Journal of the Community Development in Asia (JCDA) Vol. 7 No. 2, pp.263-279, May, 2024
P-ISSN: 2685-8819 E-ISSN: 2654-7279
https://www.ejournal.aibpmjournals.com/index.php/JCDA

Designing and Building a Risk Management Model for the Pork Supply Chain in North Sulawesi

Eusebius K. M. Endoh[1], Jolyanis Lainawa[2]
Faculty of Animal Science, Sam Ratulangi University[1, 2]
Bahu, Malalayang, Manado City, North Sulawesi 95115, Indonesia
Corresponding Email: jolylainawa@unsrat.ac.id

ARTICLE INFORMATION

Publication information

Research article

HOW TO CITE
Endoh, E. K. M., & Lainawa, J. (2024). Designing and building a risk management model for the pork supply chain in North Sulawesi. *Journal of The Community Development in Asia, 7*(2), 263-279.

DOI:
https://doi.org/10.32535/jcda.v7i2.3188

Received: 17 March 2024
Accepted: 18 April 2024
Published: 20 May 2024

ABSTRACT

This study aims to present a comprehensive model for managing supply chain risks in the pork industry, comprising four primary components: (1) a risk identification (2) a risk assessment (3) a risk mitigation Employing the Snowball Sampling method, the research investigated 30 pig farms across North Minahasa, Bolaang Mongondow, and Minahasa districts, focusing on model identification and risk assessment within farmer and marketing institutions. Findings revealed that supply chain risks within pig farm products are primarily attributed to the perishable nature of the goods, persisting from farm activity processes through distribution channels to final traders. Risk assessment highlighted that farms face the highest level of risk compared to traditional market retailers and supermarkets, with breeders carrying the greatest risk among distributors and retailers. Consequently, identified risks significantly impact production quantity and pork quality, categorizing them as critically important risks. The decline in production adversely affects the income of farmers and distributors/retailers, underscoring the high risk associated with farm-level production activities. In light of these findings, enhancing farm-level performance requires government intervention to regulate the pork supply chain in North Sulawesi.

Keywords: Price Calculation; Risk Assessment Model; Risk Identification; Risk Management Model; Supply Chain

INTRODUCTION

The need for pork as the main source of nutrition in the community in North Sulawesi is common and often found. The lifestyle of the people of North Sulawesi has led to a constant high demand for pork food products. Statistical data of North Sulawesi in 2020, explained that pork production in 2018 was ranked fourth highest in Indonesia, with a total of 24,827.50 tons. In 2019, pork production increased to 25,112.90 tons, but decreased in 2020 to 23,434.96 tons (Taula et al., 2022). The ups and downs in the amount of production that occur, due to farmers feeling pressured by the low selling price situation, which is caused by the influence of supply chain risks that result in increased selling prices at the retailer level. The uncertainty of market conditions in the form of prices and the amount of supply and demand can affect supply chain operations. As a result, there is an influence on the selling value of processed pork products (pork satay, ragey, and traditional Minahasa processed foods) that are very popular with culinary traders in Manado city. This influence is manifested in the form of an increase in selling prices or a decrease in the size of processed products sold (smaller / less), to cover the selling price of pork. The increase in the selling price of pork at the retailer level in Manado City, due to the influence of price increases due to transportation costs, packaging, and labor wages that occur during the marketing process from producers to retailers in traditional markets in Manado City (Pandey et al., 2022)

Supply chain risks occur in operational aspects that result in substandard supply chain processes. If this is ignored, it results in disruption of supply chain activities which can reduce the level of productivity, efficiency, and effectiveness (Nurhuda et al., 2017). Therefore, according to Grover and Dresner (2022), implementing supply chain management is very important strategy so that each process flow function which includes product flow, financial flow, and communication flow can be interrelated and supportive. The main objective of supply chain management is to deliver the appropriate product to customers, in the right quantity and quality, at the appropriate price, and within the specified timeframe (Chopra & Meindl in Lietyana et al., 2022). To create a resilient and effective supply chain management system, it is very important to conduct risk assessment in supply chain management.

This study designed a risk identification model, a risk assessment model, a risk mitigation model, and a pork price calculation model at the farm level by incorporating risk values. With these models, a proactive rather than reactive knowledge base can be established, providing systematic and organized relationships among risks, risk factors, and consequences within supply chain networks. This system integrates the model, and it can help policymakers evaluate the existing conditions of pig farming in North Sulawesi. The evaluation encompasses the implementation of technical aspects in existing farms and marketing institutions, such as animal feed, reproduction, and marketing support facilities. A comprehensive evaluation of the risks that may occur to all stakeholders can assist in determining the priority of solving problems within the pork supply chain. Furthermore, the calculation of risk-based pork prices can serve as a consideration for policymakers in improving the welfare of farmers.

Based on the previous explanation, various formulations of research problems were raised: (1) What are the results of risk identification? (2) What is the magnitude of the biggest risk that occurs in the supply chain that has not been carried out systematically and measurably? and (3) How do the risks experienced by farmers manifest? This research aims to design a pork supply chain risk management model, a supply chain risk assessment model, a supply chain risk mitigation model, and a risk-based farm gate pork price calculation model. This research is considered very urgent as the nation faces food sovereignty and independence programs. Furthermore, there is an increasing demand

for pork for the culinary business, which contributes positively to the development of the pig farming business and the welfare of farmers. Therefore, a pork supply chain risk management model is needed in North Sulawesi to contribute to the fulfillment of food and nutrition needs, as well as to play a role in stunting prevention, support culinary business, and enhance the welfare of farmers.

