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Labor Productivity Study in Construction Projects Viewed from Influence Factors

Rusdi U. Latief [1*], N. M. Anditiaman [1], I. R. Rahim [1], R. Arifuddin [1], M. Tumpu [2]

[1] *Department of Civil Engineering, Faculty of Engineering, Universitas Hasanuddin, Makassar, Indonesia.*

[2] *Department of Disaster Management, Graduate School, Hasanuddin University, Makassar, Indonesia.*

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Abstract

Productivity is one of the fundamental factors affecting competitiveness in the construction industry. Construction and productivity are two things that are interrelated. This study aims to identify the factors and model relationship these factors that affect labor productivity using the Structural Equation Modelling (SEM) in road construction projects in Indonesia as seen from each side area I, II, and III, respectively. The results obtained the factors that influence labor productivity in road construction projects in Indonesia, namely field conditions, time, financial factors, and internal labor. The study's findings indicate that internal labor is one of the elements influencing labor productivity in Indonesian construction projects, particularly road maintenance work. Labor productivity research in Indonesia is conducted by comparing planned and realized labor productivity calculations, which are conducted by collecting project data and making firsthand observations of work in the field. Labor productivity is measured using characteristics other than the variables used in the research, as well as a larger population and sample coverage. The findings of this study can be utilized as input for government agencies in determining the ability of specialists to carry out work in the field connected to the preservation of non-structural flood handling roads on Indonesian territory.

Keywords: Productivity; Labor; Construction Projects; Smart PLS.

1. Introduction

Productivity is one of the fundamental factors affecting competitiveness in the construction industry. The government's commitment to infrastructure development is also reflected in the declaration and determination of the acceleration of 201 National Strategic Projects [1–3]. This was stated in Presidential Regulation No. 109 of 2020 Implementation of National Strategic Projects, which has encouraged an increase in the construction sector. One of the strategic projects is the road and bridge sector, with 54 projects spread across several provinces. Based on the 2020–2024 RPJMN, it is a starting point for achieving the goals of Indonesia's 2045 Vision, namely an Advanced Indonesia [4, 5]. Strengthening the process of economic transformation in order to achieve the development goals of 2045 is the main focus in order to achieve better infrastructure, quality human resources, public services, and people's welfare. As well as the idea of moving the National Capital (IKN), it is necessary to encourage the performance of the construction industry, especially for the success of various infrastructure development projects [6–10].

Due to the severity of the construction project, the construction team had to face incomparable circumstances. The successful completion of a construction project depends on highly correlated management inputs such as capital,

* Corresponding author: rusdiusmanlatief@unhas.ac.id

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materials, and labor. The construction industry is a labor-intensive industry, and labor is considered a company asset; therefore, an understanding of the concept of labor productivity is very important. Labor productivity has a high impact on construction management, where the best management practice is to measure and monitor productivity on time. Problems associated with unsatisfactory project completion are productivity issues, mostly related to workforce performance [11].

Construction and productivity are two things that are interrelated. Construction is a series of activities involving the initiative, planning, and implementation of a building. According to the regulatory context, the construction sector in Indonesia is referred to as "construction services" and not "construction industry." Regulations regarding construction services in Indonesia are still interpreted in various ways by related parties [12, 13]. Despite the fact that construction activities also include non-engineered buildings, Therefore, multi-disciplinary and sectoral involvement is a necessity. The term "construction industry" is used as an ideal embodiment of the ideals of reform in the construction sector in Indonesia. While productivity is a measure used of construction activities as an indicator of the actual achievement of science and technology as a source of economic growth.

Many studies on labor productivity have been undertaken, including those by Hutasoit et al. (2017) [14]. The rupiah value of items or services is calculated through analysis, especially work sampling, by inputting the amount of time, labor, total labor cost, and material used in creating the number of physical units of products or services [15]. Ahn et al. (2014) [5] calculated work duration using the inputs of work volume and labor coefficient. Working hours were used as input material for RII and Matlab analysis by Heravi & Eslamdoost (2017) [7] and Karatas & Budak (2022) [16]. Furthermore, Juliansyah (2017) [17] employs LUR analysis to leverage effective working time and contributing working time as inputs.

Dadi et al. (2014) [18] use the time spent by workers from the beginning to the finish of work in work units that can be measured in hours or minutes to create work in advanced meters (m^1), square meters (m^2), and kilograms (kg). Abdel-Hamid & Mohamed Abdelhaleem (2022) [19] examines time and expenses based on labor productivity analysis, employing job length and worker count to produce work amount. Seyis (2019) [20] and Jarkas (2016) [21], investigated labor productivity utilizing the LUR technique and work sampling, with inputs including total time, total labor, total labor cost, amount of material, working hours, duration, and number of workers producing items or services (kg).

Seikh et al. (2017) [9] calculated the quantity of work generated by analyzing worker productivity using the time study method with the input working hours or standard time from field observations. Other things employed by Veeren et al. (2016) [22] use total observations as an input and effective time and contributor time as outputs.

In this study, the division of measurement areas was carried out based on the regional sectors of the Ministry of Public Works and Public Housing, which consisted of Region I, which included Aceh, West Sumatra, Jambi, Bengkulu, South Sumatra, North Sumatra, Riau, Riau Islands, Lampung, North Kalimantan, West Kalimantan, Central Kalimantan, East Kalimantan, and South Kalimantan. Region II, which includes Banten, Jakarta-West Java, Central Java-DIY, NTB, East Java-Bali, and NTT as well as region III, which includes Gorontalo, Central Sulawesi, West Sulawesi, South Sulawesi, North Sulawesi, Southeast Sulawesi, North Maluku, Maluku, Pabar, Merauke, Jayapura, and Wamena (based on Regulation of the Minister of Public Works and Public Housing No. 3/PRT/M/2019). This study aims to identify the factors that affect labor productivity, determine the level of significance of each of these factors that affect labor productivity, and model the relationship between these factors that affect labor productivity in road construction projects in Indonesia seen from each side. areas I, II, and III, respectively.

2. Research Methodology

The analysis used in this research is quantitative data analysis where the data collected by the researcher is questionnaire data, in the form of information related to the perspective of opinion in the form of numbers or values. of the 200 respondents who filled out the questionnaire grouped by region. Distributing questionnaires to project management or contracted labor to identify factors that affect labor productivity in road construction projects in Indonesia based on a Likert scale and then processed using SEM SmartPLS. Figure 1 shows the operational model in the form of a flowchart used in this study. Figure 2 shows a map of the distribution of research locations.

