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QUANTIFYING INNOVATION IN CONSTRUCTION: SPSS ANALYSIS OF PROJECT MANAGER PERCEPTIONS AND THEIR EFFECTS

Kola Veera Gani Durga Prasad, Aravindan A. and Nadigatla Naveen Kumar
Department of Civil Engineering, Koneru Lakshmaiah Education Foundation (KL Deemed to be University), Guntur, Vaddeswaram, India
E-Mail: kolaprasad121@gmail.com

ABSTRACT

The construction industry has increasingly adopted innovations, primarily in materials, processes, and methods, yet innovation often occurs at the project level rather than organizationally. This study investigates how project managers' perceptions influence innovation success. Identifying 25 key perception factors from existing literature, it categorizes them into four areas: leadership, capabilities/competencies, personality traits, and non-engineering skills. Using a quantitative approach with an online survey of 66 experienced construction professionals, the study finds that these factors significantly affect innovation outcomes. Analysis with SPSS confirms data validity and reliability. The findings recommend that construction organizations enhance innovation by focusing on project managers' attributes in selection criteria and project requirements.

Keywords: construction innovation, delivering successful innovation, perceptions factors, capabilities, competencies, personality traits.

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1. INTRODUCTION

1.1 Background

From the 20th to the 21st century, project management leadership has evolved from a focus on the 'iron triangle'-time, cost, and quality to a broader philosophy emphasizing added value and organizational competence (1, 2, 3, 4). The 1990s recession prompted changes in construction procurement methods, necessitating project managers to stay updated with new knowledge and practices (5, 6, 7, 8). This period saw significant growth in project management development and standards due to an increase in projects across various industries (9, 10, 11, 12). Understanding a project manager's personality and mindset is crucial for integrating advancing practices, as engagement with new methods influences project success (13, 14, 15).

Some authors argue that techniques effective in other industries do not always translate well to construction (16, 17, 18). Despite this, the demand for construction project management (CPM) is rising, prompting professional associations like IPMA, AIPM, APM, PMI, CIOB, and ICE to offer training and certification (19, 20, 21, 22). Effective construction project management requires a blend of experience and accredited training (23, 34, 35). Since 1995, improved project briefs and customer focus have alleviated performance issues in construction, leading to better integration of knowledge and skills (24, 25, 31).

Recent studies cover a broad spectrum from technical skills to strategic alignment of projects with organizational goals. Theories also address projects as information processing systems and explore the role of critical management in controlling projects (26, 32, 33).

1.2 Projects

1.2.1 What is a construction project?

A construction project involves organizing human, material, and financial resources to complete a unique scope of work with specific requirements, within budget, and on time (27, 28, 30). Key characteristics include:

- **Uniqueness:** Each project is distinct and does not replicate previous projects exactly.
- **Complexity:** It involves intricate coordination and management to achieve specific goals within constraints of time and cost, often crossing organizational boundaries.
- **Temporal boundaries:** The project has defined start and finish dates.
- **Process:** It represents a progression from initiation to completion, operating in a complex and dynamic environment (29, 36, 37).

1.2.2 The project lifecycle

The project lifecycle includes five stages: initiating, planning, executing, controlling, and closing (38).

- **Initiating:** Establishes strategy, standards, resource availability, limitations, and assumptions.
- **Planning:** Involves preparing and estimating activities to meet project requirements (39).

- **Executing:** Involves performing project work and utilizing resources to achieve project deliverables (40).

- **Controlling:** Manages and monitors project progress, including human management, procurement, and quality control (41).

- **Closing:** Concludes the project, ensuring all objectives are met.

Effective planning and control are crucial, especially for complex projects, as they address goal setting, resource management, risk management, and procurement. Proper planning and control help estimate required resources and track progress (42). Projects are temporary and involve unique tasks that have not been performed before (43).

1.2.3 The temporary nature of projects

Projects are often viewed as temporary organizations created to fulfill specific obligations (44). They are inherently complex, and understanding this complexity is essential for determining strategy, cooperation, and control. This complexity impacts the required skills and techniques for project management and affects procurement, management, and the project's time, cost, and quality [45]

1.2.4 Types of projects

Projects are commonly classified into three types:

- **Infrastructure:** Includes transportation systems (roads, bridges, airports) and utility projects (electricity, water, sewerage) (46).

- **Buildings:** Covers commercial properties, offices, hospitals, and schools (47).

- **Process plants:** Encompasses power plants, oil refineries, chemical plants, and pharmaceuticals (48).

