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IMPACT OF CHANGE ORDERS ON ROAD CONSTRUCTION PROJECT : CONSULTANS' PERSPECTIVE

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Change orders in construction projects have a significant negative impact on project performance. This study aims to determine the impact of change orders in terms of cost, quality, time, organization, and other factors in road construction projects. This was achieved through the distribution of questionnaires and the return of 30 consultant respondents engaged in road construction projects from the provinces of DKI Jakarta, Banten, and West Java. After that, the data obtained is processed using a statistical tool known as Smart PLS. Data processing with Smart PLS tested the validity and reliability and the relationship between variables. There are 6 variables, namely X1, X2, X3, X4, X5, and Y with each indicator, with a total of 17 indicators from X1 to X5 and a total of 4 indicators for Y indicators. The results of this study resulted in the impact of change orders significantly affecting cost (X1), quality (X2), time (X3), organization (X4), and others (5) on road construction projects, the biggest impact being others. The results also show three significant indicators, change orders reduce labor productivity (X5.2), change orders cause disputes in projects (X4.1), and change order to reduce the quality of work (X2.2)

Keywords: impact of change orders, road construction projects, consultant respondents

1 INTRODUCTION

The success of a project depends on the achievement of desired performance as regards the schedule, cost, and quality which are usually measured through project schedule, budget certainty, and satisfactory conformance to functional and technical specifications (Baccarini 1999[1] ; McKim et al. 2000[2]). Meanwhile, Hao et al. (2015)[3] defined change order as the major cause of project delays, cost overruns, defects, and project failures which is normally due to several factors such as design errors, design changes, scope modifications, or unknown conditions in the field (Hanna et al. 2002 [4]; Hanna and Swanson 2007[5]). Change orders are also generally explained as the corrections, additions, or deletions to contracts and design drawings due to the complex nature of relationships and processes in construction work (Alnuaimi et al. 2010 [6]; Hwang and Low 2012 [7]). The six types are described by O'Brien (1998)[8] to include unforeseen circumstances, plans and/or specifications, changes in scope through the additions or enhancements by the owner, value engineering, force majeure, and acceleration.

These change orders have a significant negative impact on project performance which is difficult to evaluate due to the highly integrated nature of construction operations (Finke 1998)[9] as indicated by several factors associated with the process which have certain effects required to be considered (Karim and Adeli, 1999; Motawa et al., 2007) in the research of Hwang and Low, 2012[7]

1.1 Existing Studies

Cattano (2010)[10] interviewed project owners and contractors and also reviewed project documents while Taylor et al. (2012)[11] presented a statistical analysis of engineering change orders for highway projects using frequency and average percentage change in project costs for different types of change orders and found the main causes to include contract omissions, owner-induced increases, and redundant contract items. Moreover, Hanna and Iskandar (2017)[12] used a regression model to measure and predict the cumulative impact of change orders for 68 electricity and heating, ventilation, and air conditioning (HVAC) projects and found a strong correlation between the number of change items initiated on a project and the reduction in productivity. It also showed that there was only a subtle difference in the impact of change order costs between mechanical-electrical projects.

Keane (2010) [13] discussed the impact of change orders based on 5 categories which include cost, quality, time, organization, and others while 9 categories used by Hwang and Low (2012) [7] include

increasing project costs, recruiting professional workers, increasing overhead costs, decreasing quality, decreasing labor productivity, delays in the procurement process, rework and dismantling, worker safety, delays in the completion schedule. Meanwhile, Martanti and Hardjomuljadi (2018) [14] used 4 categories based on the involvement of respondents in the project and these include contractors, consultants, owners, and auction units while Alnuami et al., (2010) [6]showed that the highest impact was the delay in project completion time which normally causes claims and disputes, rising costs, increase in the budget for contractors, and reduction in the quality of work.

1.2 Research purposes

The purpose of this study is to analyze the impact of change orders on costs, quality, time, organization, and others. Another impact is a factor that influences but is not related to cost, quality, time, and organization. Like one other impact, the change order statement causes significant progress without delay (Keane, 2010)[13]. Adverse time-related effects of a change order can be compensated with the help of floats on construction activities and acceleration of work progress.

