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RESEARCH ARTICLE

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Impact of Project Planning and Risk Management on Project Team Performance: Moderating Role of Project Managers' Competencies

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Abstract: A project management is a precondition to success in the high-uncertainty fields like biotechnology. This empirical study examines how Project Planning (PP) and Project Risk Management (PRM) affect the Project Team Performance (TP) in the biotechnology industry in Pakistan as moderated by project Manager Competencies (MC). The quantitative design based on Competency, Contingency theory and Project Management, a structured questionnaire is administered to 120 project experts working within Pakistani biotechnology companies. Analysis of data was done using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS 4. The results show that the effect of PP on TP is statistically significant and positive ($\beta=0.199$, $p=0.008$). PRM also shows a positive, though statistically insignificant, direct correlation with TP($\beta=0.182$, $p=0.070$). More crucially, MC is an important moderator of the PP–TP relationship ($\beta=0.211$, $p=0.013$), where planning is positively associated with team outcomes. On the other hand, MC does not significantly moderate the PRM-TP relationship ($\beta=0.028$, $p=0.780$). The paper concludes that, in the demanding biotechnology environment, strong planning and risk management represent the pre-requisites but the skills of project managers are the key to transferring the plans, which may not be standardised risk protocols, to excellent team performance. The study provides theoretical evidence about the conditional influence of managerial capabilities and presents managerial advice applicable to biotechnology companies to emphasize leadership growth and strategic planning.

Keywords: Project Planning, Project Risk Management, Managerial Competencies, Team Performance, Biotechnology, Pakistan, PLS-SEM

Introduction

Proper project planning, risk management, and project-team performance are fundamental drivers of successful implementation in any multifaceted initiative; nevertheless, the dependencies among the constructs are not well studied in a sector characterized by extreme uncertainty such as biotechnology(Ahmed &Younis, 2014). Project planning serves as a kind of strategic map showing goals, timetable, and resource distribution, thus rendering coherence and guidance in settings characterized by uncertainty(Ahmed, 2018). Project risk management provides a systematic approach to identification, assessment, and mitigation of possible disruptions to allow resilience and adaptation. The project-team performance is a picture of the synthesis of these synchronized activities; the overall ability to achieve goals, become innovative, and deliver on demand (Alvarenga et al., 2020).

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Pakistan biotechnology provides an interesting backdrop for exploring these forces. Biotechnology, which is included as a strategic emphasis in the Pakistan Vision 2025 plan, will make essential differences in the issues facing the country in the areas of health, food security, and industry(Project Management Institute, 2021). However, the projects in this field are associated with high levels of scientific uncertainty, strong regulatory control, and multidisciplinary collaboration that increase the complexity of executing the project(Bertolotti et al., 2015). Besides, infrastructural constraints, unstable funding sources, and skill gaps will further increase these issues, which tend to result in schedule slippage, cost overruns, as well as wasteful performance(Fazly et al., 2024).

There is already a recognized individual importance of project planning (PP), project risk management (PRM), and project managers' competencies (MC)(Bouchaut & Asveld, 2021). However, there is scant information regarding the interaction of these antecedents to affect the project-team performance (TP) in the unique setting of the high-technology industry of a developing economy(Habib et al., 2021). This information gap is consequential, with the traditional paradigms of project management failing to be applicable (biotechnological context) where discovery activity is in a loop of iterative activity and regulatory environments are dynamic and warranting context-dependent response(Kavianifar&Jalili, 2025).

In this regard, the current study will explore the direct influence of PP and PRM on TP in the Pakistani biotechnology industry context and will also explore how the competencies of the project managers moderately affect the same(Irfan et al., 2021). Based on Project Management Theory, Competency Theory, as well as Contingency Theory, this study hypothesizes that the effectiveness of formal project processes depends on the abilities of those who implement them. Particularly, the following research questions are covered by the study:

1. How do project planning and project risk management directly influence project-team performance in biotechnology projects in Pakistan?
2. How do the competencies of project managers moderate these relationships?

