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Analysis of Internal and External Factors on Project Performance Based on Risk Management in Smelter Construction

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ABSTRACT

The mining industry has projects that require effective risk management, especially regarding smelter construction. Smelter construction is a complex process requiring attention to various internal and external factors affecting project performance. This research uses quantitative research methods. In this study, the data collection method used will be a questionnaire technique. The data that has been collected is then analyzed using statistical analysis techniques using Structural Equation Modeling - Partial Least Square (SEM PLS). The results showed that the risk factors that obtained the most dominant value with a high-risk category consisted of 8 indicators of internal and external risk factors, namely labor shortages, rising material prices, inexperienced project managers and experts, supplier changes close to project closure causing cost overruns, unclear project priorities where less important work is completed, uncertain weather, contaminated environment pollution, weather during construction activities. Internal and external factors together have a significant effect on project performance in terms of cost, quality, and time in direct effect.

Keywords: internal factors; external factors; project performance; risk management; smelter.

INTRODUCTION

Indonesia's mineral resources have tremendous potential and are almost spread throughout the country (Agung et al., 2022). Indonesia, which has a lot of mineral resources, generates a large amount of money for the country through taxes and royalties every year. Nickel is one of the minerals available in Indonesia. According to the data (Kementerian ESDM, 2020), Indonesia's nickel reserves are the largest in the world with a total of 72 million tons of Ni or 52% of the total reserves in the world of 139,419.00 tons of Ni, then Australia has reserves of 15%, Brazil 8%, Russia 5% And the remaining 20% are countries such as (Cuba, Philippines, China, Canada).

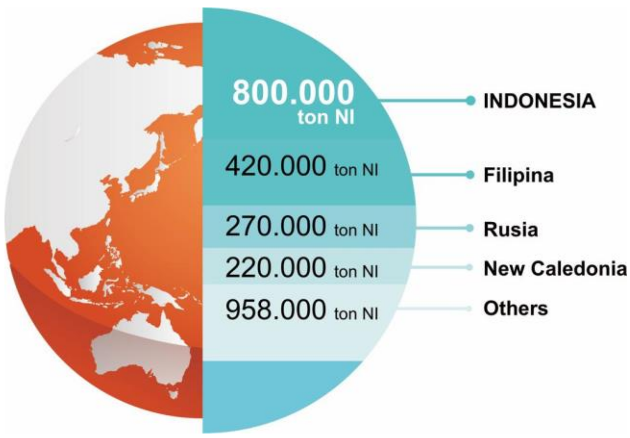

Figure 1. Indonesian Nickel Mining Production in the Eyes of the World Source: USGS 2020

Therefore, to increase added value the government issued Mining Law Number 4 of 2009 which stipulates that raw minerals must go through a processing process (*smelting)* before being exported

(Pemerintah RI, 2009 Undang undang No 4 Tahun 2009). Indonesia's processed nickel production trend continues to increase every year, the Ministry of Energy and Mineral Resources estimates that production will reach 2.47 million tons in 2021, up 2.17% (percent) from 2.41 million tons in 2020. In particular, the largest processed *nickel production is ferronickel* at 1.669 million tons., nickel *pig iron production at* 831 thousand and nickel matte at 82.3 thousand tons. Such as the production value of processed nickel in 2018-2022 which can be seen in Figure 2.