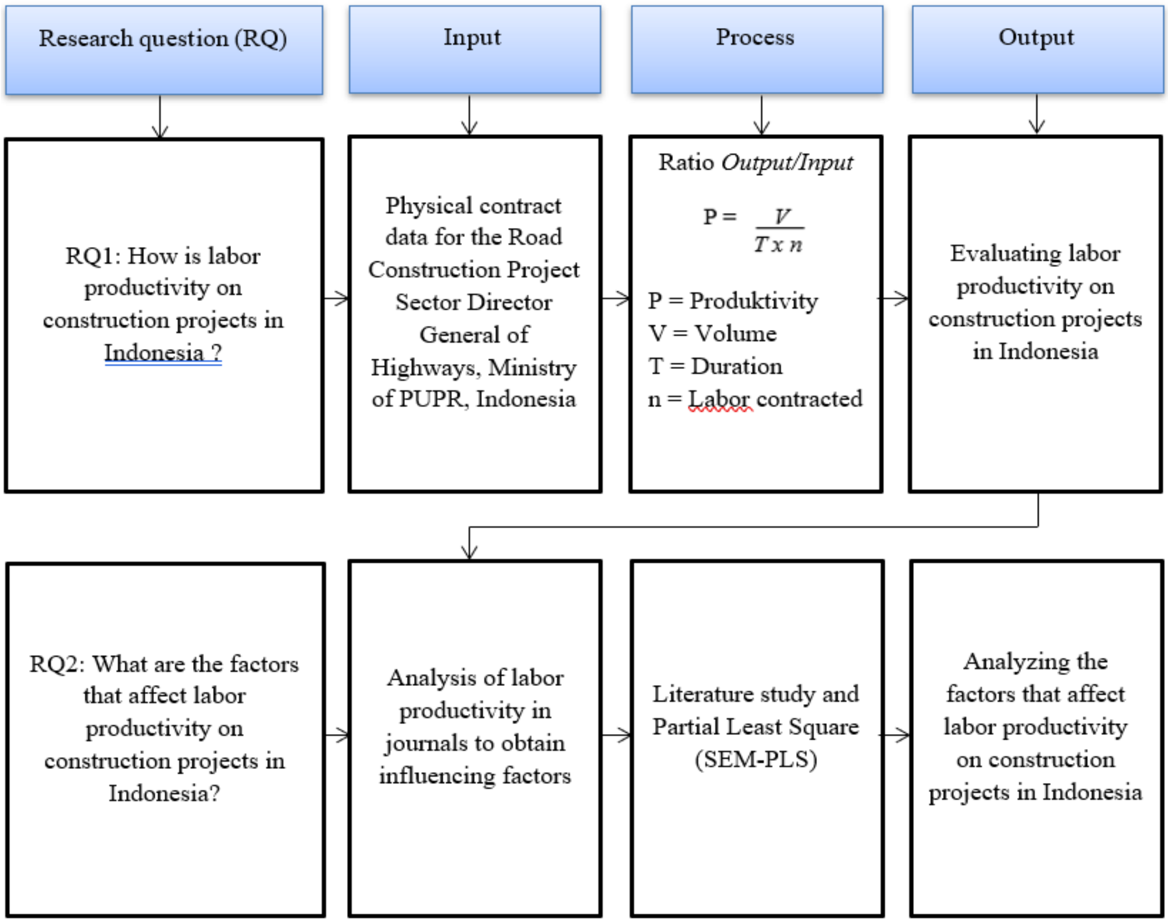

Figure 1. Operational model in the form of flowchart

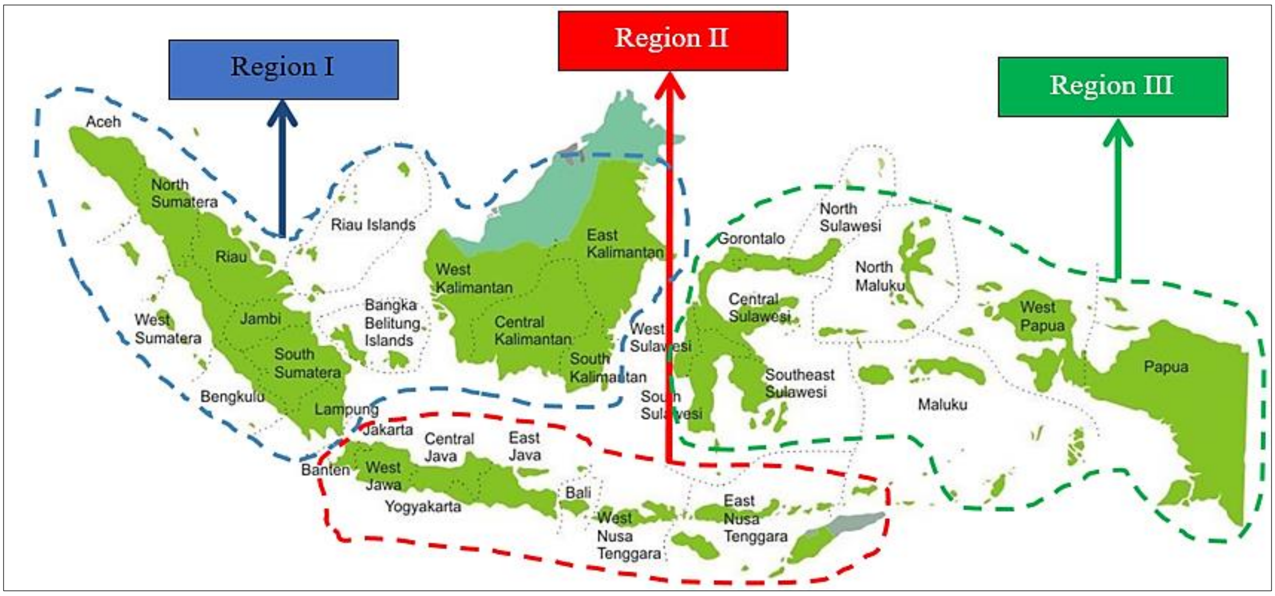

Figure 2. Research location

3. Results and Discussion

3.1. Overview of Respondents

The number of samples obtained in this study were 200 respondents who were divided into 3 regions covering regions I, II and III, namely 71, 68 and 61 respondents. Based on the number of respondents from each regional division, it was shown that the sample size met the requirements for the number of samples in data processing using SEM PLS. Table 1 to 3 shows the experience respondent, respondent position and respondent work location in region I, II and III.

