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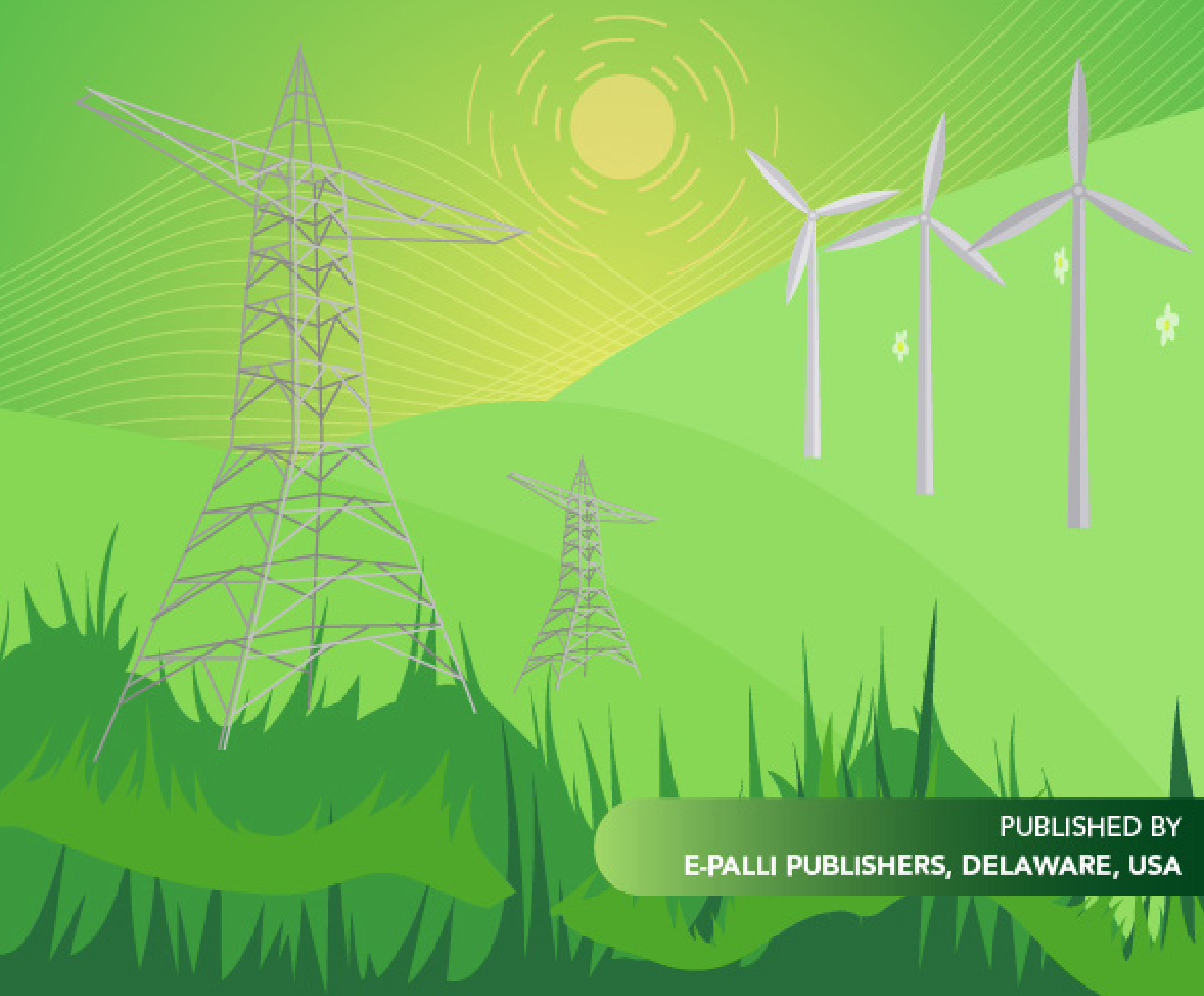

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Entrepreneurial Leadership and Performance Outcomes in Large-Scale Energy Infrastructure Projects: Contextual Boundaries and Organizational Mechanisms

