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Integrated Probability-Impact and Regression Framework for Negative Cash Flow Risk in High-Rise Construction Projects

Kerangka Kerja Terintegrasi Probabilitas-Dampak dan Regresi untuk Risiko Arus Kas Negatif pada Proyek Konstruksi Bangunan Tinggi

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Abstract

Negative cash flow represents a critical financial challenge that threatens liquidity and execution timelines across the construction sector. **General Background** Negative cash flow represents a critical financial challenge that threatens liquidity and execution timelines across the construction sector. **Specific Background** High-rise developments such as the X Apartment Project frequently experiencesevereliquidity imbalances due to delayed owner payments, estimation discrepancies, and productivity bottlenecks. **Knowledge Gap** Prior studies have largely evaluated cash flow anomalies from isolated financial perspectives without integrating risk matrices and regression models to assess operational impacts in high-rise settings. **Aims** This study aims to identify negative cash-flow risk factors, evaluate their severity, analyze their statistical effects on project operations, and formulate validated mitigation strategies. **Results** The analysis revealed that delayed payments, weak financial management, and low labor productivity are the most critical determinants directly impairing operational continuity and schedule performance. **Novelty** The integration of a Probability-Impact Matrix with multiple linear regression provides an empirical framework that bridges financial risk assessment with operational performance metrics. **Implications** Contractors can utilize these structured mitigation techniques to optimize liquidity management and safeguard the operational execution of high-rise construction projects.

Highlights

- Statistical evaluations confirm that payment delays, weak financial control, and low productivity significantly impair project operations.
- The integration of probability-impact assessments with regression analysis effectively bridges financial risk identification and operational management.
- Prioritized mitigation strategies emphasize proactive payment tracking and liquidity buffers rather than complete risk avoidance.

Keywords

Negative Cash Flow; Risk Management; Construction Project; Probability-Impact Matrix; Risk Mitigation

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INTRODUCTION

The construction industry is an essential industry that drives infrastructure development and economic growth. However, the complexity of their activities, the involvement of multiple stakeholders, the long implementation periods, and the need for large capitals expose construction projects to considerable financial risks. Previous studies have found that infrastructure projects are subject to a number of financial risks and constraints including availability of limited funding , high investment requirements , financing costs and uncertainty in project revenues . Besides, investment cost, income, and interest rates are also other significant risk variables that may influence project feasibility and continuity (Amin et al., 2025; Suwandairi et al., 2025). Thus, alternative financing instruments such as Islamic finance and cash waqf have been proposed to address these financial constraints and enhance project financial sustainability (Suwandari & Suratkon, 2025, 2026). Negative cash flow is one of the major financial risks contractors face. This is when the cash outflows from a project in a period are greater than the cash inflows received. In the event of prolonged negative cash flow, the liquidity of the contractor may be impaired and thus the contractor may fail to meet its financial obligations to suppliers, subcontractors and workers. If not carefully managed, this situation can cause project disruption, increase project costs, delay project delivery, and possibly cause project failure (Khaled et al., 2021; Koopman & Cumberlege, 2021). There are several interrelated factors that may lead to negative cash flow of construction projects. Major causes of imbalance between project cash inflows and outflows are delayed payments from project owners, poor financial management, change orders, fluctuation in material prices and low labour productivity (Allethi et al., 2021; Tarawneh et al., 2023). Gusman Simon (2024) also pointed out that 80% of the financial problems of a project are related to poor cash-flow management. Such conditions may lead to liquidity pressure, limiting contractors' ability to finance ongoing construction activities and meet financial obligations during project implementation.

Negative cash flow has an impact on the financial performance and the operations of the project. Insufficient liquidity may result in delayed payments to suppliers and sub-contractors, interruption in the procurement of materials, lower productivity of labour, delays in construction progress and additional costs to the project. Therefore, negative cash flow should be viewed not only as an accounting or financial problem but also as an operational risk that can threaten the fundamental objectives of construction projects in terms of cost, time, quality, and overall performance. Thus, the effective cash flow management is an integral part of the risk management of construction projects (Hillson, 2019; Koopman & Cumberlege, 2021; Project Management Institute, 2017). This problem also exists in the X Apartment Project studied in this research. The internal project data indicated that the project had negative cash flow in the first stage of implementation. The ideal project cost was estimated at a higher price than the contract value arrived at through the tender process. This meant the profit margin was low. Consequently, the cash received by the contractor was not adequate to meet the cash requirements for the continuation of the project. This mismatch resulted in late payments to suppliers, subcontractors and workers as well as the postponement of several construction activities. Most notably, the real progress of the project was slowed down by 17.68% relative to the planned schedule. The condition indicates that financial constraints had become operational risks that affected the project's timing, cost and overall performance (Internal Data of X Apartment Project, 2025).

Although the body of literature on cash-flow management in construction projects is increasing, previous research has mainly focused on the identification of individual determinants of cash-flow problems or an evaluation of project cash flow in a general financial perspective. Limited attention has been paid to an integrated approach that can simultaneously identify negative cash-flow risk factors, assess their risk levels, empirically examine their effects on project operations, and translate the findings into validated mitigation techniques, especially in high-rise construction projects in Indonesia. This limitation indicates a research gap between the identification of financial risks and the development of risk responses that can be applied to operations. To bridge this gap, the current study integrates a probability-impact matrix for the assessment and prioritisation of negative cash-flow risks, statistical analysis using SPSS for analysing their impact on project operations, and expert validation for formulating suitable mitigation plans. This integrated framework is the methodological and practical contribution of the study as it ties together risk identification, risk assessment, dominant-risk prioritisation, empirical impact analysis and mitigation within a single case-study framework. Hence, the objective of this study is to identify the factors that lead to negative cash flow of X Apartment Project, determine the risk level for each factor, analyse their effects on the project operations and develop appropriate mitigation measures to minimise their impact on the project operations. The results are anticipated to enrich the construction risk management literature and provide practical guidance to contractors to sustain project liquidity, operational continuity, and overall project performance.