Other classifications use matrices considering technical uncertainty and project scope to categorize projects (49).

1.3 The Project Manager

1.3.1 What is a project manager?

A project manager oversees projects of various sizes and complexities, ensuring they meet parameters such as time, cost, regulations, specifications, and quality (50). Effective project managers focus on people, control, and administration while keeping the project on track (51). They need to understand project objectives, scope, issues, and commercial values, and foster cooperation among stakeholders (52).

1.3.2 Management as leadership

Management requires both leadership and management skills. Leadership involves inspiring and guiding a team to achieve better performance and adapt to changes (53). Project managers must balance project, technical, and team leadership skills, including setting direction, aligning teams, and motivating members (54). They may adopt various leadership styles, including autocratic, participative, and delegatory (55).

1.3.3 The project manager role

Project managers need both technical knowledge (e.g., materials, methods) and non-engineering skills (e.g., communication, positive traits). They must stay updated with new tools and techniques, combining traditional engineering knowledge with modern project management practices (56). Their role includes problem-solving, managing activities, supporting the team, enhancing communication, and meeting deadlines (57).

1.3.4 The project managers and their role in project success

The competence of project participants is widely recognized as a critical factor in the success of construction projects. The project manager, as a pivotal participant, significantly impacts project delivery outcomes (58). The performance of construction projects is often enhanced by the experience and managerial skills of the project manager, who applies best practices in project management (59). Different project management approaches require varied ability profiles and leadership styles from the construction project manager (60). Risk management is also a crucial aspect of the project manager's role in ensuring project success (61). The project's success is influenced by factors such as the project manager's leadership style, flexibility, managerial culture, competence, and personal traits (62). Thus, the project manager is accountable for delivering the project within the constraints of cost, time, quality, and objectives (63).

1.4 Innovation

1.4.1 What is innovation?

Innovation has been integral to human progress, beginning with the use of tools and evolving to influence national economic growth, competitiveness, and living standards (64). According to the Oslo Manual, innovation involves using technology to produce new or significantly improved products and processes (65). Process innovation, as defined by the OECD, includes the introduction of advanced management methods (66). Innovation involves the interaction between organizations and various actors, influenced by cultural, regulatory, and organizational factors (68). It encompasses personal creativity, theoretical concepts, technical innovations, and the development of new products or processes (67). In construction, innovation integrates products, technology, technical knowledge, and organizational management to enhance performance, despite inherent risks and challenges (69).

1.4.2 Types and forms of innovation

Innovation types include product, service, process, managerial, and technological innovations. Innovations can offer new advantages or technologies, with breakthroughs leading to significant improvements. Innovation laboratories, which involve structured experimental forms and infrastructure content, facilitate the development of new ideas (70). In construction, innovations are categorized into organizational and technical types. Organizational innovations involve changes in structures and management systems, while technical innovations include product and process innovations (71). Notable innovation types in construction include incremental, modular, architectural, system, and radical innovations (72).

1.4.3 Implementing innovation

The implementation of innovation involves stages such as idea generation, exploitation, and evaluation. Effective implementation requires identifying suitable innovation efforts, organizational competencies, and relevant factors (73). In construction, the adoption of project management techniques, technology, change management, and cost evaluations are crucial for innovation. Successful innovation implementation is influenced by developing stakeholder competencies and a conducive innovation environment.

1.4.4 Factors that may constrain innovation

Innovation constraints include the reliance on internal information and limited external sources. Organizational capability for innovation depends on creating a supportive environment, managing risks, decision-making, and selecting appropriate managers (64). Factors influencing innovation include managerial support, environmental stability, and effective use of technology and people (5). The construction industry faces unique constraints such as project duration, participant types, procurement methods, and supply chain complexity, which can limit innovation capabilities (9).

1.4.5 Innovation in projects and project management

Innovation in the construction industry involves introducing novel ideas, technologies, products, and processes to improve execution efficiency and address challenges (7). Project managers play a significant role in fostering innovation by encouraging and supporting innovation trends among project teams (34). Key areas for innovation include supply chain management, value and risk management, and technical advancements. Successful innovation requires capturing and applying solutions learned from project experiences (55).

1.4.6 The role of managers in delivering and enhancing innovation

Developing an innovation strategy is crucial for enhancing organizational innovation capabilities and creating a supportive environment. Managers are responsible for adopting innovation strategies, fostering a conducive work climate, and maintaining preferences for innovation, which can positively affect financial performance (56).