Table 1. Experience respondent in regions I, II and III

No.	Experience	Region		
		I	II	III
1	< 5 years	9	12	5
2	6-10 Years	44	42	41
3	11-15 Years	12	7	9
4	> 15 Years	6	7	6

Table 2. Respondent positions in regions I, II and III

No.	Position	Region		
		I	II	III
1	K3 Construction Expert	11	12	8
2	Main Director	3	6	6
3	Drafter	3	1	2
4	General Superintendent	6	2	6
5	Inspector	2	5	1
6	Logistics	2	3	5
7	Management Construction	10	19	13
8	Road Executor	11	3	1
9	Supervisor	2	8	6
10	Quality Engineers	8	6	7
11	Quantity Engineer	5	3	2
12	Supervisors	2		4
13	Surveyor	6		

Table 3. Respondent work location area I, II and III

Region I			Region II		
No.	Province	Total	No.	Province	Total
1	Bengkulu	5	1	Bali	1
2	Jambi	4	2	Banten	8
3	West Kalimantan	6	3	Special Region of Yogyakarta	6
4	South Kalimantan	8	4	DKI Jakarta	13
5	Central Kalimantan	9	5	West Java	12
6	East Kalimantan	1	6	Central Java	10
7	North Kalimantan	5	7	East Java	9
8	Bangka Belitung Islands	4	8	West Nusa Tenggara	6
9	Riau Archipelago	4	9	East Nusa Tenggara	3
10	Lampung	2			
11	Nanggroe Aceh Darussalam	6			
12	Riau	3			
13	West Sumatra	1			
14	South Sumatra	9			
15	North Sumatra	4			
Region III					
1	Gorontalo	1			
2	Maluku	4			
3	North Maluku	2			
4	Papuan	7			
5	West Papua	8			
6	West Sulawesi	10			
7	South Sulawesi	12			
8	Central Sulawesi	9			
9	Southeast Sulawesi	7			
10	North Sulawesi	1			

3.2. Measurements (Outer Model)

The calculation of the outer model is a measurement model that assesses connections among variables. To see the relationship between existing variables, statistical tests such as converging validity, discriminant validity, and reliability tests are needed. The outer model for each region (region I, region II, and region III) was described as follows in Figures 3 to 5. The three criteria for using data analysis techniques with SmartPLS to assess the outer model are convergence validity, discriminant validity, and composite validity. The outer model is often also called the outer relation or measurement model, which explains how each indicator block relates to its variables.

