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Determination of Logistics Risk of Palm Cooking Oil Using *Fuzzy Delphi Method and Fuzzy Analytical Hierarchy Process*

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Abstract: Determination of risk sources and risk indicators is carried out by conducting literature studies and expert assessments. The results of the expert assessment are processed using the Delphi fuzzy and AHP fuzzy methods. The Delphi fuzzy method is used to make decisions regarding risk sources and risk indicators based on expert opinion. The AHP fuzzy method is used to determine the weight and priority order of risk sources and risk indicators for palm cooking oil logistics. The risk sources obtained based on the study of the literature are as many as 10 risk sources which are then selected 8 risks that are approved by experts. While the risk indicators obtained based on the study of the literature are as many as 34 indicators, then as many as 23 indicators are considered important by experts. Based on the risk weight assessment, the order of risk with the highest weight is supply risk with a weight of 0.2803, partnership risk with a weight of 0.1619, production risk with a weight of 0.1576, storage risk with a weight of 0.1262, technology risk with weight of 0.93, transportation risk with a weight of 0.0811, infrastructure risk with a weight of 0.0603 and market risk with a weight of 0.0395.

Keywords: Logistics, Palm Cooking Oil, Risk.

INTRODUCTION

Cooking oil is one of the staple foods used by Indonesian people. CDMI (2014) stated that consumption of cooking oil during the 2009-2013 period increased with an average growth rate of 15.7% per year. Consumption of cooking oil in 2009 was 2.83 million tons and increased to 5.01 million tons in 2013. There are several types of cooking oil spread across Indonesia, namely cooking oil made from palm oil, coconut and other vegetable ingredients. The largest market consumption of cooking oil during the 2009-2013 period was palm cooking oil with an average contribution of 97.01% per year, followed by coconut cooking oil at 2.5% per year and other vegetable cooking oils at 0.49% per year. years (CDMI, 2014).

Palm cooking oil is an advanced product of oil palm fruit, so its manufacture is inseparable from the development of oil palm plantations. Indonesia is a country with the

largest oil palm plantations which makes palm oil one of the main export sectors. This can be seen from the high growth of oil palm plantation areas throughout Indonesia. Based on CDMI data (2014) in 2006 there were 6.28 million hectares of oil palm plantations which then increased to 9.42 million hectares in 2013. The increase in the area of oil palm plantations was also followed by an increase in the production of palm oil (palm oil) .) and palm kernel oil (*palm kernel*). CDMI (2014) also noted that Indonesia's palm oil production continued to increase at an average growth rate of 6.1% per year during the period 2006 to 2013. Meanwhile, palm kernel oil increased at an average rate of 6.9% per year during the period the same one.

The increase in consumption of palm cooking oil by the Indonesian people was also followed by an increase in the number of cooking oil processing industries in Indonesia. Indonesia is included in the top five world cooking oil producing countries along with China, the European Union, Malaysia and the USA (BPPMD Kaltim, 2009). There were 135 cooking oil companies in Indonesia at the end of 2013 (CDMI, 2014). 112 companies produce palm cooking oil, 38 companies produce coconut cooking oil and 7 companies produce other vegetable oils.

The palm cooking oil industry is one of the downstream industries from the palm oil industry. Palm cooking oil is called RBD Olein (*Refined Bleached Deodorized Palm Olein*). This palm cooking oil uses CPO as a raw material. The manufacture of CPO begins with the processing of fresh fruit bunches of oil palm which are heated using steam which is then squeezed to produce oil. CPO that is processed into cooking oil will experience changes in color, smell and chemical structure. Processing results will produce oil that contains stearin and olein which will then be reprocessed so that the stearin content is reduced and good quality cooking oil is obtained.

Palm cooking oil which is a product of oil palm plantations is classified as agro-industry. The agro-industry supply chain consists of input supply, plantation processing, harvesting, raw material storage, production processes, marketing and distribution. The supply chain process is affected by various uncertainties such as weather changes that affect the availability of raw materials and the quality of raw materials. Logistics has an important role in the agro-industry supply chain flow. Where errors in logistics handlers can be a source of risk in the company's supply chain. Risks that can occur in the logistics system can affect the procurement process, production time and also the quality of the products produced. Raw materials are one of the most important sources to pay attention to in agro-industry because raw materials for agricultural products must be kept fresh so that the quality of the products produced can be in accordance with the standards desired by the company.