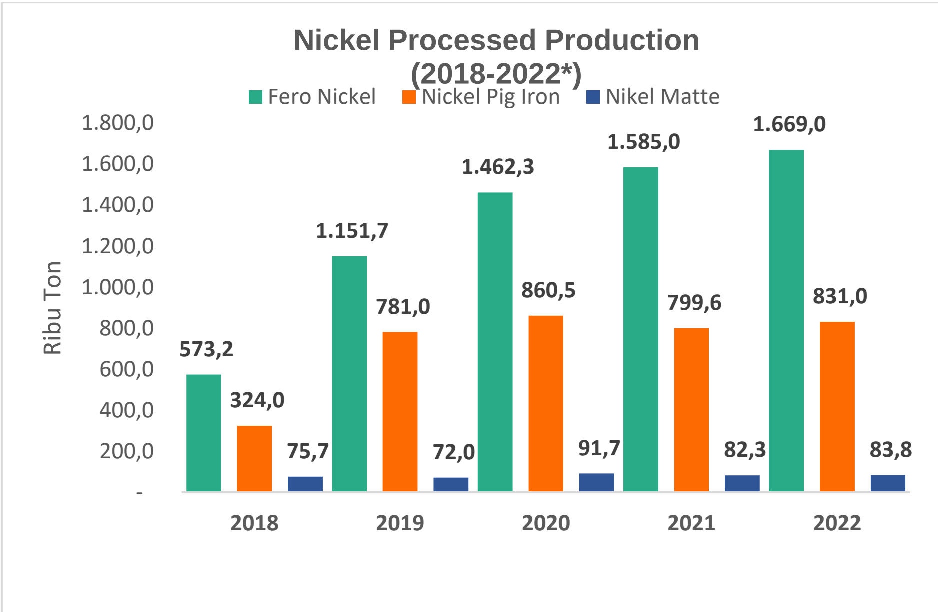

Figure 2. Nickel Processed Production Value in 2018-2022. Source: Ministry of Energy and Mineral Resources 2022

According to Mining Law Number 4 of 2009 raw minerals must be processed before export, so the construction of smelters is very relevant in Indonesia. This is because Indonesia has many natural resources that can help the development of an integrated nickel industry (Kementerian ESDM, 2020).

In the construction of a smelter there are project risks that must be identified because every phase of the project life cycle contains risks, from the planning stage to the maintenance stage (Susanti, 2022). According to research (Ridwan, 2021) Effective risk management greatly affects the development of the project, so from the very beginning the project must be carried out. Four different stages of project risk management are important components in project planning such as: (1) risk identification, (2) likelihood and impact analysis (3) approaches to risk reduction and (4) control and documentation.

Previous studies of project risk factors related to cost, quality and time found that there are several risk variables that may occur in projects. Of the number of risk variables that may occur, there is the most dominant risk and will have a significant impact in the journal written by (Sugiharto, 2020), Price estimation errors are the results of analysis that have an impact on project performance in other journals written (Nurdiana & Setiabudi, 2018), Termination of a contract due to delay is an outcome that impacts performance. Thesis (Wijaya et al., 2017) Implementation methods, design changes, and bad weather during construction activities are the main factors affecting project performance. Other factors that affect project performance are lack of workers, natural factors, and heavy equipment. Due to the long distance of material delivery from the construction site, risks that often arise in smelter projects include difficulties in construction activities and delays in material delivery. Project managers and construction management face the challenge of implementing effective risk management to reduce the impact of risk so as not to disrupt overall project activities. Therefore, it is necessary to conduct in-depth research on the analysis of internal and external factors on project

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performance based on risk management in the construction of smelters.

Work safety in construction is an important effort to protect workers from the risk of accidents and injuries. The first step is to identify potential hazards at the work site, such as falling from a height, falling material, and the use of heavy equipment. After identifying risks, companies must develop safety procedures and ensure all workers understand and comply with these protocols. Regular safety training is essential. Workers must be equipped with knowledge about the use of personal protective equipment (PPE) such as helmets, protective shoes, gloves and safety belts. In addition, it is important to conduct emergency response simulations so that workers are prepared to face accident situations (Arjon A, Hardjomuljadi S, 2024; Nuranto A, 2024).

Close supervision by a safety manager or Occupational Safety and Health (OHS) officer helps ensure compliance with safety standards. They are also tasked with monitoring working conditions and providing suggestions for improvements if potential dangers are found. By implementing these measures, construction companies can create a safer work environment, reduce the risk of injury, and improve worker well-being (Salsabala A et.al, 2024; Irvania A et.al, 2024; Sabariah I et.al, 2012).

RESEARCH METHODS

Referring to the formulation of the problem that has been set in the previous chapter, this study uses a quantitative approach to test and prove hypotheses that have been made through various tests and data processing (v. M. buyanov, 1967). This research is included in the category of comparative causal research (causal-comparative research), which is a type of research that looks at the relationship between independent variables and dependent variables and evaluates the relationship (Sudaryono, 2017: 89). In this study, the data collection method to be used is the questionnaire technique (questionnaire).

