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Probabilistic Risk Modeling for Performance Deviation in Multinational Construction Projects in Bali

Putu Risna Pastawan*, A.A. Gde Agung Yana, I Gusti Agung Adnyana Putera
Universitas Udayana, Indonesia
Email: risnapass@gmail.com*, agungyana@unud.ac.id, apute@unud.ac.id

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Abstract

Multinational construction projects in tourism regions are exposed to complex uncertainty arising from cultural differences, fragmented organizational systems, differing technical standards, and cross-border stakeholder coordination. This research examines how performance deviations may occur in multinational construction projects in Bali, Indonesia, by applying a probabilistic risk-based approach. The model was built incrementally, beginning with the identification of risks from earlier studies and expert input. The risks were then assessed through questionnaire surveys and a risk matrix before being modeled using triangular probability distributions and Monte Carlo simulation. The final stage employed sensitivity analysis to identify the most influential risks and to support the development of mitigation strategies. This research was carried out in the context of accommodation and tourism-residential projects in the Sarbagita area of Bali, where foreign owners, consultants, designers, or specialists frequently interact with local contractors. The dominant risks were selected by considering both their frequency and impact, and were then expressed as minimum, most likely, and maximum impact values for the time, cost, and quality models. A 10,000-trial Monte Carlo simulation indicated that the simultaneous occurrence of dominant risks could generate average deviations of 8.37% in time, 15.90% in cost, and 7.88% in quality. Sensitivity analysis revealed that the effectiveness of multinational team communication was the most influential factor for time deviation, whereas technical and project information readiness was the most influential factor for cost and quality deviation. This study contributes a structured decision-support approach for translating qualitative multinational construction risks into probabilistic performance estimates and practical mitigation priorities.

INTRODUCTION

Construction projects are temporary activities that are often carried out under uncertain conditions. In multinational construction projects, the level of uncertainty can be higher because the parties involved may have different national backgrounds, business practices, legal perspectives, technical standards, decision-making cultures, and ways of communicating. Such projects may involve foreign owners, international architects, overseas consultants, imported technical specialists, local contractors, local subcontractors, and community or regulatory stakeholders. This configuration gives multinational projects strategic advantages, such as access to international investment and technical knowledge, but it also produces additional managerial and coordination risks (Ainamo et al., 2010; Project Management Institute [PMI], 2013).

Bali provides a strong empirical context for this issue. The tourism economy continues to stimulate the development of hotels, resorts, villas, townhouse projects, and tourism-related residential facilities. Many of these projects are concentrated in the Sarbagita area, covering Denpasar, Badung, Gianyar, and Tabanan. In this market, foreign investment and international design expectations interact with local construction practices, local regulations, community norms, site constraints, and environmental sensitivity. Project teams must therefore satisfy international performance expectations while adapting execution methods to local conditions.

The construction risk literature defines risk as an uncertain event or condition that may influence project objectives, such as time, cost, scope, and quality. Earlier studies show that construction project performance is affected by internal factors including organizational capacity, poor coordination, weak project control, technical information failures, resource shortages, delayed approvals, and ineffective communication (Alaloul et al., 2016; Obonadhuze et al., 2018). In multinational projects, these internal risks can become more severe because decision authority and operational knowledge are often distributed across organizations with different working cultures (Ding, 2024; Lee et al., 2023; Ochieng & Price, 2010).

Multinational construction projects may also be affected by risks arising from the surrounding project environment, as project continuity is often influenced by conditions outside the project team's control. These may include site constraints, permit requirements, community expectations, environmental concerns, regulatory or political changes, price escalation, and social-institutional pressure — all of which can increase the risk of delay, cost overrun, and quality non-conformance (Amca et al., 2025; Xie et al., 2022). In tourism accommodation projects, local traditions and community acceptance are especially important, as many projects are located near residential areas, sacred spaces, agricultural land, coastal zones, or tourist destinations. Therefore, the local context should be understood not only as an external condition, but also as a key element in the project performance risk structure.

