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The Application of Exponential Comparison Method and Analytical Hierarchy Process to Analyze Supply Chain Performance

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Abstract

The purpose of this research is to map the structure of the fruit supply chain, determine the fruit supplier that best meets the criteria, measure the performance of the fruit supply chain management, and recommend improvements to the fruit supply chain management performance. This research uses the descriptive analysis method for mapping fruit supply chain structure, the Exponential Comparison Method (MPE) for selecting the best supplier, the SCOR model, the Analytical Hierarchy Process (AHP), and Snorm de Boer normalization for measuring fruit supply chain management performance in a period of 1 month, as well as a fishbone diagram to recommend performance improvements. Based on the research results, it is known that members of the fruit supply chain consist of 50 suppliers (fruit and packaging), 4 sub-distributors, 240 retail stores, and 800 resellers. Based on the MPE analysis, there are five selected local and imported fruit suppliers. Based on the results of performance measurements, the fruit supply chain management is good, except for two processes, namely procurement and production, so six practices are recommended that can be implemented by the company.

Keywords: Fruit, Supply Chain, Analytical Hierarchy Process.

1. Introduction

Fruit is one of the agribusiness products that is part of the horticultural crops sub-sector. Fruit has the same characteristics as other agribusiness products, namely being perishable and having a relatively short shelf life. This is because several types of fruit still carry out respiration after being harvested. The respiration process triggers the ripening of the fruit up to the decay stage. If this product is not handled properly, the rate of loss and wastage of fruit will be high, so business actors will suffer losses. The Food and Agricultural Organization (FAO) defines lost and wasted food as food loss and waste (FLW). Fruit is one of the types of food that contributes the most FLW. The percentage of fruit loss is in the range of 14%–70%, depending on the product (Parfitt et al., 2010: 3072). In the 2021 FLW study report in Indonesia, it was revealed that the percentage of FLW of fruits generated from domestic supply that was utilized for the 2000–2019 period reached 45.5%. Based on Bappenas (2022), the average FLW generation of fruits is proportionally higher than that of vegetables, where the percentage of fruits reaches 20% while vegetables are only 16%. Bappenas explained that the FLW originates from activities along the food supply chain, starting from the production, post-harvest, and storage stages, processing and packaging, distribution and marketing, and finally consumption. Members along the supply chain are considered to be contributors to the high number of FLWs, especially the attitudes of these stakeholders. In the fruit supply chain itself, the members involved are at least farmers, collectors, wholesalers, retailers, and consumers. Each member of the supply chain generates a significant FLW.

The fruit supply chain is indeed more difficult to manage compared to other supply chains because of the unique product characteristics, namely limited shelf life and durability, safety, and fluctuations in demand and prices [1]. These difficulties must be overcome by companies by optimizing the performance of their supply chain management [2]. Companies need indicators that can measure how well the performance of supply chain management has been running so that each problem can be converted to cost-based performance measurements and process-based to support supply chain performance models [3]. In addition, the buyer-supplier agreement is one of the important factors responsible for the generation of FLW. Therefore, supplier performance in meeting product demand is also important to consider so that companies can choose the best supplier for their products [4]. Based on the results of the author's initial observations, information was obtained that damaged fruit at one of private company consisted of fruit that was not sold due to excess stock and fruit that was returned. This happens because the performance of the fruit supply chain management is not optimal [5]. In the planning process, demand forecasting is inaccurate, giving rise to excess stock. The company still has difficulties in forecasting, as acknowledged by the director. The existence of accurate forecasting should be able to produce much better supply chain management, including improved inventory management and service levels [6]. The results of these

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observations indicate that the implementation of the fruit supply chain management has not been optimal, so it is necessary to evaluate the performance of the fruit supply chain management that has been running so far [7]. Suppliers who have collaborated also need to evaluate their performance so that the best supplier can be selected from the many suppliers in the company [8]. First, the fruit supply chain mapping needs to be done as an illustration of the supply chain structure in the company [9]. Second, it is necessary to select the best supplier based on the results of its performance analysis. Third, the fruit supply chain management process that has been running needs to be described as a reference for measuring performance. Fourth, the performance of fruit supply chain management that is not yet optimal will be improved with alternative practices from the Supply Chain Operation Reference (SCOR) model [10].

