developing countries and its implications for health and safety: an exploratory study in Ghana," *International Journal of Environmental Research and Public Health*, vol. 17, no. 11, p. 4110, Jun. 2020, doi: 10.3390/ijerph17114110.

49. Desapex, "How BIM leads to cost savings and increased efficiency in construction," *Medium*, Jul. 10, 2024. [Online]. Available: https://medium.com/@Desapex/how-bim-leads-to-cost-savings-and-increased-efficiency-in-construction-b515379a2c26

50. "What are the key factors or criteria for prioritizing resources in operations?" https://www.linkedin.com/advice/0/what-key-factors-criteria-prioritizing-resources

51. J. Zhang and X. Huang, "Investigation on the application of cost management in operational efficiency and performance evaluation," *Manufacturing and Service Operations Management*, vol. 4, no. 5, Jan. 2023, doi: 10.23977/msom.2023.040502.

52. N. A. A. Akinsulire, N. C. Idemudia, N. A. C. Okwandu, and N. O. Iwu Anyanwu, "Supply chain management and operational efficiency in affordable housing: An integrated review," *Magna Scientia Advanced Research and Reviews*, vol. 11, no. 2, pp. 105–118, Jul. 2024, doi: 10.30574/msarr.2024.11.2.0113.

53. “Quality management systems: An introduction,” *ISO*. https://www.iso.org/quality-management/what-is-qms

54. A. W. Saarinen and M. A. Hobel, “Setting and meeting requirements for quality,” *Journal of Management in Engineering*, Apr. 1990, doi: 10.1061/(ASCE)9742-597X (1990)6:2(177.

55. Simply Psychology, “Likert Scale Questionnaire: Meaning, Examples & Analysis,” *Simply Psychology*, Jul. 31, 2023. https://www.simplypsychology.org/likert-scale.html

56. “Decision-Making in Management: 5 common pitfalls to avoid,” *Business Insights Blog*, Mar. 24, 2020. https://online.hbs.edu/blog/post/decision-making-in-management

57. Y. R. Shrestha, V. Krishna, and G. Von Krogh, “Augmenting organizational decision-making with deep learning algorithms: Principles, promises, and challenges,” *Journal of Business Research*, vol. 123, pp. 588–603, Feb. 2021, doi: 10.1016/j.jbusres.2020.09.068.

58. M. Yazdi, F. Khan, R. Abbassi, and R. Rusli, “Improved DEMATEL methodology for effective safety management decision-making,” *Safety Science*, vol. 127, p. 104705, Jul. 2020, doi: 10.1016/j.ssci.2020.104705.

59. G. Bucăţa and A. M. Rizescu, “The role of communication in enhancing work effectiveness of an organization,” *Revista Academiei Forţelor Terestre*, vol. 22, no. 1, pp. 49–57, Mar. 2017, doi: 10.1515/raft-2017-0008.

60. M. Montes-Guerra *et al*, "THE INFLUENCE OF MONITORING AND CONTROL ON PROJECT MANAGEMENT SUCCESS," *International Journal of Construction Project Management,* vol. 6, *(2),* pp. 163-184, 2014. Available: https://www.proquest.com/scholarly-journals/influence-monitoring-control-on-project/docview/1625563034/se-2.

61. G. Zhenjing, S. Chupradit, K. Y. Ku, A. A. Nassani, and M. Haffar, “Impact of Employees’ workplace environment on Employees’ performance: A Multi-Mediation Model,” *Frontiers in Public Health*, vol. 10, May 2022, doi: 10.3389/fpubh.2022.890400.

62. C. D. Ittner and D. F. Larcker, “Quality strategy, strategic control systems, and organizational performance,” *Accounting Organizations and Society*, vol. 22, no. 3–4, pp. 293–314, Apr. 1997, doi: 10.1016/s0361-3682(96)00035-9.

63. “Prioritization of multi-dimensions of project management by using FAHP and FTOPSIS: A hybrid approach,” *ResearchGate*, Jun. 01, 2020. https://www.researchgate.net/publication/375446699_Prioritization_of_multi-dimensions_of_project_man-_agement_by_using_FAHP_and_FTOPSIS_A_hybrid_approach

64. C.-B. Cheng, “Group opinion aggregation based on a grading process: A method for constructing triangular fuzzy numbers,” *Computers & Mathematics With Applications*, vol. 48, no. 10–11, pp. 1619–1632, Nov. 2004, doi: 10.1016/j.camwa.2004.03.008.

65. W. Abbass, A. Shahzad, F. Aslam, S. Shahzad, A. Ahmed, and A. Mohamed, “Characterization and Economization of Cementitious Tile Bond Adhesives using Machine Learning Technique,” *Case Studies in Construction Materials*, vol. 20, p. e02916, Jul. 2024, doi: 10.1016/j.cscm.2024.e 02916.

66. “Company culture – the backbone of any organization - Faber Infinite,” *Faber Infinite*. https://faberinfinite.com/company-culture-the-backbone-of-any-organization/

67. P. Miç and Z. F. Antmen, “Sağlık hizmeti Tesis yerleşimi problem in in değerlendirilmesine çok kriterli bulanık bir yaklaşım,” *European Journal of Science and Technology*, pp. 750–757, Aug. 2019, doi: 10.31590/ejosat.584217.

68. Abbass, W., Ahmed, A., Ali, M. et al. Artificial Intelligence based model of pozzolanic and non-pozzolanic micro fillers in the binary and ternary blend to produce high-performance hybrid fiber-reinforced concrete. Arch. Civ. Mech. Eng. 26, 153 (2026). https://doi.org/10.1007/s43452-026-01514-5