Modeling the Influence of Integrated Risk Management Practices on Sustainable Project Success in Oil and Gas Megaprojects

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Abstract

This study models the influence of four integrated risk management practices risk identification, risk assessment, risk mitigation, and risk monitoring and control on sustainable project success in oil and gas megaprojects. Using survey data collected from over 200 project managers and engineers employed by multinational companies operating in Pakistan, and applying Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS, the study finds that all four dimensions of risk management exert a statistically significant, positive effect on sustainable project success, collectively explaining 52.5% of the variance in the outcome construct. Risk assessment emerged as the strongest predictor ($\beta = 0.401$), followed by risk monitoring and control ($\beta = 0.327$), risk mitigation ($\beta = 0.228$), and risk identification ($\beta = 0.143$). The findings extend integrated risk management theory into the sustainability domain and offer practical guidance for project sponsors and risk managers seeking to improve megaproject delivery in high-risk, resource-constrained operating environments.

Keywords: *integrated risk management, sustainable project success, oil and gas megaprojects, PLS-SEM, Pakistan*

1. Introduction

1.1 Background of the Study

Megaprojects, large-scale, capital-intensive ventures typically defined as those exceeding US$1 billion in value, have become central to global infrastructure and energy development (Parth, 2014). These projects are distinguished not merely by their financial scale but by their multi-year timelines, technical complexity, and the high degree of uncertainty that accompanies their execution. Within this broader category, oil and gas megaprojects occupy a particularly demanding position: they combine subsurface geological uncertainty, extreme capital exposure, long lead times between sanction and first production, and operating environments shaped by volatile commodity prices and shifting geopolitical conditions (Rcademy, 2024). Independent Project Analysis (IPA) research indicates that oil and gas megaprojects average a 59% cost overrun relative to their original sanction estimate and a 35-month schedule

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https://doi.org/10.58932/MULA0049

overrun from final investment decision to first production (Rcademy, 2024). Earlier industry benchmarking from EY found that 78% of upstream megaprojects experienced either cost overruns or schedule delays a deterioration from 2003, when only half of projects faced similar setbacks (EY, n.d.). Flyvbjerg's (2017) widely cited analysis attributes these persistent failures to a combination of complex technical interfaces, extended planning horizons, participants with competing interests, evolving project scope, and, at times, misrepresentation of costs and benefits to stakeholders and the public.

The scale of this challenge is not confined to a handful of high-profile failures. Across infrastructure sectors, annual global spending on megaprojects is estimated at between US$6 and 8 trillion roughly 8% of global GDP yet research from Oxford University's Saïd Business School found that fewer than 3% of megaprojects are delivered on time and within budget (OilPrice.com, 2023). For an industry as capital-intensive as oil and gas, where the International Energy Agency (IEA, 2023a) projects global energy investment to reach US$3.3 trillion in 2023, with roughly US$1.1 trillion directed toward oil, gas, and coal, the cumulative cost of poor risk management is measured in hundreds of billions of dollars annually. The International Energy Forum (2024) further estimates that a cumulative US$4.3 trillion in new upstream investment will be required between 2023 and 2030 simply to meet projected demand growth underscoring that the industry cannot afford the chronic overruns and delivery failures that have historically characterized its largest undertakings.

These pressures have pushed risk management from a peripheral compliance function toward a strategic capability that determines whether megaprojects succeed. Industry analyses of 2024–2023 trends in oil and gas project management point to a growing emphasis on sustainability, digital transformation, and more structured governance as organizations attempt to close the persistent gap between planned and actual project outcomes (SchedulerReader, 2024; Okoli et al., 2024). Frameworks such as ISO 31000:2018 reconfirmed without changes in 2023 have reinforced this shift by embedding risk management into core organizational decision-making rather than treating it as a standalone technical exercise, and by promoting a principles-based approach adaptable across sectors and project types (International Organization for Standardization, 2018). Within this framework, risk management is commonly understood as a cyclical process comprising risk identification, risk analysis and assessment, risk treatment or mitigation, and ongoing monitoring and control (ScienceDirect, 2023/2024). It is this four-stage structure identification, assessment, mitigation, and monitoring and control that forms the conceptual backbone of the present study, and which this research treats as an integrated system rather than four isolated activities.

