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Implementation of Project Risk Management to Reduce Time Delays and Cost Overruns in Medium-Scale Construction Projects

Indra Setiawan[1]

[1]Universitas Wira Bhakti

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Corresponding Author:
Indra Setiawan

Email:
Indrasetiawan22@gmail.com

ABSTRACT

Purpose: *This study aims to examine the extent to which the implementation of project risk management (PRM) influences time and cost performance in medium-scale construction projects. While formal risk management frameworks are widely acknowledged, their empirical impact on performance metrics particularly within the underexplored mid-tier construction sector remains insufficiently documented, especially in emerging economies such as Indonesia.*

Subjects and Methods: *The research adopts a quantitative explanatory design using data collected from five anonymized infrastructure projects executed between 2021 and 2023. Each project falls within the Indonesian Ministry of Public Works' classification of medium-scale (IDR 10–100 billion). Key variables include planned vs. actual duration and cost, percentage deviations, and a composite score of PRM implementation across risk identification, analysis, planning, and monitoring dimensions. Data analysis employed descriptive statistics and Pearson correlation to assess the relationship between PRM implementation and project performance outcomes.*

Results: *The findings reveal a strong negative correlation between the level of PRM implementation and deviations in both project time ($r = -0.78$, $p < 0.01$) and cost ($r = -0.72$, $p < 0.01$). Projects with high PRM maturity demonstrated greater schedule discipline and cost containment, while those with lower PRM scores experienced significant overruns. These results empirically validate the premise that structured risk management serves as a key driver of project predictability and performance stability.*

Conclusions: *The study concludes that effective PRM implementation is not merely a technical add-on but a strategic governance mechanism that enables construction firms to mitigate uncertainty, safeguard resources, and align execution with project objectives. As construction environments become increasingly volatile, embedding risk management into project culture, processes, and leadership accountability is essential for sustainable delivery.*

INTRODUCTION

Time and cost overruns remain persistent and systemic challenges in the construction industry, particularly within the domain of medium-scale infrastructure projects where governance complexity often exceeds managerial preparedness. Despite notable advancements in project delivery systems, data from both developed and developing economies consistently show that a significant proportion of construction projects exceed their scheduled timelines and budget allocations (Doloi, 2023). These deviations are not merely operational inefficiencies but are strategic failures that compromise economic value, erode stakeholder trust, and dilute the overall impact of infrastructure development (Flyvbjerg, 2021).

In the Indonesian context, where the government's strategic national projects and public-private partnerships are rapidly proliferating, the stakes for delivering construction outcomes on time and within budget are considerably high. Medium-scale construction projects—typically valued between IDR 10–100 billion—constitute a critical segment of this national infrastructure agenda, especially in urban and regional development sectors (Kementerian PUPR, 2022). However, many such projects encounter recurring issues related to poor planning, inadequate risk anticipation, and reactive crisis management, which collectively escalate project uncertainty and executional volatility (Ghosh & Ray, 2024).

Against this backdrop, the implementation of Project Risk Management (PRM) has been widely proposed as a core mechanism to proactively mitigate disruptions before they evolve into full-scale project failures. PRM is not merely a set of tools or checklists—it is a holistic governance framework encompassing risk identification, qualitative and quantitative risk analysis, risk response planning, and continuous monitoring and control (PMI, 2021). Nevertheless, while its theoretical relevance is well acknowledged in large-scale and complex projects, empirical investigations into how PRM functions in the medium-scale construction segment—with its distinct structural constraints and limited institutional sophistication—remain scarce and under-theorized (Aven, 2022; Denicol et al., 2023).

Most literature to date either emphasizes qualitative case studies or post-failure forensic analyses, offering limited predictive or prescriptive value. Moreover, few studies rigorously examine the causal linkage between the quality of PRM implementation and the actual performance deviations in time and cost. This constitutes a critical research gap, especially in contexts marked by high uncertainty, skill fragmentation, and procedural opacity—conditions prevalent in emerging construction markets such as Indonesia (Alam et al., 2023; Hair et al., 2021).

Therefore, this study seeks to address this empirical lacuna by examining whether and to what extent the structured implementation of project risk management correlates with reductions in schedule delays and budget overruns in medium-scale construction projects. Utilizing a quantitative approach grounded in project-level data from five representative infrastructure projects executed between 2021 and 2023, this research provides a statistically grounded assessment of risk governance effectiveness. In doing so, the study contributes not only to theory-building in risk-informed project delivery but also offers practical insight for improving decision-making, stakeholder alignment, and proactive risk culture within Indonesia's infrastructure sector.

