Study on Factor of Delays on a Construction Project During the Covid-19 Pandemic in Indonesia

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Study on Factor of Delays on a Construction Project During the Covid-19 Pandemic in Indonesia

Rosmariani Arifuddin[1], M. Tumpu[2], Indah Wahyuni[1] and Rifan Fadillah[1]

[1]Civil Engineering Department, Faculty of Engineering, Hasanuddin University

[2]Disaster Management Study Program, The Graduate School, Hasanuddin University

[1]rosmarianiarifuddin@unhas.ac.id*, [2]tumpumiswar@gmail.com, [1]Indahwahyuni30051999@gmail.com, [1]rifanfadillah2000@gmail.com

Abstract:

The COVID-19 pandemic has had a significant negative impact on all sectors in several countries. The construction industry is one of the sectors that experienced a decline in productivity during the COVID-19 pandemic. The negative impact of the COVID-19 pandemic on the construction industry delays. Delays in construction projects are a significant issue for various parties because the impact is enormous. So a comprehensive study is needed to look for factors that cause project delays during the COVID-19 pandemic as a knowledge base for developing strategies for handling pandemics in the future. This research is a comprehensive study to model the multifactor causes of delays in construction projects during the COVID-19 pandemic. Questionnaire data were obtained from respondents who were directly involved in construction projects that experienced delays during the COVID-19 pandemic in Indonesia. The analysis data used is a quantitative multivariate analysis with the PLS-SEM. The results show that the causes of delays in construction projects during the COVID-19 pandemic are multifactorial and complex. Human Resources Factors provide an enormous contribution with a percentage value of 37.5%, then Contractual Factors are 20.9%, Equipment Factors are 19,7%, Material Factors are 16,5%, and Environment Factors are 13,5%. The human resource factor is greatly influenced by the spread of disease among employee indicator (Value 0,9197). Furthermore, the contractual factor is strongly influenced by the financial availability during the limited implementation (funding difficulties of contractors) indicator (Value 0,8821). The equipment factor is greatly influenced by the Delays of distributed equipment indicator (Value 0.9086). The delays strongly influence the Material Factors in the material Distribution indicator (Value 0,8568). The Environmental Factors are strongly influenced by the project location in the red zone indicator (Value 0,8747).

***Keywords**: COVID-19, Construction, Project Delay, Partial Least Square*.

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I. INTRODUCTION

The COVID-19 pandemic has had a devastating impact on global life around the world. Almost all commercial, economic and social activities experienced a decline in performance during the COVID-19 pandemic [1, 2]. Likewise, the construction and engineering industries are experiencing a multi-dimensional crisis worldwide during the COVID-19 pandemic in Singapore [3]. Furthermore, research shows the impact of the COVID-19 pandemic on the construction industry in several countries [4]. Most of the construction projects were affected due to operational, financial, delayed, and legal difficulties faced by the project stakeholders during the COVID-19 pandemic in the Indian construction industry [5]. The COVID-19 pandemic is causing operational and financial issues in the Malaysian construction industry. Malaysia's economic growth would significantly impact if any major construction projects got delayed [6]. One of the significant effects of the COVID-19 pandemic on construction projects is the project completion schedule [7]. Several construction works were stopped or temporarily postponed, causing the project to experience delays in completion. The delay occurred due to several factors that occurred during the COVID-19 pandemic [8]: (i) delays in land acquisition, (ii) delays in legal permits, (iii) lockdowns imposed by private institutions and local governments to limit the spread of the COVID-19 pandemic. This lock causes the transportation and supply chain of the project's resources to be disrupted. Correspondingly, the COVID-19 pandemic has had a significant impact on the economy of Indonesia. The prospect of Indonesia's economic growth in 2020, which was initially targeted to reach 5.3%, was revised down to -0.4 to 2.3% taking into account the slowdown in almost all components of Indonesia's gross domestic product [9, 10].

