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Assessing the Effectiveness of Procurement Risk Mitigation on Cost, Quality, And Schedule Performance in Industrial Construction Projects

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ABSTRACT: Procurement-related risks are among the primary factors affecting cost, quality, and schedule performance in industrial construction projects. While previous studies have mainly focused on risk identification and assessment, limited empirical evidence exists regarding the effectiveness of mitigation measures implemented during project execution. This study evaluates the effectiveness of procurement risk mitigation practices and their contribution to project performance. A qualitative case study was conducted on a polymer industrial construction project in Cikande, Indonesia. Data were collected through Focus Group Discussions (FGDs) involving key project stakeholders and supported by project document reviews, including risk registers, procurement records, quality reports, and project schedules. The findings reveal that only 10 of the 20 procurement risks identified during project planning materialized during project execution, indicating the dynamic nature of procurement risk. The major risks included delays in critical activities, material approval bottlenecks, supplier dependency, specification changes, and material price escalation. Mitigation measures such as schedule acceleration, supplier diversification, enhanced coordination, and quality control were found to reduce the adverse impacts of procurement risks. Overall, procurement risk mitigation contributed positively to maintaining project performance by minimizing schedule disruptions, supporting quality compliance, and limiting additional costs.

KEYWORDS: procurement risk, risk mitigation, project performance, industrial construction, supply chain management

I. INTRODUCTION

Industrial construction projects are characterized by complex interactions among engineering, procurement, and construction activities. The successful delivery of these projects depends not only on technical execution but also on the ability of project organizations to manage risks that may affect project performance. Among the various sources of uncertainty, procurement-related risks have been recognized as one of the major contributors to project delays, cost overruns, and quality problems.

Procurement activities ensure the availability of materials, equipment, and services required for project execution. In industrial projects, disruptions in procurement processes may significantly affect construction operations because project activities are highly dependent on timely material supply and supplier performance. Common procurement risks include delivery delays, supplier non-performance, material shortages, quality non-conformance, approval bottlenecks, and material price fluctuations. Recent studies have highlighted that supply chain disruptions and procurement uncertainties continue to challenge construction projects worldwide (El-Sayegh et al., 2021; Ivanov & Dolgui, 2021).

Effective procurement management has therefore become an important component of project success. Previous studies have demonstrated that procurement performance directly influences project outcomes by affecting cost efficiency, quality compliance, and schedule achievement (Olanrewaju et al., 2022). In response to procurement uncertainties, project organizations commonly implement mitigation measures such as supplier diversification, early procurement planning, enhanced coordination, inventory control, and supplier performance monitoring. These measures aim to reduce the likelihood and consequences of procurement-related disruptions.

Despite the growing body of research on construction risk management, existing studies have primarily focused on identifying procurement risk factors and developing risk assessment frameworks (El-Sayegh et al., 2021). Limited attention has been given to evaluating whether mitigation measures implemented during project execution effectively reduce the impacts of procurement risks on project performance. Furthermore, many studies examine risks identified during planning stages rather than risks that actually materialize during project implementation. As a result, empirical evidence regarding the effectiveness of procurement risk mitigation practices remains limited.

This gap is particularly relevant in industrial construction projects, where procurement activities are often associated with specialized materials, multiple suppliers, strict quality requirements, and complex approval procedures. Procurement disruptions in such environments may have significant implications for project performance and operational continuity.

Therefore, this study investigates the effectiveness of procurement risk mitigation practices in a polymer industrial construction project located in Cikande, Indonesia. The project had reached approximately 85% completion at the time of the study, providing an opportunity to evaluate actual procurement risks, mitigation measures, and their impacts on project performance. Specifically, the study aims to: (1) identify procurement risks that occurred during project execution, (2) evaluate the mitigation strategies implemented to address those risks, and (3) assess the effectiveness of procurement risk mitigation in supporting project performance from cost, quality, and schedule perspectives. The findings are expected to provide practical insights for construction practitioners and contribute to the growing literature on procurement risk management in industrial construction projects.

II. METHODOLOGY

2.1 Research Design

This study employed a qualitative case study approach to evaluate the effectiveness of procurement risk mitigation practices in an industrial construction project. A case study methodology was considered appropriate because it enables an in-depth investigation of actual risk events, mitigation measures, and their impacts on project performance within a real project environment. According to Yin (2018), case studies are particularly suitable for examining contemporary phenomena where the boundaries between the phenomenon and its context are not clearly evident.

