

A COMPREHENSIVE FRAMEWORK FOR PREDICTING PROJECT SUCCESS IN DYNAMIC ENVIRONMENTS: INTEGRATING TECHNICAL, BEHAVIORAL, AND ENVIRONMENTAL FACTORS

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DOI: <https://doi.org/10.5281/zenodo.17776266>

Keywords

Article History

Received: 08 October 2025

Accepted: 19 November 2025

Published: 29 November 2025

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Abstract

Project environments increasingly characterized by volatility, uncertainty, complexity, and ambiguity (VUCA) present substantial challenges for sustaining project success. Although scholars have examined individual technical, behavioral, and contextual drivers of project outcomes, limited research has integrated these dimensions into a unified predictive framework. This study develops and evaluates a comprehensive model that incorporates technical planning quality, leadership competencies, team dynamics, stakeholder engagement, and environmental turbulence as multidimensional predictors of project success. Using a mixed-methods design and survey data from 362 project professionals across ICT, construction, and service industries, the study tested the proposed framework through structural equation modeling (SEM). Results indicate that technical planning quality and stakeholder engagement exert the strongest direct effects on cost, schedule, and scope performance, while leadership competency and team cohesion influence success indirectly through improved risk management and communication effectiveness. Environmental turbulence demonstrated a significant moderating effect, weakening the relationship between planning quality and schedule performance but strengthening the impact of adaptive leadership on overall success. The integrated model explained 64% of the variance in project success, outperforming single-dimension models commonly cited in the literature. These findings provide empirical support for a more holistic conceptualization of project success and highlight the need for organizations to balance technical rigor with behavioral capabilities and contextual adaptability. The paper concludes with theoretical contributions, practical implications, and recommendations for future research on predictive project analytics.

## INTRODUCTION

The accelerating pace of technological advancement, globalization, and organizational transformation has fundamentally reshaped the landscape of modern project management. Projects now unfold in environments characterized by rapid change, heightened competition, global interdependencies, and increasingly unpredictable market conditions. Collectively termed volatile, uncertain, complex, and ambiguous (VUCA) environments, these conditions challenge traditional assumptions about planning, control, and predictability in project execution (Bennett & Lemoine, 2014). While project management frameworks have evolved to accommodate greater agility and adaptability, organizations across diverse sectors continue to struggle with achieving consistent cost, schedule, and scope performance. The persistent gap between project management theory and project outcomes underscores the need for more comprehensive, empirically grounded frameworks capable of predicting success in dynamic environments.

Existing research has established that project success is a multi-dimensional and multi-determined phenomenon. Classical perspectives emphasize the importance of technical planning, structure, and process control as foundational components of project success (Kerzner, 2022). More recent research has highlighted the pivotal role of behavioral and relational factors, such as leadership style, team cohesion, communication quality, and stakeholder engagement, in shaping performance outcomes (Aga et al., 2016; Müller & Turner, 2010). A parallel stream of scholarship has examined the influence of contextual conditions, including environmental uncertainty, organizational culture, and digital maturity, on the success or failure of project initiatives (Patanakul & Shenhar, 2012). Although these bodies of research have yielded meaningful insights, they often operate in isolation, resulting in fragmented theoretical explanations and limited predictive power. The fragmented nature of the project success literature has produced several critical gaps. First, studies that focus exclusively on technical factors often understate behavioral and environmental influences, despite evidence suggesting that communication breakdowns, leadership deficits, and stakeholder misalignment frequently undermine

technically sound plans. Second, behavioral studies tend to overlook the structural and methodological foundations required to translate relational strengths into measurable performance outcomes. Third, contextual studies often frame environmental turbulence as an exogenous threat rather than examining how it interacts with organizational capabilities to shape project trajectory. These fragmentation patterns reveal an urgent need for research that holistically integrates technical, behavioral, and contextual perspectives into a unified explanatory and predictive model of project success.

This paper responds to these gaps by developing and evaluating a comprehensive, multidimensional framework designed to predict project success in dynamic environments. The proposed model synthesizes three major clusters of determinants: (1) technical factors, including planning quality, requirements clarity, risk assessment rigor, and methodological alignment; (2) behavioral factors, including leadership competencies, team cohesion, communication effectiveness, and stakeholder engagement; and (3) environmental factors, including environmental turbulence, organizational culture, and digital maturity. By integrating these dimensions, this study aims to offer a more holistic and theoretically coherent understanding of project success, reflecting the complex reality in which contemporary projects operate.

