

SUPPLY CHAIN PERFORMANCE FOR LEAN CONSTRUCTION: A SCOR 14.0 EVALUATION OF A TOLL ROAD PROJECT

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ABSTRACT

The construction sector plays an important role in economic development, yet construction projects continue to face critical challenges in material procurement and supplier logistics. These challenges can delay material flows, disrupt project schedules, and weaken overall supply chain performance. This study evaluates supply chain performance in an Indonesian toll road construction project using the SCOR 14.0 framework to identify performance gaps and propose improvement strategies that support lean construction. The analysis focuses on supplier reliability, responsiveness, and agility from the contractor's perspective using the Objective Matrix (OMAX) and Traffic Light System. The results show that reliability was the strongest attribute across suppliers, while responsiveness and agility remained moderate, indicating weaknesses in delivery coordination, production responsiveness, and adaptation to demand changes. The findings suggest that SCOR 14.0 provides a useful project-level framework for evaluating multiple suppliers and identifying strategic recommendations to improve supply chain integration, reduce waste, and support workflow continuity.

KEYWORDS

Lean construction, supply chain management, supplier performance.

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INTRODUCTION

The construction sector plays a significant role in national economic development, contributing 2.18% to Indonesia's Gross Domestic Product (GDP) in the first quarter of 2025 (Statistics Indonesia, 2025). Infrastructure development in Indonesia, particularly toll road construction, has been prioritized to enhance connectivity and economic growth. However, toll road construction projects often face challenges related to material procurement and logistics from supplier, such as delivery delays, inconsistencies in material availability, and limited responsiveness to project schedule changes (Hardina et al., 2022; Ogundipe et al., 2024). This main issue can lead to the low productivity and various forms of waste, including delays, waiting time, rework, and inefficient material handling (Alwi et al., 2002; Wibowo & Sholeh, 2016).

These challenges were further intensified by site-specific constraints, including limited stockyard capacity at the project location. This constraint reduced flexibility in material handling and inventory management, increasing dependency on precise delivery timing. In addition, external factors also contributed to material delivery delays. Heavy traffic conditions and unpredictable weather caused deliveries to arrive later than scheduled, further reducing supply reliability. When these uncertainties are not properly managed, they increase the likelihood of material-related delays, waste, and negatively affect overall project performance. (Vrijhoef and Koskela, 2005).

Lean construction has been widely recognized as an approach that creates customer value by eliminating waste and promoting continuous improvement throughout the project lifecycle (Bajjou, 2019; Lello & Emuze, 2024). From this perspective, improving construction supply chains becomes a critical sub-principle of lean construction, as project delivery depends on the coordinated performance of multiple stakeholders involved in the flow of materials, equipment, and information (Pavón et al., 2025). High supply chain management performance supports lean objectives by enabling smoother logistics flow, reducing unnecessary inventory, and ensuring that only the materials and equipment required for the construction process are available when needed (Bajjou, 2019).

In achieving a high supply chain performance, it is necessary to evaluate the overall supply chain performance and strengthen the coordination among suppliers, contractors, and customers (Wibowo et al., 2025). The Supply Chain Operations Reference (SCOR) model has been widely acknowledged as an effective framework for evaluating and benchmarking the link between supply chain activities and performance (ASCM, 2022). Pan et al (2010) further highlighted in his previous work that using SCOR model to evaluate the supply chain performance helps the contractor to improve inter-organizational communication and support the project managers in identifying bottlenecks and developing continuous improvement strategies.

Previous studies have applied the Supply Chain Operations Reference (SCOR) model to measure supply chain performance in construction projects, enabling researchers and practitioners to assess how effectively supply chain management has been implemented and to identify areas for improvement. Thunberg and Persson (2014), for example, used SCOR to evaluate supplier reliability and construction-site responsiveness in a single nursing home project in Sweden. Other studies examined SCOR dimensions such as reliability, responsiveness, flexibility, cost, and asset performance in similarly limited contexts, including a highway project (Wibowo & Sholeh, 2015) and a factory construction project (Ramadian & Amrina, 2019). Marzuqi and Abma (2024) more specifically assessed customer-facing performance through reliability, responsiveness, and agility attributes, but their analysis was confined to the ready-mix concrete supply chain in a single building project.

