

SUPPLY CHAIN RISK MANAGEMENT IN DAIRY INDUSTRY OF THE CZECH REPUBLIC

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Abstract: Food production is one of the key sectors of the food industry in the Czech Republic and the European Union. Its direct link to the primary agricultural sector is also crucial, from which it takes inputs, which it further processes and markets. A necessary condition for this process is the quality and safety of the commodity produced. The businesses must demonstrate food quality and safety through an effective system of traceability and traceability of these criteria. These conditions significantly affect aspects of production and logistics. The paper is focused on the dairy industry. This industry forms an essential part of the entire agri-food chain. Processes in enterprises of this type are specified in that several regulations affect production and logistics operations. Raw materials and products are perishable. On the other hand, the customer expects a quality and safe product at the right time. The paper's main aim was the identification of risks in individual phases of the dairy industry logistics processes. The area of purchasing, production, and the transport was examined in particular. The secondary aim was to expand theoretical knowledge of dairy management. Expert studies and scientific articles in this area are insufficient.

1 Introduction

The food industry is a mainstay of all European and world economies [1,2]. Lukiewska and Juchniewicz state that the sector is significant for long-term sustainable growth in Central European national economies [3]. The food sector is one of the critical branches of the processing industry in the Czech Republic. Trnková et al. stated that supplies food to the market and thus ensures the population's diet [4]. Farmers are the backbone of our society, and they support the whole world's population [5]. The food industry also plays a significant role in essential macroeconomic aggregates. According to the Ministry of Industry and Trade, the food industry accounted for CZK 322.2 billion in sales of its products and services in 2019, which is approximately 6.1% of sales in the entire manufacturing industry 2019. In 2019, the food industry employed over 95,000 employees, representing 7.2% of employees in the Czech manufacturing industry. These indicators rank the food production sector among the essential domestic employers [6].

As stated by Syrůček et al. and Naglová et al., the production of dairy products is a mainstay of the Czech food industry [7,8]. A number of studies deal with the performance of the dairy and food industry in the Czech

Republic [8-10]. High performance and competitiveness of the dairy industry and the ability to finalize the primary raw material into products with higher value-added (and successfully face the competition within the European and global market) are essential prerequisites for keeping the dimension of the milk production in the EU regions [10]. Businesses in the food chain are forced by the pressure of global markets and the ever-increasing demands on consumers and end-users to take a comprehensive approach to managing their activities. This management involves integrating food quality and safety with a risk management approach. They point to the significance of an integrated management approach within the agri-food chain [11,12]. Rapid and dynamic changes in the environment, technologies, consumer behaviour, policymaking, and climate are putting extra pressure on the food supply chain, especially in efficiently managing food security, food surplus, food loss, and waste [13]. Higher quality and safer food are still the highest priority in the food industry [14]. Food safety is an essential prerequisite for ensuring the health of the population. The Food Safety System was established in the Czech Republic in 2001. The essential tool legislation requires is the Hazard Critical Control Point (HACCP). As Havinga demonstrates, private standards are prevalent in the food industry in numerous

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European countries [15]. Private food safety standards have become a critical governance mechanism in contemporary food supply chains [16]. International food safety management systems standards can be applied to all or part of the food chain. The standards can then be used as a risk identifier in individual logistics processes. The most commonly used standards include the British Retail Consortium (BRC) and International Food Standard Logistics (IFS Logistics). Several studies address international food safety standards and highlight the significance of their implementation in food safety management throughout the food chain [17-19]. The production and logistics process of the dairy industry has its specifics.

In research papers, we can find several definitions of logistics. The basic definition based on the Cambridge Dictionary states that it is the process of planning and organizing to ensure that resources are in the places where they are needed [20]. An activity or process happens effectively. Ghiani et al. add that it represents the functional activities determining the flow of materials and the relative information [21]. In this publication, we will learn that we can include here as well the service sector (water services, postal services, urban solid waste collection, and others). These definitions can be supplemented by Rushton et al., who list logistics as critical components – transport, inventory, and warehousing [22]. Kumara explains that logistics is

mainly associated with the supply chain processes and handling goods, not people [23]. The supply chain represents the processes that need to be done, from the primary raw material to the delivery of the final product to the final customer. As the title of the article suggests, the paper focuses on the field of agriculture, specifically in the dairy industry. In research articles, we come across concepts such as food supply chain and agriculture supply chain. Van der Vorst defines the agricultural supply chain involves all stakeholders, from farmers, agro-processors, distributors, transporters, and retailers to end consumers, aiming to provide a wide variety of consumer products that consists of fresh foods, meat products, a wide variety of processed food including beverages, canned foods, confectionery, and bakery or dairy products [24]. Rossini et al. added that practitioners and researchers identified the agricultural supply chain as a significant area [25].

