# Design for Supply Chain Performance Assessment in Supermarket

Elisa Kusrini, Suci Miranda, and Gunawan M

***Abstract*—The purpose of this paper is to design supply chain performance assessment at Milk Department in Supermarket. The design process is initiated by mapping the business process based on SCOR method and categorizing them into 3 levels consisted of process type, process category, and process element. The data required are obtained by interviewing three experts of Milk product supply chain. It shows 28 metrics grouped into five primary management processess based on Version 11.0 of the SCOR-model: plan, source, deliver, return, and enable. The important weight of each type process is gained by distributing questionnaire to expert then it is analyzed using AHP (Analytic Hierarchy Process). The final score of supply chain are as follows: plan is the highest weighted of 0.265; enable and deliver are lower than plan with the weighted respectively 0.259 and 0.216; while source is almost 0.20; and return is 0.064. It is identified the metrics with lower SNORM of 50%: DSI, % orders/lines received on-time to demand requirement, and stock out rate. Plan process type becomes the main priority in designing supply chain performance for Milk Product Department. It comprises 5 performance metrics: plan cycle time, fill rate stock, inventory days of supply, Day Sales Inventory (DSI), and warehouse utilization. By reaching 80% of supply chain score, the Milk Department is in the excellent process.**

***Index Terms*—Performance metric, supply chain, AHP, SCOR, supermarket.**

## I. Introduction

Supply chain management (SCM) has become a key management focus and the source of competitive advantage for many firms. According to [1], firms in the retail industry implementing SCM intend to respond to the increasing uncertainty and complexity of the business environment as well as to advance their competitive position in the entire value chain. The retail supply chain performs the dimensions of performance including both financial performance and non-financial performance. In order to ensure growth, performance measures become critical to achieve such tasks (complete order fill, accurate and timely information, reliable and short order cycle time, for instance). It also enables firms to benchmark their current levels of practice againts the best-in-class performers [1]. As it has been stated by Lord Kelvin that, “If you cannot measure it, you cannot improve it”. By measuring the performance, firms may understand their level and set several strategies in order to improve their performance particularly in supply chain.

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This paper applies a model for Supply Chain Performance Measurement (SCPM) based on Supply Chain Operation Reference (SCOR) model. There are five processes to be assessed except make (plan, source, deliver, return, and enable). Since supermarket is a merchandising company where it does not manufacture product, the SCOR make process is excluded. The attributes or performance standards are reliability, responsiveness, and asset management. This study is carried out in a supermarket consisted of 8 branches in Yogyakarta Province, particularly in Milk Product Department. A set of experts chosen by supermarket weighted the construct of the SCOR model under Analytical Hierarchy Process (AHP). Analytic Hierarchy Process (AHP) method is a weighting method that is capable of weighting not only on the basis of hierarchical relationships between perspectives but also able to accommodate the nature of the interrelationships (dependencies) between the supply chain perspectives used as a benchmark of designing and assessment of company performance. The experts expressed their judgement related relevance. Then, the experts identified the metrics regarding each process.

The main contribution of this study is a measurement design that informs the global performance of a SC at Milk Product Department and how the measuring results were obtained. Nowadays, supermarkets have been widely growth in Yogyakarta. As one of famous tourism objects in Indonesia, many visitors spend their time here for holiday. Yogyakarta is also a famous city for those who want to continue their undergraduate and postgraduate study, not only from Indonesia but also overseas. Therefore, supermarket needs to be adaptive that are flexible enough to meet the demand of changing customer markets [1]. Under such circumstances, it justifies the need of such study.

A combination of the SCOR model with the AHP has been implemented by [2] in order to identify selected targets for re-design of supply chain model in an Airline MRO (Maintenance, Repair, Overhaul) supply chain. The advantage of this combination is that the SCOR model provides a standard and accepted structure of supply chain metrics as a criterion for the selection of a target for performance improvement. Moreover, using SCOR metrics will potentially facilitate the evaluation process considering that managers involved will be familiar with this set of metrics. Furthermore, those managers will be able to utilize their experiences in the selection of the target for re-design. Previous researches have been conducted most in manufacturing company such as footwear industry [3]. Yet, the research related to perishable product is limited. A SCOR model is constructed by [4] in order to measure the management of a fruit growing supply chain of small producers.