More recently, Wibowo et al (2025) applied SCOR 14.0 to evaluate supply chain performance in two building projects. Their study showed that SCOR can be used to identify waste and formulate comprehensive improvement strategies in construction supply chain

systems to support lean construction. However, their measurement focused primarily on sustainability attributes, particularly environmental and social aspects, in projects involving the same supplier. Despite the growing use of SCOR model in construction, in-depth case studies applying SCOR 14.0 to evaluate the customer-facing performance of multiple parallel suppliers from the contractor's perspective remain limited. Therefore, this study aims to evaluate the supplier performance using the SCOR 14.0 framework from a customer-facing perspective. Using a case study approach in an Indonesian toll road construction project, this study helps contractors eliminate waste and improve supply chain flow by identifying supplier performance gaps and determining improvement priorities to enhance construction supply chain performance.

HOW SCOR-BASED SUPPLY CHAIN PERFORMANCE SUPPORTS LEAN CONSTRUCTION

Lean construction and supply chain management are two different approach to improve supply chain efficiency (Guo & Mantravadi, 2025). Bajjou (2019) argued that supply chain management, together with supplier involvement and supplier development, is necessary to achieve optimal logistics flow, reduce unnecessary inventory, and ensure that only the required materials and equipment are available during the construction process. This shows that improving supply chain performance is one of the practical ways to support lean construction implementation.

Because supply chain performance plays an important role in supporting lean objectives, an appropriate framework is needed to evaluate how effectively the construction supply chain contributes to project delivery. The Supply Chain Operations Reference (SCOR) model has been widely recognized as a fundamental framework for evaluating and improving supply chain management performance in construction projects (Ahmad & Susanty, 2019; Marzuqi & Abma, 2024; Ramadian & Amrina, 2019; Thunberg & Persson, 2014; Wibowo et al., 2019, 2025).

SCOR provides a standardized definition of supply chain processes, making it easier to identify bottlenecks, compare performance, and determine where lean approach can be applied within supply chain activities. In general, the SCOR model evaluates supply chain effectiveness through three main elements, namely performance attributes, metrics, and processes (ASCM, 2022). In addition, SCOR performance attributes can be grouped into customer-facing, internal-facing, and outward-facing. Among these categories, the customer-facing view is the most relevant to this study because it reflects how well suppliers fulfill project requirements from the contractor's point of view. In this perspective, supply chain performance is represented by three main attributes, namely reliability, responsiveness, and agility (ASCM, 2022).

The first SCOR attribute, reliability, refers to the supplier's ability to fulfill project requirements accurately and consistently, including order fulfillment, on-time delivery, and the provision of materials in the required condition (Guo & Mantravadi, 2025). From a lean construction perspective, reliability contributes directly to planning and scheduling, because reliable supply enables construction activities to proceed according to plan. High reliability also strengthens supply flow (Adewale et al., 2024; Kim & Ballard, 2025), and supports waste elimination by reducing delays, material defects, rework, and unnecessary inventory. As a result, reliability also helps meet project needs in line with the expected customer value (Bajjou, 2019).

The second attribute, responsiveness, measures the speed of the supply chain in processing and fulfilling customer orders, from ordering to delivery (Guo & Mantravadi, 2025). This attribute supports lean construction by enabling project activities to continue without unnecessary delay, thereby reinforcing planning and scheduling. Responsiveness also contributes to waste elimination, since a more responsive supply chain can reduce lead time and cycle time, minimize waiting, and prevent disruptions in project execution (Bajjou, 2019).

The third attribute, agility, refers to the supplier's ability to respond and adapt to change under dynamic project conditions. In lean construction, agility is closely related to continuous improvement, because an adaptive supply chain is more capable of adjusting to changing project requirements and improving its response over time. Agility also supports planning and scheduling, since changes can be accommodated without causing major disruption to the project schedule, and it reinforces supply by maintaining continuity under uncertain conditions (Bajjou, 2019). In addition, agility contributes to waste elimination by minimizing material and resource waste and reducing inefficiencies caused by disruptions, sudden changes, and delayed adjustments (Mohamed et al., 2023)

Reliability, responsiveness, and agility show that customer-facing supply chain performance is closely linked to the implementation of lean construction principles. Therefore, evaluating these attributes through the SCOR framework is not only useful for assessing supplier performance, but also for understanding how far the supply chain supports lean objectives in construction projects.

