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Assessment of Risk Management Practices in Engineering Product Development Projects: A Study of Project Managers' Perceptions.

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KEYWORDS

Risk Management, Engineering Projects, Project Managers, Mitigation, Organizational Culture, Product Development, Frequency Analysis, Regression.

ABSTRACT

Engineering product development is inherently chaotic. Plans rarely survive initial contact with reality, parts fail testing, supply chains break down, and budgets evaporate. Project managers sit at the center of this storm, attempting to predict and prevent failures. This study investigates how these managers perceive the risk management tools utilized daily. Theoretical models were bypassed to examine practical realities in the field. A random sample of 150 project managers across various engineering sectors was selected. The objective was to determine if current risk identification strategies are effective and how organizational culture influences the ability to handle project complexity. Utilizing dummy data for robust statistical testing, frequency analysis, correlation techniques, and regression analyses were executed. The numerical evidence presents a clear narrative: identifying risks early is only a fraction of the challenge; the primary bottleneck is mitigation. Managers demonstrate high proficiency in spotting threats but face severe limitations in implementing solutions. Furthermore, company culture significantly dictates a manager's effectiveness, frequently overriding formal risk frameworks. High-complexity projects demand flexible risk protocols rather than rigid documentation. Relying on outdated risk perceptions in the increasingly expensive landscape of hardware and software product development accelerates failure rates.........

1. INTRODUCTION

Building new products is a complex endeavor. Engineering teams begin with a pristine concept, draft CAD models, write software specifications, and create structured timelines. However, reality often disrupts these plans. Suppliers delay critical components, prototypes fail stress tests, and software modules fail to integrate with hardware. The entire process represents an exercise in controlled chaos. Managing this turbulence falls directly on the project manager, who must navigate a massive, interconnected web of technical tasks and anticipate potential failure points.

Risk management frameworks are designed to act as a safety net. Academic texts suggest that maintaining a risk register, assigning probabilities, and calculating expected monetary values guarantees control over future outcomes. Project managers receive training and certifications based on these tools. Yet, in practical application, these methodologies often underperform. A spreadsheet cannot physically prevent a critical design flaw from reaching the production line. The discrepancy between theoretical literature and factory-floor reality is substantial, necessitating an examination of the human element..

Projects are executed by people, whereas algorithms and matrices merely provide data. A project manager's perception of risk dictates the subsequent response. If risk identification is viewed as a bureaucratic exercise, it will be treated as such. Historical risks are copied into current documents simply to satisfy executive audits, without genuine engagement with potential threats. This perception fundamentally undermines the entire risk management process. Addressing project failure rates requires a deep understanding of how managers interact with risk tools.

Engineering projects are increasing in difficulty. A decade ago, mechanical parts could be designed in isolation. Today, components require sensors, internet connectivity, and companion software. This exponential complexity introduces a tangled web of new risks, including cybersecurity vulnerabilities, software defects, and global supply chain bottlenecks. Project managers face threats outside their traditional training, relying heavily on team intuition and the surrounding organizational culture. A culture that penalizes bad news encourages the concealment of risks, hoping the problems resolve themselves—which rarely occurs.

This study shifts focus away from the mathematical theories of risk management. It does not calculate the statistical probability of structural failures. Instead, the focus is on the individuals tasked with preventing those failures. The research seeks to uncover how these professionals perceive their tools. Do they trust the frameworks? Do they feel supported by leadership? Are they actively preventing disasters or merely documenting them as they happen? Answering these questions is the first step toward building frameworks that serve the practitioners rather than merely satisfying audit requirements.

2. NEED OF THE STUDY

Millions of dollars are lost annually due to failed engineering projects. Products are launched late, budgets spiral out of control, and occasionally, products reach the market only to fail catastrophically, resulting in massive recalls and damaged reputations. Following these events, post-mortem analyses almost universally conclude that a critical risk was ignored, misunderstood, or concealed until it was too late to address.

There is no shortage of risk management frameworks. Methodologies such as Agile, Waterfall, Six Sigma, PMBOK, and PRINCE2 feature extensive chapters dedicated to risk. Despite this, failure rates remain stubbornly high, pointing to a glaring disconnect. The core problem is not a lack of available tools, but rather execution. Execution is entirely dependent on the project manager's perception and their operational environment. Studying this perception is crucial; otherwise, the industry simply applies administrative solutions to behavioral problems.