The population in this study is a Smelter construction project on Obi Island. Obi Island has an area of 3.11 $km^{2.}$ With the geographical location of Obi Island lies 1o 30' South Latitude and 127o 45' East Longitude with a total population of 42,774 people Obi Island. The reason for choosing the research location on Obi Island, South Halmahera, North Maluku as the research location is because there has never been a similar research, especially regarding internal and external factors on the performance of risk management-based projects in smelter construction The population determined in this study includes stakeholders in smelter building contractors with a total population of five contractors and each respondent collected from all *stakeholders* of smelter construction as follows:

Table 1. Population Distribution and Research Sampling

No	Contractor Name	Number of Samples	%
1.	China Metalurgical Group Corporation	20	20,0
2.	China National Chemical Engineering Group	20	20,0
3.	China Rood and Bridge Construction Coorporation	20	20,0
4.	China Civil Engineering Construction Coorporation	20	20,0
5.	Jiangxi Therma Power Construction Coorporation	20	20,0
	Amount of Data	**100**	**100%**

Source: Processing researcher data

Sampling will be carried out using proportional stratified techniques according to the population distribution of each stakeholder directly involved in the smelter construction process. It is then recorded using the Cochran formula to determine the number of research samples needed, with a confidence level of 95% or a margin of error of 5%.

$$M = \frac{Z^2 \times P^* \times (1-P)}{r^2}$$

$$n = \frac{m}{1+ m-1}$$

N

Hasil:

$$M = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.05^2} \quad \ldots\ldots(1)$$

$$= 384.16$$

$$n = \frac{384.16}{1+\frac{(384-1)}{124}} \quad \ldots\ldots(2)$$

$$= 93.95 \longrightarrow \textbf{94 Respond}$$

From the number of samples based on the formula s above, it can be tabulated in the table, the distribution of stakeholder populations and the number of samples taken to be the object of this study. The collected data is then analyzed using statistical analysis techniques using Structural Equation Modeling – Partial Least Square (SEM PLS).

RESULTS AND DISCUSSION

Evaluation of Measurement Model dengan SEM-PLS

This test is carried out to determine how each indicator relates to the latent variable being measured. The tests carried out on this model consist of validity and reliability tests. The validity test aims to assess whether a questionnaire has validity. The validity of the questionnaire is proven if the questions in the questionnaire are able to reflect what the questionnaire wants to measure.

This validity testing process is applied to every question contained in each variable. This process involves several stages of testing, including convergent validity tests, calculation of the average variance extracted (AVE), and discriminant validity tests. On the other hand, reliability tests are used to measure the extent to which measuring instruments are consistent in measuring a concept or the extent to which respondents are consistent in answering statements in questionnaires or research instruments.

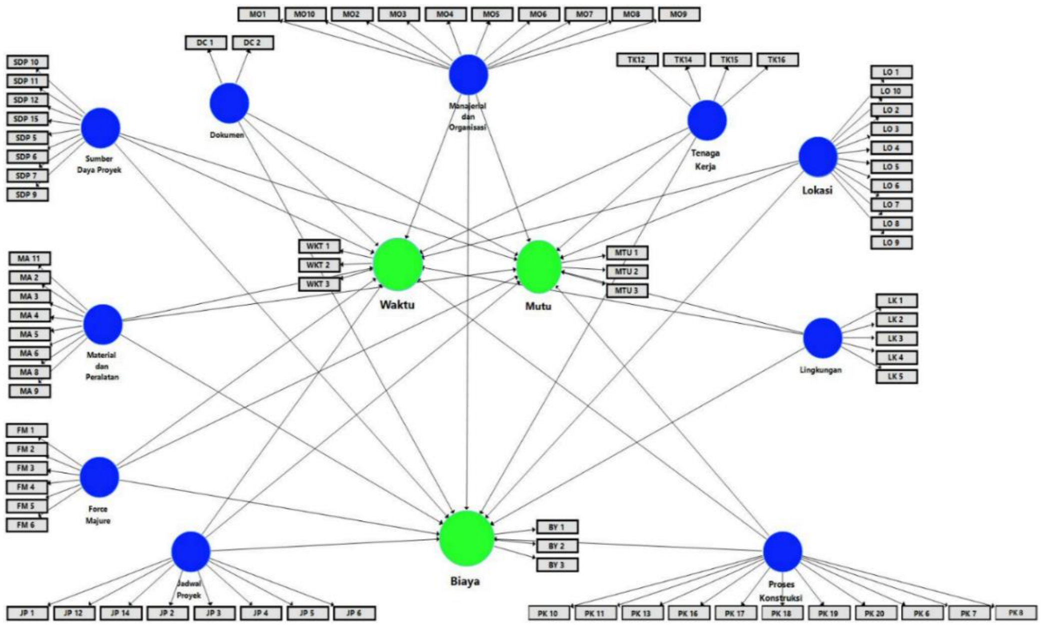

Figure 3. Model of the Effect of Internal and External Risk on Project Performance **Source:** Processing Researcher Data, 2023

