Designing System Assessment of Supply Chain Management Performance in Bridge Project using SCOR

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Abstract

The supply chain is also a significant aspect in project infrastructure because almost all activities in it are included in the supply chain. Good supply chain management have a positive impact on the construction projects development. The way to determine the condition of the supply chain in construction is by measuring the supply chain performance. This research was conducted on The Sikatak Bridge construction project in Indonesia. The several constraints that occur are changing the pillar body design that make having a more time to finish, delaying in material delivery, and the bad weather conditions. Based on those problems, performance assessment can be done using the Supply Chain Operation Reference (SCOR) method. The result of the study is there are 10 indicators of supply chain performance assessment and in this study uses only four indicators because the determination of indicators is based on the needs of the project and project data actual. The indicators used in this study are Perfect Order Fulfillment (POF), Total Supply chain Management Cost (TSCM), Cost of Goods Sold (COGS), and Return on Supply chain Fixed Cost (ROF).

Keywords
Supply Chain Performance, SCOR, Construction Project

1. Introduction

The construction industry is an important sector that support economic growth through infrastructure development. Construction projects have characteristics that are limited in time, cost, and resources, are unique jobs and non-recurring events, are completed according to performance requirements and specifications designed to meet customer needs, results are measurable and can be quantified, activities are planned, implemented and controlled (Cleland and King 1975).

For company that concern on profitability, global development, and global competitive, supply chain management become a serious issue (Lakri, Dallery, and Jemai 2015). Supply chain management (SCM) involves building strategic relationship with customers and suppliers and customers, sharing information, improving knowledge in product and system and also long-term partnership (Qi et al. 2017). So, it can gain many benefits such as customer satisfaction, inventory reduction, optimization on the resources usage (Chorfi, Benabbou, and Berrado 2018; Ko, Tiwari, and Mehnen 2010). Therefore, assessment the supply chain performance to measure SCM practices and strategies effectiveness has become crucial (Chorfi et al. 2018; Lakri et al. 2015). The supply chain is also a significant aspect in project infrastructure because almost all activities in it are included in the supply chain. Good supply chain management have a positive impact on the construction projects development. The way to determine the condition of the supply chain in construction is by measuring the supply chain performance. Previous study states that 3 aspects that can be used as benchmarks for SCM performance, namely quality, cost, and delivery time (Lima-Junior and Carpinetti 2019). Failure to achieve the target in one of the aspects will have an impact on the work process until the project's final result.

This research was conducted on The Sikatak Bridge construction project in Indonesia. The several constraints that occur are changing the pillar body design that make having a more time to finish, delaying in material delivery, the bad weather conditions. Based on those problems, performance assessment can be done using the Supply Chain Operation Reference (SCOR) method, which is a method that integrates the reengineering, benchmarking, and measurement processes into the supply chain assessment framework. The SCOR method uses 5 attributes where each attribute has a different Key Performance Indicator (KPI) at each level. Each KPI have a value that describes the condition of the supply chain in the construction being carried out so that it can be known whether certain aspects need to be repaired or not. Several researchers have already concerned in assessment SCM performance using SCOR. Research conducted by (Wibowo and Sholeh 2015) regarding the assessment of SCM performance on highway construction projects using the SCOR level 1 indicator because it is considered to describe the SCM of the project. (Dissanayake and Cross 2018) applying SCOR in measuring the most influential factors in supply chain performance in asphalts plants. (Lima-Junior and Carpinetti 2019) conducted research in designing supply chain performance model by changing the existing variables. (McCormack, Ladeira, and de Oliveira 2008) examined the relationship between maturity level and supply chain performance using the SCOR method and statistical tests. The results show that companies have good SCM performance and have a good maturity level as well. Therefore, this study conducted the research in assessment designing system of supply chain management performance in Sikatak Brigde project using SCOR.

The remainder of the paper is structured as follows. The chapter 2 is literature review about SCOR and the theoretical context of the research. Then, chapter 3 explain the methodology. The result and analysis will explain in chapter 4. Finally, chapter 5 will conclude the results.