## II. Research Methodology

The Supply Chain Council (SCC) developed the SCOR model in 1996 [5], to understand, describe and evaluate supply chains. The SCOR model follows a hierarchical structure with different levels of decomposition. The basis hierarchical composition of the SCOR model Version 11.0 is explained below:

- SCOR model level I Process Type (scope): Level 1 defines scope and content using six process type: Plan, Source, Make, Deliver, Return, and Enable.
- SCOR model level II Process Categories (configuration): This level defines configuration level where a supp chain can be defined using core process categories.
- SCOR model level III Process Elements (Steps): Level 3 defines the configuration of individual processes. At level 3 the ability to execute is set such as Schedule deliveries, Receive product, Verify product, Transfer Product, and Authorize payment.

TABLE I: SCOR Performance Metrics

| No | SCOR Process Type | SCOR Process Configuration | METRICS | ATTRIBUTES |
|---|---|---|---|---|
| 1 | PLAN | Plan Supply Chain (sP1) | Plan cycle time | Responsiveness (RS) |
| 2 | | | Fill rate stock | Reliability (RL) |
| 3 | | | Inventory days of supply | Asset Management (AM) |
| 4 | | Plan Source (sP2) | Day sales inventory (DSI) of Milk | Reliability (RL) |
| 5 | | | Warehouse utilization | Reliability (RL) |
| 6 | SOURCE | Source Stocked Product (sS1) | Supplier delivery performance | Responsiveness (RS) |
| 7 | | | Inventory days of supply | Asset Management (AM) |
| 8 | | | Turn over ratio | Reliability (RL) |
| 9 | | | % orders/lines received on-time to demand requirement | Reliability (RL) |
| 10 | | | Availability level of Milk | Reliability (RL) |
| 11 | | | % orders/lines received with correct shipping documents | Reliability (RL) |
| 12 | | | % orders/lines received defect free | Reliability (RL) |
| 13 | | | Source employee reliability | Reliability (RL) |
| 14 | | | % milk stored based on FIFO and FEFO | Reliability (RL) |
| 15 | | | suitability of milk stock between warehouse card stock and existing product | Reliability (RL) |
| 16 | DELIVER | Deliver Stock Product (sD1) | Perfect order fulfillment | Reliability (RL) |
| 17 | | | Fill rate | Reliability (RL) |
| 18 | | | Stock out rate | Reliability (RL) |
| 19 | | | On time delivery | Reliability (RL) |
| 20 | | | Pick and pack accuracy | Reliability (RL) |
| 21 | | Deliver Retail Product (sD4) | Perfect order fulfillment | Reliability (RL) |
| 22 | | | Stock out rate | Reliability (RL) |
| 23 | | | Pick and pack accuracy | Reliability (RL) |
| 24 | | | % milk displayed based on FIFO and FEFO | Reliability (RL) |
| 25 | | | Average time of transaction service | Responsiveness (RS) |
| 26 | RETURN | Source Return Defective Product (sSR1) | Return rate | Reliability (RL) |
| 27 | | Deliver Return Defective/Excess Product (sDR1/sSDR3) | Return rate | Reliability (RL) |
| 28 | ENABLE | Manage Performance (sE2) | Manage integrated supply chain inventory cycle time | Reliability (RL) |

The SCOR model aids the understanding of a particular supply chain by means of mapping it in business terms. It is important to note that this model focuses on the activity involved not the person or organizational element that performs the activity. SCOR model level I (process types) and II (process categories) can be used to identify and map the supply chain processes present. The mapping process starts at level I by identifying the process types present in the supply chain under study. Once the adequate process types have been selected, it is necessary to select which configuration better describes the supply chain processes present. The SCOR performance attributes embrace reliability – perfect order fulfilment; responsiveness – order fulfilment cycle time; agility – flexibility, adaptability, value-at-risk; cost – total cost to serve; and asset management efficiency – cash-to-cash cycle time, return on assets, return on working capital. In the SCOR model, performance attributes serve to define generic supply chain charateristics and to describe supply chain strategy. Identify SCOR Process Levels

The SCOR-model has been developed into six primary management processes (level-I processes) of Plan, Source, Make, Deliver, Return, and Enable. In this study, Make is not considered since supermarket is a merchandising company. For the Plan process, there are two configurations: plan supply chain (sP1), plan source (sP2). For the Source and Enable processess, they are comprised one configuration, respectively: source stocked product (sS1), and manage performace (sE2). The Deliver process has two configuration: stock product (sD1), and deliver retail product (sD4). The Return process are source return defective product (sSR1) and deliver return defective/excess product (sDR1/sDR3).

