The analysis of supply chain performance measurement at construction project

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Abstract

During recent years, supply chain has become a major subject of management research and manufacturing theory. The impact of various supply chain management practices on project performance has been measured through a combination of a survey and the development of simulation models. Supply chain performance measurement on the road project has not been much discussed today. As it is known that the road project is one of the very high construction project roles. Performance measurement using the Supply Chain Operations References (SCOR) will analyze how the supply chain management of contractor. The aim of the study is to analyze supply chain performance in road projects. This measurement using the SCOR model as a Key Performance Indicator (KPI) is calculated using the weighted criteria Analytical Hierarchy Process (AHP). Weighting and measurement results were analyzed using Objectives Matrix (OMAX) and traffic light. The results of the analysis and the measurement of supply chain performance are medium score or good enough for road projects. The factors that leads to the success of this supply chain are the readiness of the contractor, supplier partners, supply chain strategy, and the ability of labors.

Keywords: supply chain; performance measurement; SCOR model; construction; road

1. Introduction

Supply chain has become a major subject of management research and manufacturing theory recently. The supply chain has previously been defined as the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands

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that of the ultimate customer [1]. The readiness of supply chain in integrated material procurement becomes one of the important indicators to define contractor performance. Contractor will be called competent if contractor can order the material and build without delay.

The objective of study is to measure performance of supply chain using SCOR model. Research in industry and organization, about performance measurement of supply chain explains the Supply Chain Operations References (SCOR) with dimensions of reliability, responsiveness, flexibility, costs, and assets [2]. The previous study about the measuring performance of supply chain in house building indicates that the framework is needed to identify the balance of supply chain performance [3]. Supply chain performance measurement on the road project has not been much discussed today. As it is known that the road project is one of very high construction project roles. The road becomes a liaison between local lands. In addition, road project becomes the backbone of the economy of a region where movements with the mobilization of people and goods from one area to another.

Road project requires a strong supply chain, especially road with high function such as toll roads. Therefore, supply chain performance measurement on road projects is necessary to determine the ability of contractor. Performance measurement using the Supply Chain Operations References (SCOR) will analyze how the supply chain management of contractor is. SCOR will analyze how the reliability, responsiveness, flexibility, cost, and assets of the contractor. Based on the analysis, it can be seen how the performance and readiness of the contractor in supply chain management. The more ready supply chain of contractors in road project, the higher the possibility of success.

2. Theoretical background of supply chain and performance measurement

2.1. Construction supply chain management

The modeling of construction supply chain is a subject that has been mainly investigated since the early 1990s. The goal is to explore how manufacturing concepts can be transferred to the construction concept in order to improve production efficiency and to reduce project costs [4]. Supply chain management has four specific roles in construction, see Fig. 1. Practical initiatives in each role to advance the construction supply chain are analyzed. The present status of construction supply chains is investigated by the means of case studies and a comparison with previous research [5].

The impact of various supply chain management practices on project performance has been measured through a combination of a survey and the development of simulation models [6]. That is because construction supply chain relationships are usually multifaceted, complex, and difficult to be measured in a quantitative manner [7]. Contractor will reduce costs by procuring raw materials and equipment from the lowest cost sources [8]. The impacts of construction supply chain management on value projects are bad relationships among subcontractors cause poor performance in supply chain, integration of the supply chain eliminates waste and adds value to the process, project
delivery outcomes suffer when open and defined communication links are absent in the supply chain, and alignment of project goals is difficult without supply chain mutual trust [9].

2.2. Performance measurement

Performance measurement of supply chain must be classified to the clear steps because procurement and material storage on construction sites determine the success of project [10] [11]. Fig. 2 explains about steps of performance measurement:

![Fig. 2. Step of performance measurement](image)

The first step is set Key Performance Indicator from SCOR. SCOR (Supply Chain Operations References) is a reference model that is based on the supply chain process [12]. This model integrates three main elements in the management of business process reengineering, benchmarking, and process measurement into a cross-functional framework in the supply chain [13]. This step will identify Key Performance Indicator (KPI) that influences construction supply chain performance. The second step is validation. Validation is used to know whether the indicators (KPI) are valid and able to find the data [14]. The third step is AHP weighting calculation. Analytical Hierarchy Process (AHP) is a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales [15]. In other study, AHP is an algorithm which is capable to solve complex decision-making problems [16]. The AHP analysis steps are defining goal, criteria, and sub-criteria [17], structuring hierarchy, AHP weighting calculation [18], and global weight calculation. The next step is scoring system with OMAX. OMAX (Objective Matrix) was found by Prof. James L. Riggs (productivity lecture from Department of Industrial Engineering at Oregon State University). OMAX connects the criteria of productivity into model [19]. The last step is scoring system with traffic light. Traffic light system is measurement model with three colors. Green is parameter for good, yellow is parameter for medium, and red is parameter for bad [20].

3. Methodology

3.1. Research design

To research the possibilities of adopting of SCOR model in construction industry, a case of supply chain material procurement was selected and an exploratory case study project is conducted [21]. The specification objects of this study are road project in Indonesia and having a material procurement scheme.

The case study was divided into two parts. The first part, the purpose was to find key performance indicator based on SCOR model. In scor models there are a variety of criteria ranging from the reliability, responsiveness, flexibility, cost, and assets [12]. Each of the criteria set out in the performance. It can be selected by the respondents which are used in the project and the available data. The purpose of the second part is to determine the maximum and minimum values of each KPI as further calculations in OMAX and traffic light.