Communication and technical information management are significant sources of risk in multinational construction projects. When project participants come from different cultural and professional backgrounds, design intent may be interpreted differently, instructions may become inconsistent, and decisions may take longer to reach (Obonadhuze et al., 2018; Ochieng & Price, 2010). These issues can create a gap between field implementation and the expectations of international stakeholders. Similar problems may arise from differences in technical standards, particularly when drawings, specifications, and acceptance criteria are not clarified at the outset of construction (You et al., 2022). Digital tools and collaborative platforms may help project teams coordinate more effectively; however, their benefits depend on the organization's preparedness to use them, the existence of agreed data-sharing procedures, and the provision of clear access arrangements (Menegon Lopes & Silva Filho, 2024; Rehman et al., 2025; Zhang et al., 2023).

Several methods have been used in previous studies to assess construction project risks. Risk matrices help screen and prioritize risks, while the analytic hierarchy process supports the organization of expert judgments. Structural modeling can also be used to examine possible relationships between risk factors (Rani et al., 2022; Starczyk-Kolbyk & Jedras, 2025; Ugural, 2023; Yao & Lan, 2025). However, these methods often stop at ranking risks or assigning fixed scores, and do not fully capture how project time, cost, and quality may vary when multiple risks occur simultaneously. Monte Carlo simulation offers a useful complement, as it can estimate a range of possible outcomes, including mean values, percentiles, and sensitivity measures (Pritchard, 2014).

This study develops a thesis-based risk model into a journal-style study of performance risk in multinational construction projects. It combines qualitative risk identification with frequency-impact assessment, triangular probability modeling, and Monte Carlo simulation. The study contributes by identifying the dominant risks in Bali's tourism-related construction projects and estimating their possible effects on time, cost, and quality performance. The sensitivity results are then used to determine the most important mitigation priorities.

Based on the background and research gaps identified above, this study aims to identify the dominant risk factors that influence time, cost, and quality performance in multinational construction projects in Bali; estimate the probabilistic impacts of these dominant risks on project performance using triangular distributions and Monte Carlo simulation; and determine the most influential risk drivers through sensitivity analysis to support mitigation planning. This research is expected to provide both theoretical and practical benefits. Theoretically, it contributes to the body of knowledge on multinational construction risk management by demonstrating how qualitative risk assessments can be translated into probabilistic performance estimates, thereby extending conventional risk-matrix approaches. The study also enriches the understanding of how internal coordination factors — such as communication effectiveness and information readiness — and external contextual factors — such as environmental mismatch and local traditions — interact to affect project outcomes in a tourism-driven developing region. Practically, the findings offer a structured decision-support tool for project owners, contractors, consultants, and foreign stakeholders involved in Bali's tourism construction sector. The sensitivity-based mitigation priorities can help project teams allocate resources more effectively, reduce delays and cost overruns, and improve quality compliance. Furthermore, the probabilistic modeling framework can be adapted during the early planning stages of similar multinational projects to assess contingency needs and to design proactive risk responses.

METHOD

Study design and empirical scope

To understand project risk more clearly, this study used both practitioner input and quantitative analysis, followed by probabilistic modeling. The risk factors were first identified from the literature, then discussed with experienced practitioners so that the final risk structure reflected conditions found in the project setting. After the risk factors were identified, the first questionnaire was used to assess how frequently each risk might occur and how strongly it could affect project performance. A second questionnaire was then distributed to obtain minimum, most likely, and maximum impact estimates for the dominant risks. These estimates were later used to form triangular probability distributions for the simulation model. This approach was considered suitable because historical data on multinational construction risks in Bali are still limited, while the judgment of experienced practitioners provides context-specific insight for the analysis.

This study was limited to construction projects in Bali where foreign stakeholders work together with local contractors. The project types included hotels, villas, resorts, townhouses, and other residential buildings connected to the tourism market. The geographical scope was the Sarbagita area. Infrastructure projects and public works were excluded because they usually involve different stakeholder structures, funding systems, and regulatory exposure from private tourism accommodation projects.

