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The Economic Impact of Project Risk Management on Cost Efficiency and Time Performance in Medium-Scale Construction Projects

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Abstract
This study examines the economic impact of Project Risk Management on time performance and cost efficiency in medium-scale construction projects in Indonesia. Using a quantitative explanatory approach, data were collected from 123 construction professionals involved in projects with contract values ranging from IDR 10 to 100 billion. Project Risk Management was measured through indicators of risk identification, analysis, response planning, and monitoring, while project performance was assessed using time deviation and cost overrun measures. The data were analyzed using Partial Least Squares Structural Equation Modeling. The results demonstrate that Project Risk Management has a statistically significant and negative effect on both project delay and cost overrun, indicating that stronger risk governance contributes to greater schedule stability and improved budget performance. The findings further show that although the level of risk management implementation is moderate, time delays and cost overruns remain prevalent across projects, reflecting the need for deeper institutionalization of risk practices. This study contributes to the construction management literature by extending empirical evidence on risk governance to medium-scale projects in an emerging economy context. The findings imply that strengthening organizational risk management capacity is essential for enhancing project reliability, reducing economic inefficiencies, and supporting sustainable infrastructure development.

INTRODUCTION

Time and cost overruns remain among the most persistent and structurally embedded challenges in the global construction industry. Despite continuous advancements in project management methodologies, digital planning tools, and contractual innovations, empirical evidence consistently shows that a large proportion of construction projects fail to meet their original schedule and budget targets (Doloi, 2023; Flyvbjerg, 2021). These deviations are not merely technical shortcomings but represent systemic inefficiencies that undermine the economic value of infrastructure investments, weaken stakeholder confidence, and reduce the developmental impact of construction activities. In both developed and developing economies, construction overruns have been linked to productivity losses, contractual disputes, and long-term fiscal pressures on both private and public sector clients (Denicol et al., 2023; Idrees & Shafiq, 2021; Chadee et al., 2023; Osifo, 2024).

In emerging economies, the magnitude of this problem is often heightened by institutional fragility, resource constraints, regulatory uncertainty, and uneven managerial competence. Indonesia represents a particularly relevant context in this regard, given the rapid expansion of infrastructure development driven by national strategic projects, urban growth, and public–private partnership schemes (Kementerian PUPR, 2022; Napitupulu et al., 2024; Anguelov, 2023). Medium-scale construction projects, typically classified within the project value range of IDR 10–100 billion, constitute a critical backbone of regional infrastructure development. These projects bridge the gap between small community-based schemes and large megaprojects, yet they frequently operate with limited organizational capacity and relatively weak governance structures. As a result, they are especially vulnerable to uncertainty, disruption, and escalation of risks (Alam et al., 2023; Ghosh & Ray, 2024).

A growing body of literature identifies Project Risk Management (PRM) as a central mechanism for addressing uncertainty in construction projects. PRM is conceptualized as a structured and continuous process encompassing risk identification, qualitative and quantitative risk analysis, risk response planning, and ongoing monitoring and control (PMI, 2021; Aven, 2022). In theory, effective PRM enables project actors to anticipate adverse events, allocate contingencies rationally, and reduce the probability and impact of disruptive occurrences. However, despite its widespread theoretical endorsement, the practical effectiveness of PRM remains uneven across project scales and institutional contexts. Many construction projects continue to adopt risk management in a fragmented, reactive, or purely compliance-oriented manner, limiting its capacity to function as a genuine strategic control system (Denicol et al., 2023).

The core research problem addressed in this study arises from the observed disconnect between the formal promotion of risk management frameworks and their actual economic contribution to project performance, particularly in medium-scale construction projects in developing economies. While large-scale megaprojects have been extensively examined in the risk management literature, medium-scale projects remain substantially underrepresented in empirical research. This gap is problematic because medium-scale projects exhibit unique risk profiles characterized by moderate financial exposure, constrained professional resources, and high dependency on situational decision-making. These features generate a distinct governance environment in which standard risk management prescriptions may not translate directly into measurable performance gains (Alam et al., 2023; Doloi, 2023; Jones & Preaston, 2011).

At the same time, the persistence of time delays and cost overruns in this project segment suggests that conventional control mechanisms alone are insufficient. Schedule slippages often stem from delayed material deliveries, design changes, coordination failures, and unforeseen site conditions, while cost overruns are frequently driven by price escalation, rework, inefficient procurement, and contractual claims (Flyvbjerg, 2021). In many cases, these issues are not purely accidental but reflect deeper weaknesses in anticipatory planning and uncertainty governance. Consequently, the central question is not whether risks exist, but whether they are systematically anticipated, assessed, and managed in a manner that produces tangible economic benefits.