METHOD

The research was conducted using a mixed-method approach with a case study design to analyse the risks of negative cash flow and its impact on the operational performance of the X Apartment Project in South Jakarta, Indonesia. The quantitative and qualitative approaches were combined to identify and rank negative cash-flow risk factors, investigate their impacts on project operation and develop proper mitigation plans. The research has been based on both primary and secondary data. The primary data were collected through questionnaires, interviews and expert validation. The secondary data were collected from project documents such as project data, budgets, time schedules, progress records and relevant literature. The first set of risk factors was identified on the basis of a literature review and validated by three project experts with a minimum of 10 years of professional experience and direct involvement in project cash-flow management. The study population included 42 personnel working on the X Apartment Project including the Commercial, Finance, Engineering, Construction and Project Management divisions. Respondents were selected on the basis of their involvement and knowledge of project financial and operational activities. The quantitative analysis consisted of 30 respondents that were determined using the Slovin formula with a 10% margin of error from the population of the project. For the expert-validation stage, purposive sampling was applied to select individuals with managerial responsibilities, relevant professional

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experience and direct knowledge of project cash-flow conditions.

Risk assessment was conducted through the Probability-Impact Matrix based on the risk assessment framework of Project Management Institute (PMI). Each identified negative cash-flow risk was evaluated in terms of the probability of occurrence and potential impact using a five-point Likert scale. The risk score was calculated by multiplying the probability score with the impact score (Risk Score=Probability x Impact) and then risks were classified and prioritised to identify the dominant factors for further analysis. Negative cash-flow risk factors impacting project operations were further analysed using SPSS Version 25. The statistical methods used are validity and reliability tests, multiple linear regression, F-test for simultaneous effect and t-test for partial effect between independent risk variables and project operational performance variables. Finally mitigation plans were formulated based on the dominant risks identified through the Probability–Impact Matrix and the result of statistical analysis. The effectiveness, feasibility of implementation and potential applicability of the proposed mitigation measures under actual project conditions were assessed through a semi-structured interview with the experts and project practitioners. Finally, the proposed strategies were validated by experts to ensure their relevance to the real conditions of the X Apartment Project. Through this process, a set of prioritised mitigation measures was developed to minimise the operational impacts of negative cash flow and support the continuity of project implementation.

RESULT AND DISCUSSION

Identification of Negative Cash Flow Risk Factors

The analysis was performed in a stepwise manner to identify the risk factors contributing to negative cash flow, to determine the dominant risks and to evaluate their impacts on the project operations and to develop appropriate mitigation plans. The first step consisted of identifying potential negative cash-flow risks through a literature review and initial expert validation. The identified factors were then assessed by the Project Management Institute (PMI) Probability–Impact Matrix to determine the probability and impact level of the factors. The questionnaire data was analysed using SPSS to quantitatively analyse the effect of identified risks on the project operational performance. Finally, the qualitative formulation of mitigation plans was enabled by semi-structured interviews with project experts and managers. The data was processed and statistically analysed using Microsoft Excel 2017 and SPSS. The first step was to identify factors that could be potential causes of negative cash flow in the X Apartment Project. The initial list of risk factors was prepared by surveying relevant scientific literature, textbooks and project risk-management references. Then these factors were incorporated into the first questionnaire and experts were asked to rate them according to their importance for the conditions in an actual construction-project. Expert validation was conducted initially to confirm that the identified risk factors were appropriate within the context prior to their subsequent inclusion into risk assessments. Factors found to be irrelevant were removed and validated factors were further analysed. Three experts were involved in the first phase of validation. Respondents were selected based on predetermined criteria, such as permanent employment at PT X, minimum education of bachelor's degree, more than 5 years of professional experience, managerial position of at least section-head level or equivalent, and adequate knowledge of overall project implementation and project cash-flow management. The experts represented the project management and financial management functions and presented views from technical and financial aspects of the project.

No.	Expert	Position	Education	Nationality	Work Experience
1	Expert 1	Deputy Project Manager	Bachelor's Degree	Japanese	15 years
2	Expert 2	Finance Manager	Bachelor's Degree	Japanese	8 years
3	Expert 3	Deputy Project Manager	Bachelor's Degree	Indonesian	14 years

Table 1. *Profile of Experts Involved in the Initial Validation*

Source: Authors' analysis.

The composition of the expert panel indicates that the validation process involved practitioners with substantial professional experience and direct involvement in project management and financial activities. Their experience ranging from 8 to 15 years provided an appropriate basis for assessing whether the risk factors derived from the literature reflected the actual conditions of the X Apartment Project. The validated risk factors were subsequently used as the basis for assessing probability and impact and identifying the dominant negative cash-flow risks in the following stage.

