Supply Chain Performance Measurement Using Supply Chain Operation Reference (SCOR) in Sugar Company in Indonesia

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Abstract. This study aims to measure supply chain performance by using SCOR (Supply Chain Operation Reference), a process-based model. It focuses on five business processes namely Plan, Source, Make, Deliver, and Return. There are 45 KPIs grouped into 5 main KPI attributes: Reliability, Responsiveness, Agility, Cost, and Asset Management. In order to get a more precise performance value, then weighted by using Analytical Hierarchy Process (AHP) method. The final value is obtained from the multiplication of the value of performance by the weight of importance. This study was conducted by taking a case study at one of the sugar company in Indonesia. The results of this study indicate that the supply chain performance of the sugar company is in a good category with the final grade of 70.94 from the 0-100 scale. Value of each process consecutively as follows: Plan 18.47, Source 16.12, Make 10.73, Deliver 10.79, and Return 7.1. Some recommendations are given to the company for evaluation and refinement focused on low business process values.

1. Introduction

XYZ Ltd is one sugar-cane based agroindustry company. The company has a sugar factory and a spiritus factory. Industry in the field of sugar production is one promising industry because sugar is one of the staple food needs used by humans every day. At present, the sugar-producing industry is increasing in number. In addition, demand for products, especially sugar, continues to increase. This is evidenced by the comparison between total production and total consumption. According to the Executive Director of the Indonesian Sugar Association (AGI), the need for sugar for both household and industrial will continue to increase in line with the increasing population. This phenomenon requires companies to rearrange their business strategies and tactics. Therefore, companies need to think about how to implement processes in producing products that are better, faster, and cheaper than other competitors.

Based on observations there are problems in the supply chain XYZ Ltd. These problems come from suppliers and consumers. Judging from the aspect of suppliers, the quality of sugar cane supplied is quite a lot which has not been in accordance with the standards for the production process. Usually, the sugar cane is damaged like wilting, too young, and the condition is dirty, causing low water content and sugar cane is not good. In addition, the weather factor is also a determinant of the quality of sugarcane, when it is in the rainy season it will usually result in increased sugarcane growth rates and affect the quality
of sugarcane due to decreased yield levels. Furthermore, from the aspect of the consumer where there are still products returned by consumers due to damage or return products.

From the problems found in the aspects of supply chain performance, it can be concluded that supply chain performance is less efficient. It is necessary to evaluate the supply chain system at XYZ Ltd as a whole so that the company know the supply chain conditions and improve the supply chain process going forward. Some companies carry out supply chain analysis in improving their performance to gain competitive advantages [1]. Performance measurement is also carried out for many studies [2]. The Hellenic Sugar Industry (HSI) conducts a combination of supply chain analysis with analysis of customer demand, logistics costs and the development of suitable transportation models [3]. Many methods of supply chain performance measurement system (SCPMS). One method of measuring supply chain performance is using processes, where the activities of business processes are used to identify performance measures and metrics [4]. SCOR (Supply Chain Operation Reference) provides standard process definitions, including terminology and metrics [5]. The Supply Chain Council develops SCOR that aims to evaluate supply chains. SCOR also provides usual performance framework, standard terminology, and optimum practices [6]. SCOR also has advantages in terms of process details and can be used for benchmarks. Some SCOR applications are widely used in many industries, one of them in Taiwan [7]. The SCOR model is a useful tool and is widely followed by the manufacturing industry [8], but it is not easy to apply it. For example, the application of SCOR in the construction industry [9].

One process and other processes in the supply chain has a different critical level [10]. To be able to distinguish priorities between processes, one weighting method is used, namely the Analytical Hierarchy Process [11]. Thus, the supply chain can also be combined with the Analytical Hierarchy Process (AHP) to overcome various problems, such as in the poultry supply chain [12]. SCOR with AHP (Analytical Hierarchy Process) and fuzzy AHP to create a valuation model in risk uncertainty in the supply chain of body manufacturing bus [13]. SCOR is also quite extensive in its application if it is associated with environmental issues, namely green SCOR [14]. Therefore, in this study using SCOR and AHP in measuring performance in sugar companies and providing recommendations on improvements in order to improve the efficiency of supply chain performance at XYZ Ltd.