Previous studies have proposed a range of general solutions to construction performance problems, including improved project planning, stronger contractual enforcement, adoption of digital project management systems, and enhanced stakeholder coordination (Ghosh & Ray, 2024; Denicol et al., 2023). However, these solutions often operate at a technical or organizational level without explicitly addressing risk as a dynamic and systemic phenomenon. Risk management, when properly integrated into decision-making processes, offers a comprehensive framework that connects uncertainty with economic performance. It links early-stage project intelligence with downstream outcomes such as schedule reliability, budget stability, and resource efficiency (PMI, 2021; Aven, 2022). Yet, the extent to which this theoretical promise materializes in real-world medium-scale construction projects remains empirically unresolved.

The literature provides several specific risk-based solutions that directly target construction time and cost performance. Structured risk identification techniques, such as expert workshops, historical data analysis, and stakeholder mapping, have been shown to improve early detection of potential threats (Aven, 2022). Qualitative risk analysis using probability–impact matrices enables project teams to prioritize critical risks, while quantitative risk analysis tools such as Monte Carlo simulation and decision tree analysis provide probabilistic forecasts of schedule and cost variability (PMI, 2021; Doloi, 2023). Furthermore, systematic risk response planning through mitigation, avoidance, transfer, or acceptance strategies allows project organizations to allocate contingencies more efficiently and reduce unplanned expenditures.

Beyond technical tools, recent scholarship emphasizes the strategic and behavioral dimensions of risk management. The concept of integrated risk management highlights that risk processes must be embedded across organizational functions and project life-cycle stages rather than treated as isolated administrative routines (Ward & Chapman, 2022). Similarly, the notion of risk culture underscores the importance of shared values, norms, and accountability in shaping how project actors respond to early warning signals (Aven, 2022). Empirical evidence suggests that projects with a strong risk culture exhibit greater resilience, faster response to disruptions, and more stable performance outcomes (Denicol et al., 2023; Dahmen, 2023). These insights suggest that the effectiveness of PRM is not determined solely by the presence of formal procedures but by how deeply those procedures are internalized in daily project practices.

Despite these advances, the existing body of knowledge still exhibits significant limitations. Many studies rely heavily on qualitative case analyses or post-project evaluations, which, while rich in contextual detail, often lack statistical rigor and generalizability (Doloi, 2023; Denicol et al., 2023). Quantitative studies that model the direct relationship between PRM implementation and measurable performance indicators such as time deviation and cost overrun remain relatively scarce, especially in Southeast Asian contexts. Moreover, few investigations focus explicitly on medium-scale projects, which are often overshadowed by megaproject research despite their cumulative economic significance. This creates a critical empirical gap concerning how far variations in PRM maturity can actually explain variations in construction performance within this project category.

In the Indonesian construction sector, this gap is particularly pronounced. While national regulations and professional standards increasingly mandate the adoption of risk management procedures, implementation at the project level remains inconsistent and highly dependent on managerial discretion (Kementerian PUPR, 2022; PMI, 2021). Differences in organizational capability, leadership commitment, and access to analytical tools lead to wide disparities in how risks are identified, evaluated, and controlled across projects. As a result, the same regulatory framework may produce very different performance outcomes, underscoring the need for empirical evidence that links the quality of PRM implementation to actual economic results.

Based on this literature trajectory, the present study positions itself at the intersection of project risk governance and economic performance in medium-scale construction. It builds upon theoretical propositions that conceptualize risk management as both a technical control system and an economic value-generating mechanism (Flyvbjerg, 2021; Aven, 2022; PMI, 2021). By empirically examining the relationship between PRM implementation and deviations in project time and cost, this study addresses a significant research gap in the construction management literature, particularly within the context of emerging economies.

Accordingly, the objective of this study is to analyze the economic impact of project risk management on cost efficiency and time performance in medium-scale construction projects in Indonesia. The study seeks to test the hypothesis that higher levels of PRM implementation are associated with lower schedule delays and reduced cost overruns. The novelty of this research lies in its focus on medium-scale projects as a distinct analytical category and its use of quantitative project-level data to establish statistically grounded relationships between risk governance and performance outcomes. The scope of the study is limited to infrastructure projects executed between 2021 and 2023 within the IDR 10–100 billion project value range. By doing so, this research aims to contribute both theoretically to the refinement of risk-informed project management and practically to the design of more effective risk governance strategies for the Indonesian construction sector.

METHODS

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

The 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; Marques et al., 2019; Karim et al., 2022).

