RISK ASSESSMENT AND MITIGATION STRATEGIES IN THE MILK AND DAIRY SUPPLY CHAIN

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Abstract

Today's supply chains are very complex and their participants are exposed to numerous risks that can threaten their operational efficiency, profitability and reputation. This complexity increases the interdependence among participants and makes the supply chain more vulnerable to various internal and external disruptions. Effective supply chain risk management enables organizations to be more proactive in facing challenges and to develop risk mitigation strategies. The aims of this paper are to examine the process of risk identification and assessment, and to propose risk mitigation strategies in one milk and dairy supply chain. First, the risks are identified using both a SWOT (Strengths, Weaknesses, Opportunities, and Threats) and questionnaire-based data analysis. Then, the risk matrix and the FMECA (Failure Mode, Effects and Criticality Analysis) methods are applied in order to assess risk. Finally, several important risk mitigation strategies are proposed for the considered milk and dairy supply chain. The findings of this study bring new practical insights related to supply chain risk management.

Keywords: supply chain risk, risk assessment, mitigation strategies, milk and dairy supply chain

1. INTRODUCTION

Today's supply chains are much more complex than a couple decades ago, all supply chains are globally interdependent, and as such have a heighten exposure to various sources of risk [1, 8]. According to [2] supply chain risk in the simplest way can be defined as the likelihood of an unexpected event happening that adversely affects supply chain performance. Such risks might arise internally, from operational inefficiencies and lack of resources, or externally, from fluctuating energy costs, regulatory requirements, and competitive pressures [8, 11]. The dairy industry is particularly sensitive to different types of risks due to the perishability of raw materials, very strict food quality standards, and a high dependency on logistics infrastructure [8].

These different challenges inspire researches and companies to find ways to be more proactive when it comes to risk management. In academic research numerous analytical approaches have been developed to support the identification, assessment, and prioritization of risks. One of the older and most widely used qualitative tools is SWOT analysis, which enables the classification of internal strengths and weaknesses, as well as external opportunities and threats [5]. Managers and researches often use survey-based methods analysis, which identifies risk from the employee perceptions, providing a valuable bottom-up perspective on operational vulnerabilities [3, 6]. The survey percentages were used qualitatively to highlight which risks are perceived as most relevant by the employees. These values were not converted into numerical weights, rather they were used as the base line for further analysis as well as supporting the decision of which risks should be included in the risk matrix and the FMECA analysis. For risk assessment or risk ranking, the risk matrix approach is often applied to categorize risks based on probability and impact, offering a clear prioritization framework

[4, 9]. For a more detailed approach the FMECA (Failure Mode, Effects and Criticality Analysis) method can be used, it enables a systematic assessment of potential failures in terms of severity, occurrence, and detection [10]. Using FMECA in one document risks can be ranked and suggestions made [7].

Building on these different approaches, this paper applies a combination of survey response analysis, SWOT analysis, risk matrix, and FMECA to examine a milk and dairy supply chain. The objective is to identify and assess critical risks and to propose mitigation strategies that can enhance operational resilience, efficiency, and sustainability.

2. CASE STUDY

Risk management in supply chains is in a growing trend and companies are investing their resources in order to identify as many potential risks in order to create appropriate risk mitigation strategies and actions. A short case study was conducted on risk management in one dairy production company from Serbia. This company oversees all the processes from sourcing the milk to the delivering the final dairy products to the customer. The production process produces over 200 types of dairy products, and distribution of these products is worldwide. The structure of the methodology of collecting and analysing data is shown in Figure 1.
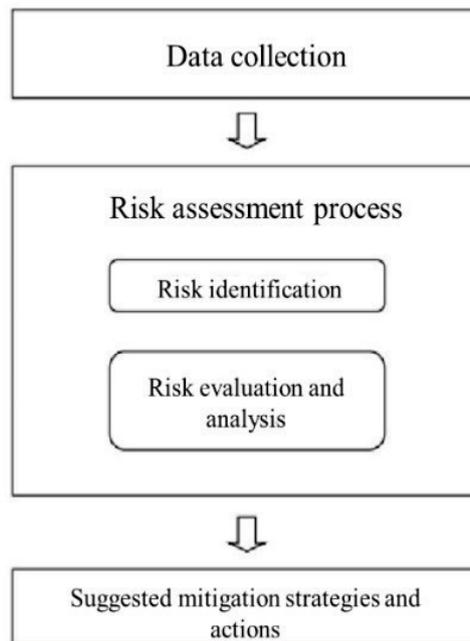
Figure 1. Methodology used for collecting and analysing data

