J. Basic. Appl. Sci. Res., 6(7)24-33, 2016

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Model of Change Order Management Influence towards the Loss of Productivity in Construction Project and its Performance

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Received: April 30, 2016
Accepted: July 2, 2016

ABSTRACT

Change order (CO) on the construction project is a change of job, comprising: adding volume, personification volume, additional items of work, job reductions. *Change orders* on road construction projects virtually unavoidable. Job changes occur because it needed in the field, and to enhance physical work in order to meet the objectives of the project. But there is also a *change order* that causes lost productivity that result in a decrease in the construction project performance. The purpose of this study was to analyze the relationship of *change order* to the loss of productivity in construction projects, reviewing the causes of the loss of productivity due to *change orders* at construction projects, to elaborate on the *change order* and the impact on project performance and lost productivity construction projects, modeling the measurement of the impact of *change orders* to lose productivity and performance of the construction project. The method used in this research is a theoretical system consisting of *soft system* and *hard system*. Soft system using the Soft System Methodology (SSM) is to create a conceptual model of *change order* in tackling the soft factors, such as ideas, feelings of motivation, which are not easily measured. Hard system using structural equation models of *Partial Least Square (PLS)*, for measuring model *change orders* that is built on performance associated with its lost productivity. The results of the model simulation analysis show that if *change order* is done of approximately 1% in construction projects, it gives result in lost productivity by approximately 0.5%. If the lost productivity of the project amounted to approximately 1%, the result would be a decrease in the performance of construction projects approximately 1%.

KEYWORDS: *change order*, losing productivity, project performance, soft system, hard system, structural equation.

INTRODUCTION

Change order (CO) on the construction project is a job change, which is adding volume of activities, volume reduction, additional items of work, and the reduction of the work item. Change orders on road construction projects are unavoidable, [1]. Change of work happens because it is needed in a field work, and enhances physical work in order to meet the original objectives of the project. However, there is also a change order that led to loss of productivity and resulted in decreased performance.

Change order in construction projects is the most significant, raises contingency or unexpected additional costs. Change order is one of the risk in fourth in construction projects, and includes one of the four variables that influence risk analysis in Thailand, [2]. National Office report in 1998 in Taiwan, declare that based on the audit in one of the main aspects of a mistake on the construction project is a change order. Change orders resulting in a reduction means or a predetermined goal. Furthermore, claims and legal disputes due to change orders at construction instruction in the United States nearly 50 billion per year, [3].

Technical analysis is conducted on three industrial projects that were built in 1989 - 1992, it was concluded as a result of the change order in a loss of efficiency of approximately 25% - 50%, [1]. In the meantime, the electrical project in Washington was 87% of the 865 projects, as much as 6431 cases of change orders happened with an estimated value of 94 million US $. Problems caused by the change order are not only the uncertainty of contractor profit, but it can be difficult to make all parties to take the deal thus delaying the completion of the work in time and resulting overruns cost, [4][5].

Furthermore, change orders can decrease the productivity of a project, lost productivity (delta) due to change order because the supply is too low, waste contractors, and other influences difference between the working hours of actual to complete the project with the working hours offer included approved within change order. Positive value Δ (delta) indicates that, there is a decline in productivity in the construction project, while negative value (delta) indicates that there is an increase in productivity of the construction projects. The Δ (delta) can be connected with a wrong estimated calculation of the contractor. Wastage contractor, or the impact of productivity-related factors of these factors include change orders, weather conditions, termination of employment, and repetitive work. Change order becomes the principal reason for the decline of efficiency and

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no factor calculation inaccuracies or weather factors. Thus, the Δ (delta) is expressed as a result of a change order on the project, [5].

MATERIALS AND METHODS

1. Understanding of change order

Change orders are defined as less additional work to adjust the volume of the field (revised schedule) without changing the clauses of the contract. Opinions are aligned that the change order is a formal document signed by both parties between the service users and service providers, due to job changes, job additions, delays activities without violating the terms of the contract documents, [6]. Another understanding of change order is an event due to the change / modification of a field, in fact, is a decision time and cost, of the continuity of a project, [3]. change order is a written consent to modify, alter, add to the scope of the project work as set out in the contract documents after deals, [7].