1.4.7 The role of project managers in delivering and enhancing innovation in projects

Modern construction project managers need diverse approaches, skills, and knowledge to manage complex environments and support project participants effectively. They must integrate project teams and promote innovative ideas to address execution problems (54). Innovation is often implemented at the project level, and project managers play a crucial role in managing innovation due to their responsibilities in driving project success (23). Enhancing construction productivity through innovation involves addressing challenges such as client needs, project complexity, equipment advancements, cost reduction, and technology development (2).

2. STUDY AREA

The construction industry is experiencing a shift towards incorporating innovations, particularly in new materials, processes, and methods. Unlike other sectors where innovations are often integrated at an organizational level, the construction industry's innovation is predominantly applied at the project level, placing project managers at the heart of managing and facilitating these advancements. Despite this critical role, the rate of innovation in construction lags behind other industries, which may be attributed to a shortage of dedicated research and development efforts. This study delves into the role of project manager perceptions and their impact on successful innovation implementation at the project level. Through an extensive review of existing literature, the research identifies 25 key perception factors, which are then classified into four major categories: leadership, capabilities/competencies, personality traits, and non-engineering skills. A quantitative research design was employed, utilizing an online survey administered to 66 experienced construction professionals. The data, analysed with SPSS, demonstrates that these perception factors play a significant role in influencing innovation outcomes within construction projects. The findings underscore the importance of fostering a conducive environment for innovation through the enhancement of project managers' attributes. Recommendations include revising the criteria for selecting project managers and embedding these key attributes into project requirements to better support successful innovation. This approach aims to address the existing gap in innovation rates by aligning project management practices with the necessary perceptual factors that drive effective implementation.

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3. METHODOLOGY

This research examines construction management and its impact on on-site activities. To bridge the theory-practice gap, empirical data is gathered via a survey based on established theories. Hypotheses will be tested using this data, and analysis will help build and validate theories within a conceptual framework. Figure-3.1 illustrates the research process.

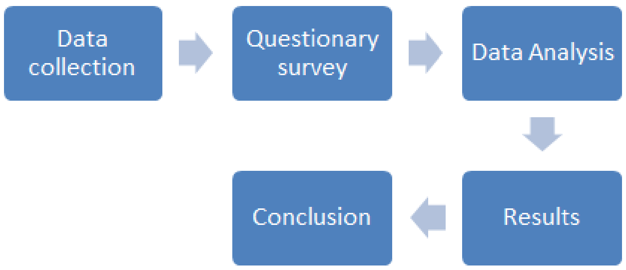

Figure-2.1. The research process.

3.1 Research Approach and Limitations

This research employs a mixed-methods approach, combining qualitative and quantitative methodologies. While existing studies on construction management often use quantitative methods, this research integrates qualitative insights to enhance the understanding of quantitative findings. This approach aligns with the complementary nature of both methods, as discussed in the literature. However, limitations include a focus solely on the construction industry and its participants, time constraints affecting survey responses, and varying definitions of innovation impacting participation. The research aims to increase awareness of project manager perceptions influencing successful innovation in construction projects.

3.2 Data Collection

Data was collected using an online survey distributed via email, and social media. Online surveys are practical for targeting specific audiences and accommodating time and budget constraints. The survey, a common tool in quantitative research, was designed to gather data from construction industry professionals and included options for feedback. The data will be used to analyze variable relationships and assess the impact of project manager perceptions on innovation success.

4. ANALYSIS OF DATA AND FINDINGS

This chapter presents the analysis of data from the online survey using SPSS. Statistical techniques, including correlation and regression tests, are employed to evaluate the relationship between project managers' perceptions and successful innovation. Results will be displayed in tables, figures, and graphs to facilitate further discussion.

4.1 Descriptive and Inferential Statistics

4.1.1 Validity of data collected

The validity of the data is crucial to ensure accuracy, as outlined in the pilot study of the research methodology. Out of 70 responses, 66 were valid, with a 94% success rate. Data entry and analysis in SPSS were handled correctly, ensuring no missing or erroneous data. The online survey's features improved data validity.

4.1.2 Demographic variables

- Personal Variables:
- **Gender:** 80.5% male, 9.5% female.
- **Education:** 60% college degree, 6% high school diploma, 30% master's or higher.
- **Age:** 59.1% aged 36-46, 37% aged 25-35, 3% under 25.