The research focused on a polymer industrial construction project located in Cikande, Banten Province, Indonesia. At the time of the study, the project had reached approximately 85% completion, allowing sufficient procurement-related information to be collected and evaluated. This project stage provided a valuable opportunity to assess procurement risks that had actually materialized and to examine the effectiveness of mitigation measures implemented during project execution.

2.2 Case Study Description

The selected project involved the construction of industrial facilities supporting polymer production operations. The project included civil works, structural construction, utility infrastructure, and supporting facilities requiring extensive procurement of construction materials and equipment.

Due to the interdependency between procurement activities and construction operations, procurement performance played a critical role in maintaining project progress. Several procurement-related challenges were encountered during project execution, including material delivery delays, specification changes, supplier constraints, approval bottlenecks, and market price fluctuations. These conditions provided a relevant context for evaluating procurement risk management practices.

To maintain confidentiality, the contractor organization involved in this study is referred to as PT X.

2.3 Data Collection

Data were collected through Focus Group Discussions (FGDs) and project document reviews. The combination of these methods enabled triangulation between participant experiences and project records.

2.3.1 Focus Group Discussions

Three FGD sessions were conducted involving six key project personnel representing procurement, project management, engineering, quality control, planning, and site execution functions. Participants were selected using purposive sampling because they possessed direct knowledge of procurement activities and risk management practices throughout project execution.

The discussions were organized into three sessions:

1. Identification of actual procurement risks encountered during project execution.
2. Evaluation of mitigation strategies implemented for each risk event.
3. Assessment of mitigation effectiveness from cost, quality, and schedule perspectives.

The FGD approach facilitated the collection of expert insights and enabled consensus-based evaluation of procurement risk management practices.

2.3.2 Document Review

Project documents were reviewed to validate information obtained during the FGDs. The reviewed documents included:

a. Initial procurement risk register;
b. Procurement monitoring records;
c. Material submittal and approval records;
d. Progress reports;
e. Quality control reports;
f. Project scheduling records.

The document review provided objective evidence regarding risk occurrence, mitigation implementation, and project performance outcomes.

2.4 Data Analysis

The analysis was conducted in four stages.

Stage 1: Identification of Actual Procurement Risks

Information obtained from the FGDs and project documents was analyzed to identify procurement risks that actually occurred during project execution. Risks that were initially identified during project planning but did not materialize were excluded from further analysis.

Stage 2: Evaluation of Mitigation Strategies

For each actual risk, the mitigation measures implemented by the project team were identified and categorized according to their primary response approach. Mitigation measures included preventive actions, corrective actions, supplier management initiatives, coordination mechanisms, and quality control interventions.

Stage 3: Assessment of Mitigation Effectiveness

The effectiveness of each mitigation measure was assessed based on its contribution to reducing adverse impacts on project performance. The assessment was conducted through consensus among FGD participants and verified through supporting project documentation.

Stage 4: Performance Impact Evaluation

The final stage examined how procurement risk mitigation influenced project performance from cost, quality, and schedule perspectives. The analysis focused on understanding whether implemented mitigation measures successfully prevented procurement risks from developing into major project disruptions.

2.5 Evaluation Framework

The effectiveness of procurement risk mitigation was evaluated using three project performance dimensions: cost, quality, and schedule. These dimensions were selected because they represent the most widely accepted indicators of project success in construction management literature.

Table 1. Procurement Risk Mitigation Effectiveness Criteria

Performance Dimension	Evaluation Indicator
Cost Performance	Ability to minimize additional procurement-related costs and financial losses
Quality Performance	Ability to maintain compliance with technical specifications and quality requirements
Schedule Performance	Ability to prevent procurement disruptions from causing critical project delays

Based on these criteria, mitigation measures were classified into three effectiveness levels:

- Effective: Mitigation successfully minimized the impact of procurement risks on project performance.
- Moderately Effective: Mitigation reduced part of the risk impact but did not eliminate all consequences.
- Less Effective: Mitigation provided limited influence on reducing risk impacts.

Figure 1. Conceptual Framework

This evaluation framework enabled a structured assessment of how procurement risk mitigation practices contributed to maintaining project performance throughout project execution.

