Investigation of Project Delays: Towards a Sustainable Toll Road Project

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Abstract. Private investment in toll roads is anticipated to surge due to their potential to cover operational and developmental costs through toll fees. However, the allure for investors and lenders hinges on achieving long-term sustainability, a challenging feat in the context of frequent project implementation delays, especially in Indonesia's toll road construction. This study delves into the primary obstacles thwarting timely project completion, drawing insights from the literature to gauge their significance in ensuring the sustainability of toll road projects. Based on a 5-point Likert scale questionnaire survey, the report reveals four pivotal challenges, most profoundly linked to variables associated with the Social Environment and Society. Additionally, contract management emerges as a potent factor influencing project time overruns. The model developed herein serves as a valuable tool for academics, researchers, and practitioners seeking an effective approach to address time overrun challenges in toll road projects.

1 Introduction

Many economically developing countries prioritize infrastructure development as a key component of their development plans, as it is vital for society's advancement and economic growth [1]. The Indonesian government has increased its budget for education, health, and infrastructure, despite challenges in Southeast Asia's infrastructure industry due to financial constraints and stakeholders' lack of support [2].

Indonesia's budget deficit is a concern due to overspending on infrastructure and a focus on input parameters over performance metrics, hindering its ability to achieve developmental goals [3]. Projects must attract investors and ensure that they will be profitable [4]. In Indonesia, a project is being promoted to be built. Toll road construction has several distinctive characteristics, such as long project duration, intricate procedures, environmental issues, financial intensity, and changing organisational structures.

A construction project's success is determined by how quickly it is completed, how much it costs, how effectively it is completed, and whether there are any disagreements [5]. Expected outcomes, time, and cost are increasingly being utilized to determine project success Delays in construction hurt sustainability [6][7]. The construction industry contributes significantly to severe environmental problems. Longer construction timeframes caused by delays will extend the negative environmental impact of development. Construction delays, in general, influence projects that interrupt the movement and psychology of the surrounding community.

Several studies have been performed to investigate why construction delays occur and how they might be avoided. However, due to the complexity of construction projects and the numerous potential reasons for delays, these studies have been unable to provide effective answers to delay control [7] [8]. One option to close this gap, and the emphasis of this research, is to find hidden factor linkages among probable causes; this allows the number of reasons to be reduced and centred on the primary factors causing delays [9]. This research investigates the various variables that contribute to delays in the Solo Yogya Toll Road project, which is also a National Strategic Project (PSN) [10].

In this study, factor analysis was chosen for delay analysis since it is an appropriate method when applied to concepts that are difficult to measure [11]. Furthermore, it can reduce a huge number of variables to a few interpretable underlying factors. Given that the causes of construction delays are numerous, making them difficult to quantify, and that dealing with each potential source of delay necessitates time and money, this strategy is appropriate for this purpose.

2 Research Method

Qualitative methods were used to answer questions regarding delay factors in toll road infrastructure in Solo-Yogya. In this method, a literature review is carried out by considering delay factors that currently frequently occur on toll roads. Delay factors are identified to understand the factors affecting toll road project slowness. These factors are defined through in-depth interviews, and

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 https://doi.org/10.1051/e3sconf/202451705014

the most suitable factors are identified through literature studies, interviews, and document collection, providing an overview of research methods and techniques.

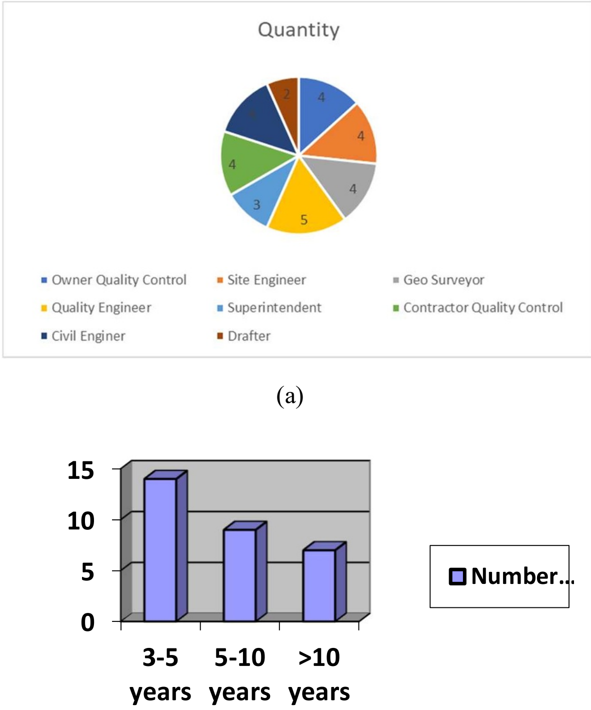
The initial questionnaire was created by creating a sheet of questions on the factors that were causing delays in the construction of the Solo-Jogja toll road project. The initial questionnaire contained criteria derived from earlier studies [12]. The delay variables on toll roads can be seen in Table 1.

