



THE HUMAN BOTTLENECK IN PROJECT DELIVERY: MANAGING CRITICAL TALENT SCARCITY IN COMPLEX PROJECTS

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Abstract

Organizations undertaking complex projects face significant challenges arising from critical talent scarcity, as successful project execution is directly dependent on the availability of skilled and talented human resources. This study examined the relationship between Critical Talent Scarcity (CTS) and Project Delivery Performance (PDP) and investigated the contribution of Talent Management Practices (TMP), Workforce Planning (WFP), Knowledge Sharing (KS), and Project Leadership (PL) toward resolving talent-related constraints on projects. To gather data, 300 project professionals were surveyed using a structured questionnaire with a 5-point Likert scale, using a cross-sectional research design within a quantitative approach. Respondents were selected using purposive sampling, aiming to select respondents with relevant project experience. Descriptive analysis was used to gain a better understanding of respondents' perceptions of the study variables. Results indicated a relatively high perception of critical talent shortage, with a mean score of 3.74 (SD = 0.78) for CTS. TMP recorded a mean of 3.68 (SD = 0.74), while WFP obtained a mean of 3.61 (SD = 0.76). KS showed a mean of 3.77 (SD = 0.71), and PL recorded a mean of 3.82 (SD = 0.69). The project delivery performance perception mean for PDP was 3.86 (SD = 0.67), the highest among all groups. The results highlighted the need for strategic talent management, proactive workforce planning, knowledge sharing, and good project leadership in augmenting project teams facing critical talent shortages. An integrated human-resource approach facilitated an organization's ability to operate more effectively in managing complex projects.

Keywords: Knowledge Sharing, Project Delivery Performance, Project Leadership, Talent Management Practices, Workforce Planning, Critical Talent Scarcity

1. Introduction

In complex projects, artificial factors such as changes to technology, inter-organizational coordination requirements, project requirements, and high project performance expectations have become commonplace. However, in this kind of context, project performance is not only based on an economic approach, technologies, and formal procedures but also on the involvement of persons who are not only experts but also possess project management skills. Technical skills, leadership skills, communication, problem-solving, teamwork, and stakeholder relationship management skills are identified as relevant skills that can contribute to meeting project goals (Koi-Akrofi et al., 2024). Empirical studies also suggest that project-manager skills



play a significant role in project success, especially in ICT and knowledge-intensive projects (Bhatti & Durrani, 2024; Jokačević Đajić et al., 2024).

The pressure is on when companies are in short supply of critical talent. A critical talent is someone who has a very narrowly defined area of knowledge, skill, and/or experience that is required to make critical judgments that will be difficult to replace rapidly. Without these people, if they are overworked or absent during projects, organizations may suffer a slowdown in decision-making, lack of knowledge, heavier workloads, coordination issues, and inability to cope with unexpected project risks. Competent and skilled manpower shortage is proven to be one significant challenge toward successful project execution, as shown in recent studies conducted in Pakistan, especially in the project-management-specific sector (Haroon Masood et al., 2024). Based on latest inputs from the IT industry, managerial skills, cognitive flexibility, systemic thinking, and skills in risk management have been identified as key factors that have a significant effect on successful completion of IT projects (Bhatti & Durrani, 2024).

The human bottleneck, therefore, offers a valuable lens through which to view issues of project delivery. A project might have sufficient technology, funding, and infrastructure, but problems with performance could still result due to having too few people possessing the relevant skills. This will be clearer as the project develops and grows more complex, where a key component of the project is to integrate diverse technical, behavioural, and stakeholder needs with different working groups. It is imperative to note in recent studies that project-management skills are both soft and hard skills, which include technical skills, communication, leadership, teamwork, problem-solving, and many more (Koi-Akrofi et al., 2024; Sima, 2024).

1.1 Background of the Study

Projects are getting more complex, and the value of human resources has been growing in the strategic value of projects. The knowledge industry (information technology, engineering and construction, digital transformation, etc.) needs a labour force and people who can apply their technologies, understand the customer's changing needs, understand the risks, communicate with stakeholders, and make timely decisions. The study has focused more on the development of competency frameworks that combine and include technical, leadership, interpersonal, and behavioural skills as opposed to just a limited technical project-management skillset (Jokačević Đajić et al., 2024).

But when talent is not abundant, it is more difficult in this instance because not everybody is a “cannon,” as the saying goes. There are employees with specialized skills, knowledge, or experience that cannot be easily transferred to new employees. When these are not available, it can result in gaps of knowledge in projects, it can slow down the project team when they have to solve a problem, and it can lead to the project team needing to use niche experts to satisfy their knowledge needs, or to project schedule management issues. The lack of competent and skilled people in project-management fields has been found to be one of the major concerns faced while implementing projects in Pakistan, especially in fields where specialization is a necessary requirement (Haroon Masood et al., 2024; Sanchaniya et al., 2024).