1.2 Global Contribution of Oil and Gas Megaprojects

Oil and gas megaprojects remain foundational to the global energy system and to the economies of resource-producing nations. In the Middle East alone, upstream oil and gas investment is projected to reach approximately US$130 billion in 2023, representing around 15% of global upstream spending, with Saudi Arabia's investment alone approaching US$40 billion (IEA, 2023b). Beyond upstream extraction, downstream megaprojects such as multi-billion-dollar petrochemical and refining complexes in Saudi Arabia and the United Arab Emirates illustrate how oil and gas capital programs now extend across integrated value chains, from extraction through to specialty chemicals and low-carbon fuels (Global Megaprojects, 2023). These projects generate substantial direct, indirect, and induced economic effects; input-output analyses of strategic oil and gas megaprojects in Kuwait, for example, have quantified their contribution to national GDP and employment beyond the immediate scope of construction and operation (ScienceDirect, 2022). Collectively, this body of evidence establishes that the economic footprint of oil and gas megaprojects extends well beyond the balance sheets of the operating companies themselves, touching national income, employment, industrial development, and energy security across producing and importing nations alike.

At the same time, the industry is navigating a period of relative capital reallocation. Global investment in coal, oil, and gas declined by 31.3% in 2023 to US$61 billion, marking a second consecutive annual decline, even as overall energy investment continued to rise (Visual Capitalist, 2024). This reallocation toward renewables, grids, and low-emissions technologies does not diminish the importance of the oil and gas megaprojects that remain in the pipeline; if anything, it raises the stakes for the projects that do proceed, since capital is increasingly scrutinized for its risk-adjusted returns and its ability to deliver sustainable, rather than merely profitable, outcomes. This is the context in which the concept of “sustainable project success” has gained prominence in the megaproject literature moving beyond traditional cost-schedule-quality metrics to incorporate environmental performance, stakeholder legitimacy, and long-term operational viability (Abdulla, 2024).

1.3 National Contribution: The Case of Pakistan

Within Pakistan, energy megaprojects have played a defining role in addressing a chronic power deficit while also illustrating the risks inherent in large-scale energy development. The China–Pakistan Economic Corridor (CPEC), launched in 2015, allocated a substantial share of its investment portfolio to energy generation and transmission, with cumulative energy-sector commitments estimated at approximately US$33–35 billion (CPEC Energy Portal, n.d.; ResearchGate, 2018). Between 2015 and 2019 alone, nine new power plants were commissioned under CPEC's early-harvest program, adding 5,320 MW of generation capacity (PIDE, 2023). By the end of FY2024, Pakistan's installed electricity generation capacity had reached 45,888 MW, though average capacity utilization stood at only about 34%, a gap that itself reflects downstream planning, transmission, and demand-side risks that were not fully anticipated at the design stage (PIDE, 2023). Complementary analysis using a GTAP-E-Power model found that CPEC's 31 energy projects raised the share of zero-emission electricity in Pakistan's grid to 49.1% and reduced CO2 emissions by an estimated 18.61 million tons, demonstrating tangible environmental and economic returns when energy megaprojects are executed effectively (Wang et al., 2024). More broadly, CPEC-linked energy investment has been credited with adding more than 8,000 MW of generation capacity by 2024 and supporting wider economic diversification, from special economic zones to digital trade infrastructure (Eurasia Review, 2024).

Yet Pakistan's experience also illustrates the consequences of inadequate risk management at a national scale. Delays in completing planned Special Economic Zones have left costly energy capacity underutilized relative to its original demand projections, and security, land acquisition, and community relations risks in CPEC-linked construction have periodically disrupted project timelines (PIDE, 2023; Belt and Road Initiative Report, 2023). These outcomes mirror the broader global pattern in which technically sound projects underperform not because the underlying engineering is flawed, but because risks across identification, assessment, mitigation, and monitoring stages are not managed as an integrated, continuous process.

1.4 Problem Statement and Research Gap

Despite the well-documented economic significance of oil and gas megaprojects, both globally and within Pakistan, the sector continues to exhibit a persistent gap between planned and delivered outcomes, with the majority of upstream megaprojects still experiencing cost or schedule overruns (EY, n.d.; Rcademy, 2024). Existing literature has examined individual dimensions of project risk governance structures (Okoli et al., 2024), stakeholder engagement (ScienceDirect, 2023/2024), and supply-chain risk yet comparatively little empirical work has modeled how the four core stages of risk management (identification, assessment, mitigation, and monitoring and control) function together, as an integrated system, to influence sustainable project success specifically within oil and gas megaprojects. This gap is especially pronounced in the context of multinational companies operating in Pakistan, where megaproject delivery intersects with unique regulatory, security, and infrastructural constraints not fully captured in studies drawn from mature Gulf or Western markets.