Table 1. Factors causing time overrun in toll road projects.

Construct	Item Code
Labour	X1
Materials	X2
Equipment	X3
Design (X4)	X4
Planning & Implementation	X5
Social Environment & Society	X6
Financial	X7
Managerial	X8

A questionnaire was used to collect quantitative ordinal data. The purpose of this poll was to find out more about how experts in the Solo-Yogya toll work business perceive the reasons for the delay. Practitioner responses were recorded on a 5-point Likert scale, with 01 representing Not Significant, 02 representing Slightly Significant, 03 representing Somewhat Significant, 04 representing Very Significant, and 05 representing Very Significant. The data acquired is then checked and processed in the following stage. The following test steps were used to analyse the data using the SPSS version 23. The Classic Test and Hypothesis Test were used to determine the truth and level of influence of the delay factor.

It is crucial to note that the appropriateness of the chosen sample size depends on the research objectives, the methodology, and the level of precision required for the study. In some cases, a smaller sample size with targeted participants may provide valuable and meaningful insights. The decision to restrict the data collection to a sample of 30 construction professionals stems from practical considerations, primarily the constraints on data-gathering resources. This selected group of stakeholders, comprising contractors, consultants, and owners, was chosen due to their direct and integral connection to the project, ensuring that the insights obtained are closely aligned with the key facets of the study. As illustrated in Figure 1, the participants had extensive experience managing building projects and technical understanding.



(a)

(b)

Figure 1. (a). Demographic information of the respondents; (b). Level of respondent experience

Most survey respondents have work experience in related construction work of 3 to 5 years, with 14 people or 47% of the total respondents, 5 to 10 years with 9 people or 30% of the total respondents, and more than 10 years with 7 people or 23% of all respondents.

3 Discussion

Several assumptions must be met in multiple linear regression for the resulting regression equation to be valid when utilized for prediction. This assumption is used because of calculating the linear regression equation. The assumption of regularly distributed data, the assumption of multicollinearity, and the assumption of heteroscedasticity are some of these assumptions. questions should be centred and should be numbered with the number on the right-hand side.

3.1 Normality Test

The normality test determines if the confounding or residual variables in the regression model have a normal distribution. Graphic analysis, such as the P-plot, can be used to determine if the residuals are normally distributed or not [13]. If the plotted data (dots) that show the real data follow a diagonal line, the regression model is normally distributed [14]. Figure 2 shows the results of the Test normality with graphic analysis using the P-Plot.

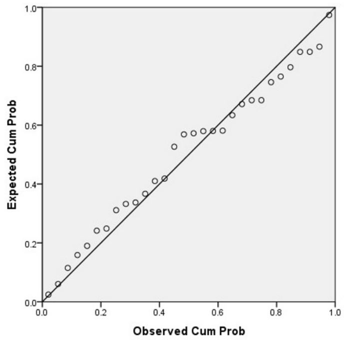


Figure 2. P-plot Normal Graph

From Figure 2, the plotting data (dots) follow a diagonal line, this proves that the variable is normally distributed so it can be used for research.

3.2 Multicollinearity test

The multicollinearity test is used to see if there is a substantial connection between the independent variables in the model. If there is a considerable link between the independent variables, multicollinearity occurs. Based on the VIF (Variance Inflation Factor), multicollinearity is observed in this study. According to the guidelines, there is multicollinearity if the VIF value is more than 10. The multicollinearity results show that the VIF value in this model is less than 10, indicating that there is no multicollinearity in this study [15]. Table 2 shows the results of the multicollinearity test.

Table 2. Multicollinearity test result

Item Code	Collinearity Statistics	
	Tolerance	VIF
X1	0.255	3.928
X2	0.268	3.726
X3	0.393	2.542
X4	0.584	1.712
X5	0.283	3.538
X6	0.209	4.789
X7	0.251	3.986
X8	0.283	3.535

Based on the findings of the data analysis above, it can be inferred that all variables are free of multicollinearity because the VIF value is less than 10 and the tolerance value is more than 0.1, implying that the model is multicollinear.