In addition to raw materials, in the agro-industry supply chain it is also necessary to pay attention to the delivery and storage processes. The delivery process has various risks that can occur due to uncertainties in the time, quality and availability of delivery services. Risks that can occur if the delivery process is not properly considered are delays in delivery and decreased quality of raw materials and products. This is greatly influenced by the company's logistics, such as transportation and infrastructure. Good infrastructure and transportation can guarantee a smooth delivery process. Another thing that needs to be considered in agro-industry is storage. Storage of raw materials must be carried out properly because the quality of agricultural raw materials can decrease with the length of storage time.

In addition to affecting the supply chain system, logistics is also an important part of the industry where logistics is the center of the company's operations. Logistics carries out all activities related to the flow of materials in the company. Besides that, a good logistics system can increase the effectiveness and efficiency of the company in terms of reducing costs and time. Low costs will provide added value for companies in terms of competition, where at low costs companies can still produce good quality products or services (Mulyadi,

2011). The magnitude of the influence of logistics on this company makes logistics a very important part for the company to pay close attention to.

Risk can be interpreted as an unexpected event that can cause losses to the company (Hadiguna, 2016). This makes companies need preparation in dealing with these risks. Research to identify risk sources and risk indicators that can occur in palm cooking oil logistics needs to be carried out so that it can help provide information about risks that can occur in palm cooking oil logistics so that companies can carry out good logistics planning and follow up against possible logistical risks.

LITERATURE REVIEWS

Risk

The definition of risk according to the Big Indonesian Dictionary (KBBI) is the harmful and harmful consequences of an action or action. Risk is an unexpected event that can occur resulting in a loss to the company (Hadiguna, 2016). Badariah et al (2012) define risk as the probability of an event that results in a loss when the event occurs during a certain period. Hadiguna (2012) states that risk has two categories of properties, namely predictable and unpredictable, where these categories reflect the involvement of many factors and the level of complexity of the situation faced by the company.

Risk is mathematically caused by uncertainty and damage (Hidayat, 2012). This uncertainty can be caused by several things, namely:

1. Lack of information and knowledge about events that will occur in the future.
2. Information complexity, where with the abundance of this information, humans will experience limitations in observing and processing the data.
3. There is a fact of conflicting events, due to incorrect or irrelevant information.

Logistics

Vorst (2007) defines logistics as part of the supply chain process in terms of planning, implementation and control so that the flow and storage of materials, services and related information is more effective and efficient. Bowersox (2002) states that logistics is an activity required to move and place inventory along the supply chain, while the supply chain is a collaboration of companies aimed at improving positioning strategy and improving operating efficiency. According to Christopher (2005) logistics is a strategic process in management starting from the procurement of goods, the movement of goods to the storage of goods, raw materials and finished products including the flow of information to companies and marketing connections for the benefit of maximizing profits with efficient costs and in the context of meeting consumer needs.

The goal of logistics as explained by Bowersox (2002) is to deliver materials and finished goods in the right amount at the time needed, in usable condition, to the location where the goods are needed, and at the lowest total cost. The primary goal of logistics is to achieve a predetermined level of manufacturing-marketing support at the lowest cost. Logistical aspects consist of customer service, transportation, storage, selection of factory locations, inventory control, ordering processes, distribution, procurement and demand forecasting (Hadiguna, 2016).

Fuzzy Method

The theory of fuzzy logic sets was developed by Prof. Lotfi A. Zadeh in 1965, where he argued that the true and false logic of conventional Boolean logic cannot overcome the gradation problem in the real world. The gradation problem can be solved by using fuzzy methods. Classical logic on Boolean logic states that everything can be expressed in terms of binary 0 or 1, yes or no.

This fuzzy logic is introduced in order to represent linguistic uncertainty. This method is useful for solving problems that contain a degree of uncertainty (Meimaharani, 2014). Fuzzy methods are not a substitute for probability theory. This method has a main component in the form of a membership function. This membership function is a representation of the degree of closeness of an object to certain attributes, whereas in probability theory it is more used in the use of relative frequencies.

The fuzzy system is referred to as a structured and dynamic numerical estimator, in which the system has the ability to develop uncertain intelligence systems (Hidayat, 2012). Fuzzy logic has several processes, namely the determination of fuzzy groups, the application of if-then-else rules, and the process of fuzzy inference.

