

Organizational Determinants and Project Performance: Mediating Roles of AI and Environmental Responsiveness in Malaysia's Oil & Gas

George Anak Budit^{1*}, Mohd Zainal Munshid Harun², Rahmat Aidil Djubair³

^{1,2,3} University of Technology Sarawak, Malaysia

* pbm23120001@student.uts.edu.my

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ABSTRACT

Project performance remains a persistent challenge in Malaysia's oil and gas industry, where cost overruns, schedule delays, and operational inefficiencies continue to occur despite extensive prior research. Although earlier studies have examined organizational, technological, and environmental determinants, limited attention has been given to how these dimensions interact to influence project outcomes. This conceptual paper addresses this gap by proposing a dual-mediation framework in which Artificial Intelligence (AI) adoption and environmental responsiveness function as mechanisms through which organizational factors enhance project performance. Drawing on the Technology–Organization–Environment (TOE) framework, the Resource-Based View (RBV), and Diffusion of Innovations (DOI) theory, the study reconceptualizes five organizational factors—top management support, organizational culture, communication, change management, and training—as strategic resources that facilitate digital transformation. AI adoption is theorized as an internal capability that translates managerial commitment and cultural readiness into improved efficiency, accuracy, and project timeliness. In parallel, environmental responsiveness reflects the organization's adaptive capacity to meet regulatory requirements, sustainability expectations, and evolving stakeholder pressures. The integration of these mediating mechanisms produces a comprehensive model that explains how internal competencies and external pressures jointly shape performance in a high-risk, capital-intensive sector. The paper contributes theoretically by extending the TOE framework through a dual-mediation perspective and offers practical implications for managers seeking to leverage AI and adaptive capabilities to achieve sustainable improvements in project performance.



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1. Introduction

Globally, nearly 70% of oil and gas megaprojects exceed cost and schedule targets, with overruns averaging 20–30% [1]. Malaysia mirrors this trend, as EPC projects frequently record 5–10% cost increases due to scope changes, resource misallocation, and weak controls [2]. These inefficiencies drain capital, delay delivery, and erode confidence in a sector that contributes nearly 20% of national GDP [3]. With projects such as the Satu Malaysia Terminal and Sipitang LNG expansion underway [4], improving performance is imperative. Organizational factors top management support, culture, communication, change management, and training are recognized as key drivers of success. Yet, most studies examine them in isolation, neglecting their interaction with technological and environmental dynamics. In the era of digitalization and sustainability transition, this approach is insufficient.

Artificial Intelligence (AI) is a transformative enabler, with the global oil and gas AI market projected to rise from USD 3 billion in 2025 to nearly USD 7 billion by 2032 [5]. Evidence highlights benefits such as cost reductions, predictive maintenance, and improved decision-making [6]. ADNOC, for example, created USD 500 million in value and prevented one million tons of CO₂ emissions in 2023 through AI [7]. In Malaysia,

however, adoption remains limited, and organizational readiness is underexplored. At the same time, firms face mounting pressure for environmental responsiveness, driven by global energy targets, Malaysia's National Energy Policy 2022–2040, and rising ESG scrutiny. While green practices improve resilience [8], few studies consider environmental responsiveness as a mediator of performance. This study addresses these gaps by proposing a dual-mediator framework integrating TOE, RBV, and DOI that explains how organizational factors influence project performance through AI adoption and environmental responsiveness.

A strong theoretical foundation is essential to explain how organizational determinants shape project performance in the oil and gas industry. This study integrates three complementary perspectives: the Technology–Organization–Environment (TOE) framework, the Resource-Based View (RBV), and the Diffusion of Innovations (DOI) theory. Together, these theories provide a multi-level lens to capture how internal resources, technological pathways, and external pressures interact to influence project outcomes.

The TOE framework, developed by Tornatzky and Fleischer [1], analyzes the interplay of three dimensions:

- a. Technological context, availability, characteristics, and perceived usefulness of technologies.
- b. Organizational context, leadership support, culture, communication, structure, and resource allocation.
- c. Environmental context, external pressures such as regulation, competition, and stakeholder demands.