LITERATURE REVIEW

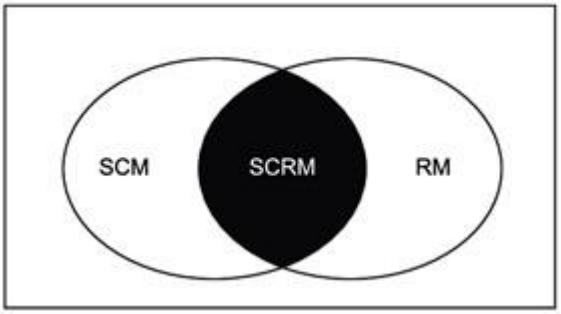
In the process, there will be various risks that affect the flow of the supply chain, which can cause the supply chain to run smoothly (Handoko & Swara, 2020). Therefore, according to Septiani and Djatna (2015), appropriate risk management is needed to overcome supply chain network problems with a systematic and comprehensive risk management approach. The critical point of the pork supply chain lies in the perishable characteristics of the product. The scope of this supply chain ranges from farmers (producers) to consumers.

The supply chain risk referred to in this study is the risk that may occur in every activity of the marketing distribution channel from the pig farm to the final consumer, which is studied starting from the possibility of occurrence, causes, and consequences. According to Tummala and Schoenherr (2011), supply chain risk is influenced by the amount of risk that can be avoided (systematic) and the amount of risk that cannot be avoided (unsystematic). Furthermore, risks or disruptions that occur in supply chain management can be reduced if an industry applies the principles of Supply Chain Risk Management (SCRM) in accordance with applicable rules, which consist of three steps, namely risk identification, risk assessment, and risk mitigation). Risk identification is an effort made by the company to find out the potential risks that occur, risk assessment is an assessment of potential risks, and risk mitigation is an effort to control risks (Pertiwi et al., 2019).

The model design incorporates three key components: performance profile, risk profile, and risk magnitude. It encompasses a comprehensive SCRM framework involving identification, assessment, and mitigation of risks within the supply chain. The risk assessment model includes various components such as risk measurement, risk chain relationships, and risk performance evaluation. Additionally, the risk mitigation model involves risk evaluation, mitigation strategies, and a risk-based farm gate price calculation model.

In North Sulawesi, a correlation chain model is established to analyze the risks within the pork supply chain across three hierarchical levels: risks, risk factors, and consequences. The proposed risk mitigation strategies are devised based on the interrelationship between supply chain risks, aiming to address potential disruptions effectively. For instance, the relationship between variable production costs and the level of risk on pig farms is quantified using the risk adjustment factor. Furthermore, prices at the farm level are calculated by integrating the value of risk, allowing for a comparison with previous prices. The implementation of SCRM is crucial for enhancing company performance, particularly in optimizing supply chain arrangements (Hjaila et al., 2016). The SCRM framework is depicted in the following Figure 1.

Figure 1. Supply Chain Risk Management



Source: Brindley in Handayani (2016)

According to Pujawan and Geraldin in Elvandra et al. (2018), supply chain risk encompasses all risks stemming from the flow of information, materials, and products, or disruptions arising from the complexity of the company's relationships with external parties. Conversely, Peck et al. in Handayani (2016) define SCRM as the risks occurring throughout the flow of products, information, and raw materials to the delivery of the final product. Supply chain risk, therefore, emerges from an imbalance between demand and supply. SCRM, as a risk management approach, is executed within the supply chain structure (Sinha in Anggrahini et al., 2015). Strategies employed to mitigate supply chain risk typically involve risk management practices (Punniyamoorthy et al., 2013; Moktadir et al., 2018), characterized by systematic efforts to analyze and control risks to minimize losses stemming from goal non-achievement (Rilyani et al., 2015; Mariana, 2017; Moktadir et al., 2018). One such method of risk control is Failure Mode and Effect Analysis (FMEA), which entails identifying and preventing potential failures within the supply chain process to minimize future risks (Setiasih & Junadi, 2017). FMEA aims to mitigate potential losses related to costs, information, and process activities, making it a suitable method for risk control in supply chain management (Hisprastin & Musfiroh, 2021).

RESEARCH METHOD

This mixed-method research, started by identifying the pork supply chain system and analyzing the model that was built. Risk analysis begins with analyzing unavoidable risks consisting of an analysis of environmental characteristics and supply chain configuration. The stages of model development are divided into two groups, namely the development of a supply chain risk identification model and a supply chain risk assessment model, at the risk-based farmer level. The research was conducted in North Sulawesi province (Minahasa Regency, North Minahasa Regency, Bolaang Mongondow Regency) from March 2023 to October 2023. The determination of this location is based on having potential in the pig farming business. The type of data in this study uses primary and secondary data. Primary data is obtained through interviews, survey, and observation, which include three main streams, namely: (1) Flow of goods from suppliers to consumers; (2) Information flow contains order delivery and delivery status review; and (3) Financial flow consists of credit limits, payments, and payment schedules, delivery accuracy and owner identity. The secondary data is obtained through books, journals, internet, and other related sources.