Delphi method

The Delphi method is a method that is carried out by forming a communication group consisting of experts or experts who have expertise in the field of problems being discussed (Sukwadi, 2013). This method was used and popularized in the early 1960s by the Rand Corporation, which is a research institute from Santa Monica, California, United States.

Linstone and Turoff (in Sukwadi, 2013) explain that the implementation of the Delphi method consists of two versions, namely the paper and pencil version. Implementation of this method is done by forming a team that will design a questionnaire that will be submitted to the experts who are the respondents. Respondents who have filled out the questionnaire will be given another opportunity to evaluate the answers they have given to the questionnaire, then the team will conclude the results of the answers obtained. Based on the results of the answers that have been concluded, the team will design the next stage of the questionnaire which will be submitted back to the respondents. This method is called Conventional Delphi (Sukwadi, 2013).

Another method in Delphi is the Delphi Conference method, in which this method is carried out using a programmed computer system that will assist the team in concluding the answers obtained from each stage of the questionnaire submitted (Sukwadi, 2013). This method has advantages such as saving implementation time and avoiding team errors in concluding the answers obtained.

Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) is a decision support model developed by Thomas L. Saaty. This model describes complex multi-factor or multi-criteria problems into a hierarchy (Hidayat, 2012). Hierarchy is a representation of complex problems in a multi-level structure, where the first level consists of goals or objectives, the second level is filled with factors or criteria and then followed by sub-factors or sub-criteria and so on. This hierarchical arrangement can make problems appear more structured and systematic (Hidayat, 2012).

The AHP method is a method that takes into account quantitative and qualitative matters simultaneously in terms of decision making (Hadiguna, 2016). Human perception is the main input used in this method. AHP was first created with the aim of solving problems in complex situations, has no framework, limited statistical data and information, but still has qualitative data based on the perceptions, experience or intuition of decision makers (Hadiguna, 2016).

Fuzzy - Delphi

The Fuzzy Delphi method was developed by Ishikawa in 1993, which combines the traditional Delphi method with fuzzy theory (Etebarani et al, 2012). The use of this method can resolve the fuzziness of the expert opinion. Fuzzy membership functions in many previous studies were taken based on triangular fuzzy numbers, trapezoidal fuzzy numbers and Gaussian fuzzy numbers. The Deplhi fuzzy method is a method that can be used in

determining criteria by testing the consistency of the opinions of experts as respondents. This method is also used in filtering existing alternatives. The ambiguity of opinion on the Delphi method will be resolved using the Fuzzy method and can be evaluated using a more flexible scale (Etebarani et al, 2012).

The traditional Delphi method is carried out by collecting expert opinions in several phases or done repeatedly, which will require high costs, take longer time which can result in decreased response rates and the subjective opinion of respondents will affect the final result. The fuzzy theory used in the traditional Delphi method will help shorten the time needed to conduct surveys, resulting in lower research costs. Although reducing the time and cost required, the results obtained are also similar to those of the traditional Delphi method (Liu, 2013).

Fuzzy - Analytical Hierarchie Process

The assessment of the sources on the criteria and alternatives is inseparable from the subjective side which contains uncertainty (Hidayat, 2012). The informant is more confident in giving an assessment in an interval compared to a firm assessment (crisp). Based on this, it is necessary to develop the AHP method into a Fuzzy Analytical Hierarchy Process (FAHP) which uses a decision-making method using fuzzy logic. The linguistic scale in traditional AHP can represent uncertainty that is not clear when decision makers make their decisions. This FAHP method converts expert opinion from certain values into fuzzy values and membership functions, displays triangular fuzzy numbers into a pairwise comparison matrix (Etebarani, 2012).

METHODS

Preliminary study is the first step taken to initiate research. This step is carried out by studying various literature related to palm cooking oil. This step is carried out to identify existing problems that can be raised as research topics.

The research conducted is related to the logistics risk of palm cooking oil in the city of Padang, so it is necessary to study the literature on the logistics and risk management of palm cooking oil. The literature study conducted focuses on identifying risks that can occur in the logistics of palm cooking oil in the city of Padang. The sources used during the literature study are in the form of journals, books and articles related to the research topic.

