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Success Factors for Lean Six Sigma Implementation and Time Cost Trade off in High Rise Office Buildings to Improve Cost and Time Performance

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Abstract

A high-rise office building is a physical form of construction work that is integrated with its seat, partly or completely located above and/or in the ground and/or that is sailed as a place for humans to carry out their activities. This research was carried out with the aim of determining Cost and Time Performance in high-rise office buildings with the Implementation of Lean Six Sigma and time cost trade off. In project execution, scheduling and good quality play an important role in the timeliness, cost, and quality of project completion. Project delays often occur in the process of implementing construction projects. The quality is not good because it does not match the technical specifications. In the end there is a loss on a project. The results of the analysis study used "Structural Equation Modeling" (SEM). In the High-Rise Building project, 10 influential indicators were obtained where the indicators were: Implementation, Design Improvements, Delay, Planning, Define, Analyze, Improvel, Measure, Tender Documents, Process.

Keywords
success factors; high rise office building; lean six sigma; time cost trade off

I. Introduction

Construction growth in the world with the most dominant construction development in 2020 to 2030 is China, India, the US, and Indonesia which account for 58.3% of global economic growth. China will account for 26.1% of the global constructive growth. India is expected to account for 14.1% and the US 11.1%, while Indonesia is expected to account for 7.0% almost the same as the combined growth of Australia, the UK, France and Canada, which are the next four countries. Development is a systematic and continuous effort made to realize something that is aspired. Development is a change towards improvement. Changes towards improvement require the mobilization of all human resources and reason to realize what is aspired. In addition, development is also very dependent on the availability of natural resource wealth. The availability of natural resources is one of the keys to economic growth in an area. (Shah, M. et al. 2020).

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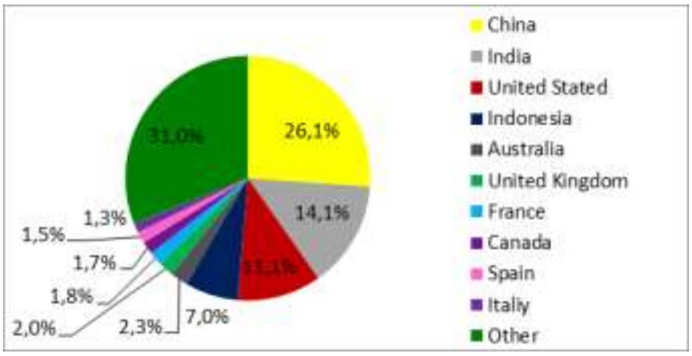

Figure 1. *World Construction Growth 2020 – 2030*

Oxford Economics/Haver Analytics, 2021 the construction market in 2020 to 2030 will reach 15.2 trillion USD which was originally only 4.5 trillion USD, and the classification trend of art construction growth is dominated by the construction of Multi-Storey Buildings which develop by 3.6%, Houses 3.5%, Non-Houses 3.2% and Infrastructure 4%.

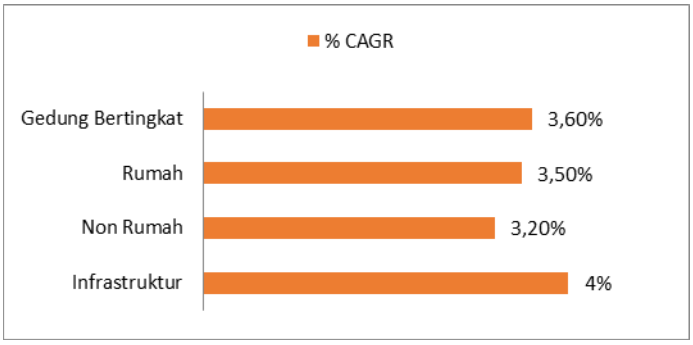

Figure 2. *Classification of Construction Growth 2020-2030*

Referring to these developments, the construction of high-rise buildings will continue to be held and the use of high-rise buildings itself is mostly used for Office 38%, Residential 27%, Hotel / Office 20%, Hotel 6%, Office retail 2%, and other utilization 17%.

Figure 1. *Utilization of High-Rise Buildings*

II. Review of Literature

2.1 Lean Six Sigma

Lean six sigma is a systemic approach to identifying and eliminating waste or things that have no worth added by using radical continuous improvement to achieve six sigma performance levels. Combining lean with six sigma, lean six sigma is a method for business that identifies and eliminates waste or non-value-added operations through radical continuous improvement to reach six sigma levels by distributing products and information using systems pull from pursuing excellence and perfection in the form of producing for both internal and external clients only 3.4 defective products with relation to a million opportunities or production.

