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Cost Efficiency During Construction

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This study aims to provide advice for project management in improving cost performance. This study adopts value engineering methods and lean construction in the case study of high-rise buildings at the time of construction. Trigunarsyah (2004) identified that only 30% of the projects studied completed their work within budget, 34% completed less than the budget, and 36% completed projects outside the stipulated budget, so that there is an effort to help reduce project cost overruns due to various factors, such as many design changes, poor project management, natural and environmental factors, estimation error factors, labor factors and other factors. Then it was found that 5 main factors helped these problems, namely: (1) Selection of appropriate work methods (2) Increased productivity of workers (3) Alternative Material (4) Reduction / suppression of material waste (5) Use of BIM technology and application of value engineering concepts through fast diagrams and lean construction through the utilisation of construction waste.

Key words: *Value Engineering, Lean Construction, Waste, Cost Efficiency, Cost Overrun, Project management.*

1. Introduction

The construction project is an activity that is unique and temporary in nature which is required to succeed in the cost of quality and safety. Does the building, bridge or other construction project require supervision and control in both the planning and construction period? During the construction period, all of these projects were bound to create waste. Therefore, it is necessary to do cost efficiency through all aspects. Value Engineering is a technique in management that takes a systematic approach to find the best functional balance between project cost, reliability and performance while Lean Construction is a management philosophy which focuses on identifying waste,and utilising tools and principles to minimise or eliminate waste. So that it can be concluded that the two methods are appropriate in terms of cost efficiency plus other supporting factors from the journal literature.

2. Literature review

2.1. Cost Aspect Project Success

One of the project's successes was the realisation of construction work according to the set budget. Kaming, et.al (1997) have identified that 54.5% of project managers complete 90% of project completion according to budget, 15.2% of project managers complete 70 - 90% of project completion according to budget and 30.3% of project managers complete less than 70% completion of the project according to the budget. Trigunarsyah (2004) identified that only 30% of the projects studied completed their work in accordance with the budget, 34% completed less than the budget, and 36% completed projects more than the set budget. The cost efficiency aspect is one aspect of project success that is very important for company stakeholders to pay attention to. After conducting a research gap sourced from 40 international journals, several main clusters of cost efficiency indicators were found:

1. Shahhosseini et al. (2018) stated that choosing an alternative could lead to efficiency of up to 41% in construction costs. Lee (2018) stated that the selection of alternative facade finishing materials can result in reduced life cycle costs and defects for the facade building.
2. Suranata et al. (2019) stated that reducing the use of materials such as wood such as conventional formwork and solid wood is often able to provide solid savings of at least 11.50% and also reduce construction waste . According to Mandujano et al. (2017), Lean is a management philosophy, which focuses on identifying waste and utilising its tools and principles to minimise or eliminate waste. The green building council of Indonesia Buildings consume 39% of the world's energy & 12% of the world's water and then produce 25% of waste and 35% of greenhouse emissions So that in building environment management states in the 5Rs, namely Re Use waste material.
3. Ma et al. (2018) stated that the BIM-based IDM framework in the context of the project for lean construction through a case can produce value efficiency. According to Azhar, (2011) also the use of BIM can accelerate, and collaboration within the project team should increase, which will lead to increased profitability, reduced costs, better time management, and improved customer-client relationships.
4. Li et al. (2011) stated that choosing an alternative work method could lead to cost efficiency.
5. Tanko et al. (2018) stated that the application of value engineering with the VM method creates innovative and systematic ideas, reduces unnecessary costs, optimises quality, and develops teamwork as a means of increasing productivity.

2.2. Value Engineering

VE was born in the United States (USA) in World War II. So that it is not a new concept; this method has long been developed and applied to advanced industries and projects in the world. So that the results of the achievement from its application cannot be doubted. Value Engineering is defined as "a systematic process used by multidisciplinary teams to increase project value through an analysis of its functions" (Save International, 2007). Al-Yousefi (2007) notes that Value Engineering is a team effort that aims to analyse the function and quality of a project to produce practical cost-effective alternatives that meet end-user requirements. The concept that is often used in value engineering is Fast Diagram.