1.3 Hypotheses Formulation

This study formulated 5 hypotheses to be tested which are stated as follows:

- Change orders have a significant impact on costs for road construction projects (X1)
- Change orders have a significant impact on the quality of road construction projects (X2)
- Change orders have a significant impact on the time for road construction projects (X3)
- Change orders have a significant impact on the organization of road construction (X4)
- Change Order has a significant impact on other aspects of road construction (X5)

2 RESEARCH METHODS

The research was conducted by conducting literature studies, field observations, and making and distributing questionnaires. The study of literature as a previous study was used as a reference for this research, only for observations in the field. Based on the results of field observations and then referring to the previous literature, a questionnaire was made that resulted in the impact of change orders as shown in Table 2. Before researching the impact of change orders, research was carried out to find the causes of change orders for road construction projects and study 26 real data on the latest projects on the project road construction.

2.1 Study of literature

Referring to the literature study on change orders seen in Keane, 2010[13] which divides the impact into 5 main parts, namely: cost, quality, time, organization, and other impacts as shown in Table 1. below.

2.2 Field Observation

Field observations with three professional consultants with over 20 years of experience produced input and suggestions, then using the Delphi method consulted three experts to determine the impact of change orders. The three experts who were contacted were experienced experts in the field of civil engineering, working on road construction works, with a minimum of over 20 years of experience. Based on field experience, the decision to determine the impact of change orders refers to Keane's research, 2010[13] in Table 1.

Table 1. Effect of Variations (Change Orders) (Keane, 2010)[13]

Effects of Change Order
Cost-related Effects:
-Increase in overhead expenses (O'Brien 1998)[8]
- Additional payment for the contractor (O Brien 1998)[8]
- Rework and demolition (Clough and Sears 2005 [15]; CII 1990 a)[16]
Quality–related effects :
-Quality degradation (CII, 1990a)[16]
Time-related effects :
-Delay in Payment (CII, 1990 a)[16]
Procurement delay (O'Brien 1998)[8]
-Rework and demolition (Clough and Sears 2005[15] [25]; CII,1990 a)[16]
-Logistic delay (Fisk, 2014)[17]
-Completion schedule delay (Ibbs, 1997) [18]
Organization and its reputations- related effects :
- Tarnish firm's reputation (Fisk, 2014)[17]
- Poor Safety conditions (O' Brien 1998)[8]
- Poor Profesional relations (Fisk, 2014) [17]
- Dispute among professionals (Fisk, 2014) [17]
Other Effects:
- Progress affected without delay (CII, 1994 a) [19]

Then consultations with experts were held, resulting in the impact of the change order as stated in the draft questionnaire below, namely in Table 1.

2.3 Change Order Impact Questionnaire

The questionnaire was designed based on Alnuami, 2010[6], Onkar, 2015 [20], Duah, 2017[21], and Martanti and Hardjomuljadi,2018[14], O'Brien, 1998 [8]. Fisk, 2014[17] and CII, 1990 a [16], CII, 1994 a [19] to consist of 5 groups which include (1) Cost, (2) Quality, (3) Time, (4) Organization, and (5) Others with a total of 17 indicators as well as the 4 indicators of the causes as presented in Table 2.

2.4 Questionnaire distribution

Questionnaires were also distributed to the consultants to determine their perspective on the impact of change orders in DKI Jakarta and Banten Provinces after which the data obtained were analyzed through Smart PLS which is a statistical tool using 17 indicators for cost, quality, time, organization, and others and another 4 indicators for the cause of the change orders.