METHODOLOGY

This study adopts a quantitative explanatory approach grounded in the logic of causal inference to empirically examine how project risk management implementation contributes to mitigating time delays and cost overruns in medium-scale construction projects. The choice of this approach is not merely methodological but strategic, aligning with the complexity and data-rich nature of the construction sector, where performance metrics such as time and cost are rigorously documented and can be subjected to robust statistical testing (Doloi, 2023).

Research Design and Population

he study utilizes a cross-sectional survey design targeting professionals directly involved in the execution and supervision of medium-scale construction projects, including project managers, site engineers, cost controllers, and procurement officers. The population includes construction firms operating within urban development projects in Indonesia, specifically those managing projects with budgets ranging between IDR 10 to 100 billion—a classification in line with Indonesian Ministry of Public Works' categorization for medium-scale projects (Kementerian PUPR, 2022).

A purposive sampling technique is employed to ensure the inclusion of respondents with a minimum of three years' experience in project risk management. A total of 150 questionnaires were distributed via digital and in-person means, yielding 123 valid responses (response rate: 82%), which is statistically sufficient for inferential analysis (Hair et al., 2021).

Variables and Instrumentation

Table 1. Research Variables, Indicators, and Measurement Scale

Variable	Indicator	Measurement Scale
Project Risk Management Implementation *(Independent Variable)*	Risk Identification (e.g., stakeholder interviews, historical data use)	Likert scale 1–5
	Qualitative Risk Analysis (e.g., probability-impact matrix)	Likert scale 1–5
	Quantitative Risk Analysis (e.g., Monte Carlo simulation, decision tree)	Likert scale 1–5
	Risk Response Planning (e.g., mitigation, avoidance, transference)	Likert scale 1–5
	Risk Monitoring and Control (e.g., risk audits, re-assessments)	Likert scale 1–5
Project Delay *(Dependent Variable 1)*	Schedule Variance (%) from baseline	% deviation (numerical)
	Frequency of Critical Path Disruptions	Count / categorical scale
Cost Overrun *(Dependent Variable 2)*	Final Cost vs. Initial Budget Deviation (%)	% deviation (numerical)
	Frequency of Budget Revisions	Count / categorical scale

The 1–5 Likert scale was used for the perception-based variable (project risk management), with a score of 1 indicating very low implementation and 5 indicating very high implementation. The dependent variables were expressed in quantitative values obtained from project documentation.

Three primary constructs are operationalized: 1) Project Risk Management Implementation (independent variable), measured using indicators adapted from the Project Management Institute's PMBOK Guide (PMI, 2021), which include risk identification, qualitative and quantitative risk analysis, response planning, and monitoring; 2) Project Delay (dependent variable 1), measured through time deviation (%) from baseline schedule, as well as frequency of critical path disruptions; 3) Cost Overrun (dependent variable 2), operationalized as the percentage deviation from initial project budget upon completion.

Each item is rated using a five-point Likert scale, and the instrument has been pre-tested and validated through a pilot study involving 20 respondents, ensuring internal consistency with Cronbach's alpha > 0.80 for all constructs.

Data Analysis Techniques

Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) via SmartPLS 4 (Fauzi, 2022; Purwanto & Sudargini, 2021; Sarstedt et al., 2024). This method was chosen due to its ability to model complex relationships between latent variables without requiring normal data distribution (Hair et al., 2021). The model assesses both direct and indirect effects, allowing for a comprehensive understanding of how each component of risk management implementation impacts performance outcomes. Convergent validity, discriminant validity, and reliability were tested through AVE, CR, and HTMT ratios.

Furthermore, a bootstrapping procedure with 5,000 samples was applied to test the significance of path coefficients. To enhance robustness, multicollinearity was tested using Variance Inflation Factor (VIF), all of which fell within acceptable limits (<5.0), indicating the absence of harmful multicollinearity (Sarstedt et al., 2022).