The data collection process was done by using internal and external sources. Internal data was collected by employee-only survey, as well as analysing management approved documents and data sets. External data was sources using other sources such as company sites, executive interviews and other reliable data. The survey consisted of 15 closed questions focusing on risk identifications from the employee's perspective. The surveyed participants are either employees from the operations department or are middle management employees. The second step the risk assessment process consists of two groups of analysis. The first group focuses on risk identification – the chosen methods are the survey data results analysis and the uses of the SWOT analysis. The second group focuses on risk evaluation and analysis – the chosen method are the risk matrix and the FMECA analysis. Having these four different methods of data analysis was purposely chosen to provide the most in-depth and comprehensive conclusion. In the following results chapter, the individual of each analysis is shown, while in the conclusion chapter, more in-depth conclusions and correlations are highlighted.

3. RESULTS

This chapter showcases the individual results concluded by each analysis. Following the methodology showcased in the section before, the results are presented first for the survey response analysis, followed by the SWOT analysis, the risk matrix and finally the FMECA analysis.

The survey data analysis findings are presented using a neatly table view for all fifteen questions (Table1). The survey was conducted with employees from the operations department and their middle management, in total 21 responses was collected. The sample size is seen as adequate, and represents 25% of all on site employees that work in this department and all of them have been working for the company between 2 and 5 years. All of the questions were closed and employees selected one or two answers that found to be truest.

Table 1. Survey response analysis

Survey Question	Key Finding based on the majority response	% of response
Position of respondents	Majority were operational level staff	71.4%
Impact of energy and fuel prices on operating costs	Significant increase in total operating costs	71.4%
Perception of competition	Competition from imports and domestic producers has increased in the past 5 years	66.7%
Challenges in raw material supply	Rising procurement costs identified as the main issue	90.5%
Availability of reliable suppliers	Limited number of reliable suppliers	28.6%
Flexibility of supply chain	Mostly assessed as moderate	85.7%
Adaptability to unexpected changes	Very adaptable	14.3%
Frequency of delivery delays (raw materials or finished goods)	Occasional delays reported	61.9%
Main consequences of delivery delays	Increased production costs and sales losses	76.2% (costs)
Employee training adequacy	Training exists but quality could be improved	71,4%
Employee support in supply chain operations	Support exists but considered insufficient	66.7%
Impact of supply chain complexity on operation processes	Significant or moderate negative effect on operations	100% combined
Key drivers of complexity	Larger number of suppliers, regional distribution and logistics	19% (most frequent)
Compliance with quality standards by suppliers	Standards mostly fulfilled with occasional issues	61,9%
Production capacity adaptability	Assessed as moderate	76.2%
Approach to risk management	Mostly ad hoc, situational handling	61.9%
Main everyday challenges	Lack of resources, high costs, supplier reliability, limited internal coordination	57.1% (lack of resources)

The survey's key findings show that rising energy and fuel prices, along with rising raw material procurement costs, are the main causes of the supply chain's severe cost pressures. Market positioning is further complicated by the respondents' emphasis on the growing competition from both domestic and foreign producers. Frequent problems like delivery delays and inadequate staff training have been

identified as factors lowering operational efficiency, although the supply chain was generally thought to be moderately flexible. The increasing complexity of the supply chain was unanimously acknowledged as a major burden on day-to-day operations, and employee support was deemed as being present but limited. According to the survey's overall findings, the system stays with its essential functions but needs to be upgraded to be more flexible, accommodating to employees, and cost-effective with the goal to remain competitive.

Using the survey response analysis method, the main risk that employees see are identified, these risks are mostly identified using internal data and know-how. The SWOT analysis method is used for identifying not only internal risk but external risk as well, with the addition of highlighting the companies' strengths and future opportunities [5]. Therefore, using SWOT we implemented a complementary qualitative tool for identifying both internal and external risks, using the exclusive internal knowledge that employees can provide to later position the top-ranking risks within the risk matrix and subjected to FMECA scoring. In Figure 2. the SWOT analysis key findings are shown.

