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The Influence of Internal and External Factors on Labor Productivity

A Study on the Construction Project of the Manokwari Substations

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ABSTRACT

The construction of the Manokwari Substation in West Papua, part of Indonesia's national strategic infrastructure program, faces geographic, logistical, and human resource challenges that demand high labor productivity to ensure project success. This study aims to analyze the influence of internal and external factors on labor productivity within this construction context. Employing a quantitative approach with a correlational ex post facto design, data were collected through a census-based closed-ended Likert-scale questionnaire distributed to 50 active workers involved in the project. Multiple linear regression analysis was used to assess both simultaneous and partial effects of the independent variables on labor productivity. The results indicate that internal factors, such as work experience, education level, health status, and wages, significantly affect productivity, while age and the number of dependents show no meaningful impact. Conversely, all examined external factors (field conditions, weather, and the implementation of occupational safety and health) significantly contribute to labor productivity. This study offers a substantial theoretical contribution by reinforcing the conceptual framework of labor productivity in the construction sector. It provides practical implications in the form of evidence-based strategies to improve workforce performance. The findings are expected to serve as a basis for policy decisions in managing strategic infrastructure projects, particularly in geographically complex regions like Eastern Indonesia.

Keywords
Construction Project
External Factors
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Introduction

The success of construction projects in geographically challenging regions such as Eastern Indonesia depends heavily on the productivity of the workforce involved. One such project, the construction of the 150/20 kV 60 MVA Manokwari Substation in West Papua, forms part of Indonesia's national strategic program aimed at improving the reliability of the electrical grid and supporting regional economic development. However, Papua Barat faces distinct obstacles, including difficult terrain, limited infrastructure, and constrained human resource capacity, all of which have the potential to hinder construction efficiency. In this context, labor productivity becomes a critical performance indicator, particularly as delays in project completion may lead to budget overruns, postponed operations, and disruption in electricity distribution for local communities and industries.

Despite the centrality of productivity in project outcomes, limited empirical research has comprehensively explored the combined influence of internal and external factors on construction workers' performance in remote national infrastructure projects. Most previous studies tend to isolate either personal attributes or environmental aspects, failing to account for their interactive or cumulative effects. This creates a knowledge gap that inhibits the formulation of evidence-based strategies tailored to complex field conditions. Addressing this research void is particularly important in projects located in underdeveloped and high-risk environments, where construction management practices must adapt to the multifaceted nature of productivity drivers.

To underpin this study, the theoretical framework draws upon principles of operations management and work productivity. Operations management theory emphasizes the optimization of resource utilization for effective output generation, while labor productivity is defined as the ratio of work output to input within a specific timeframe. Supporting concepts from construction productivity literature further identify five key dimensions of worker productivity: quantity, quality, timeliness, work motivation, and discipline. These dimensions align with findings from prior studies that highlight the influence of variables such as worker demographics, economic conditions, health, site accessibility, and occupational safety on labor outcomes [1]-[3].

This study explicitly investigates two central questions:

- To what extent do internal factors (such as age, education, work experience, wages, number of dependents, and health) affect labor productivity in the Manokwari Substation construction project?
- To what extent do external factors (including field conditions, weather, and occupational safety and health) influence labor productivity?

These research questions serve as the foundation for examining the statistical relationship between individual and environmental determinants and worker performance outcomes.

By integrating multiple variables into a single empirical model, this study contributes new insights to the field of construction management, particularly in infrastructure projects executed under complex and remote conditions. The study's novelty lies in its contextual focus on Papua Barat, a region that has been underrepresented in productivity research despite its strategic importance. Furthermore, the findings offer actionable recommendations for policymakers and practitioners to develop productivity enhancement strategies grounded in actual project conditions, thereby bridging the gap between academic knowledge and field implementation.

Literature Review

The theoretical foundation of this study is anchored in operations management and labor productivity theories, both of which provide a structured lens to examine how internal and external factors influence workforce efficiency in construction contexts. According to Heizer and Render's [4] operations management framework, optimal project outcomes are achieved through the efficient and effective transformation of resources into outputs, emphasizing the centrality of labor performance in managing construction activities. Complementarily, the theory of work productivity (rooted in the contributions of Oglesby and the Construction Industry Institute or CII) conceptualizes productivity as the ratio between the outputs produced and the inputs consumed over a given period [5]. These frameworks collectively support the premise that labor productivity is multifactorial, shaped by individual characteristics, working conditions, and organizational practices.