There are 0.002 defects per million or 2 defects per billion when using six sigma. Motorola's idea of 6 sigma, on the other hand, "allows for an average shift of 1.5 sigma." Motorola's six sigma number, which likewise reflects a breakdown rate not exceeding 3.4 per million, therefore, assumes an acceptable shift of 1.5 sigma. A process quality level between 4 and 5 sigma is implied by a value of 3.4 faults per million in a centralized process. This is the idea that Motorola introduced and made popular, subsequently becoming known as Six Sigma.

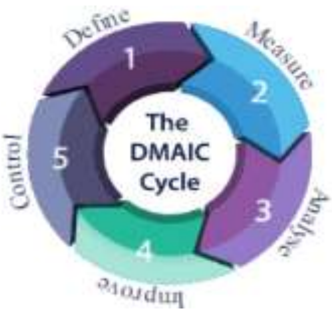

***Figure 4**. Cycle of Lean Six Sigma.*

In Figure 2, the Lean Six Sigma cycle uses statistical tools to identify several vital factors. The basic principles of Lean Six Sigma are as follows:

- Identify product value (goods and/or services) based on customer perspective, where customers want superior quality products (goods and/or services) at competitive prices and on schedule.
- Identification of for each product (goods and/or services), value flow process mapping (mapping processes on value flow) should be done.
- Remove non-value-added waste from every step of the process value chain.
- Organizing so that information Utilizing the Pull system, materials and products move through the value flow process easily and effectively.
- Constantly looking for improved instruments and methods for achieving excellence and ongoing development. The most factor responsible for improving process quality and generating profits consists of five stages known as DMAIC (defining, measuring, analyzing, improving, controlling).

2.2 Time Cost Trade off

Time cost trade off (TCTO) or the exchange of time and cost is a method used to speed up the implementation time on a project by testing all activities in a project which is centered on activities that are on a deliberate and systematic critical path.

The definition of time cost trade off analysis is an intentional, systematic, and analytical process by testing all activities in a project that are centered on activities that are in the critical path. Furthermore, the compression starts from the critical trajectory which has the lowest cost slope value.

The process of finding the best solution to a given problem from countless solutions is called optimization. Trying to calculate the best solution of all feasible solutions in a given project is impractical because the total number is an almost exponential function of the type resources which are available for the project. In real life, a project may contain thousands of activities with the utilization of different resources. It is very difficult to find the best TCT solution among possible solutions and it is very time consuming to evaluate each alternative. After trying to find the optimal solution The second step is to schedule the project and calculate its cost. Evens there are optimization models that may be able to produce an almost optimal exchange between the cost and time of the project, they have their drawbacks due to the time requirements that impractical to compose in large-scale projects

Techniques for Solving TCTO Problems divides the problems of Techniques for Solving TCTO as follows;

b. Mathematical methods
- Linear programing methods
- Non-linear programing methods for time-cost optimization
- Dynamic Programming Models

c. Genetic Algorithms
- Genetic Algorithm for cost
- Genetic algorithm for time
- Genetic Algorithms of time- cost trade-off
- Genetic Algorithm for resource allocation and leveling
- Genetic algorithm for time- cost- quality trade-offs

2.3 Key Success Factors

Consider the Oxford Didictionaryaries definition of success: Success is defined as the achievement of a goal or objective; success is defined as the completion of a goal or objective. Tuman (1986) defines "project success" as "having everything turn out to be as expected: anticipating all project requirements and having enough resources soon," defining "project success" as "getting everything as expected, meeting all project requirements, and having enough resources to meet the requirements after a specified time" in a hearing at the Project Management I seminar nstitute in Montreal, Canada.

While D. Ronald Daniel of McKinsey &Company originally produced or released a definition of the characteristics of success in 1961. A management term that describes the components necessary for an organization or project to meet its goals is a critical success factor (CSF). Key Success Factors (KSF) and Key Result Areas (KRA) are alternative terms (KSF) [9]. It was later further developed into a definition of Critical Success Factors by John F. Rockart between 1979 and 1981 and published in the Harvard Business Review. Rockart states that defining some of the results of profitable activities it is necessary for a particular manager to achieve his goals, and defining some activities or activities that can give the desired result, of course, requires special management to achieve the desired goals. where James A. Johnson and Michael Friesen used it in 1995 in various industries, including the health sector.

In this case, the researcher used program-assisted data analysis with Structural Equation Modeling (SEM) This technique was used to measure how close all independent variables and related characteristics of X (independent) were. from Lean Six Sigma (X2) and Time Cost Trade off (X3) on a High-rise Office Building Project (X1) with dependent variables/increased cost performance (Y1) and Time (Y2) (dependent). Measurements are said to be reliable or consistent if the results of these measurements can produce similar results if used again under the same circumstances.