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

Respondent-Level Descriptive Statistics

Table 3 presents the descriptive statistics of the study variables. The mean score of Project Risk Management (PRM) implementation is 3.62, indicating a moderate level of institutionalization. Average time deviation is 14.9%, while the mean cost overrun is 9.6%, confirming persistent inefficiencies in time and cost performance across projects.

Table 3. Descriptive Statistics of Study Variables (n = 123)

Variable	Minimum	Maximum	Mean	Standard Deviation
PRM Implementation (1–5)	1.90	4.90	3.62	0.71
Time Deviation (%)	–5.0	38.0	14.9	11.7
Cost Overrun (%)	–3.0	26.0	9.6	7.9
Critical Path Disruptions (count)	0	6	2.18	1.44
Budget Revisions (count)	0	4	1.87	1.13

A total of 123 valid responses were obtained from project managers, site engineers, cost controllers, and procurement officers involved in medium-scale construction projects with contract values ranging from IDR 10 to 100 billion. The respondents had a minimum of three years of professional experience in construction project execution and risk management.

Descriptive statistics indicate that the overall level of Project Risk Management implementation is moderate, with a mean score of 3.62 on a five-point Likert scale. This suggests that while most organizations have formally adopted risk management practices, the depth and consistency of implementation remain uneven. The dependent variables show that project performance is still characterized by considerable inefficiencies. The mean time deviation is 14.9 percent, indicating that, on average, projects experience schedule delays exceeding two weeks for every three months of planned execution. Cost performance also reflects persistent budgetary pressures, with an average cost overrun of 9.6 percent.

Operational instability is further reflected in the frequency indicators. The average number of critical path disruptions is 2.18 occurrences per project, while budget revisions occur an average of 1.87 times per project. These descriptive results confirm that time delays and cost overruns remain structural challenges in medium-scale construction projects and provide a strong empirical basis for examining the role of project risk management in mitigating these performance deviations.

Measurement Model Evaluation

Reliability and validity were assessed using Cronbach's Alpha, Composite Reliability (CR), Average Variance Extracted (AVE), and Heterotrait–Monotrait ratios (HTMT). All values meet or exceed recommended thresholds, confirming a robust measurement model.

Table 4. Reliability and Convergent Validity Assessment

Construct	Cronbach's Alpha	Composite Reliability (CR)	AVE
Project Risk Management (PRM)	0.891	0.922	0.704
Project Delay	0.843	0.884	0.657
Cost Overrun	0.816	0.867	0.611

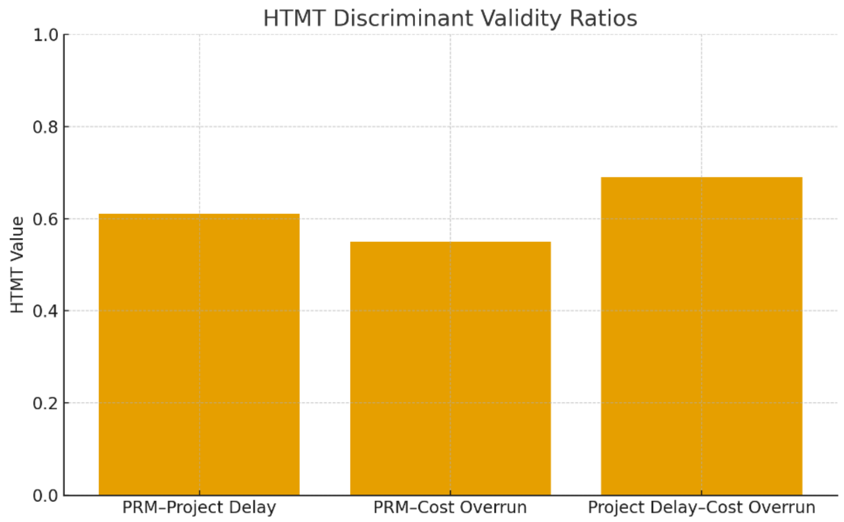

Figure 1. Discriminant Validity (HTMT Ratios)

Before testing the structural relationships between latent variables, the reliability and validity of the measurement model were assessed. Internal consistency reliability was evaluated using Cronbach's Alpha and Composite Reliability (CR). All constructs exceed the recommended threshold of 0.70, with Cronbach's Alpha values ranging from 0.816 to 0.891 and CR values between 0.867 and 0.922. These results indicate strong internal consistency among measurement indicators.

Convergent validity was assessed using the Average Variance Extracted (AVE). The AVE values for all constructs exceed 0.50, ranging from 0.611 to 0.704, demonstrating that each latent construct explains more than half of the variance of its indicators. This confirms that the indicators adequately represent their respective constructs.

