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OPERATIONAL RISK ASSESSMENT AND MITIGATION ANALYSIS ON CONSTRUCTION PROJECTS (CASE STUDY OF ENTITY XYZ CONTRACTOR)

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OPERATIONAL RISK ASSESSMENT AND MITIGATION ANALYSIS IN CONSTRUCTION PROJECTS (A CASE STUDY OF ENTITY XYZ CONTRACTOR)

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ABSTRACT

The objective of this study is to conduct a quantitative operational risk assessment and to design risk mitigation strategies to prevent and reduce operational risks in a selected sample of a construction project in Entity XYZ. This research method combines in-depth interviews and secondary data collection techniques. Operational risk was assessed by calculating the probability (P), cost (C), quality (Q), time (T), and work safety (S), and then calculating the main project risk using the Risk Significance Index (RSI). This study then identified ten risk factors with the highest RSI values. Furthermore, this study proposed a risk-mitigation strategy for each of these ten risk factors, using one of the following approaches: avoiding risk, reducing risk, transferring risk, sharing risk, or facing risk.

Keywords: Construction Project, Operational Risk, Risk Significance Index

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1. INTRODUCTION

Risk is uncertainty with a negative impact (Serpell, 2015). The risk in a project is an uncertain occurrence of circumstances which, if it occurs, will have a negative effect on the objectives of a project (Aloini *et al*. 2012). The construction industry has a high risk, due to the large contract value, the complexity of the work, the large number of parties involved, and the temporary nature (Lam *et al*., 2007). Construction projects focus on three criteria, namely cost, quality, and time (Hansen, 2015), and on the low number of work accidents during the project. A construction project is considered successful if the costs incurred are in accordance with the budget; quality is in accordance with specifications and timeliness in project completion; and there are no fatal work accidents during project implementation. The failure of a project is very difficult to avoid because it involves many parties. For example, the causes of delays (Marzouk & El-Rasas, 2012) consist of seven categories, namely owners, consultants, contractors, materials, labor and equipment, projects, and externals. Other causes of delays (Odeh & Battainesh, 2002) are contractual relationships, including disputes and negotiations during construction, and lack of communication between various parties.

Entity XYZ is a company engaged in engineering, procurement, and construction (EPC) with a project value of over Rp one billion per project, domiciled in Jakarta. The problems faced by Entity XYZ in a number of projects are: (i) it often experiences delays so that penalties are often imposed for delays; (ii) it frequently get complaints because the quality is not in accordance with the contract, which results in a dispute; (iii) there are projects that cannot be completed by Entity XYZ due to project delays and fines; and (iv) then a number of Entity XYZ projects incur costs above the specified Cost Budget Plan (RAB) value.

Based on the historical data on Entity XYZ projects, at least five problematic projects have occurred since 2018. The first issue is the occurrence of cost overruns, namely an increase in the Cost Budget Plan (RAB). If the five cases are recapitulated, then the RAB swelling ranges from the smallest (8.06 percent) namely in the residential construction project (project E), to the largest RAB swelling (20.07 percent) in the gallery building construction project and training (Project D). Overall, the average deviation of RAB (in terms of RAB unfavorable realization over budget) for the five projects is 13.6 percent. However, RAB deviation above 5 percent is considered a construction risk.

The second issue is that the project entity often deals with the problem of delays in project completion. The delay in project completion among the five projects ranged from 16.66 percent to 30.00 percent of the delay compared to the planning time, an example of which is the residential project (project E) which was planned to be completed in 24 weeks, but turned out to be completed after 28 weeks. The project with the longest delay was the gallery building and training project (Project D) which was planned to be completed in 20 weeks, but it turned out that it could only be completed after 26 weeks. The average delay in the five projects is 23.93 percent. This means that in general there have been fairly significant delays because they exceed the tolerable delay limit, which is 5 percent.

According to the summary above, the XYZ company is experiencing two operational issues with respect to the five projects i.e., the expansion of the RAB value during implementation compared to that at the planning stage, and the incidence of project completion delays from the originally planned timeframe. It is vital to identify and simultaneously reduce the reasons that lead to these two operational risks in connection with these activities in order to ensure that they do not arise in the future projects. Therefore, it is significant to conduct this research.

The problems faced by Entity XYZ are the absence of an operational risk assessment and the absence of operational risk mitigation. This study aims to address the problems by answering the research questions as follows:

a. How to assess operational risk in Entity XYZ's construction project?

b. How to make operational risk mitigation in the implementation of the Entity XYZ construction project that has been identified?