Project performance in this study was measured through three outcome dimensions: time overrun, cost overrun, and quality non-conformance. Time overrun refers to delays from the planned schedule, while cost overrun refers to spending that exceeds the planned budget. Quality non-conformance describes situations where the work does not meet the required technical standards, specifications, or contractual expectations. These three dimensions were treated as separate outputs in the model. Although time, cost, and quality may influence one another in practice, their interdependence was not directly modeled in this study and is suggested as an area for future research.

Risk variables, respondents, and instruments

In this study, the risks were viewed from two main sources: those that come from within the project and those that come from the surrounding environment. Internal risks are related to how the project is organized and managed, such as the team’s capacity, availability of technical information, quality of communication, readiness to use digital tools, adequacy of resources, and the way decisions are made. External risks refer to conditions that are not fully controlled by the project team but can still influence project delivery. These include environmental conditions, local traditions and culture, social or regulatory constraints, and wider economic or political changes (Amca et al., 2025; Xie et al., 2022).

Respondents were selected purposively from practitioners who had direct experience in multinational construction projects. The study used expert judgment to validate the research content, followed by two questionnaires. The first questionnaire assessed the perceived frequency and impact of each risk, while the second collected more detailed estimates of the possible percentage impacts on time, cost, and quality. The respondents included project managers, site managers, engineers, quantity surveyors, contractors, consultants, architects, and other project personnel involved in decision-making.

Content validity was assessed using the content validity index. This procedure is suitable for judging whether each indicator is relevant to the construct being measured. Reliability was assessed with Cronbach's alpha, which is widely used to evaluate internal consistency during instrument development (Taber, 2018). The validated and reliable instrument was then used to support the first-stage risk ranking and second-stage probabilistic estimation.

Table 1. Condensed research design and analytical outputs

Stage	Method/ Instrument	Analytical function	Main output
Risk identification	Literature review and expert interviews	Develop and refine risk factors and indicators	Validated indicator pool
Instrument validation	CVI and Cronbach's alpha	Assess relevance and internal consistency	Valid and reliable questionnaire
Risk evaluation	Questionnaire 1 and risk matrix	Score frequency x impact and select dominant factors	Dominant risks by performance aspect

Stage	Method/ Instrument	Analytical function	Main output
Probabilistic modelling	Questionnaire 2 and triangular distribution	Estimate low, most likely, and high risk impacts	Monte Carlo input distributions
Simulation and response	Monte Carlo and sensitivity analysis	Estimate deviation and identify key drivers	Mean deviations and mitigation priorities

Source: Author’s research design (questionnaires, risk matrix, Monte Carlo simulation)

Risk matrix and dominant-risk selection

The first questionnaire used a five-point Likert scale to measure risk frequency and impact. Frequency describes how often a risk could occur during a project cycle. Impact describes the consequence of a risk on time, cost, or quality. The risk score was calculated using the basic risk-matrix expression: Risk Score = Frequency x Impact. Because the matrix uses a scale from 1 to 5 for frequency and impact, the possible risk-score range is 1 to 25. Factors with risk scores of 16.00 or more were categorized as dominant because they were located in the unacceptable or highly critical area of the matrix.

The threshold was used to ensure that only the most relevant risks were included in the probabilistic simulation. If all identified risks were modeled, the analysis would become too complex and less focused on the risks that matter most in practice. For this reason, the risk matrix served as a screening tool. The dominant risks identified in the time, cost, and quality matrices were then included in the second questionnaire, where respondents provided minimum, most likely, and maximum percentage impact estimates.

Probabilistic modeling and Monte Carlo simulation

The second questionnaire asked respondents to estimate the impact of each dominant risk using three levels: low, medium, and high. These estimates were then used as the basis for the triangular distribution parameters, namely minimum, most likely, and maximum values. The triangular distribution was considered suitable because it only requires three practical inputs and can be applied when historical data are limited, but expert judgment is still able to provide reasonable lower, central, and upper estimates. This approach is suitable for multinational construction projects in Bali, where project records are often inconsistent and each project may vary in design, ownership arrangement, and local constraints.