The Government of Indonesia has regulated all community activities during the COVID-19 Pandemic in Minister of Health Regulation No. 9 of 2020 concerning Guidelines for Large-Scale Social Restrictions to Accelerate the Handling Prevention of COVID-19 [11]. Furthermore, for activities in construction projects, refer to the Decree of the Minister of Public Works and Public Housing No. 10 of 2020 Regarding the Health Protocol for Handling COVID-19 in Construction Projects [12]. This policy currently has an impact on construction project activities in Indonesia. Unfortunately, regulations for handling COVID-19 only focus on human activities and do not comprehensively regulate all elements of construction projects, materials, equipment, contracts, the environment, Etc.

Moreover, the restrictions imposed through the regulation significantly impact all stakeholders involved in the construction project, in addition to severe financial consequences. Remedies are available by law for the parties to the construction contract to protect their rights and reduce losses in extreme conditions. This unusual condition depends on the terms of the respective contract and the relevant governing law. Time extensions and claims of time and money are unavoidable. Based on regulatory gaps and the resulting negative impacts, it is necessary to conduct an in-depth study of the impact of the COVID-19 pandemic on construction projects. This study further uncovers the factors that significantly influenced project delays during the Indonesian COVID-19 Pandemic. The findings are significant in developing an effective policy strategy to prevent delays in construction projects during the pandemic, especially for construction projects in Indonesia.

II. LITERATURE REVIEW

A. Impact of Covid-19 Pandemic on Construction Project Delay

Various aspects of the construction industry in several parts of the USA have been affected by the existence of the COVID-19 pandemic. At the beginning of the pandemic period, several states, such as Michigan, New York, and Pennsylvania, formulated to close or encourage all construction project activities in order to prevent the spread of the COVID-19 virus [13]. The US government took some precautions by limiting mobility with the enactment of hours of night and locking, causing the closure of the manufacturing industry, limited working hours, and employee salary deductions, which certainly impact sales and demand for construction projects [5].

Construction elements such as material, labor, equipment, transportation, time, and mobility were directly related to restrictions during the COVID-19 pandemic period, which has implications for the construction process that does not run well, usually, effectively, and promptly [5].

During the COVID-19 pandemic, some challenges on construction projects can cause various problems resulting in gaps between plan and reality. These obstacles cause delays in project implementation so that the entire project activities implemented run differently. The delays in the project and disruptions of project activities directly impact the pandemic on construction.

The virus pandemic that hit currently affects the progress of construction in two ways: the delay caused by the closure of manufacturing facilities and suppliers by state officials and labor disorders due to restrictions on meetings as well as the absence of sick workers with COVID-19 or stay-at-home in preference to construction location visit in response to the recommendations of state officials [14].

B. Human Resource Factor

The human factor significantly affects the productivity of construction projects [15]. The human factor is a construction project resource that is heavily affected by the COVID-19 pandemic, including the limited number of workers, and skilled workers, due to restrictions that have an impact on limiting the number of workers who can work in the same area or at the same time. Limitations on the number of workers also affect project performance, resulting in delays. In addition, the shortage in the number of workers is also caused by reductions or dismissals due to insufficient funding from the company [7, 13, 16].

C. Materials Factor

The availability of resources, such as materials, on-site and in a limited market due to restrictions during the COVID-19 pandemic has not only delayed the completion of construction projects. However, it has also incurred additional costs [5]. Construction delays lead to time and cost risks, including materials, escalation and inflation, labor, plant and equipment, changes, schedules, controls, and government relations, all of which are due to the Covid-19 pandemic [8, 14, 16, 17]. Restrictions in some areas have a significant impact on the supply chain of materials or raw materials for the production of construction materials.

In addition, material suppliers mentioned that some truck drivers do not want to cross state or state boundaries for fear of contracting the virus, and some states require quarantine which can also lead to delays in material delivery [18].