RESEARCH METHODOLOGY

This study adopts a case study approach to evaluate the customer-facing dimension of supply chain performance based on the SCOR 14.0 framework. A total of 18 performance indicators were selected to represent the customer/external-facing attributes of the supply chain. The empirical analysis was conducted on an Indonesian toll road construction project executed by a leading national contractor (Contractor A). The following is the SCOR 14.0 framework used in this study, as presented in Figure 1.

This study applies three SCOR 14.0 performance attributes, operationalized into 4 KPIs and initially defined by 18 sub-KPIs. Indicator applicability for precast concrete piles with a diameter of 80 cm was validated through a data availability questionnaire completed by the contractor A to assess the performance of three suppliers: Supplier A, B, and C.

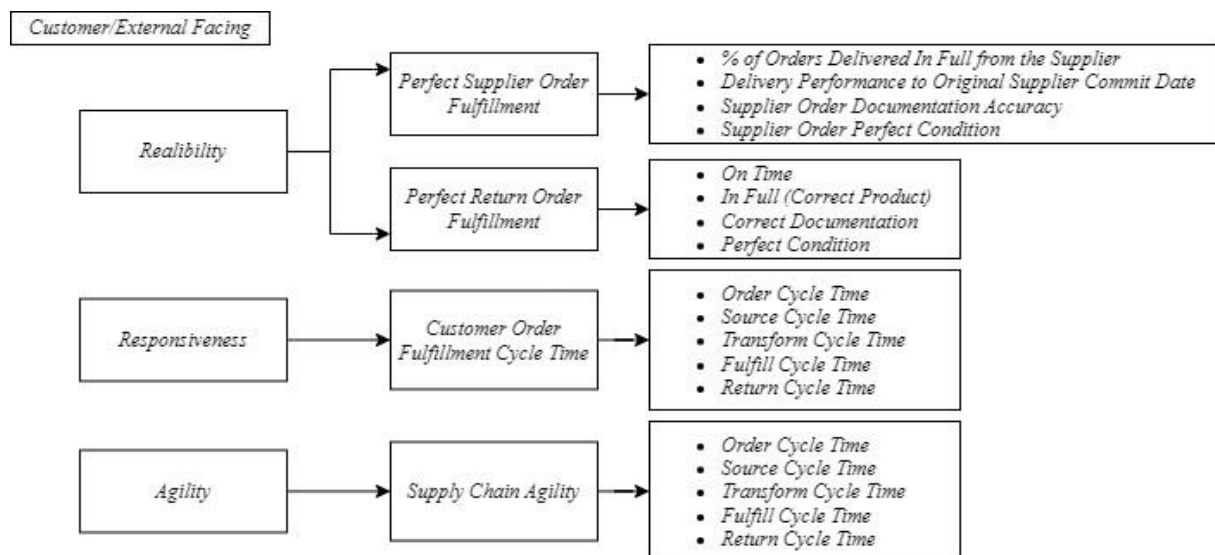


Figure 1: SCOR 14.0 Framework (ASCM, 2022)

VALIDATION OF THE SUPPLY CHAIN PERFORMANCE FRAMEWORK

The supply chain framework was validated through primary data collection using structured questionnaires to capture actual practices at the project level. Material-related information, including material names, units, quantities, unit prices, and total costs to identify priority materials based on their cost contribution to the project. Precast concrete piles with a diameter

of 80 cm were selected as the primary object of analysis due to their dominant share in total material cost.

A questionnaire based on 18 sub-indicators from the SCOR model was administered to a key expert from the selected contractor's engineering staff. The respondent was chosen due to their strategic involvement in procurement, budget control, contract administration, and supplier coordination, ensuring direct and comprehensive insight into project supply chain activities. Each sub-indicator was evaluated in terms of data availability ("available" or "not available") and feasibility ("feasible" or "not feasible"). Only sub-indicators with available or feasibly obtainable data were retained for further analysis to ensure the reliability and applicability of the assessment.