2.3. Lean Construction

The main focus of the Lean concept is cut waste value-add in. Increasing globalisation and urbanisation have led to an increase in the need for space and the public order of society. The solution to these needs is a high-rise building. However, this increase has caused a number of problems: waste generated during construction, damage to the environment due to the use of natural materials and over-budgeting. The waste generated in construction projects as a result of the use of materials brought to the site ranges from 10% - 20% (Formoso, et al 2002). Lean is a management philosophy, which focuses on identifying waste and utilising its tools and principles to minimise or eliminate waste.

3. Research methodology

3.1. Research Type

This study took a population of contractors as the executor of construction projects which focused on provinces with the highest number of contractors, namely the Jabotabek area in Indonesia. The population is based on the amount of BPS data in the Jabotabek area and the minimum requirements for using the SEM-PLS application. This research was conducted by delivering a questionnaire to the respondents.

3.2. Variables

The variables in this study are indicators of cost efficiency, value engineering and lean construction on project success, hereinafter referred to as the independent variable (X) a follow:

1. Indicators of cost efficiency (X1/EB)
2. Value Engineering (X2/VE)
3. Lean Construction (X3/LEAN)

The dependent variable is the success of the project in the cost aspect (Y/KP), which consists of the following parameters:

1. In selecting alternative materials without changing the value and function can lead to cost efficiency (Y1)
2. Reduction / suppression of material waste can lead to cost efficiency (Y2).

3.3. Hypothesis

The predictive model in this study is as follows:

1. p-value ≥ 0.05, then Ho is accepted
(H0: There is No Effect on Cost Performance Based on VE & Lean Construction)

2. p-value <0.05, then Ho is rejected and H1 is accepted
(H1: There is an Effect on Cost Performance Based on VE & Lean Construction)

3.4. Research Gap Literature

The process of research gap literature sourced from 40 international journals that focused on cost efficiency and subsequently found several main clusters of cost efficiency indicators.

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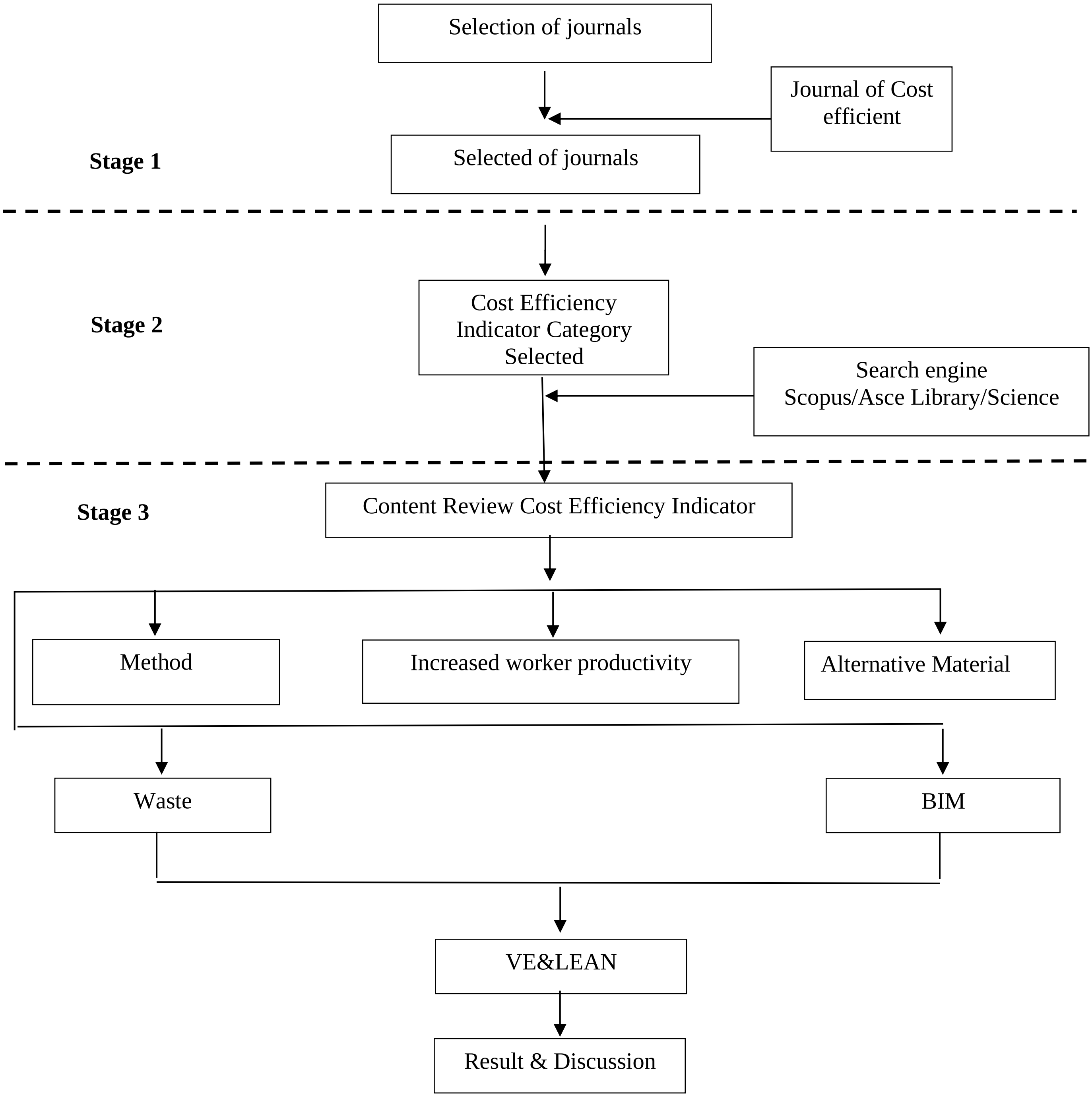

