Performance Measurement in Supply Chain Using SCOR Model in The Lithium Battery Factory

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Abstract: The research aim is to measure the performance of supply chain in the UNS Lithium Battery Factory using the SCOR model in order to determine an improvement plan for the company. The battery supply chain performance is measured using the SCOR model with following steps: (i) identifying supply chain performance metrics, (ii) validating metric level 1 as KPI, (iii) performance measurements using metrics level 1 and level 2 and (iv) normalization using Snorm de Boer formula. Based on the monitoring system of the performance indicators, the performance of reliability and cost is categorized in good while the performance of responsiveness, agility, and asset management efficiency is categorized average.

1. Introduction

The UNS Lithium Battery Factory is the first lithium battery manufacturing with independent production processing in Indonesia and has been able to produce commercially with a capacity of 1,000 cells per day. The UNS Lithium Battery Factory produces 2 types of lithium batteries, namely Lithium Ferro Phosphate (LFP) and Nickel Cobalt Aluminum (NCA) which have a voltage of 3.2 volts and 3.6 volts, with a capacity of 1400 mAh and 2700 mAh respectively. This lithium battery is marketed through the business to the business scheme, where the battery buyer company will process it further by assembling the battery cell into a battery module. This module can be applied to electric motors, electric cars, and others. Lithium Battery Factory manufactures lithium batteries with production systems both Make To Order [1].

The UNS Lithium Battery Factory has just been running commercially for 2 years so it can be categorized as a startup company. The company will strive to achieve the best performance in order to be able to compete and survive in the battery industry. Performance measurements need to be conducted on the supply chain system of the UNS lithium battery factory. In this case, the battery supply chain involves several entities consisting of 2 suppliers of raw materials, a shipping company from supplier to factory, UNS Lithium Battery Factory, freight delivery company from the factory to customer and customer itself.

Supply chain management (SCM) is defined as an approach that is used to integrate all supply chain entities efficiently so that production and distribution of goods are in the right amount, the right location, and the right time to minimize overall system costs and fulfill all needs at every level [2]. There are several methods to measure the performance of the supply chain, including the Balanced Scorecard, Activity Based Costing, Multi-Criteria Analysis, Economic Value Added, Life-Cycle Analysis, and the Supply Chain Operations Reference (SCOR) model. This study uses SCOR to measure the supply chain performance of the UNS Lithium Battery Factory.
SCOR was introduced by the Supply Chain Council (SCC), an independent, non-profit global company interested in implementing and developing sophisticated supply chain technology in management systems and practices. SCOR is a reference model with standard terminology and processes that serves as a benchmark for operational measurements by creating a portfolio of priority improvements related to the company’s financial statement to improve performance and revenue [3]. The SCOR model excels because of its balanced approach as a reference model with the ability to integrate business process reengineering, benchmarking, and best practices into supply chain frameworks in various attributes [4].

Since the company or researchers have never measured the company performance, especially the supply chain area while the company has been operating for 2 years. So that it is important to measure supply chain performance for the company. Measuring supply chain performance at the UNS Lithium Battery Factory by using SCOR 11.0 to support developing companies, design goals, evaluate performance and determine future steps. Based on the previous description, the purpose of this research is to measure the performance of the supply chain in the UNS Lithium Battery Factory using the SCOR model in order to determine an improvement plan so that the company can survive and compete with other competitors.

2. Literature Review
SCOR is a reference model used to measure supply chain performance. The SCOR model was developed by the SCC which is a global non-profit consortium by having methodologies, diagnostics and benchmarking tools to help companies develop rapid improvements in the supply chain activities. SCC developed the SCOR to analysis and compare the supply chain process and performance. The SCOR model was developed by providing a self-assessment and comparison methods of supply chain processes and performance as a standard for SCM in a cross-industry scope. This model presents a business process framework, performance indicators, best practices and techniques to support collaboration between several parties in the supply chain in order to increase the supply chain efficiency [5].