1.5 Research Objectives and Significance

This study addresses this gap by empirically modeling the influence of integrated risk management practices, risk identification, risk assessment, risk mitigation, and risk monitoring and control, on sustainable project success in oil and gas megaprojects, drawing on survey data from project managers and engineers employed by multinational companies operating in Pakistan. By applying Partial Least Squares

Structural Equation Modeling (PLS-SEM), the study quantifies the relative strength of each risk management dimension's contribution to sustainable project outcomes, offering both theoretical contributions to the integrated risk management literature and practical guidance for project sponsors, contractors, and policymakers seeking to improve megaproject delivery in resource-constrained, high-risk operating environments.

1.6 Structure of the Paper

The remainder of this paper proceeds as follows: Section 2 reviews the theoretical and empirical literature on risk management and sustainable project success; Section 3 details the research methodology, including sampling, instrumentation, and analytical technique; Section 4 presents the results of the measurement and structural model assessment; and Section 5 discusses the findings and their implications, concluding with limitations and directions for future research.

2. Literature Review

2.1 Theoretical Foundations

The theoretical foundation of this study rests on two complementary bodies of thought: risk management theory, as codified in ISO 31000 and related project-based standards, and sustainability theory, most commonly operationalized through the Triple Bottom Line (TBL) framework. Risk management theory conceptualizes risk not as a single event to be avoided but as a continuous, cyclical process of identification, analysis, response, and control that must be embedded into organizational decision-making rather than treated as an isolated technical function (Kardes et al., 2013). This view aligns with the structural model adopted in the present study, which treats risk identification, risk assessment, risk mitigation, and risk monitoring and control as four interdependent but individually consequential stages of an integrated risk management system.

Sustainability theory, meanwhile, provides the theoretical basis for conceptualizing the dependent variable, sustainable project success, as something broader than the traditional “iron triangle” of cost, time, and quality. Rooted in the Brundtland Report and formalized through the Triple Bottom Line, sustainability theory holds that project outcomes should be evaluated across economic, social, and environmental dimensions simultaneously, since a project that is delivered on budget but produces adverse environmental or social externalities cannot reasonably be considered a full success (Elgar Research Handbook, 2024). Within megaproject research specifically, this reframing has gained traction because megaprojects, by virtue of their scale, visibility, and long operational lifespans, tend to generate disproportionately large social and environmental footprints relative to conventional projects. Integrating risk management theory with sustainability theory, therefore, provides a coherent lens for this study: effective management of risk across its four canonical stages is theorized to be a necessary precondition for megaprojects to achieve success that is sustainable in the fullest sense, not merely success measured against narrow delivery metrics.

2.2 Risk Identification and Sustainable Project Success

Risk identification is widely regarded as the foundational stage of the risk management cycle, since risks that go unrecognized cannot subsequently be assessed, mitigated, or monitored. Recent scholarship has moved beyond purely qualitative, expert-judgment-based identification methods toward more systematic and data-driven approaches. Erfani et al. (2023) developed a common risk breakdown structure for major transportation projects using a data-driven methodology, demonstrating that structured identification frameworks capture a broader and more consistent set of risk categories than ad hoc expert elicitation alone. Similarly, recent work by Zhang et al. (2024) applied a hybrid retrieval-augmented generation approach to automatically identify social risks in infrastructure megaprojects, finding that automated identification produced more complete risk chains linking risk sources to events, consequences, and management responses than expert-authored reports. These findings collectively suggest that the comprehensiveness and structure of the identification process materially affect downstream project outcomes, since unidentified risks, by definition, escape subsequent management efforts. Within megaproject contexts, more specifically, a risk breakdown structure study synthesizing prior literature found that risk identification is consistently treated as the essential first step in megaproject risk management, with subsequent classification and prioritization efforts building directly on the completeness of this initial stage (ETASR, 2024). On this basis, it is hypothesized that a more thorough and systematic risk identification process contributes positively to the sustainable success of oil and gas megaprojects.

2.3 Risk Assessment and Sustainable Project Success

Where risk identification catalogs potential threats, risk assessment evaluates their likelihood and potential impact, enabling project teams to prioritize limited managerial and financial resources toward the risks that matter most. This stage has received particular empirical attention within the oil and gas sector, specifically. Kassem et al. (2020) examined the effect of external risk factors on the success of an oil and gas construction project and found that systematic assessment of factors such as political, economic, and regulatory risk had a measurable effect on project success outcomes, reinforcing the proposition that assessment quality, not merely the existence of a risk register, drives performance. Complementary work using gray fuzzy group decision-making and Monte Carlo simulation methods for mega construction projects operating under uncertainty found that probabilistic, uncertainty-aware assessment techniques produced materially different risk prioritizations than deterministic approaches, with direct implications for subsequent resource allocation decisions (Journal of Architectural Engineering, 2024). In the context of China's mega infrastructure sector, Wang et al. (2023) conducted a quantitative analysis of decision-making risk factors under combined EPC and PPP delivery models, concluding that the interplay and dynamic evolution of risk factors, when properly assessed, meaningfully shape project delivery outcomes. Taken together, this literature supports the hypothesis that rigorous risk assessment exerts a significant positive influence on sustainable project success in oil and gas megaprojects.