ASSESSING THE SUPPLY CHAIN PERFORMANCE BASED ON SCOR 14.0

Following the development of the supply chain performance framework, primary data were collected through structured questionnaires administered to a key expert from the contractor's commercial staff. The collected data included minimum, standard, target, and actual values for each SCOR performance indicator. This data was further analysed using the Objective Matrix (OMAX) method which has been widely adopted in previous works as a scoring approach for evaluating supply chain performance (Sarasi et al., 2025; Sukendar et al., 2018; Wibowo et al., 2025; Wibowo & Sholeh, 2015). The steps as follow:

1. Construction of the OMAX Scale

Each performance indicator data was transformed into a 0–10 scale using a three-point reference system consisting of minimum ($S_{\min}$), standard (S_{std}), and target (S_{target}) values. In this study, score 0 represents the minimum acceptable performance, score 3 represents the standard or baseline performance, and score 10 represents the target or desired performance. To capture performance progression more realistically, a dual-segment interpolation approach was applied. The intermediate values were calculated using linear interpolation. For scores between 0 and 3, the intermediate values calculated using Eq. (1) and for scores between 4 and 9, the intermediate values calculated using Eq. (2).

$$S_i = \frac{(S_{\text{std}} - S_{\min})}{3}, i = 1, 2 \quad (1)$$

$$S_i = \frac{(S_{\text{target}} - S_{\text{std}})}{7}, i = 4, 5, \dots, 9 \quad (2)$$

2. Scoring of Actual Performance

Actual performance values were mapped onto the constructed OMAX scale using linear interpolation to obtain standardized scores for each indicator. To facilitate interpretation, performance levels were classified using a traffic light system to classify performance levels by using three warning categories. The green color (level 8 - 10) indicates that the performance attained its maximum level. The yellow color (level 4 - 7) indicates that the performance attained its average level. The red color (level 0 - 3) indicates that the performance attained its minimum level (Sukendar et al., 2018). The overall performance score was calculated as shown in Eq (3).

$$\text{OMAX Score} = \sum_{i=1}^n w_i \times s_i \quad (3)$$

where w_i is the weight of indicator i , and s_i is the corresponding OMAX score.

RESULT AND DISCUSSION

SUPPLY CHAIN PERFORMANCE FRAMEWORK

The validation results indicate that two sub-indicators, *Supplier Order Documentation Accuracy* and *Return Agility*, were excluded due to data confidentiality and privacy constraints within the company. Therefore, the final performance evaluation in this study is conducted using three SCOR attributes, four KPIs, and 16 validated sub-KPIs.

SUPPLY CHAIN PERFORMANCE SCORE

Supply chain performance score for precast concrete pile materials was conducted using OMAX method based on SCOR 14.0 framework.

Calculation of the Supply Chain Performance Score

Supply chain performance was evaluated for three suppliers, Supplier A, Supplier B, and Supplier C, using the OMAX method. As an illustrative example, the performance assessment of Supplier A is presented through the *Perfect Supplier Order Fulfillment* KPI under the reliability attribute. This KPI was measured using three sub-KPIs: *Percentage of Orders Delivered in Full from the Supplier* (RL 2.5), *Delivery Performance to Original Supplier Commit Date* (RL 2.6), and *Supplier Order Perfect Condition* (RL 2.8). For example, *Delivery Performance to Original Supplier Commit Date*, was calculated as shown in Eq. (5), resulting in a score of 67%.

$$RL\ 2.6 = \frac{\text{Total number of orders delivered in full and on time}}{\text{Total number of orders delivered}} \times 100\% \quad (4)$$

$$RL\ 2.6 = \frac{2,086}{3,104} \times 100\%$$

$$RL\ 2.6 = 67\%$$

Table 3: Calculation of Perfect Supplier Order Fulfillment for Supplier A using OMAX

Metric		% of Orders Delivered in Full From the Supplier	Delivery Performance to Original Supplier Commit Date	Supplier Order Perfect Condition
Metric		100,00%	67,00%	99,80%
Performance Level	10	100,00%	100,00%	100,00%
	9	99,29%	99,29%	99,29%
	8	98,57%	98,57%	98,57%
	7	97,86%	97,86%	97,86%
	6	97,14%	97,14%	97,14%
	5	96,43%	96,43%	96,43%
	4	95,71%	95,71%	95,71%
	3	95,00%	95,00%	95,00%
	2	90,00%	90,00%	90,00%
	1	85,00%	85,00%	85,00%
	0	80,00%	80,00%	80,00%
Score		10	0	9
Weight		0,143	0,143	0,143
Value (OMAX)		3,33	0	2,997

After the SCOR 14.0 performance data had been obtained, the values were processed using the OMAX method combined with the Traffic Light System, as shown in Table 3. For the *Percentage of Orders Delivered in Full from the Supplier* sub-KPI, the target, standard, and minimum values were set at 100%, 95%, and 80%, respectively. Based on these reference values, the OMAX matrix was constructed using two linear intervals. The lower interval, between the minimum and standard values, as shown in Eq. (5), means that each score increase corresponds to a 5% improvement. While the upper interval, between the standard and target values, as shown in Eq. (6), indicates increments of 0.71% per score level.