The level III process is defining process elements of the configuration of individual processess. In this level, it is determined the performance attributes which is a grouping of metrics used to express a strategy. These attributes cannot be measure but are used to set strategic direction. In this study, the level I process of Plan and Source consisted of reliability, responsiveness, and asset management. There are reliability and responsiveness for Deliver process, while Return and Enable process only have reliability performance attribute. The following subclassess for performance assessment is clearly identified in Table I. Each performance attribute has a set of performance metrics to be assessed so called SCOR model level 1 metrics. It is considered to be Key Performance Indicator (KPI) intended to measure and express the overall performance of a particular performance attribute (SCC, 2012).

### A. Metrics Validation

Under the evalutain of three experts of the SC in Milk Product Department, there are performance metrics that cannot be measured compared to the relevant situation. They are: forecast accuray, procurement planning accuray, supplier payment commit date, and assess supplier performance cycle time. Table I shows the performance metrics excluded the metrics which cannot be assessed.

### B. Analytical Hierarchy Process

Once the structure is constructed, the AHP analysis will follow these steps [4]:

1. Pair-wise comparison: It aims to determine the relative importance of the elements in each level of the hierarchy starting from the second level (performance attributes) and ending at the lowest level (supply chain processess). The decision makers express their preferences ofr each pair of type.
2. Weight calculation: Mathematical normalization methods are used to calculate the priority vector from a comparison matrix constructed from the pair-wise comparisons. This priority vector shows the total relative weights among the type compared.
3. Consistency check: A consistency index (CI) is calculated to check the consistency in composing the pair-wise comparisons.
4. Hierarchical synthesis: The calculated priority vectors at different levels are integrated to allow overall evaluation of the alternatives (supply chain processes).
5. Determine priority for all alternatives: The alternative (supply chain process) with the highest overall priority weight is chosen.

### C. Final Score of Supply Chain

The SCOR indicators then normalized using standardized normalization method, SNORM [6]. The final score of each process is calculated by multiplying weighted priority with normalized value of metrics, as seen in Table V.

## III. Result and Discussion

Using the AHP analysis, we provided a priority numerical order for the supply chain process under consideration. From these priority numerical order, it will be easy to decide on which process to focus the improvement. In this study, it is not only identifying the priority numerical order but the final score of overall supply chain within Milk Department. Therefore, after the AHP analysis followed by normalization process SNORM, the final score of supply chain is gained by multiplying the priority numerical order or weighted priority with the SNORM of each metric. These final score informs the level of overall supply as well as leads the supermarket to specify several strategies of performance improvement.

The performance metrics obtained by brainstorming with the experts of SC at Milk Department. According to AHP analysis as can be seen in Table II, the highest weighted of 0.256 belongs to SCOR process type of Plan. While Return is the lowest among other with the score of 0.064. Before normalizing the weighted of each metrics, it is required the weighted priority calculation. For instance, Plan weighted priority is showed in Table III. The sum of weighted priority of all metrics within Plan process type will be equal to the weighted of Plan process type of 0.265. The remain processes type are applied the similar process of weighted priority formulation. The weighted priority is formed by multiplying the weighted of each metric with the weighted of process configuration. Once the weighted priority is obtained, then the metrics must be normalized using SNORM. In order to normalize the metrics, every metric must be defined into the best, actual, and the worst condition based on previous data collected from supermarket. The normalization process is explained in Table IV. It aims to equate the units or parameters of each metric assessed in calculating the final score of supply chain.