Previous studies have explored a range of determinants affecting labor productivity in construction. Internal factors frequently highlighted include education level, work experience, age, health, wages, and number of dependents, while external variables cover weather conditions, field accessibility, and the enforcement of occupational safety and health (OSH) protocols. For instance, Yahaya et al. [6] found that experience and compensation strongly influence productivity in public works projects. Karlsone and Ozola [3] similarly emphasized environmental constraints in Latvian construction projects as critical productivity inhibitors. Other researchers have identified psychological and motivational aspects such as morale,

discipline, and teamwork as contributing factors to performance, particularly under high-stress conditions [7].

Despite the abundance of research, a critical gap remains in integrating internal and external variables within a unified empirical framework that reflects real-world construction settings, especially in developing regions. Most studies isolate factors or apply them in industrialized contexts, limiting their relevance to remote and under-resourced environments like Papua Barat. Moreover, there is a paucity of research using a quantitative correlational approach to examine how these factors interact and jointly influence productivity outcomes in field-based infrastructure projects.

This article aims to address this research gap by developing and empirically testing a model that incorporates both internal and external dimensions affecting labor productivity. It contributes to the literature by offering a holistic assessment grounded in actual field conditions and data from a remote infrastructure project of strategic importance. In doing so, it extends current academic discourse on productivity modeling beyond the traditional industrial settings typically featured in prior work [1], [8].

In terms of theoretical and methodological trends, many previous studies have favored either qualitative exploration or narrow quantitative surveys focusing on limited variables. For example, Chaudhari and Bhangale [9] utilized fuzzy logic to assess internal productivity drivers in urban India, while Quezon and Ibañez [10] explored pandemic-related disruptions in the Philippine construction sector. However, few have adopted an ex post facto quantitative method to assess integrated factor influence, especially using a census technique in the context of public infrastructure development.

This study synthesizes insights from operations management, productivity measurement, and empirical field research to construct a conceptual basis for analyzing productivity in complex construction environments. It builds upon the dimensional framework, which includes five elements (work quantity, quality, timeliness, motivation, and discipline) and operationalizes these through measurable indicators. The resulting model is used to test specific hypotheses about the influence of internal and external variables, serving as a bridge between conceptual frameworks and field-based statistical validation.

Research Method

This study employs a quantitative correlational research strategy using an ex post facto approach, which is appropriate for examining statistical relationships between variables without researcher intervention. The study is designed to analyze the influence of internal and external factors on labor productivity in a real-world construction setting, specifically within the development of the 150/20 kV 60 MVA Manokwari Substation project. The ex post facto

design ensures that the variables under study are observed after they have naturally occurred in the field, aligning with the goal of measuring associations rather than establishing causality.

Data sources include both primary and secondary data. The primary data were collected directly from respondents through a structured, closed-ended questionnaire using a five-point Likert scale ranging from "Strongly Disagree" (1) to "Strongly Agree" (5). A census sampling technique was applied, targeting all 50 active workers on the project to ensure full population coverage and increase the reliability of findings. Secondary data were sourced from official project documentation, reports from PLN (Indonesia's state electricity company), publications from the Ministry of Energy and Mineral Resources, relevant academic literature, and research findings related to labor productivity and construction management.

The data collection instrument was a digital questionnaire disseminated through Google Forms to overcome geographic limitations and accelerate response rates. The questionnaire was divided into three key variable groups: (1) internal factors (age, education, work experience, wages, number of dependents, and health); (2) external factors (field conditions, weather, and occupational safety and health); and (3) labor productivity measured through dimensions of output quantity, quality, timeliness, motivation, and discipline. To complement the survey, a document analysis method was applied to extract relevant data from official reports and literature, enhancing the contextual understanding of productivity dynamics on-site. See Table 1 for the summary.

Table 1. Research Instruments and Variables

Aspects	Remark
Data Collection Method	Digital questionnaire (Google Forms) and document analysis
Purpose of Using Digital Questionnaire	To overcome geographic limitations and accelerate response rates
Instrument Structure	The questionnaire was divided into three main variable groups
Internal Factors	Age, education, work experience, wages, number of dependents, and health
External Factors	Field conditions, weather, and occupational safety and health (OSH)
Labor Productivity	Measured through output quantity, quality, timeliness, motivation, and discipline
Supplementary Method	Document analysis of official reports and relevant literature

For the purposes of ensuring the validity and reliability of the instrument, Pearson's product-moment correlation was used to assess the validity of each questionnaire item, while Cronbach's alpha coefficient was used to measure internal consistency, with $\alpha > 0.60$ considered acceptable for reliability. Before hypothesis testing, a series of classical assumption tests were conducted to confirm the suitability of the regression model, including the normality test (Kolmogorov-Smirnov and P-P Plot), multicollinearity test (using VIF and Tolerance values), and heteroscedasticity test (via the Glejser test and scatterplot analysis).