2. Methodology

The focus of the study is the measurement of supply chain performance using SCOR 11.0 [15] and AHP methods [11]. The K-Chart research explains in detail the research focus and state of the art from this research. The measurement of supply chain performance using the SCOR and AHP method. K-Chart describes that the type of manufacturing or the object of research is the food industry with products, namely sugar. In the next sequence is the type of production where the company uses the type of production of MTS (Make To Stock). Then, the aspects to be analyzed are economic aspects with the method chosen is SCOR 11.0.

The research stage is as follow in figure 1. Firstly, mapping the business process with SCOR approach. The SCOR approach has a plan, source, make, deliver, return, and enable activities. Then, the next stage is designing performance metrics. In evaluating using SCOR there are several parameters including reliability, responsiveness, agility, cost and asset management. These parameters needed many data. The reliability data related to fulfilling the perfect order needed, such as demand data, forecasting data, on-time delivery, timelines of order receipt, verification of the number and quality of products from suppliers, verify the number and quality of return products from the customer. The responsiveness data in this paper means cycle time in completing orders from consumers. It is obtained directly from production, marketing, purchasing, and installation. There are procurement cycle time, production cycle time, delivery cycle time, and return cycle time. The agility data is data added time that needed by the company to complete orders from consumers. The cost data is data on total expenditure cost incurred every period. Assets management data has to do with cash to cash cycle time, which is the time required in its business cycle. Supporting data are pending sales day, inventory supply data, etc.

The AHP method in this study is used for weighting wherein the results of SCOR and AHP will be integrated so that the results of the supply chain performance from the company are obtained. To be
able to understand the meaning of the calculation results, an analysis is performed for each of the performance attributes.

| Problem formulation | Mapping business processes with SCOR approach | Designing performance metrics | AHP weighting | Final calculation of supply chain performance | Analysis of each attribute in supply chain metrics |
|----------------------|-----------------------------------------------|-------------------------------|--------------|-----------------------------------------------|-----------------------------------------------|

**Figure 1. Research stage**

3. Result and Discussion

3.1. Mapping Business Processes with the SCOR Approach

This study uses the SCOR approach to supply chain measurement. Therefore, it is necessary to map business processes first. Starting from level one and level two to the third level accompanied by business metrics. Table 1 shows the mapping of XYZ Ltd business processes at level 1 and level 2 using SCOR. Then, the whole process and sub-process are summarized into one in the supply chain flow pattern using the SCOR approach (figure 2).

**Table 1. Mapping Business Processes XYZ Ltd**

| No. | Business Process | SCOR Level 1 | SCOR Level 2 | Implementing |
|-----|------------------|--------------|--------------|--------------|
| 1   | Plan             | Plan         | Plan Make    | Director, Department |
| 2   | Supply           | Source       | Source Stocked Product | Farming Facility & Planting Section, Warehouse Section, Accounting & Finance Section |
| 3   | Production       | Make         | Make to stock | Fabrication Section, Installation Section |
| 4   | Distribution     | Deliver      | Deliver Stocked Product | Marketing Section, Sugar Warehouse Section |
| 5   | Return           | Return       | Deliver Return Defective Product | Marketing Section, Sugar Warehouse Section |
| 6   | Management       | Enable       | Manage Performance | Director, Department |

**Figure 2. Supply Chain Flow Pattern With SCOR Approach**
3.2. Designing Performance Metrics

Each process has a performance metric obtained from the SCOR approach. In addition, based on the mapping of previous business processes, it can be identified as the factors that influence the supply chain performance assessment of XYZ Ltd. This is defined as the performance attributes of each metric. The specific description of each process and the classification of metrics into performance attributes can be explained as follows (Table 2).