The relevance of such a framework is further reinforced by persistent evidence that project failure rates remain unacceptably high across industries. For example, global reports from PMI (2021, 2023) highlight that only a minority of projects consistently achieve their intended performance targets, with cost overruns, schedule delays, and poor scope execution common across both traditional and agile settings. In dynamic sectors such as ICT, construction, and digital transformation, the complexity and unpredictability of project environments amplify these challenges. Projects in these sectors frequently encounter rapidly shifting requirements, resource uncertainty, regulatory changes, and the need for continuous stakeholder realignment. Consequently, organizations increasingly seek evidence-based strategies capable of enhancing predictive accuracy and improving decision-making under uncertainty.

In addition to addressing a practical need, this research contributes to the theoretical advancement of project management scholarship. Traditional models often conceptualize project success as a linear outcome resulting from planning accuracy and managerial control. However, contemporary project environments function more as adaptive ecosystems than mechanistic structures. The interactions among leadership style, team dynamics, communication flows, and environmental conditions can generate non-linear, emergent effects that challenge conventional predictive tools. The integrated framework proposed in this study recognizes these complexities and seeks to capture them through a more comprehensive theoretical architecture.

Furthermore, this research incorporates moderating variables—particularly environmental turbulence—that help explain the variability in how identical organizational capabilities may generate different project outcomes under different contextual conditions. The moderating role of environmental turbulence is especially relevant in the digital era, where unpredictable disruptions, technological shifts, and competitive pressures create conditions that require adaptive leadership and flexible planning. By empirically testing the moderating effects of environmental turbulence, this research deepens our understanding of how project success is shaped not only by internal competencies but also by the external environment's challenges and opportunities.

The significance of this study is underscored by its empirical findings, which demonstrate that technical planning quality and stakeholder engagement exert the strongest direct effects on project success, whereas leadership competencies exercise an indirect but substantial influence through improved risk management and communication effectiveness. These findings reveal that project success emerges from the alignment and interaction of diverse determinants rather than from isolated factors. Moreover, the moderating effect of environmental turbulence underscores the importance of contextual awareness and adaptive capability in project management. For example, while strong planning quality typically enhances schedule performance, this relationship weakens in high-turbulence environments, whereas adaptive leadership becomes more influential under such conditions.

This introduction establishes the groundwork for the rest of the paper, which is structured as follows. The literature review synthesizes existing research on technical, behavioral, and contextual drivers of project success and identifies the theoretical foundations supporting the proposed framework. The methodology section outlines the research design, sampling procedure, measurement model, and analytical approach used to evaluate the framework. The results section presents the findings of the structural equation modeling, including direct, indirect, and moderating effects. The discussion section interprets the results in the context of existing scholarship and dynamic project environments. Finally, the conclusion summarizes the study's contributions, practical implications, limitations, and recommendations for future research.

Together, these sections provide a rigorous, theory-driven, and empirically validated foundation for understanding and predicting project success in dynamic environments. By offering an integrated framework that accounts for technical, behavioral, and environmental influences, this research advances the field of project management and provides valuable insights for both scholars and practitioners seeking to enhance success in increasingly complex and turbulent settings.

## Literature Review

### 1. Introduction to the Literature Landscape

The study of project success has grown substantially over the last three decades, yet the field continues to struggle with fragmented theories and inconsistent empirical findings. Early project management literature emphasized technical execution—planning, scheduling, risk identification, and scope definition—as the primary determinants of project outcomes (Kerzner, 2022; PMI, 2021). However, as industries faced increasing environmental turbulence, the limitations of purely technical models became apparent. Behavioral, leadership, and contextual influences began to draw attention as alternative explanations for variations in project performance (Müller & Turner, 2010; Shenhar & Dvir, 2007). Nonetheless, even with these developments, the literature lacks a unified integrative framework capable of predicting performance under dynamic conditions. The present study addresses this gap by

reviewing, synthesizing, and integrating three major streams of scholarship: technical, behavioral, and environmental drivers of project success.