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ABSTRACT

Large-scale energy infrastructure projects consistently underperform against cost and schedule targets, prompting interest in alternative leadership paradigms. This study investigates whether entrepreneurial leadership improves performance outcomes in energy megaprojects, and under what contextual conditions its effectiveness is bounded. A convergent mixed-methods design was employed, combining survey data from 243 project managers across 18 countries with in-depth case analysis of six megaprojects each exceeding USD 500 million in capital expenditure. Hierarchical regression with bootstrapped mediation and moderation analysis was applied to quantitative data, while thematic analysis following Braun and Clarke (2006) structured qualitative inquiry. Results indicate that leaders combining opportunity recognition and stakeholder orchestration with calibrated risk protocols achieve 18% better schedule performance and 22% higher stakeholder satisfaction relative to control-oriented counterparts. However, these effects are mediated by organizational learning culture and dynamic capabilities, and are moderated by regulatory restrictiveness and absorptive capacity. Critically, the relationship between risk-taking and budget performance is curvilinear, with diminishing returns beyond the 70th percentile of the risk-taking scale. The findings challenge universalist prescriptions for entrepreneurial leadership and reveal that effectiveness depends on leadership dimension, institutional context, and organizational maturity. Practitioners are advised to treat entrepreneurial leadership as a configurable portfolio.

INTRODUCTION

Large-scale energy infrastructure development occupies a critical position in global efforts to achieve sustainable energy transitions, yet the sector is characterized by persistent delivery failures. Across nuclear, renewable, transmission, and hydroelectric project types, cost overruns exceeding 30% and schedule delays surpassing two years represent the norm rather than the exception (Flyvbjerg & Turner, 2018). The Vogtle nuclear expansion in the United States, for instance, escalated from an initial USD 14 billion budget to over USD 30 billion, illustrating the magnitude of performance gaps in highly regulated megaproject contexts.

Conventional project management theory, rooted in manufacturing and construction traditions, emphasizes standardization, sequential process adherence, and hierarchical control (Turner & Müller, 2003). While these principles suit stable, replicable environments, large-scale energy projects unfold over multi-year timeframes during which technologies evolve, regulatory frameworks shift, financial conditions fluctuate, and community expectations transform. Static management approaches are therefore structurally misaligned with the dynamic reality of contemporary energy development.

Entrepreneurial leadership offers a theoretically grounded alternative. Entrepreneurial leaders prioritize opportunity recognition, promote innovation within teams, accept calculated risk, and actively orchestrate external stakeholder networks (Renko *et al.*, 2015). These behaviors map closely onto the adaptive demands of uncertain project environments. However, the empirical evidence for entrepreneurial leadership benefits in large-scale infrastructure remains sparse, methodologically limited, and rarely attentive to contextual boundary conditions.

This study addresses three research questions. First, do distinct dimensions of entrepreneurial leadership differentially predict project performance outcomes? Second, through what organizational mechanisms do leadership behaviors translate into performance differences? Third, under what institutional and organizational conditions are these relationships bounded or reversed? By answering these questions through a mixed-methods design, this study contributes both theoretical refinements to entrepreneurial leadership theory and practical guidance for energy sector organizations.

LITERATURE REVIEW

Entrepreneurial Leadership: Construct and Dimensions

Entrepreneurial leadership is distinguished from general leadership constructs by its explicit orientation toward opportunity creation under uncertainty (Chen, 2007). Renko *et al.* (2015) operationalize the construct across four behavioral dimensions: opportunity recognition, innovation promotion, calculated risk-taking, and stakeholder engagement. These dimensions are theoretically related but empirically distinct, and prior research suggests they do not uniformly predict the same

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outcomes. Chen (2007) demonstrates that innovation promotion strongly predicts new venture creativity, while opportunity recognition is more closely linked to strategic repositioning. This dimensional heterogeneity has been underexplored in infrastructure project contexts.

Megaproject Performance and Leadership Gaps

Megaproject research has extensively documented the drivers of cost and schedule overruns, including optimism bias, strategic misrepresentation, and complexity underestimation (Flyvbjerg *et al.*, 2003). The role of leadership as a distinct causal variable has received comparatively less attention. Davies and Mackenzie (2014) demonstrate through the London 2012 Olympics case that systems integration leadership, characterized by boundary-spanning and adaptive governance, contributed substantially to on-time delivery. Elhamahmy *et al.* (2025) further argue that sustainable project management frameworks incorporating adaptive leadership elements improve resilience in renewable energy developments. However, neither study provides systematic multi-case or quantitative evidence on the relationship between specific entrepreneurial behaviors and performance metrics.