NO.	IMPACTS OF *CHANGEORDER*	SOURCE
I	**Cost-Related Impacts**	
1	Change Orders cause project costs to increase	Alnuaimi,2010 [6], O Brien, 1998 [8]
2	Change orders add to the budget for contractors	Alnuaimi,2010 [6], O' Brien, 1998[8]
3	Change orders increase overhead	Onkar,2015 [20], O Brien, 1998 [8]
4	*Changeorders* cause *rework*	Onkar,2015 [20], Clough and Sears.2005[15]; (CII, 1990 a)[16]
5	Change orders cause a decrease in project profits	Martanti and Harjomuljadi,2018[14]
6	Change orders disrupt project cash flow	Duah,2015 [21]
II	**Quality-Related Impacts**	
1	Change orders improve the quality of work	Martanti andHarjomuljadi,2018[14]
2	Change orders reduce the quality of work	Martanti andHarjomuljadi,2018[14],Fisk, 2014[17], (CII, 1990 a)[16]
III	**Time-Related Impacts**	
1	Change order adds to project duration	Alnuaimi,2010[6] , Ibbs, 1997[18]
2	Change orders cause material delays	Onkar,2015[20], Fisk 2014[17]
3	Change orders cause delays in work equipment	Onkar,2015 [20] Fisk 2014[17]
4	Change orders hinder other works	Onkar,2015 [20]
5	Change order causes a late payment	Martanti and Harjomuljadi ,2018 [20] CII, 1990 a [16]
IV	***Organization and its reputations- related impacts***	
1	Change order causes dispute in project	Alnuaimi,2010 [6] Fisk, 2014[17]
2	Change orders cause a decrease in employee performance and morale	Onkar, 2015 [20], Fisk,2014[17]
V	**Others Impacts**	
1	Change order causes Progress affected without delay	(CII, 1994 a) [19]
2	Change Order causes a decrease in labor productivity	Onkar, 2015 [20]
VI	***Cause of Change Order***	
1	A mismatch between design drawings and field conditions	Waty and Sulistio, 2021 [22]
2	Changes in the scope of work	Waty and Sulistio, 2021 [22]
3	Planning drawing changes	Waty and Sulistio, 2021 [22]
4	Insufficient equipment	Waty and Sulistio, 2021 [22]

2.5 Questionnaire Returns

The questionnaires returned by respondents reached 30 samples from the consultant's point of view and according to the results of research from Gay, LR, and Diehl, PL (1992)[23], stated that if the research carried out was correlational or related research, then the sample size was at least 30 subject (sample unit) so that this study only uses 30 samples.

2.6 Data Processing

The data collected were processed and recorded in tabular form using Microsoft Excel after which reliability and validity were tested and a T-test was applied to partially test the existing latent variables from X and Y with the eligibility criterion being the ability of the data to exceed 1.96 for the partial test on each latent variable.

The existing variables including X1, X2, X3, X4, and X5 as well as Y were found to be latent variables because they were unmeasured and this means there was the need to apply the Smart PLS 3.0 program to determine the impact of change orders (Y) on costs (X1), quality (X2), time (X3), organization (X4), and others (X5).

3 RESULTS AND DISCUSSION

The results showed the impacts of change orders on road construction projects based on the perspectives of consultants that have handled road projects. The questions were focused on the effect on cost, time, quality, organization, and others. The responses were provided using a Likert scale with a 1-5 scale ranging from never exists, rarely to always exists.

3.1 Model Design

The data obtained from the survey were tabulated in Excel and saved. CSV (Comma Delimited) format to allow its importation into the Smart PLS 3.0 program. The study used 1 endogenous variable and 5 exogenous or influenced variables which are described with their respective indicators as follows:

Causes of Change Orders Y are:

- Mismatch between design drawings and field conditions (Y1)
- Changes in the scope of work (Y2)
- Change of planning drawing (Y3)
- Inadequate equipment (Y4)

Cost (X1)

- Change orders cause project costs to increase (X1.1)
- Change order adds budget for contractors (X1.2)
- Change orders increase overhead costs (X1.3)
- Change order causes rework (X1.4)
- Change order causes a decrease in profit (X1.5)
- Change orders disrupt project cash flow (X1.6)

Quality (X2)

- Change orders improve work quality (X2.1)
- Change orders reduce the quality of work (X2.2)

Time (X3)

- Change order adds to project duration (X3.1)
- Change orders cause a material delay (X3.2)
- Change orders cause delays in work equipment (X3.3)
- Change orders hinder other works (X3.4)
- Change order causes late payment (X3.5)

Organization (X4)

- Change order causes dispute in the project (X4.1)
- Change orders cause a decrease in employee performance and morale (X4.2)

Others (X5)

- Change orders cause progress affected without delay (X5.1)
- Change Order causes a decrease in labor productivity (X5.2)

3.2 Preliminary Model

Calculations with Smart PLS were carried out in the seventh round and the final results were used as a research model because from the initial round to the sixth round they could not meet the requirements which caused the elimination of several indicators such as X5.1, Y4, X4 .2, X1.2, X1.6, and X3.4 to ensure a more satisfactory result in the seventh round as shown in figure 1.