| NO. | Level 1 SCOR | Level 2 SCOR | METRIC | PERFORMANCE ATTRIBUTE |
|-----|--------------|--------------|--------|-----------------------|
| 1   | PLAN         | Plan Make    | RL 3.37 Forecast Accuracy | RELIABILITY |
| 2   | SOURCE       | Source Stocked Product | RS 3.42 Identify, prioritize, and aggregate production requirement cycle time | RELIABILITY |
| 3   |             |              | RS 3.16 Identify, assess, and aggregate production resources cycle time | RESPONSIVENESS |
| 4   |             |              | RS 3.13 Balance production resource with production requirement cycle time | RESPONSIVENESS |
| 5   |             |              | RS 3.28 Establish production plans cycle time | RESPONSIVENESS |
| 6   |             |              | RL 3.18 %Order/lines processed complete | RELIABILITY |
| 7   |             |              | RL 3.20 %Order/lines received on-time to demand requirement | RELIABILITY |
| 8   |             |              | RL 3.24 %Order/lines received damage free | RESPONSIVENESS |
| 9   |             |              | RL 3.21 %Order/lines received with correct content | RESPONSIVENESS |
| 10  |             |              | RL 3.25 %Product transferred on-time to demand requirement | RESPONSIVENESS |
| 11  |             |              | RS 3.14 Verify product cycle time | RESPONSIVENESS |
| 12  |             |              | RS 3.8 Authorize supplier payment cycle time | RESPONSIVENESS |
| 13  |             |              | CO 3.009 Purchased material cost | COST |
| 14  |             |              | AM 3.16 Inventory days of supply raw material | ASSET MANAGEMENT |
| 15  |             |              | RL 3.39 Scheduling achievement | RELIABILITY |
| 16  |             |              | RL 3.58 Yield | RELIABILITY |
| 17  |             |              | RS 3.49 Issue material cycle time | RESPONSIVENESS |
| 18  |             |              | RS 3.101 Produce & test cycle time | RESPONSIVENESS |
| 19  |             |              | RS 3.142 Package cycle time | RESPONSIVENESS |
| 20  |             |              | RS 3.114 Release finished product to deliver cycle time | RESPONSIVENESS |
| 21  |             |              | CO 3.014 Production labor cost | COST |
| 22  |             |              | CO 3.016 Production property, plant, & equipment cost | COST |
| 23  |             |              | AM 3.9 Capacity utilisation | ASSET MANAGEMENT |
| 24  |             |              | RL 3.33 Delivery item accuracy | RELIABILITY |
| 25  |             |              | RL 3.34 Delivery location accuracy | RELIABILITY |
| 26  |             |              | RL 3.35 Delivery quantity accuracy | RELIABILITY |
| 27  |             |              | RL 3.41 Orders delivered damaged free conformance | RESPONSIVENESS |
| 28  |             |              | RL 3.50 Shipping documentation accuracy | RESPONSIVENESS |
| 29  |             |              | RS 3.100 Process inquiry & quote cycle time | RESPONSIVENESS |
| 30  |             |              | RS 3.112 Receive, enter, & validate order cycle time | RESPONSIVENESS |
| 31  |             |              | RS 3.116 Reserve resources & determine delivery date cycle time | RESPONSIVENESS |
| 32  |             |              | RS 3.18 Consolidate orders cycle time | RESPONSIVENESS |
| 33  |             |              | RS 3.16 Build loads cycle time | RESPONSIVENESS |
| 34  |             |              | RS 3.126 Ship product cycle time | RESPONSIVENESS |
| 35  |             |              | RS 3.102 Receive & verify product by customer cycle time | RESPONSIVENESS |
| 36  |             |              | AG 3.32 Current delivery volume | AGILITY |
| 37  |             |              | CO 3.022 Transportation cost | COST |
| 38  |             |              | AM 3.45 Inventory days of supply finished goods | ASSET MANAGEMENT |
| 39  |             |              | AG 3.31 Current delivery return volume | RESPONSIVENESS |
| 40  |             |              | RS 3.19 Current return order return cycle time | RESPONSIVENESS |
| 41  |             |              | RS 3.104 Receive defective product cycle time | RESPONSIVENESS |
| 42  |             |              | RS 3.136 Transfer defective product cycle time | RESPONSIVENESS |
| 43  |             |              | AG 3.31 Current defective product cycle time | AGILITY |
| 44  |             |              | RS 3.78 Manage production performance cycle time | RESPONSIVENESS |
| 45  |             |              | CO 3.017 Production GRC, inventory & overhead cost | COST |

The Plan process has a subprocess namely Plan Make. The metrics in this sub-process are: (1) Forecast accuracy with the attributes of Reliability; (2) Identify, prioritize, and aggregate cycle time production requirements; (3) Identify, assess and aggregate cycle time production resources; (4) Balance production resources with cycle time production requirements; and (5) Establish cycle time production plans with Responsiveness attributes. The Source process has subprocesses there are Source Stocked Products, the metrics in this subprocess are: (6) % Orders/lines processed complete; (7) % Orders/lines received on-time to demand requirements, (8) % Orders/lines received defect free; (9) % Orders/lines received with correct content; (10) Product transferred on-time to demand requirements with
Reliability attributes; (11) Verify cycle time products; (12) Authorize cycle time payment suppliers with Responsiveness attributes; (13) Purchased material costs with Cost attributes; (14) Inventory days of supply raw material with Asset Management attributes.