Change orders can hardly be avoided in a construction project, but as a result of the change order can cause harm, as is evident from the study, [2]. National Office report in 1998 in Taiwan, change orders resulting in delayed projects, waste, impact investment becomes not achieve the targets set. Technical analysis is conducted on three industrial projects built in 1989-1992, concluded that as a result of the change order is losing efficiency by 25% -50%, depending on the problems happened, [1] .

Problems that caused by change order are not only creates profit uncertainty of the contractors, but can make it difficult taking various parties thereby delaying agreement that causes dispute resolution and increased costs, [5]. Uncertainty of contractor profit and an increase in production costs can cause adverse effects, especially on the productivity of the construction project.

2. Productivity and Performance

Productivity is the ability to produce or to create something. In more detail productivity is the ratio between output and input or the ratio of the output of the total resources used. In a construction project ratio is the value measured in the process of construction that can not be separated into the costs of labor, materials, money, and methods and tools. Success or failure of a construction depends on the effectiveness of resource management. The production is a manifestation of the results of a planning and project location is always different from one another so that the need for tools used can not be determined. In a propulsion system that have function to run the organization. The decline in productivity, if not handled or anticipated well it may affect the performance of the project. Starting from several studies described above, the researchers want to develop a model to measure the impact of change orders to the performance of construction projects related to the lost productivity, [1].

Change order becomes the principal reason for the decline of efficiency and not about inaccuracy calculation or weather factors. Thus the delta is expressed as a result of change orders on the project. Delta can be calculated by this formula:

$$\Delta\% = \frac{working\ hours - (deals\ hours + change\ order\ hours)}{actual\ working\ hours} \times 100\%$$

From the above formula it can be said that the value of Δ (delta) is positive, there will be a decrease in productivity, on the contrary, the value of Δ (delta) is negative there will be an increase in productivity.

3. Variables, Dimension, and Indicators

Variable Change Order (CO) has the indicator as follows: (CO.1) Design review, (CO.2) Adding volume, (CO.3) Volume reduction, (CO.4) Additional work items, (CO.5) Reduction of work items, (CO.6) Execution time enhancement. Variable Loss of Productivity (LP), has the indicator as follows: (LP.1) Percentage change, (LP.2) Work productivity, (LP.3) Process time, (LP.4) Percentage of change order due to the use of the services, (LP.5) Time percentage of project manager in the field, (LP.6) Percentage of change order in terms of design errors. Variable Performance (P), has the following indicators: (P.1) Right Time, (P.2) Right quality, (P.3) Proper cost , (P.4) Proper function, (P.5) Service user satisfaction, (P.6) Satisfaction of building users. The relationship between the dependent variable with the independent variable is presented as in Figure 1 such as Relationships Change Order Impact on Lost Productivity and Performance and Table 1. Variable and Indicator, illustrated as follows, [8][9][10][11]:

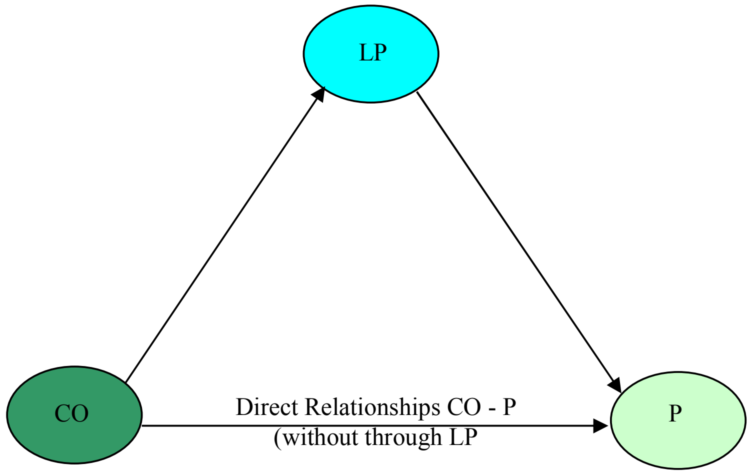

Figure 1. Relationships Change Order Impact on Lost Productivity and Performance

Table 1 Variable and Indicator

No	Variables	Indicators
1	CO. Change Order	CO.1. Design review
		CO.2. Adding volume
		CO.3. Volume reduction
		CO.4. Additional work items
		CO.5. Reduction of work items
		CO.6. Execution time enhancement
2	LP. Loss of Productivity	LP.1. Percentage change
		LP.2. Work productivity
		LP.3. Process time
		LP.4. Percentage of change order due to the use of the services
		LP.5. Time percentage of project manager in the field
		LP.6. Percentage of change order in terms of design errors
3	P. Performance	P.1. Right Time
		P.2. Right quality
		P.3. Proper cost
		P.4. Proper function
		P.5. Service user satisfaction
		P.6. Satisfaction of building users

Source: Result of Research

4. Formulation of the Problem and Goal of Research

Based on above problems, it is clear that a project implementation must be managed well, because it affects the performance of the project. One of the causes of the decline is caused by the project performance and loss of productivity. Loss of productivity can be caused by a change order, [12][13][14][5]. Therefore, the purpose of this research is to formulate the problem as follows: (1). To analyze the relationship of change order to the loss of productivity in construction projects, (2). Investigating the causes of the loss of productivity due to change orders at construction projects, (3). Elaborating on the change order and its impact on the quality of construction, the project cost, execution time, and user satisfaction on project services, (4). Modeling measuring the impact of change orders to loss of productivity and performance of the construction project. The hypothesis in this study is an influential factors to the performance of the construction project, [15][16].

5. Research design

The survey research was described as inferential study to determine the relationship between variables with a variable or variables with the indicator. To facilitate this research process, a design is required, [17][18]. From the study of literature, it can be set on each model which includes soft models and hard models. (1). Soft models include (a) Model phase 1 describing the variable, (b). Models faze 2 describing the variable, (c) models phase 3 describing the variable, (d). model phase 4 describing the phase 1, phase 2, phase 3, in detail. (2). Hard models includes (a). model phase 5 describing the variable (b). model phase 6 describing the variable and so on. From the description of the soft models and hard models, it can be determined the final model, then obtain validation / calibration and ultimately discussed simulation / application. Here is the flow of research as shown in Figure 2 Flow Chart of Study.