III. Research Method

The research method is the basis of the scientific method to obtain the correct data with the aim of becoming a discovery so that the results can be used to understand, solve and solve problems. This study used descriptive quantitative method. The method of descriptive analysis describes the data as it has been collected without trying to draw generalizations or conclusions that apply to the entire population. While utilizing research equipment for data collection and processing of quantitative or statistical data with the aim of testing the prepared hypothesis, quantitative research is a research approach based on positivist ideology used to analyze population or certain groups. In carrying out this research, researchers follow the rules made in the form of a research flow, so that there are no deviations in the research process. The research will be processed and analyzed using "Structural Equation Modeling" (SEM) as can be seen in Figure 5. This method seems to be able to dominate the use of path analysis that has been used frequently so far. This is because this analysis is more comprehensive. The analysis of this method is more comprehensive because each value in each question of each latent variable or factor or in this method referred to as an observed variable or sub-factor of a latent variable can be analyzed comprehensively. Researchers will also use SEM SMART-PLS 3.0 software as areference for the process of this analysis method.

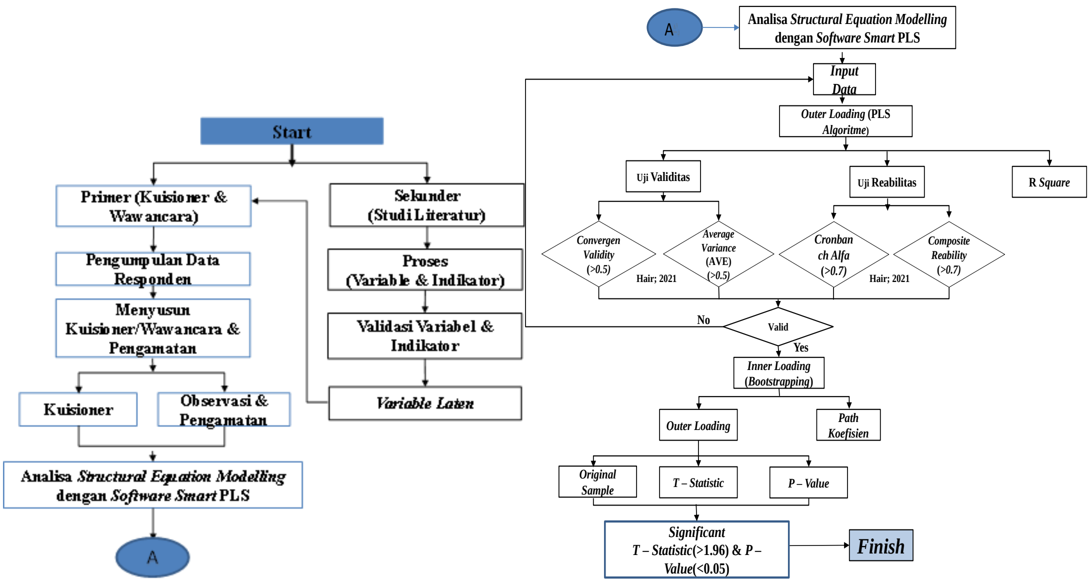

Figure 5. *SEM flowchart*

Figure 5 shows the stages and results of average statistical analysis in this study. The data that must be inputted are data generated from the preparation of questionnaires obtained from literature studies (international journals, e-books, national journals and related books) to obtain key success factors or important points of discussion material used as components such as questionnaire variables surveying main factors and sub factors. Next, they are collected in the form of a list of questions to ask respondents who have been calculated using the Slovin method. There were five variables and fourteen main factors in the study: variables, main factors, and sub factors.

IV. Result and Discussion

Table 1 shows a list of key success factors obtained from literature studies and expert validation. The minimum number of respondents answering the required questionnaire is a limitation in collecting the required results**.** According to the minimum sample size taken is based on the difference in levels at path coefficients (p Min) and statistical strength tests of 80%. (Hair et al,2021) So that it can determine the minimum sample size can be determined in table 2.2. Each variable will be tested using an SEM **tool**, namely Smart PLS, namely by testing validity and reliability, where **the** validation convergent validity test is more than 0.5, Avenger valiance (AVE) is more than 0.5, Reliability Test i.e., Cronbach Alfa is greater than 0.7, Composite Reliability is greater than 0.7 then it can be declared valid.