III.RESULTS & DISCUSSION

3.1 Actual Procurement Risks Encountered During Project Execution

The project's initial procurement risk register identified twenty potential procurement risks during the planning stage. However, after approximately 85% project completion, only ten risks were found to have materialized and significantly influenced project execution. This finding indicates that not all anticipated risks eventually occur and highlights the dynamic nature of procurement risk throughout the project lifecycle.

The identified actual risks originated from four primary sources: internal project factors, supplier/vendor-related factors, owner-related factors, and external environmental conditions. The most significant risks included delays in bore pile contractor activities, owner-driven specification changes, delays in material submittal approvals, material price escalation, and dependency on single suppliers.

Table 2. Major Procurement Risks Identified During

Risk Category	Actual Risk Event	Primary Source
Schedule	Delay in bore pile activities affecting downstream works	Contractor
Procurement	Delay in material approval process	Owner
Procurement	Dependency on single supplier	Supplier
Cost	Material price escalation	Market

Quality	Material non-conformance	Supplier
Coordination	Design and specification changes	Owner
Logistics	Material delivery delays	Supplier
Inventory	Limited material availability	Supplier
Planning	Procurement schedule mismatch	Internal
Communication	Coordination delays among stakeholders	Internal

The findings suggest that procurement risks were not solely associated with material supply issues. Several risks originated from stakeholder interactions, approval processes, and project coordination mechanisms. This observation supports previous findings by Alaloul et al. (2023), who argued that procurement risk in construction projects extends beyond traditional supply chain disruptions and includes organizational and managerial dimensions.

Furthermore, owner-related risks emerged as one of the dominant sources of procurement uncertainty. Delays in material approval and changes in specifications created downstream impacts on procurement schedules and construction activities. These findings reinforce the argument that procurement performance is highly dependent on effective coordination among project stakeholders.

3.2 Procurement Risk Mitigation Measures

Following the occurrence of procurement risks, the project team implemented a range of mitigation measures aimed at minimizing their adverse impacts. The mitigation strategies primarily consisted of preventive and corrective actions.

Preventive actions focused on reducing the likelihood of future disruptions through enhanced coordination, supplier diversification, quality control reinforcement, and proactive monitoring. Corrective actions were implemented after risk events occurred and included schedule acceleration, procurement rescheduling, additional inspections, and alternative sourcing arrangements.

Table 3. Procurement Risk Mitigation Strategies

Risk Category	Actual Risk Event	Primary Source
Schedule	Delay in bore pile activities affecting downstream works	Contractor
Procurement	Delay in material approval process	Owner
Procurement	Dependency on single supplier	Supplier
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Planning	Procurement schedule mismatch	Internal
Communication	Coordination delays among stakeholders	Internal

The implemented mitigation measures indicate that project teams relied heavily on collaborative and adaptive approaches rather than purely contractual mechanisms. Similar findings were reported by Osho et al. (2024), who emphasized that stakeholder coordination and information sharing significantly improve supply chain resilience and project continuity.

The results also demonstrate the importance of flexibility in procurement management. In several cases, mitigation effectiveness depended on the project's ability to quickly adapt procurement plans to changing project conditions.

3.3 Effectiveness of Procurement Risk Mitigation

The effectiveness assessment revealed varying levels of mitigation performance across different risk categories. Mitigation measures associated with quality control, schedule acceleration, and procurement planning were generally perceived as highly effective. In contrast, mitigation efforts addressing market-driven risks and owner-induced changes were considered only moderately effective due to factors beyond the contractor's direct control.

Table 4. Assessment of Procurement Risk Mitigation Effectiveness

Risk Category	**Cost Impact**	**Quality Impact**	**Schedule Impact**	**Overall Effectiveness**
Bore pile delay	Low	Low	Moderate	Effective
Material approval delay	Low	Low	Moderate	Moderately Effective

Single supplier dependency	Moderate	Low	Moderate	Effective
Material price escalation	Moderate	Low	Low	Moderately Effective
Material non-conformance	Low	High	Low	Effective
Specification changes	Moderate	Moderate	Moderate	Moderately Effective
Delivery delay	Low	Low	Moderate	Effective
Material shortage	Moderate	Low	Moderate	Effective
Schedule mismatch	Low	Low	High	Effective
Coordination issues	Low	Low	Moderate	Effective

The findings indicate that mitigation effectiveness was strongly influenced by the degree of control that project teams possessed over the risk source. Risks originating from internal project processes and supplier performance were generally more manageable than risks arising from market conditions or owner decisions.