2. Methods

The type of data used in this study consisted of qualitative and quantitative data. The data is sourced from primary and secondary sources. Primary data is obtained from direct observation, structured interviews, and questionnaires. The secondary data used in this study is historical data relating to suppliers and supply chain management in the company. The data processing methods used in this study are qualitative and quantitative. Qualitative analysis in the form of descriptive analysis and quantitative analysis in the form of analysis of supplier selection and measurement of supply chain performance in this study, the data obtained will be analyzed with the help of the computer program. Descriptive analysis is used to help map the supply chain structure and supply chain management of fruit. In addition, descriptive analysis is also used to assist in the interpretation of the results of calculating the performance of the fruit supply chain and the criteria for the selected supplier. In this study, the exponential comparison method will be used to select the best supplier. The analysis will be assisted by the MS Excel. In this study, the SCOR model will be used to analyze the fruit supply chain management process, measure the supply chain performance, and provide recommendations for improvement based on the results of the fruit supply chain performance measurements. This study will use the American Production and Inventory Control Society's (APICS) SCOR Model, which consists of a level 1 and level 3 matrix.

3. Results and Discussion

3.1. Fruit Supply Chain Structure Mapping

Suppliers involved in the fruit supply chain consist of both local and imported fruit suppliers and packaging suppliers. Local fruit is obtained from Indonesian fruit farmers in several regions in Indonesia, such as West Sumatra, Bengkulu, South Sumatra, Lampung, West Java, Central Java, East Java, and Sulawesi, with approximately 460 hectares of arable land. In addition, the company also purchases fruit from fruit collectors through a drop-buy system. For imported fruits, the company purchases them from several importing companies in Indonesia. The packaging suppliers consist of two types of vendors, namely cardboard packaging vendors and fruit sticker vendors. Distributors do not distribute fruit directly to consumers but to other companies. This is because producers, distributors, and wholesalers are prohibited from distributing goods in retail to consumers (PP No. 29 of 2021 concerning Implementation of the Trade Sector Article 55 paragraph (1)). Therefore, the company's distribution channel consists of sub-distributors, outlet retailers, resellers, and companies. There are five sub-distributors in the fruit supply chain who distribute to the resellers.

3.2. Fruit Supplier Selection Analysis

Starting from the stage of introduction and product offerings by potential suppliers. Then, potential suppliers are asked to send 5–10 kg of product samples for assessment and QC of the products offered. If the product samples sent pass the assessment and QC from the production team, then the product procurement team will then negotiate offers from potential suppliers regarding price and quality, shipping costs, delivery times, and the number of products supplied. After reaching an agreement with the potential supplier, the next step is to conduct a test market by selling 50% of the product to the existing potential market. If the product receives a positive response from the market, then the potential supplier will be accepted as one of the suppliers. So far, the company has only assessed suppliers based on price and fruit quality variables. There are four criteria for supplier selection: quality, price, service, and delivery.

Based on the results of questionnaires from informants for determining supplier criteria, information was obtained that there were 5 most important criteria for selecting fruit suppliers, namely product conformity with established quality standards (K4), percentage of products returned (K5), level of supplier responsibility (K9), timeliness (K11), and the level of product continuity (K12), with each weight equal to 0.090. The least important criteria, according to the informants, were the ability to provide price discounts (K2) and ease of payment mechanisms (K3), with a weight gain of 0.072. The company, as previously disclosed, has so far only used the criteria in the price and quality variables to assess performance and select fruit suppliers; the criteria in the price variable have a low weight value when compared to the criteria in other variables. The criteria in the variables that are not used,

namely service and delivery, have a fairly high weight value. Therefore, companies should consider adding two other criteria variables, namely service and delivery, when selecting suppliers.