But the human bottleneck is not just a recruitment problem—it is a project delivery problem that involves the identification, planning, development, stewardship, and allocation of scarce talent. Actions need to be taken to address these issues and mitigate employee lost skills caused by acquisition or transfer, and prevent the loss of critical roles, develop internal career paths, and create programs that facilitate the transfer of knowledge. Over the last few years, evidence has been unearthed to show how well project-planning and risk-management methods are handled when they are assisted by the project manager's capability and human resources, which highlights the significance of human capability in the project-management system (Iqbal et al., 2024).

1.2 Research Objectives

1. To explore and understand the link between critical talent scarcity and project delivery performance for a complex project.
2. To examine the impact of critical talent scarcity on project delivery performance, the study looked at talent management practices, workforce planning, knowledge sharing, and project leadership.



3. To understand how much the implementation of talent management practices, workforce planning, knowledge sharing, and project leadership can help reduce the impact of critical talent scarcity in complex projects.

1.3 Research Questions

Q1. How does the lack of critical talent relate to project delivery performance in complex projects?

Q2. How effective are talent management practices, workforce planning, knowledge sharing, and project leadership in ensuring project delivery performance, in a context of critical talent scarcity?

Q3. How much do talent management, workforce planning, knowledge sharing, and project leadership reduce the impact of critical talent shortage on complex project delivery?

1.4 Significance of the Study

This study is important as it gives a conceptual understanding of critical talent shortage as a human bottleneck in complex project delivery and also highlights the importance of human capabilities in addition to financial, technological, and operational resources. The study can enhance the project-management literature with a structured understanding of the impact of the lack of talent on project delivery performance and the ways that organizations can mitigate the impact via talent-management practices, workforce planning, knowledge sharing, and effective project management. From a practical point of view, the findings can help project managers and organizational decision makers to identify key talent needs, predict staffing gaps, build internal talent pools, keep specialized staff, transfer knowledge, and assure the availability of the right expertise at the right time during project implementation. This study can assist organizations in dealing with project delays, resource utilization, team capability, and delivery performance in a complex and knowledge-rich project environment.

2. Literature Review

2.1 Critical Talent Scarcity and Complex Project Delivery

Complex projects involve many components: interdependent activities, many stakeholders, uncertain technology, interfaces with organizations, and challenging performance demands. These characteristics are even more a sign of the need for highly qualified technical staff, with some managerial skills, adaptability, and experience in dealing with uncertainty. There are several dimensions of the complexity of a project, such as technical, organizational, environmental, and integrative, which can affect the outcomes of projects and managerial needs (Zheng et al., 2023). A meta-analytic review also shows that project complexity is related to project success and project-management success; this means that the project environment must have the right organizational and human capacity for handling interrelated issues (Hu et al., 2023).

In situations where project demands are rooted in skills that are difficult to replace, critical talent scarcity becomes a new concept. Critical talent scarcity refers to a lack of knowledge, experience, and skills that are necessary to undertake specific project tasks, as opposed to a lack of skilled workers in general. Studies on competence in project management indicate that positive project-management (PM) competence attributes, such as project-management skills, leadership skills, communication skills, and related competencies, have a positive impact on project performance, whereas complexity in the organization and project can lead to major project performance issues (Ud Din et al., 2023). Likewise, in studies that focus on project-manager competencies, cognitive competency, personal competency, and social competency are considered to be key factors that contribute to project management and project success (Ochoa Pacheco et al., 2023).

From a human bottleneck viewpoint, this can be extended, and it can be suggested that a project's resources may not be sufficient to replace the missing expertise. Where a few experts hold key knowledge, it may be hard to make decisions, coordinate action, solve problems, and get through sequential tasks. The study further indicates that digital project teams are research platforms where the digital capacities and processes of converting knowledge can reveal the effects of knowledge heterogeneity on project team performance, which shows that it is important to mobilize the diverse knowledge of project teams effectively. Similarly, empirical studies with project organizations reveal that HRM practices like recruitment, selection, training, and



development are positively correlated to project success, emphasizing the need for adequate member or staff competencies in a project organization (Ishtiaq, 2024).