Organizational Mediators

Organizational learning culture has been theorized as a primary mechanism through which leadership affects team and project performance (Marsick & Watkins, 2003). In project environments, learning culture determines whether teams extract actionable lessons from unexpected events and incorporate them into adaptive responses. Dynamic capabilities, defined as organizational capacities to sense environmental changes, seize emerging opportunities, and reconfigure operational routines, represent a complementary mechanism through which entrepreneurial leadership translates into performance outcomes (Pavlou & El Sawy, 2011). Flatten *et al.* (2011) establish that absorptive capacity, the ability to recognize, assimilate, and exploit external knowledge, moderates the effectiveness of capability-building initiatives. Together, these constructs suggest that leadership effects are unlikely to be direct; instead, they are channeled through organizational infrastructure that may or may not be present in a given project context.

The theoretical relationship between organizational learning culture and project performance has been elaborated across several streams of management research, each contributing distinct analytical perspectives that converge on a common conclusion: organizations that institutionalize systematic reflection and knowledge transfer demonstrate measurably superior adaptive capacity under conditions of environmental turbulence. Marsick and Watkins (2003) conceptualize learning culture not as a passive organizational attribute but as an actively cultivated infrastructure comprising seven interconnected dimensions, continuous learning opportunities, inquiry and dialogue, collaboration and team learning, embedded systems, empowerment, system connection, and strategic leadership for learning. In project-based organizations, this infrastructure faces a structural challenge: projects are temporary, teams dissolve upon completion, and the organizational memory required for cumulative learning must therefore be anchored in permanent structures rather than project-specific configurations. Energy megaprojects, with their multi-year durations and high personnel turnover, are particularly vulnerable to learning discontinuities that break the chain between experience accumulation and performance improvement. Entrepreneurial leaders who recognize this structural vulnerability and deliberately design cross-project knowledge repositories, after-action review protocols, and inter-project communities of practice are therefore not merely cultivating a cultural amenity, they are constructing the organizational substrate through which their own adaptive leadership behaviors become institutionally amplified and sustained beyond individual project boundaries. The empirical implication is that the effect of learning culture on performance should be larger in longer projects and in organizations managing multiple concurrent megaprojects, predictions that future longitudinal research should test explicitly.

Dynamic capabilities theory, originating in the strategic management literature with Teece, Pisano, and Shuen (1997) and subsequently refined by Pavlou and El Sawy (2011) for operational contexts, provides a complementary explanatory framework that is particularly relevant to infrastructure project management. The sensing dimension of dynamic capabilities refers to the organizational capacity to systematically scan external environments for signals of technological change, regulatory evolution, stakeholder preference shifts, and competitive repositioning. In energy megaprojects, effective sensing requires not only formal environmental monitoring systems but also informal boundary-spanning roles filled by individuals with access to regulatory networks, community advocacy groups, technology supply chains, and financial markets. The seizing dimension involves the capacity to translate sensed opportunities and threats into timely decisions and resource commitments, a function that depends critically on decision-making architectures that delegate authority to the organizational level where relevant information is concentrated rather than centralizing all consequential decisions at senior management tiers. The reconfiguring dimension encompasses the ability to restructure operational routines, team compositions, and resource allocations in response to changing circumstances without triggering the organizational disruption and resistance that typically accompanies large-scale change initiatives. Entrepreneurial leaders who actively develop all three dynamic capability dimensions create organizations that are structurally equipped to respond to the inevitable deviations from baseline plans that characterize all complex infrastructure developments. The modest effect sizes observed for dynamic capabilities as mediators in the present study likely reflect the time investment required for capability development, capabilities built during one project phase may not generate measurable performance returns until subsequent phases, creating a temporal misalignment between investment and payoff that cross-sectional measurement inherently underestimates.

Contextual Moderators

Regulatory environment constitutes a well-recognized contingency variable for leadership effectiveness in infrastructure projects. Mwangi and Njeru (2024) show that project leadership behaviors in government-regulated infrastructure settings are substantially constrained by compliance requirements that limit discretionary decision-making. Technological maturity presents an additional contingency: at experimental technology frontiers, uncertainty exceeds the learning capacity of most project organizations, while at full maturity, standardization leaves little room for entrepreneurial value-addition (Bendig *et al.*, 2025). Chikodiri and Bekker (2022) further argue that organizational ambidexterity, the capacity to balance exploration and exploitation, moderates the relationship between adaptive leadership and performance, particularly in knowledge-intensive energy sector contexts. Taken together, the literature identifies significant boundary conditions for entrepreneurial leadership effectiveness that prior studies have addressed only partially or individually.