Descriptive statistics:

- **Gender:** Mean = 1.5, Median = 1, SD = 0.65
- **Education:** Mean = 4, Median = 3, SD = 0.996
- **Age:** Mean = 3, Median = 3, SD = 0

- Job-Related Variables:

- **Years in current organization:** 18% ≤1 year, 55% 2-7 years, 18% 8-13 years, 11% 14-19 years.
- **Years of experience:** 19% 2-7 years, 34% 8-13 years, 56% 14-19 years, 2% ≥20 years.
- **Job level:** 36% first level, 59% middle level, 6.5% lower level.
- **Primary role:** 20% project team members, 33% project/site managers, 34% other managers, 5.2% directors/general managers/CEOs, 14% others.
- **Industry:** 100% construction-related.
- **Organization discipline:** 19% client, 35% consultant, 38% contractor, 7.8% subcontractor, 1% supplier/manufacturer.
- **Experience location:** 71.2% India, 19.7% GCC, 9.1% other regions.

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Descriptive statistics:

- **Years in current organization:** Mean = 2.5, Median = 2, SD = 1.995
- **Years of experience:** Mean = 3.5, Median = 4, SD = 0.854
- **Job level:** Mean = 2, Median = 2, SD = 0
- **Primary role:** Mean = 2.89, Median = 2, SD = 1.216
- **Organization discipline:** Mean = 2.38, Median = 2, SD = 0.941
- **Experience location:** Mean = 1.38, Median = 1, SD = 0.651

Table-4.1. Personal variables.

Personal Variables			
	SEX	Education	Age
Male	80		
Female	10		
College Degree		60	
High Diploma		6	
Master or Above		30	
Less than 25			3
25-35			29
36-46			37
Total	90	96	69

Table-4.2. Job-related variables.

Job related Variables							
	No. Of Years		Job Level	Primary role	Principal industry	Organisation discipline	Working location
	In current organisation	Of Experience					
One year or less	14						
02-Jul	38						
Aug-13	12						
14-19	9						
02-Jul		15					
Aug-13		20					
14-19		36					
20 Years or more		3					
First Level			29				
Middle level			40				
Lower Level			6				
Project Team Member				16			
Project Manager or Site Manager				22			
Other Manager				22			
Director / GM / CEO				5			
Other				9			
Related to Construction industry					69		
Client						15	
Consultant						24	
Contractor						26	
Subcontractor						7	
Supplier / manufacture						2	
india							49
GCC Countries							16
Other							8
Total	73	74	75	74	69	74	73

Table-4.3. Job and personal descriptive stats.

Descriptive Stats										
				No. Of Years						
	SEX	Education	Age	In current organisation	Of Experience	Job Level	Primary role	Principal industry	Organisation discipline	Working location
Mean	1.5	4	3	2.5	3.5	2	2.89	1	2.38	1.38
Median	1	3	3	2	4	2	2	1	2	1
Std. Deviation	0.65	0.996	0	1.995	0.854	0	1.216	0	0.941	0.651

Table-4.4. Respondents' professional orientation to organisational disciplines.

	Client	Consultant	Contractor	Sub contractor	Supplier	Total
Project team member	7	3	4	2	-	16
Project manager or Site manager	5	12	8	0	-	25
Other managers	5	9	6	6	-	26
Director/GM/ CEO	-	1	1	-	-	2
Other	1	1	2	-	1	5
Total	18	26	21	8	1	74

Table-4.4 displays the participants' professions and organizational disciplines. Most respondents (69%) were project, site, or other managers, with 74% working as consultants or contractors. The high percentage of middle-level respondents suggests substantial experience in construction and project management. This background lends confidence to the data's accuracy and reliability, aligning with findings that emphasize that participant experience can impact the reliability of survey results.

4.2 Reliability Test

The study assessed internal consistency using Cronbach's alpha in SPSS, as outlined.

Overall project manager perceptions factors: 29 items, Cronbach's alpha = 0.961.

- **Successful innovation:** 19 items, Cronbach's alpha = 0.961.
- **Leadership:** 9 items, Cronbach's alpha = 0.90.
- **Capabilities/competency:** Cronbach's alpha = 0.90.
- **Personality traits:** Cronbach's alpha = 0.70.
- **Skills (Non-engineering):** Cronbach's alpha = 0.75.

All reliability coefficients exceed the acceptable threshold of 0.70, indicating satisfactory internal consistency.

Table-4.5. Cronbach's alpha results (Global variables).

	Project manager	Delivering successful
	perceptions factors	innovation
Cronbach's alpha	0.951	0.961
No. Of Items	29	19

Table-4.6. Cronbach's alpha results (Factors of global independent variable).