TOE has been widely applied to information systems, digitalization, and innovation studies [9]. Recent research confirms its relevance to sustainability transitions, AI adoption, and digital transformation in emerging economies [10]. In the oil and gas sector, it explains how AI is adopted, how organizational structures facilitate or hinder uptake, and how sustainability pressures reshape strategies. Its main limitation, however, is that it remains broad and generic, with limited attention to the strategic role of internal resources or the processes by which innovations diffuse [11].

Resource-Based View

The RBV, articulated by Barney [12], complements TOE by emphasizing internal resources as sources of sustained advantage. It posits that resources that are valuable, rare, inimitable, and non-substitutable (VRIN) enable superior performance. In project-based industries, determinants such as top management support, training, and communication are not only contextual enablers but also strategic resources that condition effective technology adoption and environmental adaptation [13].

RBV helps explain why firms facing similar external conditions achieve different outcomes. Organizations with stronger resource bases are better positioned to leverage AI, respond to ESG requirements, and deliver superior results. Recent studies confirm its relevance: knowledge-based capabilities and managerial commitment enhance AI adoption [14], while sustainability-oriented cultures align resources with regulatory demands. Nonetheless, RBV is often criticized as overly inward-looking, underestimating external pressures highlighting the value of combining it with TOE.

Diffusion of Innovations Theory

DOI theory, pioneered by Rogers [15], adds a behavioral and process perspective. Adoption depends on five innovation attributes: relative advantage, compatibility, complexity, trialability, and observability. It also highlights the role of communication, social systems, and change agents. In oil and gas, AI adoption hinges not only on technological readiness but also on employee perceptions of its value and ease of use [16]. Training, communication, and change management therefore play central roles in diffusion. Empirical studies validate DOI's applicability to AI adoption, sustainable practices, and green technology diffusion [17]. Yet DOI does not adequately account for the strategic role of resources (RBV) or external pressures (TOE), underscoring the need for integration.

Complementarity of the Three Theories

Individually, each theory has limitations: TOE offers breadth but lacks depth, RBV emphasizes resources but downplays context, and DOI captures diffusion processes but overlooks strategy. Combined, they provide theoretical triangulation: TOE situates determinants within technological and environmental contexts, RBV highlights their strategic value, and DOI explains their diffusion dynamics.

Theoretical Foundations

The TOE framework explains how technological readiness, organizational support, and environmental pressures jointly shape innovation adoption [9]. In Malaysia's oil and gas industry, it is particularly relevant given the pressures of digital transformation and sustainability. The RBV complements TOE by framing organizational resources as strategic assets. Resources that are valuable, rare, inimitable, and non-substitutable (VRIN) generate sustained competitive advantage [18]. Leadership commitment, organizational culture, and

training represent internal resources that enable firms to adapt effectively to technological and environmental demands. DOI theory adds nuance by emphasizing innovation attributes relative advantage, compatibility, complexity, trialability, and observability that influence adoption decisions [15]. In project-intensive industries, diffusion depends not only on technological attributes but also on organizational readiness and environmental pressures. Together, TOE, RBV, and DOI provide a robust lens for examining how organizational determinants influence project performance through AI adoption and environmental responsiveness.

Organizational Factors and Project Performance

Top management support drives alignment and resource allocation. Studies show that strong leadership improves efficiency, while its absence leads to fragmented communication and delays [19][20]. Organizational culture shapes values and attitudes toward innovation. Adaptive cultures foster success, while rigid, hierarchical cultures hinder change [21][22]. Communication ensures alignment and reduces resistance. Transparent exchanges enhance performance, while poor communication in AI-related projects fosters resistance [20][23]. Change management enables adaptation. Structured approaches and stakeholder engagement improve outcomes, while weak change leadership undermines transformation [24][25]. Training builds workforce capacity. Investments in training enhance productivity and adaptability, while insufficient training limits technology adoption [26][27]. Although each factor contributes to success, most studies examine them in isolation, leaving a gap in understanding their combined impact on performance.