D. Equipment Factors

Delays in equipment or machine delivery also result in delays in project progress which causes major schedule disruptions [5]. Similar to material factors, project delays during the COVID-19 pandemic were also heavily influenced by the equipment or machine supply chain as tools in construction projects. As a result of the restrictions also significantly affect the availability of equipment or machines on the site [8].

E. Contractual Factors

Contractual factors also contributed to delays in construction projects during the COVID-19 pandemic. Contractual factors include: delays in document revision and approval, delays in completed work approval, delays in instruction provision from consultants, financial availability during limited implementation (funding difficulties of contractors), Poor communication among parties (consultants, project managers, site engineering, etc.) [8].

F. Environmental Factors

The environmental factors also contributed to delays in construction projects during the pandemic: the project location is in the red zone, impacts on environmental security of construction projects, licensing from the government related to the COVID-19 prevention [7, 8].

III. METHOD

The research instrument was a questionnaire consisting of questions from variables and indicators causing delays in construction projects during the COVID-19 pandemic. Data collection through a questionnaire survey to respondents by providing some the questions consisting of factors causing delays in construction projects during the COVID-19 pandemic. Variables and indicators as causes of project delays are collected from previous research studies and obtained 5 main variables as latent variables (human resource factors, material factors, equipment factors, contractual factors, and environmental factors). Furthermore, from the 5

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variables, each variable is developed as shown in Table 1.

TABLE I Variables and indicators causing construction project delays

Code	Variables and Indicators	References
A	Human Resource Factors	
A1	Lack of employee number	[7, 8, 16]
A2	Low employee productivity	[7, 8, 16]
A3	Spread of disease among employees	[7, 14]
B	Material Factors	
B1	Delays in material distribution	[7, 14, 18]
B2	Lack of construction materials	[7, 14]
B3	Escalation and inflation of material prices	[7, 8]
C	Equipment Factors	
C1	Lack of construction equipment damage	[7, 8]
C2	Delays of distributed equipment	[7]
D	Contractual Factors	
D1	Delays in document revision and approval	[5, 8]
D2	Delays in completed work approval	[5, 8]
D3	Delays in instruction provision from consultants	[5]
D4	Financial availability during limited implementation (funding difficulties of contractors)	[5, 8, 14]
D5	Poor communication among stakeholders	[8]
E	Environment factors	
E1	The project location is in the red zone	[7, 8]
E2	Impacts of environmental security of construction projects	[7, 8]
E3	Licensing from the government related to the COVID-19 prevention	[7, 8]
F	Delays	
F1	The project construction delay during COVID-19 Pandemic	[5, 14]

Respondents are parties directly involved in construction projects that experienced delays during the COVID-19 pandemic. There were 5 construction projects randomly selected that experienced schedule delays during the COVID-19 pandemic in Indonesia. A total of 96 respondents were involved in 5 selected projects. Respondents were selected from various positions: (i) project manager, (ii) construction manager, (iii) Site Manager, (iv) supervisor, (v) surveyor, (vi) site engineer, (vii)) quality control, and (viii) logistics staff.

Respondent's experiences and opinions on delayed projects during the COVID-19 pandemic were set out in a questionnaire. Answers from respondents on a Likert scale with Rating Scale: (i) 5=Very Influential; (ii) 4=Influence; (iii) 3=Moderately Influence; (iv) 2=Less Influence and (v) 1=Not Influence.

Structural Equation Modeling (SEM) is a generational multivariate data analysis technique that can assist researchers in examining the relationship between latent variables and indicators. Meanwhile, PLS-SEM is an alternative estimation method for Structural Equation Models (SEM), a nonparametric method that does not require distribution assumptions from the data. PLS-SEM can be used on data that is not normally distributed because the PLS algorithm

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transforms data that is not normal through the central limit theorem. In other words, PLS-SEM can be used on data with small sample sizes [18]. Furthermore, the advantage of using the PLS-SEM is knowing the complexity of several variables' relationships and their indicators. However, this PLS-SEM method can be applied to more minor sample data, at least 30 to 100 data [17]. This study uses PLS-SEM analysis with SmartPLS 2.0 PLS-SEM software because variables are multifactorial and complex with limited data. The stages of data processing analysis from the PLS-SEM in this study [18]: (i) design model; (ii) outer model testing; (iii) inner model testing; (iv) goodness of fit evaluation; (v) hypothesis testing.