Dependent variables	No. Of Items	Crombach's alpha
Leadership	9	0.9
Capabilities / Competency	9	0.9
Personality Traits	6	0.7
Skills (Non-Engineering)	8	0.75

Therefore, all Cronbach's alpha values indicate strong internal consistency. The overall reliability scores for global variables show good to high reliability, while each factor of the global independent variable meets acceptable reliability standards. No additional improvements are needed for the results.

4.2.1 Pearson correlation test

The Pearson correlation test evaluates the strength of the relationship between independent and dependent variables. As illustrated in Bar Chart 4.2, the correlation coefficient ranges from -1 (perfect negative correlation) to +1 (perfect positive correlation). A positive coefficient indicates that as one variable increases, the other also increases, while a negative coefficient means that as one variable increases, the other decreases.

Based on the reliability test results, the Pearson correlation test was conducted in SPSS to examine the strength of relationships between variables. The correlation analysis covered 9 factors and 2 global factors, totaling 11 variables. Table-4.7 displays the correlation coefficients, ranging from 0.292 (weak positive) to 0.872 (strong positive), with a coefficient of 1 for identical variables on the vertical and horizontal axes.

The correlation matrix in Table-4.7 reveals that all relationships are significant and positive. Specifically, the two global variables- project manager perceptions factors and delivering successful innovation strongly positively related, with a coefficient of 0.677 (Sig. Level 0.000). This indicates that more favorable project manager

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perceptions at the construction site level are associated with a higher likelihood of delivering successful innovation in construction projects.

Table-4.7. Pearson correlation results between all variables.

Variable		1	2	3	4	5	6	7	8	9	10	11
Leadership	Pearson Correlation Sig. (2-tailed)	1										
	N											
		66										
Capabilities / Competences	Pearson Correlation	0.609**	1									
	Sig. (2-tailed)	0										
	N	66	66									
Personality Traits	Pearson Correlation	0.443**	0.430**	1								
	Sig. (2-tailed)	0	0									
	N	66	66	66								
Skills	Pearson Correlation	0.384**	0.302*	0.387**	1							
	Sig. (2-tailed)	0.001	0.014	0.001								
	N	66	66	66	66							
Organisational Pearson culture for Correlation innovation Sig. (2-tailed)		0.309*	0.350**	0.325**	0.397**	1						
N		0.012	0.004	0.008	0.001							
		66	66	66	66	66						
Innovation orientation	Pearson Correlation	0.516**	0.535**	0.504**	0.585**	0.611**	1					
	Sig. (2-tailed)	0	0	0	0	0						
	N	66	66	66	66	66	66					
Form of True innovation	Pearson Correlation	0.507**	0.401**	0.372**	0.577**	0.493**	0.547**	1				
	Sig. (2-tailed)	0	0.001	0.002	0	0	0					
	N	66	66	66	66	66	66	66				
Market competition	Pearson Correlation	0.376**	0.292*	0.324**	0.529**	0.470**	0.610**	0.677**	1			
	Sig. (2-tailed)	0.002	0.017	0.008	0	0	0	0				
	N	66	66	66	66	66	66	66	66			
Improving Deliverable	Pearson Correlation	0.418**	0.350**	0.352**	0.574**	0.426**	0.621**	0.713**	0.710**	1		
	Sig. (2-tailed)	0	0.004	0.004	0	0	0	0	0			
	N	66	66	66	66	66	66	66	66	66		
Project manager perceptions	Pearson Correlation Sig. (2-tailed)	0.844**	0.827**	0.683**	0.641**	0.448**	0.697**	0.607**	0.487**	0.546**	1	
	N	0	0	0	0	0	0	0	0	0		
		66	66	66	66	66	66	66	66	66	66	
Delivering successful innovation	Pearson Correlation Sig. (2-tailed)	0.522**	0.462**	0.450**	0.653**	0.697**	0.797**	0.869**	0.846**	0.872**	0.677**	1
	N	0	0	0	0	0	0	0	0	0	0	
		66	66	66	66	66	66	66	66	66	66	66
**. Correlation is significant at the 0.01 level (2-tailed).												
*. Correlation is significant at the 0.05 level (2-tailed).												

4.2.2 Regression test

The regression test was conducted in SPSS to evaluate the strength of the numerical relationship between the dependent variable (delivering successful innovation) and independent variables (project manager perceptions) as detailed in Appendix F []. The analysis assumes a linear relationship, normal distribution of the dependent variable, and homogeneity of variances.