The purpose of answering these questions is that this study will theoretically contribute to the research on the integration of structural and human factors in project management, as well as provide practical solutions to improve team effectiveness and project success in the strategically important biotechnology sector of Pakistan.

Literature Review and Hypotheses Development

Project Planning and Team Performance

Project planning refers to the orderly identification of project goals, sequencing of tasks, allocation of resources, and a schedule(Bilal et al., 2024). Planning in biotechnology settings with inherently iterative workflows that rely on the results of experiments requires a balance between structure and flexibility in response to scientific findings and protocol modifications(Kavianifar & Jalili, 2025). Successful PP minimizes uncertainty and ambiguity, improves the coordination of various experts, and offers a logical roadmap to direct teams in their efforts to achieve shared goals (Khaled Ali Al-Balawneh & Saeed Tarabieh, 2024). Innovation-based research has proved that teams that are characterized by clearly established planning models are better organized, have fewer workflow interruptions, and can achieve better performance results(Li et al., 2025). In the Pakistani context, with resource limitations and regulatory burdens that escalate project implementation difficulties, structured planning is specifically essential in keeping project momentum and team focus on track(Ahmed, 2018).We therefore hypothesize:

H1: *Project Planning has a significant positive effect on Project Team Performance.*

Project Risk Management and Team Performance

Project risk management is defined as the systemized recognition, evaluation, ranking, and mitigation of risks, which can threaten project goals (Project Management Institute, 2021). In the context of biotechnology,

risk profiles are complex, and include scientific uncertainties (e.g., experiment failures), compliance issues (e.g. with regulations), biosafety risks, and market uncertainties (Haddad et al., 2021). An active risk-management practice keeps organisations better prepared and makes them better at making decisions in the face of uncertainty and limits disruptive surprises that might halt the project. Groups with a strong risk-management culture are more resilient, faster adjusted to the emergence of unexpected weaknesses, and achieve greater operational efficiency(Fazly et al., 2024). However, in the context where the risks are inevitably part and parcel of a scientific process, the direct correspondence between the risk-management activities and perceived team performance might be less apparent(Khaled Ali Al-Balawneh& Saeed Tarabieh, 2024). Based on these considerations, we suggest: H2.

H2: *Project Risk Management has a significant positive effect on Project Team Performance.*

Project Managers' Competencies as a Moderator

The competencies of project managers are a holistic group of knowledge, skills, and behaviours, such as leadership, emotional intelligence, communication competence, and adaptation of decisions, which are capable of guiding teams effectively in a complex environment (Li et al., 2025). This competency theory accentuates that these characteristics have a primary role in determining the way people perceive and react to challenges within organisations(Malii et al., 2025). The contingency theory also supports that managerial performance depends on the alignment of the leadership styles with environmental requirements(Pavez et al., 2022). Within the scope of project management, a highly effective manager can significantly contribute to implementing project plans through the articulation of a strategic vision, adjusting plans to emerging challenges, motivating members of the staff, and collaborative problem-solving(Muhammad Huzaifa Butt et al., 2021). On the other hand, a carefully designed strategy would not provide optimal results in the presence of weak leadership(Phan et al., 2019). Similarly, the ability of a manager to interpret warning signs of risk, communicate risk, and mobilize the team response may, hypothetically, enhance the value and usefulness of formal risk-management systems(Maalouf& Achi, 2023). However, when managerial competencies are moderating, standard operating procedures increasingly institutionalise risk management, or in biotechnology, where the risks are more procedure-based than managerial, the moderating effect might be lessened (Fazly et al., 2024). Based on that, the following moderation hypotheses are as follows:

H3: *Project Managers' Competencies moderate the relationship between Project Planning and Team Performance, such that the relationship is stronger when competencies are high.*