2.4 Risk Mitigation and Sustainable Project Success

Risk mitigation translates assessment findings into concrete action, and the empirical literature on oil and gas construction projects offers some of the most directly relevant evidence for this study's model. A structural equation modeling (PLS-SEM) study of oil and gas construction projects in Yemen found that project success required addressing and mitigating external risks, including security-related, political, and economic risk factors, with each factor showing a measurable path coefficient toward reduced project cost and improved delivery outcomes (MDPI, 2022). This finding is particularly salient given that the present study also employs PLS-SEM and operates in a similarly volatile environment. Practitioner-oriented literature reinforces this empirical pattern: contracting organizations in the oil and gas construction space report that mitigation strategies ranging from risk reduction (equipment maintenance, safety protocols) to risk elimination (design modification to avoid severe-consequence risks entirely) are core levers for preventing schedule delays and managing budget exposure (Rogue Energy Services, 2023). What distinguishes mitigation from mere assessment is its action orientation: mitigation translates analytical insight into operational safeguards, and the reviewed literature consistently finds that projects with more developed mitigation protocols experience fewer cost and schedule deviations. Accordingly, it is hypothesized that risk mitigation has a significant positive impact on sustainable project success in oil and gas megaprojects.

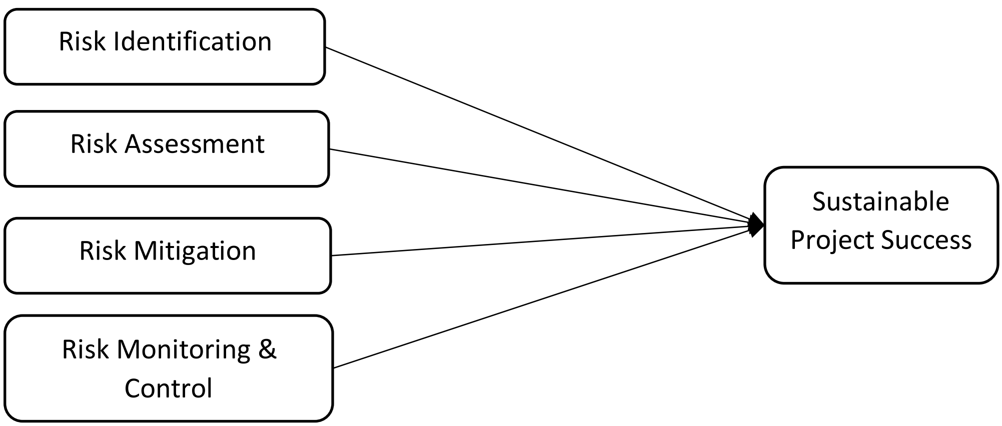
2.5 Risk Monitoring and Control, and Sustainable Project Success

The final stage of the risk management cycle, monitoring and control, ensures that identified, assessed, and mitigated risks are continuously tracked throughout project execution, as risk profiles evolve through the design, procurement, construction, and commissioning phases. Empirical work applying SEM to external risk factors in oil and gas project success found that political, economic, social, and environmental risk factors retained significant explanatory power for project outcomes even after accounting for governmental support mechanisms, underscoring that ongoing monitoring rather than a one-time assessment is necessary to manage risks that shift over a project's lifecycle (ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, 2021). A related SmartPLS-based study of PetroVietnam construction projects reported a coefficient of determination (R^2) of 0.743 for a project success model incorporating monitored risk-response processes, indicating that continuous risk control accounts for a substantial share of variance in project success outcomes (Academia.edu, 2024). Recent work on construction safety in megaprojects similarly frames monitoring and control as central to "resilient governance," arguing that the capacity to detect, respond to, and adapt to emerging risk events rather than static risk planning alone determines whether megaprojects absorb shocks without catastrophic schedule or safety consequences (ScienceDirect, 2024). This body of evidence supports the hypothesis that risk monitoring and control have a significant positive impact on sustainable project success in oil and gas megaprojects.