## 2. Technical Drivers of Project Success

### 2.1 Planning Quality and Project Control Mechanisms

Planning quality remains one of the most consistently examined predictors of project success. High-quality project planning includes accurate scoping, detailed scheduling, resource allocation, risk identification, and contingency planning (Pinto & Slevin, 1988). The PMI (2021) asserts that comprehensive planning reduces uncertainties by establishing structured decision-making pathways and aligning stakeholder expectations. Planning quality is frequently linked with cost and schedule performance, yet recent evidence shows that its impact is strongly dependent on environmental stability (Joslin & Müller, 2016). In volatile contexts, rigid planning may become obsolete, and lack of flexibility can adversely affect outcomes. Thus, planning quality remains a critical but conditional predictor of success.

### 2.2 Requirements Clarity and Scope Stability

Requirement's clarity is foundational to effective project management, particularly in ICT and engineering domains. Research has demonstrated that ambiguous requirements lead to rework, cost escalation, and scope creep (Nerur et al., 2005). Waterfall-based methodologies emphasize upfront requirements, but such approaches perform poorly when requirements evolve rapidly. Agile methodologies accommodate emergent requirements but require strong communication and iterative feedback loops to maintain stability (Serrador & Pinto, 2015). Multiple studies conclude that requirement clarity is strongly associated with both cost and schedule outcomes but depends on the flexibility of the project methodology.

### 2.3 Methodology Fit and Process Alignment

The literature recognizes that no single methodology (Agile, Waterfall, Hybrid) is universally superior. Rather, effectiveness depends on "methodology-context fit" (Conforto et al., 2016). Waterfall is suited for stable environments with few uncertainties, while Agile thrives in unpredictable settings requiring

continuous stakeholder feedback. Hybrid methodologies attempt to combine structured planning with iterative flexibility, though their effectiveness remains debated. Contrary to widespread belief, several empirical studies have shown no significant differences in cost or schedule performance when comparing Agile, Hybrid, and Waterfall methods, suggesting that methodology alone is insufficient as a predictor of success (Glaser, 2021; Serrador & Pinto, 2015).

### 2.4 Risk Management Capability

Risk identification, assessment, and mitigation strategies have been consistently linked with improved performance (Hopkinson, 2017). Robust risk management enables organizations to allocate resources proactively and anticipate disruptions. Modern risk frameworks incorporate quantitative (Monte Carlo, Bayesian, probabilistic models) and qualitative methods (expert judgment, workshops). However, studies highlight that risk practices are often underutilized or inconsistently applied in SMEs due to limited resources and expertise (Bannerman, 2008).

## 3. Behavioral Drivers of Project Success

### 3.1 Leadership Competencies and Styles

Leadership remains one of the most critical—and difficult to measure—determinants of project performance. Transformational leadership has consistently been associated with higher team motivation, knowledge sharing, innovation, and adaptability (Aga et al., 2016). Conversely, transactional leadership contributes to structure and discipline but may limit creative problem-solving. Research also identifies the importance of emotional intelligence, decision-making capability, communication clarity, and conflict management as leadership competencies influencing project outcomes (Müller & Turner, 2010). Adaptive leadership, in particular, appears essential in turbulent environments.

### 3.2 Team Cohesion, Trust, and Collaboration

Team dynamics shape how knowledge is transferred, decisions are made, and problems are solved. Several canonical studies emphasize trust, cohesion, and psychological safety as essential behavioral conditions enabling teams to navigate uncertainty (Edmondson,

1999). High-performing teams communicate frequently, resolve conflict constructively, and maintain shared mental models. Poor team dynamics, by contrast, correlate strongly with cost overruns and schedule delays due to misalignment and coordination breakdowns.

### 3.3 Communication Effectiveness

Communication quality influences nearly every dimension of project execution. Frequent, clear, and transparent communication reduces uncertainty, strengthens stakeholder alignment, and enables rapid decision-making during turbulence (Pinto & Slevin, 1988). Agile teams depend heavily on iterative communication cycles, daily stand-ups, and retrospective reflections. Miscommunication is among the top five causes of project failure globally (PMI, 2021).

### 3.4 Stakeholder Engagement and Relationship Management

Stakeholder engagement is increasingly recognized as a core component of successful project delivery. Strong engagement practices enhance requirement clarity, reduce resistance to change, and improve satisfaction outcomes (Bourne, 2015). Studies indicate that stakeholder involvement significantly predicts project success across industries, particularly in environments with high uncertainty, changing requirements, or political complexity.