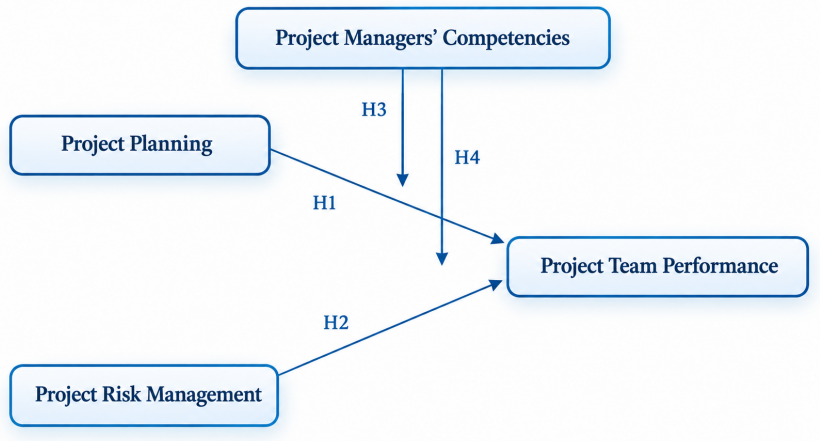
H4: *Project Managers' Competencies moderate the relationship between Project Risk Management and Team Performance, such that the relationship is stronger when competencies are high.*

Conceptual Framework

Conceptual framework in Figure 1 encapsulates the hypothesised relationships by joining theoretical understanding of project-management, competency and contingency models. Project planning (PP) and project risk management (PRM) are modelled as independent variables with a direct impact on the dependent construct, project team performance (TP). The effects of the competencies of project managers (MC) have been suggested as a moderator, which allegedly influences the strength of the PP to TP and PRM to TP relationships. As a result, the framework explains interactive nature of formalised project-management processes and human managerial capabilities in joint determination of team performance in biotechnological project environments.

Figure 1

Conceptual Framework



Source: Developed for this study based on Project Management, Competency, and Contingency Theories

Research Methodology

Population and Sampling

The sample population was composed of professionals who are actively engaged with biotechnology projects in Pakistan, which included; project managers, quality assurance officers, and regulatory affairs specialists who were recruited within the pharmaceutical, agricultural and industrial biotechnology sectors. The purposive sampling technique was used to ensure all the respondents had first hand and relevant experience in the implementation of biotechnology projects. Among the preliminary distribution, 120 complete and valid responses were obtained to be analysed and hence exceeds the minimum sample size requirement of the technique of partial least squares structural equation modelling (PLS-SEM), which considers a sample to be at least ten times the maximum number of structural paths to any specific construct in the model(Hair et al., 2014).

Measurement Scales

A structured questionnaire was used to gather the data under a five-point Likert scale (1=Strongly Disagree to 5=Strongly Agree). All measurement scales used in the project-management literature were modified to guarantee content validity and reliability. Table 1 specifies these particular instruments.

Table 1

Measurement Scale

Variables	No. of items	Reference/Scale
Project Planning (PP)	5	Adapted from Papke-Shields et al. (2021)
Project Risk Management (PRM)	5	Adapted from Hillson et al. (2020)
Managerial Competencies (MC)	5	Adapted from Müller et al. (2022)
Team Performance (TP)	5	Adapted from Carvalho et al. (2021)

Research Technique

Data analysis proceeded in two phases using SPSS 25 and SmartPLS 4. First, descriptive statistics and scale reliability (Cronbach's Alpha) were computed. Second, Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed to assess both the measurement model (convergent and discriminant validity) and the structural model (hypothesis testing)(Hair et al., 2012). The moderation effects specified in H3 and H4 were tested using the product-indicator approach, creating interaction terms (PP × MC and PRM × MC). Statistical significance of all path coefficients was determined through bootstrapping with 5,000 subsamples to generate stable estimates and confidence intervals.

Data Analysis

Descriptive Statistics and Reliability

Table 2 presents the descriptive statistics and reliability coefficients for all study constructs. The mean scores for all variables exceed the scale midpoint (3.0), indicating generally positive perceptions among respondents regarding project planning, risk management, managerial competencies, and team performance in their organizations. The Cronbach's Alpha values for all constructs surpass the recommended threshold of 0.70, demonstrating good internal consistency and reliability of the measurement scales(Phan et al., 2019).

