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Construction Supply Chain Performance Evaluation using The Supply Chain Operations Reference (Scor 12.0) (Case Study: Semarang-Demak Toll Road Project Package 2)

Nugroho Wahyu Jati[1*], Mochamad Agung Wibowo[1], Maulida Asri[1]

[1] *Department of Civil Engineering, Engineering Faculty, Universitas Diponegoro, Semarang, Indonesia*

[*)] Corresponding author(s)
E-mail: nugrohowahyujati@students.undip.ac.id

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Abstract

Inefficiencies in construction projects, aside from being caused by poor planning and control, are also attributed to delays in material delivery, especially for critical materials. One of the main causes of these delivery delays is suboptimal supply chain management. Therefore, it is essential to evaluate supply chain performance to identify and address these issues. Supply chain performance evaluation can utilize the SCOR 12.0 model, which has been widely applied in the manufacturing industry. A case study was conducted on the Semarang–Demak Toll Road Project Package 2, focusing on two key materials: precast full slabs and ready-mix concrete. The evaluation of supply chain performance employed the SCOR 12.0 model, which covers dimensions of reliability, responsiveness, agility, costs, and assets, as well as best practices implemented within the project. The research used a qualitative methodology, collecting data through questionnaires designed to assess supply chain performance indicators based on the SCOR 12.0 model, adapted for the construction context, and conducting interviews with project stakeholders and suppliers. The findings from the questionnaires and interviews were used to validate key performance indicators (KPIs), which were then scored on a Likert scale with five levels (5 = excellent, 4 = good, 3 = average, 2 = poor, 1 = very poor). The results of the supply chain performance assessment showed a score of 3.53 (good) for precast full slabs and a score of 3.8 (good) for ready-mix concrete.

Keywords: *Performance; Measurement; Construction Supply Chain; Supply Chain Operations Reference (SCOR) 12.0; Toll Road*

1. Introduction

The massive infrastructure development currently underway in Indonesia is closely tied to the Nawacita program initiated by President Joko Widodo at the beginning of his administration. Between 2015 and 2019, significant achievements were made, including the construction of 3,194 km of border roads, 1,387 km of toll roads, 811.9 km of railway tracks, 136 ports, 15 airports, 65 dams, and 12,184 kilometers of Palapa Ring fiber optic networks. These efforts continue into his second term (tempo.co).

The primary goals of accelerating infrastructure development include promoting equitable development, creating job opportunities, and boosting economic growth, which ultimately aim to enhance Indonesia's competitiveness on the global stage.

It is intriguing to observe that, particularly in the current toll road construction projects, Indonesia, as the world's largest archipelagic country with diverse landscapes, faces unique challenges and continues to experience significant inefficiencies in their implementation. The high levels of inefficiency in Indonesia are attributed to poor planning and control, lack of coordination, and delays in material delivery. Additionally, low efficiency is also caused by a high degree of fragmentation (Alwi et al., 2002). Competition in the construction industry does not only occur at the level of individual companies but also among supply chain networks. A poorly designed supply chain can significantly increase project execution costs (Wirahadikusumah & Susilawati, 2006).

To address the aforementioned issues, effective project management must be implemented. A key approach to resolving fragmentation problems is by analyzing the supply chain of the construction industry itself (Abduh et al., 2012). A well-structured supply chain can support the successful execution of a project. Therefore, a project requires a framework to evaluate the performance of the supply chain operating within it. One of the assessment models that can be utilized is the Supply Chain Operation Reference (SCOR) model, developed by the Supply Chain Council (SCC). SCOR, as a supply chain performance evaluation model, has been widely applied in the manufacturing industry (Sholeh et al., 2021; Rizkya et al., 2019; Fitrianto et al., 2020).

Based on the above explanation, the author is interested in studying the Semarang-Demak Toll Road Project Package 2, which is one of Indonesia's National Strategic Projects (PSN). This project features a combination of elevated and at-grade designs. For the elevated segment (slab-on-pile), precast full slabs are utilized, making precast full slabs and ready-mix concrete major items of work to be analyzed.

