AHP Method for Supply Chain Management Performance Measurement in Construction (Study Case: Bridge Project)

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Abstract

The objective of this study is using the Analytical Hierarchy Process (AHP) method to determine the value of supply chain performance in the Sikatak bridge construction project and provide recommendations for improvements to the Sikatak Bridge construction project. The AHP provided are accurate performance assessment on the Sikatak Bridge construction project is expected to facilitate the existing SCM process. Therefore, the effectiveness of the supply chain on the project is increasing. The results of this study are based on monitoring system of supply chain performance, this value belongs to the average index or average. There are two indicators that need to be improved from the four indicators used, namely ROF and TSCM. The strategy that can be done to increase the value of ROF and TSCM is to ensure that the process plan or project development planning is carried out optimally so as to produce optimum costs, which will benefit both the contractor and the owner.

Keywords

Analytical Hierarchy Process, Construction, Supply Chain Management, Performance

1. Introduction

In general, the construction is described sector that has low productivity, high fragmentation, time and cost overruns and many disputes compared with other sectors (Xue et al. 2007). Supply Chain Management is defined as concept that offers an innovative solution for overcoming those difficulties from system perspective (Kim and Nguyen 2018). The supply chain management (SCM) has become a fundamental strategic element for the company to improve its competitive advantages'. Based on operation supply chain evaluation, the difficulties can be resolve immediately.

Also, the goal fundamental of the SCM is can reduce the total supply chain costs and make the supply chain growth better (Guo, Liu, and Qiu 2006).

SCM is an important aspect in construction projects because it includes processes that require large costs, a lot of time, and a lot of materials. The value of materials in a project generally reach 80% of the total project cost. Therefore, managing supply chain in construction has a major impact on the success, quality, increased profits of the project. The more complex a project, the more important SCM in the project. By ensuring SCM performance is become a way to improve SCM in a construction project.

The objective of this study is using the Analytical Hierarchy Process (AHP) method to determine the value of supply chain performance in the Sikatak bridge construction project and provide recommendations for improvements to the Sikatak Bridge construction project. Measuring supply chain performance using AHP has attracted the interest of some researchers and practitioners. (Najmi and Makui 2010), using AHP in measuring the performance and identify the most important factor in automative company. (Kim and Nguyen 2018) provide AHP Framework for Evaluating Construction Supply Chain Relationships. The results are collaboration in the supply chain has criterion has the highest priority. Based on (Wibowo and Sholeh 2015), AHP shows that perfect order fulfillment is the highest score.

The AHP method examines at the most significant indicators and could arrange the several experts thinking from divers' indicators, and also provides a measurement scale to determine priority indicators, considers the inconsistency value of each respondent's answer. The AHP results provided are accurate performance assessment on the Sikatak Bridge construction project is expected to facilitate the existing SCM process. Therefore, the effectiveness of the supply chain on the project is increasing.

2. Literature Review

2.1 Analytical Hierarchy Process (AHP)

Analytic hierarchy process (AHP) (figure 1) is a structured multi-attribute decision method (Saaty 1990). The core profit of AHP is its capability to minimize and check the inconsistency of expert judgments (Aminbakhsh, Gunduz, and Sonmez 2013). While minimizing preconception in the decision making process, AHP gives group decision making by means of consensus usage of the personal judgments geometric mean. AHP concerns in evaluating scales rather than measures; therefore, it is adequate of designing conditions that deficiency measures. Analytical Hierarchy Process (AHP) is measurement concept that has function to find out the ratio scale, both from continuous and discrete pairwise comparisons. AHP divided complex multi-criteria difficulties or problems into a hierarchy (Lee and Chan 2008). While, hierarchy is explained as a description of a complicated problem in a multi-level structure. The first level is the goal. The next is the level of factors, the criteria level, the sub-criteria level and etc.

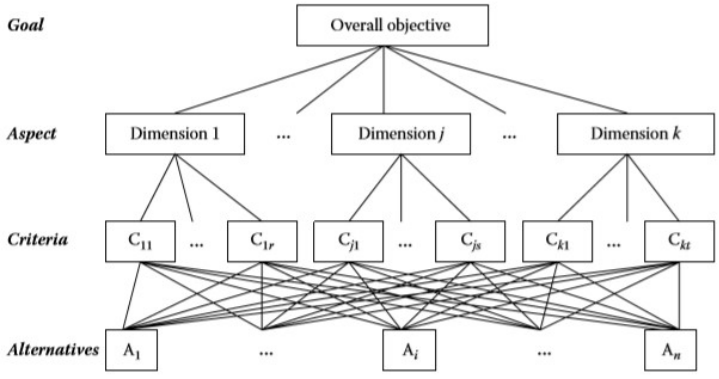

Figure 1. AHP Structure

2.1.1 AHP Steps

The problem-solving process using the AHP method generally consists of six stages, namely (Nurrahmat and Sunindyo 2019):