Outer Model Evaluation

From the equation model above, three modeling models will be applied to all test sample models,

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as well as models for test samples. In this evaluation, it is used to assess *loading factors*, validity and reliability.

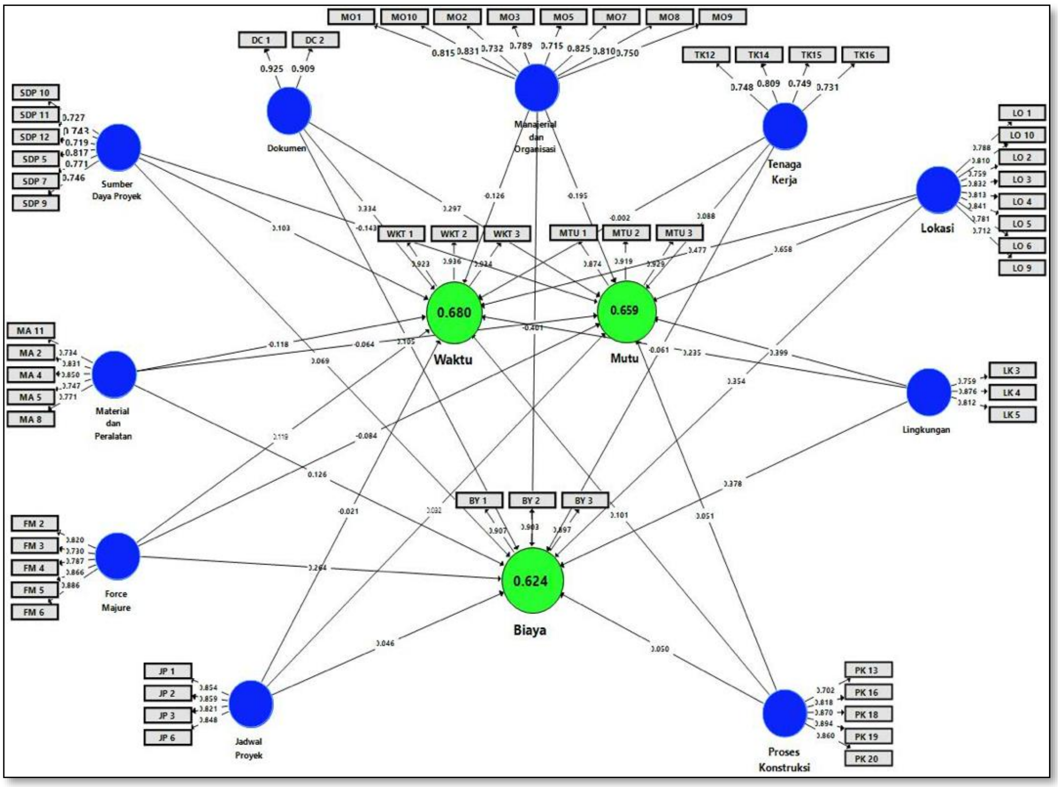

Figure 4. Outer Model Model of Internal and External Factors of the Project on Project Performance Source: Researcher data processing results (2023)

Loading Factor

Loading factor is used to assess how much participation the indicator has in explaining the construct in question. In the estimation results of this model, there are several indicators in the sample area tested have a *loading factor value* below 0.7. So that in accordance with the minimum requirements, this indicator needs to be removed from the test model. And after that the model needs to be reestimated.

After removing the indicators with *a loading* factor below 0.7, the equation model was reestimated, and the results showed that all indicators of this test sample had loading *factor* values exceeding 0.7. Therefore it can be concluded that the remaining indicators meet the requirements of their validity.