2.6 Synthesis and Conceptual Framework

Across all four constructs, the reviewed literature converges on a consistent conclusion: no single stage of risk management is sufficient in isolation, and project success, particularly sustainable project success in high-risk, high-visibility sectors like oil and gas, depends on the integrated, mutually reinforcing operation of identification, assessment, mitigation, and monitoring and control. Notably, while a substantial body of empirical work has examined individual risk-management stages in relation to conventional project success metrics (cost, schedule, quality), comparatively fewer studies have modeled all four stages simultaneously as an integrated system predicting sustainable project success specifically within oil and gas megaprojects, and fewer still have done so using data from multinational companies operating in an emerging-market, high-risk context such as Pakistan. This gap directly motivates the conceptual framework adopted in this study, in which Risk Identification, Risk Assessment, Risk Mitigation, and Risk Monitoring & Control are each modeled as independent, first-order constructs exerting a direct effect on Sustainable Project Success, consistent with the following four hypotheses:

Figure 1: *Conceptual Framework*



H1: Risk identification has a significant positive impact on sustainable project success.

H2: Risk assessment has a significant positive impact on sustainable project success.

H3: Risk mitigation has a significant positive impact on sustainable project success.

H4: Risk monitoring and control has a significant positive impact on sustainable project success.

3. Methodology

3.1 Research Design and Approach

This study adopts a quantitative, positivist research design to empirically test the hypothesized relationships between four dimensions of integrated risk management Risk Identification (RI), Risk Assessment (RA), Risk Mitigation (RM), and Risk Monitoring & Control (RMC) and Sustainable Project Success (SPS) in oil and gas megaprojects. A cross-sectional survey strategy was employed, consistent with prior PLS-SEM-based studies examining risk factors and project success in the oil and gas construction sector (Kassem et al., 2020; MDPI, 2022).

3.2 Population and Sample

The target population comprised project managers and engineers employed by multinational companies engaged in oil and gas megaprojects in Pakistan. A total sample of over 200 valid responses was collected, which comfortably exceeds minimum PLS-SEM sample size guidelines such as the commonly cited “10-times rule” (Barclay et al., 1995) and is well within the range recommended by Hair et al. (2019) for models of this structural complexity (four exogenous constructs, one endogenous construct).

3.3 Sampling Technique

Given the specialized nature of the target population, professionals with direct megaproject risk-management experience, who are not readily enumerable through a complete sampling frame, a purposive (judgmental) sampling technique was adopted, supplemented by snowball sampling to reach additional qualified respondents through professional referrals within multinational operating companies. This non-probability approach is well-suited to studies targeting knowledgeable respondents in narrowly defined professional populations and is consistent with sampling strategies used in comparable megaproject risk-management research.

3.4 Instrument and Measurement

Data were collected using a structured, self-administered questionnaire comprising closed-ended items measured on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The instrument operationalized all five constructs (RI, RA, RM, RMC, SPS) as reflective measurement models, with items adapted from established risk management and project success literature.

3.5 Data Analysis Technique

Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS. PLS-SEM was selected over covariance-based SEM (CB-SEM) because of its robustness to moderate, non-normally distributed sample sizes, its suitability for complex models with multiple predictor constructs, and its prediction-oriented orientation, which is appropriate for theory testing in an applied managerial context (Hair et al., 2019). Analysis followed the standard two-step procedure: assessment of the measurement model (internal consistency reliability via Cronbach's alpha and composite reliability [rho_a, rho_c]; convergent validity via Average Variance Extracted [AVE]; and discriminant validity via the Heterotrait-Monotrait ratio [HTMT], following Henseler et al.'s [2015] thresholds of 0.85–0.90), followed by assessment of the structural model (path coefficients, R^2, and hypothesis testing). Statistical significance of path coefficients and HTMT values was evaluated using a bootstrapping procedure with 5,000 subsamples, generating T-statistics and P-values for each hypothesized path, consistent with recommended PLS-SEM reporting conventions (Franke & Sarstedt, 2019; Sarstedt et al., 2022).

4. Results

4.1 Overview

Following the two-step PLS-SEM evaluation procedure outlined in the Methodology, this section first assesses the reflective measurement model (internal consistency reliability, convergent validity, and discriminant validity) before proceeding to the structural model (coefficient of determination and hypothesis testing). All analyses were conducted in SmartPLS using a bootstrapping procedure with 5,000 subsamples.

4.2 Measurement Model Assessment

4.2.1 Internal Consistency, Reliability, and Convergent Validity

Table 1 presents the construct reliability and validity statistics for all five constructs: Risk Assessment (RA), Risk Identification (RI), Risk Mitigation (RM), Risk Monitoring & Control (RMC), and Sustainable Project Success (SPS).