Table 1. Key success factor

Variable	Main Factor	No	Sub Factor	Reference
High-Level Office Building	Tender Document	X1.01	Technical specifications	[14]
		X1.02	Bill Of Quatity	[14]
		X1.03	Design	[15]
		X1.04	Schedule	[15]
		X1.05	RKS	[16]
		X1.06	*Out Line Spek*	[17]
	Planning	X1.07	Kelayakan Studies	[18]
		X1.08	Conceptual Design	[18]
		X1.09	Physical environment	[19]
		X1. 10	Implementation of design and planning	[20]
		X1. 11	Drawings	[21]
	Implementation	X1. 12	Organization	[22]
		X1. 13	Technology	[22]
		X1. 14	Productivity	[23]
		X1. 15	Project Risk	[23]
		X1. 16	Material	[24]
		X1. 17	Site Conditions	[24]
		X1. 18	Weather Conditions	[25]
		X1. 19	Working Tools	[25]
		X1. 20	Safety	[26]
		X1. 21	Job Control	[26]
		X1. 22	PM Performance	[27]
		X1. 23	Project Planner and Review	[27]
		X1. 24	Coordination	[28]
		X1. 25	Team Competence	[29]
		X1. 26	Working Methods	[30]

	Office Functio	X1. 27	Operations and activities of the enterprise	[31]
		X1. 28	Office Building Classification	[31]
		X1. 29	Office building needs	[32]
		X1. 30	Commercial Capabilities of Office Buildings	[33]
	Office Space Pruductiviti	X1. 31	Architect Analysis and Planning	[34]
		X1. 32	Office Building Innovation	[35]
		X1. 33	Estimated Cost of Finising	[36]
	Office Building Developmen	X1. 34	Needs Evaluation	[37]
		X1. 35	Cost and Term	[37]
		X1. 36	Project Location	[38]
		X1. 37	Inappropriate material	[39]
Lean Six Sigma	Define	X2.01	Cost reduction	[40]
		X2.02	Waste reduction	[40]
		X2.03	Product quality	[41]
		X2.04	Productivity	[41]
		X2.05	Flexibility	[42]
	Measure	X2.06	Material use and storage	[42]
		X2.07	Design changes	[43]
		X2.08	Communication	[43]
		X2.09	Waste management	[44]
	Analyze	X2.10	Knowledge of the project	[44]
		X2.11	Aligning the agendas involved	[45]
		X2.12	Lack of leadership understanding of the project	[46]
		X2.13	Availability of experts	[47]
	Process	X2.14	Supported operating system	[48]
		X2.15	App update	[48]
		X2.16	Supported PC devices	[48]
	Improve	X2.17	Defect rate in work process	[49]
		X2.18	Evaluating quality	[49]
		X2.19	Variability reduction	[49]
Time Cost Trade Off	Delay	X3.1	Characteristics of the Premises	[50]
		X3. 2	Inspection, Control System	[51]
		X3. 3	Job Evaluation	[51]
		X3. 4	Contract	[51]
	Design Improvements	X3. 5	Communication Consultant Kuran	[52]
		X3. 6	Design Knowledge	[52]
		X3. 7	Less Labor	[53]
		X3. 8	Inefficient Use of Technology	[53]
		X3. 9	Poor Management	[53]
Cost	Cost	AND 1.01	Poor design and delay in desian	[54]

		AND 1.02	The duration of the non-relaistic contract and the conditions provided	[54]
		AND 1.03	Lack of experience	[55]
		AND 1.04	Late delivery of materials and tools	[56]
		AND 1.05	The relationship between management and personnel	[56]
		AND 1.06	Delayed Preparation and approval of drawings	[57]
		AND 1.07	Inadequate planning and scheduled	[58]
		AND 1.08	Poor management and supervision	[58]
		AND 1.09	Errors during construction	[59]
		AND1. 10	Changes in specifications and material types	[59]
Time	Time	AND2.01	Unexpected weather	[60]
		AND2.02	Inaccurate prediction of production rates	[60]
		AND2.03	Material shortages	[61]
		AND2.04	Disadvantages of the tool	[62]
		AND2.05	Shortage of skilled manpower	[62]
		AND2.06	Project location restrictions	[63]

The preparation of instruments in this study was obtained from the identification of sub-factors as in the table above, then the sub-factors are compiled into the subject of the study the instrument is a questionnaire in the form of question items, respondents will answer by choosing the answers that have been given on a scale of 1-6, from various answer criteria. The scale is designed in such a way that scale 1 is the least expected answer choice (unexpected answer) and scale 6 is the most expected answer choice (expected answer). The Minimum Specified is the number of respondents based on table 2. 2 following.