2. Materials and Method

2.1. Construction Project

A construction project is a series of activities aimed at achieving a specific goal (in the field of construction) within certain constraints of time, cost, and quality (Kerzner, 2009).

2.2. Supply Chain Management on Construction Industry

Projects in the construction industry require extensive time, labor, and materials (Syahri et al., 2017). This complexity leads to various challenges, such as high fragmentation, low productivity, wasted time and costs, and prolonged risks of conflict and disputes (Wibowo & Sholeh, 2015; Wibowo et al., 2019). The construction industry generates more waste compared to other industries globally. The most common and impactful type of waste in construction projects is "waiting for materials" (Purnatha, 2013). Material procurement within construction supply chain management plays a crucial role in determining the success of a project (Hardina, 2022).

According to the Supply Chain Management in the Construction Industry Module (Lovrenčić Butković et al., 2016) Supply Chain Management (SCM) has proven to be effective when applied in the construction industry, which has a high level of waste (Santoso et al., 2020). Construction Supply Chain Management (CSCM) is a strategy for managing the flow of information, activities, tasks, processes, and costs involving various organizations from upstream to downstream, delivering value to the owner in the form of a completed project.

2.3. Supply Chain Operations Reference (SCOR) 12.0

The Supply Chain Operations Reference (SCOR) model was first introduced by the Supply Chain Council (SCC) in 1997. SCC is an international, independent, non-profit association established in 1996, with open membership for all companies or organizations. SCC focuses on research, application, and various efforts to advance systems and practices in supply chain management (SCM). The SCOR model is an effective tool for evaluating and benchmarking supply chain activities and performance. This method provides a framework that integrates business processes, metrics, best practices, and technology into a unified system to support communication among supply chain suppliers, ultimately enhancing the effectiveness of a company's supply chain (APICS, 2017; Agnes et al., 2022; Fauzi et al., 2023). By using the SCOR model, an organization or company can assess the maturity of its supply chain processes and evaluate how well these processes align with business objectives. SCOR has been continuously developed, and as of now, the latest version is SCOR 12.0.

2.3.1. Supply Chain Operations Reference (SCOR) 12.0

SCOR is a process reference model. The purpose of a process reference model or business process framework is to define process architecture in a way that aligns with the identity, functions, and objectives of a business. The architecture here refers to how a process operates and interacts, how it is configured, and the competency requirements of the process staff (APICS, 2017) (1) Processes: Defines the standard business activities required to achieve specific supply chain objectives; (2) Performance Metrics: Provides key indicators to measure the effectiveness and efficiency of supply chain processes; (3) Best Practices: Offers proven methods and techniques to improve supply chain performance; and (4) People: Focuses on the skills and competencies necessary for personnel involved in the supply chain processes.

In the performance section of SCOR, the focus is on measuring and assessing the results of supply chain process execution. It provides a comprehensive approach to understanding, evaluating, and reviewing supply chain performance, consisting of three elements: Performance Attribute, Metrics, and Process/Practice Maturity. These elements, distinct from the levels in the Process and the hierarchy of Metrics, explain different aspects/dimensions of performance (APICS, 2017). The explanation of these three elements is as follows: (1)

Performance Attributes, Strategic characteristics of supply chain performance used to prioritize and align supply chain performance with business strategy; (2) Metrics, Discrete performance measurements that consist of levels connected to a hierarchy; and (3) Process Practices Maturity, Specific objectives and explanations used as a reference tool to evaluate how well supply chain processes and practices are integrated and executed, accepted as a best practice model. The performance attribute includes five dimensions: reliability, responsiveness, agility, cost, and asset.