1.1 Objectives
The objectives of this research are to identify indicators that are in accordance with performance measurement on the Sikatak bridge construction project and to determine the value of supply chain performance in the Sikatak bridge construction project

2. Literature Review
2.1 Supply Chain Performance Evaluation
Supply chain performance is outcome of logistics and supply chain management such as management in inventory, facilities, and transportation and in cross functional such as resources, pricing and information, sourcing and pricing. Those results interact together to set the performance level of supply chain's efficiency and responsiveness (Chopra, Meindl, and Kalra 2013). Based on SCC (2012), supply chain performance is explained as the performance results of supply chain partnership process such as measurement related to cost, agility, reliability, asset management and responsiveness. Measuring supply chain performance need assessment of the differences between desired result and actual to find out the performance gaps so could know the root problem. Thus, the company can provide plans of monitoring and implementing improvement action (Melnyk, Narasimhan, and DeCampos 2014). Improving supply chain performance is frequently suggest to focus on facilitate implementation of strategies. Previous researchers find

that by choosing suffice performance metrics could encourage to the appropriate improvement steps (Elgazzar, Tipi, and Jones 2019; Melnyk et al. 2014; Qi et al. 2017). Several studies also state that it is necessary to apply metrics for supply chain performance evaluation from other perspectives to provide a balanced measurement and to manage performance objective. Yet, many companies failed in building up the system that provide an obvious picture of supply chain performance. (Lakri et al. 2015; Lima-Junior and Carpinetti 2019).

2.2 SCOR

The SCOR is explained as a process reference model that connects metrics, process elements, best practices, and also the guidance for supply chain execution (Kocaoğlu, Gülsün, and Tanyaş 2013). In 1996, the SCOR model has undergone many revisions (APICS, 2016). This model can overcome the SCM issues or problem to assist a company to reach overall processes improvement by providing benchmarking standards and practices (Akkawuttiwanich and Yenradee 2018) The SCOR model is describing how the system associate along a supply chain and how the company manage the relationship from upstream until downstream. It also can identify the attributes that encourage to customers satisfaction (Ntabe et al. 2015). The SCOR model is an appropriate model in supporting operational and tactical management. Therefore the executive could offer the decision-making of strategic planning (Estampe et al. 2013). The SCOR model propose five attributes to set the supply chain performance, that is responsiveness, reliability, agility, cost and, assets (SCC, 2012).

3. Methods

The research begins by conducting a preliminary study on the project to determine the state of the supply chain and find problems that exist. The next stage is to collect supporting theories regarding the problems obtained to find steps in solving existing problems. There are two types of data to be processed in this research, namely actual project data and questionnaire data to determine indicators. This questionnaire was filled out by the head of project logistics, the head of the supervisor, and the staff of the asset directorate. The conceptual model in this study is divided into three main parts, namely SCOR, attributes, and output as shown on Figure 1. SCOR in this model is a process consisting of plan, make, source, delivery and return where this process is considered to represent all activities in the project. The attributes consisting of reliability, responsiveness, agility, cost and assets have indicators (KPI) on each attribute where each attribute will identify each activity in the five existing processes.