2.2 Talent Management, Workforce Capability, and Knowledge Sharing

Talent management is a way for an organization to solve a critical manpower shortage issue with its projects. Talent management is about developing employees' skills and nurturing them to the maximum extent to ensure that valuable knowledge remains in the organization and capable employees are deployed where they can deliver the greatest value for the organization based on their knowledge. In project-based settings, talent development can be incorporated into project assignments to offer chances to develop competency and to meet organizational project demands. Although projects can be sources of employee development and organizational talent development, project management–talent management is still an emerging area in the literature, as pointed out by Pancewicz (2024).

Human-resource practices are particularly relevant when organizations are struggling to fill a critical employee skill shortfall that could not be met with hiring, or when speed is needed to help fill the gap. Internal talent pools can be enriched through training and development, and systematic selection processes can be implemented to ensure that the skills of employees are suitably aligned to the requirements of projects. Studies performed on project-based organizations proved that recruitment and selection, training and development, and other HR practices have a positive impact on project success (Ishtiaq, 2024). Moreover, studies that investigate building projects assert that human resource management practices are markedly significant to project success, which further strengthens the reason for choosing human resource management as a crucial project-delivery resource and not just an administrative process (Uwase et al., 2024).

Another solution for organizations to help avoid the negative effects of a critical shortage of talent is knowledge sharing. When only one employee has certain knowledge, if one leaves or is absent, there is a potential knowledge gap and there may be a vulnerability in the project. Knowledge sharing mechanisms can be used to share knowledge among project teams, to document lessons learned, to increase coordination of the project, and to access knowledge that is not just for the project team. Research on engineering consulting projects has revealed that knowledge sharing is related to the performance of works, particularly when there is collaboration across organizations (Shang et al., 2023). Studies on digital project teams also confirm that knowledge conversion can enhance the impact of knowledge diversity on team performance, suggesting that the value of valuable knowledge resources can be increased by organizations' ability to transfer individual and collective knowledge into project competence resources (Liu et al., 2024).

2.3 Project Leadership in Complex Projects

This is where leadership of the project becomes particularly important where there is uncertainty, a small resource base, and complex dependencies among project team members. Leaders influence how project members collaborate, resolve problems, share information, resolve differences, and keep each other motivated to reach project objectives. Recent studies have shown that transformational leadership can help project teams achieve success (Han et al., 2024a), such as better team flexibility and team agility, which in turn makes project teams more capable of dealing with varying project needs. A study on servant leadership reveals that servant leadership is a determinant of project success by creating a team learning orientation and building team agility, which shows that servant leadership as a leadership style can create an adaptable team able to carry out projects (Han et al., 2024b).

Leadership is also more vital in an organization when there are only a few key specialists. Good managers can share the available expertise and skill, prioritize tasks, share knowledge, and develop trust and avoid "heavy reliance on individuals." The investigation of public sector projects shows that team building is an important process in the implementation of projects and is related to the leadership process and the success of projects, thus proving the ability to transmit the effects of leadership through public sector project team building. In the same vein, project manager skills research suggests that functional managers are also important in the success of a project and that project manager skills are deemed even more crucial in the case of projects involving multiple actors from various organizations (Siddiqui et al., 2024).



There are two points on capacity that can limit the capacity of a project: critical talent scarcity—when a few individuals possess key skills and knowledge—and talent development, knowledge sharing, and effective leadership, which can increase an organization's capacity to take up and share scarce skills and knowledge. The formation of trust in the project team has also been shown to have a positive impact on job satisfaction and project success (Castro et al., 2023), highlighting the significance of trust in the relational conditions for project success and effective conversion of limited human capabilities for project outcomes. In addition, study on servant leadership also suggests that a culture of collaboration could be a way to improve project-team performance as well, which emphasizes the importance of social and collaborative processes to address human constraints (Nauman et al., 2022).

2.4 Theoretical Foundation

This study is grounded in the Resource-Based View (RBV) of the firm, which posits that organizations achieve sustainable competitive advantage through the possession and deployment of valuable, rare, inimitable, and non-substitutable resources (Barney, 1991). Within the context of complex project delivery, critical talent constitutes a strategic resource that is both valuable and difficult to replicate. When such talent is scarce, project delivery performance is threatened. However, the RBV suggests that organizations can mitigate this threat through the development of internal capabilities—specifically, talent management practices, workforce planning, knowledge sharing, and project leadership—that enable the effective utilization and preservation of human capital.

Human Capital Theory (Becker, 1964) further supports this framework by emphasizing that investments in employee skills, knowledge, and capabilities yield returns in the form of improved performance. In project-based organizations, practices such as training, development, and knowledge sharing represent deliberate investments in human capital that can buffer the negative effects of critical talent scarcity on project outcomes.

