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Impact of project management competence and complexities on the performance of mega engineering projects in Pakistan

Subhan Ud Din*[1] | Irfan Ullah[2] | Umer Farooq*[1] | Sohail Anwar[1] | Safi Ullah[3, 4]

1. Department of Business and Management Sciences, The Superior University, Lahore, Pakistan.
2. Department Civil Engineering, Iqra National University, Peshawar, Pakistan.
3. Department of Construction Management, Southeast University, Nanjing, China.
4. Global Banking School, Bath Spa University, Manchester, Lancashire, United Kingdom.

* Corresponding Author Email: umerfarooq4420@gmail.com

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Abstract:
This study examines Pakistan's public engineering projects' success based on project complexity and management expertise, using 100 questionnaires, and developing hypotheses to evaluate organizational, technical, and environmental factors. Results indicate that project performance is positively linked to Project Management (PM) competence, underscoring the significance of skilled project managers in achieving favourable outcomes. Furthermore, leadership, management skills, communication, ethics, and integrity are identified as key drivers of project performance. On the other hand, technical and organizational complexities were discovered to have a negative influence, although environmental complexity did not significantly affect project performance. Several complexities, such as project objectives, tasks, and economic conditions, emerged as influential factors affecting project execution. This research contributes to PM theory, offering practical insights beneficial for project managers overseeing large engineering endeavours and other professionals in this domain. On a broader scale, the findings may inform governmental policies to enhance project performance, including qualifications for project managers. This study provides valuable guidance for addressing project complexities and improving project success within Pakistan's public engineering projects.

Keywords: project management, management competence, project complexities, project performance, engineering projects, environmental complexity.

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1. Introduction

Following the creation of the association's procedure and setting of its vision, the administration must create individual projects, and these tasks are those activities that collectively deal with the business methodology liberation (Cooke-Davies, 2002). Due to their preference for undertaking tasks that would yield the best efficiency and business strategy results, associations do not have infinite resources for speculating (Gray & Larson, 2008) and using strategies that associations have used to manage their project portfolios, such as assessing both financial and non-financial aspects, assessing potential models for preferences, and choosing the optimal project (Jenner, 2016).

Numerous models can be used to monitor a project's development. For the evaluation, Pinto and Mantel (1990) and Baccarini (1999) settled on two methodologies: performance management of stakeholders and business deliverables for clients. The communication used as of late was an appraisal in light of triple prerequisite estimates counting time, quality, and cost. This model's solid areas for evaluating the introduction of the venture to the load-up using Key Execution Markers (KPIs) are expected to quantify specialized details, plan of time, and foreordained spending plan adherence (Bryde, 2005).

It is by and large, said to be passing ways of behaving, abilities, information, and perspectives connected with work execution prevalence. The competence's characteristic-based connection point is portrayed utilizing comprehension of ability (Heywood & Gonczi, 1992). Project complexity is being examined more, and different analytical techniques are used to provide basic characterizations using various types and attributes. For a superior view or comprehension of peril, axing frameworks the utilization of mind confusing `framework hypothesis is finished. Without comprehending the underlying factors that contribute to a project's complexity, many scholars describe the initiatives as being "complex" (Williams, 1999).

The project that the executives plan suggests a seamless relationship between the overseeing authority, task administrations, and the project's conclusion (Müller & Turner, 2007). The board uses knowledge, skills, tools, and processes to complete a task that will result in meeting project requirements (Barna, 2013). Furthermore, attempt their best to satisfy the fundamentals of partners. Project, his board capabilities comprise logical, conduct, specialized and individual skills (Khattak *et al.*, 2016) and International Project Management Association (IPMA) (Caupin, 2006). Further, individual skills are classified as board abilities, correspondence, mental capacity, and adequacy (Khattak *et al.*, 2016). For example, logical and specialized capabilities have been examined in writing the survey part.