According to the SWOT analysis, the company's strong brand recognition, superior product quality, dependence on regional suppliers, and established distribution network are its key advantages. The supply chain's general complexity, a lack of flexibility, and inadequate employee training were the main causes of the weaknesses. Opportunities on the outside were found in the potential for market expansion, the rising demand for healthy and organic products, and technological developments in supply chain management. Stricter sustainability regulations, increased competition from both domestic and foreign producers, and rising energy and fuel costs were the biggest threats.

Strengths	Weaknesses
• Local milk suppliers reduce transport costs. • High product quality and strong brand recognition. • Developed distribution network.	• Lack of training and support for supply chain employees. • Complex supply chain that is difficult to manage. • Limited flexibility in responding to emergencies.
Opportunities	Threats
• Growing demand for organic and healthy dairy products. • Technological advancements in inventory tracking and supply chain management. • Expansion into new markets and geographic regions.	• Increasing regulatory requirements related to sustainability and environmental standards. • Stronger competition from imports and local producers. • Rising energy and fuel costs.

Figure 2. SWOT analysis findings

The third step of analysis focuses on risk assessment, using the risk matrix method. In the matrix risk are sorted by the probability of happening and their impact on the company's supply chain. This method is used in order to sort the identified risk, creating differentiation between high possibility and high impact risk, and the lower possibility and lower impact risks [9]. The analysed survey data findings were used as qualitative guidance for expert-based scoring. Accordingly, the risks that the employees collectly identified or emphasized in the survey were assigned higher probability or impact scores. The scoring system was done using the standardized five-point scale [9]. This approach aligns with standard qualitative risk-assessment procedures, where expert judgment informed by empirical inputs is used to categorize risks. This creates a visual easier report that can be used for creating mitigation strategies for the higher rating risks. In Figure 3. the identified risks are sorted by their probability and overall impact.

Probability / Impact	High Impact	Medium Impact
High Probability	Complex supply chain that complicates management; Rising energy and fuel costs	Competition from imports and local producers
Medium Probability	Lack of employee training and support	–
Low Probability	Limited flexibility in responding to emergencies	Increasing regulatory requirements for sustainability and ecological standards

Figure 3. Risk matrix

As shown in the matrix, the most critical risks for this companies supply chain are the complexity of the supply chain, as a result of a high number of suppliers. The global rise of fuel and energy cost, as well as the rise and expansion of competitors are sorted as top three risks that have a high or medium impact and high probability of happening. Other risks included insufficient employee training, lack of flexibility in emergencies, and regulatory pressures related to sustainability, these risks should not be ignored, but are not listed as top priority.

One of the most used risk assessment methods the FMECA method was used for sorting risk based on a quantitative approach, with added suggested actions for mitigating or avoiding the possibility of these risks happening [10]. The FMECA was selected as the key risk assessment method for our study, because it destined in a balanced way that provides a structured and widely applied approach for evaluating operational risks, often used in risk management for the food and manufacturing supply chains. The core principle of the FMECA method is assessing each risk through three dimensions: severity, occurrence, and detection, which enables an easy-to-read report for systematic risk prioritization. In Table 2. the full FMECA analysis is presented for the risks of: rising energy and fuel costs, supply chain complexity, insufficient employee training and support, rising competition from imports and local producers and stricter sustainability regulations.

The most critical risk, with the highest Risk Priority Number (RPN = 432), was confirmed by the FMECA analysis to be rising energy and fuel costs. As an example of how the calculation is conducted, the RPN for the risk of rising energy and fuel costs was calculated as follows: Severity (8) × Occurrence (9) × Detection (6) = 432. This risk can be mitigated by exploring alternative energy sources, investing in energy-efficient technologies, and closely monitoring energy markets. Another high ranking was supply chain complexity (RPN = 360), which can be mitigated through predictive analytics, real-time tracking systems, and automation in logistics operations. Inadequate staff support and training (RPN = 336) can be mitigated by introducing digital training platforms, continuous learning programs, and systematic performance monitoring. Stricter sustainability regulations were viewed as less urgent because of their lower probability and gradual implementation (RPN = 160). This risk can be mitigated by gradually replacing packaging and equipment, and by providing mandatory training on sustainability compliance. Competition from imports and local producers was another significant risk (RPN = 392). This risk can be mitigated by strengthening customer loyalty through advanced CRM, market analytics, and brand differentiation strategies.