Concept definitions and variable measurements are as follows: (a) Supply chain is the flow of products, finances, and information of livestock and pork commodities distributed in the supply chain livestock and pork commodities that are distributed in the supply chain from the from the producer to the final trader; (b) Livestock collectors are actors/elements

or business actors who buy pig production, directly from the buying pig livestock production directly from producers in certain quantities in certain quantities; (c) Butchers or slaughterhouses are business actors who provide slaughter services for pigs provide pig slaughtering services; (d) Traders are business partners who buy pig livestock commodities from livestock collectors to be sold to final consumers from livestock collectors to be sold to end consumers; (e) Producers are farmers or people who cultivate pigs, in this case, is CVV Pig Farm Samerot in Kanonang Village 3 Kawangkoan Sub-district, Minahasa Regency; (f) Retailer is the final trader who sells pig livestock commodities in fresh form in traditional markets and supermarkets; and (g) Price referred to in this study is the price/value of pig livestock commodities determined by the market based on market conditions in the commodities determined by the market based on market conditions at the time of one time the research took place.

The population in this study were commercial pig farming companies with more than 100 animals and actively conducting routine marketing activities. Snowball sampling was used to purposively select 30 pig farming companies in Minahasa Regency, North Minahasa Regency, and Bolaang Mongondow Regency. According to Nurdiani (2014), the sample size for the snowball sampling method of 30 people is included in the large sample size. Determination of location in the form of villages and informant specifications such as name and gender in fulfilling the number of informants cannot be determined by the researchers. Through the snowball technique, the researchers will get recommendations for the names of pig farming companies from key informants and supporting informants who have been interviewed previously. In this study, two key informants were used, namely the village government and agricultural extension officers.

RESULTS

Supply Chain Risk Identification

The supply chain risk of pig farming products lies in the perishable characteristics of the product, like other livestock products. This risk starts from the activity process at the producer (farm) and then continues in the distribution process until finally at the final trader (retailer). The results of the study found the state of the pig rearing system, where the types of pigs raised are Sadelback-Landris. The pigs are intensively reared, due to direct observations where producers pay close attention to matters relating to the availability of adequate seedlings both in terms of quality and quantity, maintenance management which includes housing, cage hygiene, maintenance of sows, piglets, male pigs and growing-age pigs and handling of production. Pig barn construction is a double barn which is a two-row barn building with opposite and opposite locations. In individual sow houses and fattening pens, one room is reserved for only one pig. Meanwhile, based on the survey results at the pig farming company CV Pig Farm Samerot in Kanonang Village 3 Kawangkoan Sub-district, Minahasa Regency, it is described; that the stud pen is specially built, separate from the sows. For the size of the pen, the lambing pen is 2.5 meters long and 1.5 meters wide, the stud pen is 3 x 2 meters and the pen for pigs aged 3 months - 1 year is 1 meter long and 1 meters wide for each pig. The feed used is divided according to needs, namely; rations for starters are piglets that are still breastfeeding at the age of 8 – 10 weeks, grower rations are piglets after going beyond the starter phase until the age of 5 months that have passed the grower phase and reached a weight of 50 kg, fattening rations are fattened as slaughter pigs weighing 50 – 100 kg. Seedling rations given to heifers (pregnant pigs for the first 3 months) with food ingredients that have a relatively high crude fiber content of approximately 8.5%, 14.5% protein, and added forage, and lactating sows rations, which are rations given in the last month of pregnancy and while they are breastfeeding. Ration feeding is done twice a day with the following ration weight measurements; for piglets aged approximately 8 weeks on average 0.25 kg/head/day, for 1-year-old 1-year-old piglets

on an an average of 2 kg/head/day, for non-lactating/non-pregnant sows on average 2 kg/head/day, for pregnant sows on average 2.5 kg/head/day, for lactating sows on average 2 kg/head/day plus the number of children multiplied by 0.25 kg/head/day and for males on average 3 – 4 kg/head/day. While the activity of cutting piglets' teeth is carried out by producers with the aim of not injuring the mother's nipples or causing injuries between fellow piglets while playing or fighting.

In the sale/purchase transaction in the supply chain; the total pig population of the informant's pig farm company CV Pig Farm Samerot at the time of the study there were 2224 heads, where livestock sales were carried out on average 2 times per week with a total sales production of 60 heads per sale. Livestock sales are carried out in 2 ways, namely sold live animals and sold in the form of fresh and frozen pork, where the slaughtering process is carried out directly by the company in Kanonang Village 3 Kawangkoan Subdistrict, Minahasa Regency and using the slaughtering services of collectors or also Manado slaughterhouse services. In this marketing system, the company acts as a producer, whose function is to distribute pork products into the marketing flow. The results of this study show that there are three marketing flows: (1) Flow I: Producer - Intermediary traders (collectors) - Traditional market retailers – Consumers; (2) Producer - Middleman (collector) - Supermarket retailer – Consumer; and (3) Flow III: Producer - Inter-island retailer (Surabaya) in Tomohon - Consumer.

Several approaches to risk management stages have been developed. One such approach, proposed by Tummala and Schoenherr (2011), divides risk into three stages: (1) risk identification, measurement, and assessment; (2) risk evaluation and mitigation; and (3) risk monitoring and control. In this study, the risk factors were identified through interviews with stakeholders, aimed at risk identification and assessment, which includes Risk Severity Assessment.