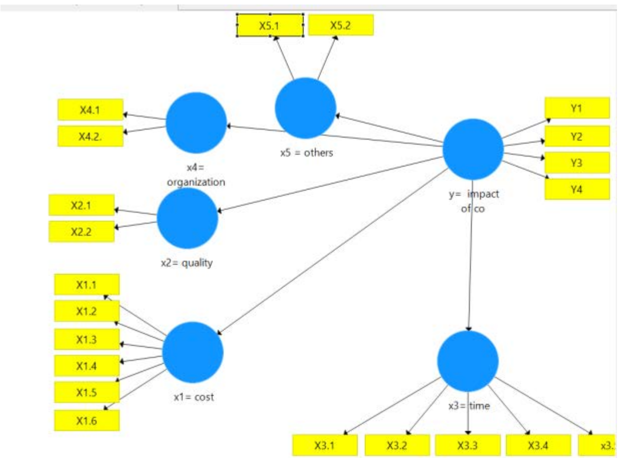

Figure 1. Path Modeling

4 FINAL RESULTS

The final results of the model used in this study are:

The calculations in this section were conducted using PLS Algorithm with the tests focused on theouter and inner models to determine the validity of the data. This is because invalid data need to be corrected and recalculated while valid ones are used for the next stage. Therefore, the results obtained up to the third model are presented in the following figure 2.

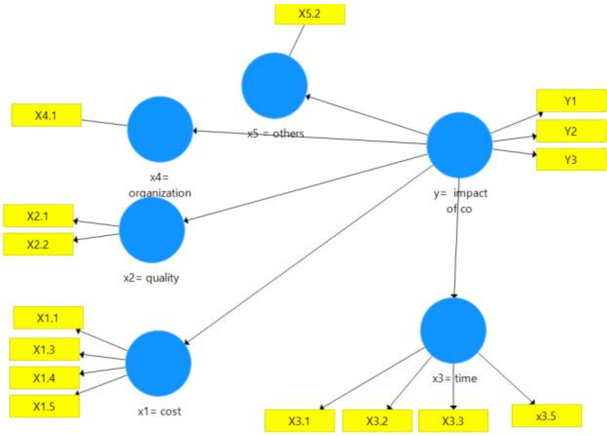

Figure 2. Last Path Modeling

4.1.1 Convergent Validity

Table 2. Outer Loadings with PLS Algorithm

Outer Loadings

Matrix

	x1= cost	x3= time	x5 = oth...	y= impa...	x2= quality	x4= orga...
X1.1	0.748					
X1.3	0.750					
X1.4	0.835					
X1.5	0.712					
X2.1					0.870	
X2.2					0.906	
X3.1		0.901				
X3.2		0.881				
X3.3		0.789				
X4.1						1.000
X5.2			1.000			
Y1				0.923		

Convergent validity is normally used to determine the validity of an indicator as a measure of the variable based on its outer loading such that an indicator with an outer loading value > 0.70 is confirmed to be reliable. Table 2 shows that the values for all the indicators are > 0.7 and this means they all have convergent validity.

4.1.2 Discriminant Validity

Discriminant validity is usually used to test the level at which a latent construct is different from other constructs and a high value normally indicates the uniqueness and capability of the construct to explain the phenomenon being measured.

*model dampak co 1 ok .splsm | model dampak co 1.splsm | dampak co 1.splsm

Discriminant Validity

Fornell-Larcker Criteri... | Cross Loadings | Heterotrait-Monotrait ... | Heterotrait

	x1= cost	x3= time	x5 = oth...	y= impa...	x2= quality	x4= orga...
x1= cost	0.762					
x3= time	0.676	0.837				
x5 = oth...	0.470	0.442	1.000			
y= impa...	0.570	0.590	0.616	0.808		
x2= quality	0.185	0.137	0.385	0.460	0.888	
x4= orga...	0.197	0.429	0.524	0.610	0.358	1.000

The cross-loading value of each construct was evaluated to ensure its correlation with the measurement item was greater than for other constructs. The value is normally expected to be greater than 0.7 (Ghozali and Latan, 2015) [24]. It is important to note that cross-loading is another method to determine discriminant validity by examining the value of cross-loading such that the loading value of each item to the construct is expected to be greater than the cross-loading value.