Initial expert validation was conducted through structured interviews in which three experts assessed whether each identified indicator was relevant as a risk factor contributing to negative cash flow in the X Apartment Project. The experts looked at eight main risk groups: late payments, design/scope changes, poor financial management, low productivity, cost overrun, very low tender prices, complex administrative procedures, and inaccurate initial estimates. Each indicator was scored as relevant or not relevant and the results were tabulated to determine which indicators to retain for further consideration. The validation results showed that all the three experts considered all the delayed payment (X1) indicators to be relevant. These indicators included the waiting period for progress payments, complex payment procedures, frequency of payment delays, absence of compensation for delays, and the effect of delayed payments on daily cash flow. Similarly, all indicators related to low productivity (X4) were retained, including low labor efficiency, daily output below the expected standard, rework, overtime resulting from delays, and failure to achieve completion targets. Most indicators under weak financial management (X3), cost overrun (X5), excessively low tender prices (X6), and inaccurate initial estimates (X8) were also considered relevant and therefore included in the subsequent analysis.

In contrast, several indicators were eliminated because they did not receive sufficient expert agreement. Within the design/scope change (X2) category, only the number of variation orders was retained for further analysis, while the availability of contract revisions, timing of variation-order issuance, the effect of variation orders on work volume, and delays caused by scope changes were excluded. All indicators within the complex administration (X7) category were classified as not relevant to the occurrence of negative cash flow in the case project. These included the number of

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documents required for each payment term, approval processing time, frequency of financial or progress-report revisions, inconsistencies between administrative units, and slow communication among stakeholders.

Overall, the initial expert validation reduced the number of indicators by retaining only those considered contextually relevant to the financial and operational conditions of the X Apartment Project. The retained indicators predominantly reflected risks associated with payment delays, financial management, labor productivity, cost escalation, tender pricing, and estimation accuracy. Based on these findings, the research questionnaire was revised by removing indicators classified as not relevant. The revised instrument was subsequently prepared for distribution to respondents in the next stage of the study.

Risk Assessment and Respondent Profile

Following the initial expert validation, the second stage focused on assessing the probability and impact of the validated negative cash-flow risk factors. Data were collected through a structured questionnaire distributed to 30 respondents directly involved in the X Apartment Project. Eligible respondents should have experience in building construction and sufficient knowledge of project implementation, and at least two years of professional experience. The respondents were ten managers and 20 professional and technical staff engaged in project management, quality control, construction, site management, planning, commercial, quantity surveying, engineering, contract administration and procurement functions. The composition was considered appropriate, because the respondents are directly involved in the technical, commercial and financial activities in the execution of projects. In terms of the occupational position, around 33% of the respondents were in managerial positions, engineering-related personnel and quantity surveyors each accounted for about 30%, followed by procurement personnel at about 7%. The assessment was strengthened by the relatively high proportion of managerial respondents as many of the participants were directly involved in the decision-making for the projects. In terms of professional experience, 57% of respondents had 5-10 years of construction experience, 27% had 10-15 years, 13% had less than five years and 3% had 15-20 years of experience. Thus, most of the respondents had more than five years of professional experience in building construction, which indicates an adequate level of practical knowledge for the assessment of financial and operational risks in the project.

Each respondent was asked to evaluate the probability of occurrence and impact of each risk indicator that had passed the initial expert-validation stage. Both dimensions were scored on a five-point scale, with larger scores indicating a higher probability of occurrence and a greater potential impact. The collected responses were tabulated based on the distribution of probability and impact scores for each risk indicator. The assessment was on risk factors associated with delayed payments, design or scope changes, poor financial management, low productivity, cost overruns, too low tender prices and wrong initial estimates. The distribution of responses indicates that several risk indicators were predominantly rated at levels 4 and 5 for both probability and impact, suggesting that these factors were perceived as relatively frequent and capable of producing substantial consequences for project cash flow. For example, respondents rated indicators such as frequency of delayed payments (X1.3), rework (X4.3), failure to meet completion targets (X4.5), unit prices that are not realistic in relation to market conditions (X6.3), and contract changes related to funding constraints (X6.5) relatively highly. The findings reveal that negative cash-flow risk in the X Apartment Project is not only associated with payment mechanisms, but also with productivity, cost control, tender pricing and project implementation conditions. Then, a quantitative risk assessment was carried out by applying the Probability-Impact Matrix approach based on the PMI framework. The risk score of each indicator was calculated based on the probability and impact scores obtained from the respondents, thus providing the classification and prioritisation of the identified risks based on their severity. This analysis provides the basis for identifying the dominant negative cash-flow risks that require further investigation in terms of their effects on project operations and the formulation of appropriate mitigation plans.

The assessment of negative cash-flow risks was performed by evaluating two dimensions, namely the probability of occurrence and the impact of each risk. Respondents rated each indicator using a five-point scale. The frequency scale ranged from 1 (Never) to 5 (Always), corresponding to probability values from 0.10 to 0.90. Meanwhile, the impact scale ranged from 1 (Very Low) to 5 (Very High). The probability and impact scales applied in this study are presented in Tables 2 and 3.

Scale	Frequency Criteria	Probability
1	Never	0.10
2	Rarely	0.30
3	Sometimes	0.50
4	Often	0.70
5	Always	0.90

Table 2. *Probability/Frequency Scale*

Source: Project Management Institute (2013).

Scale	Impact Criteria	Impact Value
1	Very Low	0.05
2	Low	0.10
3	Moderate	0.20
4	High	0.40
5	Very High	0.80

Table 3. *Impact Scale*

Source: Project Management Institute (2013).