Table-4.8 shows the results of the regression analysis:

- **R^2:** 0.498
- **Adjusted R^2:** 0.449
- **F-ratio:** 55.019 (significant at $p < 0.001$)

The R^2 value indicates that 49.8% of the variation in successful innovation is explained by project manager perceptions, demonstrating a strong goodness of fit for the model. The F-ratio confirms the model's predictive capability with high confidence. The unstandardized coefficient beta value of 0.666 suggests a positive impact of project manager perceptions on successful innovation. Thus, enhancing project manager perceptions toward innovation at the site level is recommended for improving innovation outcomes in construction.

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Table-4.8. Regression test results of dependent global variable and independent global variable and entire factors.

Independent Variables (Predictors) regressed against delivering successful	Dependent Variable – Delivering Successful Innovation				
	Model Summary		ANOVA		Unstandardized Coefficients
	R Square	Adjusted R Square	*F*-Value	*P* (Sig. level)	B
Project Manager Perceptions	0.498	0.449	55.019	0	0.666
Leadership					0.576
Capabilities / Competency	0.64	0.54	19.907	0	0.445
Personality Traits					0.36
Skills (Non-Engineering)					1.26

4.2.3 Conclusion of regression analysis

Based on the regression test results and correlation analysis, the Hypothesis that there is a positive influence of a project manager's perceptions on delivering successful innovation is accepted.

Overall Model Results:

- R^2: 0.640
- Adjusted R^2: 0.540
- F-ratio: 19.907 (significant at $p < 0.001$)

These results indicate a high degree of model fit, with project manager perceptions factors explaining 54% of the variance in successful innovation. Among the four factors-leadership, competency, personality traits, and non-engineering skills have the highest beta value of 1.260, suggesting it has the strongest impact on successful innovation. Enhancing all four factors is recommended to improve innovation outcomes at the construction site level.

Individual Factors:

- Leadership:
- R^2: 0.292
- Adjusted R^2: 0.268
- F-value: 25.416 (significant at $p < 0.001$)
- Beta: 1.298

The leadership factor alone explains 29% of the variance in successful innovation, with a strong positive impact. Thus, the Hypothesis that there is a positive influence of the project manager's leadership on delivering successful innovation is also accepted as shown in Table-4.9.

In summary, both hypotheses are confirmed, emphasizing the importance of project manager perceptions, particularly leadership, in achieving successful innovation in construction projects.

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Table-4.9. Regression test results of dependent global variable and independent global factors individually.

Independent Variables (Predictors) regressed against delivering successful innovation	Dependent Variable – Delivering Successful Innovation				
	Model Summary		ANOVA		Unstandardized Coefficients
	R Square	Adjusted R Square	*F*-Value	*P* (Sig. level)	B
Leadership	0.292	0.268	25.416	0	1.298
Capabilities / Competency	0.264	0.221	18.4	0	1.172
Personality Traits	0.209	0.2	18.239	0	1.94
Skills (Non-Engineering)	0.446	0.428	46.622	0	2.312

A further regression test was conducted for the capabilities factor of project manager perceptions about delivering successful innovation, as detailed in Table-4.9:

- R^2: 0.264
- Adjusted R^2: 0.221
- F-value: 18.400 (significant at $p < 0.001$)
- Beta: 1.172

The R^2 value indicates that 21.4% of the variance in successful innovation is explained by the capabilities factor. The high F-value confirms the model's effectiveness in predicting successful innovation, and the positive beta value suggests a strong impact.

Thus, the Hypothesis that there is a positive influence of the project manager's capabilities on delivering successful innovation is accepted. Enhancing the capabilities of project managers at the site level is crucial for improving innovation outcomes in the construction industry.

Another regression test was conducted for the personality traits factor of project manager perceptions about delivering successful innovation, as shown in Table-4.9.

- R^2: 0.209
- Adjusted R^2: 0.20
- F-value: 18.239 (significant at $p < 0.001$)
- Beta: 1.940

The R^2 value of 20.2% indicates that the personality traits factor explains about 20% of the variance in delivering successful innovation. The significant F-value confirms the model's predictive accuracy, and the high beta value demonstrates a strong positive impact of personality traits on innovation outcomes.

Therefore, the Hypothesis that there is a positive influence of a project manager's personality traits on delivering successful innovation is accepted. Emphasizing and enhancing the personality traits of project managers is recommended to improve innovation in construction projects at the site level.