Table 2

Descriptive Statistics and Reliability

Variable	N	Minimum	Maximum	Mean	Std. Deviation	Cronbach's Alpha
Project Planning (PP)	120	2.00	5.00	3.25	0.50	0.834
Project Risk Management (PRM)	120	2.50	5.00	2.85	0.64	0.839
Managerial Competencies (MC)	120	3.00	5.00	3.10	0.60	0.772
Team Performance (TP)	120	2.00	5.00	2.70	0.58	0.898

Measurement Model Assessment

Convergent validity was established as all indicator loadings exceeded 0.60 and the Average Variance Extracted (AVE) for each construct was greater than 0.50. Discriminant validity was confirmed using two criteria: (1) the Fornell-Larcker criterion, where the square root of the AVE for each construct exceeded its correlations with all other constructs; and (2) the Heterotrait-Monotrait (HTMT) ratio, where all values were below the conservative threshold of 0.85. These results confirm that the measurement model is both reliable and valid.

Hypotheses Testing (Structural Model)

The results of the structural model analysis and hypothesis testing are presented in Table 3. The model explains a substantial proportion of the variance in Project Team Performance ($R^2 = 0.451$), indicating good explanatory power.

Table 3

Path Coefficients and Hypotheses Testing

Hypothesis	Path	β-coefficient	Std. Dev	t-statistic	p-value	95% CI (LL; UL)	Decision
H1	PP -> TP	0.199	0.075	2.648	0.008	[0.052; 0.346]	**Supported**
H2	PRM -> TP	0.182	0.101	1.813	0.070	[-0.016; 0.380]	Partially Supported
H3	PP x MC -> TP	0.211	0.085	2.475	0.013	[0.044; 0.378]	**Supported**
H4	PRM x MC -> TP	0.028	0.102	0.280	0.780	[-0.171; 0.227]	**Not Supported**

Notes: CI = Confidence Interval (Bootstrapped); LL = Lower Limit; UL = Upper Limit.

- **H1 is supported:** Project Planning has a significant positive effect on Team Performance ($\beta = 0.199$, $p < 0.01$).
- **H2 is partially supported:** Project Risk Management shows a positive but marginally significant effect on Team Performance ($\beta = 0.182$, $p = 0.07$).
- **H3 is supported:** The interaction term PP × MC is positive and significant ($\beta = 0.211$, $p < 0.05$), confirming that Managerial Competencies strengthen the positive relationship between Project Planning and Team Performance.

- **H4 is not supported:** The interaction term PRM × MC is non-significant ($\beta = 0.028$, $p = 0.78$), indicating that Managerial Competencies do not moderate the relationship between Project Risk Management and Team Performance.

Findings and Discussion

This paper has explored team performance drivers in the Pakistani biotechnology industry with a special focus on the conditional aspects of the competencies that project managers play. The findings provide subtle insights that contribute to theoretical knowledge and practice.

The strong justification of H1 is consistent with the fundamental concepts of project-management and highlights the paramount significance of systematic planning being vital in complex, research-based settings (Rahmani, 2025). A clear but flexible plan is a key coordination mechanism in biotechnology, where activity is interdependent but results are uncertain, which minimizes confusion among multidisciplinary teams around shared goals. This observation is particularly relevant in the Pakistani context, where limited resources and infrastructural issues increase the necessity of effective resource distribution and schedule control (SubhanUd Din et al., 2023).

The result of H2 puts a significant twist. The path coefficient is positive, but the marginal statistical significance indicates that the direct conversion of risk-management practices into improved team performance may not be automatic as had been thought before (Tabish & Jha, 2011). This can be in response to the inherent character of risks in biotechnology, which more often than not are inherent to the process of scientific discovery (e.g., experimental variability, unexpected results) and not external risks that can be completely avoided (Tshering, 2023). As a result, teams can attach risk management to compliance or technical protection rather than a direct facilitator of their daily operational efficiency (Zwikael et al., 2014).