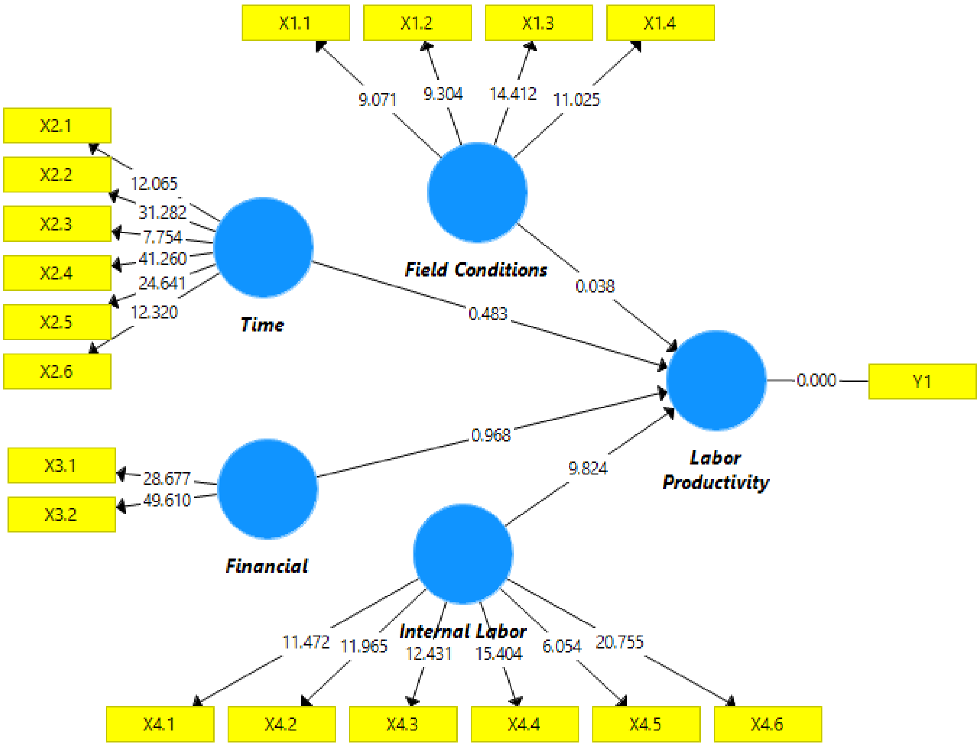

Figure 3. Measurement outer model region I

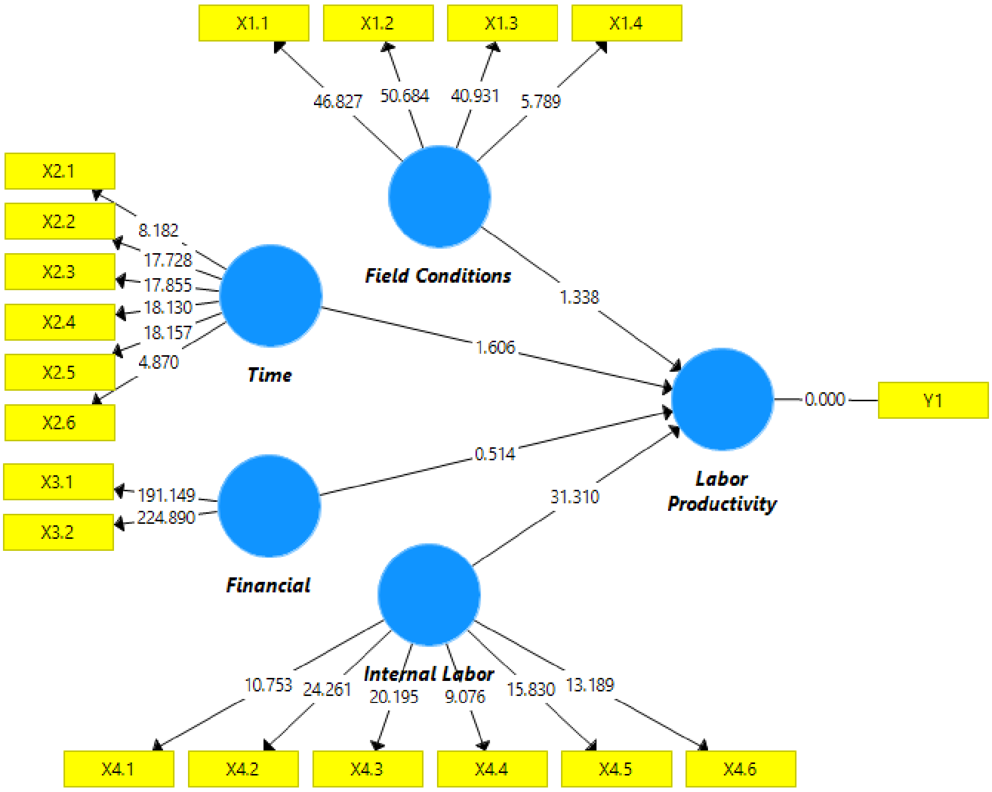

Figure 4. Measurement outer model region II

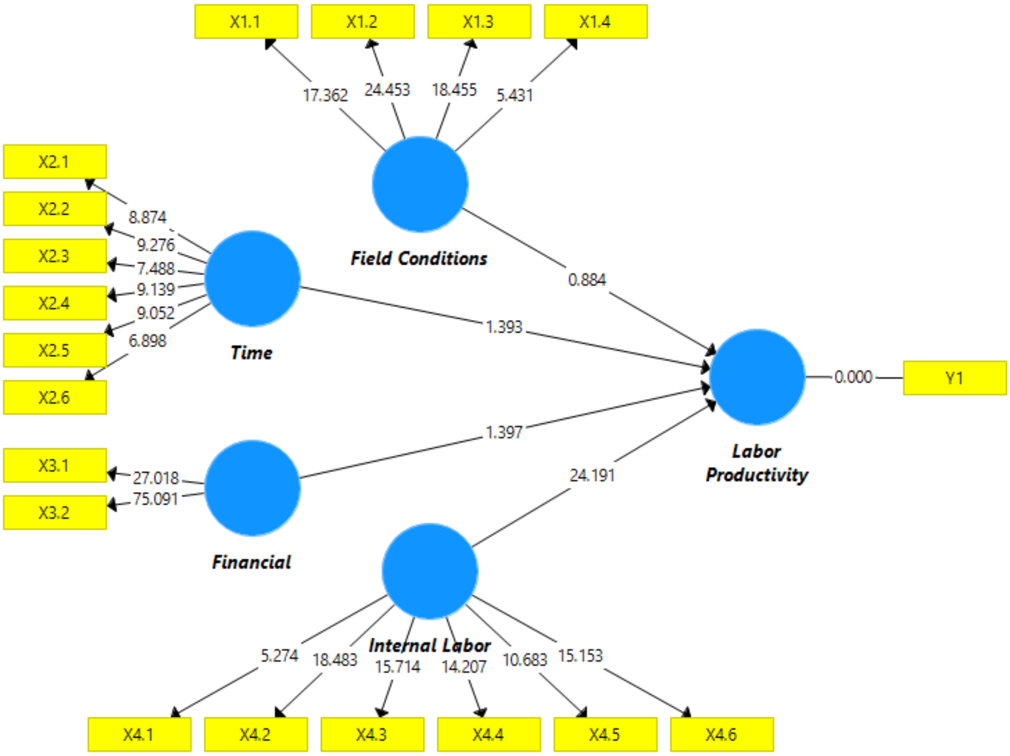

Figure 5. Measurement outer model region III

In general, the purpose of conducting validity tests is to see whether the variables used can measure what you want to measure in the research being conducted. A variable in a questionnaire is used to measure the indicators to be studied. While the reliability test is a test conducted to assess or see whether the series of questionnaires used does not have a tendency towards certain variables.

3.2.1. Convergent Validity

Convergent validity is used to prove that a statement on each variable in the study could be understood by respondents in accordance with the researcher's understanding. Indicator individual considered reliable if it has a score correlation or loading factor ≥ 0.5 [9]. The convergent validity value of each division of regions (I, II, and III) is shown in Table 4.

Table 4. Convergent Validity values in regions I, II and III

	Financial			Power internals work			Condition field			Productivity power work			Time		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
X1.1							0.730	0.960	0.910						
X1.2							0.718	0.960	0.944						
X1.3							0.797	0.954	0.900						
X1.4							0.705	0.595	0.618				0.732	0.671	0.699
X2.1													0.911	0.935	0.934
X2.2													0.712	0.924	0.900
X2.3													0.924	0.935	0.946
X2.6													0.879	0.936	0.937
X3.1	0.909	0.992	0.951										0.802	0.546	0.634
X3.2	0.934	0.992	0.969												
X4.1				0.726	0.740	0.617									
X4.2				0.723	0.797	0.791									
X4.3				0.790	0.811	0.812									
X4.4				0.808	0.638	0.782									
X4.5				0.554	0.753	0.708									
X4.6				0.823	0.773	0.816									
Y1										1	1	1			

A fit model for the variables analyzed with PLS required that they fulfill the value of convergent validity, namely an indicator with a loading factor above 0.5. An indicator with a loading factor below 0.5 is stated invalid as a construct variable empowerment and must be returned (dropped) from analysis. Based on the table above, it shows that all indicators fulfill the convergent validity test requirements of ≥ 0.5, which means all indicators used in this study are valid [10].

3.2.2. Discriminant Validity

Discriminant validity is fulfilled if average variance extracted (AVE) from the average variance obtained is higher than involving correlation with the latent variable. Following is a description of the results of discriminant validity in each division of regions I, II, and III. From Figures 6 to 8, it is visible that the score root AVE > 0.5 p shows that all variables in the estimated model fulfill criteria for discriminant validity.