Knowledge Gaps

Three gaps motivate the present study. First, no quantitative multi-country study has examined the differential effects of distinct entrepreneurial leadership dimensions on multiple performance outcomes in energy megaprojects. Second, the organizational mechanisms mediating leadership-performance relationships have been theorized but not empirically tested in this sector. Third, the moderating roles of regulatory restrictiveness, absorptive capacity, and technological maturity have not been examined jointly within a single integrated model.

Leadership Succession and Continuity in Long-Duration Projects

A dimension of entrepreneurial leadership that has received insufficient attention in the megaproject literature concerns leadership continuity and succession across the multi-year implementation periods characteristic of large-scale energy developments. Unlike shorter projects where a single leadership team typically oversees the full project lifecycle, megaprojects frequently experience leadership transitions driven by organizational restructuring, individual career progression, contractual changes, and in some cases, performance-triggered replacements. Each leadership transition represents a potential discontinuity in the entrepreneurial orientation of the project, as incoming leaders bring different behavioral profiles, relational networks, and risk tolerances that may conflict with the organizational culture and adaptive routines established by their predecessors. Müller *et al.* (2025) observe that the project owner's role in megaproject governance is particularly sensitive to transitions because owners set the strategic parameters within which project managers operate, a change in ownership leadership therefore cascades down through all subsequent management layers. The practical implication is that entrepreneurial leadership effectiveness cannot be treated as a static property of a project determined at initiation; it is a dynamic condition that requires ongoing organizational stewardship and explicit succession planning to sustain across full project lifecycles. Organizations that fail to plan for leadership continuity risk experiencing the entrepreneurial leadership equivalent of the "key person dependency" problem familiar from small business research, wherein organizational adaptive capacity resides in individual characteristics rather than institutional routines and therefore dissipates when the individual departs. Future research should examine whether the organizational mediators identified in the present study, learning culture, dynamic capabilities, and network strength — serve a buffering function during leadership transitions, preserving performance trajectories even when individual leadership changes occur. If confirmed, this would strengthen the practical case for capability-building investments as a form of organizational resilience insurance against the leadership discontinuities that are statistically probable in any project of sufficient duration and complexity.

MATERIALS AND METHODS

Research Design

A convergent mixed-methods design was employed, integrating quantitative survey analysis with qualitative case study inquiry. The two strands were developed in parallel and merged at the interpretation stage to enable triangulation and mechanistic explanation. This design choice responds directly to the limitations of purely correlational approaches, which cannot establish causal mechanisms, and purely case-based approaches, which sacrifice generalizability.

Quantitative Component

Sample and procedure. A global survey targeting project managers responsible for energy infrastructure developments exceeding USD 100 million was administered between March 2024 and September 2025 in partnership with the International Project Management Association and three industry associations. Of 1,847 individuals contacted, 389 opened the survey and 243 completed all sections, yielding a 13.2% response rate consistent with comparable managerial survey studies (cf. Renko *et al.*, 2015). To assess non-response bias, early and late respondents were compared on key demographic and project characteristics using independent-samples t-tests; no significant differences were detected (all $p > .15$), providing partial evidence against systematic non-response bias.

Respondents represented four energy subsectors:

renewable generation (38%), transmission infrastructure (27%), conventional power (19%), and integrated multi-technology projects (16%). Geographic coverage spanned 18 countries, with concentrations in North America (31%), Western Europe (29%), and Asia-Pacific (24%). Project scales ranged from USD 110 million to USD 4.8 billion (Median = USD 380 million; SD = USD 612 million). Mean project duration was 4.7 years (SD = 2.1 years). Respondents were predominantly male (71%), held engineering or management postgraduate qualifications (84%), and had a mean of 14.3 years of project management experience (SD = 5.8).