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The risk factor score (RF) for each indicator was determined by multiplying the mean probability value by the mean impact value. Mean values were employed because the analysis was intended to rank the identified risks and determine their priority levels. The calculation can be expressed as follows:

Risk Factor (RF) = Mean Probability × Mean Impact

The resulting scores were then overlaid on the Probability–Impact Matrix to determine the relative level of each risk. This allows risks that are likely to occur and have serious consequences to be prioritised over risks that have a relatively low probability or impact.

Probability	Very Low 0.05	Low 0.10	Moderate 0.20	High 0.40	Very High 0.80
0.90	0.05	0.09	0.18	0.36	0.72
0.70	0.04	0.07	0.14	0.28	0.56
0.50	0.03	0.05	0.10	0.20	0.40
0.30	0.02	0.03	0.06	0.12	0.24
0.10	0.01	0.01	0.02	0.04	0.08

Table 4. *Probability–Impact Matrix*

Source: Adapted from Project Management Institute (2013).

The risk scores obtained from Probability-Impact Matrix were classified into three priority categories. For instance, the score between 0.01 and 0.05 was classified as low risk, the score between 0.06 and 0.14 was classified as moderate risk, and the score between 0.18 and 0.72 was classified as high risk. The negative cash-flow risk indicators were then ranked using this classification and the dominant risks that should be mitigated as a priority in the X Apartment Project were identified. The classification provides an organised framework for risk response prioritisation. For the high risk indicators the most important factors were considered, since they provided the combination of a relative high probability and a significant impact on the project's cash flow and operational continuity. These dominant factors were further analysed to understand their influence on project performance and to formulate suitable mitigation plans.

The probability and impact assessment was conducted for each risk indicator using responses from 30 project personnel. The mean probability values ranged from 0.487 to 0.660, indicating that most of the identified risk events had a moderate-to-high likelihood of occurrence. The highest probability score was recorded for rework (X4.3) with a mean value of 0.660, followed by the frequency of delayed payments (X1.3) at 0.653, deviation between the budget plan and actual realization (X7.1) at 0.633, and contract changes due to funding constraints (X6.5) at 0.627. Conversely, the lowest probability score was found for profit margin (X6.2) at 0.487. These results indicate that operational inefficiencies, payment delays, estimation discrepancies, and financing constraints represented some of the most frequently encountered negative cash-flow risks in the X Apartment Project. The impact assessment produced mean values ranging from 0.270 to 0.523. The indicator with the highest impact was failure to achieve project completion targets (X4.5), with a mean impact score of 0.523, followed by rework (X4.3) at 0.510, waiting time for progress payments (X1.1) at 0.488, unrealistic unit prices compared with market conditions (X6.3) at 0.482, and contract changes due to funding constraints (X6.5) at 0.478. The results showed that significant impacts were perceived in the project operations for risks associated with productivity, payment mechanisms, tender pricing and financial constrains. The probability and impact of both rework and missing completion targets were rated high, indicating that these risks could lead to substantial additional expenditure and a delay in the generation of project revenue.

The overall risk score was calculated by multiplying the average probability score by the average impact score for each indicator. The results showed that 27 of the 31 assessed risk indicators were classified as high risk, four indicators were classified as moderate risk, and no indicators were classified as low risk. So of the risks assessed, 87% were graded as high risk, and 13% as moderate risk. The lack of low risk indicators shows that the exposure to negative cash-flows in the case project was rather high and covered more aspects of project implementation. The four moderate risk indicators are the number of variation orders (X2.1) with a risk score of 0.160, dependence on short-term financing (X3.4) with a score of 0.178, comparison between estimated project value and contract value (X6.1) with a score of 0.162 and profit margin (X6.2) with a score of 0.131. The highest ranked risk among all indicators was rework (X4.3) with a score of 0.337. This was followed by failure to achieve completion targets (X4.5) with 0.317 and frequency of delayed payments (X1.3) with 0.301. The other most critical risks were changes to the contract due to funding constraints (X6.5) 0.300, unrealistic unit prices compared to market conditions (X6.3) 0.299, and the waiting period for progress payments (X1.1) 0.293. The results indicate that the negative cash-flow condition was due to both internal operational problems and external financial mechanisms. Issues such as rework and productivity problems cause an increase in project expenditure without a corresponding progress. In contrast, delayed payments restrict the cash inflows required to finance the construction activities in progress. Likewise, unrealistic tender prices and funding-related contract adjustments may limit financial flexibility and increase liquidity pressure during project implementation.