Figure 1. Study Framework

3.5. Model Data Analysis

This study uses the Partial Least Square (PLS) analysis technique with the SmartPLS program. The following is a schematic of the PLS program model being tested.

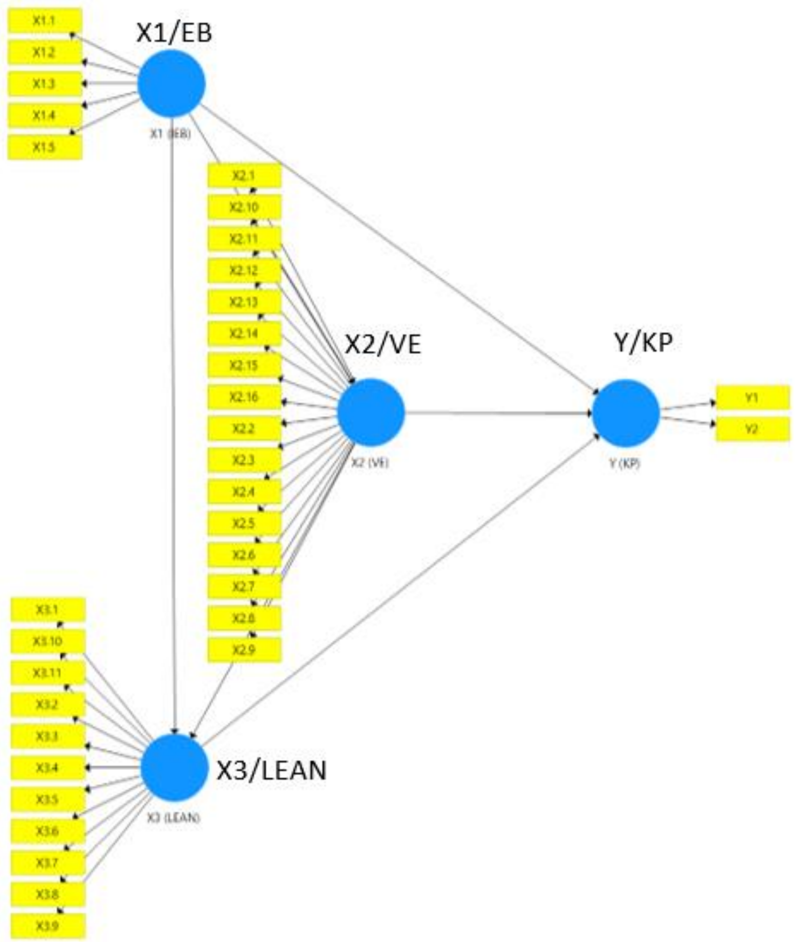

Figure 2. Interaction Model X1, X2 and X3 against Y KP (Y)

4. Results & Discussion

4.1. Evaluate The Outer Model

The loading factor is used to see how much the indicator contributes in explaining the construct variables. From this mode estimation, there are indicators that have a loading factor value of less than 0.7, so based on the minimum requirements, it must be removed from the test model and then re-estimate the model.