The research contributes to business particularly in the construction industry: first, it can detect and pinpoint the root causes of operational risks that arise in the five projects of XYZ entity so that they may be used as inputs and taken into account for the organization's upcoming building project. As a result, this research is useful as a strategic step to foresee and prevent the possibility of operational risks in construction projects, particularly extreme risks, high risks, and moderate risks. Second, this research suggests mitigation options for the causes of the operational risks in construction projects such as risk avoidance, risk reduction, risk transfer, risk decrease, share of risks, and faced risk.

2. LITERATURE REVIEW

The meta-analysis of previous research is about the risk management for construction projects with a publication period of 2017-2021. These studies (Bai *et al.* 2021; Mishra & Aithal, 2021; Oleksandr *et al*. 2020; Selyutina *et al*. 2020; Jagubhai & Yadav 2020; Mican *et al.* 2019; Kostyunina, 2018; Rahman & Adnan, 2020; Solomon-Ayeh, 2019; and Samantra *et al.* 2017) have something in common with this study, namely that they examine the operational risks of construction projects.

There are two differences between previous research and this research. First, on average, the past research looked at the risks in construction projects in general, while this study looks at the risks in the five construction projects of XYZ entity. Second, on average, the previous research identified construction project risks and assessed them but did not provide the follow-up, especially related to risk mitigation. Therefore, the state of the art and at the same time a research novelty not only pinpoint the reasons why risks occurred in earlier construction projects but can also suggest mitigating actions based on those reasons.

Selyutina *et al*. (2020) found that when choosing specific areas (tools) for managing risks arising in the process of carrying out innovation and investment activities in constructions, one should proceed from the effectiveness of analysis and assessment of risks and consequences of possible losses. According to the classification suggested, the examined risks are specific to innovative projects in construction and should be considered when building the risk management system for innovation and investment processes. The research of Bai *et al.* (2021) found that regulatory violations (external risks) have a smaller negative market reaction than operational incidents (internal risks). The different determinants of competitive forces, namely a firm's market share and product substitutability, have contrasting effects on the market reaction of all operational risks.

Micán *et al*. (2019) found that management must focus not only on the operational risk of each isolated project but also on the project portfolio management. The results can be considered a partial contribution towards building conceptual elements to support the project portfolio management process. Suggested future research is the integration between the results of this study and operational risk categories identification for project-based organizations from complementary perspectives which become part of future studies. As the emphasis of this work is to study risks in a specific organizational context, namely project-based organizations, all the previous works analyzed focused on project portfolio risks, leaving aside works related to other types of risks that could be considered; for example, operational risk categories were identified in other contexts such as operational risks in manufacturing companies or operational risks in supply chains.

The research of Oleksandr *et al*. (2020) using a quantitative approach found that in the operational risk definition, there are four basic risk factors: staff errors; incorrect functioning of the information support system; procedural errors; and environment influence. Each of the factors is influenced by other reasons defined by experts of a specific commercial enterprise. Future research should be directed towards constructing the improved decision support system based upon modern information technologies, mathematical modeling techniques, appropriate quality criteria bases, and methods of identification, and taking into consideration possible uncertainties that are always available in the model constructing and decision procedures. The research limitation is that this research has a limited amount and incomplete data.

The research of Samantra *et al*. (2017) using a quantitative approach found that from amongst twenty identified risk factors (under five risk dimensions), the following six risk factors i.e. groundwater seepage, conflicting interfaces of work items, design drawing errors, inappropriate design and poor engineering, super cyclonic storm, and heavy rainfall have been found very significant in the context of the case construct project.

The present study explores the knowledge of fuzzy set theory for quantifying the risk extent during the risk assessment process. However, this study could be extended to make a comparative analysis on the obtained results by exploring either grey numbers of set theory or vague set theory with respect to that of the fuzzy risk assessment module. The research limitation is that the fuzzy based linguistic assessment scales used in this study have been adopted from the past literature. However, the relative sensitivity of fuzzy linguistic scales has not been verified.

3. RESEARCH METHOD

This research employs a mix method (Creswell & Creswell, 2018: 41), which combines qualitative and quantitative methods (descriptive quantitative). The first research question is to be addressed by quantitative data gathered through field studies (the survey method), specifically through the distribution of questionnaires. The in-depth interview technique was used to gather qualitative data that would later be used to address the second research issue.

Entity XYZ in Jakarta is the research location, with project locations in Jakarta and surrounding cities. This research was held in 2021 on cases in five projects of Entity XYZ from 2018 to 2021. The five projects were chosen because they were problematic. A problematic project meets one of the following criteria: (1) there is a delay in project completion of at least 20% of the time specified in the project contract; (2) if the cost exceeds the previously determined RAB by at least 10%. The five projects that are used as a case study in this research are problematic projects that have met these two criteria at once.