The SCOR model is a supply chain term, which can be applied in various contexts to design, define, reconfigure various types of business activities. The application of the SCOR model within certain limits is quite flexible and can be adjusted to increase productivity to meet the needs of consumers [5]. The scope of SCOR consists of six core processes, namely plan, source, make, deliver, return, and enable. The six core processes function as follows [6]:

a. Plan describes activities related to prepare a plan of the supply chain operation. The plan includes collecting needs and information on existing resources, balancing demand and resources to determine capabilities.

b. Source is the procurement process of products to fulfill demand. Sources include shipment scheduling, receiving, inspecting and payments authorization of products, supplier selection, and supplier evaluation.

c. Make describes activities related to material conversion or the content preparation of services. This activity can operate based on make-to-stock or make-to-order. Make includes production scheduling, production, testing quality, managing work-in-process, and maintaining production facilities.

d. Deliver describes activities related to the preparation and fulfillment of customer orders. Deliver includes processing customer orders, selecting shipping companies, handling finished products in the warehouse and sending invoices to customers.

e. Return is the process of receiving a product return for various arguments. Returns include identifying product conditions, requesting a return defect authorization, scheduling returns and making returns.

f. Enable describes activities related to supply chain management. Enable includes business rules, performance management, data management, resource management, facility management, contract management, supply chain network design, managing compliance with regulations and risk assessment.

SCOR covers all customer interactions, all material transactions, and all market transactions but does not represent every business activity. The SCOR model is not intended for sales and marketing, product
development, research and development, and post-shipment customers [7]. At present, the SCOR model 11.0 is the last revision made and released in 2012. The revision of the SCOR model was conducted by SCC members because changes must be done to facilitate the practical use of the model. The change process of the SCOR Model was managed by the voluntary efforts of SCC members. The SCC relies on the contribution of members to upgrade knowledge about the supply chain by identifying, researching and validating these changes, then creating consensus on proposed changes [6].

The performance of SCOR focuses on understanding two elements, namely attributes and metrics. Attributes are the categorization of metrics used to describe specific strategies. The attribute itself cannot be measured and used to direct strategic [8] SCOR recognizes five attributes, namely reliability, responsiveness, agility, cost, and asset management efficiency. The attributes of reliability, responsiveness, and agility are consumer-oriented attributes, while the attributes of cost and asset management efficiency are internal-oriented attributes [9].

The SCOR model has been widely applied to measure the performance of company supply chains. Goparvar & Seifbarghy measured supply chain performance from Iranol Oil Company (IOC) by mapping supply chain processes level 1, level 2 and level 3 [10]. Then conducted a level 3 process analysis based on SCOR best practices and carried out improvement projects and the prioritization using TOPSIS. Seifbarghy, Akbari, & Sajadieh measured supply chain performance at steel companies by identifying supply chain processes at levels 1, 2 and 3 and analyzing level 3 based on best practices and conducting improvement projects and the prioritization using TOPSIS [11]. Erkan & Ugur measured supply chain performance in the Turkish manufacturing industry with the SCOR Model and Enterprise Resources Planning (ERP) approaches [12]. Lee, Tzong-Ru, Shiu, & Sivakumar measured supply chain performance in the manufacturing industry in Taiwan with the SCOR Model and Information, Communication, & Technology (ICT) [13]. Immawan, Marimin, Arkeman, & Maulana designed a sustainable supply chain system on the MTS-MTO system with a case study of the batik industry in Solo Indonesia [14].

3. Research Method

At this stage, the battery supply chain performance is measured using the SCOR model. The steps taken are as follows.