Table 1. Loading Factor

Indicator	X1	X2	X3	Y
X1.1	0.791			
X1.2	0.771			
X1.3	0.757			
X1.4	0.865			
X1.5	0.836			
X2.1		0.882		
X2.2		0.885		
X2.3		0.868		
X2.4		0.815		
X2.5		0.799		
X2.6		0.753		
X2.7		0.807		
X2.8		0.827		
X2.9		0.877		
X2.10		0.709		
X2.11		0.779		
X2.12		0.888		
X2.13		0.837		
X2.14		0.727		
X2.16		0.748		
X3.1			0.762	
X3.2			0.797	
X3.3			0.81	
X3.4			0.78	
X3.5			0.777	
X3.7			0.781	
X3.8			0.789	
X3.9			0.805	
X3.10			0.74	
X3.11			0.81	
Y1				0.913
Y2				0.895

From the result of the outer loading factor, the indicators that have a loading factor value of less than 0.7 are X2.15 & X.3.6. This indicator does not contribute in explaining the measurement construct variable, so it must be removed first and then re-estimated until it gets a loading factor value greater than 0.7.

4.1.1 Evaluate The Outer Model AVE

In addition to using the loading factor criteria, testing the validity of the model also sees the results of the convergent validity value using the AVE value obtained from the SmartPls output as in table 4.5 below.

Table 2. Average Variance Extracted (AVE) Value

	AVE
X1	0.648
X2	0. 664
X3	0.621
Y	0.818

The results above show that all the research variables in the sample are above 0.5; it can be concluded that the convergent validity of all the variables is good, that is, one latent variable is able to explain more than half the variance of the indicators in the average.

4.1.2 Composite Reliability And Cronbach's Alpha

Testing construct reliability on the model is carried out using measuring instruments composite reliability and Cronbach's alpha. From the estimation results of the model, it is obtained that the composite reliability value is above 0.7 and Cronbach's alpha is above 0.7, so that all constructs have good reliability.

Table 3. Value of Reliability Test Results and Cronbach's Alpha

	Composite Reliability	**Cronbach's Alpha**
X1	0.902	0.863
X2	0.967	0.963
X3	0.942	0.932
Y	0.900	0.778

4.1.3 Size of Influence f2

The values (f2) are equal to 0.02, 0.15 and 0.35. It can be interpreted that the latent predictor variables have small, medium and large effects at the structural level; here are the results:

Table 4. Magnitude of Influence f2

Relationship	ALL SAMPLES	
	f sq.	Conclusion
X1→ X2	2.849	large
X1→ X3	0.243	large
X1 → KP	0.364	large
X2→ X3	0.634	large
X2→ KP	0.123	large
X3 → KP	0.369	large

4.1.4 Size of Influence f2

The following table shows the results of the Q-square calculation for the test area model

Table 5. R^2 dan Q^2 predictive relevance

Variable	R Square	1-R Square	Q^2
X2	0.74	0.26	**0.594**
X3	0.857	0.143	
Y	0.809	0.191	

According to the model estimation results, as shown in the table above, the Q2 (Q-square predictive relevance) value obtained in the test sample area is 0.594 which means that the value is greater than 0 (zero), so that this measurement model is concluded to have a predictive relevance value.

4.2. Evaluate The Outer Model

The results of the analysis of this measurement model with PLS are shown in the figure below, which can explain the results of the R square and t-statistic values.