Fill rate stock means the level of Milk stock at warehouse comparing to missing Milk under a certain period. From the data, there are 476 cartons of Milk in August 2017 while 17 cartons are out of stock. It is around 96.43% of Milk stocks available. Here is the example of fill rate stock of Plan Supply Chain (sP1) normalization (SNORM).

$$\text{Fill rate stock (\%)} = \frac{100 \times (94.85 - 0)}{(100 - 0)} = 94.85$$

The supply chain performance measurement has identified 28 metrics comprised of 3 performance attributes (reliability, responsiveness, and asset management) and 5 process type (plan, source, deliver, return, and enable). This model is assessed by 3 experts of SC in Milk Department of a supermarket. Accordance with the weighted priority of the priority numerical order showed in Table II, Plan process type is in the high level of supply chain followed by Deliver, Enable, and Source, respectively 20.150, 19.611, 17.356, 17.217. Meanwhile, Return score is less than 10. The final supply chain score of 80.639 indicates that the overall supply chain in this particular department has an excellent process. It is supported by the process configuration, performance attributes, and performance metrics determination. In this case, there are only one process configuration of Enable and Source compared to other processes type. Although it is one configuration of Source, it is consisted of 10 performance metrics measured.

TABLE II: WEIGHTED OF PROCESS TYPE AND PROCESS CONFIGURATION

| Process Type | Process Configuration | Weighted of Process Type | Weighted of Process Configuration |
|---|---|---|---|
| Plan | Plan Supply Chain | 0.265 | 0.117 |
| | Plan Source | | 0.148 |
| Source | Source Stock Product | 0.196 | 0.196 |
| Deliver | Deliver Stock Product | 0.216 | 0.095 |
| | Deliver Retail Product | | 0.121 |
| Return | Source Return Defective Product | 0.064 | 0.028 |
| | Deliver Return Defective/Excess Product | | 0.036 |
| Enable | Manage Performance | 0.259 | 0.259 |
| | TOTAL | 1 | 1 |

Inventory days of supply performance score is the highest (6.52%) among other performance metrics. It belongs to Source Stock Product (sS1) and Asset Management attribute. The highest performance score of each process type are: Fill rate stock (Plan), Inventory days of supply (Source), Perfect order fulfillment of Deliver, and Return rate of Deliver Return Defect/Excess Product. There is only one performance metric in Enable process, thus it cannot be compared to other metrics within this process type.

The SNORM results inform the firm how the activities have been conducted based on the real condition of actual, the worst, and the best. Associated with the results, the performance metrics can be sorted and grouped into three. The first has 50% or less: Day Supply Inventory (DSI), % orders/lines received on-time to demand requirement, and Stock out rate. For instance, Day Sales Inventory is that the Milk products at inventory have to sold within 30 days. Utilizing scale of 1-5, the best condition is less than 30 days (scale 5) and the worst condition is more than 90 days (scale 1). The actual data shows that the products sold between 45 to 60 days (scale 3). The firm may pay its attention on these metrics related to stock of Milk so that it may re-design the relationship with suppliers as well as managing the inventory. Another group reaches 75%: Warehouse utilization, Supplier delivery performance, % orders/lines received defect free, Source employee reliability, and Manage integrated supply chain inventory cycle time. The rest metrics can achieve 100% of each level of measurement such as Perfect order fulfillment, Plan cycle time, and Inventory days of supply. The groups represent whether the activities have to be maintained as they have achieved the targets set or to be accelerated.

By narrowing down the supply chain score, there are several metrics considered to be improved. Some of them are: plan cycle time, % orders/lines received on-time to demand requirement, avalability level of milk, % orders/lines received with correct shipping documents, turn over ratio, % orders/lines received defect free, % milk stored based on FIFO and FEFO, and stock out rate.

The supply chain scores are influenced by SNORM and the weighted priority. Pick and pack accuray performed 100% properly, yet the weighted priority is only 0.010. Thus, its supply chain score is 0.97 of 100. These metrics may be critical for the supermarket to bring more value in its supply chain acitivities.

This SCOR model is customized for the retail firm in Milk Department particularly. This model can be applied in similar retail business to improve their performance related to supply chain.The accuracy in identifying and examining the SCOR model may cause vary results of supply chain score. While the AHP is consisted of uncertaintes associated subjective judgemental errors that can affect the rank order of decision alternatives. Therefore, the measure of consistency can be used to improve the consistency of judgements [7].