Organizational Factors and AI Adoption

Organizational determinants strongly influence AI adoption. Leadership provides strategic direction and resources [28]; innovative cultures encourage openness, while risk-averse cultures resist change [29]. Communication reduces uncertainty [30], structured change practices manage transitions [31], and training equips employees with digital skills. Evidence shows AI adoption improves scheduling and reduces overruns [32] and contributes to sustainability outcomes [33]. Yet, without organizational readiness, benefits often fail to materialize [34]. Research in Malaysia remains limited, underscoring the need to link determinants, AI adoption, and project outcomes.

AI Adoption and Project Performance

AI enables predictive maintenance, real-time analytics, and decision support, reducing delays and cost overruns [35]. It also improves scheduling, safety, and compliance. Deloitte [36] reported that adopters reduced risks and improved efficiency, but these benefits depend on organizational readiness. Hence, AI functions best as a mediator rather than a direct driver of performance.

Organizational Factors and Environmental Responsiveness

Environmental responsiveness reflects an organization's ability to anticipate and act on sustainability and regulatory pressures. Leadership embeds sustainability in strategic objectives [37][38]; culture shapes proactive versus reactive responses [39]; and communication builds trust or fuels resistance [40]. Change management enables environmental transitions, while training develops compliance and green technology skills [41]. Research shows that sustainability-oriented firms innovate more and build resilience, while reactive firms gain fewer benefits [42][43]. This underscores the importance of organizational factors in fostering proactive responsiveness.

Environmental Responsiveness and Project Performance

Responsiveness improves efficiency, mitigates risks, and strengthens legitimacy. Sustainability practices enhance resilience [44], while proactive strategies generate shared value [45]. In oil and gas, responsiveness supports competitiveness and reputation [46]. For example, Shell's 2023 report demonstrated how embedding environmental considerations enhanced both delivery and reputation. Despite its importance, responsiveness remains underexplored as a mediator between enablers and outcomes.

Closing Synthesis and Transition

The literature affirms that top management support, culture, communication, change management, and training strongly influence project performance. These determinants not only affect outcomes directly but also enable AI adoption and foster environmental responsiveness. AI enhances predictive capabilities and decision-making, while responsiveness strengthens compliance and stakeholder trust. Yet, prior studies often examine these pathways separately and through single theoretical lenses.

This study advances the field by integrating TOE, RBV, and DOI into a unified model where AI adoption (technological pathway) and environmental responsiveness (environmental pathway) serve as dual mediators between organizational determinants and project performance. By combining contextual readiness (TOE), strategic resources (RBV), and diffusion dynamics (DOI), the framework provides a more comprehensive explanation of project performance in Malaysia's oil and gas industry.

2. Mediating Role

AI Adoption as Mediator: Bridging Organizational Readiness and Project Outcomes

Artificial Intelligence (AI) has become a transformative enabler in project-intensive industries, yet its impact on performance is rarely direct. Instead, AI adoption mediates the relationship between organizational determinants and outcomes, translating readiness into measurable improvements. Top management support is pivotal, as it signals strategic intent and secures resources. Studies show that strong leadership improves efficiency, while its absence prevents firms from realizing value from AI despite similar investments [19][47]. Culture plays a comparable role: adaptive cultures accelerate adoption, whereas rigid hierarchies suppress experimentation [21][22]. Communication further conditions outcomes transparent exchanges foster alignment, while vague messaging heightens resistance [20][48]. Change management reduces adoption failures when structured processes engage stakeholders [24][25], and training equips employees with the digital skills needed to use AI effectively [9][27].

The mediating role of AI adoption is supported by empirical evidence. AI-enabled scheduling reduced construction delays by over 20% [49]; predictive analytics in oil and gas minimized downtime and enhanced safety [33]; and AI-driven drilling optimization cut costs by 10–15% while lowering environmental incidents [36]. Conversely, firms that introduced AI without leadership support or staff capabilities achieved little impact [47]. Thus, AI adoption acts as the bridge between organizational readiness and project outcomes. In Malaysia, adoption remains uneven, with experimentation in predictive maintenance and seismic analysis but limited enterprise-wide integration. This underscores AI's role as a mediator explaining why firms with similar technologies achieve different performance results depending on organizational readiness.