IV. RESULTS AND DISCUSSION

A. Profile Respondents

The results of the data analysis show that the profile of the respondents based on their position consists of: (i) Project manager; (ii) Construction manager; (iii) Field manager; (iv) Supervisor; (v) Surveyor; (vi) Site engineer; (vii) Quality control, and (viii) Logistic Staff, with the percentage of the number shown in Table 2.

TABLE II Position of respondent

No	Position	Number	%
1	Project Manager	5	5.21
2	Construction Manager	5	5.21
3	Field Manager	9	9.38
4	Supervisor	27	28.12
5	Surveyor	20	20.83
6	Site Engineer	5	5.21
7	Quality control	15	15.63
8	Logistic	10	10.42
	Total	96	100

Table 2 shows that the characteristics of the respondents based on their positions adequately represent all positions in the construction project. Furthermore, the results of data analysis obtained that the position of most respondents was the position of supervisor (28%). The results show that the respondents have represented all positions in the construction project.

The profile of respondents based on work experience are grouped into 4 categories: (i) category 1: < 5 years, (ii) category 2: 6 to 11 years, (iii) category 3: 11 to 15 years, (iv) category 4: >15 years. The results of data analysis for the respondent's experience are outlined in Table 3.

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TABLE III Respondent's work experience

No	Work Experience (Years)	Number	%
1	< 5	19	19.79
2	6 to10	23	23.96
3	11 to 15	40	41.67
4	> 15	14	14.58
	Total	96	100

Table 3 shows that most of the respondents had work experience of 11 to 15 years (40%), shown in Table 3. So the respondents involved in this study had good work experience, so they had competence in providing data answers to questions in the questionnaire. Furthermore, data processing is carried out using SmartPLS software to obtain the level of influence of each variable and indicators.

B. Measurement Model (Outer Model)

The outer model tests the validity and reliability of the instrument construct or indicator. The validity test was carried out to determine the ability of the research instrument to measure the variable in question. In contrast, the reliability test was carried out to measure the consistency of respondents' responses to each questionnaire question. There are three criteria in the use of Data Analysis Techniques with SmartPLS to assess the outer model, including [19]: (i) convergent validity; (ii) discriminant validity, and (iii) composite validity.

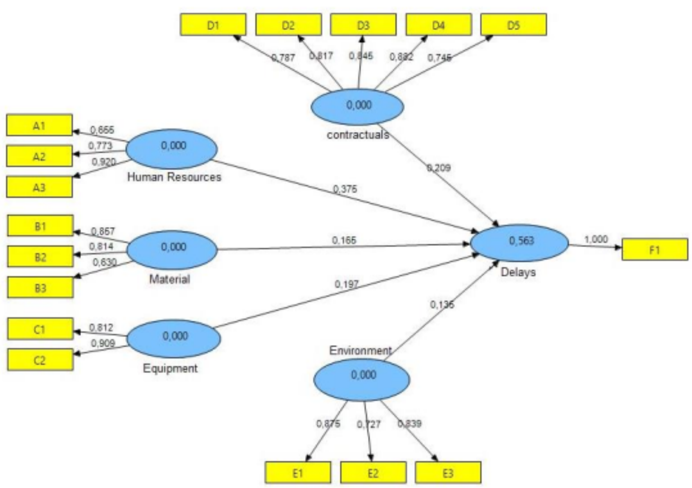

Fig 1: Measurement model/loading factor value

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- **Convergent Validity Measurement**

The fit model of a construct analyzed with PLS-SEM is required to meet the convergent validity value, namely an indicator with a factor loading > 0.50. Indicators with factor loading > 0.50 are valid as construct variables [19]. The results of data analysis for convergent validity measurement are shown in Table 4.