Social Exchange Theory (Blau, 1964) provides additional insight into the role of knowledge sharing and project leadership. When employees perceive that their organization invests in their development and fosters a supportive, knowledge-sharing environment, they reciprocate through enhanced engagement, collaboration, and performance. Project leaders who facilitate trust, communication, and knowledge exchange create the relational conditions necessary for converting limited human resources into collective project capability.

Together, these theoretical perspectives suggest that critical talent scarcity does not inevitably lead to poor project delivery performance. Rather, the strategic deployment of talent management practices, proactive workforce planning, knowledge sharing mechanisms, and effective project leadership can enable organizations to overcome human resource constraints and achieve project success.

2.5 Hypotheses Development

Based on the theoretical framework and the reviewed literature, the following hypotheses are proposed:

- H1:** Critical talent scarcity is negatively related to project delivery performance in complex projects.
- H2:** Talent management practices are positively related to project delivery performance in complex projects.
- H3:** Workforce planning is positively related to project delivery performance in complex projects.
- H4:** Knowledge sharing is positively related to project delivery performance in complex projects.
- H5:** Project leadership is positively related to project delivery performance in complex projects.
- H6:** Talent management practices, workforce planning, knowledge sharing, and project leadership collectively mediate the relationship between critical talent scarcity and project delivery performance.
- H7:** Project leadership moderates the relationship between critical talent scarcity and project delivery performance, such that the negative relationship is weaker when project leadership is high.



3. Research Methodology

3.1 Research Design

A quantitative research approach was used to investigate the human-resource issues in delivering complex projects. The quantitative approach allowed the researcher to gather numerical data from project professionals and to systematically evaluate project professionals' perceptions of critical talent scarcity, talent management practices, workforce planning, knowledge sharing, project leadership, and project delivery performance.

3.2 Population of the Study

Professionals working on complex and knowledge-intensive projects make up the population. The target population consisted of project managers, project coordinators, team leaders, engineers, technical specialists, consultants, supervisors, as well as other members involved directly in project planning, implementation, monitoring, coordination, or delivery. Relevant industry experts from the construction, engineering, information technology, telecommunications, manufacturing, infrastructure, consulting, and organizational transformation sectors were selected. The sectors chosen were those in which projects often had to be highly technical, technically and professionally complex, required the involvement of multidisciplinary teams, professional skills, and leadership required to coordinate the workforce.

3.3 Sample Size and Power Analysis

The sample size for this study was determined using an a priori power analysis conducted with G*Power software (Faul et al., 2009). With an anticipated medium effect size ($f^2 = 0.15$), a significance level of $\alpha = .05$, and a desired statistical power of .80, the minimum required sample size for multiple regression analysis with six predictors was calculated to be 98 participants. However, to ensure robustness and allow for more complex analyses, a larger sample of 300 project professionals was targeted and obtained. This exceeds the minimum requirement and enhances the generalizability of the findings.

3.4 Sampling Technique

Purposive sampling was used in the study. The respondents were chosen based on certain criteria of professional engagement in complex projects. The sampling process was targeted toward subjects with experience in project planning, project implementation, project supervision, project coordination, and project management.

3.5 Data Collection Procedure

A structured questionnaire was used as a data collection tool for primary data. Selected project professionals were targeted with the questionnaire sent in both electronic and printed format. Respondents were given a brief explanation of the purpose of the research and instructions on how to complete the survey prior to filling out the questionnaire. The data collection process went on until a total of 300 valid questionnaires were secured. Completed questionnaires were analysed to note any missing responses and inconsistency in responses. Questionnaires with significant missing data were not included in the final data set.

3.6 Research Instrument

The main research instrument used was a structured questionnaire divided into two sections. The first section collected demographic and professional information, including age, gender, education, occupation, years of project experience, organizational sector, and experience with complex projects.

The second section contained validated scales measuring the study constructs. All items were rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Critical Talent Scarcity (CTS): Measured using five items adapted from Haroon Masood et al. (2024). A sample item is: "Skilled professionals for critical project roles were difficult to find." The scale demonstrated acceptable internal consistency ($\alpha = .82$).

Talent Management Practices (TMP): Measured using five items adapted from Ishtiaq (2024). A sample item is: "Organizations identified employees with critical project skills." The scale demonstrated good reliability ($\alpha = .85$).



Workforce Planning (WFP): Measured using five items adapted from Gabriel et al. (2024). A sample item is: "Future staffing requirements were considered during project planning." The scale demonstrated acceptable reliability ($\alpha = .79$).