3.1. Identify supply chain performance metrics

The performance of SCOR focuses on understanding two elements, namely performance attributes and metrics. Attributes cannot be measured because they are set to use strategic direction. Each attribute can be measured through several metrics. Metrics are the standard for measuring the performance of a supply chain or process. SCOR has three predetermined metric levels, namely metrics level 1 to level 3. This study uses performance measurements based on metrics level 1 and level 2. Metric level-1 is diagnostic for the entire supply chain known as Key Performance Indicators (KPI) and metric level-2 measures as diagnostics for metric level-1 [6]. Diagnostic relationships help to identify the root causes or causes of performance gaps for metric level-1 [6].

3.2. Validate KPI

The questionnaire was prepared based on the results of the identification of metrics that have been conducted on the lithium battery supply chain. It aims to find out what performance metrics that represent the performance of the UNS Lithium Battery supply chain. The KPI validation questionnaire is a questionnaire with closed questions with two responses, namely valid if the metric is relevant or in accordance with the conditions and invalid if the metric is not relevant or not in accordance with company conditions. Supply chain performance metrics that have been validated by respondents are referred to as KPI so that performance can be measured.
3.3. SCOR performance measurements using metrics level 1 and level 2
Each KPI consisting of metrics level 1 and level 2 is calculated based on company data and observations of researchers. Calculations are conducted using the formulation written in the SCOR guidelines.

3.4. Normalization (Snorm de Boer)
Normalization level 1 metric will use %. Calculation of normalization using the Snorm de Boer formula:

Larger is better, \( \text{Snorm} = \frac{S_i - S_{\text{min}}}{S_{\text{max}} - S_{\text{min}}} \times 100\% \)

Lower is better, \( \text{Snorm} = \frac{S_{\text{min}} - S_i}{S_{\text{max}} - S_{\text{min}}} \times 100\% \)

where: \( S_{\text{min}} \), \( S_{\text{max}} \), \( S_i \) is the minimum value, the maximum value, the actual value of the performance attributes respectively.

4. Result and Discussion
The metrics used are metrics level 1 and level 2 contained in each performance attribute. Then the level 1 and level 2 performance metrics are identified on the five performance attributes. Performance metrics level 1 and level 2 that have been identified are then validated using a questionnaire to respondents (Site Manager). The KPI validation questionnaire is a questionnaire with closed questions with available answers that are valid and invalid. Valid also means whether the metric is important to measure or not for the company. The validity test results there are 26 valid KPIs and 15 non-valid KPIs.

### Table 1. Supply Chain Performance Measurement Results

| Attributes                | Metric L-1 (Code)                          | Metric L-2 (Code) | Score | Unit | Total    |
|---------------------------|-------------------------------------------|-------------------|-------|------|----------|
| Reliability (RL)          | Perfect Order Fulfillment (RL.1.1)         | RL.2.1            | 100   | %    | 80.75%   |
|                           |                                           | RL.2.2            | 85    | %    |          |
|                           |                                           | RL.2.3            | 100   | %    |          |
|                           |                                           | RL.2.4            | 95    | %    |          |
| Responsiveness (RS)       | Order Fulfillment Cycle Time (RS.1.1)      | RS.2.1            | 0     | hour | 4,896 hours |
|                           |                                           | RS.2.2            | 4,704 | hours |          |
|                           |                                           | RS.2.3            | 192   | hours |          |
| Agility (AG)              | Upside Supply Chain Flexibility (AG.1.1)   | AG.2.1            | 0     | hour | 1,056 hours |
|                           |                                           | AG.2.2            | 1,008 | hours |          |
|                           |                                           | AG.2.3            | 48    | hours |          |
|                           | Upside Supply Chain Adaptability (AG.1.2)  | AG.2.6            | 0     | %    | 0%       |
|                           |                                           | AG.2.7            | 0     | %    |          |
|                           |                                           | AG.2.8            | 0     | %    |          |
| Cost (CO)                 | Total Cost to Serve (CO.1.001)             | CO.2.002          | 0.33  | %    | 74.08%   |
|                           |                                           | CO.2.003          | 66.67 | %    |          |
|                           |                                           | CO.2.004          | 6.7   | %    |          |
|                           |                                           | CO.2.006          | 0.42  | %    |          |
|                           |                                           | CO.2.008          | 74.08 | %    |          |
| Asset Management Efficiency (AM) | Cash-to-Cash Cycle Time (AM.1.1) | AM.2.1         | 46    | days | 47 days |
|                           |                                           | AM.2.2            | 1     | days |          |
|                           |                                           | AM.2.3            | 0     | day  |          |
|                           | Return on Fixed Assets (AM.1.2)            | AM.2.5            | 7.2   | %    | 7.2%     |
|                           | Return on Working Capital (AM.1.3)         | AM.2.6            | 0     | %    | 3.63%    |
|                           |                                           | AM.2.7            | 0     | %    |          |
|                           |                                           | AM.2.8            | 7.14  | %    |          |
Then all of the validated KPIs are measured. The performance value of metric level 1 is an accumulation of the performance value of metric level 2. Measurements are made based on data from the company and interviews and the results can be obtained as in table 1.

