Measurement of Supply Chain Management Performance on Toll Road Projects with Design and Build Contract Using SCOR and AHP Methods

A Case Study on Tebing Tinggi-Parapat Toll Road Section III Project

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Abstract. Infrastructure performance was a highlight in the World Economic Forum, thus encouraging countries worldwide, including Indonesia, to be motivated to accelerate the provision of infrastructure facilities. One of the infrastructures that continues to be improved is toll roads, and a design and build contract scheme is chosen, which in theory has the characteristics of a faster time in infrastructure provision. This project experienced delays caused by supply chain problems for the main materials, namely rebar and concrete. This study aims to measure the performance of supply chain management for rebar and concrete materials that cause project delays of 3.251%. The population in this study was 25 contractors who understood and were involved in the supply chain management process for rebar and concrete materials. This type of research is a descriptive causal study that uses a quantitative approach and uses SCOR and AHP as analytical tools. The results show that the supply chain management performance assessment for rebar and concrete materials is 64.36 out of a scale of 100. This indicates that the supply chain management performance in toll road construction projects is at an average level. This performance is much influenced by the scarcity of materials from suppliers at certain times and the design process that coincides with the construction period, causing long waiting times for adjusting the order quantity. Based on the AHP, it was found that the most dominant variables were Plan and Source. Thus, it can be concluded that the performance of delayed toll road construction projects is influenced by the performance of the rebar and concrete supply chain. For toll road projects with design and build contracts, the corrective steps must focus on Plan and Source so that the performance level increases and can avoid the risk of delays that are detrimental to service providers.

Keywords: Supply chain management · supply chain operations reference · analytical hierarchy process

1 Introduction

Infrastructure performance was in the spotlight at the World Economic Forum, which shows the competitiveness of each country, thus encouraging countries worldwide,

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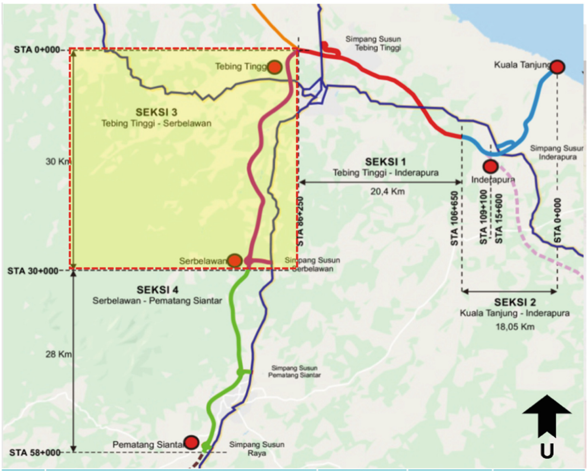

Fig. 1. Location of Tebing Tinggi-Parapat Toll Road Section III

including Indonesia, to be motivated to accelerate the provision of infrastructure facilities. One of the infrastructures that continues to be improved is toll roads, and a design and build contract scheme is chosen, which in theory has the characteristics of a faster time in infrastructure provision [1]. The Tebing Tinggi-Parapat Toll Road Project Section III is located in North Sumatra Province (Fig. 1), which connects the city of Medan with the Lake Toba tourist area. This project is targeted to be completed in a short time both for the design and construction processes, so a design and build contract was chosen.

In fact, this project experienced a delay of 3.251%. This study tries to examine the delay in project implementation from the supply chain management point of view. This is in line with previous research, which discussed that one aspect that affects construction project delays is contractor uncertainty in material procurement [2–5].

The construction supply chain is also the focus of De Souza's [6] research which stated that examples of repetitive construction supply chain problems are increased levels of non-conformance, delivery delays, and other supply disruptions. The construction industry is also known to have a high level of fragmentation and involves many parties in its supply chain [7]. The characteristics of the construction project supply chain are influenced, among others, by consumers, fragmentation, the number and type of stakeholders, buyer-supplier relationships, temporary multi-organizations, the type of make-to-order supply chain, collaboration opportunities, and repeated orders [8]. The characteristics of the construction supply chain cannot be separated from the description of the process in a construction project in general, which consists of the conceptual, procurement, production, installation, and completion phases.

The Tebing Tinggi-Parapat Toll Road Project Section III has the main type of work, namely concrete for both pavement and structural buildings. Concrete works can be detailed in terms of the supply chain related to iron and concrete (ready mix and precast), so it is important to conduct a supply chain management study on these aspects to avoid the risk of delays.

The method used to assess supply chain management is the SCOR (Supply Chain Operations Reference) issued by the Supply Chain Council on the SCOR model version 12.0 [9]. SCOR is an approach method for measuring supply chain performance, especially in a company.

As a reference model, the SCOR model is the starting point for representing, analyzing, and configuring supply chains with standard terminology for the purpose of benchmarking processes and extracting best practices from specific processes [8, 10].

Based on information obtained from monthly project reports up to the 26th period and interviews with stakeholders, it is known that the delay in the implementation of construction projects is also closely related to supply chain management of the main work, namely concrete and rebar, which can be seen in Table 1.