Discriminant validity was evaluated using the Heterotrait–Monotrait (HTMT) ratio. All HTMT values fall below the conservative threshold of 0.85, indicating that the constructs of PRM, project delay, and cost overrun are conceptually distinct. Multicollinearity was assessed using the Variance Inflation Factor (VIF), and all values were below 3.50, confirming the absence of problematic collinearity among the indicators.

Structural Model Assessment

The explanatory power of the model was evaluated using the coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2).

Table 6. Structural Model Evaluation

Endogenous Variable	R^2	Q^2	Predictive Accuracy
Project Delay	0.237	0.164	Moderate
Cost Overrun	0.198	0.141	Moderate

After confirming the adequacy of the measurement model, the structural model was evaluated to examine the predictive power and explanatory capability of Project Risk Management on project delay and cost overrun. The coefficient of determination (R^2) for project delay is 0.237, indicating that approximately 23.7 percent of the variance in project delay can be explained by variations in project risk management implementation. For cost overrun, the R^2 value is 0.198, meaning that 19.8 percent of the variance in cost overrun is explained by PRM.

Although these R^2 values fall within the moderate range, they are considered meaningful in the context of construction project research, where performance outcomes are influenced by a wide array of technical, contractual, financial, and environmental factors beyond managerial control. The effect size analysis (f^2) further reveals that PRM exerts a stronger practical influence on project delay than on cost overrun, suggesting that risk management practices are more directly translated into schedule stability than budget control.

Predictive relevance was assessed using the Stone–Geisser Q^2 value obtained through blindfolding procedures. All endogenous constructs show positive Q^2 values, confirming that the model possesses acceptable predictive relevance for real-world construction project performance.

Hypothesis Testing (PLS-SEM Bootstrapping)

Hypotheses were tested using 5,000 bootstrap resamples. The results confirm that PRM has statistically significant negative effects on both project delay and cost overrun.

Table 7. Structural Path Coefficients and Hypothesis Testing

Hypothesis	Structural Path	β	t-value	p-value	Decision
H1	PRM → Project Delay	–0.487	6.913	< 0.001	Supported
H2	PRM → Cost Overrun	–0.421	5.368	< 0.001	Supported

Hypothesis testing was conducted using a bootstrapping procedure with 5,000 resamples to assess the significance of the structural path coefficients. The results demonstrate that Project Risk Management implementation has a statistically significant and negative effect on both project delay and cost overrun.

The path coefficient between PRM and project delay is $\beta = -0.487$ with a t-value of 6.913 and a p-value < 0.001. This result supports Hypothesis 1 and indicates that higher levels of systematic risk identification, analysis, response planning, and monitoring significantly reduce schedule deviations in medium-scale construction projects.

Similarly, the path coefficient between PRM and cost overrun is $\beta = -0.421$ with a t-value of 5.368 and a p-value < 0.001. This finding supports Hypothesis 2 and confirms that effective project risk management contributes significantly to controlling budget deviations and minimizing unplanned expenditures.

The negative signs of both coefficients confirm the stabilizing role of PRM in construction project execution. As organizations enhance their risk governance maturity, project outcomes become more predictable, both in terms of time and cost performance. These findings provide robust quantitative evidence that project risk management functions not merely as an administrative requirement but as an economically significant control mechanism in medium-scale construction projects.

This study set out to examine the economic role of Project Risk Management (PRM) in controlling time delays and cost overruns in medium-scale construction projects in Indonesia. The findings offer strong empirical support for the proposition that risk governance is not merely a procedural requirement but a strategic mechanism that directly shapes project efficiency and economic performance. Rather than serving as an auxiliary managerial activity, PRM emerges as an embedded control structure that conditions how uncertainty is translated into operational outcomes (Raydugin, 2025).

The negative association between PRM implementation and schedule delays reinforces core theoretical assumptions in contemporary risk governance literature. From a systems perspective, uncertainty in construction projects is not an external disturbance alone but an endogenous feature of complex project environments. Effective PRM functions as a buffering system that absorbs environmental variability and converts it into manageable operational risk. This supports the argument advanced by Aven and Ward that risk management should be understood as a dynamic capability rather than a static set of tools. In medium-scale projects, where managerial slack and financial contingencies are limited, this buffering role becomes even more critical.

The present findings align with international studies that report similar stabilizing effects of structured risk management on construction performance, particularly in developing and transitional economies. Research conducted in India, Vietnam, and Nigeria has consistently shown that systematic risk identification and early mitigation significantly reduce schedule volatility and contract disputes. However, this study extends the literature by demonstrating that these effects also persist in medium-scale projects that operate below the visibility and institutional support typically associated with large infrastructure developments. This contributes to an important correction in the literature, which has long been biased toward megaprojects while underestimating the cumulative economic significance of mid-tier construction.