Environmental Responsiveness as Mediator: Adapting to Regulations, ESG, and Market Changes

Environmental responsiveness (ER) reflects an organization's ability to anticipate, adapt, and respond to sustainability pressures. Like AI adoption, ER mediates the influence of organizational determinants on outcomes rather than directly determining performance. Leadership embeds sustainability into strategy, with committed executives driving superior results [50], while weak leadership reduces responsiveness to compliance-focused efforts [43]. Culture is similarly influential: sustainability-oriented cultures encourage proactive adaptation, whereas profit-driven ones delay responsiveness until mandated [51]. Communication strengthens trust and legitimacy when transparent [18], but weak messaging undermines credibility. Structured change management increases the success of environmental transitions [19], while training equips employees with the knowledge to implement compliance and green practices [52].

Evidence further validates ER's mediating role. Proactive responsiveness creates shared value and competitiveness [45], while reactive approaches result in compliance costs without strategic benefit [43]. In the oil and gas sector, Shell [46] demonstrated that integrating environmental goals into project planning reduced risks and strengthened community trust. In Malaysia, the National Energy Policy 2022–2040 intensifies ESG pressures: proactive firms gain legitimacy and avoid penalties, while lagging firms face reputational and financial risks. ER therefore represents the environmental pathway through which organizational enablers influence project performance.

Dual Mediation: Complementarity of AI Adoption and Environmental Responsiveness

Individually, AI adoption and ER provide distinct pathways, but their complementarity offers the most comprehensive explanation of project performance. AI strengthens technological capability through predictive maintenance, resource optimization, and decision support, while ER ensures sustainability and stakeholder legitimacy. Their integration creates balance. Firms prioritizing AI without ER may achieve efficiency gains but risk regulatory backlash, while those emphasizing ER without AI may maintain compliance but lose competitiveness. Evidence supports this complementarity: sustainability-aligned cultures strengthen innovation [17], while AI-driven optimization enhances efficiency [13].

This dual mediation perspective advances prior models. TOE highlights contextual influences but underemphasizes the interaction between technology and environment; RBV emphasizes resources but downplays external pressures; and DOI explains diffusion but overlooks strategic alignment. Positioning AI adoption and ER as complementary mediators expands theoretical explanatory power, offering a holistic

framework that addresses the dual imperatives of digital transformation and decarbonization in Malaysia's oil and gas industry.

3. Conceptual Framework

This study develops the AI-Integrated Project Performance Framework (AIPPF) to explain how organizational determinants shape project performance in Malaysia's oil and gas industry. Unlike prior research that typically emphasizes either technological adoption or environmental adaptation, the AIPPF introduces dual mediators AI adoption and environmental responsiveness (ER) to capture the simultaneous imperatives of digital transformation and sustainability.

The framework is underpinned by three complementary theories. The Technology–Organization–Environment (TOE) model provides contextual breadth by accounting for technological, organizational, and environmental factors. The Resource-Based View (RBV) highlights organizational determinants as strategic resources. The Diffusion of Innovations (DOI) theory explains how innovation diffusion processes condition AI adoption. Together, these theories support a multi-level conceptualization of how organizational readiness translates into project performance.