This observation aligns with risk management theory, which suggests that mitigation measures are most effective when organizations possess sufficient authority and resources to influence risk drivers (PMI, 2021). Consequently, project teams should prioritize proactive management of controllable risks while developing contingency strategies for external uncertainties.

3.4 Impacts on Cost, Quality, and Schedule Performance

The analysis demonstrates that procurement risk mitigation contributed positively to overall project performance. Although several procurement disruptions occurred during project execution, the implemented mitigation measures prevented most risks from escalating into major project failures.

From a schedule perspective, mitigation measures helped maintain construction continuity despite procurement-related disruptions. Resource reallocation, schedule acceleration, and procurement adjustments reduced the likelihood of critical delays affecting project completion.

From a quality perspective, strengthened inspection procedures and quality control activities ensured that materials complied with technical requirements. Consequently, the project minimized rework and maintained compliance with project specifications.

From a cost perspective, some mitigation measures generated additional short-term expenditures, particularly those associated with expedited procurement and alternative sourcing. However, these additional costs were substantially lower than the potential financial losses that could have resulted from prolonged delays or material non-conformance.

The findings suggest that procurement risk mitigation should be viewed as an investment in project performance rather than merely an additional project cost. Effective mitigation contributes to protecting project objectives and improving organizational resilience against procurement-related disruptions.

Overall, the results indicate that procurement risk mitigation practices played a significant role in supporting project performance across cost, quality, and schedule dimensions. The findings reinforce the importance of integrating procurement risk management into broader project control systems to enhance project delivery outcomes in industrial construction environments.

CONCLUSIONS

This study evaluated the effectiveness of procurement risk mitigation practices in an industrial construction project located in Cikande, Indonesia. Using a case study approach supported by focus group discussions and project document reviews, the research examined actual procurement risks, mitigation measures, and their impacts on project performance.

The findings revealed that only a portion of the procurement risks initially identified during project planning ultimately materialized during project execution. The actual risks originated from multiple sources, including internal project factors, supplier-related issues, owner-related decisions, and external market conditions. Among these, delays in critical construction activities, material approval bottlenecks, supplier dependency, specification changes, and material price escalation emerged as the most influential procurement risks affecting project implementation.

The study further demonstrated that various mitigation measures were implemented to address procurement-related disruptions. These measures included schedule acceleration, supplier diversification, enhanced stakeholder coordination, quality control reinforcement, procurement rescheduling, and alternative sourcing strategies. The effectiveness assessment indicated that mitigation measures targeting controllable risk sources, particularly supplier performance and internal project coordination, were generally more successful than those addressing external market conditions or owner-driven changes.

From a project performance perspective, procurement risk mitigation contributed positively to cost, quality, and schedule outcomes. Effective mitigation practices reduced the likelihood of procurement disruptions developing into critical project delays, supported compliance with quality requirements, and limited the financial consequences associated with procurement failures. Although some mitigation actions generated additional short-term expenditures, these costs were substantially lower than the potential losses resulting from unmanaged procurement risks.

The findings highlight the importance of integrating procurement risk management into broader project control systems. Procurement risks should not be viewed solely as supply chain issues but rather as multidimensional challenges involving stakeholder coordination, decision-making processes, supplier management, and project governance. Consequently, successful project delivery requires continuous monitoring of procurement risks and proactive implementation of mitigation measures throughout the project lifecycle.

Practical Implications

The results suggest that project organizations should adopt dynamic procurement risk management practices rather than relying exclusively on risk registers developed during project planning. Regular risk reviews, supplier diversification strategies, early procurement planning, and stronger coordination among procurement, engineering, quality control, and project management functions can significantly improve project resilience against procurement-related disruptions.

Limitations and Future Research

This study was conducted as a single case study within one industrial construction project, which may limit the generalizability of the findings to other project types and organizational contexts. Future studies may expand the investigation by comparing multiple industrial projects or incorporating quantitative approaches to measure mitigation effectiveness more objectively. Further research may also explore the relationship between procurement risk management, supply chain resilience, and project performance using larger datasets and advanced analytical methods.

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