All things considered, the FMECA assesses the risks in an objective way, identifying the primary vulnerabilities as being cost pressures, operational complexity, and workforce difficulties.

Table 2. FMECA results for critical risks in the supply chain

Element	Risk Event	Effects of Risk Event		Severity	Cause of Risk	Occ. score	Methods for detection	Det. score	RPN	Proposed Action
		Direct	Systematic							
Production, packaging and transport	Rising energy and fuel costs	Higher production and transport costs, reduced efficiency, lower competitiveness	Increase in product prices, reduced market competitiveness, and negative impact on relationships with suppliers and distributors.	8	Price fluctuations of energy and fuel	9	Monitoring of monthly energy costs and market trends	6	**432**	Explore alternative energy sources (e.g., biogas, methane)
Procurement and coordination	Supply chain complexity	Delays, spoilage of perishable goods, higher storage costs	Brand weakening, decline in long-term profitability, and increased reliance on price promotions.	9	Geographical dispersion, seasonality, perishability	8	Real-time tracking of deliveries and raw materials	5	360	Implement predictive analytics and automation in logistics
Procurement, production and distribution	Insufficient employee training and support	Errors in production, delays, increased costs, reduced efficiency	Disruption of the entire supply chain, loss of trust among key partners, and jeopardized market share.	8	Lack of systematic training programs	7	Employee feedback, audits, KPIs	6	336	Develop digital training platforms for continuous education
Marketing and distribution	Rising competition from imports and local producers	Lower sales, need for price reductions, weaker brand positioning	Increased costs, reduced overall supply chain efficiency, and damage to corporate reputation	7	High production costs vs. lower-priced competitors	8	Market analysis and competitor tracking	7	392	Apply advanced CRM and data analytics for customer loyalty
Production and quality control	Stricter sustainability regulations	Higher compliance costs, need for equipment upgrades, risk of penalties	Risk of losing certifications, potential penalties, and long-term need for significant investments that reduce profitability	8	Gradual introduction of new EU standards	4	Regulatory monitoring, compliance audits	5	160	Gradually replace packaging and equipment; introduce mandatory e-learning training on sustainability

4. CONCLUSION

The goal of this paper was to create a short research based quantitative case study with the goal to show how risks in one milk and dairy supply chain can be identified, sorted and assessed, using four well know methods: survey response analysis, SWOT analysis, risks matrix and FMECA. Using data collected from a real dairy supply chain, provides validation for the presented results. Cross examining the result of each individual method, the overall critical risks are: rising energy and fuel costs, the complexity of geographically dispersed supply chains, insufficient employee training and support, and heightened competition from both local and international producers. The secondary results of using

these methods are the confirmation of strengths that the company clearly has, such as: reliance on local suppliers, established distribution networks, and strong brand recognition. The FMECA analysis also offers suggestions on the course of further actions if the risk happens or how to minimize the possibility of the risk impacting the supply chain operations. One great example is for the global risk of rising cost of fuel and energy, so the suggested action is switching to alternative energy sources known as green energy sources.

It must be noted that this research study has its limitations. Firstly, the paper only uses one company the collected data is not shared with the readers so no independent study can recreate the results only based on this paper alone. The qualitative approach offers detailed insights but does not capture the full range of quantitative impacts, such as cost variability or demand changes. The study is also specific to a particular regional and sectoral context, which may not reflect on other markets.

Future research on this theme can use this study as a guideline how to recreate this study using multiple organizations, while simultaneously using larger and more representative datasets, and apply quantitative methods such as simulation modelling, scenario analysis, or resilience indices to evaluate risk management strategies. Further research could also add a new layer of complexity by investigate the impact of digital transformation, the role of Industry 4.0 technologies such as: Internet of Things (IoT), blockchain, or digital twins on supply chain risk management. Addressing these gaps would help validate the current findings and provide a stronger basis for designing resilient, sustainable, and competitive dairy supply chain.

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