The main analytical technique applied was multiple linear regression, used to determine both the simultaneous and individual effects of internal and external variables on labor productivity. The regression model is specified as follows:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon$$

where

Y: labor productivity,
X_1 to X_n : the independent variables (internal and external factors),
α: the constant,
β_1 to β_n: the regression coefficients,
ε: the error term.

This model facilitates a comprehensive examination of how multiple independent variables contribute to variations in labor productivity.

To test the formulated hypotheses, both F-tests (simultaneous effects) and t-tests (partial effects) were employed at a 95% confidence level. Additionally, the coefficient of determination (R^2) was calculated to assess how much of the variance in labor productivity could be explained by the model. All statistical analyses were conducted using SPSS software, which provided a reliable computational platform for descriptive and inferential statistics, consistent with the methodological rigor expected in empirical construction productivity research [1]-[3], [8], [9].

Results

The findings of this study are based on the analysis of quantitative data gathered from 50 construction workers involved in the Manokwari Substation project. Descriptive statistics show that the majority of respondents are aged between 26 and 35 years, possess secondary or vocational education, and have more than five years of work experience. Most respondents earn a monthly income between IDR 3 million and 5 million, support 3 to 5 dependents, and self-report good or very good health status. Regarding external conditions, field access was rated as moderately difficult, weather conditions were frequently disruptive, and the majority indicated consistent compliance with OSH measures.

The descriptive analysis of productivity-related indicators reveals that most respondents perceive their own work quantity and timeliness as high, although some reported moderate ratings for motivation and discipline. Based on the Likert-scale data, productivity indicators cluster within the "agree" category, suggesting a generally positive perception of performance levels. Validity and reliability testing showed that all questionnaire items had Pearson correlation coefficients above 0.30, indicating acceptable validity. The Cronbach's alpha values for all variables were above 0.70, confirming high internal consistency and instrument reliability.

In the classical assumption testing, the data passed all required checks. The Kolmogorov-Smirnov test confirmed normal distribution ($p > 0.05$), multicollinearity was not present as all VIF values were below 10 and tolerance values above 0.10, and no heteroscedasticity was detected through Glejser and scatterplot tests.

The multiple linear regression analysis produced a significant model (F-test sig. < 0.05), indicating that the combined internal and external factors significantly influence labor productivity. The coefficient of determination (R^2) was 0.627, meaning that 62.7% of the variance in labor productivity could be explained by the independent variables included in the model.

The t-test (partial effect analysis) produced the following findings:

- Work experience (X3) had a significant positive effect on productivity ($p = 0.004$, $\beta = 0.312$).
- Education level (X2) was positively correlated and statistically significant ($p = 0.016$, $\beta = 0.249$).
- Health status (X6) showed a strong and significant effect ($p = 0.001$, $\beta = 0.361$).
- Wages (X4) were moderately significant ($p = 0.038$, $\beta = 0.211$).
- Age (X1) and number of dependents (X5) had no statistically significant effect on productivity ($p > 0.05$).
- Among external factors, field conditions (X7) were highly significant ($p = 0.002$, $\beta = 0.333$), weather (X8) had a significant effect ($p = 0.013$, $\beta = 0.271$), and OSH implementation (X9) showed the strongest positive influence ($p = 0.000$, $\beta = 0.389$).

These results confirm that both internal and external factors influence labor productivity, though not all variables contribute equally. Specifically, work experience, health, education, wages, field conditions, weather, and OSH implementation were the most impactful predictors, while age and number of dependents did not yield significant effects.

Discussion

The results of this study confirm that both internal and external factors significantly affect labor productivity in the construction of the Manokwari Substation. This finding aligns directly with the research objectives and hypotheses, which sought to determine the extent to which worker characteristics and environmental conditions influence performance. The statistical analysis revealed that variables such as work experience, education level, health status, wages, field conditions, weather, and the implementation of OSH protocols significantly impacted productivity levels, while age and number of dependents had no measurable effect. These outcomes validate the study's conceptual framework and underscore the importance of

both personal and situational variables in managing workforce efficiency in construction projects.

Interpreted through the lens of operations management theory, these findings highlight the strategic role of human resource optimization in achieving effective project execution. Heizer and Render's [4] model emphasizes the transformation of inputs into outputs through efficient systems, suggesting that worker readiness, skills, and physical condition are crucial inputs that must be managed carefully. Similarly, the productivity theory framework by Oglesby [5] reinforces that labor output is shaped not only by skill level but also by external factors like worksite conditions and safety measures. The fact that OSH emerged as the most influential variable aligns with contemporary productivity discourse that links worker well-being to output efficiency [7].