Based on the results of the analysis of the performance of fruit suppliers, it can be seen that the MPE value of each supplier tends to differ slightly for both local and imported fruit suppliers. In terms of local fruit suppliers, one of SME got first rank with an MPE value of 13.41, while Lentera Fresh ranked last with an MPE value of 12.92. The supplier of imported fruit that ranks first is Pataka Tiga Empat with an MPE value of 13.61, and the last rank is Fresh Fruits Makmur with an MPE value of 13.08. The MPE value acquisition results, which tend to differ slightly, explain that each supplier of local and imported fruit has a fairly balanced and competitive performance, although when viewed from the respective criteria for each supplier in attachments 7 and 8, there are still seven criteria whose performance needs to be met. improved. Based on this, it can be concluded that more than 50% of the criteria for fruit suppliers, both local and imported, are still in the good category. Companies need to review and evaluate this case so that the product supply chain can run smoothly up to the consumer. The results of this research can be used as evaluation material to select and map out suppliers that need to be maintained, increased, or eliminated. The criteria with performance that is still in the good category will be formulated as performance indicators in the procurement process in fruit supply chain management.

3.3. Fruit Supply Chain Management Performance Analysis

Performance indicators are identified through SCOR model approach using a level 1 and level 3 matrix. The indicators available in the model are adapted to the conditions of fruit supply chain management by verifying performance indicators with sources at the company. There are 23 performance indicators that have been verified. These performance indicators are derived from the main processes of fruit supply chain management. There are four measurement attributes used in the performance indicators of this study: reliability, responsiveness, asset management, and cost. The second step in designing a supply chain management performance measurement matrix is to assign weights to each validated performance indicator. The value of the indicator weight was obtained from the results of the questionnaires of the informants who were directly involved in the fruit supply chain management through the AHP method.

Based on the results of the questionnaire, it is known that the consistency index of AHP levels 1, 2, and 3 is below or equal to 0.1 ((CR) $\leq$ 0.1), meaning that the sources' assessments can be considered consistent and there is no need to redistribute the questionnaire. AHP level 1 has five main processes of supply chain management: planning (plan), procurement (source), production (make), delivery (deliver), and return (return). The source management or procurement process has the most important role compared to other processes, with a value weight of 0.29. The procurement process is a top priority because this company is a distributor, where there is no product processing process in its production. Products from this company are very dependent on the quality of suppliers, so if the procurement performance is poor, it will greatly affect the other four processes. AHP level 2 has attributes to measure each fruit supply chain management process. In the planning process, the cost attribute is considered to play an important role compared to the reliability attribute, while in the procurement process, the reliability attribute is considered to play a more important role than the responsiveness attribute. The same case also occurs in the production process, where the reliability attribute is considered more important than responsiveness, but the weight value is not much different from the asset management efficiency attribute, which is only worth 0.02 below the reliability attribute. As for the delivery process, there are different cases where the responsiveness attribute is considered to play a more important role than the reliability attribute. This is also the same as the return process, where the responsiveness attribute plays a more important role than the other attributes, namely cost.

There are three attributes that are important enough to be made an overall priority: responsiveness in the delivery process, cost in the planning process, and reliability in the procurement process. The attributes of reliability and responsiveness are top priorities. However, there are differences in the cost attribute. Previous researcher does not prioritize costs, while this research places costs as a priority. This is in line with the opinion of previous researcher, where supply chain management that has been running should be measured based on cost, so that the cost attribute becomes a priority. The level of responsiveness in the delivery process is a top priority because fruit is included in fast-moving products, where its life span is short. Customers want companies to be able to quickly and accurately fulfill their orders without decreasing product quality. Cost is the next priority in the planning process. Basically, a company wants big profits with low costs. The company is trying its best to cut unnecessary costs when planning. Finally, there is the level of reliability in the procurement process, which is the third priority. At level 1, it has been explained that the procurement process plays a very important role for distributor companies, so the level of reliability is an indicator of good or bad procurement performance. The existence of high reliability can guarantee the quality of products from suppliers, both in terms of timeliness, quantity, and specifications.