Monte Carlo simulation was implemented using Oracle Crystal Ball with 10,000 iterations. Baseline time, cost, and quality were expressed as relative values of 1.00 or 100%. The sampled risk impact from each triangular distribution was added as a percentage deviation from baseline. The simulation, therefore, did not claim a single deterministic value; it generated a probability distribution of possible deviations. The main outputs reported in this manuscript are the mean impact and contribution-to-variance sensitivity results. In the thesis model, percentile outputs such as P5, P50, and P95 were also used to support interpretation.

Sensitivity analysis was used to identify which input risk factors contributed most strongly to variation in the simulated output. This is important for mitigation because the highest first-stage risk score is not always the same as the strongest simulation driver. A factor with a slightly lower risk score may become more influential if its probabilistic impact range is wider or more strongly associated with output variation. The mitigation plan was therefore based on both risk dominance and simulation sensitivity.

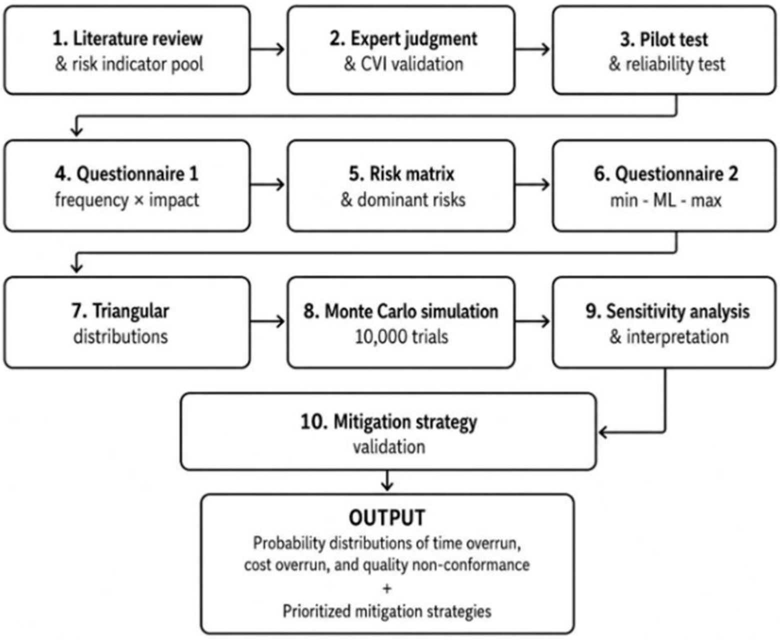

Figure 1. Probabilistic modeling workflow translated and condensed from the thesis methodology

Source: Author's synthesis based on research methodology (2025)

RESULTS AND DISCUSSION

Dominant risk factors from the first-stage risk matrix

The first-stage risk matrix identified six dominant risk factors for time, four for cost, and three for quality. Time deviation was represented by both internal and external factors. The highest time risk score was organizational readiness for digital technology adoption, followed by multinational team communication effectiveness and technical and project information readiness. This means that schedule performance is vulnerable to weak information sharing, slow coordination, and insufficient ability to use digital tools or shared data systems.

Cost deviation was mainly associated with the readiness of technical and project information, communication effectiveness, environmental mismatch, and local traditions and culture. Among these factors, environmental mismatch in multinational projects received the highest score in the first-stage assessment. This indicates that additional costs may arise when design assumptions, work methods, or management practices introduced by foreign project parties do not fit local site conditions, community expectations, regulatory requirements, or procurement practices. When this gap occurs, the project may face rework, idle time, extra coordination, and changes in construction methods.

Quality non-conformance was mainly linked to technical and information-readiness problems, environmental mismatch, and local traditions and culture. This shows that quality issues are not only caused by workmanship on-site. They can also arise when technical standards are not clearly communicated, when local project conditions are not properly understood, or when project participants have different expectations about the required quality level. The dominant factors identified from the thesis risk-matrix analysis are summarized in Table 2.