Risk Occurrence Assessment

During this phase, informants evaluate the risk events based on severity values, which are categorized into five levels. These levels range from almost no impact or failure to a very dangerous impact on the performance or overall quality of the supply chain process. The severity values provide a structured framework for assessing the potential consequences of each risk event. They include (1) negligible impact, indicating minimal interference with the supply chain process; (2) minor impact, signifying slight disruption of performance or quality; (3) moderate impact, marking the beginning of performance disruption; (4) major impact, posing a significant threat to performance or quality; and (5) very dangerous impact, representing a severe risk to the overall supply chain process. This systematic approach enables a comprehensive evaluation of risk events, allowing for informed decision-making and effective risk management strategies.

During the risk agent stage, informants assess the probability of occurrence using a scale that ranges from almost never happens to almost always occurs. This scale provides a structured framework for evaluating the likelihood of events. The levels include: almost never happens, where the occurrence of events is extremely rare; the number of events is very small, indicating a minimal occurrence rate; the number of events is small/few, representing a limited occurrence; the number of events is very low, signifying an extremely low occurrence rate; the number of events is low, indicating a low but noticeable occurrence rate; the number of events is moderate, suggesting a moderate occurrence rate; the number of events is quite high, representing a significant occurrence rate; the number of events is high, indicating a substantial occurrence rate; the number of events is very high, signifying a very high occurrence rate; and almost always occurs, where events happen almost consistently. This systematic approach enables informants

to assess the probability of occurrence accurately, facilitating effective risk management strategies.

Furthermore, to simplify the analysis, each risk and risk factor is given a code, namely; The coding of risks and risk factors includes:
R : Risk, FR: Risk Factor, P: Producer/Breeder, D: Distributor, PP: Retailer
PA : Pork delivery from Breeder (P) to Retailer (PP)
PB : Pork delivery from Distributor 1 (D1) to Distributor 2 (D2)
PC : Pork delivery from Distributor (D) to Retailer (PP)

The results of the analysis conducted based on the coding of risks at farmers, distributors, and retailers are described in Table 1 below.

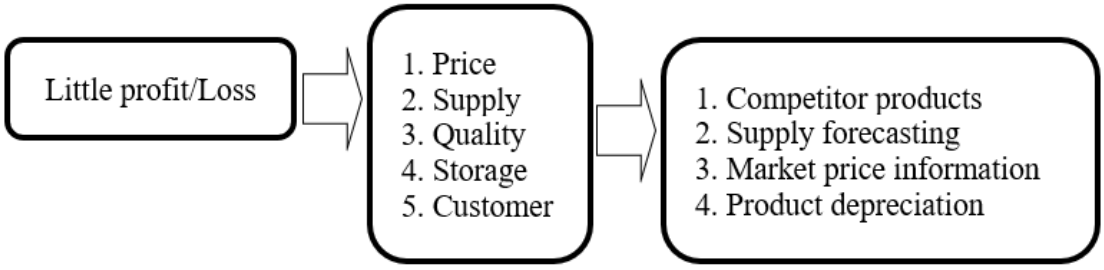
Table 1. Risk Coding at Farmers, Distributors, and Retailers

Code	Risk at Farmers	Risk at Distributor	Risk at Retailers
R1	Seedling Selection	Price	Meat Safety
R2	Housing	Supply	Meat Quality
R3	Feed	Quality	Consumer Perception
R4	Pig Husbandry	Storage	Meat Price
R5	Disease Treatment and Prevention	Customer	Livestock Disease Issue

Risk factors were identified based on the results of literature studies and field surveys by selecting a sample from the population and interviews with experts. Risks and risk factors were validated based on expert judgment. One of the results of the validation of the conceptual model of pig healthcare risk can be seen in Figure 2 below.

Identification of Risks and Risk Factors at Distributors
The risk factors that have the highest weight from the results of risk identification using fuzzy AHP at the distributor level in the supply chain of pig livestock products are price risk, supply risk, quality risk, and storage risk. A detailed explanation of the distributor-level risk factor comparison analysis results can be seen in Figure 2.

Figure 2. Validation of Risk Model at Distributor



The results of the evaluation of risk variables at the distributor level in the supply chain of pig livestock products indicate that the four main risk factors obtained from the assessment do not receive significant risk variables to be considered in supply chain risk analysis, as all risk variables at the distributor level have low values. Through interviews with several distributors of pig livestock products, it was revealed various risks that should be taken into account at the distributor level within the pork commodity supply chain. These include price risk due to competition from other products, the risk associated with supply forecasting, market price information, and the risk of product depreciation during storage. However, upon assessing the risk factors at the distributor level, it was found that the four main risk factors identified did not yield significant risk

variables. In other words, the evaluation indicated that the risks at the distributor level generally had low values and were not considered important (see Table 2).

Table 2. Distributor Risk Impact

Probability	Impact	Indicator	Frequency of Occurrence
Sometimes	Medium	Competition with other products	<2 times
Rare	Small	Supply forecasting	<1 times
Sometimes	Medium	Market price information	<3 times
Rare	Small	Risk of product shrinkage during storage	<1 times
Rare	Small	Delays in the overall distribution process	<1 times

Risk factors related to competing products arise from shifting consumer preferences and the lack of innovation in recent technological advancements. Another risk factor pertains to supply forecasting due to the absence of historical sales data and inadequate future projections. Additionally, challenges in obtaining market price information stem from the difficulty in predicting disease outbreaks such as (African Swine Fever) ASF. Lastly, risks associated with product shrinkage result from issues like poor preservation systems leading to flabby, discolored, and unappetizing pork (see Table 3).