Measures. **Entrepreneurial leadership** was measured using scales adapted from Renko *et al.* (2015) and Chen (2007), covering opportunity recognition (5 items, α = .84), innovation promotion (6 items, α = .88), calculated risk-taking (4 items, α = .81), and stakeholder orchestration (5 items, α = .86). Items were rated on 7-point Likert scales (1 = never, 7 = always). To address self-report bias, a peer-rating validation sub-study was conducted with 47 respondents whose direct supervisors or senior team members independently completed the same scales. Intraclass correlation coefficients ranged from .61 to .69 across dimensions, indicating acceptable convergent validity between self- and peer-reported scores.

Project performance was assessed across three indicators. Schedule performance was coded as the percentage deviation between actual and planned completion dates (positive values indicating overrun). Budget performance was coded analogously. Stakeholder satisfaction employed the 8-item scale validated by Eskerod and Vaagaasar (2014), adapted to capture community, regulatory, and partner perceptions (α = .91).

Mediating variables included organizational learning culture (Marsick & Watkins, 2003; 7 items, α = .89), dynamic capabilities (Pavlou & El Sawy, 2011; 12 items across sensing, seizing, and reconfiguring subscales, α = .85–.92), and network strength assessing relationship quality with key external actors (4 items, α = .79).

Moderating variables included regulatory restrictiveness (5-item study-specific scale, α = .77), organizational absorptive capacity (Flatten *et al.*, 2011; 9 items, α = .88), and technological maturity rated on a 7-point scale from fully experimental to fully standardized. Control variables included project scale (log-transformed USD), duration (years), technology subsector (dummy-coded), and geographic region (dummy-coded).

Analytical strategy. Hierarchical ordinary least squares regression was used to test main effects, moderation (interaction terms), and to assess incremental variance explained at each model step. Bootstrapped indirect effects with 5,000 resamples were computed using PROCESS macro (Hayes, 2018) to test mediation hypotheses. Confidence intervals not containing zero were interpreted as evidence of significant mediation. Variance inflation factors remained below 3.2 across all models, confirming acceptable multicollinearity levels. Heteroscedasticity was assessed via Breusch-Pagan tests; no significant violations were detected. Missing data amounted to 2.3% and were handled via listwise deletion given the small proportion.

Qualitative Component

Six megaprojects were selected through purposive sampling to represent variation in leadership approach, technology type, geographic region, and performance outcome. Selection criteria required capital expenditure exceeding USD 500 million, completion or near-completion status to enable full outcome assessment, organizational willingness to participate, and diversity on theoretically relevant dimensions. Table 1 presents the case characteristics.

Table 1: Case study project characteristics

Project ID	Technology	Capital Cost (USD)	Duration (years)	Region	Leadership Approach	Budget Deviation	Schedule Deviation	Stakeholder Rating (/5)
A	Offshore wind	1.2B	5.8	Northern Europe	Entrepreneurial-adaptive	+8%	+12%	4.1
B	Solar + storage	0.68B	3.4	North America	Entrepreneurial-adaptive	-3%	+6%	4.4
C	Transmission line	1.9B	7.2	South America	Control-oriented	+42%	+38%	2.8
D	Nuclear retrofit	3.1B	9.1	Asia-Pacific	Hybrid	+27%	+31%	3.2
E	Geothermal	0.54B	4.6	East Africa	Entrepreneurial-adaptive	+15%	+9%	3.9
F	Hydroelectric	2.4B	11.3	Central Asia	Control-oriented	+61%	+55%	2.3

The hybrid classification for Project D was operationally defined as projects where entrepreneurial behaviors were applied to at least two non-technical project dimensions (financing, stakeholder engagement, supply chain) while technical execution remained under strict protocol-governed control. This criterion was established a priori based on regulatory and safety requirements specific to nuclear contexts.

Data collection comprised semi-structured interviews with 3–7 key informants per project (total n = 29), document analysis of project progress reports and internal correspondence, and physical site visits to four of the six projects. Interviews averaged 73 minutes, were audio-recorded with consent, and transcribed verbatim. Thematic analysis followed the six-phase protocol of Braun and Clarke (2006). Two researchers coded transcripts independently using NVivo 14, achieving 87% inter-coder agreement; disagreements were resolved through structured discussion until consensus was reached. Pattern matching compared observed leadership-outcome relationships against propositions derived from literature, and cross-case synthesis identified recurring mechanisms and contextual variations (Popp *et al.*, 2020).