Table 2. Dominant risk factors selected from the first-stage risk matrix

Aspect	Code	Dominant risk factor	Risk score
Time	FI.1	Project organizational capacity	16.34
Time	FI.3	Technical and project information readiness	17.23
Time	FI.6	Multinational team communication effectiveness	17.66
Time	FI.7	Organizational readiness for digital technology adoption	17.78
Time	FE.3	Environmental mismatch in multinational projects	17.21
Time	FE.4	Traditions and culture	16.62
Cost	FI.3	Technical and project information readiness	16.83
Cost	FI.6	Multinational team communication effectiveness	16.36
Cost	FE.3	Environmental mismatch in multinational projects	17.55
Cost	FE.4	Traditions and culture	16.35
Quality	FI.3	Technical and project information readiness	16.30
Quality	FE.3	Environmental mismatch in multinational projects	17.31
Quality	FE.4	Traditions and culture	16.37

Source: First-stage questionnaire survey and risk matrix analysis (n = expert respondents, 2025)

Triangular distribution parameters for simulation

The second questionnaire produced the low, medium, and high percentage impacts that formed the minimum, most likely, and maximum parameters of the triangular distributions. Time-impact parameters were relatively close across dominant factors. The maximum values ranged from 14.16% to 15.03%, indicating that the dominant time risks were perceived as having similar upper-bound schedule exposure. The most likely time impacts ranged from 6.97% to 7.61%.

The estimated cost impacts were higher than the time and quality impacts. The maximum cost impact ranged from 25.94% to 26.81%, while the most likely impact ranged from 14.32% to 14.71%. This finding is important from a managerial perspective because some risks may initially appear to be related only to communication or technical control. In practice, however, their financial effects can grow through labor inefficiency, material changes, subcontractor claims, additional supervision, design clarification, and increased project overhead.

The quality-impact values were lower than the cost-impact values, but they were still important. The most likely impact on quality ranged from 7.35% to 7.55%, while the maximum impact ranged from 12.65% to 13.00%. These results suggest that quality problems may become significant when technical information is unclear, when actual site conditions differ from the assumptions made during planning, or when cultural and organizational expectations are not properly aligned. Table 3 presents the triangular input parameters used in the simulation.

Table 3. Triangular distribution parameters for dominant risk impacts (%)

Aspect	Code	Dominant risk factor	Min	Most likely	Max
Time	FI.1	Project organizational capacity	3.19	7.03	14.16
Time	FI.3	Technical and project information readiness	3.65	7.39	15.00
Time	FI.6	Multinational team communication effectiveness	3.10	7.16	14.29
Time	FI.7	Readiness for digital technology adoption	3.58	7.61	15.03
Time	FE.3	Environmental mismatch in multinational projects	3.39	6.97	14.29
Time	FE.4	Traditions and culture	3.58	7.23	14.16
Cost	FI.3	Technical and project information readiness	6.84	14.71	26.81
Cost	FI.6	Multinational team communication effectiveness	6.68	14.32	26.42
Cost	FE.3	Environmental mismatch in multinational projects	6.84	14.61	26.65
Cost	FE.4	Traditions and culture	6.68	14.48	25.94
Quality	FI.3	Technical and project information readiness	3.45	7.55	13.00
Quality	FE.3	Environmental mismatch in multinational projects	3.45	7.35	12.84
Quality	FE.4	Traditions and culture	3.45	7.52	12.65

Source: Second-stage questionnaire survey (expert judgment of minimum, most likely, and maximum percentage impacts, 2025)

Monte Carlo outputs and sensitivity interpretation

Based on the Monte Carlo simulation, the combined occurrence of dominant risks could lead to an average time deviation of 8.37%, a cost deviation of 15.90%, and a quality deviation of 7.88%. Cost deviation appears as the most affected performance dimension, in line with the wider cost-impact distribution shown in Table 3. This finding suggests that multinational project teams need to look beyond schedule control and pay closer attention to cost exposure caused by coordination delays, rework, design clarifications, and the need to adjust work practices to local conditions.