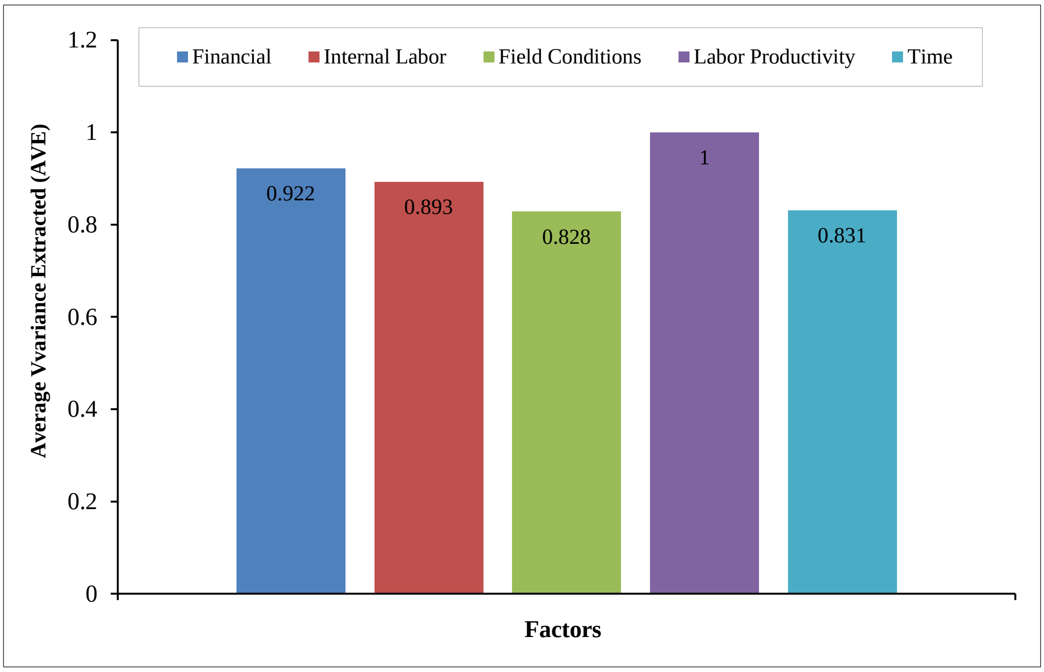

Figure 6. Discriminant validity values in region I

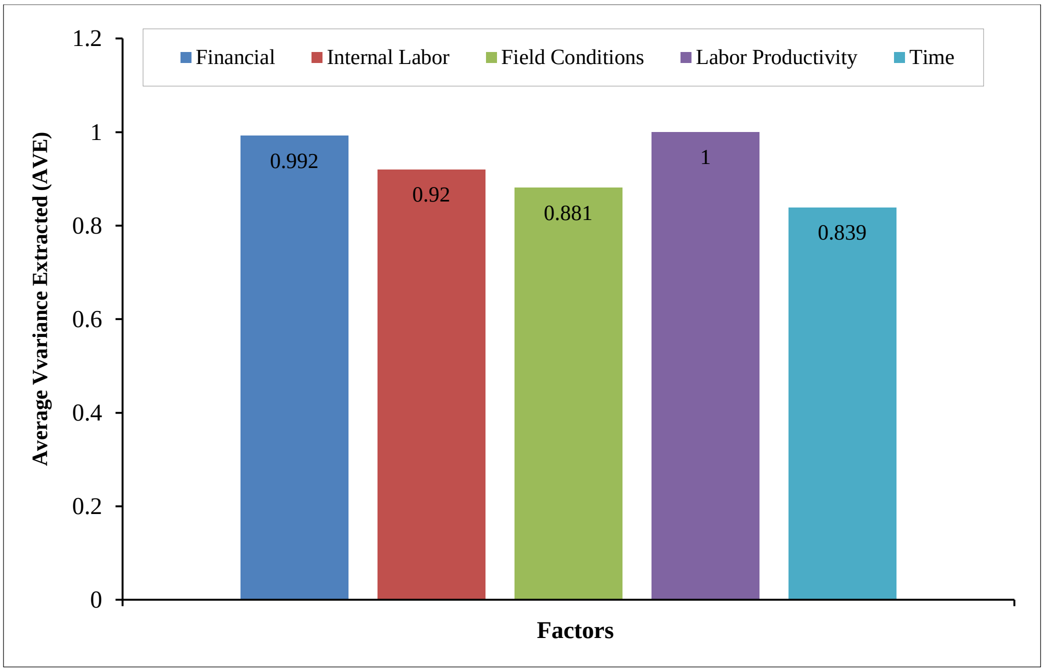

Figure 7. Discriminant validity value in region II

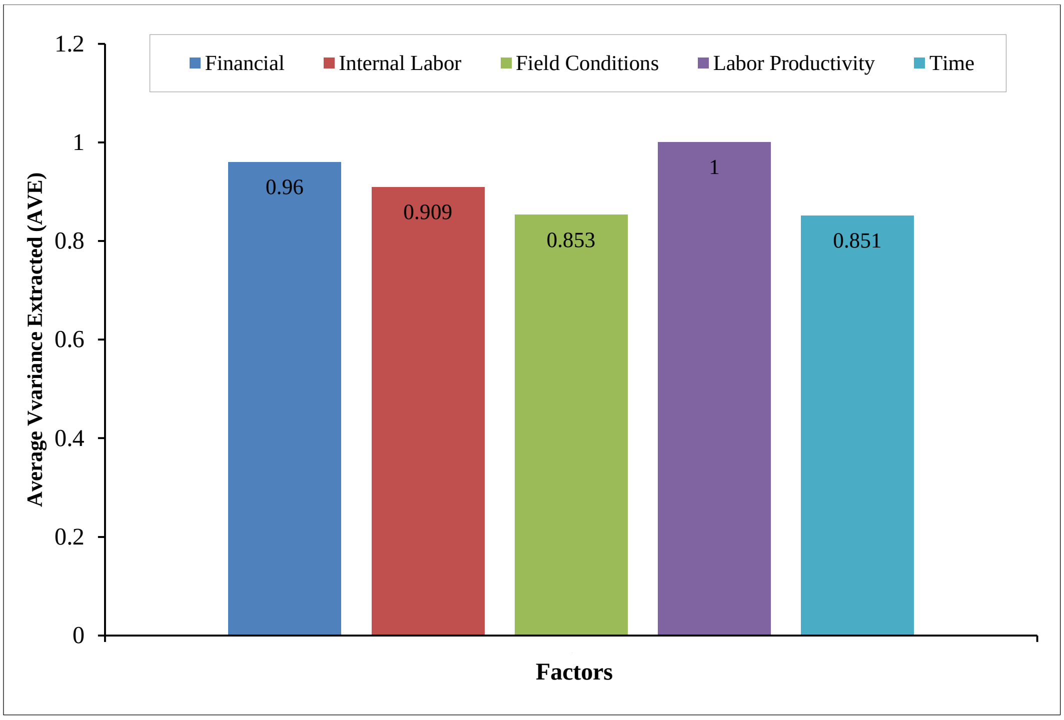

Figure 8. Discriminant validity value in region III

3.2.3. Reliability Test

The reliability test was carried out using the composite reliability score from the indicator construct. Composite Reability Results will show a satisfactory value if ≥ 0.6. Following is a description from the score: The composite reliability of each region is shown in Figures 9–11. Table shows that the composite reliability value for all constructs is greater than 0.6, which indicates that all constructs on the estimated model have high reliability, which means that regions I, II, and III comply with the criteria for reliability.