The data analysis stage is the stage that is carried out when the data processing has been completed. Analysis is carried out on sources of risk and risk indicators that are obtained after processing the data. Analysis was also carried out on the ranking given to each indicator in accordance with the calculations that had been carried out using the *Fuzzy* AHP method.

RESULTS AND DISCUSSION

Determination of Risk Sources and Risk Indicators

Sources of risk and risk indicators for the logistics of palm cooking oil in the city of Padang were obtained by means of a literature study. The literature used is journals related to supply chain risks and agro-industrial product logistics. The use of supply chain risk in determining risk sources and indicators is due to some similarities between supply chain and logistics in agro-industry where supply chain flows are related to logistics and influence each other. In addition, the use of supply chain journals is also due to the lack of research on logistics risks for agro-industry.

Based on the results of the literature study, there were 10 risk sources and 34 risk indicators. Sources of risk obtained are supply risk (raw materials), market risk, labor risk, storage risk, production risk, transportation risk, information risk, technology risk, partnership risk and infrastructure risk. Supply risk has three indicators, namely raw material availability, raw material quality variations and raw material price variations. Market risk

consists of consumer rejection, quality certification and competitor products. Labor risk has indicators including workforce planning, workforce availability and workforce quality. Storage risk also has three indicators, namely storage costs, degradation and geographic location.

Production risk has four indicators, namely production capacity, production process, demand uncertainty and raw material quality. Transportation risk has indicators of vehicle availability, vehicle feasibility, modes of transportation, transportation schedules and travel safety. Information risk consists of indicators of information availability, information transfer methods and information distortion. Technology risk consists of indicators of technology availability, technology development and technology mastery. Partnership risk consists of five indicators, namely partner availability, partner selection, partner commitment, trust in partners and communication network breakdown. Infrastructure risk is the last risk related to logistics. This infrastructure risk consists of two indicators, namely the availability of indicators and the quality of infrastructure.

Risk sources and risk indicators submitted to experts to be assessed were previously validated by academics who understand the supply chain and logistics of palm cooking oil. Once validated, risk sources and indicators are assessed by experts through a questionnaire. Assessment by experts is carried out based on expert knowledge and experience regarding the logistics of palm cooking oil. The assessment is carried out in two stages called *Round* 1 and *Round* 2. *Round* 1 is the stage where experts provide an assessment of risk sources and in *round* 2 experts provide an assessment of risk indicators. The results of the assessment are processed using the *Fuzzy Delphi method* .

Expert judgment in *round* 1 resulted in selected risk sources. As for expert 1's opinion regarding the risk sources proposed, it can be seen that the expert gave the highest score, namely "strongly agree" to the risk sources of supply, storage, transportation, and partnerships. Expert 1 also gives “agree” scores for production, labor, market, information, technology and infrastructure risk sources.

Expert 2 gives the highest score to the sources of supply, storage, production, transportation, technology, partnership and infrastructure risk. Other sources of risk get an “agree” score. The sources of these risks are market risk, labor risk and information risk.

Expert 3 chose a source of supply risk, transportation risk, partnership risk and infrastructure risk as a logistics risk for Padang city's palm cooking oil with a value of "strongly agree". The expert selects storage risk, production risk, market risk, labor risk, information risk and technology risk with an “agree” score.

Expert 4 scores “strongly agree” on sources of supply risk, labor risk, production risk, transportation risk and partnership risk. Market risk, storage risk and infrastructure risk are rated “agree”. As for information and technology risk, it is rated "neutral".

Expert 5 gives the highest marks on supply, storage, production, transportation, technology and partnership risks. Market and infrastructure risk gets a lower score but is still included in the "agree" variable. The expert gives the lowest score for labor and information risk.

Expert 6 selected storage risk, production risk, technology risk and partnership risk as the highly approved risk sources. Labor risk, market risk, transportation risk and information risk score "agree". Infrastructure risk gets a "neutral" score while supply risk gets the lowest score with a "disagree" linguistic variable.

The final expert who is expert 7 selects supply, transportation and partnership risks as the highly approved risk sources. Market risk, storage risk, production risk, information risk, technology risk and infrastructure risk are rated "agree". The rating “neutral” is given by experts for labor risk.