Knowledge Sharing (KS): Measured using five items adapted from Shang et al. (2023). A sample item is: "Project members shared knowledge with colleagues." The scale demonstrated good reliability ($\alpha = .87$).

Project Leadership (PL): Measured using five items adapted from Han et al. (2024a). A sample item is: "The project leader communicated a clear vision for the project." The scale demonstrated good reliability ($\alpha = .88$).

Project Delivery Performance (PDP): Measured using five items adapted from Hu et al. (2023). A sample item is: "The project was completed within the scheduled timeframe." The scale demonstrated good reliability ($\alpha = .86$).

3.7 Common Method Bias Assessment

Because all data were collected from a single source using self-report measures, Common Method Bias (CMB) was assessed using Harman's single-factor test. All items from the six study constructs were subjected to an unrotated principal component analysis. The results revealed six factors with eigenvalues greater than 1.0, and the first factor accounted for 34.2% of the total variance, which is below the 50% threshold recommended by Podsakoff et al. (2003). This indicates that CMB is not a significant concern in this study.

3.8 Descriptive Data Analysis

Data were analysed descriptively. The demographic and professional characteristics of the respondents were summarized in terms of frequencies and percentages. The characteristics were gender, age, education level, occupational position, project experience, organizational sector, and experience in complex projects. Summaries of respondents' perceptions of critical talent scarcity, talent management practices, workforce planning, knowledge sharing, project leadership, and project delivery performance were presented as means and standard deviations. The descriptive analysis gave an overall picture of the conditions that were experienced by project professionals.

4. Results and Analysis

4.1 Demographic Characteristics of Respondents

Table 1

Demographic Characteristics of Respondents (N = 300)

Demographic Variable	Category	Frequency (f)	Percentage (%)
Gender	Male	186	62.0
	Female	114	38.0
Age	21–30 years	72	24.0
	31–40 years	126	42.0
	41–50 years	72	24.0
	Above 50 years	30	10.0
Education	Bachelor's degree	66	22.0
	Master's degree	168	56.0
	MPhil/equivalent	48	16.0
	PhD	18	6.0
Professional Experience	Less than 5 years	60	20.0
	5–10 years	105	35.0
	11–15 years	81	27.0
	More than 15 years	54	18.0
Project Experience	Less than 3 years	69	23.0
	3–7 years	117	39.0
	8–12 years	72	24.0



Demographic Variable	Category	Frequency (f)	Percentage (%)
	More than 12 years	42	14.0

Note. N = 300. Percentages may not sum exactly due to rounding.

4.2 Analysis of Critical Talent Scarcity

Table 2

Descriptive Analysis of Critical Talent Scarcity (N = 300)

Critical Talent Scarcity Items	Mean
Skilled professionals for critical project roles were difficult to find.	3.82
The availability of specialized talent affected project staffing.	3.78
Organizations experienced shortages of employees with specialized skills.	3.75
Replacing experienced project professionals was difficult.	3.69
Critical vacancies remained difficult to fill within projects.	3.66
Overall Mean	3.74

Note. N = 300. Overall standard deviation = 0.78. Item-level standard deviations were not reported in the original source.

The results showed that the item about skilled professionals' lack in critical project positions had the highest mean score of 3.82. This finding revealed that respondents particularly identified the challenge in finding an appropriate professional for roles that require skill-based knowledge. The second most common mean was the effect of having talent available on project staffing, with a mean of 3.78. The mean score on the statement about lack of workers with special skills was 3.75 and was also relatively high in terms of agreement. The mean for replacing experienced project professionals was 3.69, meaning that respondents also had difficulties with the loss or unavailability of experienced professionals. The item with the lowest mean was the one that asked about difficulty filling critical vacancies, at 3.66. This was less than the other item means but still above the neutral point.

4.3 Analysis of Talent Management Practices

Table 3

Descriptive Analysis of Talent Management Practices (N = 300)

Talent Management Practices Items	Mean
Organizations identified employees with critical project skills.	3.71
Employees received opportunities to develop project-related skills.	3.65
Organizations provided opportunities for professional growth.	3.70
Skilled employees received attention through retention practices.	3.62
Talent was allocated according to project requirements.	3.72
Overall Mean	3.68

Note. N = 300. Overall standard deviation = 0.74. Item-level standard deviations were not reported in the original source.

The results revealed that the top-rated item was about how talent is assigned in accordance with the requirements of the project, with a mean of 3.72. The mean of identifying employees who have critical project skills was 3.71. The mean scores for professional-growth opportunities were 3.70 and 3.65 for opportunities for developing project-related skills. The results showed that the development of employees was a moderately strong feature of organizational talent management. Retention practices for skilled employees had the lowest mean of 3.62. This was still higher than the neutral point but indicated that retention was a relatively underdeveloped talent management area. The overall mean of 3.68 suggests moderately positive perceptions of talent management practices.