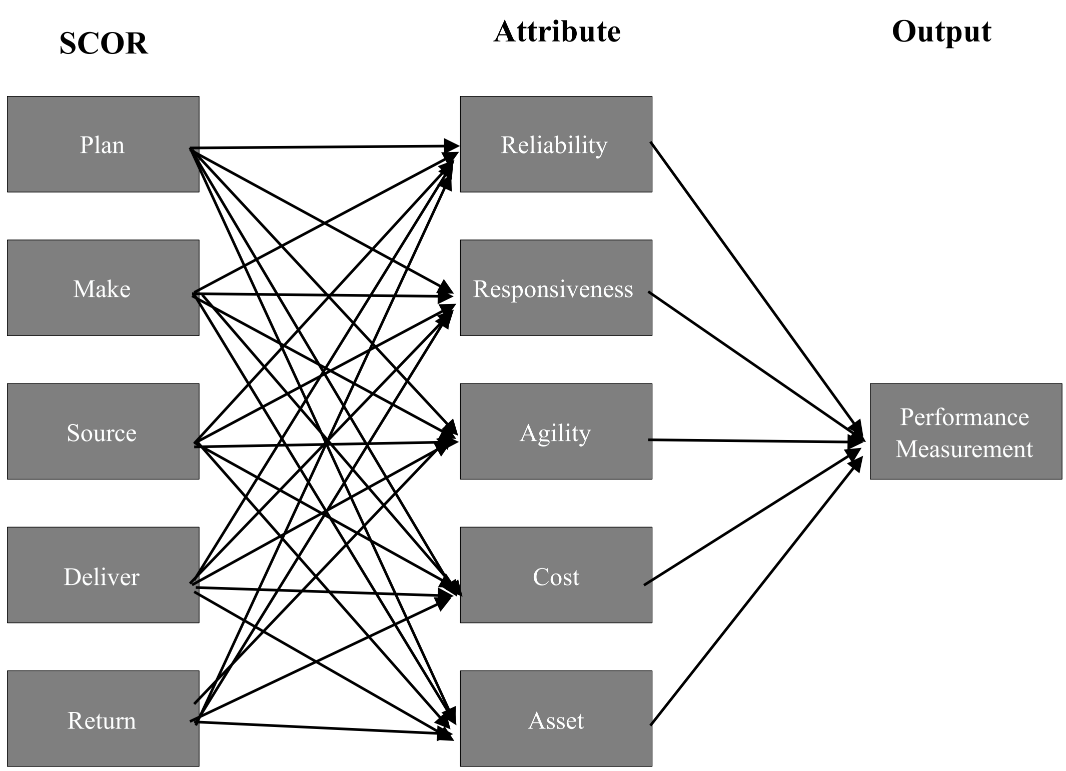

Figure 1. Conceptual Model

In general, the stages of work in SCOR are divided into four parts, namely:

a) Develop a supply chain performance model. This performance model divided into two poins, that is (1) the performance assessment design, in which there is a balanced structured assessment, (2) the dependencies map of the performance measurement
b) Measure supply chain performance. Measures can be calculated based on process definitions and actual data taken from the supply chain. Performance evaluation is a process of assigning weights to various performance measures to represent the importance of each dimension.
c) Performance analysis. At this stage, several methods of performance analysis will be produced for decision making and improvement (gap analysis).
d) Improvements. Improvement is divided into two points. (1) Analyzing the importance level and the relations among performance measures. (2) Based on process reengineering and gap analysis, it can give improvement of the real supply chain performance.

The indicators used in this study are indicators in the SCOR 12.0 which consists of 10 indicators based on APICS as shown on Table 1.

Table 1. Indicators of Performance Attributes

Performance Attributes	**Level 1 Strategic Metric (KPI)**	**Definition**	**Formulation**
Reliability	*Perfect Order Fulfillment*	Percentage of the number of goods sent, delivery performance according to schedule, and delivery in good condition.	$POF = \frac{Total\ Perfect\ Orders}{Total\ Number\ of\ Orders}$
Responsiveness	*Order Fulfillment Cycle Time*	The duration of the material delivery time by the supplier to the contractor from the date of the order.	$OCFT = Source\ cycle\ time\ (day) + Delivery\ cycle\ time\ (day) + Delivery\ retail\ cycle\ time\ (day)$
Agility	*Upside Supply Chain Flexibility*	The supplier's ability to adapt to changes in the increase in the amount of material desired by the contractor.	$USCF = \frac{Number\ of\ order\ changes}{Number\ of\ orders\ increase} x100\%$
	Upside Supply Chain Adaptability	The supplier's ability to adapt to maximum delivery of an unplanned increase in the number of orders.	$USCA = \frac{Number\ of\ orders\ fulfilled}{Number\ of\ orders\ increase} x100\%$
	Downside Supply Chain Adaptability	The supplier's ability to adapt to minimum deliveries for unplanned decrease in number of orders.	$= \frac{Number\ of\ orders\ fulfilled}{Amount\ of\ decrease\ in\ supply\ of\ raw\ materials} x$ $DSCA$