Table 2. Internal Loading Factor Value

	Document	**Project Resources**	**Workforce**	**Construction Process**	**Managerial and Organizational**	**Materials and Equipment**	**Project Schedule**
DC 1	0,925						
DC 2	0,909						
SDP 10		0,727					
SDP 11		0,743					
SDP 12		0,719					

SDP 5	0,817					
SDP 7	0,771					
SDP 9	0,746					
TK12		0,748				
TK14		0,809				
TK15		0,749				
TK16		0,731				
PK 13			0,702			
PK 16			0,818			
PK 18			0,870			
PK 19			0,894			
PK 20			0,860			
MO1				0,815		
MO10				0,831		
MO2				0,732		
MO3				0,789		
MO5				0,715		
MO7				0,825		
MO8				0,810		
MO9				0,750		
MA 11					0,734	
MA 2					0,831	
MA 4					0,850	
MA 5					0,747	
MA 8					0,771	
JP 1						0,854
JP 2						0,859
JP 3						0,821
JP 6						0,848

Source: Processing Researcher Data (2023)

Table 3. Value Loading factor External

	Force Majure	**Milieu**	**Location**
FM 2	**0,820**		
FM 3	**0,730**		
FM 4	**0,787**		
FM 5	**0,866**		
FM 6	**0,886**		
LK 3		**0,759**	
LK 4		**0,876**	
LK 5		**0,812**	
LO 1			**0,788**
LO 10			**0,810**
LO 2			**0,759**
LO 3			**0,832**
LO 4			**0,813**
LO 5			**0,841**
LO 6			**0,781**
LO 9			**0,712**

Source: Processing Research Data (2023)

Table 4. Value of Loading Project Performance factors (Cost, Quality, and Time)

	Cost	**Head**	**Time**

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BY 1	**0,907**		
BY 2	**0,903**		
BY 3	**0,897**		
PERSON 1		**0,874**	
PERSON 2		**0,919**	
MAN 3		**0,929**	
WKT 1			**0,923**
WKT 2			**0,936**
WKT 3			**0,934**

Source: Processing Research Data (2023)

Convergen Validity

In addition to considering the loading factor as a criterion, model validity testing also checks convergent validity results by checking the AVE value obtained from the SMART-PLS output as shown in Table 5 below.

Table 5. Average Variance Extracted (AVE) Value

	Average Variance Extracted (AVE)
Cost	**0,814**
Document	**0,840**
Force Majure	**0,672**
Project Schedule	**0,715**
Milieu	**0,667**
Location	**0,629**
Managerial	**0,616**
Material	**0,621**
Head	**0,824**
Construction Process	**0,692**
Project Resources	**0,569**
Workforce	**0,577**
Time	**0,867**

Source: Processing Research Data (2023)

The above results show that all research variables in the sample model have values above 0.5. Therefore, it can be concluded that the convergent validity of all these variables is **good.**

Composite Realibility and Cronbach's Alpha

Construct reliability in the test model using composote realibility and Cronbach's alpha measurement methods. The model estimation results show that the composite reliability value is above 0.7 and crobanch's alpha value is above 0.6. Therefore, it can be concluded that the reliability of all constructs in the model is good.

Table 6. Values of Reliability Test Results and Cronbach's Alpha

Construct Reliability and Validity	**Cronbach's Alpha**	**Composite Reliability**
Cost	**0,886**	**0,929**
Document	**0,810**	**0,913**
Force Majure	**0,881**	**0,911**
Project Schedule	**0,868**	**0,909**
Milieu	**0,748**	**0,857**
Location	**0,915**	**0,931**
Managerial and Organizational	**0,911**	**0,927**
Materials and Equipment	**0,847**	**0,891**
Head	**0,893**	**0,933**
Construction Process	**0,888**	**0,918**

Project Resources	**0,852**	**0,888**
Workforce	**0,759**	**0,845**
Time	**0,923**	**0,951**

Source: Processing Research Data (2023)

Hypothesis testing

Partial Hypothesis Testing

Testing the significance of the relationship separately from each predictor variable to its criteria variable aims to test the hypothesis described in Chapter II earlier. The process of testing this hypothesis involves comparing the t-Count value with the t-table value and evaluating the level of significance.