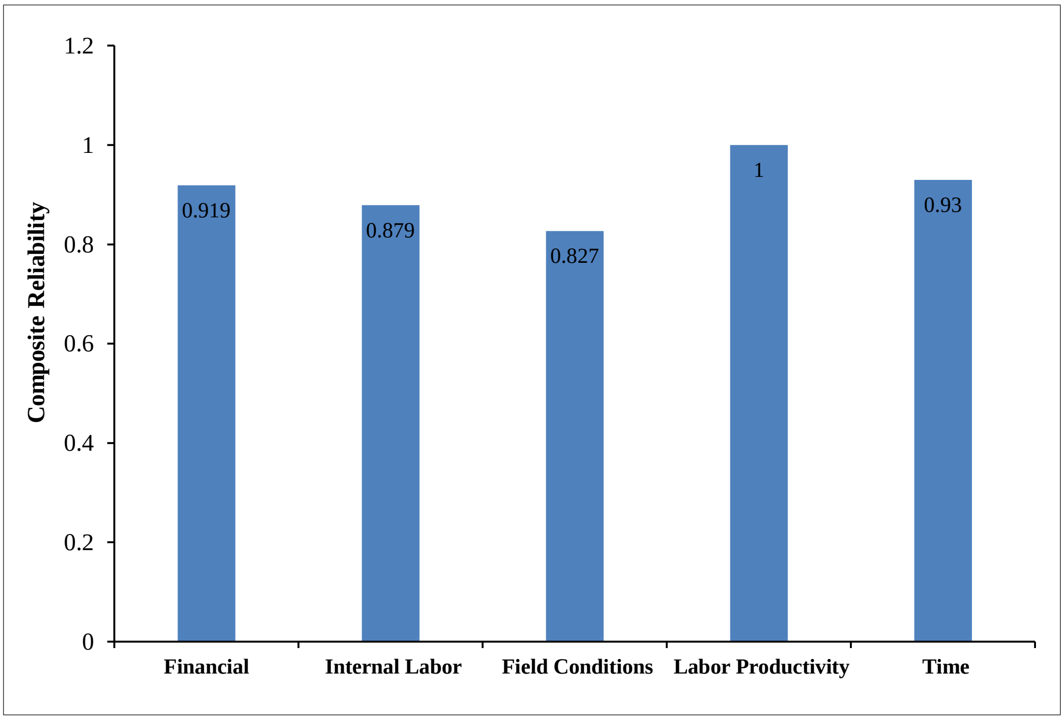

Figure 9. Composite reliability value in region I

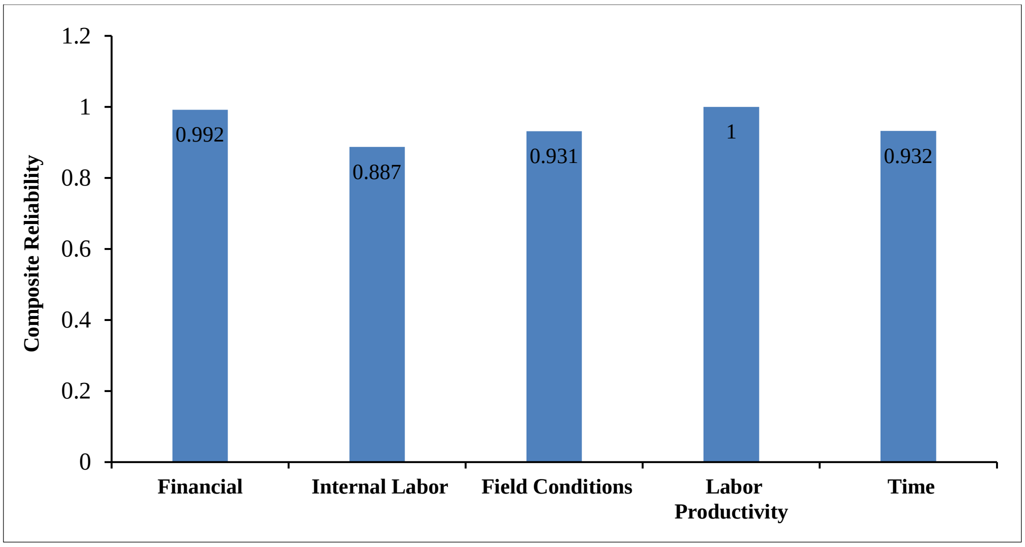

Figure 10. Composite reliability value in region II

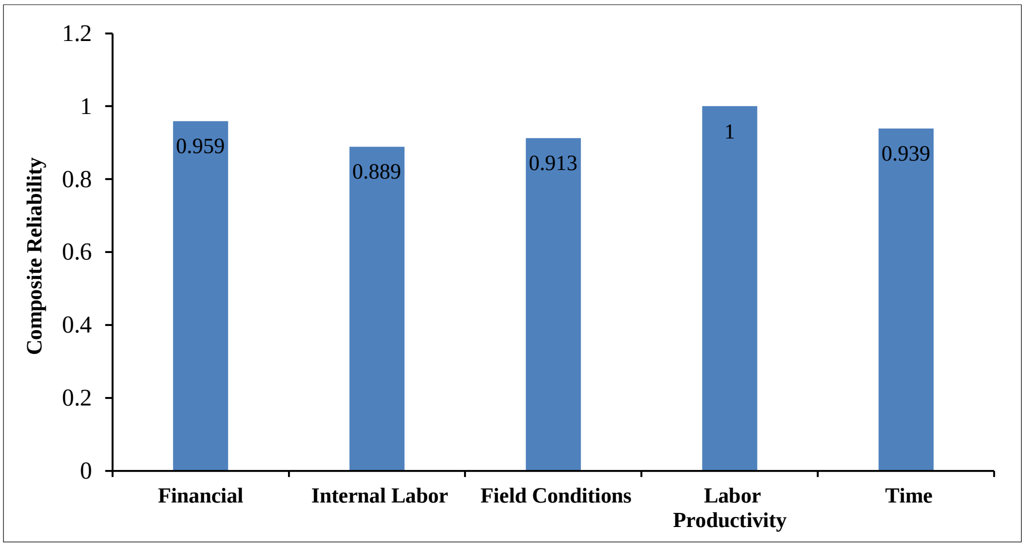

Figure 11. Composite reliability value in region III

Reliability test can also strength with Cronbach's Alpha where value said good if $\alpha \geq 0.5$ and it is said enough if $\alpha \geq 0.3$. Following is Cronbach's Alpha output from SmartPLS software. Following is description Cronbach's Alpha testing of each region is shown in Figures 12 to 14.