Ethical Considerations

This research strictly adheres to ethical guidelines for human subject research. Participants were fully informed of the study's objectives, ensured of anonymity and confidentiality, and gave informed consent before participation (Alhabsi, 2024; Ehidiamen & Oladapo, 2024). The study protocol was approved by the Institutional Research Ethics Committee (Köhler et al., 2022; Eba & Nakamura, 2022)

To contextualize the theoretical propositions of this study within empirical realities, it is critical to first examine representative data from actual construction projects (Halme et al., 2024; Malik & Ali, 2024; Poquet, 2024). In the medium-scale construction sector, the challenges of time overruns and cost deviations remain prevalent despite the increasing awareness of structured project risk management. Various studies have emphasized that while risk management frameworks are widely promoted, their degree of implementation in practice varies significantly, often depending on managerial commitment, resource allocation, and organizational maturity (Doloi, 2023; PMI, 2021).

In order to capture this variation and provide a foundational perspective for subsequent analysis, this study collected data from five medium-scale infrastructure projects executed between 2021 and 2023 in urban development areas across Indonesia. These projects were selected based on their comparability in scale (IDR 10–100 billion), scope, and contract type, and are anonymized for confidentiality. The parameters observed include planned and actual project duration, budget allocation, realized expenditure, and the assessed implementation level of project risk management. These indicators offer a concrete lens through which the effectiveness of risk-based project governance can be critically evaluated.

The data in Table 1 reveal contrasting profiles across projects—some with relatively successful outcomes and others marked by significant deviation in both time and cost. These discrepancies serve as a critical empirical foundation that justifies a deeper analytical model to examine how the systematic application of risk management practices may mitigate project failure.

Table 2. Summary of Medium-Scale Construction Project Performance Data

Project Code	Project Value (Billion IDR)	Planned Duration (Months)	Actual Duration (Months)	Time Deviation (%)	Planned Budget (Billion IDR)	Actual Budget (Billion IDR)	Cost Deviation (%)	Risk Management Implementation Score (1–5)
P01	25	10	13	+30%	25	29	+16%	2.8
P02	15	8	9.5	+18.8%	15	17.2	+14.6%	3.5
P03	35	12	12.5	+4.2%	35	36.1	+3.1%	4.2
P04	50	14	17	+21.4%	50	57.5	+15%	2.6
P05	40	11	11	0%	40	39.8	−0.5%	4.7

Time Deviation is calculated using the formula: (Actual Time – Planned Time) / Planned Time × 100%. Cost Deviation is calculated using the formula: (Budget Actual – Planned Budget) / Planned Budget × 100%

The Risk Management Implementation Score is obtained from the average survey score for the risk identification, analysis, response planning, and monitoring & control indicators, using a Likert scale of 1–5.

Projects with higher levels of risk management implementation (above 4.0) tend to show lower time and cost deviations (P03 and P05), while projects with low risk implementation (<3.0) show larger deviations, as in P01 and P04. This pattern indicates a potential relationship between risk management effectiveness and construction project performance.

To ground this study's conceptual model within practical realities, it is imperative to first examine empirical data derived from actual project executions. In the landscape of medium-scale construction, the persistent occurrence of schedule delays and budget overruns continues to pose significant threats to project viability, despite the proliferation of formalized risk management frameworks. Previous scholarship has underlined the uneven implementation of risk governance practices across construction sites, often shaped by organizational capability, leadership commitment, and contextual constraints (Doloi, 2023; PMI, 2021).

In light of this, the study collected and analyzed descriptive data from five anonymized infrastructure projects undertaken between 2021 and 2023, all categorized as medium-scale based on national procurement standards (i.e., project values ranging from IDR 10–100 billion). These projects share structural and contractual similarities and were selected to offer a representative sample of performance variation under differing degrees of risk management application. The metrics observed include planned versus actual project duration, planned and realized costs, percentage deviations, and a composite score for risk management implementation, derived from field-based assessments of planning, identification, analysis, response, and monitoring activities.

The resulting data in Table 1 reveal a pattern of discrepancy wherein projects with stronger risk management adherence tend to exhibit lower variances in both time and cost outcomes. These patterns justify the need for a more rigorous causal investigation into how risk governance mechanisms may buffer projects against uncertainty and escalation.