The performance indicators that are considered the most important in the procurement process with the reliability attribute are S.RL.3 and S.RS.1 on the responsiveness attribute. Then, in the production process, the performance indicators that are considered to play an important role are M.RS.3 on the responsiveness attribute and M.A.1 on the asset management efficiency attribute. In the delivery process, the D.RL.1 performance indicator is considered

the most important on the reliability attribute and D.RS.1 on the responsiveness attribute. The planning process and several other indicators are not listed because they are singles with a full weight of 1.00. The next stage in measuring the performance of fruit supply chain management is the process of normalizing the value of performance indicators. The unit of each performance indicator is different. Differences in indicator units will produce inconsistent and diluted values when calculated, so normalization of performance indicator values needs to be done to prevent this from happening. The process of normalizing values in this study uses the Snorm de Boer method with two categories. There are three values needed in the process of normalizing the snorm de boer: the actual value, the minimum value, and the maximum value. The minimum and maximum values are obtained from a comparison of the performance indicator values in the June, July, and August periods. The minimum value is the lowest score obtained during the month's period, while the maximum value is the highest value obtained. The results of normalizing the values of performance indicators are snorm values. The snorm value is the performance value of the calculation results with the formula lower is better, and larger is better.

The results of the fruit supply chain management performance assessment based on the performance monitoring system can be categorized as good," with a total score of 81.25. If viewed proportionally, the planning process (plan) contributes the highest performance value to fruit supply chain management with an acquisition value of 19.97. The procurement process (return) has the lowest proportion of performance values, with a value of 2.51. If we review the results of the fruit supply chain management performance evaluation for each process, it can be seen that there are several processes that cannot be categorized as good, even though the overall performance evaluation shows a good category. The planning process is in the good category with a total performance value of 86.85. The cost attribute shows a perfect score of 100.00 compared to the reliability attribute, which only gets a score of 45.20. Therefore, it can be concluded that the planning process does not have good reliability. Based on this, it is necessary to maintain this performance value and increase the reliability attribute in the planning process. The planning process is in the average category, with a total performance value of 61.65. When viewed proportionally, the weight of the attribute reliability is higher than responsiveness, but the performance value shows the opposite. The responsiveness attribute scored 66.69, while the reliability attribute scored slightly different, namely 57.18. The performance indicators used for both the reliability and responsiveness attributes are in the same category, namely the average. Based on this, it is necessary to increase the value of this performance.

The production process is in the marginal category, with a total performance value of 47.17. The responsiveness attribute has the highest performance value of 80.50, followed by asset management efficiency with a value of 74.38, and reliability in the lowest position with a value of only 44.44. Based on these data, it is known that two attributes of the production process can be said to be good. However, the total value of the overall performance of the production process shows a marginal category. This can happen because the weights of the responsiveness and asset management efficiency attributes are lower than the reliability attributes, namely 0.12, 0.45, and 0.43. The responsiveness attribute can get a high score because the two performance indicators, namely M.RS.1 and M.RS.2, have a value of 100.00, while M.RS.3 has a value of 70.00. The asset management efficiency attribute gets a high score because the MA2 indicator has a value of 90.94, while MA1 only gets a value of 64.65. The delivery process is in the very good category with a total performance value of 98.54. The reliability attribute has received a perfect performance score of 99.00, while the responsiveness attribute has received a value of 98.45. Almost all performance indicators in the shipping process received a perfect score of 100.00; only the D.RS.2 indicator received a score of 90.91. The delivery process is in the very good category with a total performance value of 97.32. All attributes used in the return performance measurement process, namely reliability, responsiveness, and cost, are in the very good category, with consecutive values of 97.96, 100.00, and 93.92. That is, it is necessary to maintain performance values on this return process.