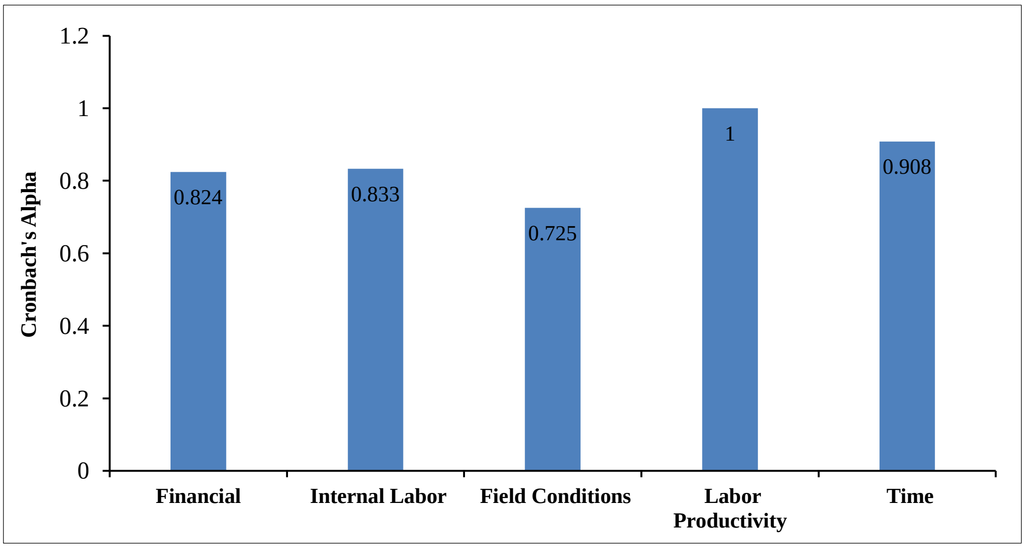

Figure 12. Cronbach's Alpha value in region I

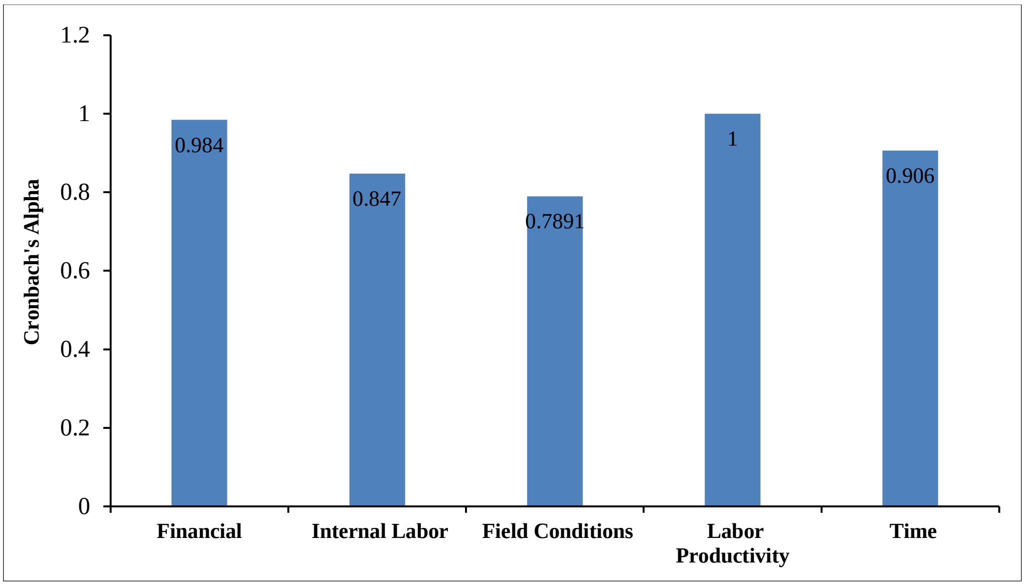

Figure 13. Cronbach's Alpha value in region II

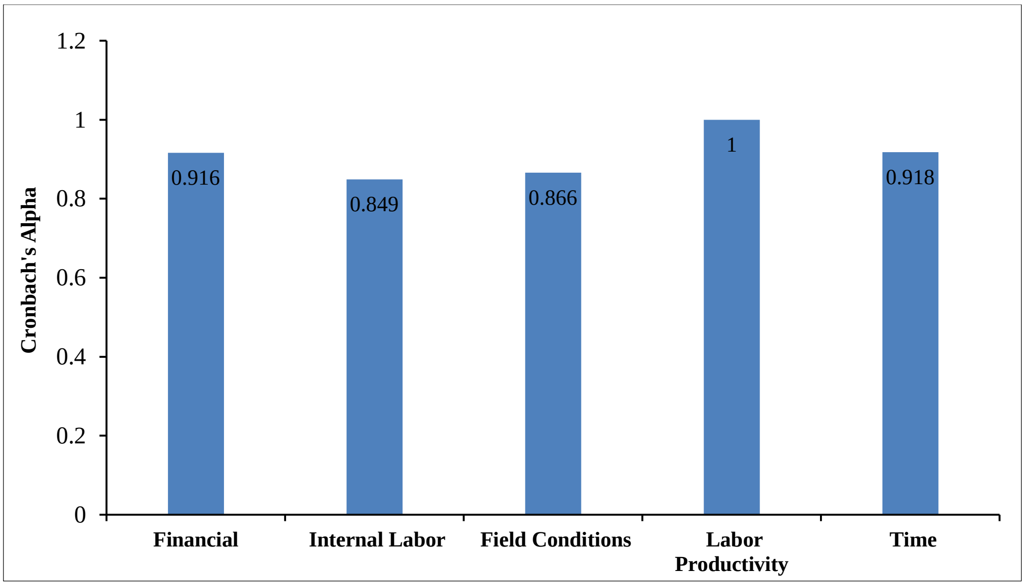

Figure 14. Cronbach's Alpha value in region III

Based on the figure, it can be seen that Cronbach's alpha value is ≥ 0.6, which means that all variables had good reliability. As a result, we can conclude that the consistency measurement questionnaire performed well in regions I, II, and III.