2.3.2. Metric

Metrics are the performance measurement standards for the supply chain. SCOR metrics are diagnostic metrics (similar to those used in medical diagnostics). SCOR recognizes three levels of metrics, as follows (1) Metric Level 1, Metric level 1 is the "overall supply chain health diagnosis." This metric is also known as the strategic metric and KPI. Defining metric level 1 helps in setting realistic targets to support strategic goals; (2) Metric Level 2, Metric level 2 functions to "diagnose metric level 1." The diagnostic relationship helps identify the root cause or performance gap at metric level 1; and (3) Metric Level 3, Metric level 3 functions to "diagnose metric level 2."

Performance analysis of metrics from level 1 to level 3 is known as metrics decomposition, performance diagnosis, or root cause analysis of metrics. Metrics decomposition is the first step in identifying processes that require further investigation. In this research, only metrics decomposition up to level 2 is used to simplify and introduce the SCOR model, which is still unfamiliar in the construction industry, to contractors and suppliers.

2.4. Likert Scale

The assessment of performance or determining the value of a case has previously been a challenge in the research world. The Likert scale emerged as a solution, offering a measurement for character, personality, and later developed into a measurement for attitude scales (Boone Jr & Boone, 2012; Pranatawijaya et al., 2019). The Likert scale can be used to measure attitudes, opinions, and perceptions of individuals or groups about a social phenomenon (Sugiyono, 2017). This scale is used to complement questionnaires that require respondents to indicate their level of agreement with a series of questions, where the questions are specific and serve as research variables in a study.

2.5. Methodology

This study uses a qualitative method with a descriptive approach. Quantitative research is used to address problems that require an in-depth understanding in the context of time and relevant situations, conducted naturally and objectively, in accordance with field conditions, without manipulation, and the data collected is qualitative (pelajaran.co.id).

The research process begins with problem and objective formulation, followed by field studies (interviews and observations), literature review (supply chain management and SCOR), adaptation of SCOR 12.0 indicators to the construction context, data collection through questionnaires and best practice assessments, KPI validation, performance evaluation using the Likert scale, analysis and discussion, and concludes with recommendations.

3. Result and Analysis

3.1. Key Performance Indicators (KPI) Validation

The Key Performance Indicator (KPI) SCOR 12.0 is a supply chain performance measurement item based on the SCOR 12.0 model, consisting of customer-facing (intended for the project team) and internal-facing (intended for the supplier) indicators.

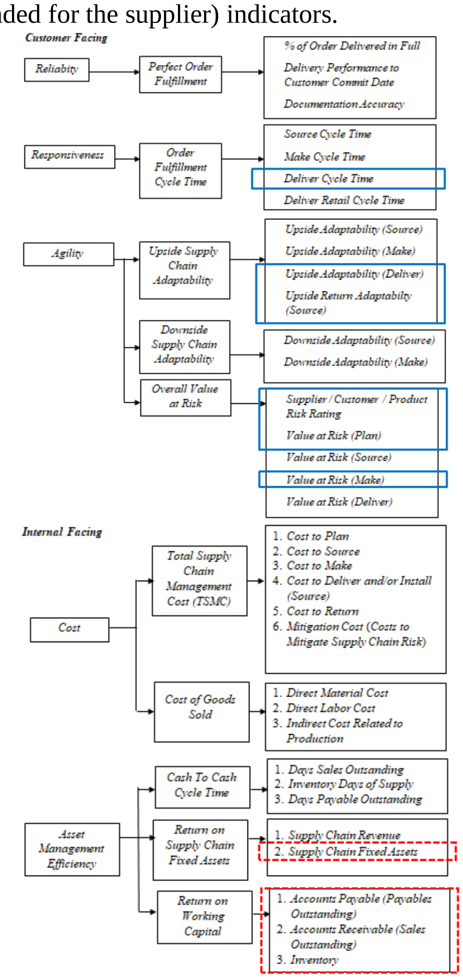

Figure 1. Recap of SCOR 12.0 KPI Validation

After validating the SCOR KPIs (level 1 to level 2) with both the project team and the suppliers (precast full slab and ready-mix concrete), different perspectives emerged regarding which indicators could or could not be used (see Figure 1).