Table 1. Indicators of Performance Attributes

Performance Attributes	**Level 1 Strategic Metric (KPI)**	**Definition**	**Formulation**
	Overall Value at Risk	Risk value to suppliers when sending materials to contractors	$VAR = \sum VAR\ of\ plan\ (Rp) + \sum VAR\ of\ make\ (Rp) + \sum VAR\ of\ source\ (Rp) + \sum VAR\ of\ deliver\ (Rp) + \sum VAR\ of\ return\ (Rp)$
Cost	*Supply chain Management Cost*	The overall costs required in implementing the supply chain, for example planning costs, resource costs, implementation costs, delivery costs, return costs, and prevention costs.	$TSCMC = Cost\ to\ plan + Cost\ to\ source + Cost\ to\ deliver + Cost\ to\ return + Cost\ to\ make + Mitigation\ cost$
	Cost of Goods Sold	The costs in the supply chain consist of labor costs, material costs, and indirect costs during project implementation.	$COGS = \frac{Direct\ labor\ (Rp) + Direct\ material\ (Rp) + Overhead\ cost\ (Rp)}{Total\ cost\ to\ serve\ (Rp)} x100\%$
Assets	*Cash-to-cash Cycle Time*	The time it takes for suppliers to get costs after purchasing materials to produce materials.	$CTCCT = Inventory\ days\ of\ supply\ (day) + Days\ sales\ outstanding\ (day) - Days\ payable\ outstanding\ (day)$
	Return on Supply chain Fixed Assets	Return of assets for the use of technology or equipment to produce materials.	$ROF = \frac{Supply\ chain\ revenue - Total\ cost\ to\ serve}{Supply - Chain\ fixed\ assets} x100\%$
	Return on Working Capital	Value of return on capital used during project activities.	$RWC = \frac{Supply\ chain\ revenue - Total\ cost\ to\ serve}{Inventory + Accounts - Accounts\ payable} x100\%$

4. Results and Analysis

Supply chain activities in the Sikatak bridge construction project from upstream to downstream. In general, the parties involved in the Sikatak bridge construction project are the owner managed by the Commitment Making Officer (PPK), the implementing contractor is PT Mitra Andalan Sakti, and the supervisory consultant is PT Agrasinar Puripratama. In the supply chain process in the Sikatak bridge construction project, these related parties have different but interconnected tasks and responsibilities. The initial stage in this research is the calculation of the actual value and the validation of the indicators that will be used by adjusting the project needs obtained through respondents' answers to the questionnaire by adjusting the availability of data on the project. The calculation of the actual value of work indicators uses historical data from the Sikatak bridge construction project. The following is a calculation of the actual value of each indicator used.

1) Perfect Order Fulfillment (POF)

Table 2 is a list of Perfect Order Fulfillment for each period

Table 2. List of Perfect Order Fulfillment

Period	Total Order	Perfect Order	POF
1	1	1	100%
2	4	4	100.00%
3	8	8	100.00%
4	17	15	88.24%
5	17	17	100.00%
6	3	3	100.00%
7	7	6	85.71%
8	13	12	92.31%
Actual			95.78%
Minimal			85.71%
Maximum			100.00%

2) Order Fulfillment Cycle Time (OFCT)
This indicator aims to determine the number of days needed in the process of ordering and receiving materials to arrive at the project site. This indicator was not used in the study due to the unavailability of material ordering data.

3) Upside Supply chain Adaptability (USCA)
In this study, the USCA indicator could not be calculated because the application of USCA in the Sikatak bridge construction project could not be seen clearly. The ordering of materials on the project is not fixed or not constant because the ordering of materials is in accordance with the needs of the work on the project, so it cannot be known with certainty the increase in existing material orders.

4) Downside Supply chain Adaptability (DSCA)
In this study, the DSCA indicator cannot be calculated because the application of DSCA in the Sikatak bridge construction project cannot be seen clearly. The ordering of materials on the project is not fixed or not constant because the ordering of materials is in accordance with the needs of the work on the project, so it cannot be known with certainty the decline in the supply of raw materials.

5) Overall Value at Risk (VAR)
In this study, this indicator cannot be used because there is no data regarding the costs of each risk in the Sikatak bridge construction project.

6) Total Supply Chain Management Cost (TSCM)
TSCM on the Sikatak bridge construction project is obtained by subtracting the contract costs from the profits and additional costs.