The applied model in the exploration above consists of three structure blocks. Project Management (PM) skills and complexity are independent factors, while project performance is the dependent variable. In this study, we evaluated the questions: (i) how Pakistani engineering projects perform in relation to environmental complexity; (ii) how Pakistani engineering projects perform in terms of technical complexity; (iii) how Pakistani engineering projects perform in terms of organizational complexity, and (iv) how Pakistani engineering projects perform in relation to PM proficiency. Based on the above questions we will gather the data, and the study objective is to investigate the various forms of complexity and PM proficiency that impact Pakistani mega-engineering project performance and also to determine how large-

scale public engineering projects, including the provision of water, sewage, rail and roads, as well as oil and gas, waste disposal and transportation networks will be impacted (Mubin *et al.*, 2008).

The Technology Organization Environment (TOE) framework will be used to investigate the connection between project performance and complexity. At last, the public sector assumes a crucial role in the development of the economy. Hence, this sector will be examined in Pakistan and mega engineering projects are essential for economic growth, expanding infrastructure, and raising living standards in emerging nations like Pakistan. However, these projects require complicated management, and the skill of the project managers is crucial to their success. In Pakistan, despite considerable investments in infrastructure projects, the failure rate of these projects remains high. This shows a knowledge gap about the execution of large-scale engineering projects in Pakistan and the impact of PM complexity and skill. Therefore, it is necessary to examine how PM expertise and complexity affect the performance of large-scale engineering projects in Pakistan and pinpoint the crucial elements that determine whether they succeed or fail. This research intends to close this gap by examining the effects of PM expertise and complexity on the success of large-scale engineering projects in Pakistan and offering suggestions for improvement.

PM is essential for overcoming project complexity. One will have the opportunity to expect to manage both major and minor activities, a single project, and the driving force behind an organization's entire portfolio. According to research on PM, projects are becoming increasingly dynamic and “marvellous” and there is a need to appreciate this diversity (Williams, 1999). According to Williams (1999), the project's complexity is expected to rise as a result of rapid climate shifts, increased item complexity, and increased deadline pressure. Relationships have struggled to survive in today's turbulent world due to the rapid spread of globalization and inventive changes. As a result, the projects have flaws; however, the conventional formal approach to managing project organization is based on a predetermined, established, fundamental, and firm model (Shenhar & Dvir, 2007). Controls find it difficult to actually administer most improvement projects due to their distributed quality, weakness, and component nature. The difficulties and board issues are also growing as a result of the rapid pattern of mega-development project (Ejaz *et al.*, 2013).

2. Literature review

Different situations and unanticipated elements that could originate from numerous sources could impact the project technique. A significant thought found in writing is that all projects require a, custom-made board approach (Shenhar & Dvir, 2007). There are numerous connections between the project board and project completion. Organizational skills and specific power are appropriate for certain task types (Müller & Turner, 2007). For accomplishment, various power capacities are compulsory in projects with distinctive complexities. An issues' part connected with the project the undertaking the executives’ capacities were awful development depiction, lacking getting sorted out, shady objectives, non-existent association instruments, and nonattendance of direction of assignment the board strategies and contraptions like Task The executives Assortment of Information (PMBOK) (project management body of knowledge) (Ejaz *et al.*, 2013). During the process of separating Pakistan's big building projects, it was found that “project planning and scheduling” and “choice made by the PM” which are aspects of the project the board skills, play crucial roles in the success of projects. This exemplifies the importance of having effective PM abilities.

Clear coworker competencies are necessary for a variety of task difficulties (Noordegraaf, 2011).