3.2. Assessment of Vendor / Supplier Best Practices by The Project Contractor

In addition to the Key Performance Indicators (KPI) (level 1 to level 2) of the SCOR 12.0 model mentioned above, the project team (contractor) has its own assessment procedures for evaluating the performance of vendors/suppliers, which are called the Vendor Performance Index (VPI) and Vendor Satisfaction Index (VSI) (see Table 1).

Table 1. Parameters and KPIs of VPI

No	Parameters	KPI	Target	Weight %	Value	Score
				A	B	(A x B)
1	Quality	Accuracy of progress	280	35	Fill in a value with a range of 1-10 for each KPI	
2		Work quality result	280	35		
3	K3L/5R	K3L	120	15		
4		5R	60	7.5		
5	Safety	Safety Tools	60	7.5		
		Total	**800**	100		

The Vendor Performance Index (VPI) is an assessment conducted to evaluate the performance of each vendor/supplier on a monthly basis. This assessment is carried out from the time the vendor/supplier starts working until the completion of he job. Table 2 shows the parameters that are assessed.

Table 2. Parameters of VSI

No.	Assessment Parameters
1.	Opportunity offers
2.	Opportunity for clarification and negotiation
3.	Tender (open/closed)
4.	Payment term commitment according to the contract
5.	Field coordination (production)
6.	Communication with the implementation/project team
7.	Organizational openness / access to complaints
8.	Speed of response / decision making

The Vendor Satisfaction Index (VSI) is a survey used to assess the level of satisfaction of vendors/suppliers in their collaboration with the project team. This is conducted as part of an internal evaluation to improve professionalism and maintain good relationships with partners for the benefit of future projects. Table 3 show the factors that are assessed.

Table 3. Level of Satisfaction VSI

No.	Score	Category
1.	VSI < 25%	Very Dissatisfied
2.	VSI 26 – 60%	Less Satisfied
3.	VSI 60 – 80%	Satisfied
4.	VSI > 80%	Very Satisfied

The Vendor Satisfaction Index (VSI) is completed on an annual basis, and the VSI form is distributed to all active vendors/suppliers on the project.

3.3. Recap of Supply Performance Evaluation

After validating the KPIs with the project team and the suppliers, the performance scale and supply chain performance evaluation can be determined based on the data collected from the questionnaires, interviews, and other supporting data using the likert scale. The supply chain performance evaluation is conducted for each indicator according to the results of the KPI validation up to level 2 indicators. The results are then summarized and presented in Tables 4 and 5.

Table 4. Recap of Precast Full Slab Material Supplier Performance

No.	Indicators (Lv.1)	Score Range	Category	Actual Score	Level
1	Perfect Order Fulfillment	> 90%	Excellent	**99.68%**	**5**
2	Order Fulfillment Cycle Time	≤ 20 days	Excellent	**20**	**5**
3	Upside Supply Chain Flexibility	26 – 50 %	Average	**50%**	**3**
4	Downside Supply Chain Adaptability	26 – 50 %	Average	**27.67%**	**2.33**
5	Overall Value at Risk	0.16 – 0.30 %	Poor	**0.255%**	**2.5**
6	Total Supply Chain Management Cost	91 - 100 %	Poor	**97.09 %**	**2**
7	Cost of Goods Sold	81 % - 85 %	Good	**82.52%**	**4**
8	Cast to Cast Cycle Time	45 Days	Excellent	**45**	**5**
9	Return on Supply Chain Fixed Assets	2 – 3%	Average	**2.91%**	**3**
Total					**31.83**
Average = 31.83 / 9					**3.53**