The Make process has subprocess namely Make to Stock. The metrics in this subprocess are: (15) Schedule Achievement; (16) Yield with Reliability attribute; (17) Issue material cycle time; (18) Produce and test cycle time; (19) Package cycle time; (20) Release finished product to deliver cycle time with Responsiveness attribute; (21) Production labor cost; (22) Production property, plant, and equipment cost with the attribute Cost; (23) Capacity utilization with the Asset Management attribute. Deliver process has sub-processes, namely Deliver Stocked Product. The metrics in this subprocess are: (24) Delivery item accuracy; (25) Delivery location accuracy; (26) Delivery quantity accuracy; (27) Orders delivered defect-free conformance; (28) Shipping documentation accuracy with Reliability; (29) Process inquiry and quote cycle time; (30) Receive, enter, and validate orders cycle time; (31) Reserve resources & determine delivery date cycle time; (32) Consolidate orders cycle time; (33) Build loads cycle time; (34) Ship products cycle time; (35) Receive & verify products by customer cycle time with Responsiveness attributes; (36) Current delivery volumes with Agility attributes; (37) Transportation costs with Cost; (38) Inventory days of supply finished goods with attribute Asset Management.

Table 3. Results of XYZ Ltd Score Calculation

| L1       | Metric Name   | Final Score | Weight | Score   | Total  |
|----------|---------------|-------------|--------|---------|--------|
| PLAN     | Reliability   | 91.69       | 0.67   | 61.43   | 92.37  |
|          | Responsiveness| 93.75       | 0.33   | 30.94   |        |
| SOURCE   | Reliability   | 99.83       | 0.33   | 32.94   | 76.79  |
|          | Responsiveness| 63.77       | 0.22   | 14.03   |        |
|          | Cost          | 55.28       | 0.25   | 13.82   |        |
|          | Asset Management| 80        | 0.20   | 16      |        |
| MAKE     | Reliability   | 53.24       | 0.36   | 19.17   | 63.14  |
|          | Responsiveness| 70.1        | 0.22   | 15.42   |        |
|          | Cost          | 38.89       | 0.22   | 8.55    |        |
|          | Asset Management| 100     | 0.20   | 20      |        |
| DELIVER  | Reliability   | 99.98       | 0.30   | 30      | 71.94  |
|          | Responsiveness| 69.86       | 0.29   | 20.26   |        |
|          | Agility       | 66.67       | 0.12   | 8       |        |
|          | Cost          | 55.39       | 0.20   | 11.08   |        |
|          | Asset Management| 28.95   | 0.09   | 2.6     |        |
| RETURN   | Responsiveness| 86.8        | 0.70   | 60.76   | 70.76  |
|          | Agility       | 33.33       | 0.30   | 10      |        |
| ENABLE   | Responsiveness| 50          | 0.47   | 23.5    | 42.94  |
|          | Cost          | 36.69       | 0.53   | 19.44   |        |
The Return process has subprocesses namely Deliver Return Defective Product. The metrics in this subprocess are: (39) Authorize defective product return cycle time; (40) Current customer return order cycle time; (41) Receive defective product cycle time; (42) Transfer defective product cycle time with Responsiveness attribute; (43) Current deliver return volume with Agility attribute. The Enable process has subprocesses that are Manage Performance. The metrics in this subprocess are: (44) Manage production performance cycle time with Responsiveness; (45) Production GRC attributes, inventory, and overhead costs with Cost attributes. So, there are 45 metrics from 6 processes in the implementation of SCOR at XYZ Ltd.

3.3. AHP weighting
The scores for each attribute in table 3 obtained from the previous calculation. The weight used is the result of weighting calculations on level 2 using the AHP method. AHP calculations are performed on levels 1, 2 and 3, where weighting at level 3 is given the assumption that each metric has the same important weight. The data used amounted to 4 people, therefore in the previous calculation also used Geometric Mean method to find the average value of paired comparison. After that, a consistency test is also carried out where if the value of Consistency Ratio (CR) less than 0.1, then the data is declared true or consistent. Based on the results of this attribute score calculation, a score can be obtained for each process, where the score of this process will be recalculated to determine the final measurement of the supply chain performance.