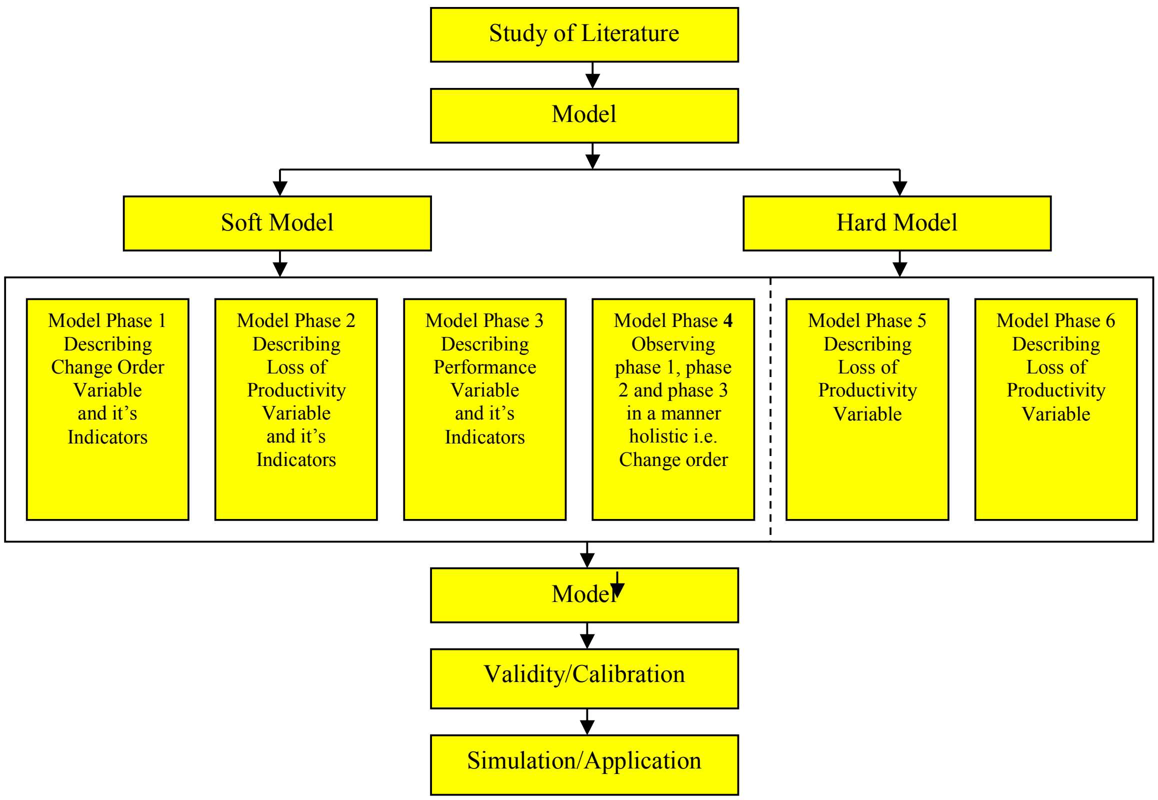

Figure 2 Flow Chart of Study1

6. Statistic analysis

The analysis tool uses Structural Equation Modelling (SEM) based on the variance with the Partial Least Square (PLS) program Smart PLS, [17][18]. Population and sample are the construction projects in East Kalimantan province, with a total sample of 110 packages of projects undertaken from 2002 - 2008. The primary data obtained by direct interviews with respondents consist of the consumers, the service provider for the road project. This study used the interview structure. The primary data collection is done by using *purposive sampling* with a list of factors to be considered as an indicator of the change order in the province. Purposive sampling is used in the study because of sampling techniques only for special purposes; making model change order on a road construction project, [19].

RESULTS AND DISCUSSION

1. Model Effect of Change Orders and Loss of Productivity to the Performance of the project

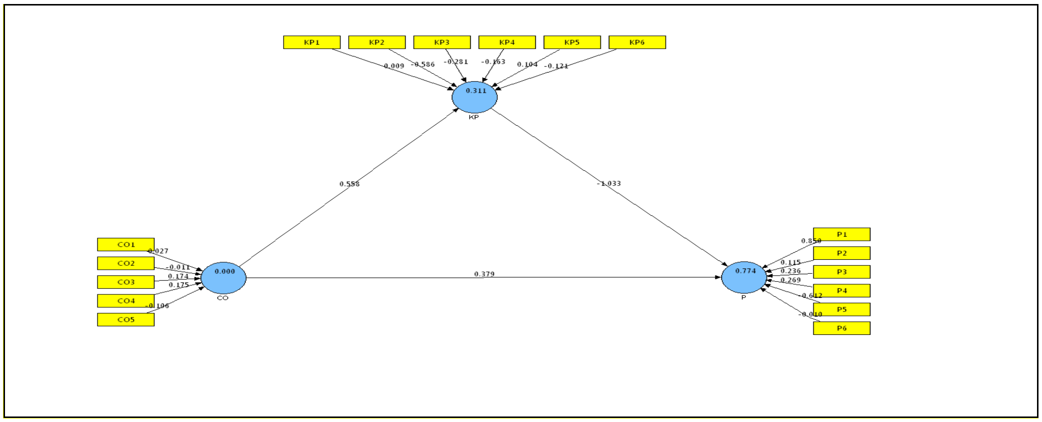

Figure 3. The result of the Effect of Model Change Order on Performance

The results of the model are in Figure 3. The result of the effect of model change order on performance, shows that: The impact of change orders has strong influence on Loss of Productivity = 0.558. Loss of Productivity strongly influence the performance of the value of path analysis = -1.033. The Change Orders effect is low on performance with a value of path analysis = +0.379. However, to see whether the model is actually significant or should the *t-test* is not done, thus in smart PLS is done with boos tapping.