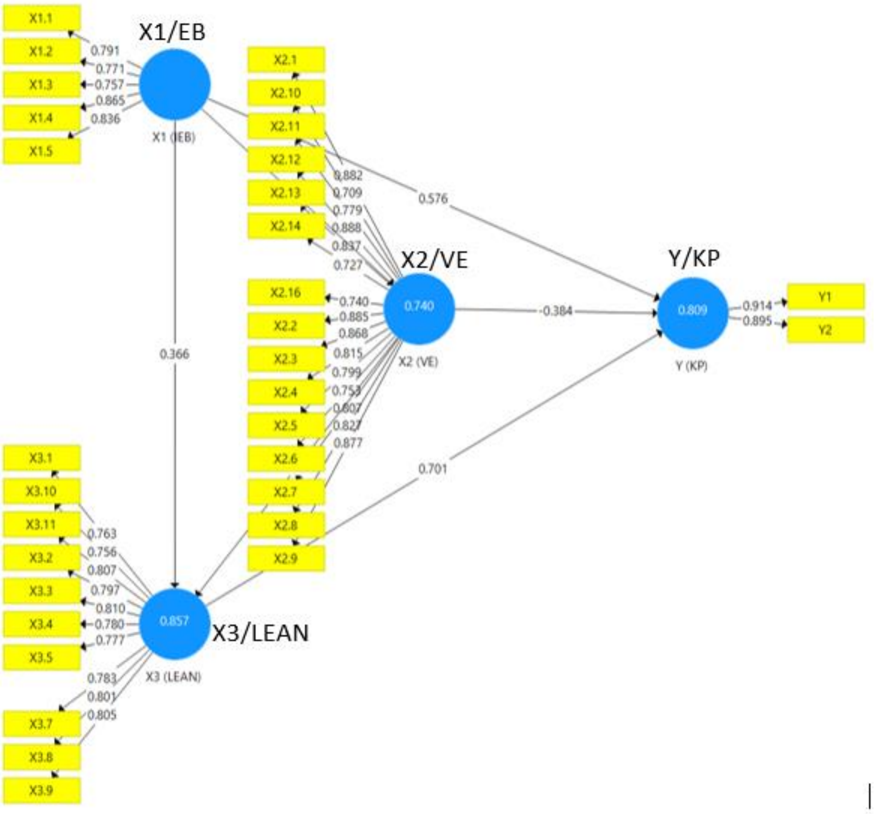

Figure 3. Standardised R-Square Measurement Model for the test sample

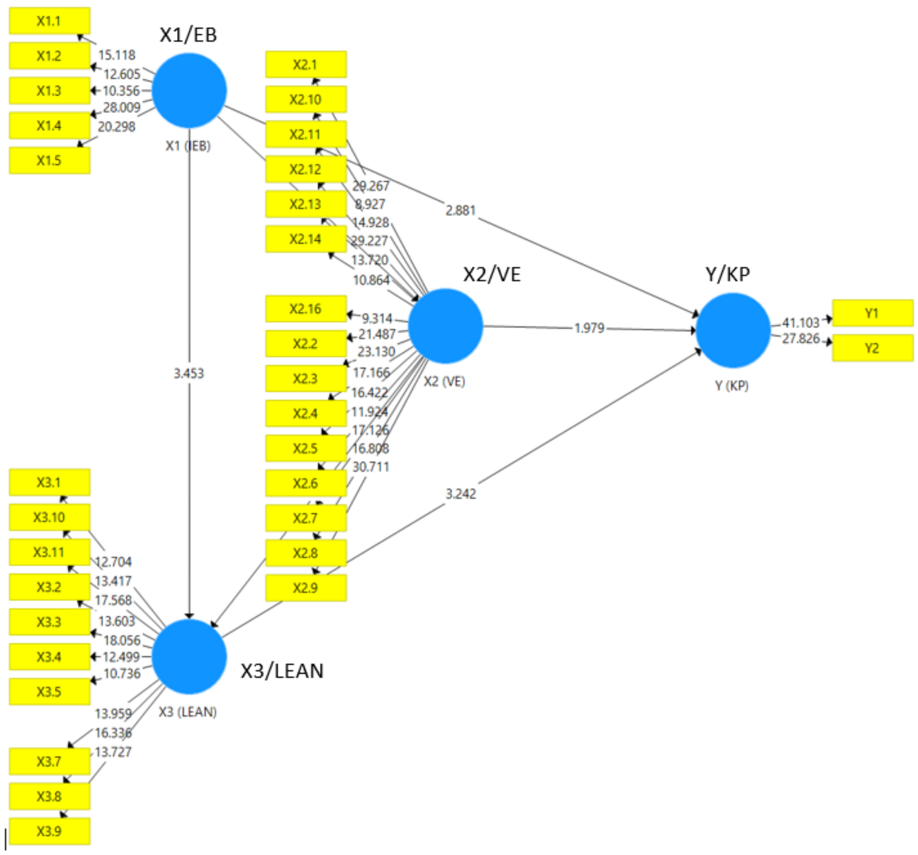

Figure 4. Measurement t-value model for the test sample

From the image of the measurement model above, the equation obtained from this measurement model is as follows:

KP = 0.86 EB + 0.591 VE + 0701 LEAN, R2 = 0.809
KP = 0.86 EB + 0.384 VE, R2 = 0.809
KP = 0.366 EB + 0.701 LEAN, R2 = 0.809
KP = 0.576 EB R2 = 0.809

Based on this equation, it can be concluded that the Cost Efficiency Variables, Value Engineering and Lean Construction have an effect of 82.2% on Cost Performance. While the remaining 17.8% is influenced by other factors not included in this study. The value of the contribution path is as follows:

- The variable cost efficiency through VE & Lean Construction has the greatest influence according to this equation with a contribution coefficient of 0.809 in a positive and unidirectional direction,
- VE has a positive contribution of 0.74,
- Lean contributed 0.857 and
- The cost efficiency indicator contributed 0.576

4.3. Hypothesis Testing

4.3.1 Partial Hypothesis Test

Testing the significance relationship partially or individually from each predictor variable to its criterion variable. This hypothesis testing uses a comparison between the t-value and the t-table and its significance value.

Table 6. Coefficient Path, t-count and Partial Hypothesis

Relationship	**Coefficient**	**t-value**	Significance	**Conclusion**
EB → VE	3.175	18.537	0.000	**H1**
EB → LEAN	3.894	3.545	0.001	**H2**
EB → KP	3.175	3.225	0.004	**H3**
VE→ LEAN	6.12	5.76	0.000	**H4**
VE→ KP	.2.008	2.008	0.048	**H5**
LEAN→ KP	3.434	3.434	0.001	**H6**

4.3.2 Simultaneous Hypothesis Test

To determine the effect of the independent variable simultaneously on the dependent variable, calculations are performed using the following formula:

F value = ((n-k-1) R^2) / (k (1-R^2))
The F table is obtained from the table using the DF1 and DF 2 instruments obtained from the following formulations:

DF 1 = number of independent variables
DF 2 = n - k - 1

Information:
n = number of samples
k = number of independent variables
R2 = r square (from the estimation results)

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

Table 7. Simultaneous Hypothesis Testing Model

Relationship	F value	F table	Conclusion
EB → VE → LEAN → KB	4.95	2.73	**H7 accepted**
EB → LEAN → KB	4.95	2.73	**H8 accepted**

Based on the table above, the hypothesis can be formulated with the conclusion that, simultaneously or together, the predictor variables in the test sample have a significant effect on the criterion variable. The three variables of Cost Efficiency, Value Engineering and Lean Construction are proven together to have a significant effect on Cost Performance in the test sample area. Thus, all test sample models prove that H7 & H8 are acceptable.