Table 7. Path coefficien, T-count and partial hypothesis of internal factors

Factor Internal	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**	**Conclusion**
Documents -> Fees	0,086	1,220	**0,111**	**Rejected**
Quality > Documents	0,090	3,280	**0,001**	**Accepted**
Time-> Documents	0,075	4,473	**0,000**	**Accepted**
-Cost > Project Schedule	0,089	0,515	**0,303**	**Rejected**
Project Schedule -Quality >	0,077	0,422	**0,337**	**Rejected**
-> Project Schedule Time	0,075	0,278	**0,391**	**Rejected**
Managerial and Organizational -> Costs	0,137	2,934	**0,002**	**Accepted**
Managerial and Organizational -> Quality	0,136	1,433	**0,076**	**Rejected**
Managerial and Organizational -> Time	0,108	1,169	**0,121**	**Rejected**
Materials and Equipment -> Cost	0,094	1,335	**0,091**	**Rejected**
Quality > Materials and Equipment	0,089	0,721	**0,236**	**Rejected**
Materials and Equipment -> Time	0,098	1,206	**0,114**	**Rejected**
Construction Process -Cost >	0,069	0,725	**0,234**	**Rejected**
Construction Process -Quality >	0,071	0,716	**0,237**	**Rejected**
Construction Process -> Time	0,068	1,485	**0,069**	**Accepted**
Project Resources -Cost >	0,086	0,800	**0,212**	**Rejected**
Project Resources -Quality >	0,081	1,770	**0,039**	**Accepted**
Project Resources -> Time	0,082	1,258	**0,104**	**Rejected**
-> Labor Cost	0,051	1,200	**0,115**	**Rejected**
Workforce -Quality >	0,051	1,721	**0,043**	**Accepted**
Workforce -> Time	0,047	0,051	**0,480**	**Rejected**

Table 8. Path Coefficient, t-count and Partial hypothesis of External factors

Faktor External	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**	**Conclusion**
Force Majure ->	0,083	3,160	**0,001**	**Accepted**

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Cost				
Force Majure -> Mutu	0,083	1,011	**0,156**	**Rejected**
Force Majure -> Time	0,071	1,680	**0,047**	**Accepted**
Environment -> Cost	0,095	3,967	**0,000**	**Accepted**
Environment - Quality >	0,089	4,471	**0,000**	**Accepted**
-> Environment Time	0,070	3,369	**0,000**	**Accepted**
Location -> Cost	0,126	2,821	**0,002**	**Accepted**
Location -> Quality	0,108	6,092	**0,000**	**Accepted**
-> Time Location	0,105	4,551	**0,000**	**Accepted**

Source: Processing Researcher data, 2023

From the results of the model estimation, conclusions can be obtained stated as follows:

1. Hypothesis 1 (H1) states that internal document risk factors have a *significant influence* on project performance, quality and time.
2. Hypothesis 2 (H2) states that internal, managerial, and organizational risk factors only affect project performance, i.e. cost.
3. Hypothesis 3 (H3) states that the internal risk factors of project resources only have a significant effect on the performance of quality projects.
4. Hypothesis 4 (H4) states that internal risk factors of labor only affect the performance of quality projects
5. Hypothesis 5 (H5) states that external *force factors have* a significant influence on project performance, namely cost
6. Hypothesis 6 (H6) states that external environmental risk factors and location have a significant influence on project performance, cost, quality and time.

While internal document factors are not significant to cost, project schedule is not significant to cost, quality and time, managerial is not significant to quality and time, labor is not significant to project performance cost and time, project resources are not significant to project performance cost and time, materials and equipment, construction process, project schedule. For external factors, *the* quality and time advance are not significant to project performance.

Simultaneous Hypothesis Testing

To assess the joint effect of the independent variable on the dependent variable simultaneously, calculations are carried out using

$$\boldsymbol{F\ hitung}\ \frac{(\boldsymbol{n}-\boldsymbol{k}-\mathbf{1})\boldsymbol{R}^{\mathbf{2}}}{\boldsymbol{k}(\mathbf{1}-\boldsymbol{R}^{\mathbf{2}})}$$

F table is obtained from the table using DF 1 and DF 2 instruments obtained from the following formulation below:

DF 1 = Number of independent Variables
DF 2 = n-k-1
Information:

n = Number of samples
k = Number of independent variables
R^2 = r square (from the estimated results)