$$S_{1-2} = \frac{(95\% - 80\%)}{3} = 5\% \quad (5)$$

$$S_{4-9} = \frac{(100\% - 95\%)}{7} = 0.71\% \quad (6)$$

Using this scale, the actual values of the three sub-KPIs were converted into OMAX scores. The first sub-KPI, with an actual value of 100%, reached the maximum score of 10. The second sub-KPI, with an actual value of 67%, fell below the minimum threshold and therefore received a score of 0. The third sub-KPI, with an actual value of 99.8%, was assigned a score of 10 because it was within the highest performance range.

Each sub-KPI was then multiplied by its corresponding weight (all sub-KPIs were assigned equal weights), resulting in weighted OMAX scores of 1.43, 0, and 1.43, respectively. The aggregated values of the sub-indicators and indicators represent the overall level of the performance attribute. Based on this evaluation, the reliability of Supplier A was categorized at level 9, indicating a high level of performance.

The SCOR-based performance evaluation reveals distinct variations among the three suppliers in terms of reliability, responsiveness, and agility. Overall, the results indicate that each supplier contributes differently to the overall performance of the piling material supply chain, with specific weaknesses that collectively contribute to the moderate supply chain responsiveness observed at the project level.

Table 4: Supply Chain Performance for Supplier A, B, and C

Attributes	Indicators	Supply Chain Performance		
		Supplier A	Supplier B	Supplier C
Reliability	Perfect Supplier Order Fulfillment	Level 9	Level 9	Level 9
Responsiveness	Perfect Return Order Fulfillment	Level 8	Level 8	Level 6
	Customer Order Fulfillment Cycle Time			
Agility	Supply Chain Agility	Level 4	Level 6	Level 7

Analysis of Reliability Performance Score

Among the three suppliers, Supplier A demonstrates a delivery performance of 67%, higher than Supplier B (56%) but lower than Supplier C (87%). The low reliability values, especially for Supplier A and B, suggest recurring issues with on-time delivery against the committed schedule. According to interviews with the contractor's commercial division, these delays were mainly caused by traffic congestion, unpredictable weather, and poor route planning. This confirms prior studies that highlight how deficiencies in material delivery directly disrupt construction processes and degrade overall project performance (Thunberg & Persson, 2014). In addition, limited coordination between supplier logistics scheduling and project demand timing further contributed to late arrivals of piling materials. Insufficient synchronization between supplier dispatch planning and project site readiness resulted in frequent rescheduling

of deliveries. This condition reflects a myopic control of the construction supply chain, where actors focus on optimizing their own activities without considering downstream impacts (Vrijhoef & Koskela, 1999). As highlighted by Pan et al. (2010), effective construction supply chain management requires proper coordination and integration of logistics processes to improve productivity and reduce inefficiencies.

Additionally, for Supplier C, although reliability is relatively better, it remains below the target level due to material defects (order perfect condition at 99.2%). The defect due to external logistics disruptions including heavy traffic congestion, weather-related road closures, and limited transport capacity. Additionally, coordination gaps between supplier dispatch schedules and the contractor's on-site readiness contribute to minor mismatches in delivery timing. These factors indicate that Supplier C's reliability challenges are not rooted in production or quality issues but in logistics management and delivery synchronization, which must be improved to achieve consistently high reliability levels. These findings confirm prior studies indicating that effective supply chain management can optimize material flow, improve inventory management, and enhance supplier collaboration, while also supporting lean principles within the supply chain. Furthermore, previous research suggests that digital tools providing real-time visibility, tracking, and data integration can further strengthen these processes (Adewale et al., 2024).

Analysis Responsiveness Performance Score

In terms of responsiveness, Supplier A records a fulfill cycle time of 7 days, while Supplier B performs better in the fulfill phase at 4 days but exceeds the transform target with 15 days. Interviews suggest that delays in both suppliers are driven by transport scheduling problems, limited transport capacity, insufficient coordination, and shipment consolidation practices aimed at reducing costs, which ultimately extend delivery times. In addition, the lack of real-time communication with the contractor slows delivery confirmation and document approval.