## 4. Environmental and Contextual Drivers

### 4.1 Environmental Turbulence

Environmental turbulence refers to the intensity and unpredictability of external changes—market volatility, regulatory shifts, technological disruption, competitive moves, or socio-political instability (Patanakul & Shenhar, 2012). High turbulence weakens the predictive power of technical planning because early assumptions become obsolete. At the same time, turbulence amplifies the impact of adaptive leadership and stakeholder engagement, as flexible decision-making becomes more valuable.

### 4.2 Organizational Culture

Organizational culture—including norms, values, and shared assumptions—shapes decision-making, communication patterns, and risk tolerance. Cultures

emphasizing collaboration, transparency, and learning are positively associated with project success (Schein, 2010). Conversely, rigid, hierarchical cultures suppress adaptability and are negatively linked with performance, especially during complex or uncertain projects.

### 4.3 Digital Maturity and Technological Infrastructure

Digital maturity encompasses an organization's ability to leverage digital tools, analytics, automation, and collaborative platforms. Higher digital maturity improves planning accuracy, transparency, risk forecasting, and stakeholder communication (Kane et al., 2015). Organizations lacking digital readiness struggle with data-driven decision-making and cross-functional coordination.

## 5. Integrative Theoretical Contributions

### 5.1 The Shift from Linear to Complex Adaptive Systems

Traditional project management frameworks conceptualize projects as mechanistic systems governed by linear planning and control. In contrast, contemporary theory positions projects as complex adaptive systems, where outcomes emerge from the interaction of behaviors, structures, and environments (Remington & Pollack, 2007). This paradigm shift highlights the need for integrative frameworks that account for nonlinear interactions and emergent properties.

### 5.2 Contingency Theory and Fit Models

Contingency theory argues that no single managerial approach is universally effective; instead, effectiveness depends on alignment with environmental conditions (Donaldson, 2001). Project success depends on the “fit” among technical processes, leadership behaviors, and contextual characteristics. This theory underpins the rationale for integrating multiple dimensions into a unified predictive framework.

### 5.3 Resource-Based View (RBV)

The RBV posits that organizations achieve sustained performance through unique internal capabilities (Barney, 1991). Leadership competency, team cohesion, communication quality, and digital

maturity represent strategic internal resources that can differentiate performance in turbulent environments.

**5.4 Dynamic Capabilities Theory**

Dynamic capabilities—sensing, seizing, and transforming—enable organizations to adapt to environmental turbulence (Teece, 2007). This theory explains why adaptive leadership and stakeholder engagement may become more influential predictors under high uncertainty.

**6. Conceptual Model and Hypotheses**

Based on the reviewed literature, the study proposes an integrated model where:

- Technical factors (planning quality, requirements clarity, risk rigor) directly influence cost, schedule, and scope outcomes.
- Behavioral factors (leadership, team dynamics, communication, stakeholder engagement) influence success directly and indirectly through risk and communication mechanisms.
- Environmental turbulence moderates the relationships between technical/behavioral factors and project outcomes.

- Digital maturity enhances predictive accuracy by strengthening communication and integration capabilities.

These conceptual relationships form the basis for the empirical model tested in this research.

**Methodology**

**1. Research Design**

This study employed a quantitative, hypothesis-testing design using Structural Equation Modeling (SEM) to validate the proposed multi-dimensional project success framework. A cross-sectional survey was used for data collection. Both measurement and structural models were analyzed using AMOS 26 and Smart PLS 4 to ensure robustness.

**2. Population, Sample, and Respondent Profile**

A total of 362 valid responses were obtained from project professionals across ICT, construction, telecommunications, and public-sector digital transformation initiatives.



**Table 1  
Respondent Demographics**

Variable	Category	Frequency	Percentage
Gender	Male	241	66.6%
	Female	121	33.4%
Experience	1-5 years	94	26.0%
	6-10 years	142	39.2%
	11+ years	126	34.8%
Industry	ICT	168	46.4%
	Construction	96	26.5%
	Public Sector	56	15.5%
	Telecom	42	11.6%

**3. Instrument Development and Construct Operationalization**

The instrument comprised 48 items across 11 latent constructs, adapted from validated scales in prior

literature. All items were measured using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree).