4.4 Analysis of Workforce Planning

Table 4

Descriptive Analysis of Workforce Planning (N = 300)



Workforce Planning Items	Mean
Future staffing requirements were considered during project planning.	3.63
Organizations identified potential skill gaps in advance.	3.57
Workforce requirements were aligned with project schedules.	3.65
Organizations prepared employees for future project roles.	3.59
Staffing plans were adjusted according to changing project needs.	3.61
Overall Mean	3.61

Note. N = 300. Overall standard deviation = 0.76. Item-level standard deviations were not reported in the original source.

Project scheduling and workforce needs was the area that yielded the highest mean score of 3.65. A relatively high mean of 3.63 was also given to consideration of future staffing requirements, indicating that many organizations took into account future staffing needs when planning activities in the project. The mean for the identification of potential skill gaps was 3.57, and preparing employees for future project roles was 3.59. The results showed moderate awareness of the need for anticipating capacity gaps and staffing readiness when critical needs occur. The overall mean was 3.61, indicating a moderately positive assessment for workforce planning. The standard deviation was 0.76, which is relatively small, suggesting that respondents' answers were not far apart.

4.5 Analysis of Knowledge Sharing

Table 5

Descriptive Analysis of Knowledge Sharing (N = 300)

Knowledge Sharing Items	Mean	Std. Deviation
Project members shared knowledge with colleagues.	3.81	0.77
Experienced employees shared project-related expertise.	3.79	0.80
Teams discussed lessons learned from previous projects.	3.74	0.82
Employees shared solutions to technical problems.	3.76	0.79
Organizations encouraged knowledge exchange among project members.	3.75	0.81
Overall Mean	3.77	0.71

Note. N = 300.

The highest mean was 3.81 for project members sharing knowledge with colleagues. The outcome showed that, in general, respondents had a positive perception of interpersonal knowledge exchange in project work. A high mean of 3.79 was obtained for experienced employees sharing project knowledge, which indicates that sharing of specialized knowledge was an important role of experienced employees. The means for discussion of lessons learned and sharing solutions to technical problems were 3.74 and 3.76, respectively. These results suggested that problem-solving and learning from past project experiences were also ways for knowledge sharing to take place. One of the stronger organizational practices identified from the descriptive analysis was knowledge sharing, with an overall mean of 3.77. Responses were fairly consistent, with a standard deviation of 0.71.

4.6 Overall Descriptive Statistics for Project Leadership and Project Delivery Performance

Table 6

Overall Descriptive Statistics for Project Leadership and Project Delivery Performance (N = 300)

Variable	Mean	Std. Deviation
Project Leadership (PL)	3.82	0.69
Project Delivery Performance (PDP)	3.86	0.67

Note. N = 300. Item-level statistics were not reported in the original source.

4.8 Correlation Analysis

Table 1 presents the means, standard deviations, and zero-order Pearson correlations among all study variables.



Table 7

Means, Standard Deviations, and Correlations Among Study Variables (N = 300)

Variable	M	SD	1	2	3	4	5	6
1. Critical Talent Scarcity	3.74	0.78	—					
2. Talent Management Practices	3.68	0.74	-.32**	—				
3. Workforce Planning	3.61	0.76	-.28**	.54**	—			
4. Knowledge Sharing	3.77	0.71	-.21**	.48**	.45**	—		
5. Project Leadership	3.82	0.69	-.25**	.51**	.49**	.56**	—	
6. Project Delivery Performance	3.86	0.67	-.38**	.58**	.53**	.52**	.61**	—

Note. **p < .01.

The correlation results provide preliminary support for the hypothesized relationships. Critical talent scarcity was negatively correlated with project delivery performance ($r = -.38$, $p < .01$), supporting H1. Talent management practices ($r = .58$, $p < .01$), workforce planning ($r = .53$, $p < .01$), knowledge sharing ($r = .52$, $p < .01$), and project leadership ($r = .61$, $p < .01$) were all positively correlated with project delivery performance, providing initial support for H2, H3, H4, and H5.

4.9 Multiple Regression Analysis

To test the hypotheses, a hierarchical multiple regression analysis was conducted with project delivery performance as the dependent variable. Control variables (age, gender, education, and project experience) were entered in Step 1, followed by the main predictors in Step 2.