Table 3 shows that all loading indicators for constructs are greater than those cross-loading them to other constructs as indicated in X1.1 where the loading value, 0.718, is greater than the cross-loading values to other constructs including 0.136 to X2 and 0.285 to Y. The same trend was also observed in all other items and this indicates the model met the requirements for discriminant validity.

Fornell Larcker Criterion which is a traditional method applied for more than 30 years to compare the square root value of the Average Variance Extracted (AVE) of each construct with the correlation between other constructs in the model was applied to test the discriminant validity (Henseler et al., 2016)[25]. The condition to determine a good determinant validity is when the square root value of the AVE for each construct is greater than the correlation value between the construct and others in the model (Fornell and Larker, 1981)[26] .

Table 3 shows that all the roots of the AVE (Fornell-Larcker Criterion) for each construct are greater than their correlations with other variables as indicated in X1 where the AVE value was 0.555 and the AVE root was 0.745.

4.1.3 Construct Reliability

Construct Reliability and Validity

Matrix | Cronbach's Alpha | rho_A | Composite Reliabili

	Cronbach...	rho_A	Composi...	Average ...
x1= cost	0.764	0.796	0.847	0.581
x3= time	0.859	0.913	0.903	0.701
x5 = oth...	1.000	1.000	1.000	1.000
y= impa...	0.729	0.788	0.848	0.653
x2= quality	0.734	0.746	0.882	0.789
x4= orga...	1.000	1.000	1.000	1.000

Figure 3. Construct Reliability

Construct Reliability which is also known as Cronbach's alpha was used to measure the reliability of the latent variable constructs with the constructs determined to be reliable when they have values higher than 0.60. It is also important to note that the internal consistency reliability focuses on the capability of the indicator to measure its latent construct. The tools used for this test are composite reliability and Cronbach's alpha with values between 0.6 - 0.7 and above 0.6 respectively considered to represent good reliability (Ghozali and Latan, 2015) [24].

Figure 3 shows that all the constructs have Cronbach's Alpha values > 0.6 and this indicates they are all reliable as indicated by 0.845 recorded for X1.

The unidimensionality test was applied to ensure there are no problems in the measurement process and it was also conducted using composite reliability indicators and Cronbach's alpha with the cut-value set at 0.7 for the two indicators. Therefore, Figure 3 also shows that all the constructs satisfy the unidimensionality requirements with their composite reliability values discovered to be > 0.7 as indicated by the 0.845 recorded for X1.

4.1.4 Average Variance Extracted (AVE)

The convergent validity was determined based on the principle that the metrics of a construct should be highly correlated (Ghozali and Latan, 2015) [24] and the value for each construct with reflective indicators was evaluated using Average Variance Extracted (AVE). The AVE value is expected to be 0.5 or more to indicate that the construct can explain a minimum of 50% of the item variance. Meanwhile, Figure 3 shows that all the constructs satisfied the requirements because they all values higher than 0.50 as indicated by X1 with 0.555 > 0.5 which shows that it is convergently valid.

4.2 Inner Model

An inner model is a structural model normallyused to predict causality (cause-effect relationship) between latent variables or those that cannot be measured directly. It also describes the causal relationship between latent variables developed based on the substance of the theory. The test on the structural or inner model is usually conducted based on the Bootstrapping and Blindfolding procedures in Smart PLS. Some of the tests normally applied include (1) R-Square or coefficient of determination on endogenous constructs (Sekaran & Bougie, 2016) [27], and the value was classified by Chin (1998) [28] to be 0.67 for strong, 0.33 for moderate, and 0.19 for weak,(2) Path Coefficients estimate which is the value of the path coefficient or the magnitude of the relationship of influence of latent constructs determined through Bootstrapping procedure,(3) Effect Size (F-Square) which is normally applied to determine the goodness of the model, (4) Prediction relevance (Q-square) which is also known as Stone-Geisser's test was used to determine the predictive capability based on the blindfolding procedure such that 0.02 value indicates small, 0.15 medium, and 0.35 large. It is important to note that this method is only applicable to endogenous constructs with reflective indicators (Ghozali, 2016) [29].