**Table 2  
Constructs, Measurement Items, and Literature Sources**

Construct	No. of Items	Sample Item	Source
Planning Quality	6	“The project plan clearly defines activities and deliverables.”	Pinto & Slevin (1988)
Requirements Clarity	4	“Requirements were clearly specified at project initiation.”	Nerur et al. (2005)
Risk Management Capability	5	“Risks were continuously monitored and reassessed.”	Hopkinson (2017)
Methodology Fit	4	“The methodology matched the project’s uncertainty level.”	Conforto et al. (2016)
Leadership Competency	6	“The project leader inspired confidence and motivation.”	Müller & Turner (2010)
Team Cohesion	5	“Team members supported each other in achieving goals.”	Edmondson (1999)
Communication Quality	4	“Information was communicated transparently and timely.”	Pinto & Slevin (1988)
Stakeholder Engagement	4	“Stakeholders were actively involved in decision-making.”	Bourne (2015)
Environmental Turbulence	5	“Unexpected changes frequently affected project execution.”	Patanakul & Shenhar (2012)
Digital Maturity	3	“The organization uses advanced digital tools for coordination.”	Kane et al. (2015)
Project Success	6	“The project was completed within planned cost and schedule.”	PMI (2021)

4. Reliability and Validity Testing (CFA Results)

Confirmatory Factor Analysis (CFA) was conducted using AMOS. All measurement models met recommended thresholds.

**Table 3**  
**Reliability and Convergent Validity**

Construct	Cronbach's $\alpha$	CR	AVE	Decision
Planning Quality	0.89	0.92	0.68	Accept
Requirements Clarity	0.83	0.88	0.61	Accept
Risk Capability	0.87	0.91	0.65	Accept
Methodology Fit	0.82	0.86	0.58	Accept
Leadership Competency	0.93	0.94	0.70	Accept
Team Cohesion	0.88	0.91	0.66	Accept
Communication Quality	0.85	0.89	0.67	Accept
Stakeholder Engagement	0.86	0.90	0.68	Accept
Environmental Turbulence	0.88	0.91	0.64	Accept
Digital Maturity	0.81	0.86	0.61	Accept
Project Success	0.92	0.94	0.73	Accept

All AVE values were greater than 0.50, confirming convergent validity.

**Table 4**  
**Discriminant Validity (Fornell-Larcker Criterion)**

Construct	PQ	RC	RM	MF	LC	TC	CQ	SE	ET	DM	PS
Planning Quality (PQ)	0.82										
Requirements Clarity (RC)	0.47	0.78									
Risk Management (RM)	0.42	0.39	0.81								
Methodology Fit (MF)	0.36	0.33	0.41	0.76							
Leadership Competency (LC)	0.40	0.37	0.38	0.31	0.84						

Team Cohesion (TC)	0.33	0.29	0.32	0.28	0.56	0.81					
Communication Quality (CQ)	0.45	0.41	0.39	0.30	0.52	0.51	0.82				
Stakeholder Engagement (SE)	0.38	0.34	0.33	0.29	0.50	0.46	0.55	0.82			
Environmental Turbulence (ET)	0.28	0.24	0.26	0.27	0.22	0.20	0.25	0.23	0.80		
Digital Maturity (DM)	0.31	0.25	0.22	0.29	0.27	0.23	0.28	0.26	0.24	0.78	
Project Success (PS)	0.61	0.57	0.53	0.41	0.50	0.44	0.58	0.52	0.29	0.33	0.85

Diagonal values (bold) are greater than correlations, confirming discriminant validity

5. Common Method Bias (CMB) Testing

To control for CMB:

- Harman’s Single Factor Test showed the largest factor = 29.4%, below the 50% threshold.
- Full Collinearity VIFs were all < 3.3, confirming absence of pathological collinearity.

6. Structural Equation Modeling (SEM)

A two-stage SEM approach was used:

- 1.
2. Measurement Model Assessment
3. Structural Model Analysis

Model fit indices met recommended thresholds.

Table 5  
Model Fit Summary

Fit Index	Recommended	Achieved	Decision
$\chi^2/df$	< 3.0	2.64	Good
CFI	> 0.90	0.94	Good
TLI	> 0.90	0.92	Good
RMSEA	< 0.07	0.058	Good
SRMR	< 0.08	0.046	Good

Path	Interaction $\beta$	p-value	Moderation Effect
PQ → Schedule Success	-0.21	0.011	Significant weakening
LC → Project Success	+0.24	0.004	Significant strengthening
RM → Cost Performance	-0.07	0.318	Not significant

Moderation Analysis

7.

Environmental turbulence was tested as a moderator using both interaction terms and multi-group analysis (MGA).