For Supplier B in production rescheduling delays, limited transport capacity, and lack of real time communication between Supplier B and the contractor. Interviews revealed that material dispatching was often postponed due to vehicle queueing at the loading area and inconsistent confirmation of delivery readiness. Furthermore, the supplier's focus on cost optimization through consolidated shipping often led to extended delivery lead times.

Supplier C shows the lowest responsiveness, with a transform cycle time of 20 days, due to limited manufacturing resources, poor coordination among internal units, batch-based production, and delivery constraints related to vehicle availability and road access. These issues collectively cause delays in order fulfillment, reducing the supplier's ability to respond promptly to project demand fluctuations.

Consequently, all three suppliers demonstrate suboptimal responsiveness, particularly in inefficient transportation costs, lack of real-time coordination between supplier and contractor, directly reducing overall supply chain agility and delaying project schedules. These findings confirm prior studies that nowadays supply chain are complex and faces many challenges, such as high cost and poor collaboration between partners. Furthermore, previous research suggests the implementation of digital twin to provide real-time collaboration leading to reduced lead time and cycle time (Guo & Mantravadi, 2025; Thunberg & Persson, 2014). This potential idea has acknowledged for cost optimization in associated with the lean principles (Guo & Mantravadi, 2025).

Analysis of Agility Performance Score

Agility indicators show relatively stable but non-optimal performance across all suppliers. Supplier A records source, transform, and fulfill agility values at 40%, 40%, and 20%, each meeting the standard threshold but still below target levels. These results suggest that Supplier A's responsiveness to changes remains limited and primarily reactive. Several factors

contribute to this condition, including rigid production scheduling that makes it difficult to adjust manufacturing processes quickly, dependency on single-source raw material suppliers, and restricted capacity flexibility when facing increased or urgent demand. In addition, communication gaps and delayed decision-making between the supplier and contractor reduce the speed of response to order adjustments.

Supplier B achieves slightly better results, with order agility at 51% (above standard), though source and transform agility remain moderate. Supplier B can manage demand reductions or adjustments with some flexibility but struggles with rapid operational adaptation. Several factors contribute to this limitation, including rigid production planning, where adjustments require advance approval; dependency on a limited number of raw-material sources, which constrains alternative sourcing and slow decision-making coordination between the supplier and the contractor when order quantities or schedules change. In addition, logistics arrangements are optimized for stable orders, reducing responsiveness to sudden variations.

Supplier C maintains agility levels around 42%, satisfying the standard but far from the target range. These values suggest that while the suppliers maintain a baseline ability to respond to fluctuations in demand, their adaptive capabilities remain limited, particularly in sourcing and transformation activities. The primary challenges include semi-fixed production capacities and limited sourcing flexibility. Furthermore, decision-making processes remain hierarchical and slow, delaying responses to sudden order revisions or schedule adjustments. From the logistics perspective, the supplier relies on pre-scheduled shipping arrangements instead of dynamic routing or real-time rescheduling, reducing its capacity to handle last-minute project demands.

The findings highlight that all three suppliers face inflexibility in many changes, such as rigid production planning and adjustments, limited raw material sources, and slow decision-making coordination between partners. These findings confirm prior studies that agility needs a strategic risk planning which promotes a flexible structure that leads to just-in-time approach and adaptability. Furthermore, top management support to develop a information sharing infrastructure to support collaboration also increases the agility of the supply chain (Ghufran et al., 2022).

STRATEGIC RECOMMENDATION

The analysis reveals three SCOR attributes categorized as having low performance Supplier A and Supplier B, and one attribute for Supplier C. Therefore, improvement strategies were developed through project stakeholder interviews and literature review, ensuring both practical relevance and theoretical grounding. The proposed recommendations are presented in Table 3.

Table 3: Strategic Recommendation for Supplier A, B, and C.