Mega engineering projects represent an essential choice towards accomplishing manageable improvement targets in agricultural nations, and these projects require high plan information, specialized abilities, equipped human assets, and administrative capacities (Othman, 2013). Managers are primarily to blame for many activities being abandoned or disappointing. Since managers form the basis of every project, the project will eventually be completed more effectively if they are active participants in each activity (Farooq, 2022). In emerging nations, the use of PM tools and systems is still in its infancy, and as resources become more important so does the need to employ cutting-edge PM methodologies. Ill-advised arranging is one reason that create setback for Malaysian development projects. Evaluated According to a 2008 study on Pakistan's development sector, there are major barriers to project execution when it comes to a lack of resources, knowledge, and the application of PM procedures, methods, and tools. Pakistan, a developing country, is also plagued by issues related to establishment development, including a lack of competent human resources, lack of presence of mind, and management skills, which have resulted in delays and overruns in framework development projects. Emerging nations like Pakistan have been shown to lack high-level knowledge, specialized skills, skilled human resources, and administrative capabilities, which impedes the development of super designing activities (Othman, 2013). This demonstrates that project achievement is concerned with project results and impact, whereas PM is concerned with quick project results and measuring execution against cost, time, and quality.

Westerveld (2003) considered task results in terms of cost, time, and quality as additional indicators of speedy achievement. The creator made sense of that project the executive's achievement is conveyance on time, spending plan, and as indicated by particulars. Three estimates of project completion and considered how project completion is influenced by the success of the PM, the items, and the business area. It suggests that the success of PM is a factor in how well a project is executed in relation to its entire goals, including time, budget, and quality standards. Success in PM often requires performing the work promptly, affordably, satisfactorily, and at a high standard (Ejaz *et al.*, 2013).

In different research articles, there were different factors researchers had notified that effected the project performance, Therefore, it is necessary to look at how PM expertise and complexity affect the performance of large-scale engineering projects in Pakistan and pinpoint the crucial elements that determine whether they succeed or fail. So, we decided that the following four factors for example, the effects of technological complexity, organizational complexity, environmental complexity, and project management complexity will be discovered on the project's performance. Due to this research, we found that how we can improve the performance of mega engineering projects and this research article will contribute for the betterment of project performance domain in government sectors as well as in private sectors organizations.

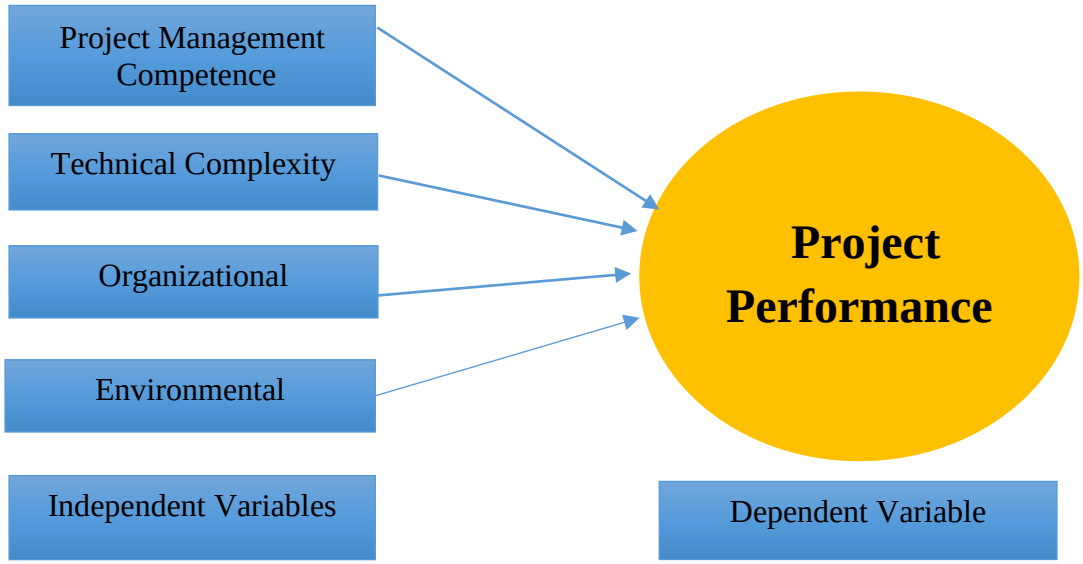
2.1. Explanations of the variables and hypothesis of the study

2.1.1. Theoretical framework

The model is derived from the previous TOE, IPMA, and PMCD system project competence

models, and project performance models. The impact on project performance of four hypothesis assumptions project performance, organizational complexity, technical complexity, and environmental complexity is depicted in this model. Competence in PM, environmental complexity, organizational complexity, and technical complexity.