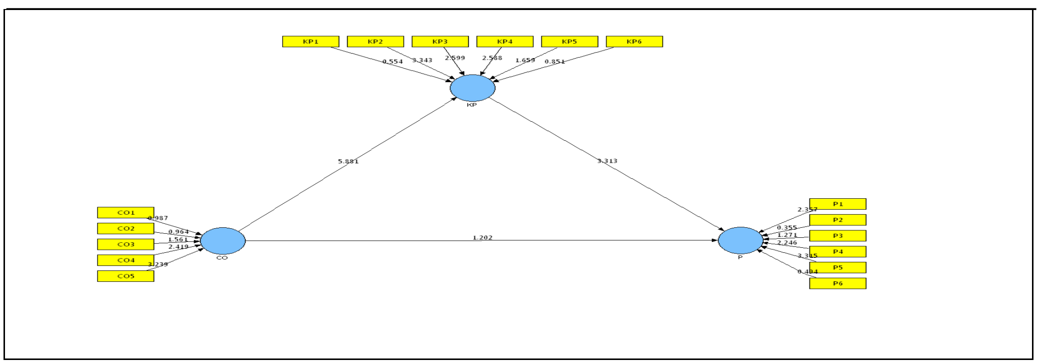

Figure 4. The Results Bootstrapping Model (t-test)

From the results of the t-tests is conducted by bootstrapping in Figure 4. The Results Bootstrapping Model (t-test), obtained by Change Order (CO) to affect *(influence)* Loss of Productivity (LP) significantly by 5.881 > 1.96 (CR-table). The relationship between the Loss of Productivity (LP) with the performance of 1.202 <1.96 means insignificant. This is conclusion mean Change Order (CO) indirectly affect *(influence)* Performance (P) that is better pass the Loss of Productivity (LP) first.

2. Outer model

The results of the analysis obtained outer equation models is the relationship between the indicator variable as follows:

Change Order (CO) = 0.027 CO1 – 0.011 CO2 + 0.174 CO3 + 0.175 CO4 – 0.106 C05 + δ

Loss of Productivity (LP) = 0.009 LP1 – 0.586 LP2 – 0.281 LP3 – 0.163 LP4 + 0.104 LP5 – 0.121 LP6 + δ

Performance (P) = 0.850 P1 + 0.115 P2 + 0.236 P3 + 0.269 P4 – 0.612 P5 – 0.010 P6 + δ

3. Inner model

The results of model output analysis in the relationship between variables with other variables is that CO relationship has relation with KP and P can be seen in Table 2 Path Coefficient below.

Tabel 2. *Path Coofficients*

	CO	LP	P
CO		0.558	0.379
LP			- 1.003
P			

Source: Result of Research

The results of the analysis obtained outer equation models is the relationship between the indicator and it's variable as follows:

LP= 0.558 CO + δ

P= -1.033 LP + 0.379 CO + δ

4. Hypothesis test

The results of the 5 hypotheses, each hypothesis can be explained in the description of Ho and Ha as follows