TABLE IV Convergent Validity's Value

Code	Delays	Contractual Factors	Environment Factors	Material Factors	Equipment Factors	Human Resources Factors
A1						0.6555
A2						0.7731
A3						0.9197
B1				0.8568		
B2				0.8140		
B3				0.6302		
C1					0.8117	
C2					0.9086	
D1		0.7871				
D2		0.8166				
D3		0.8452				
D4		0.8821				
D5		0.7451				
E1			0.8747			
E2			0.7268			
E3			0.8390			
F1	1.0000					

Sources: Output SmartPLS 2.0 M3

Based on Table 4 shows that all indicators meet the requirements of the convergent validity test> 0.50, which means that all indicators used in this study are valid. The human resource factor is greatly influenced by the spread of disease among employee indicator (Value 0.9197). This shows that worker restrictions significantly reduce work productivity [7]. The financial availability strongly influences the contractual factor during limited implementation (funding difficulties of contractors) indicator (Value 0.8821). The contractor's financial capability significantly affects the schedule because it is closely related to the ability to purchase materials and equipment, which has increased due to the impact of the COVID-19 pandemic [5]. The equipment factor is greatly influenced by the delays of distributed equipment indicator (Value 0.9086). The delays strongly influence the material factors in the material distribution indicator (Value 0.8568). The supply chain of equipment and materials was disrupted during the COVID-

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19 pandemic, which affected construction project delays during the COVID-19 pandemic [7, 8]. The Environment Factors are strongly influenced by the project location in the red zone indicator (Value 0.8747). The prohibition on activities in the red area significantly affects the productivity of construction projects during the COVID-19 pandemic [7, 8].

- **Discriminant Validity Measurement**

Discriminant validity is an indicator measurement with the indicator itself, which is carried out to ensure that each concept of each latent variable is different from other variables [19]. Discriminant validity was measured by comparing the Root of Average Variance Extracted (AVE root) for each of these constructs to the other constructs in the model [19]. Suppose the AVE root value of a construct is greater than the construct's correlation value to other constructs in the model. In that case, it can be concluded that the construct has good discriminant validity and vice versa. Recommended AVE measurement values should be > 0.5.

TABLE V AVE Value

Variable	AVE	AVE Root
Delays	1	1
Contractual Factors	0.6677	0.8166
Environment Factors	0.6659	0.8159
Material Factors	0.5979	0.7733
Equipment Factors	0.7422	0.8615
Human Resources Factors	0.6244	0.7902

Table 5 shows that the composite reliability values for all constructs are > 0.8, which indicates that all constructs on the estimated model have high reliability and meet the reliable criteria. The reliability test can also be strengthened with Cronbach's alpha, in which the value is said to be good if the α is ≥ 0.5 and is said to be sufficient if α ≥ 0.3. Table 5 shows Cronbach's alpha outputs from the SmartPLS 2.0 software used. Based on table 6, Cronbach's alpha value for the human resource, material, equipment, contractual, and environment factors≥ 0.6. These results indicate that all factors are good reliability.

TABLE VI Cronbach's Alpha's Value

	Cronbach's Alpha
Delays	1.000000
Contractual Factors	0.883114
Environment Factors	0.768411
Material Factors	0.661472
Equipment Factors	0.661005
Human Resources Factors	0.734849

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C. Structural Model Testing (Inner Model)

Internal or structural model testing is performed to see the relationship between the research model's constructs, significance values, and R-squared. Structural models are evaluated using R-square for the T-test as well as significant structural path parameter coefficients.