Table 5. Recap of Beton Ready Mix Material Supplier Performance

No.	Indicators (Lv.1)	Score Range	Category	Actual Score	Level
1	Perfect Order Fulfillment	96 – 100%	Excellent	**99.69%**	**5**
2	Order Fulfillment Cycle Time	≤ 1 Days	Excellent	**42 minutes**	**5**
3	Upside Supply Chain Flexibility	26 – 50 %	Average	**50%**	**3**
4	Downside Supply Chain Adaptability	32 – 49 %	Average	**33%**	**3**
5	Overall Value at Risk	0.46 - 0.60 %	Good	**0.56 %**	**4**
6	Total Supply Chain Management Cost	91 % – 100 %	Poor	**96.77 %**	**2**
7	Cost of Goods Sold	≤ 80 %	Excellent	**72.47%**	**5**
8	Cast to Cast Cycle Time	45 Days	Excellent	**45 Days**	**5**
9	Return on Supply Chain Fixed Assets	4 – 5%	Good	**4.58%**	**4**
Total					**31.83**
Average = 31.83 / 9					**3.53**

3.4. Supply Chain Performance Assessment (Project Best Practice and SCOR 12.0 Model)

The project team actually has its own procedure for assessing vendor/supplier performance, namely through the Vendor Performance Index (VPI) and Vendor Satisfaction Index (VSI). In general terms, the relationship between VPI and VSI can be illustrated as in Figure 2.

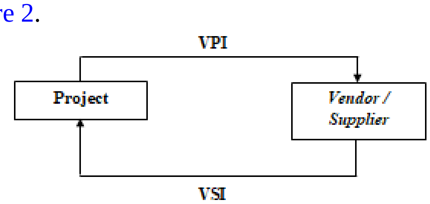

Figure 2. VPI and VSI Relationship

The project team evaluates vendor/supplier performance through the VPI, while the vendor/supplier provides feedback by conducting a customer satisfaction assessment for the project team (VSI). The VPI assessment parameters are relatively simple, consisting of quality, K3L/5R, and security. The quality parameter is also part of the SCOR 12.0 perfect order fulfillment indicator, while the K3L/5R and security parameters can be considered characteristic of the construction industry. In construction projects, which are a series of activities with constraints (such as time, quality, budget, location, etc.), enforcing K3L/5R and security becomes a unique challenge. It can be complex depending on the project location and must be addressed by the project team with all available resources. Evaluating construction supply chain performance using the SCOR 12.0 model approach can serve as an alternative to diagnose the root causes of supply chain issues in a project more thoroughly, enabling the project team to take appropriate preventive and corrective actions.

4. Conclusion

Based on the data analysis and discussion, this study concludes that the Supply Chain Operations Reference (SCOR) 12.0 model can be used to evaluate construction supply chain performance by adapting its operational definitions to construction applications. According to the SCOR 12.0 guidelines, the indicators are classified into customer-facing and internal-facing metrics, where customer-facing indicators are applied to the project team and internal-facing indicators to suppliers. The evaluation framework was developed through questionnaires, interviews, supporting documents, and previous studies to determine the highest and lowest values for each SCOR 12.0 indicator. Performance was assessed using a five-point Likert scale ranging from 1 (very poor) to 5 (excellent). The evaluation results showed that the supply chain performance was 3.53 (good) for precast full slab materials and 3.80 (good) for ready-mix concrete materials.

Despite the overall good performance, several supplier indicators were still rated poor. For precast full slab materials, the weak indicators were Overall Value of Risk and Total Supply Chain Management Cost, as suppliers only allocated risk costs for value at risk (make) and value at risk (return), while supply chain management costs accounted for 97.09% of the cost of goods sold, leaving a profit margin of only 2.91%. For ready-mix concrete materials, the poor-performing indicators were Total Supply Chain Management Cost and Return on Working Capital, with supply chain management costs reaching 96.77% of the contract value and a profit margin of only 3.63%, while the return on working capital was 104.8%. These conditions were mainly attributed to competitive pricing strategies adopted to maintain market share amid intense market competition and the impacts of the COVID-19 pandemic. Overall, the findings indicate that construction supply chain performance evaluated using the SCOR 12.0 model may vary depending on the project type and location.

5. Acknowledgment

From the results of the research conducted, it is recommended that future studies include a wider variety of construction materials to expand the references and further introduce the SCOR model in the construction industry. Additionally, the study could also be applied to other types of projects, such as buildings, dams, airports, and so on.

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