The results of measuring the performance of the fruit supply chain management show that there are two management processes that are still in the average category or below, namely the processes of procurement (source) and production (make), as described in the previous sub-chapter. These two processes show the reasons for the large number of FLWs. Therefore, both processes will be a priority in improving fruit supply chain management. The causes or root causes of the two management processes need to be known before recommending improvements with the help of a fishbone diagram. Tracing the root of the problem is carried out using KPI level 3 AHP, whose performance value is still below the good category (a metric defect) as a result of the problem. There are six metric defects in the procurement process that are the result, while in the production process there are three consequences. Based on the search results, it is known that there are several secondary causes of the two processes, namely as follows: The procurement process is related to supplier relationship management. MPE analysis results on the supplier selection process also affect the low value of the fruit procurement process. There are six KPIs that have performed well in the procurement process. The KPI is a metric defect that can be used as the main factor or cause of low performance in this procurement process. The production process has three KPIs whose performance is still below the good category and is a metric defect. This KPI is the result of low performance in the production process.

Long-term supplier agreements and partnerships are one of the categories of standard practices that can be considered by companies to implement in reducing FLW so that cases of non-conformance in product quantity and specifications can be minimized and the number of FLW fruits reduced. Improving product quality can be done easily if the company has entered into agreements or partnerships with suppliers, especially local fruit farmers. This action can be in the form of a cultivation training program followed by cultivation monitoring from the company. The application of this practice is expected to reduce the number of FLW fruits because the quality of the fruit can be properly normalized by adjusting it to the demands of customers, so that the number of returned fruits can be reduced. As a first step, the company formed a PPIC (Production Planning and Inventory Control) team that would later be responsible for this CPFR. Companies can start such collaborations with medium-sized companies (medium companies) and large companies (large companies) first. This collaboration allows supply chain members to share product demand data and forecast demand together. Therefore, CPFR can be a practice that can reduce the number of FLWs. The products that have been sold so far have only been modestly developed by the director of the company together with the procurement team, while the marketing and sales teams are only involved in the product testing and launching processes. Therefore, the proportion of market acceptance for new products launched is sometimes lower.

The ABC inventory classification system is one of the standard practice categories that companies can consider implementing to reduce FLW. This system is part of inventory management, where products are grouped based on their turnover. This analysis serves as a basis for directing the attention and decision-making of planners. So far, the company has only implemented a First In, First Out (FIFO) inventory system and has not been classified based on this ABC system, so many products stay in warehouses for too long and end up damaged or rotten. In addition, fresh products such as fruit are perishable and on average have a short shelf life; therefore, some literature suggests implementing a First Expired, First Out (FEFO) inventory system for fresh products compared to FIFO.

4. Conclusion

The supply chain members consist of 50 suppliers and packaging, 4 sub-distributors, 240 retail stores, and 800 resellers spread across various regions in Indonesia. The five most important criteria are product conformity with established quality standards (K4), percentage of returned products (K5), level of supplier responsibility (K9), timeliness (K11), and level of product continuity (K12). The performance of fruit supply chain management can be categorized as good," with a total score of 70.25. There are 23 validated performance indicators. The best main management process performance was obtained by the delivery process with a value of 98.54 (very good), then returns with a value of 97.32 (very good), then planning with a value of 86.85 (good), procurement with a value of 61.65 (average), and finally production with a value of 47.17 (marginal). Improving the performance of fruit supply chain management to reduce the number of FLW can be carried out in the procurement and production processes. There are six main causes of the low performance of the two processes. Based on SCOR, six practices can be recommended that can be implemented by companies, long-term supplier agreement or partnership, raw material quality improvement, collaborative planning, forecasting, and replenishment (CPFR), product development engineering and disposition collaboration, ABC inventory classification system, and master data accuracy.

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