Table 1. Construct Reliability and Validity

Construct	Cronbach's Alpha	rho_a	rho_c	AVE
RA	0.776	0.789	0.847	0.526
RI	0.805	0.813	0.872	0.632
RM	0.798	0.800	0.869	0.623
RMC	0.863	0.863	0.893	0.510
SPS	0.819	0.836	0.873	0.581

All five constructs exceed the commonly recommended threshold of 0.70 for Cronbach's alpha and composite reliability (rho_a and rho_c), confirming strong internal consistency reliability across the measurement model (Hair et al., 2019). RMC exhibits the highest reliability (α = 0.863, rho_c = 0.893), while RA shows the lowest, though still comfortably acceptable, reliability (α = 0.776, rho_c = 0.847). Convergent validity was assessed via Average Variance Extracted (AVE), with all five constructs exceeding the minimum acceptable threshold of 0.50. RI demonstrates the strongest convergent validity (AVE = 0.632), while RMC records the lowest AVE (0.510) still passing the threshold, though closer to the boundary, suggesting that RMC's indicators, while reliable in combination, capture somewhat more heterogeneous variance than the other constructs. Overall, these results confirm that each construct's indicators reliably and validly measure their intended latent variable, satisfying the prerequisites for proceeding to discriminant validity assessment.

4.2.2 Discriminant Validity

Discriminant validity was assessed using the Heterotrait-Monotrait ratio (HTMT), following Henseler et al.'s (2015) recommended thresholds of 0.85 (conservative) to 0.90 (liberal).

Table 2. Discriminant Validity HTMT Ratios

	RA	RI	RM	RMC	SPS
RA					
RI	0.623				
RM	0.727	0.761			
RMC	0.724	0.687	0.839		
SPS	0.801	0.618	0.663	0.734	

All HTMT values in Table 2 fall below the conservative 0.85 threshold, with the highest value observed between RM and RMC (0.839) unsurprising given the conceptual proximity of mitigation and monitoring/control as adjacent, sequential stages of the risk management cycle, but still within acceptable bounds. The relationship between RA and SPS (0.801) is the next highest, reflecting a strong but empirically distinct association between risk assessment practices and sustainable project outcomes. Since no HTMT value approaches or exceeds 0.85, discriminant validity is confirmed across all five constructs, indicating that despite their conceptual relatedness as sequential stages of an integrated risk management process, each construct captures a statistically distinct dimension of the underlying phenomenon (Henseler et al., 2015).

Taken together, the reliability, convergent validity, and discriminant validity results confirm that the measurement model is robust and satisfies all standard PLS-SEM quality criteria, providing a sound basis for structural model evaluation.

4.3 Structural Model Assessment

4.3.1 Coefficient of Determination (R^2)

Table 3. R^2 Overview

Construct	R-square	R-square adjusted
SPS	0.525	0.519

The four exogenous constructs RI, RA, RM, and RMC collectively explain 52.5% of the variance in Sustainable Project Success ($R^2 = 0.525$; adjusted $R^2 = 0.519$). Following Hair et al.'s (2019) guidance for interpreting R^2 in PLS-SEM applied research, this represents a moderate-to-substantial explanatory power, indicating that integrated risk management practices, as modeled in this study, account for just over half of the variation in sustainable project success outcomes among oil and gas megaprojects in the sample. The remaining variance is attributable to factors outside the scope of the present model, such as macroeconomic conditions, organizational culture, stakeholder dynamics, or regulatory environment, which represents a natural avenue for future research discussed in Section 5.

4.3.2 Hypothesis Testing

Table 4. Path Coefficients and Hypothesis Testing Results

Path	O	M	STDEV	T Stat.	P Values	Decision
RA → SPS	0.401	0.403	0.060	6.710	0.000	Supported
RI → SPS	0.143	0.145	0.048	3.003	0.003	Supported
RM → SPS	0.228	0.226	0.062	3.455	0.002	Supported
RMC → SPS	0.327	0.326	0.084	3.897	0.000	Supported

All four hypothesized paths are statistically significant at the $p < 0.01$ level (with RA and RMC significant at $p < 0.001$), providing empirical support for all four hypotheses (H1–H4):

H1 (RI → SPS): Risk Identification shows the smallest, though still statistically significant, positive effect on Sustainable Project Success ($\beta = 0.143$, $t = 3.003$, $p = 0.003$). Supported.

H2 (RA → SPS): Risk Assessment exerts the strongest effect on Sustainable Project Success of all four predictors ($\beta = 0.401$, $t = 6.710$, $p < 0.001$). Supported.