73	3.97	3.12	2.73	2.50	2.34	2.23	2.14	2.07	2.01	1.96	1.92	1.89	1.86	1.83	1.81
74	3.97	3.12	2.73	2.50	2.34	2.22	2.14	2.07	2.01	1.96	1.92	1.89	1.85	1.83	1.80
75	3.97	3.12	2.73	2.49	2.34	2.22	2.13	2.06	2.01	1.96	1.92	1.88	1.85	1.83	1.80
76	3.97	3.12	2.72	2.49	2.33	2.22	2.13	2.06	2.01	1.96	1.92	1.88	1.85	1.82	1.80
77	3.97	3.12	2.72	2.49	2.33	2.22	2.13	2.06	2.00	1.96	1.92	1.88	1.85	1.82	1.80
78	3.96	3.11	2.72	2.49	2.33	2.22	2.13	2.06	2.00	1.95	1.91	1.88	1.85	1.82	1.80
79	3.96	3.11	2.72	2.49	2.33	2.22	2.13	2.06	2.00	1.95	1.91	1.88	1.85	1.82	1.79
80	3.96	3.11	2.72	2.49	2.33	2.21	2.13	2.06	2.00	1.95	1.91	1.88	1.84	1.82	1.79
81	3.96	3.11	2.72	2.48	2.33	2.21	2.12	2.05	2.00	1.95	1.91	1.87	1.84	1.82	1.79
82	3.96	3.11	2.72	2.48	2.33	2.21	2.12	2.05	2.00	1.95	1.91	1.87	1.84	1.81	1.79
83	3.96	3.11	2.71	2.48	2.32	2.21	2.12	2.05	1.99	1.95	1.91	1.87	1.84	1.81	1.79
84	3.95	3.11	2.71	2.48	2.32	2.21	2.12	2.05	1.99	1.95	1.90	1.87	1.84	1.81	1.79
85	3.95	3.10	2.71	2.48	2.32	2.21	2.12	2.05	1.99	1.94	1.90	1.87	1.84	1.81	1.79
86	3.95	3.10	2.71	2.48	2.32	2.21	2.12	2.05	1.99	1.94	1.90	1.87	1.84	1.81	1.78
87	3.95	3.10	2.71	2.48	2.32	2.20	2.12	2.05	1.99	1.94	1.90	1.87	1.83	1.81	1.78
88	3.95	3.10	2.71	2.48	2.32	2.20	2.12	2.05	1.99	1.94	1.90	1.86	1.83	1.81	1.78
89	3.95	3.10	2.71	2.47	2.32	2.20	2.11	2.04	1.99	1.94	1.90	1.86	1.83	1.80	1.78
90	3.95	3.10	2.71	2.47	2.32	2.20	2.11	2.04	1.99	1.94	1.90	1.86	1.83	1.80	1.78

Figure 5. F Simultaneous Hypothesis Test Table

Using the formula above, F count and F table for each construct relationship are calculated and the following results are obtained:

Hubungan	F hitung	F tabel	Kesimpulan
ALL SAMPEL			
TK-MA-PK-DOC-M0-SDP-JP-FM-LOC-LK → Biaya	47,9	1.99	H 7 Diterima
TK-MA-PK-DOC-M0-SDP-JP-FM-LOC-LK → Mutu	69,3	1.99	
TK-MA-PK-DOC-M0-SDP-JP-FM-LOC-LK → Waktu	46,2	1.99	

Figure 6. Simultaneous Hypothesis Testing Model Source: Researcher data processing results (2023)

Based on the table data above, the hypothesis can be prepared with the conclusion that simultaneously or together *endogenous* variables in ten test sample models have a significant influence on *exogenous* variables. The ten variables of labor, tool materials, construction processes, documents, organizational management, project resources, project schedule, *force majure*, location and environment are proven to have a *significant* influence on project performance cost, quality and time on test samples. Thus the entire test sample proves that H 7 is acceptable.

DISCUSSION

Model of the Influence of Internal and External Factors on Cost Performance

The coefficient of determination of the model of the influence of Internal and External Risk Variables on Cost Performance, based on the results of the PLS-SEM analysis is as follows:

R2 = 0.624

This means that the Internal and External Factor variables are only able to explain the variation that occurs in the cost variable by 62.4%, which is included in the *moderate* category , while the remaining 37.6% is explained by other variables that are not included in this study. However, this is reasonable according to Hair et al. (2017) stating that the small, moderate and strong R2 value is caused by the lack of predictor variables used.