3.3 Heteroscedasticity test

The heteroscedasticity test is used to assess whether there are departures from the basic heteroscedasticity assumption, which is the unequal variance of the residuals for all data in the regression model. If the value is less than 0.05 (5%) [16], the regression equation has heteroscedasticity and vice versa for non-heteroscedasticity or homoscedasticity. Table 3 shows the results of the scedasticity test using Spearman Rank.

Table 3. Multicollinearity test result

Item Code	Sig.
X1	0.709
X2	0.451
X3	0.815
X4	0.685
X5	0.698
X6	0.617
X7	0.405
X8	0.694

The above test results demonstrate that all of the factors tested are bigger than 0.05 (5%) or have no heteroscedasticity. This suggests that there is no relationship between the magnitude of the residual data and enlarged data, so increased data does not cause the residual (error) to be larger.

3.4 Regression Analysis

In the absence of deviations from classical assumptions, data processing can be continued using the multiple regression model data analysis method. Multiple linear regression analysis determines the influence between two or more independent variables and the dependent variable. Multiple linear regression model calculations were carried out using the SPSS for Windows Release 23.0 program.

In this study, the regression equation formula is as follows:

$$Y = 2.601 + 0.114X1 + 0.088X2 - 0.069X3 - 0.000X4 - 0.058 + 0.196X6 + 0.08X7 - 0.169X8 \quad (1)$$

The regression equation is explained as follows:

The constant value is 2.601, which indicates that if all variables are set to 0 (zero), the project delay level is positive 2.601 or grows.

Then there are some with a positive value (+), indicating that they have a considerable influence on project delays [17]. Labour factors (0.114), Materials (0.087), Social & Community Environment (0.196), and Financing (0.169) have a considerable influence on project delays. Those with a negative value (-) indicate that they have no meaningful influence on project delays [17]. Variables that do not exist Equipment variables (-0.069), design (-0.000), planning and implementation (-0.058), and managerial (-0.169) had no meaningful influence.

3.5 T-Test

The t-test is used to measure the significance of each independent or independent variable's influence on the dependent variable. As a result, the testing for each variable was described using statistic theory [18].

H0 is rejected because the labour factor has a calculated t value of -1.161 with a probability value of 0.002 0.05, indicating that the labour factor has a significant negative effect on the effect of project delays. This demonstrates that labour plays a significant role in project delays.

H0 is rejected because the material factor has a t-calculated value of 0.963 with a probability value of 0.005 0.05, indicating that the labour component has a strong positive effect on the effect of project delays. This demonstrates that the material factor is a significant contributor to project delays.

The predicted t value for the equipment factor is 0.831, with a probability value of 0.314 > 0.05, hence H0 is accepted, indicating that the equipment factor has no substantial positive effect on the effect of project delays. This demonstrates that the equipment component is unimportant in project delays.

H0 is rejected because the design factor has a calculated t value of -0.002 with a probability value of 0.095 > 0.05, indicating that the design factor has a considerable negative effect on the effect of project delays. This demonstrates that the design component is unimportant in project delays.

The planning and implementation factor has a computed t value of 0.305 and a probability value of 0.763 > 0.05, therefore H0 is accepted, indicating that the factor has a strong positive effect on the effect of project delays. This demonstrates that the planning and implementation element is unimportant in project delays.

H0 is rejected because Social & Community Environmental Factors have a computed value of 3.389 and a probability value of 0.000 0.05, indicating that Social & Community Environmental Factors have a considerable positive effect on the effect of project delays. This demonstrates the importance of social and community environmental elements in project delays.

H0 is rejected because the financing factor has a calculated t value of 2.599 and a probability value of 0.000 0.05, indicating that the financing factor has a strong positive effect on the effect of project delays. This demonstrates the importance of money in project delays.

H0 is accepted because the managerial component has a t-value of -0.771 and a probability value of 0.449 0.05, indicating that the managerial factor has a significant negative effect on the effect of project delays. This demonstrates that funding is not a significant issue in project delays.

3.6 F-Test

The F test is used to assess if the independent variables have a significant effect on the dependent variable concurrently or jointly. Table 4 shows the results of the F test.

Table 4. F-test result

Variable	F_{test}	Sig.
Independent	3.826	0.001

The Fcount value in Table 4 is 3.826, with a Sig value of 0.001 0.05, indicating that there is a very strong significant influence on project delays [19] between the factors Labour (X1), Materials (X2), Equipment (X3), Design (X4), Planning & Implementation (X5), Social & Community Environment (X6), financing (X7), and managerial (X8).