Attributes	Supplier	Priority sub-indicator	Main Cause	Strategic Recommendations
Reliability	A, B	Delivery Performance to Original Supplier Commit Date (RL 2.6)	Heavy traffic conditions, traffic accidents, and muddy road access to the site	Optimization of delivery routes and schedules through the selection of routes with minimal traffic congestion and the avoidance of rainy periods where possible, Scheduling of deliveries outside peak traffic hours, Insurance of shipments and ensuring the proper condition of drivers and heavy equipment
Responsiveness	A, B, C	Fulfill Cycle Time (RS 2.4)	the site during rainfall	
	C	Transform Cycle Time (RL 2.3)	Slow and weather-dependent production processes, Delayed raw material procurement	Utilization of technology to accelerate production processes without compromising quality, acceleration of raw material procurement through supplier diversification, improvement of interdepartmental coordination (production, procurement, and logistics)
Agility	A	Source Agility AG (2.2)	Mismatch between project plans and on-site conditions	Implementation of detailed and comprehensive site surveys to ensure accurate material ordering without shortages or excesses
		Transform Agility (AG 2.3)	Limited production capacity of Supplier A's Bogor plant	Allocation of material production to PT Supplier A's factory closest to the project site to meet additional material demand
	B	Fulfill Agility (AG 2.4)	Slow procurement and delivery processes, Inflexible production processes	Simplification of procedures to improve procurement and distribution speed, adjustment of production capacity to accommodate fluctuating demand

CONCLUSION

This study evaluated the performance of the construction supply chain for the toll road construction project using the SCOR 14.0 model, focusing on customer-facing consisting of three key performance attributes: reliability, responsiveness, and agility. The assessment involved three main suppliers of piling materials, whose performance was analysed through the OMAX and traffic light system based on contractor evaluations.

Among the three attributes, reliability appeared to be the strongest. All of the suppliers generally have a good performance in reliability with the green level of nine. All suppliers demonstrated the ability to fulfil orders accurately and maintain material quality according to contractual specifications. However, common constraints were founded in on-time delivery performance, which remains affected by external factors such as transportation bottlenecks,

traffic congestion, and weather conditions. This finding highlights that supply reliability issues are mainly associated with logistics coordination and delivery synchronization rather than production or quality capability.

A different picture emerged in responsiveness. Supplier A and Supplier B remained in the green category at level 8, while Supplier C fell into the yellow category at level 6. This variation suggests that meeting production and order processing targets alone was not sufficient to ensure a responsive supply process. Delays in the transform and fulfil cycle were still evident, particularly when production schedules were rigid, transport capacity was limited, and coordination across actors was not supported in real time. Under project conditions that demand quick adjustment, these weaknesses become more visible.

Agility showed the clearest performance gap. Supplier A was positioned at level 4, while Supplier B and Supplier C reached levels 6 and 7, both still within the yellow category. Compared with reliability, this attribute points more directly to the suppliers' limited capacity to respond to changes rather than to maintain routine performance. While normal operations could still be handled adequately, fluctuations in material demand and project schedule changes exposed the lack of flexibility in production planning, sourcing alternatives, and internal decision-making. This makes agility the most critical area for improvement among the three SCOR attributes assessed in this study.

These findings indicate that supply chain performance constraints in construction projects stem not from supplier incompetence, but rather from fragmented coordination and minimal integration between stakeholders. Therefore, from a strategic perspective, contractors need to shift their role from conventional "order managers" into "supply chain integrators". When several suppliers operate in parallel, the contractor becomes central in linking delivery schedules, project demand, and communication among stakeholders. Stronger integration in these areas would likely support faster response to change, greater flexibility, and more dependable material flow during project execution.

This study contributes to construction supply chain management by showing how the SCOR 14.0 framework can be operationalized at the project level to evaluate the performance of multiple parallel suppliers from a customer-facing perspective. In contrast to earlier studies that tend to focus on single suppliers or narrower project settings, this study offers a more structured comparative evaluation through the use of OMAX, allowing specific performance gaps to be identified across reliability, responsiveness, and agility. The study also contributes to the Lean Construction discussion by demonstrating that improvements in supplier coordination, delivery synchronization, and adaptive capacity are closely related to waste reduction, workflow continuity, and more reliable just-in-time material flow. In this way, the study provides both a practical evaluation approach for contractors and empirical support for the use of SCOR-based performance measurement in Lean Construction implementation within complex infrastructure projects.

The findings of this study need to be read within the limits of the case itself. Since the analysis was confined to a single toll road project and centered only on customer-facing attributes, it cannot yet explain whether similar patterns would appear across other projects or under different supply chain conditions. This opens an important direction for further research. A useful next step would be to assess supplier performance from a contractor-level perspective, particularly to examine consistency across multiple projects. Another issue that still deserves closer attention is how SCOR performance attributes contribute into lean construction outcomes in practice. It is also important to test quantitatively whether SCOR performance attributes are associated with lean construction outcomes, including waste reduction, workflow continuity, and project efficiency. In a broader sense, this area of research could also be strengthened through digital support systems that improve visibility and coordination among supply chain actors.

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