3.4. Final Calculation of Supply Chain Performance
The final calculation of supply chain performance is obtained from the calculation of the results of SCOR calculations with AHP. Based on the calculation, it can be obtained the final score for the performance of the XYZ Ltd supply chain is 70.94 that can be seen in table 4. The data used is the total score for each process multiplied by the weight of each process. The weight is obtained from the weighting results at level 1 using the AHP method.

| Process | Total Score | Weight | Final Score |
|---------|-------------|--------|-------------|
| Plan    | 92.37       | 0.20   | 18.47       |
| Source  | 76.79       | 0.21   | 16.12       |
| Make    | 63.14       | 0.17   | 10.73       |
| Deliver | 71.94       | 0.15   | 10.79       |
| Return  | 70.76       | 0.10   | 7.1         |
| Enable  | 42.94       | 0.18   | 7.73        |
| Total   |             |        | 70.94       |

3.5. Analysis of Each Attribute in Supply Chain Metrics
Table 4 indicates the value of attribute scores in each process. The Plan process has two attributes. There is Reliability with a score of 91.69 and Responsiveness 93.75. This shows that for planning XYZ Ltd is good in terms of accuracy and time efficiency. However, there are still some attributes that still score below 70 including the Source process with the attributes of Responsiveness and Cost. Then, Make process with attributes Reliability and Cost, Deliver process with attributes of Responsiveness, Agility, Cost, and Asset Management, Return process with attribute Agility, and finally, Enable process with the attributes of Responsiveness and Cost.
Therefore, the company needs to evaluate and improve so that the company's supply chain performance can be better. Suggestions for improvements are improvements focused first on sugar cane farmers because to produce sugar the main raw material used is sugar cane. Thus, sugar cane is the most important thing in the continuity of production at XYZ Ltd. It is important to always maintain the quality and continuity of sugarcane from sugar cane farmers so that in the future XYZ Ltd can maintain the quality of sugar produced with the maximum production target according to achieve. It is also necessary to improve the quality of the Source process. Identification of key performance indicators and best practices that conducted an analysis of level 3 (metric) needs to be done. In modeling the Source process a Design Chain Operation Reference (DCOR) can be made before integrating it with the SCOR model [16].

Table 4 shows that the Return process has the lowest value. One way to manage the Return process is to use functional integration in the company [17]. The focus of that research is on the integration of marketing and logistics which can affect the effectiveness of the return management process. The results of the identification of external factors that can influence it, such as the customer market, competitive environment, and regulatory environment. Therefore, repairs also need to be done for the product delivery process, because every month there are still products returned by consumers. It happened because they are damaged during the shipping process. The company needs to add a protector to the product that is sent to minimize damage to the packaging. In terms of the speed of time in shipping also need to be considered to increase customer satisfaction to the company.

4. Conclusions and Recommendations

Supply chain measurements are carried out using SCOR 11.0. The conclusion of the research is as a priority weight determinant which includes 5 processes, namely Plan, Source, Make, Deliver, and Return. It is known that the level of supply chain performance XYZ Ltd is 70.94 on a scale of 0-100. This can be said that the level of performance of the XYZ Ltd supply chain is good. In addition, the weighting results using AHP according to 4 experts are for the highest weight process in the Source process with a weight of 0.21 and the lowest weight in the Return process with a weight of 0.10. Suggestions that can be given to companies are companies can hold training for farmers and company employees, tighten the process of quality control for raw materials and finished products, provide additional protection for products shipped, provide subsidies for superior seeds to farmers to improve product quality, holding forums with farmers to establish good relationships with companies, tighten selection supplier and prioritize suppliers loyal to maintain contract sustainability.

Companies need to establish methods used to assess supply chain performance so that companies can improve performance from all sides, such as product quality and company resources. So, it is expected that the company will get more profit and overall company performance will increase as well. For further research, it is expected to be more completed in determining the performance measurement using SCOR. For example, we can add skills to people in using SCOR and make sustainability to implementing SCOR in industry. It is hoped that this method of SCOR 11.0 can be developed to measure supply chain performance by integrating supply chain performance measurement with the environment, ICT, etc.

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