TABLE III: WEIGHTED PRIORITY OF PLAN PROCESS TYPE

| No | Process Type and Process Configuration | METRICS | EIGEN VECTOR | | WEIGHTED PRIORITY |
|---|---|---|---|---|---|
| | **PLAN** | | **0.265** | | |
| | **Plan Supply Chain (sP1)** | | 0.442 | 0.117 | |
| 1 | | Fill rate stock | 0.445 | | 0.052 |
| 2 | | Plan cycle time | 0.186 | | 0.022 |
| 3 | | Inventory days of supply | 0.369 | | 0.043 |
| | **Plan Source (sP2)** | | 0.558 | 0.148 | |
| 4 | | Day sales inventory (DSI) of Milk | 0.645 | | 0.095 |
| 5 | | Warehouse utilization | 0.355 | | 0.052 |
| | **TOTAL** | | 1 | 0.265 | 0.265 |

TABLE IV: NORMALIZATION RESULTS OF PLAN PROCESS TYPE

| No | Process Type and Process Configuration | ATTRIBUTES | METRICS | THE BEST | ACTUAL | THE WORST | SNORM |
|---|---|---|---|---|---|---|---|
| | **PLAN** | | | | | | |
| | **Plan Supply Chain (sP1)** | | | | | | |
| 1 | | Reliability (RL) | Fill rate stock | 94.85 | 100 | 0 | 94.85 |
| 2 | | Responsiveness (RS) | Plan cycle time | 3 | 3 | 1 | 100 |
| 3 | | Asset Management (AM) | Inventory days of supply | 6 | 6 | 1 | 100 |
| | **Plan Source (sP2)** | | | | | | |
| 4 | | Responsiveness (RS) | Day sales inventory (DSI) of Milk | 5 | 3 | 1 | 50 |
| 5 | | Asset Management (AM) | Warehouse utilization | 5 | 4 | 1 | 75 |

TABLE V: FINAL SCORE OF SUPPLY CHAIIN

| Process Type and Process Configuration | WEIGHTED PRIORITY | SUPPLY CHAIN SCORE |
|---|---|---|
| PLAN | 0.265 | 20.150 |
| SOURCE | 0.196 | 17.217 |
| DELIVER | 0.216 | 19.611 |
| RETURN | 0.064 | 6.305 |
| ENABLE | 0.259 | 17.356 |
| **TOTAL** | | **80.639** |

## IV. CONCLUSION

The strategies of leveraging performance can be arranged by communicating these parameters to the stakeholders involved in supply chain so that many supplier can cooperate from the very beginning as well as increasing supplier flexibility. Plan source type becomes the main priority in designing supply chain performance for Milk Department. It comprises of 5 performance metrics: plan cycle time, fill rate stock, inventory days of supply, Day sales inventory (DSI), and warehouse utilization.

For further research, this model may be compared to another retail firm with the same product, Milk. By benchmarking the existing model, each firm can examine. Its supply chain performance and apply the best strategy in order to achieve a high level performance. A combination of SCOR and Fuzzy AHP may present a better result. Moreover, version 11 of SCOR has completely design the metrics assessment for each process type and performance attribute.


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## REFERENCES


[1] N. Anand and N. Grover, "Measuring retail supply chain performance," *Benchmarking: Bradfor*, vol. 22, pp. 135-166, 2015.

[2] A. J. Palma-Mendoza, "Analytical hierarchy process and SCOR model to support supply chain re-design," *International Journal of Information Management*, vol. 34, pp. 634-638, 2014.

[3] A. S. Miguel, M. P. Giancarlo, B. Miriam, Rosnaldo, I. Da Silva, and V. V. Claudia, "A SCOR-based model for supply chain performance measurement application in the footware industry," *International Journal of Production Research*, vol. 53, pp. 4917-4926, 2015.

[4] L. P. Diego and R. Leonardo, "Sensitivity analysis of the SCOR metrics seleceted for the measurement of the management of a fruit-growing supply chain," vol. 84, pp. 306-315, 2017.

[5] *Supply Chain Operations Reference Model Version 11*, Supply Chain Council Inc., Pittsburgh, 2012.

[6] J. H. Trienekens and H. H. Hyolby, "Performance measurement and improvement in supply chain," in *Proc. the 3rd CINET Conf. CI 2000 from Improvement to Innovation*, 2000.

[7] T. L. Saaty and L. G. Vargas, *Models, Methods Concepts & Applications of the Analytic Hierarchy Process*, 2nd ed., New York: Springer, 2012.

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