Table 3. Distributor Risk Identification and Risk Factors

No.	Risk	Risk Factors
1	Competitor Products	1.1 - Consumer preferences are changing
		1.2 - Not innovating, growing, and staying up to date on the latest trends and technologies
2	Supply Forecasting	2.1 - No historical data (previous sales)
		2.22 - No future projections with mathematical models
3	Market Price Information	3.1 - Unpredictable price (easy to change)
		Disease outbreak (ASF)
4	Product Depreciation	4.1 - Pork is mushy
		4.2 - Pork discoloured
		4.3 - Pork smells not fresh

Risk Assessment Model

Risk assessment is carried out using a fuzzy logic approach, involving the inference process from the risk rule base and risk factors using the Fuzzy Inference System (FIS) approach. This includes compiling the rule base for risk assessment in pig farming and pork delivery activities. The results of the risk factor assessment at the farm level show the highest risk compared to traditional market retailers and supermarkets. Based on the results of the risk assessment, it is evident that farmers face the highest risk compared to distributors and retailers. Risk assessment in pork delivery activities is divided into two parts: risk assessment of meat delivery from farmers to distributors and delivery from distributors to retailers.

The results of the linguistic risk assessment for pork delivery from farmers to distributors fall into the category of unimportant risk. The chance of occurrence is rare, the severity is low, and this risk is easy to detect, so the risk factors in this delivery activity can be ignored. The results of the risk factor assessment of pork delivery from distributors to retailers mostly indicate that the risk falls into the important category. Risks and risk

factors from each supply chain network are interrelated, necessitating evaluation of their impact on each network.

The evaluation results serve as input for constructing the supply chain risk relationship model. The stages involved in preparing the risk relationship chain for the pork industry supply chain in North Sulawesi are as follows: (1) The risk assessment results categorize risk factors into five groups based on their assessment category: very important, important, moderate, not important, and very unimportant; (2) Risks and risk factors are assessed for their impact on other sub-systems. Specifically, risks deemed very important and important are evaluated. Risk factors at farms are assessed for their impact on retailers and consumers, risk factors at distributors are assessed for their impact on farms and the culinary industry as users of pork products, while risks in the culinary industry are assessed for their impact on farmers and retailers; (3) Risk factors from farmers and retailers are categorized based on their relationships, causes, and impacts, and then their interrelationships are organized in stages, informed by field observations and discussions with experts and academics; and (4) Development of risk linkages and factors using the risk dependency chain method, which includes risk factor level, risk level, and consequence level resulting from the relationship between risks and risk factors.

The risk chain model encompasses four consequences: decreased pork production, diminished pork quality, financial loss due to negligence and adulteration, and delayed delivery of pork to retailers. These risk chain models illustrate the connections between risks and risk factors. Establishing these linkages contributes to understanding the consequences, which ultimately affect the overall supply chain performance. The performance of the pork supply chain risk is defined by the level of achievement of outcomes, reflecting the positive or negative impact of risk occurrences on the supply chain. The measured risk magnitude is translated into performance metrics such as time, cost, and quality.

The risk magnitude and risk performance of the pork business supply chain, which include decreases in product quantity, decreases in production quality, financial loss due to negligence, and delays in delivery to retailers, are described in Table 3 below.

Table 4. Magnitude Risk vs. Risk Performance of Pork Business Supply Chain

Supply Chain Risks	Risk Magnitude	Risk Performance		
		Time	Cost	Quality
Decrease in product quantity	Very Important (SP)	-	SR	S
Decreased production quality	Important (P)	-	R	SR
Financial loss due to negligence	Important (P)	-	SR	R
Delayed delivery to retailers	Medium (S)	S	S	S

The data in Table 4 shows the risk performance obtained for the four main risk consequences that have been measured are (1) decreasing the amount of pork production with a very important risk magnitude has a Very Poor (SR) effect on cost performance and Moderate (S) on quality performance, (2) decreasing the quality of pork with an important risk magnitude, very bad (SR) on quality performance and bad (R) on cost performance, (3) financial losses due to loss and counterfeiting with an important risk magnitude have a very bad (SR) effect on cost performance and bad (R) on quality performance, and (4) delays in delivery to retailers with moderate risk magnitude (S) affect the performance of time, cost and moderate quality (S).

Based on Table 4, the results of the identification of risks in the supply chain network activities are distributed across farms, distributors, and retailers. Most risks were identified at the producer (farm) level, followed by risks at the distributor level, and then at the retailer level in traditional markets and supermarkets. Risks in delivery activities were the most prominent, comprising risks during pork delivery from farmers to retailers and risks from distributors to retailers. These risks in each network serve as a knowledge base for actors and decisions in the supply chain network, aiding in deciding on appropriate risk management plans. Each risk factor is measured and assessed through three dimensions: Occurrence (O), Severity (S), and Detectability (D). The greatest risk (Very Important) on farms lies in the risk factor of reproduction and livestock health, while the greatest risk for distributors is in the risk factor of decreased quality and pork prices not aligning with estimates. Retailers face the biggest risk factor of product damage. These assessment results feed into the risk evaluation stage. The design of the risk linkage model yielded four risk linkage chain models, specifically related to decreased production, decreased quality, financial losses due to decreased pork quality and selling price, and obstacles in the distribution process to retailers.