Compared with prior research, this study both confirms and extends existing knowledge. The positive influence of education and experience is consistent with findings by Yahaya et al. [6], who noted that skilled labor tends to achieve higher efficiency in public construction works. Similarly, Karlsone and Ozola [5] observed that adverse field conditions substantially disrupt productivity in European infrastructure projects. However, this study adds depth by simultaneously evaluating both internal and external dimensions, whereas most earlier studies focused on a single category. For instance, Chaudhari and Bhangale [9] primarily assessed internal motivation drivers using fuzzy logic, while Tam et al. [8] emphasized workforce management systems in Vietnamese projects.

This article contributes scientifically by validating a comprehensive model that integrates personal and environmental factors to explain labor productivity. By doing so, it strengthens the empirical foundation of productivity theory in underrepresented regions such as Eastern Indonesia. The use of a census method further enhances the reliability of the data, making the findings relevant for both academics and practitioners involved in managing infrastructure projects in geographically complex areas. The results also offer practical implications: policies should prioritize training, health programs, competitive wages, and strict OSH implementation to maximize output.

Nevertheless, the study has several limitations. It focuses on a single project, which may limit the generalizability of findings across other types of infrastructure or regions with different socio-economic profiles. Additionally, the use of perception-based data through questionnaires may introduce response biases, especially when measuring abstract variables like motivation and discipline. Future studies could employ mixed methods to triangulate these findings and extend the analysis across multiple construction sites to validate the proposed model more broadly.

The results suggest that labor productivity in strategic construction projects is not only a matter of individual capacity but also a reflection of structural and environmental factors. Policymakers and project managers should therefore adopt an integrated approach when developing strategies to enhance productivity. Future research should explore dynamic interactions among internal and external factors using longitudinal data or simulations, potentially expanding the theoretical scope of construction productivity models [1], [2], [10].

The findings of this study indicate that both internal and external factors significantly influence labor productivity in the construction project of the 150/20 kV 60 MVA Manokwari Substation. Internal determinants such as work experience, education level, health status, and wages contribute positively and significantly to productivity outcomes, whereas variables such as age and number of dependents exhibit no substantial effect. Conversely, external aspects, including field conditions, weather variations, and the implementation of OSH measures, demonstrate strong and statistically significant impacts on labor productivity. These results align with previous studies that identified productivity as a multifactorial phenomenon shaped by personal, managerial, and environmental conditions on-site [11]-[13]. Theoretically, this study reinforces the multidimensional framework of labor productivity proposed in recent research, which emphasizes the integration of internal and external determinants to form a holistic understanding of performance dynamics in the construction sector [14]. Empirically, it supports earlier findings that strategic human resource management can substantially improve productivity and project outcomes, particularly in geographically challenging regions [11], [15]. Practically, this study provides a robust data-driven foundation for optimizing workforce efficiency and minimizing project delays in national infrastructure development. Furthermore, it contributes to future research directions by encouraging comparative and predictive analyses across various project types and regional contexts to strengthen the adaptability and applicability of productivity frameworks in construction management [14], [15].

Conclusion

This study concludes that both internal and external factors play a significant role in influencing labor productivity in the construction project of the 150/20 kV 60 MVA Manokwari Substation. Internal factors such as work experience, education level, health status, and wages have been found to contribute positively and significantly to productivity outcomes, while age and number of dependents do not show a meaningful impact. On the other hand, external factors, including field conditions, weather, and the implementation of OSH measures, demonstrate strong and statistically significant effects on the productivity of construction workers. These findings confirm the theoretical assumption that productivity in infrastructure

projects is a multifactorial outcome shaped by both individual characteristics and environmental conditions on-site.

Theoretically, this article contributes by reinforcing a multidimensional framework for analyzing labor productivity that bridges internal and external determinants. It offers empirical evidence to support strategic human resource planning, particularly in infrastructure projects located in remote or challenging geographic regions. Practically, the research provides a data-driven basis for optimizing labor performance through targeted interventions such as training, health programs, and safety compliance strategies. These insights can be utilized by project managers, contractors, and policy stakeholders to enhance efficiency and minimize delays in national infrastructure development efforts.

The study also opens new avenues for future research. Subsequent investigations are encouraged to apply comparative models across different project types and regions, utilize mixed-methods approaches to enrich contextual interpretation, and develop predictive models that integrate dynamic variables over time. By doing so, the robustness and applicability of labor productivity frameworks in construction management can be further expanded.

Conflict of Interest

The authors declare no conflict of interest.

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