The final regression test focused on the non-engineering skills factor of project manager perceptions about delivering successful innovation, as shown in Table-4.9:

- R^2: 0.446
- Adjusted R^2: 0.428
- F-value: 46.622 (significant at $p < 0.001$)
- Beta: 2.312

The R^2 value of 42.8% indicates that non-engineering skills explain approximately 42% of the variance in successful innovation. The high F-value confirms the model's predictive accuracy, and the substantial beta value highlights a strong positive impact of non-engineering skills on innovation.

Therefore, the Hypothesis H5-that there is a positive influence of the project manager's non-engineering skills on delivering successful innovation is accepted. Enhancing non-engineering skills for project managers is crucial for achieving successful innovation in construction projects at the site level.

5. DISCUSSION OF RESULTS

This research interprets the statistical findings from SPSS, focusing on the relationships between project manager perceptions and the delivery of successful innovation in construction projects. The discussion integrates the results with existing literature and theoretical frameworks, emphasizing how project manager perceptions impact innovation.

5.1 The Influence of Project Manager Perceptions on Delivering Successful Innovation

Summary of Findings

- **Correlation:** The overall correlation between project manager perceptions factors and successful innovation is strong ($r = 0.546$, $p < 0.001$), indicating a significant positive relationship.

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- **Factors examined:** The factors include leadership, capabilities/competence, personality traits, and non-engineering skills.

- **Innovation aspects:** These perceptions impact various aspects of innovation, such as organizational culture, market competition, innovation orientation, true innovation forms, and improving deliverables.

Discussion: The strong positive correlation supports the theoretical framework which posits that project manager perceptions directly influence the success of innovation. The findings align with previous research and others, reinforcing that perceptions of leadership, competence, and personality traits are crucial for fostering innovation. This confirms the hypotheses and supports the notion that effective project management can drive successful innovation.

However, organizational culture and market competition showed slightly weaker correlations compared to other factors. This could be due to these elements being more systemic and less directly influenced by individual project managers. As noted organizational culture and market competition are influenced by broader organizational strategies and external market forces rather than individual perceptions alone.

Key insights

- **Organizational culture for innovation:** The impact is moderated by the need for organizational-level initiatives.

- **Market competition:** The influence is also affected by broader organizational and market factors.

- **Direct control factors:** Innovation orientation, true innovation forms, and improving deliverables have higher correlations, suggesting that project managers have more direct control over these aspects.

5.2 The Influence of the Project Manager's Leadership on Delivering Successful Innovation

Summary of Findings

- **Correlation:** Leadership shows a strong positive relationship with innovation ($r = 0.292$, $p < 0.001$).

- **Beta value:** The unstandardized coefficient for leadership highlights its significant impact.

Discussion: The strong correlation between leadership and innovation underscores the importance of effective leadership in driving successful innovation. This finding supports those who emphasized leadership as a key factor in managing successful innovation. Leadership skills such as motivating teams, inspiring creativity, and managing stakeholders are critical for innovation success, aligning with

The results indicate that project managers with strong leadership qualities can better foster an environment conducive to innovation, thereby achieving better outcomes.

5.3 The Influence of Project Manager's Capabilities on Delivering Successful Innovation

Summary of Findings

- **Correlation:** Capabilities show a strong positive relationship with innovation ($r = 0.264$, $p < 0.001$).

- **Beta value:** The impact of capabilities on innovation is significant.

Discussion: The positive relationship between project manager capabilities and innovation supports the work of competence and capabilities are essential for managing innovation processes, overcoming challenges, and leading project teams effectively. The results highlight the necessity for project managers to possess strong capabilities to drive successful innovation, corroborating findings from others.

The ability to manage innovation, understand project requirements, and build trust within teams are critical aspects of project manager capabilities that contribute to successful innovation.

5.4 The Influence of the Project Manager's Personality Traits on Delivering Successful Innovation

Summary of Findings

- **Correlation:** Personality traits exhibit a strong positive relationship with innovation ($r = 0.209$, $p < 0.001$).

- **Beta value:** The impact of personality traits on innovation is notable.

Discussion: The significant relationship between personality traits and innovation aligns with previous studies. Traits such as flexibility, respect, and positivity play crucial roles in fostering an innovative environment. The results support the view that a project manager's personality can influence team dynamics and innovation outcomes, emphasizing the importance of fostering a supportive and positive working environment.

The impact of personality traits, including inspiring respect and flexibility, is crucial for encouraging innovative behaviors and solutions.