Figure 1: Conceptual framework



Project performance is the dependent variable in the framework above, while complexity in PM, technical difficulty, organizational difficulty, and complexity in the environment are the independent factors. Variation in these four independent variables can change the project performance positively or negatively. Based on these we will make the hypothesis, the details explanations are here, Competence in PM: Project is an impermanent undertaking embraced to make something uncommon or association (Project Management Institute, 2001). Any series of tasks and activities is referred to as a project if they:

- Have a clear goal that must be accomplished within predetermined parameters.
- Have a deadline.
- Have a little amount of capital (if applicable).
- Use up all available human and nonhuman resources (such as cash, people, and machinery).
- Have several uses (i.e., straddle a variety of useful boundaries).

According to Williams (2002), PM got its start in the compound business in the 1930s, and then it got created and became obvious in the 1950s. Project execution is the practice of extending activities to address undertaking basics by the use of knowledge, skills, tools, and processes (Project Management Institute, 2001).

The Latin word “Competentia” from which the English word “competence” is derived, means both “has the right to speak” and “is approved to pass judgement” (Caupin, 2006). Barna (2013) and Abraham *et al.* (2001), defined ability as a collection of connected knowledge, attitudes, and abilities and indicated that what other people attribute has a substantial impact on one's work:

- It relates to the establishment of work.
- It tends to be estimated against sound recognized values
- It tends to be upgraded through preparation and progress.

H1: A project's performance is significantly enhanced by competent PM.

A. Project complexity

According to the Oxford online word reference, “complex” comprises different, associated parts and is difficult to comprehend, confounded, or unpredictable. Examination of project complexity or complexity of projects is turning out to be more perceived, with scientists attempting to zero in on this issue utilizing various stages, varying from a straightforward type-by-type display of the exhibit's elements to the use of intricate framework theories to explain their behaviour better (Geraldi & Adlbrecht, 2007).

B. Organizational complexity

Vertical and horizontal separation are the two types used to divide organizational complexities. For instance, the number of levels in an association is vertically separated in organizational hierarchical design. The number of offices in an organization is referred to as an organizational unit, and the assignment structure refers to the separation of tasks into general assignments and routine chores. Authoritative intricacies by interdependencies are the joint effort and useful states of the task's hierarchical parts (Baccarini, 1999).

C. Technological complexity

The difficulty of performing a task is typically used to define technological complexity in terms of diversity or various assignments, inputs, results, tasks, or claims to fame as innovation. Innovation complexity is compared to hierarchical interdependencies, which are communication, dependence, and reliance between obligations, groups, abilities, or efforts (Baccarini, 1999).

D. Structural complexity

According to Williams (1999) model, this complexity can be found in most large projects. This complexity is considered when overseeing and staying informed about several connected tasks and projects (Remington & Pollack, 2007).

E. Technical complexity

Such complexity results from specialized or plan-related problems with novel elements as well as novel cycles. It resembles weakness in techniques for the (Turner & Cochrane, 1993) model and the (Williams, 1999) model. Another study, led by Ishtiaq and Jahanzaib (2017), examined how environmental factors and project complexity affected project outcomes in Pakistan's oil and gas open area. The variety of tasks, the number of organizational design hierarchies, the impact of outside partners, the difficulty of organizational relationships, the interdependencies between deadlines, and the susceptibility of PM techniques and tools are all aspects of the project complexity factor.

H2: Project performance is significantly impacted negatively by technical complexity.