The sensitivity analysis helps identify which risks should receive priority in mitigation planning. For time deviation, the largest contributor was communication effectiveness within the multinational team, with a contribution of 18.3%. This was followed by technical and project information readiness at 17.9% and digital-technology adoption readiness at 17.7%. These factors are closely related. Good communication is difficult to achieve when technical information is incomplete, and digital platforms will have limited value if the organization is not ready to use them consistently. Therefore, schedule risk in multinational projects should not be seen only as a field-productivity problem, but also as a problem of information flow.

Cost deviation was influenced almost equally by several factors. Technical and project information readiness contributed the most at 25.5%, followed by communication effectiveness at 25.0%. Traditions and culture, as well as environmental mismatch, each contributed 24.7%. The small difference between these values suggests that cost exposure does not come from a single dominant source. Instead, it reflects the combined effect of technical readiness, communication, cultural understanding, and local environmental conditions. Therefore, cost mitigation needs to be handled through an integrated system rather than a single corrective action.

For quality deviation, technical and project information readiness gave the largest contribution, at 34.3%. Environmental mismatch followed at 33.2%, while traditions and culture contributed 32.3%. These results show that quality performance is strongly influenced by how clearly technical information is prepared and communicated. In multinational projects, international design standards often need to be interpreted and applied by local field teams. Quality problems may arise when drawings are incomplete, standards are not converted into practical inspection criteria, or local construction methods do not fully match the assumptions used in the design. Table 4 presents the mean deviation values and the sensitivity contribution of each factor.

Table 4. Monte Carlo mean impacts and sensitivity contributions

Aspect	Mean deviation (%)	Risk factor contributing to variance	Sensitivity (%)
Time	8.37	FI.6 Communication effectiveness	18.3
Time	8.37	FI.3 Technical and project information readiness	17.9
Time	8.37	FI.7 Digital technology adoption readiness	17.7
Time	8.37	FI.1 Project organizational capacity	16.5
Time	8.37	FE.3 Environmental mismatch	14.9
Time	8.37	FE.4 Traditions and culture	14.7
Cost	15.90	FI.3 Technical and project information readiness	25.5
Cost	15.90	FI.6 Communication effectiveness	25.0
Cost	15.90	FE.4 Traditions and culture	24.7
Cost	15.90	FE.3 Environmental mismatch	24.7
Quality	7.88	FI.3 Technical and project information readiness	34.3
Quality	7.88	FE.3 Environmental mismatch	33.2
Quality	7.88	FE.4 Traditions and culture	32.3

Source: Monte Carlo simulation results (Oracle Crystal Ball, 10,000 iterations) and sensitivity analysis (author, 2025)

Mitigation implications

Mitigation efforts should begin with the risks that show the highest sensitivity, although other dominant risks should not be ignored. For time performance, communication among multinational project teams should be handled in a more structured way. One official communication platform needs to be agreed upon from the start of the project, and each organization should appoint a communication focal point. When necessary, meeting minutes, technical instructions, and decision logs should be provided in both languages. Daily short coordination meetings can help speed up responses and make sure that design intent is clearly understood at the site level.

Technical and project information readiness should be the main focus of mitigation for both cost and quality performance. Before critical work packages begin, the project should establish a joint technical review team involving both local and foreign parties. Key documents such as shop drawings, specifications, mock-ups, and method statements need to be reviewed in stages, with clear approval timelines agreed either contractually or through project procedures. This approach can help reduce rework, avoid design changes that have not been properly priced, and ensure that quality acceptance criteria are clear before work is carried out on site.

Using digital tools in a project is not enough on its own. The project team also needs to agree on practical rules for managing information, such as who owns the data, who can access it, how files are named, how revisions are controlled, and how quickly responses should be given. If BIM, cloud-based document control, or shared scheduling platforms are introduced, the users and their responsibilities should be clarified before construction starts. Training is also needed so that the tools are used consistently. Without this preparation, digital systems may add more coordination work instead of helping the project deal with uncertainty (Menegon Lopes & Silva Filho, 2024; Rehman et al., 2025; Zhang et al., 2023).