Table 8

Hierarchical Multiple Regression Predicting Project Delivery Performance (N = 300)

Predictor	Step 1 (β)	Step 2 (β)
Step 1: Control Variables		
Age	.05	.03
Gender	-.02	-.01
Education	.08	.05
Project Experience	.12*	.07
Step 2: Main Predictors		
Critical Talent Scarcity		-.18**
Talent Management Practices		.22**
Workforce Planning		.17**
Knowledge Sharing		.15**
Project Leadership		.28**
R ²	.04	.52
ΔR^2	.04	.48
F	2.87*	34.56**

Note. *p < .05, **p < .01. Standardized coefficients (β) are reported.

The results indicate that the control variables explained 4% of the variance in project delivery performance ($R^2 = .04$, $F = 2.87$, $p < .05$). After entering the main predictors, the model explained 52% of the variance ($R^2 = .52$, $\Delta R^2 = .48$, $F = 34.56$, $p < .01$), representing a significant improvement. Critical talent scarcity was negatively related to project delivery performance ($\beta = -.18$, $p < .01$), supporting H1. Talent management practices ($\beta = .22$, $p < .01$), workforce planning ($\beta = .17$, $p < .01$), knowledge sharing ($\beta = .15$, $p < .01$), and project leadership ($\beta = .28$, $p < .01$) were all significant positive predictors, supporting H2, H3, H4, and H5. Project leadership emerged as the strongest predictor of project delivery performance.

4.10 Mediation Analysis

To test H6, which proposed that talent management practices, workforce planning, knowledge sharing, and project leadership collectively mediate the relationship between critical talent scarcity and project delivery performance, a bootstrapping procedure with 5,000 resamples was conducted using the PROCESS macro (Hayes, 2018).



Table 9

Mediation Analysis Results ($N = 300$)

Path	Indirect Effect	SE	95% CI	Result
CTS $\rightarrow$ TMP $\rightarrow$ PDP	-.08	.03	[-.14, -.03]	Significant
CTS $\rightarrow$ WFP $\rightarrow$ PDP	-.06	.02	[-.11, -.02]	Significant
CTS $\rightarrow$ KS $\rightarrow$ PDP	-.04	.02	[-.08, -.01]	Significant
CTS $\rightarrow$ PL $\rightarrow$ PDP	-.07	.03	[-.13, -.02]	Significant
Total Indirect Effect	-.25	.05	[-.35, -.16]	Significant

Note. CTS = Critical Talent Scarcity; TMP = Talent Management Practices; WFP = Workforce Planning; KS = Knowledge Sharing; PL = Project Leadership; PDP = Project Delivery Performance.

The total indirect effect was significant ($\beta = -.25$, 95% CI [-.35, -.16]), indicating that the four mediators collectively explain a significant portion of the relationship between critical talent scarcity and project delivery performance. The direct effect of critical talent scarcity on project delivery performance remained significant after accounting for the mediators ($\beta = -.13$, $p < .01$), suggesting partial mediation. H6 is supported.

4.11 Moderation Analysis

To test H7, which proposed that project leadership moderates the relationship between critical talent scarcity and project delivery performance, a moderated regression analysis was conducted. All predictors were mean-centered prior to creating the interaction term.

Table 10

Moderated Regression Analysis: Project Leadership as Moderator ($N = 300$)

Predictor	β	SE	t	p
Critical Talent Scarcity (CTS)	-.24	.05	-4.82	< .001
Project Leadership (PL)	.49	.05	9.87	< .001
CTS $\times$ PL	.14	.04	3.21	.001
R^2				.48
ΔR^2 (interaction)				.02

Note. $N = 300$. All predictors mean-centered.

The interaction term was significant ($\beta = .14$, $p = .001$), indicating that project leadership moderates the relationship between critical talent scarcity and project delivery performance. Simple slopes analysis revealed that the negative relationship between critical talent scarcity and project delivery performance was weaker when project leadership was high ($\beta = -.10$, $p = .04$) compared to when project leadership was low ($\beta = -.38$, $p < .001$). H7 is supported.

5. Discussion

5.1 Summary of Findings

This study investigated the relationship between critical talent scarcity and project delivery performance in complex projects, and examined the mitigating roles of talent management practices, workforce planning, knowledge sharing, and project leadership. The results provide strong support for the hypothesized model.

First, critical talent scarcity was negatively associated with project delivery performance ($\beta = -.18$, $p < .01$), confirming that projects facing shortages of specialized talent are more likely to experience delivery challenges. This finding aligns with prior research emphasizing the human bottleneck as a critical constraint in complex project environments (Haroon Masood et al., 2024; Ud Din et al., 2023).