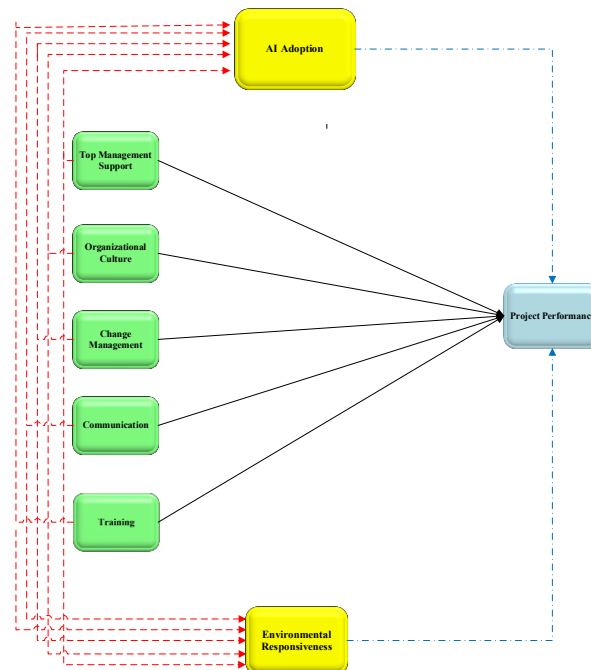


Figure 1. AI-Integrate Project Performance Framework (AIPPF)

Independent Variables (IVs): Organizational Determinants

The framework identifies five key determinants as independent variables, acting as both strategic resources (RBV) and contextual enablers (TOE):

- Top Management Support (TMS): Leadership provides vision, resources, and legitimacy.
- Organizational Culture (OC): Shared values shape openness to change and innovation.
- Communication (COM): Clear, transparent communication aligns stakeholders.
- Change Management (CM): Structured processes reduce resistance to transformation.
- Training (TRN): Skill development supports AI-enabled and sustainable practices.

Mediating Variables

- AI Adoption (Technological Pathway) Transforms readiness into analytics, decision support, and efficiency (TOE–tech, DOI). Mediates TMS, OC, COM, CM,
- Environmental Responsiveness (Environmental Pathway) Enables adaptation to regulations, ESG, and stakeholder demands (TOE–env, RBV). Mediates TMS, OC, COM, CM,

By integrating these theories, the AIPPF provides a multi-level explanation of how organizational determinants translate into project performance through dual mediators. The AIPPF advances theory and practice by positioning AI adoption and ER as complementary mediators. It extends prior frameworks by linking organizational readiness to project outcomes through dual pathways of technological capability and

environmental legitimacy. The 16 hypotheses provide a testable structure for future empirical studies and practical guidance for managers aiming to balance digital transformation and sustainability imperatives.

4. Discussion

Extending the Technology–Organization–Environment (TOE) Framework

This study advances the Technology–Organization–Environment (TOE) framework by positioning AI adoption and environmental responsiveness (ER) as dual mediators between organizational determinants and project performance. TOE traditionally explains technology adoption by highlighting technological, organizational, and environmental contexts but is often critiqued for being too broad and not addressing how determinants translate into outcomes. The AI-Integrated Project Performance Framework (AIPPF) addresses this gap by embedding mediators within TOE. AI adoption operationalizes the technological dimension, showing how readiness factors leadership, culture, communication, training, and change management translate into capability. ER operationalizes the environmental dimension, capturing how determinants enable firms to adapt to sustainability pressures. This dual mediation strengthens TOE's explanatory power in project-based industries, particularly oil and gas, where adoption and adaptation are essential for survival.

Integrating TOE with the Resource-Based View (RBV)

The AIPPF also enriches the Resource-Based View (RBV) by showing how organizational determinants act as strategic resources that generate competitive advantage through technology and sustainability. While RBV emphasizes valuable, rare, inimitable, and non-substitutable (VRIN) resources, prior studies often underplay how these resources interact with environmental pressures. By integrating RBV with TOE, this study demonstrates that determinants are not only internal resources but also enablers of transformation when strategically deployed. Leadership provides vision, while training develops unique digital skills. These resources achieve full potential when channeled through AI adoption and ER. Thus, AIPPF bridges RBV's inward focus with TOE's contextual breadth, highlighting that resources must be strategically mobilized to create value in the face of digitalization and decarbonization.

Integrating TOE with the Diffusion of Innovations (DOI) Theory

DOI theory complements TOE and RBV by providing a behavioral lens. It explains how adoption is influenced by relative advantage, compatibility, complexity, trialability, and observability [5]. While these attributes shape AI adoption [6], DOI is rarely integrated into holistic performance frameworks. The AIPPF embeds DOI into the technological mediation pathway, emphasizing that adoption depends on how employees perceive AI's value, compatibility, and transparency. Training, communication, and change management shape these perceptions, facilitating diffusion. DOI also complements ER by explaining how sustainability practices diffuse within organizations and supply chains. Transparent communication and stakeholder engagement make practices observable, accelerating uptake. Thus, the AIPPF integrates DOI's micro-level insights into TOE's macro-level structure.