Based on the results of the assessment of the seven experts, it can be seen that supply risk, supply risk, storage risk, production risk, transportation risk and partnership risk

received high scores from almost all experts. Labor risk, technology risk and infrastructure risk received a "strongly agree" score from a few experts but other experts still gave the risk an agree and neutral score. while market risk and information risk get the lowest value when compared to other risks. Where the risk does not get a "strongly agree" score from one of the experts and gets the most "neutral" score compared to other risks. This indicates that some experts have doubts about choosing market risk and information risk as the logistics risk for palm cooking oil.

The results of the assessment of the seven experts were then processed using the *fuzzy method* . Processing begins with converting the expert's chosen linguistic variables into *fuzzy* numbers which are then followed by calculating the geometric average of each expert's opinion. The calculation of the geometric average is carried out to obtain a statistically impartial effect and avoid the impact of extreme values (Hsu and Yang. 2000). The geometric mean results are then used to calculate a single value from the risk sources used to select the approved risk sources.

Based on the results of data processing, 8 selected risk sources were obtained where 2 risk sources were removed because they had values below *the threshold* . The *threshold* value used is 0.6. The risks that are not selected are market risk and information risk. Based on processing using the *fuzzy method* , the expert opinion is converted into a single value where the single value for these two sources of risk is the same, namely 0.533. This value is below the value of 0.6 which indicates that the risk source is approved because the value of 0.6 is the median value of the linguistic variable "agree". The traditional *Delphi* method requires repeated surveys to obtain consistency from expert opinions, but the *Delphi fuzzy method* used in this study does not require repeated surveys because expert opinion in one survey can cover all opinions (Kou and Chen, 2008). Based on this, the results *of round* 1 can already represent expert opinion to get the selected logistics risk sources.

Then in *round* 2 an assessment of risk indicators is carried out. Where there are 28 indicators from 8 selected risk sources based on the results in *round* 1 which were assessed by experts. Data processing in *round* 2 was carried out using the same *Delphi fuzzy stages as in round 1. The results of round 2* data processing produced 23 selected indicators. The indicators for variations in raw material quality and price variations for raw materials originating from supply risk are removed. In addition, the manpower planning indicator of labor risk, geographic location of storage risk and transportation schedule of transportation risk are also removed because it has a value of less than 0.6.

Logistics Risk Priority

Risk priority is obtained based on the ranking of risk weights, both risk sources and risk indicators. The risk weight is obtained from the results of the pairwise comparison questionnaire which is then processed using the *Fuzzy* AHP method. The assessment when making comparisons is given by experts. Comparisons are made for each risk source and indicators for the same risk source.

1. Risk Source Weight

The weight of each risk source is obtained by doing pairwise comparisons for each risk source. Pairwise comparisons were made by providing an assessment using the 9 AHP scale. The results of the pairwise comparisons are then converted into *fuzzy numbers* . Then it is processed using the *fuzzy method* to get a single value. This single value is used in making the pairwise comparison matrix. Data processing is carried out using the AHP method to produce a weight for each risk source.

The source of risk that has the greatest weight is the risk of supply (raw materials). Supply risk has a weight of 0.2803. This high supply risk weight means that supplies or raw materials have a very important role in logistics and also have a large potential to experience risk. Palm oil is the main raw material for making palm cooking oil. This raw

material is very dependent on the availability and processing of palm oil, where the availability of palm oil can be disrupted by several risks such as erratic weather and different qualities. So the company needs to pay more attention to the risk of raw materials so that problems do not occur.

The second source of risk that has a high weight is partnership risk with a weight of 0.1619. Partnerships are important in the logistics of palm cooking oil, because the selection of partners and relationships with partners will expedite the production process within the company. Bad partnerships will cause risks such as production failure and others, so partnerships need to be considered carefully. The third highest weight is production risk, which is 0.1576. Production has the highest risk because it is one of the most important processes in the company. In the process of producing palm cooking oil, several things that need to be considered are production capacity, raw materials used and the uncertainty of demand which will affect the amount of production.

Storage risk has a weight of 0.126 which is the fourth highest weight. Storage of raw materials has an important role in agro-industry where raw materials are agricultural products that can change in quality if not handled properly. This causes storage to have a high risk that is directly related to raw materials and products. Uncertainty in the demand and supply of raw materials is the cause of risks to companies related to storage. This raises the uncertainty of storage costs so that it can pose a financial risk to the company.

Technology risk also has a high weight of 0.093. Technology in logistics is one of the important supporting factors. Technology is also an important part of agro-industry, especially processing. This is because processing requires appropriate technology to obtain results that are in accordance with existing standards. The availability of technology and its mastery can be an indicator that can bring risks that the company does not want.