External and cultural risks need to be addressed early by adapting the project approach to the local context. Before work begins, construction methods should be reviewed against local regulations, site access limitations, weather conditions, environmental sensitivity, and community expectations. A local liaison can also help the project team understand local traditions, communicate project procedures to community stakeholders, and reduce the risk of conflict. This is particularly relevant in Bali, where local customs and community acceptance may influence whether project activities can continue smoothly. Table 5 presents the mitigation priorities developed from the thesis risk plan.

Table 5. Sensitivity-based mitigation priorities translated from the thesis risk plan

Priority area	**Typical trigger**	**Recommended mitigation action**	**Risk owner**
Communication effectiveness	Slow response, misunderstanding between parties, meetings without clear decisions	Use one official communication platform, bilingual minutes, organization-level PICs, and short daily coordination meetings	Project Manager, Site Manager
Technical and information readiness	Rework, conflicting standards, delayed drawing or document approval	Create a joint local-foreign technical review team, staged shop-drawing checks, and maximum approval turnaround time	Project Manager, Site Engineer, Consultant
Digital adoption readiness	Unsynchronized data, BIM or document access failure, inconsistent revision control	Define data standards, access rights, training, and shared-document procedures before execution	Project Manager, BIM Coordinator, IT Support

Priority area	Typical trigger	Recommended mitigation action	Risk owner
Environmental mismatch	Method changes due to local site, regulatory, social, or environmental constraints	Adjust method statements to local constraints and perform early local-context and constructability reviews	Project Manager, Site Manager, Site Engineer
Traditions and culture	Community resistance, cultural misunderstanding, different work practices	Use local liaison roles, cultural briefings, and agreed collaboration protocols	Project Manager, HR, CSR

Source: Adapted from thesis risk mitigation plan and simulation sensitivity outputs (author, 2025)

Research contribution and limitations

This study extends the usual risk-ranking approach by estimating how selected risks may affect project performance. Practitioner judgments are first used to evaluate the risks, and a risk matrix is then applied to identify the dominant factors. These factors are converted into triangular distributions and tested through Monte Carlo simulation to estimate possible deviations in time, cost, and quality. This approach is useful in project contexts where historical data are limited, as it provides more practical information for mitigation planning than a static list of risk priorities.

The results also extend the discussion of multinational construction risk. The dominant factors are not isolated technical variables. They represent the interaction of organizational capacity, technical information, communication, digital readiness, local environmental fit, and cultural understanding. This indicates that multinational construction performance is affected by how well international project expectations are translated into local execution systems.

The study has limitations. First, the model does not represent dependency among risks or cascading effects between time, cost, and quality. Second, the empirical scope is limited to tourism accommodation and tourism-residential projects in the Sarbagita area of Bali. Third, triangular parameters were based on expert and practitioner estimates, which are appropriate under limited data but still depend on the experience and judgment of respondents. Future research should test the model in more project types, add dependency modeling, and compare simulation estimates with actual post-project performance data.

CONCLUSION

This study develops a probabilistic risk modeling framework for multinational construction projects in Bali. The framework begins with risk identification from previous studies and expert validation, followed by frequency-impact assessment, triangular estimation, Monte Carlo simulation, and sensitivity-based mitigation planning. The main risks identified in this study include project organizational capacity, readiness of technical and project information, communication effectiveness within multinational teams, readiness to adopt digital technology, environmental mismatch, and local traditions and culture.

Based on the simulation, the combined effect of the dominant risks could lead to average deviations of 8.37% in time, 15.90% in cost, and 7.88% in quality. Communication effectiveness appears to be the primary factor behind time deviation, whereas technical and project information readiness has the strongest influence on cost and quality deviation. In practical terms, these findings indicate that mitigation should not focus solely on technical control or schedule monitoring. Multinational project teams also require stronger cross-organizational coordination, clear technical documentation, bilingual communication records, digital readiness, local-context review, and cultural alignment both before and during construction.

The framework can be applied during the early stages of a project to help teams identify key risks, review contingency needs, prepare control measures, and prioritize mitigation actions. This is particularly useful for projects involving both foreign and local stakeholders. From a research perspective, the study also demonstrates how a risk matrix can be linked with Monte Carlo simulation to translate practitioner judgment into estimated impacts on time, cost, and quality performance.

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