The risk-ranking results further indicate that negative cash flow cannot be attributed to a single financial factor. Instead, it arises from interactions among operational inefficiency, payment delays, inadequate financial control, cost escalation, unrealistic pricing, and inaccurate project estimates. The financial management indicators that are at high risk are lack of control over incoming and outgoing funds (X3.2) with a risk score of 0.277; there is a difference between the planned and realised cash flow (X3.3) of 0.274; not maintaining the minimum cash balance (X3.5) of 0.253. The pattern indicates the contractor's internal cashflow control mechanism is an important factor to reduce the project financial vulnerability. Costs also had relatively high levels of risk. The risk score of the difference between initial estimates and actual costs (X5.1) is 0.276, project delays (X5.3) is 0.275, and material price fluctuations (X5.2) is 0.267. The results support the association between project delays and financial pressure, since delays may increase both direct and indirect costs, while at the same

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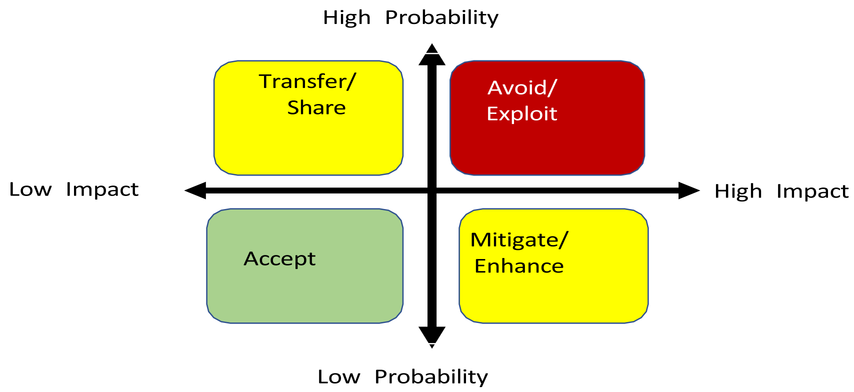
time delaying the receipt of payments. Negative cash flow can result in a virtuous cycle where lack of liquidity causes slower project execution, resulting in increased costs and delay to future cash inflows. Overall, the Probability–Impact Matrix demonstrates that the majority of identified negative cash-flow risks require priority management attention. The dominance of high-risk indicators confirms that the financial difficulties experienced in the X Apartment Project are closely linked to project operational performance. Therefore, the 27 high-risk indicators were prioritized for further examination in the subsequent statistical analysis using SPSS to determine their relationship with project operational performance. The findings from this stage also provide the empirical basis for developing mitigation strategies focused on the most critical negative cash-flow risks.



Source: Project Management Institute (2017).

Assessment of the Impact of Negative Cash Flow on Project Operations

Following the risk assessment phase, the analysis moved to assessing impact of negative cash flow on project operations. The data were collected through a questionnaire, in which the respondents evaluated the impact variables through a Likert scale. This stage involved a total of 30 respondents with experience in building construction. Respondents were from different functions directly involved in project implementation such as project and construction management, quantity surveying, engineering, quality control, procurement, scheduling, planning, contracts and supervision. Minimum two years of construction experience was considered as a respondent eligibility criterion to ensure that the assessments were based on adequate professional knowledge and practical exposure to construction-project operations.

The occupational distribution showed that the respondents represented both managerial and technical functions. Approximately 33% were managers, 33% were quantity surveyors, 30% were engineering personnel, and 3% were procurement personnel. The high representation of managers and quantity surveyors was particularly relevant to this study as these roles are strongly associated with project decision-making, cost control, progress monitoring, procurement and financial administration. The involvement of engineering and procurement personnel also provided operational insight into how financial constraints could affect construction activities in the field. The composition of respondents thus enabled the assessment to incorporate both managerial and technical perspectives on the operational implications of negative cash flow.

In terms of professional experience, the largest proportion of respondents (43%) had 5–10 years of experience in building construction, followed by 33% with 10–15 years of experience, 20% with less than five years, and 3% with 15–20 years of experience. So, about 79% of the respondents had experience of at least 5 years in construction, meaning that most of them had reasonable practical experience in project implementation. The professional exposure at this level strengthened the relevance of their assessments on the relationship between negative cash flow and project operational performance. The profile of the respondents in general indicates that the impact assessment involved people with different functional backgrounds and sufficient experience in building construction. The data collected through the questionnaire were further processed in SPSS to statistically analyse the effect of the negative cash flow risk factors on project operations. The analysis involved the validity and reliability testing of the instrument, followed by statistical tests to determine the significance and magnitude of the relationship between negative cash-flow risks and operational project performance.

Validity and Reliability Test

The validity test was conducted to determine whether each questionnaire item was capable of accurately measuring the research variables. The test employed the Pearson Product-Moment Correlation using SPSS Version 25. An item was considered valid when the calculated r value (r-count) was greater than the critical r value (r-table) and the significance value was < 0.05. With 30 respondents, the r-table value used in this study was 0.374.

Variable	Item	*r*-Count	*r*-Table	Sig.	Result
X1 Payment Delay	X1.1	0.803	0.374	0.000	Valid
	X1.2	0.857	0.374	0.000	Valid
	X1.3	0.779	0.374	0.000	Valid
	X1.4	0.708	0.374	0.000	Valid
	X1.5	0.797	0.374	0.000	Valid
X3 Weak Financial Management	X3.1	0.831	0.374	0.000	Valid
	X3.2	0.822	0.374	0.000	Valid

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	X3.3	0.927	0.374	0.000	Valid
	X3.5	0.829	0.374	0.000	Valid
X4 Low Productivity	X4.1	0.739	0.374	0.000	Valid
	X4.2	0.738	0.374	0.000	Valid
	X4.3	0.639	0.374	0.000	Valid
	X4.4	0.818	0.374	0.000	Valid
	X4.5	0.919	0.374	0.000	Valid
X5 Cost Overrun	X5.1	0.850	0.374	0.000	Valid
	X5.2	0.876	0.374	0.000	Valid
	X5.3	0.866	0.374	0.000	Valid
	X5.4	0.886	0.374	0.000	Valid
	X5.5	0.883	0.374	0.000	Valid
X6 Tender Price Too Low	X6.3	0.836	0.374	0.000	Valid
	X6.4	0.871	0.374	0.000	Valid
	X6.5	0.900	0.374	0.000	Valid
X7 Incorrect Initial Estimate	X7.1	0.810	0.374	0.000	Valid
	X7.2	—	0.374	—	Valid
	X7.3	—	0.374	—	Valid
	X7.4	—	0.374	—	Valid
	X7.5	—	0.374	—	Valid