3.2.4. Testing the Structural Model (Inner Model)

Testing the inner model or structural models is conducted to see the connection. Among the constructs, value significance, and R-square of the research model, structural models are evaluated with the use of R-square for construct-dependent t tests as well as significant path parameter coefficients. In assessing the model with PLS started with the R-square for every dependent latent variable. Coefficient determination (R-square) is method for evaluate how much big endogenous constructs can described by constructs exogenous. A coefficient value (R-square) determination is expected between 0 and 1. Here are the results of R-square estimation with SmartPLS, shown in Table 5.

Table 5. R-Square value in region I, II and III

Productivity power work	Region		
	I	II	III
R Square	0.697	0.743	0.728
R Square Adjusted	0.585	0.644	0.716

Based on the table specifications, one could draw the conclusion that the research model conducted in each region (I, II, and III) is included in the powerful model specifications because it is in the range of 50–75% and has a good goodness of fit.

Based on the findings of the research, it appears that the internal labor variable has the most influence or has the highest level of significance in regions I, II, and III. This is because the labor variable describes the individual character of each contracted workforce, which includes the quantity of people, their health, their level of expertise, their motivation, and their level of skill, training, and work experience.

3.2.5. Hypothesis Testing

Testing hypothesis used for test there is no influence variable from an exogenous to an endogenous variable. Criteria testing state that if $T_{statistics} \geq T$ - table (1.96) then stated exists influence positive/negative and significant variable exogenous to endogenous variable. In PLS (Partial Least Square) testing, in a manner based on statistics, every hypothesized relationship is conducted with the use of simulation. In practice, this method bootstraps a sample. Testing with bootstrap also meant for minimize problem abnormal research data. Test results by bootstrapping from PLS analyses of the respective regions I, II, and III show that all hypotheses based on financial variables, internal personnel work, field conditions, and time is hypothesis could receive so that variable is one that can influence productivity at work on construction projects in Indonesia. The equations derived from data analysis on research findings are as follows:

1. ***Region I***

$$Y = 0.462X_1 + 0.45X_2 + 0.44X_3 + 0.987X_4 \tag{1}$$

2. ***Region II***

$$Y = 0.499X_1 + 0.637X_2 + 0.581X_3 + 0.916X_4 \tag{2}$$

3. ***Region III***

$$Y = 0.626X_1 + 0.534X_2 + 0.643X_3 + 0.912X_4 \tag{3}$$

where: X_1 = Condition field; X_2 = Time; X_3 = Financial; X_4 = Internal Labor

A study of labor productivity in construction projects that is not limited to road construction must be created so that it may be used as a reference for the overall demand for labor productivity in construction projects. The study's findings indicate that internal labor is one of the elements influencing labor productivity in Indonesian construction projects, particularly road maintenance work. To project labor productivity in construction projects in Indonesia's Regions I, II, and III, a conceptual model of labor productivity in construction projects in Indonesia, i.e., the output of the quantity of work as well as the input of the duration and number of contracted workers, can be developed.

Labor productivity research in Indonesia is conducted by comparing planned and realized labor productivity calculations, which are conducted by collecting project data and making first-hand observations of work in the field. Labor productivity is measured using characteristics other than the variables used in the research, as well as a larger population and sample coverage. The findings of this study can be utilized as input for government agencies in determining the ability of specialists to carry out work in the field connected to the preservation of non-structural flood handling roads on Indonesian territory.

4. Conclusions

Based on the results of the analysis it can be concluded:

- Factors that affect labor productivity in road construction projects in Indonesia are field conditions, time, finances, and internal labor;
- The level of significance of the factors that affect labor productivity in road construction projects in Region I are internal labor, field conditions, time, and then financial. Region II, namely internal labor, time, and finance, followed by field conditions. Region III, namely internal labor, finance, field conditions, and time;
- Based on the analysis of the data obtained in this study, a relationship model can be constructed between the factors that influence labor productivity in road construction projects in Indonesia in Region I, namely field conditions, which have an effect of 46.2% on labor productivity, time, which has an influence of 45% on labor productivity; finance, which has an influence of 44% on labor productivity; and internal labor, which has an influence of 98.7%. Region II, namely field conditions, has an influence of 49.9% on labor productivity; time

has an influence of 63.7% on labor productivity; finance has an influence of 58.1% on labor productivity, and internal labor has an influence of 91.6 %. Region III, namely field conditions, has an influence of 62.6% on labor productivity, time has an influence of 53.4% on labor productivity, finance has an influence of 64.3% on labor productivity, and internal labor has an influence of 91.2%;

- Given the importance of internal labor factors in determining labor productivity, further research on this link is required to achieve improved labor productivity results;
- To improve the accuracy of the research, variables utilized in identifying factors that affect labor productivity in building projects should be incorporated.

5. Declarations

5.1. Author Contributions

Conceptualization, R.U.L., N.M.A., I.R.R., R.A., and M.T.; methodology, R.U.L., N.M.A., and R.A.; validation, I.R.R., and M.T.; formal analysis, R.U.L., N.M.A., M.T., and R.A.; investigation, R.U.L., N.M.A., R.A., and M.T.; resources, R.U.L., N.M.A., I.R.R., and R.A.; writing—original draft preparation, M.T.; writing—review and editing, N.M.A and M.T.; project administration, M.T. All authors have read and agreed to the published version of the manuscript.

5.2. Data Availability Statement

Data sharing is not applicable to this article.

5.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

5.4. Conflicts of Interest

The authors declare no conflict of interest.

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