5.5 The Influence of the Project Manager's Skills (Non-Engineering) on Delivering Successful Innovation

Summary of Findings

- **Correlation:** Non-engineering skills show a strong positive relationship with innovation ($r = 0.446$, $p < 0.001$).
- **Beta value:** The high beta value highlights the significant role of non-engineering skills.

Discussion: The strong relationship between non-engineering skills and innovation underscores the importance of skills such as communication, negotiation, and financial understanding. The results corroborate findings that emphasize the importance of these skills in managing and fostering innovation.

Non-engineering skills, such as effective communication and understanding financial impacts, play a critical role in facilitating innovation and ensuring project success.

5.6 Importance of Project Manager Perceptions Factors

Summary of Findings

- **Ranking analysis:** The statistical ranking analysis of project manager perceptions factors is consistent across different methods.
- **Homogeneity:** The results from various methods indicate a similar impact of different factors on innovation.

Discussion: The consistency in the ranking of project manager perceptions factors highlights their collective importance in driving successful innovation. The similarity in results across different statistical methods supports the reliability of the findings. Further research could focus on exploring additional factors or refining the understanding of how these factors interact to influence innovation outcomes.

6. CONCLUSIONS

The construction industry, despite its significant advancements, lags behind other sectors in terms of innovation. Innovations in construction are primarily realized at the project level, rather than being industry-wide. Effective innovation management, therefore, hinges on how project managers and their competencies are leveraged to deliver successful outcomes.

This research explored the influence of project manager perceptions on the delivery of successful innovation within the construction industry. By integrating a comprehensive literature review and developing a theoretical framework, this study identified and analyzed key project manager perception factors that impact innovation success. Using a quantitative research methodology and data from an online survey, the findings reveal a strong positive relationship between project manager perceptions factors and the success of innovation.

The study highlights four critical project manager perception factors: leadership, capabilities/competence, personality traits, and non-engineering skills. Each factor was found to significantly impact innovation delivery, with non-engineering skills showing the strongest relationship. The results underscore the importance of these perception factors in achieving successful innovation on construction sites. Additionally, unexpected findings suggest that clients play a crucial role in fostering innovation through their influence on project managers, particularly in terms of leadership and skills.

7. RECOMMENDATIONS/IMPLICATIONS

7.1 Recommendations for Construction Organizations

a) **adopt innovation policies:** Construction organizations should develop and implement policies that prioritize the perception factors of project managers, including leadership, capabilities, personality traits, and non-engineering skills.

b) **Selection criteria:** During the recruitment and selection of project managers, emphasize characteristics that align with the ability to contribute to innovation. Assess these attributes through practical evaluations and interviews.

c) **Enhance skills and competencies:** Invest in continuous professional development for project managers to improve their skills and competencies, focusing on fostering an innovative mindset.

d) **Cultivate an innovation culture:** Develop a culture that supports innovation by encouraging information sharing, utilizing diffusion modelling, and promoting both top-down and bottom-up approaches to innovation.

e) **Client engagement:** Clients should define project requirements that include specific innovation goals and support project managers in implementing innovative solutions.

7.2 Recommendations for Project Owners

a) **Define innovation requirements:** Include clear innovation criteria in project specifications to guide project managers in achieving desired outcomes.

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b) **Support innovation efforts:** Actively engage in the innovation process and provide necessary resources and support to project managers to facilitate successful innovation.

7.3 Recommendations for Further Research Expanding Research Scope

a) **Broaden context:** Investigate the influence of project manager perception factors across different industries and project phases to assess their generalizability.

b) **Explore additional factors:** Examine other potential perception factors that might impact innovation success, beyond the four identified in this study.

c) **Comparative studies:** Conduct comparative studies to analyze the influence of project manager perceptions in various contexts and project types.

d) **Success factors definition:** Define and explore critical success factors for innovation in construction projects, and evaluate how project manager perceptions align with these factors.

e) **Client influence:** Investigate the impact of project owners' involvement on project manager perceptions and innovation outcomes to understand their role in driving innovation.

8. LIMITATIONS OF THE STUDY

This study has several limitations:

a) **Industry focus:** The research is limited to the construction industry, which may affect the generalizability of the findings to other sectors.

b) **Sample and demographics:** The results are based on a sample with specific demographic characteristics, which may not fully represent the broader population.

c) **Perception factors:** The study focuses on four specific perception factors, potentially overlooking other relevant factors that may influence innovation.

d) **Project phase:** The research is limited to the site execution phase of construction projects, excluding other phases that might impact innovation.

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