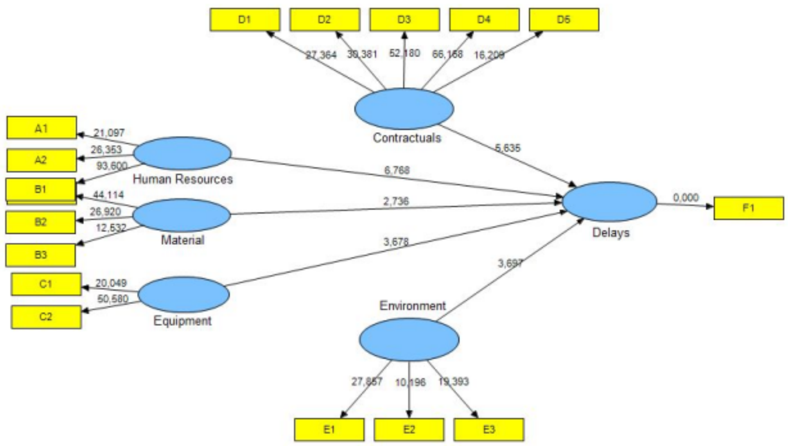

Fig 2: Inner model measurement

Measurement of the inner model with SEM-PLS by looking at the R-square for each latent dependent variable (y = Delays). The R-square value is a way to assess how much an exogenous construct can explain an endogenous construct. The R-square value is a way to assess how much an exogenous construct can explain an endogenous construct. Moreover, the expected R-square value is 0 to 1. Hasil analisis data untuk nilai R Square untuk faktor laten dependen (y = delays) ditunjukkan dalam Table 7. The results of data analysis for the R Square value for the latent dependent factor (y = Delays) are shown in Table 7.

TABLE VII R-Squared values

	R-Square
Delays	0.563052

Table 7 shows that the Delays factor's R-Squared value is 0.56 or 56%. The results show that the diversity of Delays factors can be explained by all the variables analyzed with a delay value of 56%, or in other words, the contribution of human resource factors, material factors, equipment factors, contract factors, and environmental factors to construction project delays during COVID-19 pandemic is 56%. In comparison, the remaining 44% is the contribution of other variables not discussed in this study. Based on these findings, it can be concluded that the research model carried out is included in the specification of a robust model because it is in the range of 50-75% [19] and can be said to have good goodness of fit.

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D. Hypothesis Testing

The testing is used to find out if there is an effect of exogenous variables on endogenous variables. The test criteria state that if T-statistics T-table is 1,960, there is a positive or negative and significant effect of exogenous variables on endogenous variables [19]. In this case, the bootstrap method was carried out on the sample. The bootstrap test was also intended to minimize the problem of abnormal research data. The results of the analysis are shown in Table 8.

TABLE VIII Hypothesis testing

Hypothesis	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standars Error (STERR)	T Statistics ([O/STERR])	Result
Human Resource Factors - Delays	0.209203	0.209157	0.034379	0.034379	6.085141	6.085141> 1.960 Hypothesis accepted
Materials Factors - Delays	0.135494	0.135784	0.037610	0.037610	3.602615	3.602615> 1.960 Hypothesis accepted
Equipment Factors - Delays	0.165024	0.176240	0.067135	0.067135	2.458096	2.458096> 1.960 Hypothesis accepted
Contractual Factors - Delays	0.198816	0.186873	0.052338	0.052338	3.760483	3.760483> 1.960 Hypothesis accepted
Environment Factors - Delays	0.374932	0.366997	0.059100	0.059100	6.344010	6.344010> 1.960 Hypothesis accepted

The equations of the factors causing construction project delays obtained from the results of data analysis in this study are: Y=Delay; X1=Human Resource Factors; X2 = Material; Factors, X3= Equipment Factors, X4= Contractual Factors, X5= Environment Factors.