**Table 6**

**Moderation Result**

**8. Summary of**

**Methodological Rigor**

The final validated dataset and measurement model exhibit:

- High reliability ( $\alpha > 0.80$ )
- Strong convergent and discriminant validity
- Good model fit (CFI = 0.94)
- Stable structural estimates
- No CMB risk
- Adequate statistical power (n = 362)

This ensures robust empirical testing of the theoretical framework.

**Results**

**6.1 Overview**

This section reports the findings from the confirmatory measurement analysis and structural model estimation used to test the integrated

framework introduced earlier. Analyses reported below were conducted using covariance-based SEM (AMOS) and cross-checked with variance-based estimation (SmartPLS) for robustness. Model fit for the final structural model met commonly accepted thresholds ( $\chi^2/df = 2.64$ ; CFI = 0.94; TLI = 0.92; RMSEA = 0.058; SRMR = 0.046). All reported p-values are two-tailed. Statistical significance is flagged at  $p < .05$ ,  $p < .01$  and  $p < .001$  where noted.

**6.2 Measurement Model Results**

Confirmatory Factor Analysis (CFA) established that the measurement model demonstrated acceptable convergent and discriminant validity. Factor loadings were all statistically significant ( $p < .001$ ) and exceeded the practical threshold of 0.60 for the vast majority of items. Composite reliability (CR) values ranged from 0.86 to 0.94; Average Variance Extracted (AVE) values ranged from 0.58 to 0.73, fulfilling conventional criteria for convergent validity. The Fornell-Larcker and HTMT diagnostics confirmed discriminant validity across constructs.

**Table 6.1**  
**Selected Measurement Model Indicators**

Construct	Items (n)	Range Factor Loadings	Cronbach's $\alpha$	CR	AVE
Planning Quality (PQ)	6	0.65 - 0.84	0.89	0.92	0.68
Requirements Clarity (RC)	4	0.62 - 0.81	0.83	0.88	0.61
Risk Mgmt Capability (RM)	5	0.63 - 0.82	0.87	0.91	0.65
Methodology Fit (MF)	4	0.61 - 0.79	0.82	0.86	0.58
Leadership Competency (LC)	6	0.68 - 0.88	0.93	0.94	0.70
Team Cohesion (TC)	5	0.64 - 0.83	0.88	0.91	0.66
Communication Quality (CQ)	4	0.66 - 0.85	0.85	0.89	0.67

Stakeholder Engagement (SE)	4	0.67 – 0.86	0.86	0.90	0.68
Environmental Turbulence (ET)	5	0.61 – 0.81	0.88	0.91	0.64
Digital Maturity (DM)	3	0.62 – 0.79	0.81	0.86	0.61
Project Success (PS)	6	0.70 – 0.90	0.92	0.94	0.73

No items were dropped in the final measurement model; modification indices suggested only minor covariances between methodologically adjacent items (added only where theoretically justified).

**6.3 Structural Model – Direct Effects**

The structural model evaluated the hypothesized direct effects of technical and behavioral predictors on project success, while controlling for digital maturity and methodology fit. Table 6.2 summarizes path coefficients (standardized  $\beta$ ), associated t-values (or z), and p-values.

**Table 6.2**  
**Structural Path Estimates (Direct Effects)**

Hypothesized Path	Standardized $\beta$	SE	t (approx.)	p	Decision
PQ → Project Success	0.36	0.06	6.00	< .001	Supported
RC → Project Success	0.21	0.07	3.00	.003	Supported
RM → Project Success	0.14	0.06	2.33	.020	Supported
SE → Project Success	0.32	0.06	5.33	< .001	Supported
CQ → Project Success	0.18	0.07	2.57	.010	Supported
TC → Project Success	0.12	0.06	2.00	.046	Supported
LC → Project Success (direct)	0.08	0.05	1.60	.109	Not significant
MF → Project Success	-0.02	0.04	-0.36	.72	Not significant
DM → Project Success	0.10	0.05	2.00	.046	Supported
Control: Industry dummies (ICT ref)	Mixed, small	–	–	–	–

**Interpretation (direct effects):**

- Planning Quality (PQ) and Stakeholder Engagement (SE) are the strongest direct predictors of project success, with substantial standardized effects ( $\beta = .36$  and  $\beta = .32$  respectively,  $p < .001$ ). These two variables together account for a large share of the explained variance.
- Requirements Clarity (RC) and Communication Quality (CQ) show

meaningful and statistically significant direct effects ( $\beta = .21$ ;  $\beta = .18$ ).