1. **Hypothesis 1**
   Ho = change order often occur at the beginning of the project
   Ha = change order often occur not at the beginning of the project
   The results of the above analysis known that Ho is accepted because 78.6% of respondents confirmed that change orders occurred at the stage of weighting = 0% - 25%. Means Ha = rejected.
2. **Hypothesis 2**
   Ho = there is no effect of change orders to lost productivity
   Ha = there is effect of change orders to lost productivity
   The results of path analysis modeling showed that Ho is rejected because change orders has strong influence on loss productivity, it is characterized by the value of the relationship path models : 0.558 and the t-test results obtained by 5.8881> 1.96 means that a significant change orders has strong influence on lost productivity, Means Ha is accepted.
3. **Hypothesis 3**
   Ho = the more the number of change orders, the not so greater the impact on lost productivity
   Ha = the more the number of change orders, the greater the impact on lost productivity
   The results of the modeling path analysis showed that Ho is rejected because based on the output of smart PLS path coefficient from CO to lost productivity is positive, , +0558 and t-test for 5881> 1.96 means significant, it can be said that the greater the CO, the greater the loss of productivity , Means Ha is accepted
4. **Hypothesis 4**
   Ho = there is no effect of lost productivity to the decline in the performance of the project
   Ha = there is effect of lost productivity to the decline in the performance of the project
   The results of the modeling path analysis showed that Ho is rejected because based on the output path pathway the coefficient value of lost productivity is = -1.033 and t-test results obtained amounted to 3.313> 1.96 means significant. So it can be said that the greater the loss of productivity caused declining performance
5. **Hypothesis 5**
   Ho = there is no effect of CO on the performance of the project
   Ha = there is effect of CO on the performance of the project
   the results of the analysis path modeling showed that Ho is rejected because there is influence of the change order to the performance, but it is not directly but passed the loss of productivity, it can be seen in the results of the analysis path models namely = change order relationships to the lost productivity = 0.558 and the t-test results obtained by 5.881> 1.96 means that there is a significant loss of productivity and also has relationship to performance = -1.033 and t-test obtained 3.313> 1.96 means significant. Ha is accepted.

1. Model Simulation

Simulation models are models that have been tested if the results of the model have the power to answer the actual phenomenon. In the validation process used by end models then simulated with the data obtained from the survey.

1. The results of the model on the iteration of the outer part of variable Loss of Productivity (LP) with 6 variables LP1 : % CO; LP2 : productivity; LP3 : process time; LP4 : % CO due to demand use of the service; LP5 : % time project managers in the field; LP6 : 5 CO design error; obtained equation LP = 0.027 LP1 – 0.201 LP3 + 0.005 LP4 – 0.059 LP5 – 0,063 LP6 + δ

2. The results of the model at the outer iteration variable CO with 5 variables CO1: volume expansion; CO2 : reduction of volume; CO3 : Extra work items; CO4 : lost work items; CO5 : Extra time on execution, then, the equation obtained CO = 0.004 CO1 + 0.010 CO2 – 0.242 CO3 + 0.157 CO4 – 0.028 CO5 + δ
3. The results of the model at the outer iteration variable performance with 6 variables, namely P1: timely; P2: precise quality; P3 : precise costs; P4 : proper function; P5 : service user satisfaction; P6 : building user satisfaction, equation obtained P = 0.416 P1 + 0.162 P2 + 0.421 P3 – 0.201 P4 – 0.110 P5 + 0.044 P6 + δ
4. To measure the effects of CO on the LP model must be analyzed holistically, namely CO - KP - P. iteration results obtained from the equation : LP = 0.805 CO + δ; P = - 0.626 LP + 0.249 CO + δ. The next calculation model the effects of CO on LP be shown in Table 3. Estimation of the impact of CO on LP and P
5. The impact between the CO to the LP of the formula: LP = 0.805 CO + δ then this indicates that the case of CO on the project, each 1% lead to LP's impact of the project amounted to 0.81%. In other words, the higher the presentation of CO on a project to bring, the greater impact of LP of the project with a ratio of CO: LP = 1: 0.81, as shown in Table 3. Estimation of the impact of CO on LP and P.
6. The impact between the CO to the LP of the formula: LP = 0.805 CO + δ then this indicates that the case of CO on the project, each 1% lead LP impact as much as 0.81%. In other words, the presentation of the CO on a project is higher and bring greater impact LP of the project with a ratio of CO: LP = 1: 0.81, as shown in Table 3. Estimate the impact of CO on LP and P.
7. Furthermore, LP impact on P can be shown in the formula: so P = - 0.626 LP + 0.249 CO + δ. This indicates that in case of lost productivity on the project, each 1% lead impact project performance decreased by 0.32%. In other words, the higher is the lost productivity on a project, it declines the impact of performance of the project by comparison LP : P = 1 : - 0,32.
8. While the relationship of the CO of formula P = - 0.626 LP + 0.249 CO + δ. It is noticeable that in the event of CO on every 1% lead impact on project performance that decreased by - 0.26%. In other words, the higher CO on a project, then the performance will go down in the ratio of CO : P = 1: - 0.26. Furthermore, the results of model analysis and comparison can be seen in Figure 5. Relationships CO Effect towards LP and P.