Multi-Theoretical Integration

By synthesizing TOE, RBV, and DOI, this study contributes in three ways:

- a. **Pathway Extension**, TOE is expanded with dual mediators that explain how determinants influence outcomes.
- b. **Resource Contextualization**, RBV highlights determinants as resources whose value is realized through AI adoption and ER.
- c. **Behavioral Dynamics**, DOI adds adoption and diffusion processes that condition success or failure.

This integration provides a holistic, multi-level explanation of project performance in oil and gas, moving beyond siloed theory applications to reflect the realities of digitalization and sustainability transitions.

Guidance for Oil and Gas Managers

The AIPPF offers practical insights for managers in Malaysia's oil and gas sector. First, organizational readiness is foundational: without strong leadership, supportive culture, transparent communication, effective change management, and robust training, AI or sustainability initiatives are likely to fail. Managers must prioritize these enablers before major investments. Second, AI adoption and ER should be treated as complementary, not separate, initiatives. Many firms emphasize digitalization while neglecting sustainability, or vice versa. Long-term performance requires both. AI delivers efficiency and predictive capacity, while ER ensures compliance, trust, and resilience. Balanced strategies prevent one-sided progress that creates future risks. Third, training and communication are critical levers. Technical training equips employees to use AI

effectively, while environmental training builds capacity for sustainable practices. Transparent communication reduces internal resistance to AI and enhances external legitimacy with regulators, investors, and communities.

Strategic Use of AI and Environmental Responsiveness

From a strategic perspective, the AIPPF provides a roadmap for aligning organizational strengths with industry imperatives:

- a. AI Adoption as a Performance Driver, Prioritize applications that directly improve outcomes, such as predictive maintenance, scheduling optimization, and safety monitoring. Pilot projects should demonstrate quick wins (observability) before scaling.
- b. ER as a Legitimacy Driver, Embed proactive responsiveness into governance, moving beyond compliance to achieve reputational and competitive gains.
- c. Dual Pathway Integration, Design strategies that link AI adoption with ER. For example, deploying AI to monitor emissions aligns efficiency with accountability.
- d. Industry-Wide Collaboration, Leverage shared platforms, partnerships, and consortia to accelerate diffusion of both AI and sustainability practices.

5. Conclusion

This study introduces the AI-Integrated Project Performance Framework (AIPPF) to explain how organizational determinants influence outcomes in Malaysia's oil and gas industry through the dual mediating roles of AI adoption and environmental responsiveness (ER). By linking five organizational factors top management support, culture, communication, change management, and training to performance indicators such as cost, time, quality, safety, and stakeholder satisfaction, the framework provides a comprehensive view of organizational readiness and project success. Theoretically, it extends the Technology–Organization–Environment (TOE) framework by embedding dual mediators, integrates the Resource-Based View (RBV) by positioning determinants as strategic resources, and advances the Diffusion of Innovations (DOI) theory by clarifying adoption dynamics.

Collectively, these perspectives move beyond siloed approaches and present a holistic explanation of project performance. Practically, the AIPPF offers managers a roadmap for balancing digital transformation with sustainability. It emphasizes that strong leadership, adaptive culture, transparent communication, structured change management, and effective training form the foundation of success. AI adoption and ER are presented as complementary pathways: AI enhances efficiency and technological capability, while ER strengthens legitimacy and resilience. Their integration fosters both operational excellence and sustainable competitiveness. The novelty of this study lies in positioning AI adoption and ER as simultaneous mediators, creating a dual-pathway model for project-intensive industries. While conceptual, the framework calls for empirical validation using Structural Equation Modelling–Partial Least Squares (SEM-PLS), and future research is encouraged to test variations across organizational size, project type, and regulatory context. This dual contribution advances theory while offering actionable insights for industry practice.

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