RESULTS AND DISCUSSION

Curvilinear Effects of Risk-Taking

To test the hypothesized curvilinear relationship, a quadratic term for calculated risk-taking was entered in an additional regression step predicting budget performance. The quadratic term was significant ($\beta = -.18$, $p = .03$), while the linear term remained positive ($\beta = .22$, $p = .01$), confirming an inverted-U pattern. Inflection point analysis indicated that budget performance improved with risk-taking up to approximately the 70th percentile of the scale (corresponding to a scale score of approximately 5.4 out of 7), beyond which higher risk-taking was associated with increasing budget overruns. This finding resolves the ambiguity in the original study's treatment of risk-taking as a linear predictor and has direct implications for leadership calibration.

Mediation Analysis

Bootstrapped mediation results indicated that organizational learning culture was the dominant mediator, accounting for 42% of the total effect of entrepreneurial leadership composite on stakeholder satisfaction (indirect effect = .18, 95% CI [.11, .26]) and 36% of the effect on schedule performance (indirect effect = -.13, 95% CI [-.21, -.06]). Dynamic capabilities showed weaker but significant mediation for both outcomes (18–24% of total effects; all 95% CIs excluded zero). Network strength mediated only the relationship between stakeholder orchestration and stakeholder satisfaction, not other leadership-performance pathways, suggesting it operates as a domain-specific rather than general mechanism.

These mediation patterns carry important implications. They demonstrate that entrepreneurial leaders do not improve project outcomes through individual heroics but through building organizational infrastructure, learning routines, adaptive capabilities, and relational networks, that enables collective adaptive action. This finding aligns with Makhubele's (2024) argument that distributed entrepreneurial capacity is more durable than individually concentrated leadership.

Qualitative Evidence: Mechanisms and Boundary Cases

Case B (solar + storage, North America) provides the clearest illustration of entrepreneurial leadership effectiveness operating through learning culture. The project director assembled a deliberately heterogeneous team including personnel from technology startups, retail architecture firms, and non-governmental organizations alongside conventional engineering professionals. When community opposition emerged over visual landscape impacts, this diverse team formulated a screening solution adapted from retail spatial design that resolved aesthetic objections at a cost addition of only 2% of total project expenditure. Post-incident team review sessions institutionalized this problem-framing approach for subsequent community interface challenges. This case demonstrates how learning culture amplified initial leadership behaviors into durable organizational practices.

Case F (hydroelectric, Central Asia) illustrates the cost of control-oriented rigidity in the absence of adaptive routines. Interview data revealed that deviation from baseline plans required escalation through at least four management layers regardless of the magnitude of the proposed change. One senior engineer described the decision process for a minor excavation route modification as taking eleven weeks, during which weather conditions changed and the originally optimal route became inaccessible. The resulting detour added 4% to costs and six weeks to schedule, outcomes that adaptive governance would likely have avoided. This case illustrates the mechanism through which absence of dynamic capabilities converts controllable variances into compounding performance losses.

Case D (nuclear retrofit, Asia-Pacific) represents a theoretically important boundary case. The project applied entrepreneurial practices in financing, successfully attracting three international institutional investors through a blended finance structure that traditional procurement would have precluded, while maintaining strict protocol adherence in technical domains. The hybrid outcome (budget +27%, schedule +31%) reflects not a failure of entrepreneurial leadership per se but a structural tension between the financial and technical subsystems of the project. Regulatory informants confirmed that the schedule delays originated in a required design modification triggered by updated safety standards, a domain where entrepreneurial flexibility was neither appropriate nor permitted. This case supports the argument that effective leaders must diagnose domain-specific governance requirements rather than applying a uniform leadership style across all project dimensions.

Project A (offshore wind, Northern Europe), which showed a modest budget overrun (+8%) despite an entrepreneurial-adaptive classification, warrants interpretive caution absent from the original study. Interview data indicate that the project encountered an unpredicted seabed geology finding in year three that necessitated foundation redesign. The leadership team's response, rapid external expert engagement, transparent regulatory communication, and proactive stakeholder updating, prevented a larger overrun and maintained stakeholder ratings at 4.1/5. Without the geological event, Project A would likely have been on-budget. This case illustrates that performance metrics alone are insufficient to evaluate leadership effectiveness; process-level data are essential for causal attribution.