Table 5. *Validity Test Result*

The validity test results indicate that the questionnaire items have calculated correlation coefficients exceeding the r-table value of 0.374. For example, the item-total correlations for X1 range from 0.708 to 0.857, while X4 ranges from 0.639 to 0.919. Similarly, X5 shows coefficients ranging from 0.850 to 0.886, and X6 ranges from 0.836 to 0.900. Therefore, the tested questionnaire items satisfy the validity criteria and are considered valid, indicating that the instrument is appropriate for subsequent statistical analysis.

Variable	Variable Description	Cronbach's Alpha	Number of Items	Result
X1	Payment Delay	0.849	5	Reliable
X3	Weak Financial Management	0.872	4	Reliable
X4	Low Productivity	0.827	5	Reliable
X5	Cost Overrun	0.921	5	Reliable
X6	Tender Price Too Low	0.835	3	Reliable
X7	Incorrect Initial Estimate	0.884	5	Reliable

Table 6. *Reliability Test*

The results show that all variables have Cronbach's Alpha values above 0.70, indicating good internal consistency. The highest reliability coefficient was obtained for Cost Overrun (X5) at 0.921, while the lowest was found for Low Productivity (X4) at 0.827. Therefore, all research variables can be considered reliable and suitable for subsequent statistical analysis.

Normality Test

The Kolmogorov–Smirnov normality test was conducted as part of the classical assumption tests to determine whether the regression residuals were normally distributed. A regression model satisfies the normality assumption when the significance value is greater than 0.05. Conversely, a significance value below 0.05 indicates that the residuals are not normally distributed.

Parameter	Unstandardized Residual
N	30
Mean	0.0000000
Std. Deviation	0.89014356
Absolute Difference	0.091
Positive Difference	0.080
Negative Difference	−0.091
Test Statistic	0.091
Asymp. Sig. (2-tailed)	**0.200**

Tabel 7. *Kolmogorov-Sminrov Normality Test*

The Kolmogorov–Smirnov test yielded an Asymp. Sig. (2-tailed) value of 0.200, which is greater than the significance threshold of 0.05. Therefore, the residuals can be considered normally distributed, indicating that the regression model satisfies the normality assumption and can proceed to subsequent statistical analyses.

Multiple Linear Regression Analysis

Multiple linear regression analysis was used to explore the direction and strength of the association between the negative cash-flow risk variables and their impact on project operations. The dependent variable (Y) is the effect of negative cash flow on project operation while the independent variables are Payment Delay (X1), Weak Financial Management (X3), Low Productivity (X4), Cost Overrun (X5), Tender Price Too Low (X6) and Incorrect Initial Estimate (X7). The general multiple linear regression model is:

Y = a + b1X1 + b2X3 + b3X4 + b4X5 + b5X6 + b6X7

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where Y is the dependent variable, a is the constant, b represents the regression coefficient of each independent variable, and X represents the respective independent variables.

Variable	B	Std. Error	Standardized Beta	*t*	Sig.
Constant	4.247	0.399	–	10.633	0.000
X1 – Payment Delay	-0.445	0.149	-0.724	-2.986	0.007
X3 – Weak Financial Management	0.379	0.156	0.702	2.440	0.023
X4 – Low Productivity	0.313	0.144	0.483	2.180	0.040
X5 – Cost Overrun	0.237	0.143	0.474	1.662	0.110
X6 – Tender Price Too Low	-0.253	0.123	-0.521	-2.050	0.052
X7 – Incorrect Initial Estimate	-0.178	0.169	-0.330	-1.052	0.304

Table 8. *Multiple Linear Regression Analysis*

Based on the unstandardized coefficients, the resulting regression equation is:

$$Y = 4.247 - 0.445X1 + 0.379X3 + 0.313X4 + 0.237X5 - 0.253X6 - 0.178X7$$

The constant value of 4.247 represents the predicted value of Y when all independent variables are held at zero. The regression coefficient for Payment Delay (X1) is −0.445, indicating a negative association with Y when the other variables are held constant. In contrast, Weak Financial Management (X3) and Low Productivity (X4) have positive coefficients of 0.379 and 0.313 respectively, suggesting that increases in these variables are associated with increases in the operational impact score. The Cost Overrun variable (X5) has a positive coefficient of 0.237, while Tender Price Too Low (X6) and Incorrect Initial Estimate (X7) have negative coefficients of −0.253 and −0.178, respectively. The partial relationship of 3 variables with the dependent variable is statistically significant at 5% level of significance: Payment Delay (X1; $p = 0.007$), Weak Financial Management (X3; $p = 0.023$) and Low Productivity (X4; $p = 0.040$). Cost Overrun (X5; $p = 0.110$) and Incorrect Initial Estimate (X7; $p = 0.304$) are meanwhile not significant. The Tender Price Too Low (X6; $p = 0.052$) is also just above 0.05 so not statistically significant at the 5% level, but close to the threshold.