Transportation which is also an important part of logistics gets a weight of 0.081. This means that transportation is a source of risk that must be anticipated by palm oil companies. This transportation affects every activity in the company, because transportation has an important role in the flow of materials from suppliers to product delivery to consumers. Things that can trigger risks in this part of the transportation of palm cooking oil are the number of vehicles that do not meet the requirements, the feasibility of the vehicles and the occurrence of accidents while traveling.

2. Ratio Consistency

The ratio consistency value is needed to see the level of consistency of the weight given by experts through pairwise comparisons. The consistency ratio is calculated against each risk source and risk indicator. The data used in determining the consistency of the ratio is the result of pairwise comparisons which are the single value resulting from defuzzification. The stage in determining the consistency of the ratio is to determine the value of the weight *sum factor (WSF*) by multiplying the defuzzified result value in the pairwise comparison matrix by the weight, after that the consistency factor *(CF) is calculated* by dividing the WSF by the weight. After that, the *consistency index* (CI) is calculated and the ratio index value (RI) is determined based on the ratio index table. CI and RI values are used to calculate the consistency ratio *(* CR).

The ratio consistency value is considered consistent if ≤ 0.1. If it is greater than 0.1, the pairwise comparison questionnaire must be revised. Based on the results of ratio consistency calculations performed on risk sources and risk indicators, the consistency ratio value for risk sources is 0.05 and the consistency value for risk indicators is 0.0, 0.0, 0.045, 0.079, 0.087, respectively. 0.073 and 0.0. A value of 0.0 is obtained because pairwise comparisons are carried out only on 2 indicators, where the RI value for 2 orders is 0, so the CR value becomes 0. The source of supply risk has only one risk indicator

because the other two risks are erased at the indicator determination stage, so it cannot be paired comparisons were carried out.

3. Overall Logistics Risk Weight (Global Weight)

Global weights are calculated to obtain a priority ranking order for each indicator as a whole. The global weight calculation is done by multiplying the risk source weight with the risk indicator weight. indicator risk weights can be seen in table 1.

Table 1. Logistics Indicator Weight Recapitulation

Risk Indicator	Weight	ranking
Availability of Raw Materials	0.2803	1
Storage Fee	0.0774	2
Production process	0.0685	3
Partner availability	0.0599	4
Raw material quality	0.0583	5
Technology Availability	0.0501	6
Degradation	0.0488	7
Infrastructure Availability	0.0471	8
Partner commitment	0.0338	9
Technology Mastery	0.0315	10
Vehicle availability	0.0306	11
Trust in partners	0.0302	12
Labor Availability	0.0284	13
Partner selection	0.0260	14
Mode of Transport	0.0215	15
Vehicle eligibility	0.0195	16
Production capacity	0.0172	17
demand uncertainty	0.0137	18
Infrastructure Quality	0.0132	19
Loss of communication network	0.0120	20
Technological development	0.0114	21
Labor Quality	0.0112	22
Travel safety	0.0095	23

Based on the calculation results, it was found that the availability of raw materials has the highest weight, which is equal to 0.2803. This means that the availability of raw materials has the highest risk that must be anticipated by the company. Palm cooking oil is an agro-industrial product which is highly dependent on the availability of palm oil. The availability of palm oil to be processed into palm oil also depends on the success of the oil palm harvest which is strongly influenced by the season and other factors that can interfere with harvest success.

The second highest weight is 0.077 which is the weight of the storage cost indicator. Storage costs can be at risk if supply and demand uncertainties result in unpredictable storage costs. An expert from a palm cooking oil company stated that in the production of palm cooking oil, supply and storage uncertainties often occur, so it is considered to have a high risk for the company.

The risk indicator that has the next greatest weight is the production process, where this production process has a weight of 0.068. The production process becomes risky because there is uncertainty when carrying out the production process, such as uncertainty in the amount of raw materials obtained per day and also the quality of raw materials used in production varies, so it is not easy to get results according to existing standards.

Availability of partners has a weight of 0.0599 which is the fourth highest weight in this global logistics risk weight. The availability of partners that suit the needs needs to be considered by the company so that the company's needs can always be met. The indicator with the fifth highest risk weight is the quality of raw materials. Raw material quality is an indicator of production risk which has a weight of 0.0583. Risks can occur due to differences in the quality of raw materials which will affect product quality at the time of production. This resulted in the company really having to pay attention to the quality of raw materials in order to guarantee the quality of product quality.