The moderation tests provide the most important theoretical contribution. H3 was supported strongly, and it gave solid empirical views that managerial competencies tend to increase the positive effects of managerial planning on team performance. This observation eloquently demonstrates the integrative approach of contingency and competency theories. Skilled project managers are not only implementers of plans; they read, communicate, and change them (Malii et al., 2025). They take static documents and convert them into dynamic and shared mental models; they inspire teams during times of uncertainty, and they support problem-solving in situations where plans are blocked by new challenges (Kavianifar & Jalili, 2025). Therefore, the structural basis of planning is followed by the management skill as to whether the architecture is well exploited to deliver performance results (Li et al., 2025).

On the other hand, H4 was not upheld, indicating that there was a vital threshold condition of the managerial competency influences. This finding indicates that, possibly in highly regulated, proceduralized fields where biotechnology is involved, the efficacy of formal risk-management systems in shaping the performance of the team functions somewhat independently of the leadership capacities of the particular managers (Irfan et al., 2021). It is a common practice to formalize risk management in such settings with standard operating procedures, compliance protocols, risk officers, and quality management systems (Bouchaut & Asveld, 2021). Its effect on team functioning could thus be more systemic and procedural, less responsive to improvement through individual managerial interventions on the side of motivation or communication (Fazly et al., 2024). This distinction between the processes of planning and risk management has significant ramifications both to theory and practice.

Contributions

Theoretical Contributions

This research contributes to three areas of theory. First, it addresses the demand to employ more integrated models in project-management research by both investigating the direct impact of major project-management practices and the conditional position of human capabilities within one framework (Project Management

Institute, 2021). Second, it presents subtle empirical data points that managerial competencies act as a powerful moderator of planning efficacy yet not risk-management efficacy among high-technology and controlled environments. This refinement is one that goes a step further to define what project processes are more contingent on the quality of leadership. Third, it generalizes the use of competency theory into the biotechnology industry within an emerging economy by showing how the individual competencies interact with organizational processes to determine overall performance.

Practical Contributions

For practitioners and organizations within Pakistan's biotechnology sector and similar innovation-driven environments, the findings offer clear, actionable guidance:

1. **Invest in Adaptive Planning Systems:** Develop robust yet flexible planning frameworks that can accommodate scientific uncertainty while providing sufficient structure to guide team efforts.
2. **Prioritize Leadership Competency Development:** Allocate significant resources to building project managers' competencies in communication, emotional intelligence, adaptive leadership, and interdisciplinary coordination. This represents the highest-leverage intervention for maximizing returns on planning investments.
3. **Institutionalize Risk Management:** Approach risk management as a specialized, procedural function that requires systemic implementation. Ensure it is embedded in organizational routines, technical roles, and quality systems rather than relying primarily on individual managerial initiative.

Recommendations

Multiple particular recommendations can be drawn based on the findings. The biotechnology companies must develop interactive training opportunities incorporating both technical project-planning tools as well as the development of leadership competencies. The industry associations and educational institutions are encouraged to join efforts with the aim of coming up with context-based project-management courses that would address the requirements of science-based industries in the emerging economies. The policymakers are supposed to encourage projects which develop project leadership in national science and technology development programmes. One new career path that organisations should consider is the possibility of a dual career path in which technical experts can acquire managerial skills without losing their scientific skills. Future studies should examine what particular set of competencies (e.g., transformational leadership, emotional intelligence, decision-maker agility) plays the greatest role in moderating the plan performance relation.

Limitations and Future Directions

There are a number of limitations to this study which point to future research. The cross-sectional design does not allow conclusive causal conclusions; longitudinal research that will monitor projects from start to completion will enhance causal arguments. The narrow scope of generalisability (one industry (biotechnology), one country (Pakistan)) could be improved by replications in other areas with high uncertainty (including software development, renewable energy) and other cultural settings. This could create common method bias due to self-reported perceptual assessments; objective measures of performance and multi-source ratings are necessary in future research. The research explored managerial competencies as a unitary construct; future research can break it into smaller competency dimension identities to determine the most impactful.