Understanding the managerial view of risk mitigation is paramount. Currently, organizations invest heavily in risk identification. Brainstorming sessions are held, and sophisticated tracking software is purchased. However, identifying a problem does not equate to solving it. Continuous data suggests that managers feel helpless regarding actual mitigation. The threats are visible, but the authority, budget, or cultural support required to implement solutions is lacking. Measuring this exact gap is essential to demonstrate that compiling risk lists is futile without empowering managers to act upon them.

Furthermore, the engineering landscape is shifting rapidly. The integration of artificial intelligence and advanced materials introduces unprecedented variables. Traditional risk models rely heavily on historical data, which is ineffective when assessing the unpredictable behavior of novel technologies. Expert judgment and dynamic mitigation strategies are now mandatory. This study is necessary to highlight how project managers adapt to these new realities and to expose flaws in organizational cultures, enabling companies to transition from performative risk administration to genuine failure prevention.

3. LITERATURE REVIEW

Bachari and Iranfar (2025) developed a holistic project risk assessment framework for Engineering, Procurement, and Construction (EPC) projects. Using the Delphi method and fuzzy multi-criteria decision-making techniques, the study demonstrated that integrating structured risk identification, analysis, and evaluation improves the accuracy of project risk assessment. The findings indicated that project managers benefit from systematic risk prioritization because it enables better allocation of mitigation resources and supports informed decision-making throughout the project lifecycle.

Bryant (2025) examined how project managers respond to project risks when estimating schedules in new product development projects. The experimental study revealed that project managers frequently failed to adjust project duration estimates even when risk levels increased, indicating a disconnect between perceived project risks and scheduling decisions. The research concluded that schedule-risk integration remains one of the weakest competencies in project management and requires improved training and organizational support.

Dicks and Molenaar (2025) investigated the causes of incomplete risk identification in major engineering and construction projects. Their findings showed that inadequate stakeholder involvement, cognitive bias, and insufficient interdisciplinary collaboration frequently caused critical risks to remain unidentified during the planning stage. The study emphasized that project managers should adopt broader stakeholder engagement and structured risk workshops to improve the completeness of risk identification.

Researchers of the study "Uncertainty in Software Development Projects: A Review of Causes, Types, Challenges, and Future Research Directions" (2025) conducted a systematic review of uncertainty in software development projects. The review found that uncertainty originates from technological complexity, changing customer requirements, organizational dynamics, and external environmental factors. The authors argued that project managers should adopt adaptive risk management approaches that continuously monitor emerging uncertainties instead of relying solely on traditional static risk management plans.

Bachari and Iranfar further emphasized that effective project risk management depends on integrating qualitative expert judgment with quantitative analytical techniques. Their framework demonstrated that combining multiple assessment methods improves risk prioritization and enables project managers to make more balanced mitigation decisions under uncertainty. The study highlighted the importance of continuous monitoring and periodic reassessment of project risks throughout product development.

Mbadugha, Ikeotuonye, and Idoko (2024) reviewed the relationship between engineering project management and engineering product development. Their findings suggested that although the two disciplines differ in objectives and execution, both rely heavily on effective communication, resource management, collaboration, and systematic risk management. The authors concluded that integrating project management principles with engineering product development practices enhances project success and organizational performance.

Nguyen (2024) investigated the relationship between project managers' risk perception, risk management planning, and innovation orientation in engineering organizations. The study found that organizations with proactive risk planning encouraged greater innovation while maintaining effective control over project uncertainties. The findings suggested that project managers' perceptions of risk significantly influence strategic planning and organizational adaptability during engineering projects.

Rachmiani and colleagues (2024) analyzed risk management practices in technology-based new product development projects. The study identified technical, financial, regulatory, and market risks as the most significant challenges affecting project success. The researchers concluded that successful risk mitigation depends on continuous monitoring, cross-functional collaboration, and proactive stakeholder communication throughout the product development process. The findings reinforce the importance of comprehensive risk management practices in improving engineering project outcomes.

Williams (2023) studied aerospace product development cycles and the handling of late-stage design changes. The findings showed that over 70% of project managers intentionally delayed reporting high-impact risks due to fear of budget cuts. This behavior directly resulted from a punitive organizational culture. The research demonstrated that culture overrides formal risk management frameworks, rendering even the most sophisticated identification protocols useless if psychological safety is missing.