Table 2. Minimum sample size table for level difference with mimimum path coefficient and 80% strength test

P Min	Significance Level		
	1%	5%	10%
0,05-0,1	1004	619	451
0,11-0,2	251	155	113
0,21-0,3	112	69	51
0,31-0,4	63	39	29
0,41-0,5	41	25	19

In this study model, the determination of the minimum sample size taken was based on the path coefficient value of 0.25 and the statistical strength test of 80% at a significant level of 5% so that a minimum sample of 69 was obtained.

Then a minimum number of respondents were obtained as many as 69 people. With a total of 100 questionnaires distributed, there were 20 questionnaires that were not accepted back, while 80 questionnaires were received again. The following is a diagram of the distribution of response data from this study questionnaire.

Figure 6. *Questionnaire questionnaire delivered*

Of the total 80 respondents in this study, among others came from various professional backgrounds, namely; Directors of 3 people, Project Manager 10 people, Site Engineer or Field Executor as many as 15 people. Engineering 32 people, Quantity Surveyor 12 people, supervisory consultant 8 people. The following is a diagram of the professional data distribution of respondents.

Figure 7. *Respondent's profession*

4.1 PLS Algorithm

a. Reliability Test

The extent to which test results are considered reliable, a study is trustworthy, and a data reliability test is an instrument used to assess the actual level of accuracy indicated by a data collection tool, accuracy, or stability. Instruments that have good are those that, when used repeatedly, will produce the same data. A good instrument will not tend to lead the respondent to choose a particular answer. The result of the variable reliability test is that if it is said to be reliable, it gives the Cronbach Alfa greater than 0.7, the Composite Reliability is greater than 0.7 (as the standard value for the reliability of generally accepted research instruments). The results of the complete reliability test are presented in table 2 below:

Table 3. Result of reliability.

Variable	Cronbach's Alpha	Composite Reliability	Description
Building High-rise office building (X1)	0. 968	0,970	Reliable
Lean Six Siqma (X2)	0,958	0. 962	Reliable
Time Cost Trade Off (X3)	0. 917	0,932	Reliable
Cost (Y1)	0,928	0,939	Reliable
Time (Y2)	0,904	0,926	Reliable

It can be seen that the factors X1, X2, X3, Y1 and Y2 included in SEM all have Cronbach Alpha values > of the minimum requirement of 0.7 so that above them are reliable.

b. Validity Test

A validity test is a test that determines how reliable or valid a measurement tool is. Validity tests are used to measure how valid an instrument can provide information from properly investigated variables. The validity test is carried out by inputting each of the existing data according to the variable factor into the SEM PLS **worksheet**. Based on the table of values by testing validity and reability, where the validation convergence walidity test is more than 0.5, the Avenger valiance (AVE) is more than 0.5) > of the minimum requirement of 0.5 so that above it is reliable. so that the data is declared valid. The table below shows the test results of factor data X1, X2, X3, Y1 and Y2 which are valid data.

Table 4. Result of validity.

Variable	Avenger valiance (AVE)	Description
Building High-rise office building (X1)	0,554	Valid
Lean Six Siqma (X2)	0. 570	Valid
Time Cost Trade Off (X3)	0. 606	Valid
Cost (Y1)	0,607	Valid
Time (Y2)	0,678	Valid

4.2 Bootstrapping

After the Reliability Test and validity test are declared Valid, the process is Bootstrapping including;

a. Outer Loading

Table 5. Mean and ranking.

Rank	T. Statistic	Mean	Main Factor
1	127,792	0,949	Implementation (A3)
2	71,240	0.909	Design Improvements (C2)
3	47,825	0,886	Delay (C1)
4	39,124	0,881	Planning (A2)

5	37,649	0,878	Define (B1)
6	35,162	0,866	Analyze (B3)
7	30,673	0,848	Improve (B5)
8	27,156	0,84	Measure (B2)
9	26,669	0,774	Tender Documents (A1)
10	26,772	0,769	Process (B4)

V. Conclusion

In the implementation of the project High-rise office buildings, both the timeliness, cost, and quality of completion of the entire project are all affected by scheduling and quality control. Project delays often occur in the process of implementing construction projects. Thisis a result, it is of low quality and does not meet the technical criteria. Eventually, it led to the failure of the project. This study will analyze the key success factors for the implementation of lean six sigma and time cost trade off in high-rise office building projects

The conclusion of this study is that there are significant key success factors for the implementation of lean six sigma and time cost trade offs in high-rise office building projects. Based on the results of the study, there are ten (10) that affect cost and time performance in High-Rise Office Building projects" namely: Implementation, Design Improvements, Delay, Planning, Define, Analyze, Improvel, Measure, Tender Documents, Processes".

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