Future directions of interest concern: determining how competent managers intervene through mediating variables (e.g., team psychological safety, shared mental models, transactive memory systems) to improve plan implementation; and using mixed-method methods to understand more deeply qualitatively how project managers maneuver the interaction between formal processes and team relationships within biotechnology contexts.

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Appendices

Appendix A

Questionnaire

Demographic Information

Demographic Variable	Options
Gender	[ ] Male [ ] Female
Age Group	[ ] 20-25 [ ] 26-30 [ ] 31-35 [ ] 36-40 [ ] 41 and above
Years of Experience	[ ] Less than 1 year [ ] 1–3 years [ ] 4–6 years [ ] 7–10 years [ ] 10+ years
Highest Level of Education	[ ] Bachelor's degree [ ] Master's degree [ ] MPhil/PhD [ ] Other (Specify)
Department	[ ] R&D [ ] Quality Assurance [ ] Regulatory Affairs [ ] Production [ ] Project Management [ ] Other (Specify)

Project Planning

Statement	1 (Strongly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly Agree)
Our organization uses clear and detailed project planning tools (e.g., Gantt charts, Work Breakdown Structure) to guide project execution.	[ ]	[ ]	[ ]	[ ]	[ ]
Project planning ensures that all team members are aware of their roles, responsibilities, and deadlines.	[ ]	[ ]	[ ]	[ ]	[ ]
There is effective coordination among different departments during project planning.	[ ]	[ ]	[ ]	[ ]	[ ]
Project plans are reviewed and updated regularly to address any changes or emerging risks.	[ ]	[ ]	[ ]	[ ]	[ ]
Project planning includes contingency planning for unforeseen circumstances or risks.	[ ]	[ ]	[ ]	[ ]	[ ]

Risk Management

Statement	1 (Strongly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly Agree)
Our organization has a structured process for identifying and assessing project risks at the beginning of the project.	[ ]	[ ]	[ ]	[ ]	[ ]
Risk management is integrated into the project lifecycle, from planning to execution and closure.	[ ]	[ ]	[ ]	[ ]	[ ]
The project team receives adequate training on risk management procedures.	[ ]	[ ]	[ ]	[ ]	[ ]
Risk management is seen as a priority, and team members are regularly updated on potential risks.	[ ]	[ ]	[ ]	[ ]	[ ]
Our organization has a risk response plan for major project risks, which is communicated to the team and stakeholders.	[ ]	[ ]	[ ]	[ ]	[ ]

Project Managers' Competencies

Statement	1 (Strongly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly Agree)
Project managers in our organization demonstrate strong leadership skills that inspire and motivate the project team.	[ ]	[ ]	[ ]	[ ]	[ ]
Our project managers possess strong communication skills that help in conveying goals and instructions to the team.	[ ]	[ ]	[ ]	[ ]	[ ]
Project managers in our organization are skilled in decision-making, even under uncertain or stressful conditions.	[ ]	[ ]	[ ]	[ ]	[ ]
The emotional intelligence of our project managers helps in managing team dynamics and resolving conflicts.	[ ]	[ ]	[ ]	[ ]	[ ]
Project managers are effective in motivating their teams to achieve project goals and milestones.	[ ]	[ ]	[ ]	[ ]	[ ]

Project Team Performance

Statement	1 (Strongly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly Agree)
The project team consistently meets the deadlines set during the project planning phase.	[ ]	[ ]	[ ]	[ ]	[ ]
The team is able to effectively collaborate and communicate to achieve project goals.	[ ]	[ ]	[ ]	[ ]	[ ]
Our team demonstrates high levels of creativity and problem-solving when faced with challenges during the project.	[ ]	[ ]	[ ]	[ ]	[ ]
The project team is highly motivated and demonstrates a strong commitment to the project's success.	[ ]	[ ]	[ ]	[ ]	[ ]
The project team’s overall performance consistently meets or exceeds expectations.	[ ]	[ ]	[ ]	[ ]	[ ]