This study will examine the performance of supply chain management on delays in project implementation with a design and build contract scheme for toll roads so that the demands for completion must be on time without neglecting quality and cost factors. The process includes identification of supply chain aspects, providing an assessment of each of these aspects, considering design and build contract aspects of the supply

Table 1. The problem of supply chain management in toll road project

SCOR Indicator Performance	Supply Chain Management Problems
Plan	The number of detailed changes/revisions (DED) to the initial design (BD), which is the reference for a tender document by the contractor
	Full responsibility for the preparation of the DED by the contractor, which adds to the workload during the construction period
Source	Scarcity of cement and aggregate supply at ready mix concrete suppliers, resulted in delays in foundry work, idle workers, and additional equipment rental costs.
	Damage to the Batching Plant production machine at the ready-mix concrete supplier resulted in delays in foundry work, idle workers, and additional equipment rental costs.
Make	The high waste material due to the realization of work methods that are less than optimal
	Project Owner's delay in making payments to contractor
	The high intensity of complaints from Project Owners to contractor shows that some work is carried out with quality that does not meet the acceptance criteria
	The number of findings of work defects that result in rework and have an impact on the cost and time of completion of work
Deliver	The condition of the material delivery was delayed due to the late production process by the supplier and problems with the expedition
Return	The high intensity of material reject events shows that the supplier's performance has not been consistently good

chain and performance during the construction period, determining which supply chain management indicators need improvement and providing an overview of preventive steps that can be taken by the service provider to improve supply chain management performance so that the project can be completed on time as agreed in the contract in order to avoid fines for delays in the completion of work.

2 Research Methods

This research is a causal descriptive study that uses a quantitative approach where this research examines the performance of the material supply chain in toll road construction projects. Causal descriptive research is research conducted to investigate causal relationships by observing the effects that occur and the possible factors (cause) that cause these effects [11].

The location of this research is the Tebing Tinggi-Parapat Toll Road Section III project, where PT. Waskita Karya (Persero), Tbk acts as a contractor. This research focuses on supply chain performance aspects and their impact on the risk of delays in the implementation of the Tebing Tinggi-Parapat Toll Road Section III. The toll road project is carried out under a design and build contract for 730 calendar days and a maintenance period of 1.056 calendar days.

The population is the whole member or group that forms the object that is subject to investigation by the researcher [11]. The population of this research was personnel from service providers who understand and are involved in the supply chain management process for iron and concrete materials in the Tebing Tinggi-Parapat Toll Road Section III for a minimum period of 1 year. The number of respondents who met these criteria was 25 people. The sampling method used a saturated sample because all of the population will be taken as a sample [11].

3 Results and Discussion

Company data and a paired questionnaire based on the supply chain operations reference (SCOR) model were utilized in this study, which were processed using the Analytical Hierarchy Process (AHP) approach and calculated using the Expert Choice V11 tool.

3.1 Scoring

The Expert Choice V11 tool was used to score the paired questionnaire data. The following are the steps of data processing (weighting) that the Expert Choice program goes through: In the Expert Choice V11 program, build a file, a weighing hierarchy, a weighting data input, and a weighting result. Table 2 shows the results of the aforesaid weights organized in tabular style.

3.2 Performance Index Level 3

Multiplying the AHP level 3 weights with the performance value level 3 yielded the performance index level 3 value (Table 3). Calculation: Weight AHP Level 3 multiplied by Performance value level 3 equals performance index level 3.

Table 2. Performance Weighting Value

Process (Level 1)	Weight Level 1	Dimension (Level 2)	Weight Level 2	Performance Indicator (Level 3)	Weight Level 3
Plan	0,353	Reliability	0.572	Intensity of changes/revisions to the work plan	1.000
		Agility	0.428	Contractor participation in project planning	1.000
Source	0.221	Reliability	0.563	Supplier performance in meeting material delivery schedules	0.618
				Performance of heavy equipment suppliers in meeting heavy equipment rental schedules	0.382
		Agility	0.437	Owner participation in supplier selection	1.000
Make	0.229	Responsiveness	0.364	Percentage of materials used	0.385
				Owner's delay in payment to contractor	0.615
		Agility	0.300	The intensity of the obstacles during the execution of the work	0.233
				Intensity of coordination meetings between related parties	0.307
				Participation of subcontractors in project implementation	0.263
				The intensity of complaints from owners to contractors	0.197
		Reliability	0.336	Intensity of work defects	1.000
Deliver	0.142	Responsiveness	1.000	Grace time between order and delivery	1.000
Return	0.055	Reliability	1.000	Intensity of reject material	1.000

3.3 Performance Index Level 2

The performance index level 2 values were obtained by multiplying the AHP level 2 weights by performance values level 2 (Table 4). Calculation: Performance index Level 2 is AHP weight level 2 multiply by Final results level 2.