Respondents

The research subjects were supervisors or staff members, with no workers included, because the questionnaire format was assumed to be relatively hard to understand, and labor time was limited. Other respondents included six XYZ managers: the Finance Manager, Planning Manager, Managing Manager, Marketing Manager, Human Resources Manager, and Procurement Manager.

This study used 42 factors (Appendix 1) causing delays and cost overruns in construction projects at Entity XYZ in terms of operational variables causing risks, both internal and external factors. The 42 factors were derived from several of previous studies, including Jaber (2019), Rahman and Adnan (2020), Selyutina *et al*. (2020), Kostyunina (2018), Mishra and Aithal (2021), Goh, Kang, and Liew (2013), and Herdiyanto and Djakman (2020). Concerning risk assessment, a questionnaire was distributed containing 42 risk indicators that are evaluated based on four elements (cost, quality, time, and work safety). Between February and March 2022, the questionnaire was given out in person to respondents. Answers to the 42 statements were obtained from 32 respondents.

The process to analysis risk assessment is as follows: (i) a review of previous research on the causes of project operational risks; (ii) analysis of the causes of project operational risks based on a project manager review and identification of risk factors that frequently occur in construction projects at Entity XYZ; (iii) assessing probability and impact, such as cost (C), quality (Q), time (T), and workplace safety (S); (iv) identification of key project risks using the Risk Significance Index, which is the average total impact of cost, quality, time, and work safety multiplied by the likelihood of a project risk occurring.

$$R = 1/n \sum (C + Q + T + S) P$$

where R = Key risk; n = Number of risk events; C = Cost; Q = Quality; T = Time; S = Safety; P = Probability

4. ORGANIZATIONAL PROFILE

Entity XYZ is a Japanese construction, civil engineering, and architecture firm that is one of the five largest construction firms in Japan and one of the twenty largest construction firms in the world. Entity XYZ has annual sales of approximately US$ 15 billion. The company was established in 1804 and is based in Edo (now Tokyo, Japan). The company is traded on the Tokyo Stock Exchange, the Osaka Stock Exchange, and the Nagoya Stock Exchange, all of which are part of the Nikkei stock market index. Entity XYZ has a network that spans Asia. Planning & Consulting, Development & Financing, Design, Construction, Facility Management, Maintenance, Renovation, Engineering & Technology, Research & Development are all services provided by Entity XYZ. Furthermore, the company has several project concepts, including a lunar solar power plant, which consists of a generator with a belt of solar cells placed around the lunar equator. Even though entity XYZ only established a branch office in Jakarta in 1980, it has long-standing experience and knowledge in Indonesia.

5. RESULTS AND DISCUSSION

The results of the questionnaire, which included 42 indicators and was completed by 32 people, are tabulated into four categories: cost (C), quality (Q), time (T), and safety (S). The significant index (R) us the formula from Section 3. A significant risk index (R) is calculated as a result of the formula. Furthermore, the 42 indicators are ranked. According to the ranking, the highest RSI value is RSI = 23, 156 (indicating the upper limit of RSI = 24), and the lowest RSI is 13.342 (indicating the lower limit of RSI = 13).

Table 1. Classification of Risk Level

Color	Risk Significance Index	Risk Level	Decision
	22.51-25.00	Extreme Risk	Entity XYZ may not accept offers for construction projects with a value. If the board of directors has a different view on a factor, for example

Color	Risk Significance Index	Risk Level	Decision
			producing a certain value with extreme risk, then the decision to accept/reject the project must be within the authority of the Board of Directors Meeting.
	20.51-22.50	High Risk (High Risk	Authority of the Board of Directors to decide
	16.51-19.50	Moderate Risk	Authority of the Risk Committee (collection of managers)
	13.00-16.50	Low Risk	Authority of the manager concerned/relevant to the risk

Source: Previous studies' findings and the author's analysis (2022)

The risk levels can be classified based on the ranking of the highest and lowest RSI values, as shown in Table 1, starting with the Extreme risk level (RSI 22.51-25.00), High risk level (RSI 20.51-22.50), Moderate risk level (RSI 16.51-19.50), and Low risk level (RSI 13.00-16.50) (Mishra & Aithal, 2021). The operational risk rating of Entity XYZ's construction project starts from the top rank (rank 1) to the lowest rank (rank 42). For the sake of risk mitigation measures, the 10 risks with the highest rating were selected to be used as risk mitigation projects. The ten highest ranking risk indicators are presented in Table 2.