3.7 Delay Factors

The Determination Coefficient calculates the degree of effect as a percentage of the independent or independent variable. Table 5 displays the results of the Determinant Coefficient Test. This test will demonstrate how much influence the issue has and how much delay it can cause [20].

Table 5. Determinant Coefficient

R	R Square	Adjusted R Square
0.770	0.593	0.562

SPSS calculation results for Determinant Coefficient Test in Table 5 show that the Adjusted R Square value is 0.562, this can be interpreted as the variables Labor (X1), Materials (X2), Equipment (X3), Design (X4), Planning & Implementation (X5), Social & Community Environment (X6) Financing (X7) and managerial (X8) contributed 56.2%, while the remaining 43.8% was explained by other variables not studied.

Labour Factors (X1), Material Factors (X2), Equipment Factors (X3), Design Location Factors (X4), Planning & Implementation Aspects (X5), Social & Community Environmental Factors (X6), Factors Financing (X7), and Managerial Factors influence Project Delay (Y) by 56.2% with the remaining 43.8% influenced by other factors not used in this study. The other factors contribute to project delays in toll road construction, including financial issues, slow decision-making, inadequate planning, and natural disasters (21,22). These delays can lead to financial unsustainability, particularly in greenfield toll-road projects [23].

Based on the t-test derived from the Sig value. 0.05, it can be concluded that four factors influence project delays in this study, namely [1] Labour (X1); [2] Material (X2); [3] Social and Community Environmental Factors (X6); [4] X7 (Financing Factor). For project delays, the Social & Community Environment variable (X6) has the greatest t-count value. Financing (X7), Labour (X1), Materials (X2), Equipment (X3), Management (X8), Planning & Implementation (X5), and Design (X4) come next. Akomah (2016) and Mahamid (2012) both highlight the significant impact of financial issues, such as delay in payment certificates and progress payment delay, on road construction project delays (24,25). Unfavourable site conditions and equipment/material issues are also identified as key factors by Mejía (2020) [26]. Furthermore, Mahamid (2011) emphasizes the importance of a risk matrix in identifying and managing these delay factors, with a focus on the severity of their impact. These studies collectively underscore the complex interplay of labour, material, equipment, design location, planning, social, community, environmental, financing, and managerial factors in influencing project delays on toll roads [27].

This research delves into the examination of the primary causes of delays in the advancement of toll road infrastructure in Indonesia, placing a specific focus on the Solo-Yogyakarta toll route. An evident challenge arises from the imposition of restrictions within the project environment, predominantly driven by concerns expressed by residents who view the project as disruptive. Resolving this challenge requires the establishment of efficient communication channels among stakeholders, particularly during the design and monitoring phases [28]. The cultivation of a sustainable communication culture within the construction sector, marked by high accessibility and accuracy, is deemed crucial.

Emphasizing project completion becomes imperative in fortifying communication and information systems. To address delays, it is recommended to enforce rules and regulations governing communication among construction parties, along with adopting clear information and communication pathways. Acknowledging the impracticality of imposing a uniform communication paradigm on every project [29], the focus shifts toward enhancing communication techniques tailored to the specific dynamics of each project. Improved communication mitigates delays and enhances overall operational efficiency, thereby contributing to the enduring sustainability of toll projects. Moreover, the study's findings can lay the groundwork for tackling challenges associated with cost overruns in the broader construction industry. The potential implementation of generalised mixed models holds promise in providing a holistic understanding of the interrelated issues surrounding time and cost delays in construction projects.

4 Conclusion

This study examines important delay causes in Indonesian toll road infrastructure, particularly the Solo-Yogya toll route. The serious problems mentioned are project environment restrictions. This is related to local neighbours who believe that this project is a nuisance. This issue can be addressed by creating efficient and effective communication channels among the stakeholders concerned, particularly throughout the design and monitoring stages. A culture of sustainable communication must be promoted and supported in the construction sector while maintaining a high level of accessibility and accuracy. It is critical to encourage project completion to strengthen communication and information systems. Furthermore, creating rules and regulations for communication among construction parties, as well as adopting clear information and communication routes, would aid in the reduction of delays. Establishing good communication techniques is the key to overcoming the issues produced by inadequate communication. It is critical to recognise that imposing a communication paradigm on every project is impractical With enhanced communication, the project will not face delays and will function more smoothly, boosting the toll project's future sustainability. This study can be expanded to address the difficulties of cost overruns in the construction industry, as this has been identified as one of the primary challenges confronting this vast business. Generalised mixed models can also be created to examine the big picture of time and cost delays in construction projects.

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