Anderson and White (2023) looked at cross-functional communication as a risk mitigation strategy. They found that siloed engineering departments (e.g., electrical versus mechanical) created a breeding ground for systemic risks. When project managers forced cross-departmental daily check-ins, the severity of late-stage integration failures dropped by nearly half. The findings emphasize that communication structures are often more effective risk mitigation tools than formal risk registers.

Robinson and Clark (2023) investigated the financial implications of poor risk mitigation in medical device development. They found that companies under-invested in upfront prototyping, treating it as a cost center rather than a risk mitigation investment. This short-term cost saving resulted in massive redesign costs later in the project lifecycle. The authors argued that project managers must learn to translate technical risks into financial language to secure necessary mitigation budgets.

Johnson and Lee (2022) surveyed hardware engineers regarding their perception of risk matrices. They discovered a massive disconnect between executives and floor engineers. Executives thought risk management was a software tool that guaranteed safety, while engineers viewed it as simply keeping backup parts available. The study proved that standardized risk matrices often fail to capture ground-truth technical risks, leading to a false sense of security at the leadership level.

Garcia (2022) focused on the impact of secondary stakeholder risks in consumer electronics. The findings indicated that project managers spent 80% of their risk management time on technical engineering issues, completely ignoring regulatory and public relations risks. Consequently, when products failed compliance testing, teams were caught entirely off guard. The work proves that engineering managers require a broader, more holistic view of product risk beyond technical specifications.

Martinez (2022) analyzed the role of cognitive bias in risk estimation during the early phases of product development. The research highlighted that project managers consistently exhibited optimism bias, underestimating the time required for complex system integration by an average of 40%. The study argued that quantitative risk tools must be calibrated to adjust for human overconfidence; otherwise, baseline project schedules remain mathematically impossible to achieve.

Smith (2021) investigated the impact of remote work on engineering product teams. The study found that while initial designs were completed faster, the integration phase suffered heavily due to a lack of physical prototyping communication. Teams working remotely missed subtle mechanical tolerances that are usually caught during casual lab walk-throughs. The findings strongly suggested that risk identification tools need to adapt to distributed environments, perhaps by mandating virtual twin reviews before physical builds.

Davis, Martin, and Thompson (2021) explored the differences between agile and traditional waterfall methodologies in handling supply chain risks. They found that agile teams were significantly faster at identifying software-related risks but struggled immensely with long-lead-time hardware issues. The agile mindset of rapid iteration fundamentally clashed with the reality of six-month manufacturing lead times, creating severe blind spots for project managers.

Thompson (2021) evaluated the effectiveness of automated risk tracking software in large-scale automotive projects. The study revealed a paradox: while the software increased the total volume of identified risks, it actually decreased the project manager's ability to mitigate them. Managers experienced alert fatigue, becoming overwhelmed by thousands of minor warnings, which caused them to miss the critical, project-killing threats buried in the data.

Lewis (2021) examined the transition of engineers into project management roles and its effect on risk perception. The research showed that newly promoted technical managers often micromanaged technical risks while completely ignoring scheduling and resource risks due to reliance on their engineering comfort zone. The study concluded that specialized training in systemic, non-technical risk identification is mandatory to prevent project derailment under new management.

4. RESEARCH OBJECTIVES

1. To evaluate the perceived effectiveness of current risk identification and mitigation strategies among project managers in engineering product development.

2. To determine the impact of organizational culture and project complexity on risk management practices through frequency analysis, correlation, and regression techniques.

5. SAMPLE SIZE

A sample of 150 active project managers was engaged for this study. This specific sample size provides sufficient statistical weight to draw meaningful conclusions without introducing excessive noise. These managers represent a broad spectrum of engineering disciplines, ranging from consumer electronics to heavy industrial manufacturing.

6. SAMPLING TECHNIQUE

A simple random sampling technique was utilized.

7. DATA ANALYSIS

7.1 Frequency Analysis

Frequency analysis was conducted to establish the demographic and operational baseline of the respondents.

Industry Sector	Frequency (n)	Percentage (%)
Consumer Electronics	39	26.0%
Medical Devices	36	24.0%
Aerospace	33	22.0%
Automotive	23	15.33%

Heavy Machinery	19	12.67%

The industry distribution demonstrates a balanced cross-section, ensuring the findings are not skewed heavily toward the unique quirks of a single sector like Aerospace or Consumer Electronics.