Risk Mitigation Model

The identification of relevant mitigation actions against emerging risk agents in this research aims to identify what will be the handling strategy to deal with emerging risk agents. Risk mitigation actions are arranged based on prioritized risk agents. There are 10 mitigation actions that can be taken by the company to prevent and minimize the prioritized risk agents. The mitigation actions were then assessed based on their effectiveness against the risk agent and the resources used for their implementation.

A risk event refers to a conditional statement describing events or circumstances that have the potential to hinder, delay, impede, or prevent the achievement of the set objectives. These events may involve unexpected occurrences leading to losses, violations, failures, or errors. They can either be risks that have already been identified and documented in the risk register or risk dictionary, or they may be risks that have not yet been recognized. The results of the identification of risk events, including mismatch between production planning and realization, mismatch of raw material availability with production plan, mismatch of supply chain process with distribution cost budget, delayed arrival of pork products at retailers, decreased production quality due to ASF disease outbreak, product damage during distribution, product damage during storage, limited knowledge and manpower at the producer level, late product delivery, and product damage during the distribution process, are described in Table 5 below. Identification of mitigation actions that are relevant to the risk agents that appear in this research aims to identify what will be the relevant mitigation strategies. This research aims to identify what will be the handling strategy to deal with emerging risk agents.

Table 5. Risk Event Identification Results

Risk Events	Code	Severity
The mismatch between production planning and realization	E1	4
Mismatch of raw material availability with the production plan	E2	7
Supply chain process mismatch with distribution cost budget	E3	5
Delayed arrival of pork products at retailers	E4	3
Decreased production quality due to African Swine Fever (ASF) disease outbreak	E5	6
Product damage during distribution	E6	4
Product damage during storage	E7	4
Limited knowledge and labor at the producer level	E8	7
Late product delivery	E9	8

Product damage during the distribution process	E10	5

In risk event (E), the severity ratings vary across different scenarios. For instance, the mismatch between production planning and realization is rated at 4 out of 10 severity levels, indicating a high-risk category. Similarly, the risk event concerning the discrepancy between raw material availability and the production plan is rated at 7, placing it in the low-risk category. Meanwhile, the mismatch between the supply chain process and the distribution cost budget falls in the neutral category with a severity level of 5. Delays in pork product arrivals at retailers are considered highly severe with a rating of 3, while the decline in production quality due to ASF disease outbreaks is rated at 6, indicating a lower severity level. Product damage during distribution and storage both rank at severity level 4, categorized as high risk. Limited knowledge and labor at the producer level are rated at 7, indicating a low-risk level. Late product delivery falls under severity level 8, considered a low-risk scenario, whereas product damage during the distribution process is rated at 5, placing it in the neutral category.

Risk agents are factors capable of triggering specific risk events, and their likelihood is assessed using an occurrence scale that indicates the probability of these events occurring and causing operational failures. These agents represent potential events that could lead to unfavorable outcomes for the company. It is important to note that one risk agent can contribute to multiple risk events, and vice versa. The identification of risk agents involves evaluating their likelihood of occurrence. Table 6 below outlines the results of this identification process, which includes various factors such as changes in marketing demand, damage to raw materials during transportation, errors in production planning and labor, issues with information systems, prolonged product storage, raw material shortages or excess, overproduction, and poor conditions of product delivery facilities.

Table 6. Risk Agent Identification Results

Risk Agent	Code	Occurrence
Change in demand from marketing	A1	5
Raw material damage during transport	A2	6
Miscalculation of production planning	A3	5
Labor error/negligence	A4	4
Error in information system	A5	3
Prolonged storage of products	A6	8
Raw material shortage	A7	3
Excess raw materials	A8	7
Overproduction	A9	7
The poor condition of product delivery facilities	A10	4

In risk agents identified by code (A), various factors are ranked based on their occurrence rates. Changes in demand from marketing are classified as risk agent 5, indicating a neutral occurrence rate. Conversely, damage to raw materials during transportation ranks as risk agent 6, with a frequent occurrence rate. Miscalculation of production planning is categorized as risk agent 5, also reflecting a neutral occurrence rate. Labor errors or negligence are ranked at 4, indicating a high occurrence rate. Errors in the information system rank at 3, with a similarly high occurrence rate. Prolonged product storage is rated at risk agent 8, signifying a very low occurrence rate. Raw material shortages rank at risk agent 3, with a low occurrence rate, while excess raw materials and overproduction both rank at risk agent 7, also with low occurrence rates. Lastly, the poor condition of product delivery facilities is ranked as risk agent 4, with a low occurrence rate.

Risk mitigation involves actions aimed at reducing or maintaining the magnitude of the primary risk until it reaches the expected residual level. The process of risk mitigation encompasses several stages, including the selection of mitigation options, the development of action plans, the determination of expected residual levels, the implementation of action plans, and the monitoring of remaining risks. Mitigation options may consist of a combination of strategies directed toward reducing the likelihood of risk occurrence. Mitigation encompasses a series of efforts to reduce risk through physical development, as well as the enhancement of awareness and the ability to deal with threats.