$$Y = 0{,}375X1+0{,}165X2+0{,}197X3+0{,}209X4+0{,}135X5 \quad (1)$$

The equation (1) results show that the human resource coefficient is 0.375 or 37.5%. This means that human resource factors contributed 37.5% to delays in construction projects during the COVID-19 pandemic. Project delays are still dominated by labor factors [20]. The human factor is influenced by a lack of labor attendance or a shortage of labor due to regulatory restrictions on gathering, causing project productivity to drop significantly, causing delays in a construction project during COVID-19 [7, 14, 16], [14]. Low labor productivity caused by the ban on working for workers suspected of COVID-19, causing a reduction in the workforce, also impacts delays in construction projects during the COVID-19 Pandemic [7, 16]. In the future, the human factor will become an essential issue in preventing pandemics in construction projects. Regulations must pay attention to the protection of workers and can improve health facilities for workers. Setting working hours with shifts to overcome the shortage of workers can be an alternative to implementing construction projects during a pandemic.

Based on equation (1), the contractual factors coefficient is 0.209 or 20.9%. This shows that contractual factors contributed to 20.8% of delays in construction projects during the COVID-19 pandemic. Delays strongly influence contractual factors in the revision or approval of work documents due to meeting restrictions [8] and poor communication between consultants and contractors. Problems with contractor financial availability during the COVID-19 pandemic also contributed significantly to project delays [5, 8]. Contractual issues concern the policy for handling COVID-19 in construction projects in the future. The prevention strategy is to intensively increase communication from all stakeholders and increase coordination to prevent delays in work. Furthermore, the contractor's capacity-building strategy should be the primary goal as an improvement in contractor funding.

For the equipment coefficient is 0.197 or 19.7%. This shows that equipment factors contributed 19.7% to delays in construction projects during the COVID-19 pandemic. Lack of equipment supplies or equipment damage that cannot be repaired due to restrictions during COVID-19, causing delays in construction projects. The restrictions also disrupted the equipment supply chain, causing delays in construction work during the COVID-19 pandemic. In the future, it is crucial to regulate policies related to the material supply chain mechanism in any pandemic.

Based on equation (1), the coefficient for the material factor is 0.165 or 16.5%. This shows that material factors contributed 16.5% to delays in construction projects during the COVID-19 pandemic. Shortage of construction materials at the project site, limited availability of materials on the market, delays in material delivery, and inflation and escalation in material prices are triggers for delays in construction projects during the COVID-19 pandemic [7, 8]. Same with the equipment factor, material-related arrangements are essential to be regulated in the future.

Furthermore, based on equation (1), the environmental factor coefficient is 0.135 or 13.5%. This shows that environmental factors contributed 13.5% to delays in construction projects during the COVID-19 pandemic. The project environment or location in the red zone area

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causes restrictions in each project activity. The influence of environmental security on project development and the poor project environment, which triggers the spread of COVID-19, significantly contributes to delays in construction projects [7, 8]. Environmental factors must be a crucial issue in setting the protocol in dealing with any pandemic.

V. CONCLUSION

1. Based on the objectives, analysis, and discussion of the study, the factors that significantly influenced the occurrence of project delays during the COVID-19 pandemic were Human Resource Factors, Material Factors, Equipment Factors, Contractual Factors, and Environmental Factors.
2. Based on the analysis of the significance level of influence, it can be concluded that Human Resources Factors provide the most significant contribution with a percentage value of 37.5%, then Contractual Factors are 20.9%, Equipment Factors are 19.7%, Material Factors are 16,5%, and the Environment Factors are 13.5%.
3. The human resource factor is greatly influenced by the spread of disease among employee indicator (Value 0.9197). Furthermore, the contractual factor is strongly influenced by the financial availability during the limited implementation (funding difficulties of contractors) indicator (Value 0.8821). The equipment factor is greatly influenced by the Delays of distributed equipment indicator (Value 0.9086). The delays strongly influence the Material F actors in the material Distribution indicator (Value 0.8568). The Environmental Factors are strongly influenced by the project location in the red zone indicator (Value 0.8747). The findings of this study can serve as lessons learned for developing effective strategies for preventing delays in construction projects during the next pandemic. For future research, it is recommended to develop research that covers a more significant number of respondents and construction projects and further examines the factors causing delays in construction projects from various aspects.

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