- Leadership Competency (LC) does not show a strong direct effect on project success but, as reported below, exerts indirect effects via communication and risk management constructs.
- Methodology Fit (MF) shows no direct effect on success when the broader set of organizational variables is controlled; this corroborates earlier findings in the field indicating methodology alone is insufficient.

**6.4 Indirect Effects and Mediation**

Given the non-significant direct path from leadership to project success, mediation analyses examined whether leadership affects success via communication

quality and risk management capability. Bootstrapped mediation (5,000 resamples) produced the following:

**Table 6.3**  
**Indirect (Mediated) Effects for Leadership Competency**

Indirect Path	Indirect Effect ( $\beta$ )	95% CI	p
LC $\rightarrow$ CQ $\rightarrow$ PS	0.086	[0.038, 0.142]	< .001
LC $\rightarrow$ RM $\rightarrow$ PS	0.038	[0.011, 0.072]	.006
LC $\rightarrow$ CQ $\rightarrow$ RM $\rightarrow$ PS (serial)	0.017	[0.004, 0.034]	.015
<b>Total Indirect (LC <math>\rightarrow</math> PS)</b>	<b>0.141</b>	<b>[0.078, 0.213]</b>	<b>&lt; .001</b>

**Interpretation (mediation):**

- Leadership competency has statistically significant indirect effects on project success through both communication quality and risk management. The total indirect impact ( $\beta \approx .14$ ) is substantive, indicating that leadership is influential primarily by shaping behavioral processes rather than as a simple direct determinant.
- These mediated pathways are consistent with theory: leaders facilitate communication and

- risk practices that in turn improve performance.

**6.5 Moderation: Environmental Turbulence**

The hypothesized moderation tests assessed whether environmental turbulence (ET) changes the strength of key relationships. Interaction terms were computed (mean-centered predictors  $\times$  ET) and tested in the SEM.

**Table 6.4**  
**Moderation Results (Selected Significant Interactions)**

Moderated Path	Interaction $\beta$	SE	t	p	Effect Direction
PQ $\times$ ET $\rightarrow$ Schedule Component of PS	-0.21	0.08	-2.55	.011	Turbulence weakens PQ $\rightarrow$ schedule
LC $\times$ ET $\rightarrow$ Project Success (total)	+0.24	0.07	3.00	.004	Turbulence strengthens LC's effect
RM $\times$ ET $\rightarrow$ Cost Component of PS	-0.07	0.06	-1.00	.318	ns

**Interpretation (moderation):**

- The negative interaction for PQ  $\times$  ET indicates that as environmental turbulence

increases, the positive effect of planning quality on schedule performance declines

- (i.e., planning loses predictive power under high turbulence).
- Conversely,  $LC \times ET$  is positive and significant: leadership competency becomes comparatively more valuable in turbulent contexts, amplifying its indirect positive effects on success via communication and risk management.

- Risk management’s direct effect on cost performance did not show a significant moderation by ET.

**6.6 Explained Variance and Effect Sizes**

The final structural model demonstrated solid explanatory power for the principal dependent constructs

**Table 6.5**  
**Variance Explained (R<sup>2</sup>) and Effect Sizes (f<sup>2</sup>)**

Dependent Construct	R <sup>2</sup>	f <sup>2</sup> (PQ)	f <sup>2</sup> (SE)	f <sup>2</sup> (LC indirect)	Interpretation
Project Success (overall)	0.64	0.18 (medium)	0.15 (medium)	0.09 (small-medium)	Model explains 64% of variance
Schedule component	0.58	0.16	0.12	0.08	–
Cost component	0.52	0.12	0.14	0.06	–

**Interpretation:**

- The integrated model explains 64% of variance in overall project success – a strong result for multi-factor predictive models in project management.
- Effect size (f<sup>2</sup>) for Planning Quality on project success is medium (0.18), indicating a practically meaningful influence. Stakeholder Engagement also shows a medium effect (0.15). Leadership’s total mediated contribution yields a smaller but non-trivial effect (≈0.09).

3. Common method bias tests (Harman single-factor and full collinearity VIFs) indicated no serious CMB concerns.

**6.7 Robustness Checks**

Several robustness analyses were conducted:

1. Multi-group analysis (MGA) across industry sectors (ICT, Construction, Public) showed stable patterns; coefficients were directionally similar and most significance levels held. A few coefficients (e.g., PQ → Success) attenuated in public-sector subsample (likely due to institutional constraints).
2. Alternative estimation using PLS-SEM produced comparable path directions and magnitudes.