This study has identified various supply chain risk cases, including raw material shortages, supplier failures, rising material prices, machine breakdowns, uncertain demand, inaccurate forecasting, order changes, and transport failures.

The risk mitigation priority ranking, outlined in Table 7 below, includes initiatives such as building effective commitments with pork distributors and retailers, evaluating and rescheduling demand, implementing a reward and punishment system for business partners, assessing worker performance to minimize damage to raw materials and pork products, and enhancing communication both internally and externally. The potential for various risks can affect the smoothness of distribution business activities, especially, the commodities distributed are livestock commodities which are commodities that have a high risk and potential for quality decline. potential for quality degradation is quite high. (Ulfah, 2016). Research by Manir et al. (2021) revealed that along the beef supply chain from raw material procurement to distribution, there are various risks that can occur which can cause losses at the supplier level starting from raw material procurement, handling and processing, and shipping as well as at the distributor level starting from beef procurement, storage, receiving, and distribution. from beef procurement, storage, receiving, preparing, checking, and shipping orders.

For risk mitigation priority ranking based on priority ranking are; establishing effective commitment with pork distributors and retailers followed by evaluation and rescheduling of demand, implementing a reward and punishment system for business partners, evaluating worker performance to reduce damage to raw materials and pork products and improving communication both internally and externally.

Table 7. Risk Mitigation Priority Ranking

Code	Risk Mitigation
PA1	Effective commitment building with pork distributors and retailers
PA2	Evaluation and rescheduling of requests
PA3	Implement a reward and punishment system for business partners
PA4	Evaluate worker performance to reduce damage to raw materials and pork products
PA5	Improve communication both internally and externally

Pork Price Calculation Model at Farmer Level by Incorporating Risk Factors

Pig production is a profit-making activity; however, most farms have weak internal controls and empirical management and do not even know the market price of pig production. Knowing the production cost of what is to be commercialized is essential for any process involving business management, and in pig production, the same is true. However, the lack of standardized methods and simple, accessible tools makes it difficult for producers to organize the economic management of their business. In this regard, this research aims to develop a free and easy-to-use tool to calculate pig production

costs and serve as a management tool in commercial properties. The profit and loss received by farmers is influenced by the number of livestock, livestock productivity, production costs, and the price of pork received by farmers. The calculation of production costs at the farmer level in this study aims to see whether the farmer's production costs can be covered by the selling price to retailers. In addition, it also aims to see the level of income of farmers for the costs incurred during the production process. These results can be taken into consideration by retailers in setting pork prices at the farm level because prices are related to farmers' income levels.

DISCUSSION

The pork supply chain risk management design model obtained in this study is four main models: risk identification model, risk assessment model, risk mitigation model, and price calculation model at the farm level by incorporating risk factors. This system integrates three models, namely risk identification, risk assessment model, and price calculation model at the farm level.

The identification results obtained risks in supply chain network activities and delivery risks. The biggest risk at the farm is in the risk factor of reproduction and health of livestock, while the biggest risk at the distributor occurs in the risk factor of product damage and milk prices that do not match the estimate. The risk factor at retailers lies in the risk of product damage during storage at outlets. The risk in delivery activities is divided into two stages, namely the delivery of pork from farmers to distributors, and from distributors to retailers.

This study developed four models depicting the chain of risk relationships within the pork supply chain in North Sulawesi. These models are associated with a reduction in pig livestock production, a decline in pork quality, financial losses resulting from negligence, and a decrease in pork quality along with delays in delivery to retailers. These risk linkage models elucidate the interconnectedness of risks and risk factors throughout the supply chain network.

Based on the results of the risk evaluation, it is found that the largest risk relationship in the chain is a decrease in the amount of pork production and quality. The risk factors of reproduction and animal health are the most important risk factors in solving the problem. This risk factor is caused by the absence of a good planning management system. Based on the risk mitigation analysis, four main priority constraints were obtained, namely building effective commitments with distributors and retail pork traders, evaluating and rescheduling demand, implementing a reward and punishment system for business partners, evaluating worker performance to reduce damage to raw materials and pork products and improving communication both internally and externally.

Risk event analysis was conducted on the main supply chain processes consisting of planning, procurement, processing, delivery, and return. There are risk events identified in the scope of the pork supply chain research in North Sulawesi. Risk events are identified and the severity value is done by identifying the risk agent as the cause of the risk event. According to Tampubolon et al. (2013), risk agents can cause more than one risk event so activities for prevention should be focused on risk agents.

Risk mitigation actions are arranged based on prioritized risk agents. There are mitigation actions that can be taken by companies to prevent and minimize prioritized risk agents. Mitigation actions are then assessed based on their effectiveness against the risk agent and the resources used for implementation. Priority ranking of risk mitigation actions based on expert judgment. The three dimensions of risk factors are

Occurrence (O), Severity (S), and Detectability (D).

The results of the study stated that the largest risk magnitude (Very Important) was at the producer level (farms) with the main risk factors of reproduction and livestock health, the results of this assessment became input in the risk evaluation stage. The results of this assessment can change according to environmental changes within and outside the supply chain network. The results of the design of the risk linkage model obtained four risk linkage chain models, namely the linkage chain associated with a decrease in the number of pig livestock production, a decrease in the quality of pork, financial losses due to negligence in reducing the quality of pork due to errors in the distribution process and delays in delivery of fresh pork to retailers in traditional markets and supermarkets. The risk relationship chain model that has been built is expected to help solve the risks that occur in the pork supply chain in North Sulawesi which are holistic and integrated in all supply chain networks.