4.3.3 Moderating Effect Test

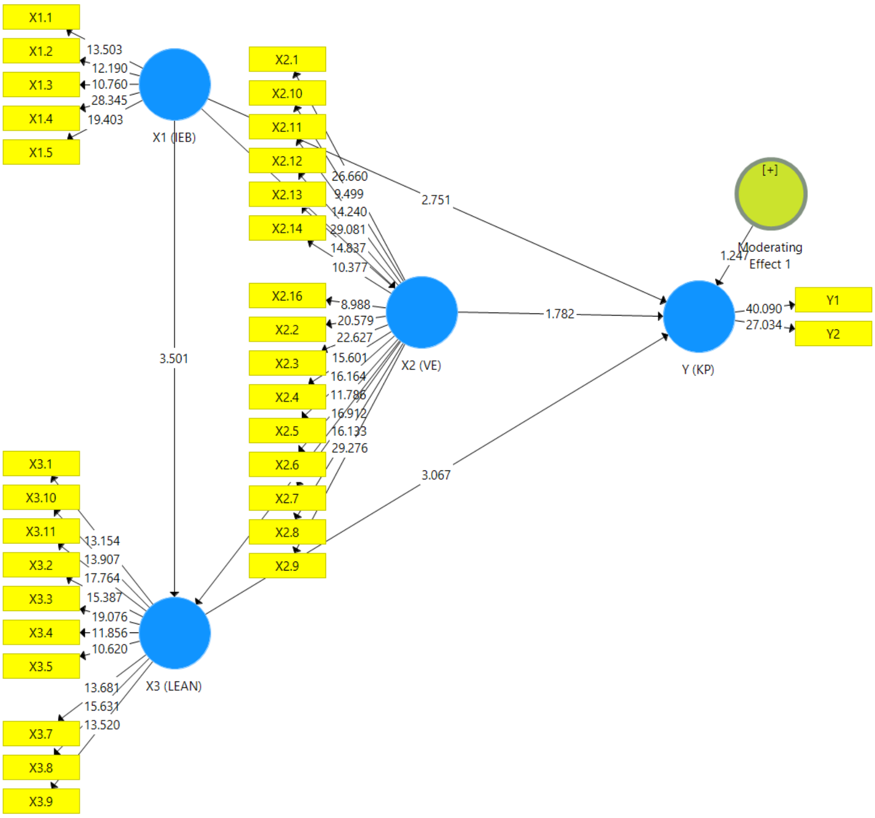

Figure 5. Moderating Effect Test

From the results of the moderating effect reaction, it is obtained that the pre-requisite test values have been fulfilled below, namely the value of construct reliability and validity that has met the requirements of Cronbach's alpha being more than 0.7 and AVE more than 0.6.

Table 8. Construct Reliability And Validity

Matric	Cronbach's Alpha	AVE
Moderating Effect 1	1	1
X1	0.863	0.648
X2	0.963	0.664
X3	0.932	0.621
Y	0.778	0.818

Table 9. Bootstrapping Path Coefficients

	Original Sample	Sample Mean	STDEV	T-statistic	P Values
Moderating Effect1→Y	0.028	0.035	0.024	1.183	0.237
X1→X2	0.86	0.853	0.052	16.614	0
X1→X3	0.336	0.372	0.103	3.54	0
X1→Y	0.589	0.562	0.205	2.87	0.004
X2→X3	0.591	0.589	0.102	5.821	0
X2→Y	-0.377	-0.0376	0.189	1.988	0.047
X3→Y	0.688	0.708	0.225	3.056	0.002

From the results of the moderating effect bootstrapping reaction, it can be concluded that:

1. The moderating effect has no effect on cost performance
2. The relationship X1, X2 that passes X3 after being given the moderating effect has an effect on cost performance with a value of 0.028, which means it strengthens the relationship because it is more than 0
3. The results of the moderating effect is included in the type of moderating effect Predictor Moderation (Predictor Moderation Variable). This means that this moderating variable only plays a predictor variable (independent) in the relationship model that is formed where the moderating effect has no effect while the values of X1, X2 that pass through X3 have an effect on cost performance.

5. Conclusion and Suggestion

5.1. Conclusion

The results of this study provide an overview of the results of cost performance with value engineering & Lean Construction based waste utilisation on cost performance. From all samples processed in this study, the following conclusions can be drawn:

1) There are 5 cost efficiency indicator factors that have the greatest contribution with the following levels of influence:

   1.Choosing the right work method during the construction process can lead to cost efficiency (X1.4) of 0.865
   2.Increasing worker productivity can lead to cost efficiency (X1.5) of 0.836
   3.In selecting alternative materials that are equivalent in specifications can lead to cost efficiency (X1.1) of 0.791
   4.Reduction / suppression of material waste can lead to cost efficiency (X1.2) of 0.771

5.The use of BIM technology (X1.3) is 0.757

2) In the model of implementing the composition of the EB-VE-LEAN-KP research, this illustrates that in the effort to be efficient on cost performance, this composition will have a significant effect on cost performance.

5.2. Suggestion

Based on the results of research on Waste Utilisation on Cost Performance in the Jabotabek area, there are benefits and suggestions that can be used and considered in similar studies in the future, namely as follows:

1. This study samples from Jabotabek, so it is necessary to carry out a similar study by taking a more diverse sample such as central Indonesia and eastern Indonesia which have very different cultures, so there is a possibility that there are differences in patterns; it will influence the final conclusion regarding the condition of construction cost performance in Indonesia.
2) This research focuses on what factors can affect cost efficiency during the construction period based on value engineering and lean construction.
3) In making a construct model, it is necessary to pay attention to whether the model is in a reflective or formative construct by paying attention to the following matters (Mackenzie et al. (2005):
   a) What indicates a manifestation of a construct or the characteristics of a construct be defined?
   b) What indicators are conceptually interchangeable?
   c) Is there any covariance between the construct indicators?
   d) What indicators have the same antecedents?

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