H3: The performance of a project is significantly impacted negatively by organizational complexity.

H4: Project performance is significantly harmed by environmental complexity.

3. Research methodology

3.1. Research approach

Deductive and inductive reasoning are two logic techniques used in a study strategy. In inductive exploration, an expert's goal is to infer hypothetical assumptions and models from observed data, whereas in an assessment, the examiner will probably evaluate assumptions and models learned from the speculation using new exploratory data (Bhattacherjee, 2012). The first step in a deductive method is to look at the hypothesis, develop a theory based on that hypothesis that applies to the subject under investigation, and then put that theory to the test. An inductive method, on the other hand, begins with a thorough examination of the research's core using a variety of evaluation frameworks and the formulation of a hypothesis based on the findings (Greener, 2008). To quantitatively analyze the information the information is be gathered mathematically from the representative's insight regarding project complexity, competence, and performance, specifically associated with Pakistani mega engineering projects 2009. Then, based on the theory used in the literature review, these variables are examined, and the results are predicted (Saunders *et al.*, 2009).

3.2. Research strategy

The quantitative research method has been used for this study. Moreover, the survey method was used as the research approach for this study. Typically, quantitative methods are employed to support the hypothesis, but occasionally results need to be revised in light of theory (Saunders *et al.*, 2009).

3.3. Research design

For this study, the “cross-sectional” research methodology was modified, and it was preferred to look into many associations. The organizations' employees have divergent perspectives on project complexity, competence, and performance. According to Bryman and Bell (2011), the data or information used in the cross-sectional design should be quantifiable. This design was chosen to establish a connection between various variables. The research comprises a survey of huge engineering projects from Pakistan's public sector. Quantitative research, or exploratory research, is the survey's focus, which will investigate the connections between project complexity, competence, and performance dimensions.

3.4. Sampling

To ensure the objectivity of the population employed in the survey, the random sampling methodology is chosen instead of the non-probability sampling method (Saunders *et al.*, 2009). It has been decided on the sample using simple random sampling. It is done because everyone in the population has a chance to be a part of the sample. For the survey, engineers, managers,

and technicians involved in the organization, supervision, and assessment of significant engineering projects in Pakistan are questioned. The review was finished inside 100 organizations associated with Uber designing framework projects explicitly connected with development for example streets, extensions, and structures.

3.5. Data collection methods

To ascertain the link between the variables, descriptive and multivariate Statistical Package for the Social Sciences (SPSS) methods are used to analyze the survey data. The three distinct factors of project complexity, PM expertise, and project performance are evaluated using descriptive approaches. We have used several regression techniques to assess the connections between these variables. A 5-point Likert scale has been used for the majority of the questions and results are analysed accordingly.

4. Data analysis and results and discussion

4.1. Demographic analysis

A total of 100 reviews were distributed, and 82 were received that were fully completed and significant. The recurrence rate for men is 79, while only 3 for women. Table-1 shows that 97% of responders were men and 3% were women.

Table-1: Demographic analysis by gender

Group	Frequency	Percentage %
Male	79	96.3
Female	3	3.7
Total	82	100

The crucial respondents belonged to the Master's Preparation level tutoring class, which accounts for 52% of the total sample size. Men who were single made up 31% of the sample population, making them the second most significant group in terms of education. As demonstrated in Table-2, 15% of the remaining respondents hold an MS or M. Phil., and 2% of the entire sample held a doctorate. Most of the respondents, 55% of the entire sample size, have experience ranging from 5 to 10 years.

Table-2: Demographic analysis by gender distribution

Group	Frequency	Percentage %
Bachelors	25	30.5
Masters	43	52.4
M.Phil.	12	14.6
Doctorate	2	2.4
Total	82	100

According to Table-3, the next substantial experience level, which comprises 42% of the entire sample size, is less than five years.