1. Define the problem and determine the desired solution

2. Create a hierarchical structure that begins with a general goal, then criteria and other alternative choices
3. Create a pairwise comparison matrix that describes the relative contribution or influence of each element to the goals or criteria at the level above.
   $a_{ij} = \frac{w_i}{w_j}$, i, j = 1, 2,…, n (2.1)
4. Perform data normalization
5. Calculating the priority weight of each criterion i
   $w_i = \frac{a_i}{n}$ (2.2)
6. Calculating eigen value
   $\lambda_{maks} = \frac{\sum a}{n}$ (2.3)
7. Calculating Consistency Index (CI)
   $CI = \frac{\lambda_{maks} - n}{n-1}$ (2.4)
8. Calculating Consistency Ration (CR)
   $CR = \frac{CI}{RI}$ (2.5)

2.1.2 Snorm de Boer Normalization

Each indicator used in measuring performance has a different value, to equalize the value of each indicator, normalization is carried out (Waaly, Ridwan, and Akbar 2018). Normalization is done by changing the value of each indicator to a value between 0 to 100, where the performance of each value is shown in Table 1.

$$S(norm) = \frac{(S_i - S_{min})}{(S_{max} - S_{min})} \times 100 \quad (2.6)$$

Table 1. Performance Indicator Monitoring System

Monitoring System	Performance Indicator
<40	Poor
40-49	Marginal
50-69	Average
70-90	Good
>90	Excellent

SCM performance assessment is one of the important aspects that must be carried out in ensuring the implementation of the project development process. Research conducted by (Dissanayake and Cross 2018)) uses the AHP and SEM methods in calculating the most influential factors in asphalt plant SCM. The results show that both methods give the same results for the most influential indicator and the least influential indicator. (Sellitto et al. 2015) used the SCOR and AHP methods in assessing the performance of SCM in footwear production using the SCOR indicator at level 1. (Lima-Junior and Carpinetti 2019) assessed SCM performance by building a predictive model so that SCM performance predictions could be made by changing the variables. That study uses the SCOR and ANN methods to considered the prediction model. (Kurien and Qureshi 2012) used the Modified Balanced Scorecard (MBSC) and AHP methods in measuring the SCM performance of a company with green criteria. Based on the considerations of previous research, this study uses the AHP method in assessing the performance of SCM on construction projects (Sikatak Bridge). The AHP is considered to provide accurate results so it can improve SCM performance.

3. Methods

The research refers to Handayani et al (2021, ongoing). SCOR is conducted to measure the Supply Chain Performace in Sikatak Bridge (Handayani et al 2021, ongoing). The next step is the validation of indicators by adjusting the project's needs to indicators. Expert Choice Software is used to determine the local weights indicators and attributes. Actual data is calculated using SCOR that already conducted by Handayani et al 2021, ongoing). The next stage is normalized the value of each indicator. The final stage is determining the final score of supply chain performance on the project. The respondents in this research are those who are considered competent regarding SCM in the project that are the head of the contractor, the Commitment Making Officer (PPK), and the head of the supervisor

4. Results and Analysis

The following are the indicator validation results that will be used by adjusting the project needs obtained. There are four valid indicators, namely Perfect Order Fulfillment (POF), Total Supply chain Management Cost (TSCM), Cost of Goods Sold (COGS), and Return on Supply chain Fixed Cost (ROF). The value of the KPIs is shown in table 2. The next step is to measure the actual value of each KPI used.

Table 2. Actual KPI Value

KPI	Code	Actual	Normal
Perfect Order Fulfillment	POF	95,78%	50,93
Total Supply chain Management Cost	TSCM	81,48%	18,52
Cost of Goods Sold	COGS	36,70%	63,30
Return on Supply chain Fixed Cost	ROF	18,34%	18,34

(Source: Handayani, et al, 2021 ongoing)

The next step is to calculate the weight of each KPI obtained from the questionnaire using the AHP method and processed using expert choice software. This calculation will also give weight to the attributes used, namely reliability, cost, and assets. The weight values of each KPI and attribute are shown in table 3.

Table 3. KPI weights

Attribute	Local Weight	KPI	Local Weight	Global Weight
Reliability	0.513	POF	1.000	0.513
Cost	0.305	TSCM	0.458	0.140
		COGS	0.542	0.165
Assets	0.181	ROF	1.000	0.181

Table 2 shows that the project prioritizes indicators of accuracy (quantity and quality) of material delivery by suppliers. Materials that are delivered on time and with appropriate specifications will facilitate project therefore it needs to establish a relationship with its suppliers. Then, costs and assets attributes have almost the same priority. The last step is to calculate the final value of supply chain performance by multiplying the actual KPI value with the global weight of the KPI. The final value of supply chain performance is shown in table 4.

Table 4. Final Score

KPI	Actual	Global Weight	Score
POF	50,93	0.51	26,18
TSCM	18,52	0.14	11,38
COGS	63,30	0.16	16,07
ROF	18,34	0.18	3,31
Total			56,90

The final value of the supply chain performance in the Sikatak Bridge construction project is 56.90. This value is in the average category or good enough, but requires improvement in several aspects. Based on the values shown in table 3, there are two KPIs that need to be improved, namely the TSCM and ROF KPIs.