The calculation *of Goodness of Fit* in the model of the effect of internal and external risk variables on Cost Performance is:

$$\text{GoF } \sqrt{Ave * R^2} = = = 0.437\sqrt{0,700 * 0,624}$$

The GoF value of 0.437 is included in the high category (Akter et al, 2011), so it can be concluded

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that the model of the influence of Internal and External Factors on cost performance is significant and valid. In particular indicators X1.2.4 Shortage of work equipment, X1.4.1 Availability of quality management system documents, X1.5.10 Inexperienced project managers and experts, X2.1.6 Riots, X2.2.5 Risk of land status, X2.3.4 The level of safety of the project environment, affecting the cost performance of the project.

Model of the Influence of Internal and External Factors on Quality Performance

The coefficient of determination of the model of the influence of Internal and External Risk Variables on Cost Performance, based on the results of the PLS-SEM analysis is as follows:

R2 = 0.659

This means that the Internal and External Factor variables are only able to explain the variation that occurs in quality variables by 65.9%, which is included in the *moderate* category , while the remaining 34.1% is explained by other variables that are not included in this study. However, this is reasonable according to Hair et al. (2017) stating that the small, moderate and strong R2 value is caused by the lack of predictor variables used. The calculation of *Goodness of Fit* in the model of the effect of internal and external risk variables on Cost Performance is:

$$\textbf{GoF}\ \sqrt{Ave * R^2} = = = 0.461\sqrt{0,700 * 0,659}$$

The GoF value of 0.461 is included in the high category, so it can be concluded that the model of the influence of Internal and External Factors on quality performance is significant and valid. In particular, indicators X1.5.10 Inexperienced project managers and experts, X1.6.5 High labor wages, X2.2.5 Land status risk and X2.3.4 Project environmental safety level, affect project quality performance.

Model of the Influence of Internal and External Factors on Time Performance

The coefficient of determination of the model of the influence of Internal and External Risk Variables on Cost Performance, based on the results of the PLS-SEM analysis is as follows:

R2 = 0.680

This means that the Internal and External Factor variables are only able to explain the variation that occurs in quality variables by 68%, which is included in the high category, while the remaining 32% is explained by other variables that are not included in this study. However, this is reasonable according to Hair et al. (2017) stating that the small, moderate and strong R 2 value is caused by the lack of predictor variables used.

The calculation *of Goodness of Fit* in the model of the effect of internal and external risk variables on Cost Performance is:

$$\textbf{GoF} = \sqrt{Ave * R^2} = \sqrt{0,700 * 0,680} = 0,476$$

The GoF value of 0.476 is included in the high category, so it can be concluded that the model of the influence of Internal and External Factors on quality performance is significant and valid. In particular indicators X1.2.4 Shortage of work equipment, X1.3.16 Material quality control from suppliers and quality of work of subcontractors in accordance with technical specifications, X1.4.1 Availability of Quality Management System documents, X1.5.10 Inexperienced project managers and experts, X1.7.2 Occurrence of design changes, X2.1.6 Riots, X2.2.5 Risk of land status, X2.3.4 The level of environmental safety of the project affects the performance of project time.

CONCLUSION

The results of this study provide an overview of internal and external project risk factors in smelter construction measured through internal variables of labor, materials and equipment, construction processes, documents, managerial, project resources, project schedules and external *force variables*, location and environment on project performance. From the results of all samples processed in this study, the following conclusions were obtained:

1) Based on analysis using the *probability x impact method and* determining the category of risk factors that obtain the most dominant value with high risk categories consisting of 8 indicators of internal and external risk factors, namely:

- X1.1.17 Lack of manpower.
- X1.2.1 Increase in material prices.
- X1.5.10 Inexperienced project managers and experts.
- X1.6.15 Supplier changes approaching project closure cause cost *overruns.*
- X1.7.18 Project priorities are unclear where less important work is completed.
- X2.1.1 Erratic weather
- X2.2.6 Polluted environment
- X2.3.5 Weather during construction activities.

2) The results showed that internal and external factors together have a significant influence on project performance cost, quality and time on direct influence

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