H3 (RM → SPS): Risk Mitigation shows a moderate positive effect on Sustainable Project Success ($\beta = 0.228$, $t = 3.455$, $p = 0.002$). Supported.

H4 (RMC → SPS): Risk Monitoring & Control exerts the second-strongest effect on Sustainable Project Success ($\beta = 0.327$, $t = 3.897$, $p < 0.001$). Supported.

Ranked by effect size, the four predictors influence Sustainable Project Success in the following order: Risk Assessment (0.401) > Risk Monitoring & Control (0.327) > Risk Mitigation (0.228) > Risk Identification (0.143). This ordering suggests that, within this sample of oil and gas megaprojects in Pakistan, the analytical evaluation of risk (assessment) and the sustained, ongoing tracking of risk (monitoring and control) exert considerably more influence on sustainable outcomes than the initial cataloging of risks (identification) or the tactical response to them (mitigation) in isolation, a pattern discussed further in the following section.

4.4 Summary of Findings

The measurement model demonstrates strong reliability, convergent validity, and discriminant validity across all five constructs, satisfying the prerequisites established by Hair et al. (2019) and Henseler et al. (2015) for proceeding to structural model interpretation. The structural model results confirm that all four dimensions of integrated risk management Risk Identification, Risk Assessment, Risk Mitigation, and Risk Monitoring & Control exert statistically significant, positive effects on Sustainable Project Success in oil and gas megaprojects, collectively explaining 52.5% of the variance in the outcome construct. All four hypotheses (H1, H2, H3, H4) are therefore supported, with Risk Assessment emerging as the most influential predictor and Risk Identification the least, though still significant, contributor to sustainable project success in this context.

5. Discussion and Conclusion

5.1 Discussion of Findings

This study set out to model the influence of four integrated risk management practices, risk identification, risk assessment, risk mitigation, and risk monitoring and control, on sustainable project success in oil and gas megaprojects operating in Pakistan. The structural model results support all four hypotheses, confirming that each dimension of risk management contributes positively and significantly to sustainable project success, and collectively explaining 52.5% of the variance in the outcome construct. This finding reinforces the theoretical premise established in Section 2 that sustainable project success in high-risk capital projects cannot be attributed to any single risk-management activity but rather emerges from the coordinated operation of an integrated system.

The most striking finding is the relative ranking of effect sizes: Risk Assessment ($\beta = 0.401$) emerged as by far the strongest predictor, followed by Risk Monitoring & Control ($\beta = 0.327$), Risk Mitigation ($\beta = 0.228$), and finally Risk Identification ($\beta = 0.143$). This pattern diverges somewhat from the intuitive assumption that identification, as the foundational first stage of the risk cycle, might carry proportionally greater weight, and instead suggests that the analytical depth applied to already-identified risks matters considerably more than the breadth of identification itself. This finding resonates with comparative PLS-SEM research on Pakistan's construction sector, which similarly found that specific, well-analyzed risk categories (such as design risk and security/fraud risk) were significantly stronger predictors of project success than generalized risk cataloging (IAENG, 2024; Scientific.Net, 2023). It also aligns with behavioral research suggesting that the quality of risk assessment, rather than its mere existence, shapes managers' anticipated and actual project outcomes, since overconfident or superficial assessment can systematically understate true risk exposure regardless of how comprehensively risks were initially identified (Springer Business Research, 2015/2024).

The second-strongest effect, Risk Monitoring & Control ($\beta = 0.327$), is consistent with the growing recognition across the oil and gas sector that static, point-in-time risk management is insufficient for megaprojects whose risk profiles evolve across multi-year execution horizons. This finding has particular resonance given the sector's current digital transformation trajectory: real-time monitoring technologies, IoT sensors, predictive analytics, and digital twins are increasingly positioned as core enablers of continuous risk control, with BP reporting a nearly 97% improvement in upstream plant reliability attributable in part to AI-enabled monitoring (DXC Technology, 2024). The global oil and gas risk management technology market, valued at approximately US$5.3 billion in 2023 and projected to nearly double by 2034, reflects an industry-wide shift toward exactly the kind of sustained monitoring and control capability this study finds to be a strong predictor of success (Intel Market Research, 2024). That Risk Mitigation ($\beta = 0.228$) and Risk Identification ($\beta = 0.143$) show comparatively smaller though still statistically significant effects suggests these stages function as necessary but not sufficient conditions: mitigation actions are only as effective as the assessment that informs them, and identification, while foundational, appears to translate into sustainable success primarily through the quality of the subsequent stages it enables rather than through its own direct effect.