Because the metric level 1 is still in different units such as percent, day, and hour, it is necessary to equalize the units in order to calculate the performance of the supply chain as a whole. Normalization metric level 1 (KPI) will use units of percent. Metric level 1 among order fulfillment cycle time, upside supply chain flexibility, and cash to cash cycle time are not in percent. In this measurement, each metric value is converted into a range of 0% to 100%. Zero is the worst value and one hundred is the best value. Normalization is done by using the Snorm de Boer formula. The results of normalization can be seen in the following table.

| Attributes                | Score     |
|---------------------------|-----------|
| Reliability               | 80.75 %   |
| Responsiveness            | 50%       |
| Agility                   | 50%       |
| Cost                      | 74.08%    |
| Asset Management Efficiency| 64.63%    |

Based on the monitoring system of the performance indicators [15], the performance of reliability and cost is included in the Good category while the attribute performance of responsiveness, agility, and asset management efficiency is included in the average category.

The performance of lithium battery manufacturers in the average category is still understandable because the company has been operating for 2 years. However, this situation is not sufficient to be able to compete with companies that have existed. So that it needs improvement action so that company performance can be improved. Company performance can be improved by referring to existing best practices. Best practices are current, structured, and repeatable practices that had a proven on supply chain performance. Based on the results of the supply chain performance measurement, the company should focus its improvement on the attributes that have the lowest value, namely responsiveness and agility.

The responsiveness attribute can be improved based on best practice as follows:

a. The variability of the order fulfillment cycle time is reduced so that it can be predicted more accurately.
b. Evaluating the performance of cargo delivery. Improvement in the quality of on-time delivery and in good conditions can increase company satisfaction.

The agility attribute can be improved based on best practice as follows:

a. Use Lean principles to increase the agility of the production run or production cycle in order to modify production planning, finished goods, and work-in-process inventory. This can be combined with a reduction of production batch size and pull-based production.
b. Applying Just in Time strategy to reduce in-process inventory and associated carrying costs.
c. Strategic sourcing is needed to improve and evaluate the purchasing activities of the company.
d. Use the supply chain visibility system that allows the supplier to see requirements and inventory levels at the customer site.

5. Conclusion
Based on the results of performance measurements, the supply chain performance of the UNS Lithium Battery Factory has not been maximized because the total value obtained is 65.13% or included in the average category. Attributes with low values are responsiveness, agility, and asset management efficiency, the values of which are 50 (average), 50 (average) and 64.63 (average) and require further improvements to increase supply chain performance of the UNS Lithium Battery Factory. In further research, it is necessary to do supply chain mapping and benchmarking with similar companies so that
recommendations for improvement are more appropriate and can be a reference for companies to determine targets based on SCOR metrics. Other research that can be done is to integrate SCOR with multi-criteria decision analysis to measure overall supply chain performance based on the priority weights of the five performance attributes.

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