4.1 Analysis

4.1.1 Supply Chain Performance Indicator Score Analysis

The supply chain performance score is a value that indicates the level of performance of the supply chain performance owned by the project. This score is obtained by multiplying the value between the actual data from the project with the weighted value of the indicators used. The value of the actual data has different units, so it is necessary to equalize the value through normalization. Normalization consists of two types, namely higher is better and lower is better. Higher is better means that the greater the indicator value indicates better conditions, while lower is better means that the smaller the indicator value indicates better conditions. The value of normalization ranges from 0-100 or 0-1, and this study uses a scale of 0-100.

There are two indicators that are classified as higher is better, that is POF and ROF. While the indicators that classified as lower is better, that is TSCM and COGS. The normalized value of each indicator is POF of 50.93, TSCM of 18.52, COGS of 63.30, and ROF of 18.34. The final value of the POF indicator is 26.18, TSCM is 11.38, COGS is 16.08 and ROF is 3.31.

Based on these results, it can be concluded that the POF indicator is the best indicator achieved by the project and the ROF indicator is the indicator that has the lowest performance and needs to be improved. ROF gets the lowest value due to two factors, that are the importance value of ROF according to respondents is on a small scale. Second is there are several things that cause additional costs during project so that the total cost increases such as the cost of adding materials, labor, and renting heavy equipment. This impact is caused by a design change that results in additional work costs and additional costs due to bad weather conditions so that an overtime system must be applied. The final value that shows the performance of the supply chain on the Sikatak Bridge construction project is 56.90. Based on the supply chain's performance monitoring system as shown on Table 1, the Sikatak bridge construction project is categorized as average.

4.1.2 Recommendation and Improvement Analysis

Improving performance in a supply chain can be done by implementing several appropriate strategies that are:

a) Supply management, where the company coordinates with upstream partners to ensure efficiency in material supply along the supply chain.
b) Demand management, where the company coordinates with downstream partners to ensure efficiency in material supply along the supply chain.
c) Information management, namely the company collaborates with various parties to obtain various information that can support the supply chain process to run smoothly.
d) Coordination, namely the company coordinates to improve its performance
e) Product management, namely the company can modify the product or modify the process design so that it is in accordance with consumer demand.

The indicators that need improvement from the four indicators used are ROF and TSCM because they are in a bad index while the POF and COGS indicators are on the average index. ROF is the return received by an organization from the capital invested in supply chain fixed assets used in the plan, make, source, deliver, and return processes. ROF on the Sikatak bridge construction project has a low value because the value of the assets is low while the supply chain value is large. Another factor is the project only carried out for 300 working days or relatively short, so that most of the tools used are loan items and only a few are fixed assets in the project. Another factor that make the high value of the supply chain is a design change which results in additional costs for adding materials, adding labor, and increasing work duration. Changes in the design of the bridge occur when working on the construction of the foundation and pillar bodies. Changes in the design structure during the construction phase can be fatal to the additional cost and time of project implementation, therefore it is necessary to coordinate between the contractor and the design architect so as to minimize errors or design changes at the stage of the work process. TSCM is the cost obtained from the entire supply chain process in a project. The TSCM score in the Sikatak bridge construction project has a low score because the costs used in the supply chain process are high.

The strategy that can be done to increase the value of ROF and TSCM is to ensure that the process plan or project development planning is carried out optimally to produce optimum costs. The plan is minimize the occurrence of design changes, unite several processes that can be combined so as to shorten the processing time, choose a supplier

who in accordance with specifications so as to minimize delays in material delivery, minimize the occurrence of damage to materials sent and obtain materials at efficient prices, anticipate of unexpected things by carrying out project risk management. Risks in construction projects must be controlled so that the project can run smoothly and will not incur additional costs. Another strategy that can be done is to minimize the cost of prevention. Prevention costs can be streamlined through regular evaluations from various parties, especially supervisory consultants and owners and contractors so as to minimize the occurrence of errors in project work. Next strategy is to supervise suppliers such as coordinating between logistics parties and suppliers which aims to ensure that the goods ordered have the right quality and quantity. Many companies today have established good relationships with their suppliers because this is considered one of the strategies to obtain optimum quality and price. Some of the actions are sharing information about the condition of the project field, the quality of the desired material, the appropriate price, the technology used and others.

5. Conclusion

The performance value of the performance of the Sikatak bridge construction project is 56.90. Based on the monitoring system, this value belongs to the average index or average. There are two indicators that need to be improved from the four indicators used, namely ROF and TSCM. The strategy that can be done to increase the value of ROF and TSCM is to ensure that the process plan or project development planning is carried out optimally so as to produce optimum costs, which will benefit both the contractor and the owner. The process that can be done to ensure that the plan has been carried out optimally is to ensure that the design built is in accordance with field conditions so as to minimize the occurrence of design changes, ensure that the work process on the project is optimal or unite several processes that can be combined so as to shorten the processing time, choose a supplier who in accordance with specifications so as to minimize delays in material delivery, minimize the occurrence of material damage sent and obtain materials at efficient prices, anticipate of unexpected things by carrying out project risk management.

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