Table 3. Performance Index Level 3

Performance Indicator (Level 3)	Weight level 3	Performance Rating (Level 3)	Performance Index Level 3
Intensity of changes/revisions to the work plan	1.000	48.700	48.700
Contractor participation in project planning	1.000	100.000	100.000
Supplier performance in meeting material delivery schedules	0.618	71.800	44.372
Performance of heavy equipment suppliers in meeting heavy equipment rental schedules	0.382	62.800	23.990
Owner participation in supplier selection	1.000	100.00	100.000
Percentage of materials used	0.385	83.640	32.201
Owner's delay in payment to contractor	0.615	0.000	0.000
The intensity of the obstacles during the execution of the work	0.233	69.700	16.240
Intensity of coordination meetings between related parties	0.307	100.000	30.700
Participation of subcontractors in project implementation	0.263	100.000	26.300
The intensity of complaints from owners to contractors	0.197	76.500	15.071
Intensity of work defects	1.000	79.800	79.800
Grace time between order and delivery	1.000	55.300	55.300
Intensity of reject material	1.000	63.750	63.750

3.4 Value of Supply Chain Performance

The overall value of supply chain performance was calculated by multiplying the value of level one performance by the weight of level one AHP, and then adding the results to get the total value of firm performance (Table 5). Calculation: AHP weight level 1 multiplied by final outcomes of performance value level 1 equals supply chain performance value.

Then the value of the Supply Chain Management performance of the Tebing Tinggi-Parapat Section III Toll Road Project is 69.360. According to the supply chain management performance monitoring table, the supply chain management performance value of the Tebing Tinggi-Parapat Section III Toll Road Project is in the range of 50–70, and is rated as average in terms of SCM performance.

Table 4. Performance Index Level 2

Process (Level 1)	Dimension Level 2	Weight level 2	Performance Rating (Level 2)	Performance Index Level 2
Plan	Reliability	0.572	48.700	27.856
	Agility	0.428	100.000	42.800
Source	Reliability	0.563	68.362	38.488
	Agility	0.437	100.000	43.700
Make	Responsiveness	0.364	32.201	11.721
	Agility	0.300	88.311	26.493
	Reliability	0.336	79.800	26.813
Deliver	Responsiveness	1.000	55.300	55.300
Return	Reliability	1.000	63.750	63.750

Table 5. Value of Supply Chain Performance

Process (Level 1)	Weight level 1	Performance Rating (Level 1)	Performance Value SCM
Plan	0.353	70.656	24.942
Source	0.221	82.188	18.164
Make	0.229	65.027	14.891
Deliver	0.142	55.300	7.853
Return	0.055	63.750	3.506
		TOTAL	69.360

3.5 Traffic Light System

A traffic light system is a mechanism for analyzing a company's achievement of performance values based on its goals. The use of a traffic light system can be used to assess performance and determine if it fulfills the aim or needs to be improved. Each performance indicator is identified by three colors: red, yellow, and green in this traffic light system. The following is a description of the colors used in the traffic light system:

1. Red. The color red denotes that a company's performance has fallen short of its goals and has to be improved immediately. The indication with a performance value of 70 is highlighted in red.
2. Yellow. The yellow color denotes a company's success of a target that has not been met, although being close to the company's target. The indication with a performance value of $>$70 and 80 is colored yellow.

Table 6. Traffic Light System on SCOR

Process (Level 1)	Dimension (Level 2)	Performance Indicator (Level 3)
Plan	Reliability	The intensity of changes/revisions to the work plan
	Agility	Contractor participation in project planning
Source	Reliability	Supplier performance in meeting material delivery schedules
		Performance of heavy equipment suppliers in meeting heavy equipment rental schedules
	Agility	Owner participation in supplier selection
Make	Responsiveness	Percentage of materials used
		Owner's delay in payment to contractor
	Agility	The intensity of the obstacles during the execution of the work
		The intensity of coordination meetings between related parties
		Participation of subcontractors in project implementation
		The intensity of complaints from owners to contractors
	Reliability	The intensity of work defects
Deliver	Responsiveness	Grace time between order and delivery
Return	Reliability	The intensity of reject material

3. Green. The green hue shows that a company's performance has met the company's goals, but the company must still be able to maintain these goals. The indication with a performance value greater than 80 is colored green.

3.6 Overall Performance Analysis

Table 6 exhibits the traffic light system on the overall SCOR Model at Toll Road Project of Tebing Tinggi-Parapat Section III.

4 Conclusion

The study's findings show that: first, the AHP Method and Expert Choice V11 software are used to calculate the weighting of performance indicators; second, the results of supply chain management performance appraisal of Toll Road Project of Tebing Tinggi-Parapat Section III are 69.360, and the total performance appraisal achievement is in the average category. Second, based on the results of the SCOR description of the traffic light system, the following are the Toll Road Project of Tebing Tinggi-Parapat Section III priorities that must be improved immediately: The performance indicator for the owner's late payment to the contractor is the first priority; the intensity of changes/revisions to the work plan is the second priority; and the grace period between order and delivery is the third priority.

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