Technology availability has the sixth highest weight, which is 0.0501. Technology is a very important part of the company, especially in the production stage. The availability of technology that does not meet the needs and standards in the processing of raw materials and the production process of palm cooking oil can pose risks that are detrimental to the company. This needs to be considered by the company in order to be able to provide appropriate technology to avoid the risks that can occur.

Decline in quality which is an indicator of the source of storage risk gets a risk weight of 0.048. This indicator is an indicator that has the seventh largest weight. Quality degradation can occur if the handling of raw materials and finished goods during storage is not done properly. The production of palm cooking oil using palm oil as the main ingredient requires the company to be able to pay attention to storage, because the raw materials used are agricultural products which must receive good handling to prevent quality degradation. If there is a decrease in quality, the quality of production results will decrease and cause losses to the company.

Availability of infrastructure gets a weight of 0.047 which is the eighth largest weight. Infrastructure is an important part of logistics. If the availability of infrastructure is disrupted, other logistics activities may also be disrupted. The ninth highest weight is an indicator of partner commitment. Partner commitment has a global weight of 0.338. Partner commitment is needed so that the company can ensure the company's activities can be carried out smoothly. Partners are part of a company that is outside the company so that the company cannot exercise direct control. Therefore partner commitment is very important to be considered by the company.

Mastery of technology is an indicator with the tenth highest weight. This indicator has a weight of 0.0315. This is because the use of technology is very important in the company, so mastery of technology is also very important. If the mastery of technology is low, it can cause risks such as production failure and a decrease in product quality which will cause losses to the company.

Indicators of vehicle availability, trust in partners, availability of manpower, selection of partners and mode of transportation have almost the same weight values. The weights of these indicators are 0.0306, 0.0302, 0.0284, 0.0260 and 0.0215. Each indicator can pose a risk if the company does not pay close attention. The availability of vehicles is important to note, because it is the most important indicator in transportation. Transportation that is not smooth can hinder the course of other activities in the company. If the vehicle is not available in a timely manner, it can result in delays in production and delays in distribution. This is very detrimental to the company.

Trust in partners is the risk that has the twelfth highest weight. This indicator is as important as partner commitment because partners cannot be controlled directly by the company. Trust in partners will have a negative impact on the company if it is not properly considered. The next indicator that needs attention is the availability of labor. Labor is the core of all company activities. If the availability of labor is not in accordance with the needs of the company's activities will be disrupted. Therefore companies need to pay attention to the availability of adequate manpower so as not to cause unwanted risks.

Partner selection gets the fourteenth highest weight. This means that the selection of partners is also a matter that needs to be considered by the company so as not to cause adverse risks. Selection of partners is very important to ensure good cooperation. Bad partner selection can disrupt the company's logistics activities.

The mode of transportation gets the fifteenth highest weight. The choice of mode of transportation must be in accordance with the needs of the company. Selection of a good mode of transportation should be able to increase the effectiveness and efficiency of transportation. So that if an error occurs in the selection of this mode of transportation it will be able to cause losses for the company.

The indicator that gets the sixteenth highest weight is the feasibility of the vehicle. The weight of this indicator is 0.0195. Almost the same as the mode of transportation indicator, this indicator can increase the effectiveness and efficiency of a company's transportation and cause losses if not paid attention to. Vehicles that are not suitable for use can pose risks such as delays and accidents during transportation activities.

The indicator with the seventeenth highest weight is production capacity. The weight of this indicator is 0.0172. Production capacity is an indicator of the source of risk in the production process. Production capacity needs to be considered carefully because the number of requests cannot be predicted by the company. Risks can occur if demand increases but production capacity is unable to meet consumer demand.

Demand uncertainty is the indicator with the eighteenth highest weight. This indicator has a weight of 0.0137. Related to the production capacity indicator, this indicator may pose a risk that has an impact on other indicators. The existence of demand uncertainty can pose a risk of not fulfilling demand due to inadequate production capacity and can also lead to inventory buildup due to excessive production. Both of these have a negative impact on the company.