Table 2. The Top Ten Causes of Operational Risks

Rank	No Indicator	RSI value	Indicator	Indicator Type
1	26	23.156	During the construction, the change of types and material specification happened.	*Material Related*
2	37	19. 863	There was price fluctuation (inflation, currency value).	*External Related*
3	40	19. 523	The government was slow in issuing permits (IMB -the permit of a building, etc.)	*External Related*
4	15	18. 805	The consultant made detailed drawings which are not clear and not sufficient.	*Consultant Related*
5	36	18. 6	There was force majeure (such as disasters, earthquake, flood, riots, etc.).	*External Related*
6	38	18,399	The lack of good communication between parties involved	*External Related*

7	23	18. 091	The contractors are bad at administering documents.	*Contractor Related*
8	25	17. 862	The contractors have difficulty in funding.	*Contractor Related*
9	8	17. 801	The owner of the project is late to give payment.	*Owner Related*
10	3	17. 508	The owner of the project often intervenes too much.	*Owner Related*

There are 42 indicators covering seven groups that can be used to identify the causes of operational risks in the XYZ construction project, namely (1) indicators related to the project owner (owner related), (2) indicators related to consultants (consultant related), (3) indicators related to contractors (contractor related), (4) indicators related to materials (material related), (5) indicators related to workers and equipment (labor & equipment related), (6) indicators related to projects (project related), and (7) indicators related to PR (external related).

The 42 risk indicators are mostly in the planning and execution cycles, according to the project life cycle analysis. Only a few of these risk indicators are in the cycle of initiation, monitoring and controlling, and closing. This demonstrates that Entity XYZ's management must pay special attention to the planning and execution cycles, as the majority of the causes of project operational risks are found in both. In terms of quality, the risk is quite high, specifically regarding late payments, which are in the initiation and closing cycles, so this must be the concern of Entity XYZ management from the start, namely when making an agreement (contract).

Them anagement determines 5 (five) risk assessment indicators in construction projects through risk identification, namely: Probability (P), Cost (C), Quality (Q), Time (T), and Safety (S), with each criterion. These five indicators serve as the foundation for the risk assessment questionnaire. Based on the responses, it is known that the Risk Significant Index (RSI) value for each indicator is 42 indicators, and that after ranking, one indicator includes those at extreme risks, as many as two indicators include those at a high risk, nine indicators include those at a moderate risk, and as many as 33 indicators include those at a low risk.

Furthermore, after all RSIs are ranked, the top ten operational indicators of Entity XYZ's construction project are obtained, and they must be prioritized to be mitigated. The ten indicators are as follows: (indicator 26) changes in the material type and specification during construction; (indicator 37) price fluctuations (inflation, currency values); (Indicator 40) the government’s slow action in issuing permits (IMB, etc.); (indicator 15) detailed drawings that are unclear and inadequate created by consultants. The occurrence of force majeure (indicator 36) (such as disasters, earthquakes, floods, riots, etc.); (indicator 38) poor communication between parties; (indicator 23) poor document administration by contractors; (indicator 25) financial difficulties by contractors; (indicator 8) late payments by the project owner; and (indicator 3) too much intervention from project owner. There are three types of mitigation for the ten indicators. The first is risk reduction by lowering the likelihood of risk (risk likelihood reduction). The possibility of a risk occurring is referred to as the likelihood of risk. As a result, the form of mitigation is to anticipate these risks so that they do not occur, or to at least minimize these risks if they cannot be avoided. The second is mitigation through risk reduction (risk consequences reduction). Third, risk avoidance is used to mitigate.

When compared with previous studies, the findings of this study have differences emerging in terms of how to mitigate operational risks identified in the study. Previous research, such as those of Bai *et al*., 2021; Mishra & Aithal, 2021; Oleksandr *et al*., 2020; Selyutina *et al*., 2020; Jagubhai & Yadav 2020; Mican *et al*, 2019; Kostyunina, 2018; Rahman & Adnan, 2020, differs at identifying risks, ranks those risks, and then proposes risk mitigation measures.

6. CONCLUSION & RECOMMENDATIONS

Based on the study's findings, it can be deduced that the XYZ entity construction project has two operational issues: the implemented RAB has become larger than the anticipated RAB, and construction projects have begun to take longer than expected to complete. If the operational hazards associated with these two issues are to be taken into consideration, it is crucial to understand their varied root causes. Forty-two (42) causes of risk were discovered including those that were project-, owner-, consultant-, contractor-, material-, labor-, and equipment-related classified as operational risk source.