4.2.1 R-Square on endogenous construct

The coefficient of determination (R2) assesses the level at which an endogenous construct can be explained by an exogenous construct with its value expected to be between 0 and 1 such that 0.75, 0.50, and 0.25 indicate a strong, moderate, and weak model respectively (Sarstedt et al., 2020) [30] while the criteria provided by Chin were 0.67, 0.33, and 0.19 respectively (Chin, 1998 in Ghozali and Latan, 2015) [24].

Table 4. R Square

R Square

Matrix | R Square | R Square Adjusted

	R Square	R Square ...
x1= cost	0.325	0.301
x3= time	0.349	0.325
x5 = oth...	0.380	0.357
x2= quality	0.211	0.183
x4= orga...	0.372	0.350

Table 4 shows the R-square values meet all the requirements as follows:

- The change order endogenous variable was able to explain the cost exogenous variable weakly as indicated by an R square value of 0.325.
- The change order endogenous variable was able to explain the quality exogenous variable weakly as indicated by the R square value of 0.211.
- The change order endogenous variable was able to explain the exogenous time variable moderately as indicated by the R square value of 0.349.
- Change order endogenous variables were able to explain exogenous organizational variables moderately as indicated by an R square value of 0.372
- Change order endogenous variables were able to explain other exogenous variables moderately as indicated by an R square value of 0.380

Table 4 shows that the R-Square value for the combined influence of X1, X2, X3, X4, and X5 on Y was 0.325 for the independent variable (X1) with an Adjusted R-Square value of 0.301 and this means all the independent variables (X1) simultaneously affect Y by 0.301 or 30.1%. Meanwhile, X5 which was used to represent time has the largest Adjusted R-Square of 38.0 % and this means it has a MODERATE effect followed by the others such as X3, X4, and X5.

4.2.2 Path Coefficients Estimate

The path coefficients between constructs were measured to determine the significance and strength of the relationship and also to test the hypotheses. The values range from -1 to +1 such that those closer to +1 indicate a positive stronger relationship between the two constructs while values closer to -1 indicate a negative relationship (Sarstedt et al., 2020) [30]

Table 5. Path Coeficient

Path Coefficients

Mean, STDEV, T-Values, P-V... | Confidence Intervals | Confidence Intervals Bias C... | Samples | Cc

	Original ...	Sample ...	Standard ...	T Statistic...	P Values
y= impact of co_ -> x1= cost	0.570	0.592	0.097	5.866	0.000
y= impact of co_ -> x3= time	0.590	0.603	0.095	6.213	0.000
y= impact of co_ -> x5 = others_	0.616	0.605	0.133	4.642	0.000
y= impact of co_ -> x2= quality	0.460	0.500	0.175	2.631	0.009
y= impact of co_ -> x4= organization	0.610	0.599	0.143	4.269	0.000

5 CONCLUSION

Data processing and analysis conducted through Smart PLS 3.0 application led to the following conclusions:

- Change orders have a significant impact on costs, quality, time, organization, and others on road construction projects with a T-value of 6.213 at a 5% error percentage while the calculated T-value was 1.96, thereby, indicating each dependent variable has a T-stat value greater than the T-count.
- The highest effect of change order was recorded on others.
- The results showed the three significant indicators which include the ability of change orders to reduce labor productivity (X5.2), cause dispute in the project (X4.1), and change order to reduce the quality of work (X2.2)
- There is 1 indicator that is most affected by change orders regarding costs is change orders cause rework (X1.4)
- There is 1 indicator most influenced by the change order about quality which is its tendency to reduce the quality of work (X2.1)
- There are 2 indicators most affected by the change order concerning the time and these include:
- Increase in project duration (X3.1)
- Material delay (X3.2)
- There is 1 indicator most influenced by the change order of organization and this is associated with its ability to cause dispute in the project (X4.1)
- There is only 1 indicator for the others too and this is its ability to reduce labor productivity (X5.2)

6 SUGGESTION

It was suggested that more attention be placed on the ability of the change orders to cause a reduction in labor productivity, disputes in projects, decrease in performance and morale of workers, quality of work, other works, contractor profits, and increase in project duration to allow each party anticipates or controls the change orders to minimize or even avoid these negative effects.

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