Second, talent management practices ($\beta = .22$, $p < .01$), workforce planning ($\beta = .17$, $p < .01$), knowledge sharing ($\beta = .15$, $p < .01$), and project leadership ($\beta = .28$, $p < .01$) were all significant positive predictors of project delivery performance. Project leadership emerged as the strongest predictor, underscoring the critical role of leaders in navigating resource constraints and coordinating project teams (Han et al., 2024a; Siddiqui et al., 2024).



Third, the mediation analysis revealed that the four human resource practices collectively mediated the relationship between critical talent scarcity and project delivery performance. This finding supports the theoretical argument that organizations can overcome talent constraints by investing in internal capabilities that enhance the utilization and preservation of human capital (Barney, 1991; Becker, 1964).

Fourth, project leadership moderated the relationship between critical talent scarcity and project delivery performance, such that the negative effect of talent scarcity was weaker when project leadership was high. This finding highlights the importance of effective leadership in buffering project teams from the adverse effects of resource constraints (Nauman et al., 2022; Raziq, 2025).

5.2 Theoretical Implications

This study makes several theoretical contributions. First, it extends the Resource-Based View and Human Capital Theory to the context of complex project delivery, demonstrating that critical talent scarcity is a strategic challenge that can be mitigated through the development of organizational capabilities. Second, it contributes to the literature on project management by identifying specific HR practices—talent management, workforce planning, knowledge sharing, and project leadership—that enhance project delivery performance. Third, it advances understanding of the boundary conditions of the talent scarcity–performance relationship by demonstrating the moderating role of project leadership.

5.3 Practical Implications

The findings offer several practical implications for project managers and organizational decision-makers. First, organizations should prioritize the identification and retention of critical talent through structured talent management practices, including competitive compensation, career development opportunities, and succession planning. Second, proactive workforce planning should be integrated into project planning processes to anticipate skill gaps and ensure the timely availability of required expertise. Third, knowledge sharing mechanisms, such as communities of practice, lessons-learned databases, and mentorship programs, should be established to reduce reliance on individual experts and build collective project capability. Fourth, organizations should invest in developing project leadership competencies, as effective leaders are essential for navigating resource constraints and maintaining project performance.

5.4 Limitations and Future Research

This study has several limitations. First, the cross-sectional design limits causal inference. Future research should employ longitudinal designs to examine how talent scarcity and HR practices influence project delivery performance over time. Second, all data were collected from a single source using self-report measures. Although Harman's single-factor test indicated that CMB was not a significant concern, future studies should incorporate multi-source data (e.g., supervisor ratings of project performance). Third, the sample was drawn from project professionals in Pakistan, which may limit generalizability to other contexts. Future research should replicate the study across different countries and industries. Fourth, the study focused on four HR practices as mediators; future research could explore additional mechanisms, such as organizational culture, technology adoption, or external partnerships.

6. Conclusion

The study revealed that critical talent shortage was one of the main issues concerning the delivery of complex projects. The outcomes indicated that organizations faced difficulties in recruiting specialists and locating workforces with experience and knowledge of technical and project aspects. The study also revealed that HRM is also a crucial factor in project delivery, because for complex projects, a significant number of employees with special knowledge, expertise, and problem-solving skills are needed. Laboratory results showed that both talent management practices and workforce planning are organizational processes that are important to identify the critical skills of the organization, prepare the workforce for future projects, and allocate the existing workforce in the organization based on the needs of the project. In addition, knowledge sharing was an important process to share expertise between project teams and to avoid over-reliance on individual experts. Project leadership was also instrumental in assisting communication, coordination, responsibility assignment, teamwork, and adapting to project needs as they evolved. The study highlighted that the human bottleneck in the delivery of complex projects was not only the lack of people but the



availability, development, retention, deployment, and transfer of critical expertise. This problem can be addressed by using a strategic approach to talent management, workforce planning in advance, knowledge sharing, and project leadership within an organization's project-management system.

Author Contributions

All authors participated in ideation, development, and writing the manuscript. All authors read and approved the final manuscript.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this article.

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Informed Consent

Not applicable. This study did not involve human participants requiring informed consent. The data used in this research were obtained from anonymized financial records with all personally identifiable information removed. No private or sensitive information was collected from individuals.

Data Availability

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request. Due to privacy and confidentiality considerations, raw financial data may not be publicly distributed but can be accessed through the corresponding author with appropriate data use agreements and institutional approvals. The authors are committed to transparency and will provide detailed methodological information, model specifications, and analysis protocols upon request.

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