3.2. Data collection and analysis by comparing the data

The research strategy will compare the data [21]. Comparing data from interviews and secondary data from questionnaire may make data analysis become more accurate. Interview to the project manager or head of logistic department will explore information of the supply chain mechanism in the project. Questions to the respondents based
on SCOR KPIs are unexplored deeper. Secondary data in questionnaire concerns to the number of projects and material ordering time will be calculated based on the analysis SCOR, weighting AHP, OMAX and traffic light. Comparison of these two data will be valid in the qualitative and quantitative analysis. The concept of comparative data such as Fig. 3.

![Diagram](image)

Fig. 3. Concurrent triangulation design of the survey in framework by Creswell [22]

3.3. Data sampling in the survey

The target sampling of the case is road project. The material that will be analyzed is steel because it exists in all of the major work in rigid pavement road. Both the interview and questionnaire samples are formed on non-probability, purposive basis. For the interview, it needs the project manager or head of logistic department who are well experienced. The questionnaires must be done carefully so that there is no miscalculation.

4. A case study: Supply chain in road project

4.1. Supply chain scheme in road project

The case study is Siliwangi Cs Widening Road Project, located in Highway Siliwangi Semarang, Central Java, Indonesia. The owner of this project is Ministry of Public Work and the contractor, PT Adhi Karya (Persero). Contractor has material procurement scheme as a strategy to build the road. It buys steel from suppliers, previously there is an election where the supplier is prepared as a supplier of steel. The location of steel suppliers such as Fig. 4. Contractor usually chooses PT Hanil Jaya Steel Sidoarjo because it is located closely to Semarang, which is about 350 km.

4.2. Problems of construction and supply chain

There are several problems occur when progress of construction was 60%. The problems were steel procurement delay. Concrete procurement delay happened because Merapi volcano, and cost for divest the utilities. Especially for material procurement delay, activity in the project delayed for all critical activity.
4.3. Performance measurement

The first step performance measurement of supply chain is identify Key Performance Indicators (KPI) from SCOR. Validation KPI in Siliwangi Road Project said that there are five KPI that are used in project: perfect order fulfillment, order fulfillment lead time, production flexibility, supply chain management cost, and inventory days of supply. Every KPI with maximum and minimum target is shown in Table 1.

| KPI                        | Code | Minimum | Normal | Maximum | Actual |
|----------------------------|------|---------|--------|---------|--------|
| Perfect order fulfillment   | POF  | 80%     | 90%    | 100%    | 94.5%  |
| Order fulfillment lead time | OFLT | 30 days | 14 days| 7 days  | 12 days|
| Production flexibility      | PF   | 95%     | 97%    | 99%     | 97.5%  |
| Supply chain management cost| SCMC | 80%     | 85%    | 90%     | 89.1%  |
| Inventory days of supply    | IDS  | 7 days  | 10 days| 14 days | 11 days|

The second step is AHP weighting calculation. Respondent fills the questionnaire to compare between some perspectives. Customer facing with internal facing, reliability with responsiveness in customer facing, reliability with flexibility in customer facing, responsiveness with flexibility in customer facing, and cost with assets in internal facing. The result of AHP weighting calculation in Fig. 5. Score for every Key Performance Indicator (KPI) in OMAX (Objective Matrix) and traffic light will be known as Table 2.

LW: Local Weight
GW: Global Weight

Fig. 4. Steel supplier in Siliwangi Road Project

Fig. 5. Structure of hierarchy AHP weight calculation
Based on scoring system in Table 2, performance of road project is 6.4 (maximum value 10). If scoring with OMAX and traffic light, contractor who build Siliwangi Road gets medium score in level 6.

5. Discussion

The case supply chain in Siliwangi road project has completed to measure the performance. SCOR (Supply Chain Operation References) gives the base concept of Key Performance Indicator. AHP weighting calculation shows that customer facing is more important than internal facing according to contractor because the value of Siliwangi Road Project is high. From five KPIs, AHP shows that perfect order fulfillment is the highest score because it is used in critical activity. If the material delays, it will influence all of project business core such as cash flow of the project. Cash flow is the income and the outcome of resources of the project.

The result of performance measurement with scoring system of OMAX (Objective Matrix) and traffic light is in medium score in level 6 because of there are several problems when project is ongoing. Perfect order fulfillment in level 6, order fulfillment lead time in level 5, production flexibility in level 5, supply chain management cost in level 9, and inventory days of supply in level 5. Overall the project is not too bad or high, but in medium score in level 6.

Contractor has made strategic plan for supply chain but in actual it can not be anticipated. Such as Merapi volcano disaster which makes contractor difficult to find sand supplier when project is ongoing. Beside that, procurement of steel delayed when concreting in the field. Contractor must have other plan to anticipate this problem. One of the strategies is loan from other near project in a company.

6. Conclusions

The steps of performance measurement from set Key Performance Indicator, validation, AHP weighting calculation, scoring system with OMAX and traffic light. Performance of Siliwangi Road Project as a case study is 6.4 (medium score). Based on a case study can be known that not all of perspectives in SCOR can be used as key performance indicator in construction because manufacturing is different with construction. Construction is more simple but difficult in supply chain management. It must be validated before applied to measure performance of supply chain. But directly with this study, SCOR model can be applied as performance measurement model at construction project. This paper only uses one case study to measure the performance of road construction project. It must be developed with several case studies and not only road project but also the other projects to get more knowledge.
Improved SCOR model as key performance indicator with OMAX (objective matrix) and traffic light as scoring system make it easy for contractor and researcher to measure how supply chain operated in road project. The research question of this paper was based on the assumption that SCOR is usually used in manufacture industry. Apparently it also can be used to measure performance of construction supply chain.

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