This study aims to analyze the relationship of CO towards LP, examines the factors causes the lost productivity due to change orders at construction projects, to elaborate on the change order and its impact on the quality of construction, the project cost, execution time, the satisfaction of service usage. The next model change impact measurement order against loss of productivity and performance of the construction project.

Based on a model built and the results of simulations show that there is a significant correlation between the change order to the loss of productivity in construction projects. The results of path coefficient analysis found that relationships change order to the loss of productivity amounted to 0.558 t-test with a result of 5.881 > 1.96 means that a significant relationship strong. This means that the greater the CO the greater the LP.

Some factors contributing to KP from the analysis of the model is the percent of CO, productivity after the CO, CO approval process time, percent CO because the owner's request, the percent time project manager in the field, and the percent of CO due to design errors. Indicator presentation of the presence of the project manager on construction projects with a value of 0.104 relationships. Based on the above, the presence indicators on project manager is the largest contributor to the influence of cause of lost productivity and is the second biggest contributor is the percent change order.

Furthermore, the relationship between Loss of Productivity with the Performance results of the Path analysis of - 1.033 with a t-test results amounted to 3.313 > 1.96 means significant. While the relationship between the CO to the Performance results of path analysis of + 0.379 with t-test results of 1.202 <1.96 means insignificant. The results of modeling states that CO indirectly affect Performance which should be through variable Loss of Productivity advance. This is the importance of the role of variable of Loss of Productivity, where the variable is the key variable.

Model measuring the impact of CO is: the impact of CO to LP = 1: 0.81. This means that every 1% CO causes LP 0.81%. The impact of lost productivity on performance = 1: -0.32. This means that every 1% LP cause a -0.32 % decline in the performance of the construction project. While the impact of CO on the performance of 1: 0,26. This means that every 1% CO causes - 0.26% in Performance.

Table 3. Estimation of the impact of CO on LP and P

No	CO	LP	P	δ
1	12.6	10.143	-3.212	0
2	16.65	13.403	-4.245	0
3	29.14	23.458	-7.429	0
4	26.41	21.260	-6.733	0
5	12.86	10.352	-3.278	0
6	42.7	34.374	-10.886	0
7	16.54	13.315	-4.217	0
8	29.39	23.659	-7.492	0
9	52.33	42.126	-13.340	0
10	79.24	63.788	-20.201	0
11	23.6	18.998	-6.016	0
12	15.72	12.655	-4.007	0
13	41.18	33.150	-10.498	0
14	99.61	80.186	-25.394	0
15	23.85	19.199	-6.080	0
16	101.54	81.740	-25.886	0
17	48.88	39.348	-12.461	0
18	12.9	10.385	-3.289	0
19	82.96	66.783	-21.149	0
20	27.78	22.363	-7.082	0
21	31.31	25.205	-7.982	0
22	41.6	33.488	-10.605	0
23	12.28	9.885	-3.131	0
24	40.88	32.908	-10.422	0
25	60.95	49.065	-15.538	0
26	106.87	86.030	-27.244	0
27	24.67	19.859	-6.289	0
28	16.68	13.427	-4.252	0
29	94.52	76.089	-24.096	0
30	31.94	25.712	-8.142	0
31	6.91	5.563	-1.762	0
32	15.08	12.139	-3.844	0
33	18.86	15.182	-4.808	0
34	13.4	10.787	-3.416	0
35	14.47	11.648	-3.689	0
36	15.21	12.244	-3.877	0
37	24.79	19.956	-6.320	0
38	76.85	61.864	-19.591	0
39	78.46	63.160	-20.002	0
40	22.25	17.911	-5.672	0