**6.8 Summary of Major Results**

- Planning Quality (PQ) and Stakeholder Engagement (SE) are the strongest direct predictors of project success ( $\beta = .36$  and  $.32$  respectively; both  $p < .001$ ).
- Leadership Competency (LC) primarily operates indirectly by improving communication and risk management, yielding a meaningful total indirect effect ( $\beta \approx .14$ ).
- Methodology Fit (MF) does not exhibit a statistically significant direct effect on project success once organizational and behavioral variables are included.
- Environmental Turbulence moderates’ relationships: it weakens PQ’s linkage to schedule while strengthening the beneficial role of leadership.
- The integrated model explains 64% of the variance in overall project success – a robust level of predictive power for a model combining technical, behavioral, and environmental factors.

A concise hypothesis outcome table is provided below:

6.9 Implications for Hypotheses

Table 6.6

Hypothesis Testing Summary

Hypothesis	Predicted Direction	Result ( $\beta$ , p)	Verdict
H1: PQ → PS (direct +)	+	0.36, p < .001	Supported
H2: RC → PS (direct +)	+	0.21, p = .003	Supported
H3: RM → PS (direct +)	+	0.14, p = .020	Supported
H4: SE → PS (direct +)	+	0.32, p < .001	Supported
H5: LC → PS (direct +)	+	0.08, p = .109	Not supported (direct)
H6: LC → PS (indirect via CQ/RM)	+	0.141, p < .001	Supported (indirect)
H7: MF → PS (direct +)	+	-0.02, p = .72	Not supported
H8: ET moderates PQ→Schedule (weakening)	negative interaction	-0.21, p = .011	Supported
H9: ET moderates LC→PS (strengthening)	positive interaction	+0.24, p = .004	Supported

6.10. Concluding Remarks on Results

The empirical findings substantiate the central proposition of this paper: project success in dynamic environments is best explained by an integrated configuration of technical quality (planning and requirements), behavioral capabilities (leadership, communication, stakeholder engagement), and contextual sensitivity (environmental turbulence, digital maturity). Methodological choice by itself does not determine outcomes once these higher-order capabilities are considered. Importantly, leadership’s role as an enabler (via communication and risk practices) and the moderating role of turbulence highlights the dynamic interplay between internal capabilities and external conditions.

6.11. Conclusion

This study developed and empirically validated a comprehensive, multi-dimensional framework for predicting project success in dynamic and turbulent environments. By integrating technical planning quality, behavioural capabilities, and contextual conditions, the research responds to long-standing calls for a more holistic understanding of project performance. The results confirm that project success is not the outcome of isolated factors but emerges from the interaction of technical rigor, relational effectiveness, and environmental adaptability. Technical factors—particularly planning quality and

requirements clarity—remain foundational predictors, yet their effectiveness diminishes when environmental turbulence increases. Conversely, behavioural constructs such as leadership competency, team cohesion, communication quality, and stakeholder engagement become increasingly influential under volatile conditions. Notably, leadership exerts significant indirect effects by shaping communication and risk practices rather than through direct managerial control.

The moderating role of environmental turbulence underscores the importance of adaptive capabilities, especially in industries characterized by rapid technological change, regulatory shifts, and market instability. The finding that the integrated model explains 64% of the variance in project success demonstrates its predictive strength and highlights the limitations of single-dimension approaches. Practically, organizations must recognize that technical tools and methodologies alone are insufficient; success requires aligning planning processes with strong leadership, collaborative team dynamics, and robust stakeholder engagement, supported by digital maturity. Theoretically, this study advances project management scholarship by offering an empirically grounded framework that aligns with contemporary views of projects as complex adaptive systems.

While the study provides significant contributions, it is not without limitations. The cross-sectional design restricts causal inference, and data were collected from a limited set of industries within a specific regional context. Future research should employ longitudinal designs, expand cross-cultural comparisons, incorporate machine-learning-based predictive analytics, and explore additional moderating conditions such as organizational resilience or governance maturity. Overall, the findings reinforce the need for organizations to develop integrated technical and behavioural capabilities that can thrive amidst uncertainty, and they offer a strong foundation for future research on predictive project analytics in dynamic environments.

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