TSCM = 75% Contract fee – Profit – Surcharge

TSCM = 75% x Rp 21.586.986.482 – Rp 1.619.023.986,15 – Rp 1.379.092.731,42 TSCM = Rp 13.192.123.143,93

$$\text{TSCM} = \frac{\text{TSCM}}{\text{Total Cost}} \text{x} 100\%$$

$$\text{TSCM} = \frac{\text{Rp } 13.192.123.143{,}93}{\text{Rp } 16.190.239.861{,}150} \text{x} 100\%$$

$$\text{TSCM} = 81{,}48\%$$

7) Cost of Goods Sold (COGS)

$$\text{COGS} = \frac{\text{Rp } 559.067.658{,}24 + \text{Rp } 4.843.089.116 + \text{Rp } 540.215.677{,}42}{\text{Rp } 16.190.239.861{,}150} \text{x}100\%$$

$$\text{COGS} = \frac{\text{Rp } 5.942.372.451{,}66}{\text{Rp } 16.190.239.861{,}150} \text{x}100\%$$

$$\text{COGS } = 36{,}70\%$$

8) Cash to Cash Cycle Time (CTCCT)
The CTCCT indicator is not used in this study because there is no data regarding the number of days sales have not been paid.

9) Return on Supply Chain Fixed Cost (ROF)
Total Cost to Serve (TSCS) is the total cost required to deliver products and services to consumers. The total cost of service includes the cost of planning supply, the cost of planning raw materials and products, the cost of producing, and the cost of material delivery.

TCTS on the Sikatak bridge construction project is the total cost incurred in carrying out construction on various aspects, namely drainage, earthworks, road shoulders, granular work and structures. TSCS = Rp 13.790.927.314,24

$$\text{ROF} = \frac{\text{Supply chain revenue} - \text{Total cost to serve}}{\text{Supply} - \text{Chain fixed assets}} \text{x}100\%$$

$$\text{ROF} = \frac{\text{Rp } 16.190.239.861{,}15 - \text{Rp } 13.790.927.314{,}24}{\text{Rp } 13.192.123.143{,}93 - \text{Rp } 108.488.750} \text{x}100\%$$

$$\text{ROF} = 18{,}34\%$$

10) Return on Working Capital (RWC)
The ROW indicator was not used in this study because there was no data regarding accounts payable during the construction of the Sikatak bridge project.

Based on the validation carried out, there are only 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 values of these KPIs are shown in Table 3.

Table 3. KPI Actual Score

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

The value in Table 3 shows that the state of material delivery by the supplier to the project location with the percentage of quantity and quality delivered in accordance with the agreed specifications is good, while the return from the assets used and the cost of the supply chain used are in not good condition.

4.1 Analysis of Performance Measurement Variables

The indicators that will be used in this study are adjusted to the needs and availability of data in the project. Based on the data and information obtained from the Sikatak Bridge construction project, there are four indicators used in determining supply chain performance measures in the project, namely Perfect Order Fulfillment (POF), Total Supply Chain Management (TSCM), Cost of Goods Sold (COGS), and Return on Supply chain Fixed Cost (ROF). Indicators that are not used are Order Fulfillment Cycle Time (OFCT), Upside Supply chain Adaptability (USCA), Downside Supply chain Adaptability (DSCA), Overall Value at Risk (VAR), Cash to Cash Cycle Time (CTCCT), and Return on Working Capital (RWC). The USCA indicator is not used because the material orders on the project are not fixed because the material orders are adjusted based on the project's needs, so it difficult to calculate the certain of existing material orders. The DSCA indicator also cannot be counted, the DSCA practice in the Sikatak bridge construction project cannot be seen clearly. Again, the ordering of materials is in accordance with the needs of the work on the project, so it cannot be known with certainty the decline in the supply of raw materials. VAR is the total cost used to prevent the risks of each activity in the development project. The VAR indicator cannot be used because there is no data on the costs of each risk involved in the Sikatak bridge construction project. CTCCT is amount of time that needed by company for investment. The CTCCT indicator cannot calculated because there is no investment process in the project. ROW is the amount of relative investment to the company's working capital position with the income generated by a supply chain. The ROW indicator also cannot be considered because there is no investment process in the project.

5. Conclusion

This study uses the SCOR 12.0 method and focuses on level 1 metrics where there are 10 indicators of supply chain performance assessment. This study uses only four indicators because the determination of indicators is based on the needs of the project and the completeness of the data from the project. Based on the information obtained from the project, the indicators used in determining the measure of supply chain performance in the project are Perfect Order Fulfillment (POF), Total Supply chain Management Cost (TSCM), Cost of Goods Sold (COGS), and Return on Supply chain Fixed Cost (ROF).

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