Problem solving is focused according to the problem and the priority order of risk handling can be known from the level of the risk relationship chain that is built. The risk performance obtained for the four main risk consequences that have been measured are (1) decreasing the amount of production with a very important risk magnitude has a very bad effect on cost performance and moderate on quality performance, (2) decreasing the quality of pork with an important risk magnitude, has a very bad effect on quality performance and bad on cost performance, (3) financial losses due to decreased pork quality and selling prices with an important risk magnitude has a very bad effect on cost performance and bad on quality performance, and (4) distribution delays to retailers with moderate risk magnitude has a moderate effect on time, cost and quality performance. The risk performance model is developed using quantitative assessment so that the impact of risks arising in terms of time, cost, and quality is quantitatively measured. Risk evaluation is determined based on the risk catalog, risk chain relationship model, risk assessment results, and risk performance.

Risk sources, causes and impacts were successfully traced from the knowledge base built as a result of expert knowledge representation, field problems, and literature studies. The results of the risk evaluation showed that the most critical problem in the pork supply chain in Minahasa district is the decline in pork production and quality. The main risks of these problems are the risk of meat color change, odor, and flabbiness, which affect the demand for pork. The main cause of reproduction risk and animal health is due to the absence of management planning and evaluation of the pig farming business.

The performance of the organic rice supply chain on the asset attribute at the farm level only reaches a superior position. However, the supply chain performance on the reliability attribute has not been able to achieve a good performance position. good performance position. Thus, there is a need for improvement efforts through disciplined delivery arrangements and improved product quality to improve supply chain performance. To minimize risk, improvement efforts are needed through disciplined delivery arrangements, improved product quality, and cost efficiency to improve supply chain performance (Handayani et al., 2019).

There are five supply channels for beef cattle and beef with different marketing margins, the profits obtained in each marketing institution are in the very high category, this triggers high risks in the supply channel which causes the selling price at the retailer level to increase and reduce the income of producers, in this case traditional farmers, the development strategy is to change the traditional supply channel model to modern by approaching the marketing industry concept (Endoh et al., 2021). The concept is to

prioritize production line technology, financial lines, and communication lines, all of which are supported by regulations governing the correct supply lines for pork marketing. This will control the risk of pork supply lines in North Sulawesi.

CONCLUSION

The results of the risk identification in supply chain network activities highlight the distribution of risks across farms, distributors, and retailers. Among these, the most significant risk magnitude lies in the chain of risk relationships affecting pork production quantity and quality, categorized as "Very Important (SP)." This decrease in production not only impacts the income of farmers but also affects the earnings of distributors and retailers. Identification results, pork supply chain risks in North Sulawesi province occur at the producer and distributor levels with different levels of risk. This is due to the state of consumer preferences, especially the existence of competing products, the absence of innovation with the latest technological developments where the production and distribution system is still traditional, not accustomed to recording historical sales data beforehand, and no future projections with a good calculation model, the threat of disease outbreaks (ASF) and the risk factor of decreasing product quality.

Risk evaluation results, there is a mismatch between planning and realization of production with high severity, mismatch of raw material availability with production plans with low severity, mismatch of supply chain processes with distribution cost budgets with neutral severity, late arrival of pork products at retailers with high severity, decreased production quality due to ASF disease outbreak with low severity, product damage during distribution with high severity, product damage during storage with high severity, limited knowledge, and labor at producer level with low severity, late product delivery with low severity, product damage during distribution process with neutral severity.

Risk mitigation based on priority ranking is establishing effective commitment with pork distributors and retailers, followed by evaluation and rescheduling of demand, implementing a reward and punishment system for business partners, evaluating worker performance to reduce damage to raw materials and pork products, and improving communication both internally and externally.

It is recommended that this research be continued by evaluating each stakeholder, in order to obtain various alternative risk mitigation actions and improve the performance of the pork supply chain in North Sulawesi that are more detailed so that they are more practical to be implemented by producers and distributors.

The findings of this research hold several implications for enhancing the efficiency and resilience of the pork supply chain. Firstly, leveraging information technology emerges as a critical strategy to expedite and ensure the success of the supply chain. Implementing robust information systems is imperative to mitigate risks inherent in the pork supply chain. Moreover, fostering transparent and seamless communication among all stakeholders is essential. Establishing routine, spontaneous, and transparent communication channels akin to those within organizational departments is paramount to bolstering the supply chain's effectiveness. Secondly, prioritizing innovation performance is crucial for producing high-quality products with a competitive edge. By continually innovating and improving product quality, businesses can strengthen their competitive position in the market. Lastly, investing in workforce development through comprehensive training initiatives emerges as a top priority. Enhancing workforce competence not only mitigates various sources of risk but also enhances overall operational efficiency and effectiveness. Therefore, prioritizing workforce development

initiatives can significantly contribute to mitigating risks and ensuring the sustainable success of the pork supply chain.

ACKNOWLEDGMENT
Sam Ratulangi University

DECLARATION OF CONFLICTING INTERESTS
The authors declared no potential conflicts of interest.

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