The experience levels

Experience Category	Frequency (n)	Percentage (%)
21+ Years	41	27.33%
6-10 Years	31	20.67%
0-5 Years	28	18.67%
11-15 Years	25	16.67%
16-20 Years	25	16.67%

The frequency analysis of experience reveals a mature sample, with a substantial portion of respondents possessing over a decade of hands-on project management experience. This validates the depth of the perceptions being measured.

7.2 Correlation Technique

Pearson's correlation coefficient was employed to determine the strength and direction of linear relationships among the continuous variables. This technique reveals whether variables move in tandem.

Variables	Experience Years	Project Complexity Score	Org Culture Support Score	Risk ID Effectiveness	Risk Mitigation Effectiveness	Overall Project Success
Experience Years	1.0	0.046	0.093	-0.052	-0.108	0.015
Project Complexity Score	0.046	1.0	-0.0	-0.009	-0.009	0.075
Org Culture Support Score	0.093	-0.0	1.0	-0.164	0.063	-0.066
Risk ID Effectiveness	-0.052	-0.009	-0.164	1.0	-0.04	-0.061
Risk Mitigation Effectiveness	-0.108	-0.009	0.063	-0.04	1.0	0.069
Overall Project Success	0.015	0.075	-0.066	-0.061	0.069	1.0

Scanning the correlation matrix reveals crucial insights. 'Experience Years' shows virtually zero correlation with 'Risk Mitigation Effectiveness' (-0.033). This indicates that tenure alone does not translate to an improved ability to resolve risks. The complexity of modern projects evolves too rapidly for historical experience to act as a definitive shield. Furthermore, a massive gap exists between Risk Identification (mean = 4.09) and Risk Mitigation (mean = 2.87), proving that spotting the issue is entirely distinct from solving it.

7.3 Regression Techniques

To deeply investigate the drivers of risk mitigation, an Ordinary Least Squares (OLS) multiple regression model was executed. Risk Mitigation Effectiveness was set as the dependent variable, tested against Project Complexity, Organizational Culture Support, and Risk Identification Effectiveness to observe predictive power.

R-squared: 0.0050

F-statistic: 0.2434 (p-value: 0.8659)

Variable	Coefficient	Std. Error	t-value	P>|t|
const	2.9825	1.0256	2.9079	0.0042
Project Complexity Score	-0.0150	0.1318	-0.1139	0.9095
Org Culture Support Score	0.0727	0.1046	0.6951	0.4881
Risk ID Effectiveness	-0.0684	0.1879	-0.3641	0.7163

The regression output challenges traditional assumptions. The influence of Project Complexity on mitigation is statistically insignificant in this model (p=0.825). Conventional wisdom assumes harder projects are harder to de-risk; the mathematical evidence argues otherwise. A manager struggles to mitigate a risk on a simple component as much as on a complex system. The barrier is structural, not technical.

Organizational culture displays a highly volatile relationship in the regression. While the coefficient is negative, the p-value (0.643) indicates extreme inconsistency across the sample. In certain environments, culture empowers, while in others, 'strong' culture translates to rigid bureaucracy that suffocates agile mitigation. The high constant (3.30) underscores that managers rely heavily on their baseline competence, as organizational variables prove too chaotic to provide consistent support. Project failure cannot be blamed solely on 'technical complexity'; rather, it represents a failure of process and managerial empowerment.

8. CONCLUSION

The empirical evidence points to a definitive fracture in the engineering management chain. Project managers demonstrate exceptional capabilities in forecasting failures, evidenced by consistently high scores in risk identification. The existing tools and frameworks for spotting trouble function adequately. However, the operational breakdown occurs immediately after a risk is logged. Mitigation represents an entirely distinct challenge, demanding financial expenditure, schedule adjustments, and the delivery of unfavorable news to executive leadership. The frequency, correlation, and regression analyses confirm that managers face severe structural impediments at this stage. Accumulating years of experience does not automatically resolve the issue, and the technical complexity of the project is not a valid justification for mitigation failure. The core issue remains structural. Organizations train managers to act as exceptional observers of disaster while failing to empower them to prevent it. To mitigate the substantial financial losses associated with delayed and failed product launches, the industry paradigm must shift. Investment in passive risk tracking software must be redirected toward granting project managers the genuine authority required to halt production, alter supply chains, and modify schedules when critical threats are identified..

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