Table-3: Demographic analysis by education wise

Group	Frequency	Percentage %
No Experience	2	2.4
Less Than 5 Years	34	41.5
Between 5-10 Years	45	54.9
Between 10-15 Years	1	1.2
Total	82	100

There were three distinct project types. Most respondents, or half of the total, work on road and street projects. The second significant group of respondents, which accounts for 44% of the total population, is concerned with construction projects. According to Table-4, only 6% of projects fit this category.

Table-4: Demographic analysis by age wise

Group	Frequency	Percentage %
Road	41	50
Building	36	43.9
Any other	5	6.1
Total	82	100

4.2. Descriptive statistics

Illustrative measurements are applied to comprehend the information mathematically. The information is evaluated for normalcy before moving on to factual tests since the normality of the information is a fundamental presumption in parametric testing. For the most part, normality is surveyed through two principal strategies, for instance, aesthetically and mathematically. All independent and dependent variables' skewness and kurtosis were examined to verify the data's accuracy. Table-5 displays the overall set of data's mean, standard deviation, skewness, and kurtosis. Information is entirely balanced if the skewness of information is equivalent to nothing. Notwithstanding, such a circumstance is very far-fetched. Hence, as proposed by Bulmer (1979) the general guideline is as follows:

- If the gearbox is significantly skewed, the skewness must be more than or equal to +1.
- Appropriation is significantly skewed if the skewness is between 1 and 0.5 or between 0.5 and +1.
- The appropriation is approximately symmetric between 0.5 and +0.5.

Table-5: Descriptive statistics

Description	N Statistics	Mean Statistics	Std. Dev. Statistics	Skewness Statistics	Std. Error	Kurtosis Statistics	Std. Error
Environmental complexity	82	2.933	0.21108	0.103	0.266	-0.059	0.526
Technical complexity	82	2.789	0.26862	-0.424	0.266	0.209	0.526
Organizational complexity	82	2.775	0.26951	1.219	0.266	1.738	0.526
Project performance	82	4.138	1.0033	-2.031	0.266	3.159	0.526
PM competence	82	2.015	1.0103	2.135	0.266	2.823	0.526
Valid N	82						

Skewness scored 0.103 for environmental complexity, -0.424 for technical complexity, and 1.129 for organizational complexity in the present instance. The PM competency score is (2.135), which is highly skewed. The project's final result has a much skewed distribution (-2.031).

4.3. Reliability test

The reliability of each variable's estimation was evaluated in this review using Cronbach's alpha approach (Bryman & Bell, 2011). It also examines each survey variable's internal consistency and relationship between items. Cronbach's alpha coefficient's reliability quality is based on the value of 0.60 (Cronbach, 1951). Table-6 displays the results of the reliability test.

Table-6: Reliability analysis

Description	Cronbach's Alpha	No. of items
Technical complexity	0.747	19
Organizational complexity	0.699	18
Environmental complexity	0.795	18
PM competence	0.983	23
Project performance	0.891	03

4.4. Correlation test

Correlation shows how much solid the connection between at least two factors is and also, tells how much these factors are connected with one another (Sekaran & Bougie, 2016). The degree of correlation between the dependent and independent variables indicates the strength of the link. The Pearson relationship is used in this. With a value of 0. 410, specialized complexity offers significant advantages for a favourable critical relationship with environmental complexity. Hierarchical intricacy has solid areas for a basic relationship with ecological intricacy with a value of 0.769. Performance and environmental complexity are negatively and insignificantly correlated, with a value of 0.075. With a value of 0.292, competence has areas of strength for a crucial link with environmental complexity, as shown in Table-7.