Source: Result of Research

2. Implications of the research results

Based on the model of one description of the effects of CO is as follows: every 1% CO causes lost productivity impacts of the project amounted to 0.81%. In other words, the higher the percentage of CO, the higher the impact of KP by comparison CO: LP = 1: 0.81

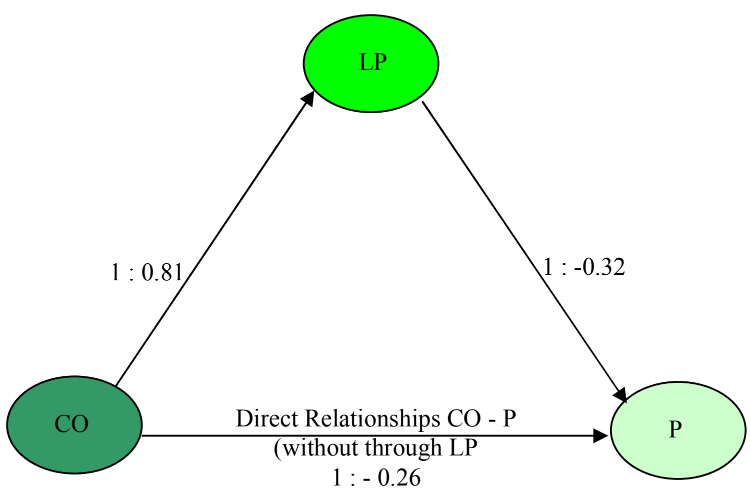

Figure 5. Relationships CO Effect towards LP and P

1. To provide a clearer picture of the following is an example of one of the following sample project package:
   The contract = Rp. 6,414,498,000
   Volume increases = Rp. 933,950,908.80 (14.56%)
   Volume decreases = Rp. 933,950,908.80 (14.56%)
   Contract CO = Rp. 933,950,908.80 + Rp. 933,950,908.80 = Rp. 1,868,543,267.40 (29.12%)
   Effect of CO to LP is approximately = 0.81 x Rp. 1,868,543,267.40 = Rp. 1,513,520,046 (23.59%)
   Furthermore, the impact of LP on P expressed by comparison LP: P = 1: - 0.32. This indicates that in case of loss of productivity on the project, each 1% lead impact on project performance decreased by -0.32%. In other words, the higher the loss of productivity, the lower the performance. The decline in performance can be experienced due to delay or special attention, so that there should be an additional labor, equipment (overtime) to improve performance.
2. To provide a clearer picture, the following example of one of the samples of other projects:
   Contract CO: Rp. 1,868,543.267 (29.12%)
   CO impact on lost productivity approximately 0.81 x Rp. 1,868,543,267 = Rp. 1,513,520,046 (23.59%)
   Impact LP to P = -0.32 x Rp. 1,513,520,046 = Rp. 484,326,415 (7.6%)
   The results of path coefficient analysis for a direct relationship between the variable CO to variable performance is not significantly by -0, 379 with the t-test 1.202 < 1.96 it indicates that CO does not directly affect performance, but must pass a key variable that is variable in lost productivity
   However, from the results of the analysis of the impact of CO to P obtained CO : P = 1 : - 0.26. This means that any occurrence of CO on every 1% lead impact of lower performance by approximately -0.26%. In other words, the higher CO on a project the lower the performance
3. To provide a clearer picture, the following is a sample package of other projects
   Contract CO = Rp. 1,868,543.267 (29.12%)
   CO impact on the performance of P approximately = - 0.26 x Rp. 1,868,543,267 = - Rp. 484,326,415 (7.6%)

CONCLUSION

From above, the result of field work may not reach the desired time and costs *(slow production),* and caused uncertainty, due to the waste of resources: material, labor, and equipment. As a result of the waiting time decision-making, job disassembly, changing material and equipment that are more relevant to the item being handled *(going Mobility and demobilization),* and ultimately going overtime for the progress that has been set.

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