An important point of interpretation is the negative coefficients of X_1, X_6 and X_7. A negative regression coefficient should not be interpreted as the greater the payment delays, the lower the tender prices or the less accurate the initial estimates, the less likely is negative cash flow. Y is the operational impact score in this model, and the direction of each coefficient depends on the coding of the questionnaire items and Y. Hence, the negative coefficients represent a statistical inverse relationship with the measured Y score after controlling for the other predictors (not evidence that these risk factors are beneficial to project cash flow). The distinction is important in order not to have contradictory substantive interpretations of the regression results.

The F-test was conducted to determine whether the negative cash-flow risk factors collectively affected project operations. The results showed an F-value of 2.906 with a significance value of $0.029 < 0.05$, indicating that Payment Delay (X1), Weak Financial Management (X3), Low Productivity (X4), Cost Overrun (X5), Tender Price Too Low (X6), and Incorrect Initial Estimate (X7) simultaneously had a significant effect on project operations. These findings indicate that the operational impact of negative cash flow is influenced by the combined contribution of various financial and operational risk factors rather than by a single factor independently. The t-test results further showed that only three variables had statistically significant partial effects on project operations, namely Payment Delay (X1) ($t = -2.986$; $p = 0.007$), Weak Financial Management (X3) ($t = 2.440$; $p = 0.023$), and Low Productivity (X4) ($t = 2.180$; $p = 0.040$). Meanwhile, Cost Overrun (X5; $p = 0.110$), Tender Price Too Low (X6; $p = 0.052$), and Incorrect Initial Estimate (X7; $p = 0.304$) did not show significant partial effects. Notably, X1, X3, and X4 were also classified as high-risk factors in the Probability–Impact Matrix, demonstrating consistency between the statistical analysis and risk assessment and identifying these three variables as priority areas for negative cash-flow mitigation.

Based on the results of expert validation, it shows that there is an agreement from all experts on further analysis of the risk of three major groups, namely Payment Delays (X1), Weak Financial Management (X3), and Low Productivity (X4). These risks include late payment of installments, complex payment procedures, poor cash flow forecasting and management, variances between cash flow forecast and actual cash flow, low labour productivity, rework, increased overtime and failure to meet project completion targets. Expert consensus supports prior findings that these three factor groups are important in managing negative project cash flow. The proposed mitigation methods are based on semi-structured interviews and comprise aspects of not only financial but also contract management and project productivity. Some tips on how to deal with late payments include fast tracking progress approvals, negotiating payment terms, building a cash flow buffer, following up on invoices and keeping tabs on payment schedules. Weak financial management strategies include preparation of cash flow forecasts, monitoring of cash inflows and cash outflows, evaluation of cost and cash flow variances and establishment of minimum cash balance requirements. Workforce optimisation, supervision of field operations, quality control measures, rework and overtime control measures, and rescheduling of activities in case of failure to meet project targets are included in low productivity mitigation measures. The strategies were then grouped into four categories according to PMI risk response framework (Avoid, Mitigate, Transfer and Accept). The classification results show that the most frequent response is “Mitigate” with 34 strategies (81%), followed by “Accept” with 5 strategies (12%), and “Transfer” with 3 strategies (7%). There are no strategies classified as “Avoid” (0%). The prevalence of mitigation techniques suggests that the management of negative cash flow in projects is more about reducing the probability/impact of the risks than eliminating the sources of the risks altogether. The management of negative cash flow, therefore, requires an integrated set of preventive and corrective actions, including payment management, financial planning and monitoring, and improvement of the productivity of project execution.

Discussion

The application of the research results in the X Project Apartment indicates that the three statistically significant risk factors, namely Payment Delay (X1), Weak Financial Management (X3), and Low Productivity (X4), also exist in the real conditions of the project. Payment delays affect the balance between project cash inflows and cash outflows as incoming payments are not received at the time of operational expenditures. This condition forces the contractor to postpone payments to suppliers, subcontractors and workers, which in turn affects the procurement of materials and field execution. In practice, the chain of delayed cash inflows leads to a domino effect where financial constraints are directly translated into operational delays. This result is consistent with previous research that has identified payment delays and poor cash-flow arrangements as major causes of project disruption and financial instability. The other important factor is Weak Financial Management (X3) which indicates the limited ability of the contractor to control the timing, allocation and adequacy of the project funds. Continuous cash-flow forecast and monitoring of cash inflows and outflows may not be carried out. There may be a mismatch between the forecast cash position and the actual cash position. No minimum cash balance may be maintained. All these factors may reduce the capacity of the contractor to finance the ongoing activities. In the X Project Apartment, this condition implies that even with the expectation of project revenues, inadequate financial planning may lead to temporary liquidity shortages. Hence, the final mitigation methods focus on preparation of cash-flow forecast, regular financial evaluation, monitoring cash in and cash out, review of cost deviations, scheduled vendor payments and establishment of a minimum cash balance. These measures are consistent with prior research suggesting that regular cash-flow monitoring and more stringent cash management can enhance financial stability during project execution.