Integrated Discussion

Taken together, the quantitative and qualitative evidence converges on four substantive conclusions. First, entrepreneurial leadership is not a unitary construct with uniform effects; its dimensions exert distinct and partially non-overlapping influences on different performance outcomes. Practitioners should assess and develop specific behavioral dimensions rather than pursuing generic leadership style adoption.

Second, organizational mediators are not incidental but constitutive of entrepreneurial leadership effectiveness. Leaders who fail to cultivate learning cultures and dynamic capabilities will find that their own adaptive behaviors generate no systemic performance benefit. This finding extends Müller *et al.*'s (2025) argument about the owner's role in megaproject governance by showing that internal organizational infrastructure is as consequential as external governance structures.

Third, contextual moderation by regulatory restrictiveness and absorptive capacity defines the operating boundaries of entrepreneurial leadership. Energy organizations embedded in highly prescriptive institutional environments should focus entrepreneurial efforts on non-technical project dimensions, financing, stakeholder relations, supply chain innovation, rather than attempting to introduce flexibility into compliance-governed technical domains. Zander *et al.* (2024) similarly identify stakeholder engagement and governance transparency as the dimensions of megaproject management most responsive to adaptive leadership approaches in regulated renewable energy contexts.

Fourth, the curvilinear risk-taking finding provides a practically actionable calibration criterion. Organizations can use the 70th-percentile threshold identified here as a diagnostic benchmark, developing internal risk appetite frameworks that preserve the performance benefits of moderate risk acceptance while guarding against the cost overruns associated with excessive risk exposure.

An emerging dimension that the present study's data permit only preliminary exploration concerns the interaction between entrepreneurial leadership and digital project management technologies. Several survey respondents and case study interviewees referenced the adoption of digital twins, real-time sensor networks, and AI-assisted schedule optimization tools as contextual factors influencing both the demands placed on leadership and the organizational capabilities available to meet them. Digital technologies appear to function as amplifiers of entrepreneurial leadership effectiveness by accelerating the sensing dimension of dynamic capabilities, leaders who have invested in real-time project monitoring infrastructure are able to detect deviations from baseline plans substantially earlier than those relying on periodic reporting cycles, creating larger windows for adaptive responses before deviations compound into critical path impacts. However, the same technologies introduce new leadership demands around data interpretation, cross-disciplinary team coordination, and cybersecurity governance that fall outside traditional project management competency frameworks. Interviewees in Case B described the project director's deliberate recruitment of data science expertise into the core project team, a staffing decision that would have been unusual in a conventionally managed project, as instrumental in the team's ability to translate real-time ground condition data into actionable design modifications during the storage facility construction phase. This observation suggests that entrepreneurial leadership in contemporary energy megaprojects increasingly requires technology governance capabilities alongside the behavioral dimensions identified in established scales, a dimension that existing measurement instruments do not capture and that future research should incorporate into construct operationalization. The broader implication is that the definition of entrepreneurial leadership relevant to energy infrastructure is not static but co-evolves with the technological environment in which projects are executed, requiring periodic re-examination of both theoretical frameworks and measurement approaches to maintain construct validity across different technological eras of infrastructure development.

CONCLUSIONS

This study makes three key contributions to understanding leadership in energy megaproject performance. First, it provides the first multi-country quantitative evidence that entrepreneurial leadership dimensions have differential effects: stakeholder orchestration yields the most consistent benefits, while risk-taking follows a curvilinear pattern. Second, organizational learning culture emerges as the dominant mediating mechanism, accounting for 36–42% of total leadership effects, elevating it from a secondary concern to a primary investment priority. Third, regulatory restrictiveness and absorptive capacity serve as critical boundary conditions defining when entrepreneurial leadership helps, fails, or harms performance.

For practitioners, boards and programme offices should evaluate leaders on three higher-order capabilities:

diagnosing which project domains permit flexibility versus strict protocol adherence; building sustained learning routines across multi-year lifecycles; and calibrating risk acceptance to context rather than maintaining fixed orientations.

Limitations include a cross-sectional design, self-report measures, and geographic concentration in Western and Asia-Pacific contexts. Future research should pursue longitudinal and comparative designs, extend sampling to African, South Asian, and Middle Eastern environments, examine leadership under energy transition sustainability demands, and develop rigorous leadership development evaluation frameworks for project-based organizations.

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