The 42 risks can be prioritized after calculating the risk significant index (RSI). Operational risks can be classified into four categories namely extreme risk, high risk, moderate risk, and low risk. Ten risks have the highest RSI values, according to the ranking of the 42 causes of operational risks. Mitigation is done in relation to the ten operational risks that are most significant for building projects so that all of these risks can be effectively anticipated. Risk management involves making decisions to avoid, transfer, decrease, share, and face risks.

This study has several limitations, including the fact that risk identification can be project-specific from the five case studies or per factor in general. This study does not identify the causes of risks for each project, but rather the risk factors in general, which are assumed to apply to the five case studies. As a result, the research findings do not reveal the specific risks that each project faces. This is the study's limitation, which is expected to be addressed by additional researchers. Risk is calculated using perceptions/opinions from both sources and respondents. One of the limitations of this study is that statistical calculations based on this opinion are not supported by empirical data. Based on the results of the study, the following recommendations are given to Entity XYZ. First, a risk committee at entity XYZ should be formed structurally and permanently. Second, a database should be created regarding the risks that occur. Third, XYZ entity risk mitigation should be expected to be more preventive in nature.

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APPENDIX

Appendix 1. Operational Risk Factors as an Option to Determine the Ten Highest RSI Values

Number	Operational Risk Factor	Number	Operational Risk Factor
1	The project owner takes a relatively long time to make decisions.	22	Contractors are doing poorly for the project site. supervision and management
2	Project owners postpone work	23	Contractors are bad at administering documents.
3	Project owners often intervene too much .	24	Contractors are late in mobilizing tools.
4	Relatively short project duration contract	25	Contractors are experiencing funding difficulties.
5	The project owners are slow in revising and approving project design documents.	26	During construction, there are changes in the type and specifications of the material.
6	The project owners are late in handing over the land to the contractor.	27	Late delivery of construction materials
7	The project owners want a late penalty that is not in accordance with the provisions.	28	Construction materials are running out of stock.
8	The project owners are late in making payments.	29	Low quality of labor
9	The project owners make changes to the scope of work (variation order) while the project is still in progress.	30	Low level of labor productivity
10	The project owners and contractors agree to work on the project in a short duration.	31	There is a shortage in labor equipment.

11	Consultants make mistakes and discrepancies in design documents.	32	There are environmental problems at the project site.
12	Consultants are late in the approval of shop drawings and sample materials.	33	A work accident occurred during the construction process.
13	Consultants do not have sufficient experience.	34	Abnormalities in soil conditions and utilities underneath
14	Consultants are inadequate in terms of quality assurance.	35	There are traffic restrictions and controls at the project site.
15	Consultants make detailed drawings that are not clear and inadequate.	36	The occurrence of force majeure (such as disasters, earthquakes, floods, riots, etc.)
16	Consultants are not accurate in preparing the budget.	37	Price fluctuations occur (inflation, currency values).
17	Insufficient contractor experience	38	Poor communication between parties
18	Repairs caused by errors during construction	39	The supervising consultant was late in inspecting the project.
19	Contractors are not effective in carrying out project plans and scheduling.	40	The government is slow in issuing permits (IMB, etc.).
20	The contractor is late in providing shop drawings.	41	Weather affects project performance.
21	There is a delay in the work of the subcontractor.	42	There are social problems around the project.

Sources: Goh, Kang, & Liew (2013), Kostyunina (2018), Jaber (2019), Rahman & Adnan (2020), Selyutina *et al.* (2020), Herdiyanto & Djakman (2020), & Mishra & Aithal (2021).

Appendix 2. The Top Ten Causes of Operational Risks

Rank	No Indicator	RSI value	Indicator	Indicator Type
1	26	23.156	During the construction, the change of types and material specification happened.	*Material Related*
2	37	19.863	There was price fluctuation (inflation, currency value).	*External Related*
3	40	19.523	The government was slow in issuing permits (IMB -the permit of a building, etc.)	*External Related*
4	15	18.805	The consultant made detailed drawings which are not clear and not sufficient.	*Consultant Related*
5	36	18.6	There was force majeure (such as disasters, earthquake, flood, riots, etc.).	*External Related*
6	38	18,399	The lack of good communicatio n between parties involved	*External Related*
7	23	18.091	The contractors are bad at administering documents.	*Contractor Related*

8	25	17.862	The contractors have difficulty in funding.	*Contractor Related*
9	8	17.801	The owner of the project is late to give payment.	*Owner Related*
10	3	17.508	The owner of the project often intervenes too much.	*Owner Related*

Source: Research results (2022)