5.2 Theoretical Implications

These findings extend the integrated risk management literature in two ways. First, by empirically disaggregating the four canonical risk-management stages and testing their independent effects within a single structural model, this study provides evidence that treating risk management as a monolithic construct, as much prior literature implicitly does, risks obscuring meaningful differences in which specific practices drive outcomes. Second, by grounding sustainable project success in Triple Bottom Line theory rather than the traditional cost-schedule-quality triad, this study extends prior oil and gas risk-success research (e.g., Kassem et al., 2020; MDPI, 2022), which has predominantly examined conventional project success metrics, into the sustainability domain, an area that remains comparatively underdeveloped for the oil and gas megaproject context specifically, and even more so within emerging-market settings such as Pakistan.

5.3 Practical Implications

For project sponsors, contractors, and risk managers overseeing oil and gas megaprojects, these findings carry several actionable implications. First, given the outsized effect of risk assessment, organizations should prioritize investment in analytical rigor, probabilistic and scenario-based assessment techniques, cross-functional risk workshops, and independent assessment review over simply expanding the volume of risks logged in a risk register. Second, the strong effect of monitoring and control supports continued investment in digital risk-monitoring infrastructure; however, practitioners should be mindful that industry-wide digital maturity remains uneven, with an estimated 70% of oil and gas companies still confined to pilot-stage digital deployments despite years of investment (CFlow Apps, 2024). Firms operating in Pakistan and similar emerging markets may therefore realize disproportionate competitive advantage by moving monitoring capabilities beyond the pilot stage ahead of slower-moving peers. Third, while mitigation and identification showed comparatively smaller effects, their statistical significance confirms they remain necessary components of the risk system; organizations should resist the temptation to deprioritize these stages, and instead view the four dimensions as complementary rather than substitutable investments.

5.4 Limitations

This study is subject to several limitations that should temper the interpretation of its findings. First, the cross-sectional research design captures risk management practices and project outcomes at a single point in time, limiting the ability to draw causal or longitudinal conclusions about how these relationships evolve across a megaproject's full lifecycle. Second, reliance on self-reported survey data from project managers and engineers introduces the possibility of common method bias and social desirability effects, particularly for a sustainability-oriented outcome construct that respondents may be motivated to portray favorably. Third, the non-probability (purposive and snowball) sampling technique, while appropriate for reaching a specialized professional population, limits the statistical generalizability of findings to the broader population of oil and gas megaproject professionals beyond the sampled multinational companies operating in Pakistan. Finally, the model explains just over half (52.5%) of the variance in sustainable project success, indicating that other unmeasured factors, such as organizational culture, leadership competency, macroeconomic volatility, or regulatory environment, likely play a meaningful role that falls outside the scope of the present model.

5.5 Directions for Future Research

Future research should consider longitudinal designs that track how the relative influence of risk identification, assessment, mitigation, and monitoring shifts across megaproject phases, from front-end engineering design through commissioning and early operations. Given this study's finding that digital monitoring technologies appear closely linked to strong RMC effects, future work could explicitly incorporate digital risk-management maturity as a moderating variable to test whether technology adoption amplifies the RMC–SPS relationship. Additionally, replicating this model across other emerging-market and mature-market contexts would help establish whether the observed ranking of effect sizes assessment and monitoring outweighing identification and mitigation holds more generally or reflects context-specific dynamics unique to Pakistan's regulatory and operating environment. Finally, incorporating additional sustainability-specific outcome indicators (e.g., emissions performance, community relations metrics) alongside the composite SPS construct used here could provide more granular insight into which risk-management dimensions most strongly influence each pillar of the Triple Bottom Line.

5.6 Conclusion

This study modeled the influence of four integrated risk management practices on sustainable project success in oil and gas megaprojects, using survey data from project managers and engineers at multinational companies operating in Pakistan and applying PLS-SEM for analysis. All four hypotheses were supported: risk identification, risk assessment, risk mitigation, and risk monitoring and control each exert a statistically significant, positive influence on sustainable project success, together explaining 52.5% of the variance in the outcome. Risk assessment emerged as the most influential predictor, followed by monitoring and control, mitigation, and identification. These findings underscore that sustainable success in oil and gas megaprojects is not the product of any single risk-management activity but of an integrated system in which analytical rigor and continuous oversight play particularly decisive roles. As the industry continues to navigate capital-intensive, high-uncertainty projects amid an evolving digital and sustainability landscape, organizations that invest deliberately across all four dimensions of integrated risk management with particular emphasis on assessment quality and monitoring capability are best positioned to achieve project outcomes that are successful not only in conventional cost-and-schedule terms, but sustainably so.

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