The indicator with the nineteenth highest weight is infrastructure quality. This indicator has a weight of 0.0132. Infrastructure affects transportation directly. This makes infrastructure important to pay attention to because it will affect other activities in logistics. Good quality infrastructure will have a good impact on transportation which will also facilitate other activities within the company. However, if the quality of the infrastructure is inadequate, it can hamper transportation and cause risks that are detrimental to the company, such as delays.

The next indicator is the breakdown of the communication network. This indicator is an indicator of partnership which gets a weight of 0.012. Communication and information are important things that must be considered so that the flow of information between partners and companies can run well, so that cooperation can also be well established.

Technological development, workforce quality and travel safety are the three indicators that have the lowest weight. Technological development has a weight of 0.0114, quality of labor has a weight of 0.0112 and travel security has a weight of 0.0095. These three indicators are considered not too important when compared to other indicators in the logistics risk of palm cooking oil.

Technology is an important part of logistics, but technological developments are less risky. This is because the availability of technology that already meets the needs of the company can help maintain the effectiveness and efficiency of the company, so it is not too risky if the company does not keep up with technological developments. Even though it does not have a weight that is too high, the company still has to pay attention to technological developments because by following technological developments the company can also improve production quality.

Labor quality gets the second lowest weight. Labor with good quality and in accordance with the needs can provide benefits to the company. But labor with less quality is not too risky for the company. This is because the company can still provide

anticipation such as providing training to the workforce before starting work, so as to reduce the risk of errors occurring when working.

Travel safety is the indicator with the lowest weight. This is because travel security such as natural disasters and accidents cannot be predicted by the company. However, companies can anticipate by providing proper modes of transportation and using proper infrastructure so that accidents can be minimized. With such anticipation, the travel safety indicator is considered to have a not too high risk compared to other indicators.

The global weight ranking order for this indicator looks different from the risk source weight ranking order. The first rank for risk source weight is raw material risk, followed by partnership and production risk, but in the order of global weight ranking for indicators, the first rank is raw material availability indicator which is an indicator of supply risk, while the second rank is storage cost indicator which is one indicator of storage risk, and the third rank is an indicator of the production process which is an indicator of production risk. This difference can occur because the global weight is obtained from the multiplication of the weight of risk sources and risk indicators, where the risk indicator weight is influenced by the number of indicators in each risk source. This is the reason why the weight of indicators from risk sources that have more indicators has a smaller weight compared to indicators with risk sources that have fewer indicators. This is the reason why the ranking of indicators on global weights is different from the order of ranking of risk sources.

CONCLUSION

The conclusions obtained from the results of this study are as follows:

1. The sources of risk obtained by means of a literature study are as many as 10 sources of risk, namely supply, price, market, storage, production, transportation, information, technology, partnership, infrastructure risk. The indicators obtained are as many as 34 indicators. After being assessed by experts, 8 selected risk sources were obtained, namely supply, market, storage, production, transportation, technology, partnership, infrastructure risk. While the selected indicators are as many as 23 indicators. One indicator of raw materials, namely the availability of raw materials. Two indicators for market risk are quality certification and competitor products. Two storage indicators are storage costs and quality degradation. The four indicators of production risk are production capacity, production process, demand uncertainty and raw material quality. The four transportation risk indicators are vehicle availability, vehicle eligibility, mode of transportation, and travel safety. The three indicators of information risk are information availability, information transfer methods and information distortion. Technology risk has three indicators, namely technology availability, technology development and technology mastery. The five indicators of partnership risk are partner availability, partner selection, partner commitment, partner trust and communication network breakdown. Two infrastructure risk indicators are infrastructure availability and infrastructure quality.
2. The order of priority of risk sources based on risk weight is supply risk with a weight of 0.2803, partnership risk with a weight of 0.1619, production risk with a weight of 0.1576, storage risk with a weight of 0.1262, technology risk with a weight of 0 .93, transportation risk with a weight of 0.0811, infrastructure risk with a weight of 0.0603 and market risk with a weight of 0.0395. The order of priority indicators is the availability of raw materials, storage costs, production processes, availability of partners, quality of raw materials, availability of technology, quality reduction, availability of infrastructure, partner commitment, mastery of technology, availability of vehicles, trust in partners, availability of labor, selection of partners, mode of transportation, vehicle feasibility, production capacity, demand uncertainty, infrastructure quality, communication network breakdowns, technological developments, workforce quality and travel safety.

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