The third factor, Low Productivity (X4), shows the close interaction between the operational performance and project liquidity. Low labour efficiency, daily output below target, repeating work or rework, excessive overtime, and not meeting completion targets increase project expenditures without producing equivalent progress. This results in higher cash outflows and potentially delayed receipt of progress-based payments, thereby worsening negative cash flow. This finding is particularly significant as rework and unachieved completion targets had previously been identified as high priority risks in the risk assessment stage. Mitigation measures such as labour optimisation, stricter field supervision, review of work standards, stronger quality control, evaluation of rework costs, overtime cost control, schedule improvement and project rescheduling where necessary have been validated by the experts. The goal of these strategies is to increase productivity and avoid unnecessary spending which could reduce the project's liquidity even more. The practical relevance of these findings was further affirmed by the final expert validation. The risks identified were validated and mitigation methods were proposed by three experts with direct experience in project management and project cash-flow control. For Payment Delay (X1) they suggested: accelerating progress approval, negotiating faster payment terms, creating a cash-flow buffer, streamlining internal documentation, tracking invoices, scheduling regular billing, incorporating clauses for compensation for late payments, and making payments in line with the progress of the project. For Weak Financial Management (X3), the experts mentioned coordinated financial planning, entry of contract and cost data, regular evaluation of financial condition, variance analysis, project cost control, vendor payment schedule, and minimum cash balance requirements. The recommendations for Low Productivity (X4) were focused on workforce optimisation, productivity versus cost analysis, field supervision, quality control, rework evaluation, overtime management, and rescheduling of delayed activities.

From the risk-response perspective, the validated strategies indicate that for the X Project Apartment, the most appropriate approach is predominantly risk mitigation, as opposed to the complete avoidance of risk. The previous semi-structured interview analysis classified 81% of the recommended responses as Mitigate, 12% as Accept, 7% as Transfer and 0% as Avoid. This distribution indicates that the identified negative cash-flow risks are inherent to the ongoing project activities and thus cannot be realistically eliminated altogether. Instead, their probability and consequences should be reduced through better payment control, stronger financial planning, tighter cost monitoring, productivity improvement and contractual risk allocation. Moreover, the results of Payment Delay (X1) are in line with the previous studies that consider payment-related problems as a critical factor for construction project cash flow. Ikediashi and Okolie (2020) identified five of the major risks to contractors' cash-flow projections as payment delays, material delays, inadequate contractor resources, exchange-rate fluctuations and inflation. Similarly, Abd El Razek et al. (2014) identified 27 major risk factors affecting construction project cash flow and payment delays were among the significant factors affecting cash inflow, outflow and net cash flow. The results of the present study are corroborated by these findings, since they show that delayed payments are not only an administrative problem, but a financial risk that can compromise the liquidity of the project and its operational continuity. Thus, to minimise the operational consequences of payment delays, it is essential to implement mitigation measures such as expediting the approval of progress claims, monitoring payment schedules, enhancing invoice tracking, negotiating payment terms, and maintaining a cash flow buffer.

The results also support the findings of past empirical evidence concerning Weak Financial Management (X3) and Low Productivity (X4). Omopariola et al. (2019) noted that project delays and financial failure occur due to delays in payments and poor cash management and stressed the significance of effective cash-flow management in the maintenance of construction project performance. Material, equipment and labour factors also have a significant effect on cost overrun and project financial performance as found by Sugiono et al. (2023). Pratama (2025) found that the main reasons of cost overrun are material price fluctuation and low productivity and proved that cost overrun has a significant influence on project cash flow. These studies are in line with the present findings that financial management and productivity should be managed together. Thus, the mitigation measures to maintain the financial and operational stability of the X Project Apartment can be incorporated as to improve cash-flow forecasting, cash inflows and outflows monitoring, reduce the rework, control the overtime costs and improve the labour productivity. The implementation and the final expert validation demonstrate that the study results in statistically significant findings as well as operationally applicable recommendations in its entirety. The combination of the results of the statistical analysis, the Probability-Impact Matrix, the actual project conditions and the expert validation provides a coherent basis for prioritising Payment Delay, Weak Financial Management and Low Productivity as the main areas of intervention. The practical contribution of the study is the integrated approach it proposes, linking risk identification, risk prioritisation, operational impact and mitigation strategy within a unified framework, thus filling a gap identified in previous works that have generally addressed cash-flow risks, project impacts or mitigation separately.

CONCLUSION

The study found that the negative cash flow in the X Apartment Project was caused by a combination of external and internal project risks including delay of payment, design and scope changes, poor financial management, low productivity, cost overrun, very low tender price, administrative constraints and poor initial estimates. The Probability-Impact Matrix identified most of these risks as high risk. The statistical analysis found that Payment Delay (X1), Weak Financial Management (X3) and Low Productivity (X4) have a significant impact on the project operations. The findings show that negative cash flow is not only a financial problem but also an operational risk that can delay project progress, increase cost and reduce project effectiveness. Thus the best mitigation strategy is an integrated approach of realistic cash-flow planning, stringent cost control, prompt payment administration, improved payment-term negotiation, adequate financing support, more precise tender estimation and enhanced labour productivity and field supervision. The contractors and project managers are advised to adopt more detailed and flexible cash flow planning supported by real-time financial monitoring, better coordination between the finance, engineering and operations teams and more careful tender pricing to avoid underpricing. The project owner shall make payments timely to the project and simplify payment administration and provide reasonable flexibility in payment mechanisms for the continuity of the project. Suppliers and subcontractors should also improve their internal financial planning and maintain open communication with the project's stakeholders. It is suggested that future research should go beyond single case study to examine a number of construction projects and explore the relationship between cash flow and project operation with larger sample sizes and more sophisticated analytical models.

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