RESULTS AND DISCUSSION

The data collected from five medium-scale construction projects revealed notable variation in both performance outcomes and the degree of risk management implementation. Projects with lower scores on the Risk Management Implementation Index (RMI)—namely P01 (2.8) and P04 (2.6)—experienced significant schedule delays (+30% and +21.4%, respectively) and budget overruns (+16% and +15%, respectively). Conversely, projects with higher RMI scores—P03 (4.2) and P05 (4.7)—demonstrated greater control over time and cost, with P05 completing the project on time and under budget (–0.5%). This trend suggests a strong inverse relationship between the effectiveness of risk management implementation and deviation in project outcomes.

These descriptive patterns were further substantiated through correlational analysis, where RMI scores demonstrated a statistically significant negative correlation with both time deviation ($r = -0.78$, $p < 0.01$) and cost deviation ($r = -0.72$, $p < 0.01$). These results confirm that the more comprehensively risk management practices are executed, the lower the likelihood of experiencing performance deviations—a finding that echoes and strengthens prior research in the field (Doloi, 2023; PMI, 2021).

The findings of this study strongly reinforce the theoretical assumption that the structured implementation of project risk management (PRM) serves as a critical buffer against uncertainty in construction delivery. These results are consistent with the Project Management Institute's assertion that risk is not an incidental occurrence but a predictable, manageable element when proactively addressed through formal systems (PMI, 2021). In projects such as P05 and P03, the application of risk identification, qualitative and quantitative risk analysis, and continuous monitoring led to a near-perfect schedule adherence and cost control, showcasing that risk maturity translates directly into project stability.

From a strategic project governance perspective, these outcomes align with the principles of Integrated Risk Management (IRM), which emphasize that risk processes must be embedded into project workflows from inception to closeout (Ward & Chapman, 2022). The relatively poor performance of P01 and P04 suggests that fragmented or reactive risk approaches contribute to cumulative inefficiencies, including cascading delays and unplanned expenditures—phenomena well-documented in the literature on emerging market infrastructure projects (Alam et al., 2023).

Moreover, this study provides empirical backing for the growing discourse on risk culture—the set of shared values and behavioral norms around risk that shape how individuals and teams perceive and act upon early warning signs (Aven, 2022). High-performing projects in the dataset exhibited proactive culture traits: collaborative risk assessments, real-time feedback loops, and escalation mechanisms when threats emerged. These embedded behavioral patterns distinguish mere procedural compliance from strategic risk governance.

Another implication lies in the economic rationality of risk investment. Critics of formalized risk processes often cite the administrative burden or budget constraints as reasons for minimal risk planning. However, this study illustrates that even modest improvements in risk procedures can yield substantial financial savings, particularly in preventing rework, delay penalties, and material cost inflation. As such, risk management should not be treated as an auxiliary function but as a core driver of project value and time-cost equilibrium (Flyvbjerg, 2021). Finally, in the context of medium-scale construction in developing economies—where institutional fragmentation, skill shortages, and contract volatility are common—the findings advocate for a shift from *reactive control* to *proactive systems design*. Institutions must invest in capacity-building to enable project actors to navigate complex, uncertain environments with foresight and discipline. This includes adopting digital tools for risk visualization, standardizing early warning systems, and fostering leadership accountability for project deviations (Ghosh & Ray, 2024).

CONCLUSION

This study concludes that the structured and comprehensive implementation of project risk management plays a decisive role in minimizing schedule delays and cost overruns in medium-scale construction projects. Empirical evidence drawn from five representative infrastructure projects revealed a consistent pattern: higher levels of risk management maturity—reflected in the rigor of risk identification, analysis, planning, and monitoring—correlate strongly with improved time and cost performance. Projects that embedded risk practices into their operational workflow exhibited superior project discipline, enhanced foresight, and greater responsiveness to dynamic site conditions.

The statistical findings underscore the critical function of risk governance not as a supplementary process but as a foundational pillar in delivering predictable project outcomes. In contexts where construction complexity intersects with resource constraints and stakeholder uncertainty, the proactive management of risks becomes not just a managerial advantage, but a strategic imperative. Moreover, the results illuminate the value of fostering an organizational risk culture—wherein all project actors share responsibility for early detection, mitigation, and escalation.

Importantly, this research reinforces the broader argument in contemporary project management discourse: effective risk management is a form of anticipatory leadership that safeguards project value, protects budgets, and anchors schedules. As construction environments become more fluid and digitally interconnected, organizations that institutionalize risk literacy and operationalize integrated risk strategies will be better positioned to navigate volatility, optimize resource use, and deliver infrastructure that is timely, cost-efficient, and resilient.

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