Table-7: Correlation analysis

Description	Environmental	Technical	Organizational	Performance	PM competence
Environmental complexity	1 82				
Technical complexity	0.410** 0.000 82	1 82			
Organizational complexity	0.769** 0.000 82	0.436** 0.000 82	1 82		
Project performance	-0.075 0.502 82	-0.029 0.797 82	0.026 0.819 82	1 82	1
PM competence	0.292** 0.008 82	0.309** 0.005 82	0.776** 0.000 82	0.125 0.265 82	82

4.5. Regression analysis

The environmental complexity beta value is -0.074 as shown in Table-8, indicating that it will have a small but unfavourable impact on the project's success. While (p 0.50) indicates a negative fundamental impact on project performance, the beta incentive for specialized complexity is - 0.035. Organizational complexity has a beta value of -0.060, demonstrating a highly detrimental effect on the success of the project (p 0.50). PM proficiency significantly improves project performance, with a beta value of 0.204 (p 0.05).

Table-8: Regression analysis

Coefficients[a]	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
Model	B	Std. Error	Beta		
Constant	5.751	1.746		3.294	0.001
Environmental complexity	-0.352	1.283	-0.074	-0.274	0.401
Technical complexity	-0.132	0.471	-0.035	-0.280	0.049
Organizational complexity	-0.223	1.508	-0.060	-0.148	0.033
PM competence	0.202	0.270	0.204	0.750	0.051

Note: a. Dependent variable: project performance

4.6. Hypothesis results

H1: Project performance is considerably impacted favourably by PM proficiency (supported)

H2: The performance of a project is strongly impacted negatively by technical complexity (supported)

H3: Project performance is severely negatively impacted by organizational complexity (supported)

H4: Project performance is adversely affected by environmental complexity (not Supported)

4.7. Explanation

The results show that PM proficiency considerably boosts project performance. The basic hypothesis' significant value is 0.051, nearly identical to 0.05. This implies that there should be a relationship between variables that may be assessed if the P-esteem is less than 0.05. Data also indicate a negative significant association between technical complexity and project performance, with an important esteem of 0.049, below 0.05. Ultimately, a complicated organization negatively affects project execution, and the importance worth of this relationship is 0.033, additionally in range as it is under 0.05.

5. Conclusion

In summary, this study shows how vital Project Management (PM) expertise and complexity are to the success of large-scale engineering projects in Pakistan. The results show that both

the complexity of the project and the knowledge, skills, and talents of the project managers have a significant impact on whether these initiatives succeed or fail. The study highlights several variables that affect how well large engineering projects turn out, including effective planning, risk management, stakeholder management, and communication. Conversely, poor PM competence, inadequate resources, lack of stakeholder engagement, and unexpected complexities can lead to project failure.

The study recommends that project managers in Pakistan should receive adequate training and development to enhance their PM competencies, including technical, interpersonal, and leadership skills. Integrating risk management and stakeholder engagement strategies from the project's inception and throughout its lifecycle is also crucial. To reduce the effect of complexity on the project's performance, there is also a requirement for excellent communication and collaboration among all project stakeholders.

Overall, this study sheds light on the variables that affect the success or failure of large-scale engineering projects in Pakistan and emphasizes the significance of PM expertise and the complexity of their operation. By applying the study's recommendations, project managers in Pakistan can improve the likelihood of successful project delivery, contributing to the country's economic development and infrastructure growth.

5.1. Limitations of the study

Some of the limitations of the study are as follows:

- Due to resource constraints, this study solely included engineering infrastructure projects in Pakistan's public sector.
- It is not easy to obtain data when only one self-reported questionnaire is on a single site.
- This is not a longitudinal study; it is a one-time study.
- Not all variables that could affect project performance are included in the current model.
- The results of this study might not be relevant to companies in other nations because it was carried out in Pakistan.
- In a survey, the varied opinions of respondents are typically included. However, these viewpoints are broken down depending on general words.

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ORCID iD

Subhan Ud Din https://orcid.org/0009-0007-8465-5547

Irfan Ullah https://orcid.org/0009-0003-5341-3706

Umer Farooq https://orcid.org/0000-0003-2589-6221

Sohail Anwar https://orcid.org/0000-0002-8977-0591

Safi Ullah https://orcid.org/0000-0001-7975-3539

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