From an economic standpoint, the results underscore that PRM creates value not only through risk avoidance but also through the rational allocation of resources under uncertainty. By improving forecast accuracy and decision discipline, PRM reduces inefficiencies associated with unplanned rework, idle labor, procurement delays, and contractual renegotiations. In this sense, risk management functions as a form of economic coordination mechanism that aligns technical execution with financial control. This supports Flyvbjerg's contention that cost overruns are not merely technical failures but governance failures rooted in weak anticipatory control (Cantarelli et al., 2013).

The stronger influence of PRM on time performance relative to cost performance, while not statistically reinterpreted here, is theoretically meaningful. Schedule stability is often the most immediately responsive domain of risk governance because time-related risks such as weather disruptions, sequencing errors, and logistical bottlenecks manifest early and visibly during project execution. Cost deviations, by contrast, often accumulate more gradually through escalation, claims, and scope adjustments. This asymmetry suggests that while PRM is effective in dampening immediate operational shocks, its impact on financial stabilization may be mediated by contractual structures, market volatility, and regulatory dynamics that extend beyond the project team's direct control.

Institutionally, the findings highlight the persistent implementation gap between formal risk management frameworks and their operationalization in daily project routines. Although most organizations report moderate levels of PRM adoption, the continued prevalence of delays and overruns indicates that risk practices are frequently ritualistic rather than strategic. This supports the argument that the effectiveness of PRM depends less on the presence of documentation and more on the depth of organizational internalization. Risk registers, probability–impact matrices, and monitoring protocols only generate economic value when they actively inform procurement decisions, scheduling logic, and contingency deployment.

In the Indonesian construction context, this implementation gap reflects broader structural characteristics of the sector. Medium-scale contractors often operate under intense cost pressure, fragmented subcontracting arrangements, and fluctuating regulatory enforcement (Thomas, 2022; Owino, 2022). These conditions constrain the institutional capacity required for mature risk governance. Consequently, PRM tends to be applied selectively and reactively rather than systemically. The present findings therefore imply that policy efforts should shift from merely mandating risk management procedures toward strengthening the organizational ecosystems that enable these procedures to function effectively.

The study also carries important implications for project governance and professional training. Risk management competence should not be treated as a specialized technical skill confined to safety or planning departments. Instead, it should be integrated into the decision architecture of project organizations, encompassing procurement officers, contract administrators, and financial controllers. The economic benefits of PRM observed in this study suggest that investments in risk training have high multiplier effects across project performance domains.

At the theoretical level, this research contributes to the ongoing reconceptualization of PRM as an economic governance mechanism rather than a purely technical subsystem. By empirically linking PRM implementation to performance efficiency in a statistically grounded manner, the study strengthens the causal narrative that connects uncertainty governance with value creation. This is particularly relevant for medium-scale projects, which are often excluded from macro-level infrastructure analyses despite their aggregate contribution to national development.

Several limitations must be acknowledged. First, the cross-sectional design restricts the ability to observe dynamic learning effects in risk management over the project life cycle. Longitudinal data would allow for a deeper understanding of how PRM maturity evolves and how its economic impacts accumulate over time. Second, although the sample size is statistically adequate for PLS-SEM, it remains geographically concentrated within urban Indonesian contexts, which may limit external generalizability. Third, performance indicators are partially based on self-reported data, which introduces the possibility of perceptual bias despite rigorous validation procedures.

Future research could address these limitations by integrating objective project accounting data with longitudinal tracking of risk governance practices across multiple project phases. Comparative studies across different national regulatory regimes would also be valuable in identifying how institutional environments mediate the economic effectiveness of PRM. Additionally, qualitative investigations could explore the micro-level behavioral mechanisms through which risk awareness translates into everyday managerial decisions.

CONCLUSION

This study concludes that Project Risk Management significantly improves time performance and cost efficiency in medium-scale construction projects in Indonesia, as higher levels of systematic risk identification, analysis, response planning, and monitoring are consistently associated with lower schedule delays and reduced cost overruns. The findings affirm that risk management functions as a strategic governance and economic control mechanism rather than merely an administrative requirement, while the persistence of performance deviations under moderate implementation highlights the need for stronger institutionalization of risk governance within organizational decision-making processes. By extending empirical risk governance analysis to medium-scale projects, this research contributes to the construction management literature and underscores the importance of strengthening managerial risk capacity to enhance project reliability and economic efficiency, while future research is encouraged to adopt longitudinal and comparative approaches to further examine the dynamic and contextual dimensions of Project Risk Management.

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