On the other hand, we can find the definition of the food supply chain by the European Commission. The food supply chain is the direct exchange of food from the farmer to the consumer, or the different stages of activities such as the processing of raw agricultural commodities as well as the checking of consumer safety standards and packing or transport activities which add value to food products before they are sold. Based on these definitions, we can conclude that we are using two concepts – food supply chain and agricultural supply chain – which are identical [26]. Kumar presents A food supply chain network (see Figure 1) [27].

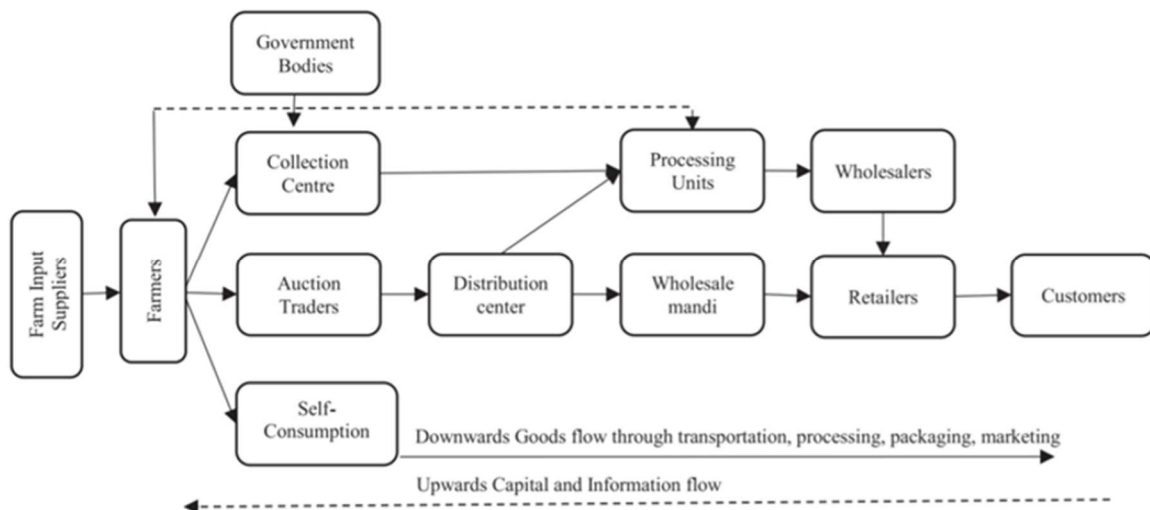


Figure 1 A food supply chain network, Kumar [27]

For all supply chain steps to work correctly, supply chain risk management must be implemented. Several authors recommend the implementation of supply chain risk management [28-30]. Within the supply chain, we may encounter several risks, such as risks in physical flow [31,32], currency, information, partnership, innovative opportunities [31], environmental and organizational risk [33], safety risk [34], and chemical and biological risk [32]. The ISO 31000 certificate is suitable for effective Food

Supply Chain Risk Management. The paper aims to address risks in individual phases of the logistics chain in the dairy industry in the Czech Republic.

2 Methodology

Several scientific methods were used in this paper. It was mainly analysis, synthesis, comparison, and using statistical methods. The methods of analysis and synthesis were used by writing introduction. The method of

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comparison was used when comparing the results of own research with already conducted studies. The main methods were Chi-square, which confirmed the statistical dependence between the method of transport of input raw materials and the size of the dairy enterprise. Furthermore, the evaluation was performed using basic descriptive statistics and box fences representations. The questionnaire survey took place in the month of September-November 2021. The questionnaire addressed a total of 72 dairy enterprises in the Czech Republic. Contact addresses were taken from the database of the Food Chamber of the Czech Republic. Thirty-five were received, and wholly completed questionnaires were processed. Incomplete or incorrectly completed questionnaires were excluded from the research. Therefore, the return is about 49%, which in this case is also the share in the basic statistical set. The questionnaire consisted of closed and open questions, and the size of the enterprises according to the number of employees also served as an identifier. In the category of up to 50 employees, 15 completed questionnaires were available. In the category of 51-250, it was again fifteen respondents, and in the size category of more than 250 employees, it was five respondents.

3 Results and discussion

The research was divided into four parts. Firstly, the issue of certification of voluntary quality, safety, and risk management systems in the dairy industry was addressed. It is generally possible to use the international certificates ISO 9001, ISO 31000, ISO 22000, the BRC, and IFS standards. Sixty percent of the addressed enterprises hold a quality certificate according to the ISO 9001 standard. Regarding differences in size groups, only larger enterprises have 100% representation of ISO 9001 quality certificate holders. For the other two groups, the holder: non-holder ratio is 8:7; in other words, about 53% of holders of a quality certificate are in other groups. Only two of the 35 enterprises surveyed hold an ISO 31000 certificate. The vast majority (94%) of enterprises do not.

On the contrary, a food safety certificate is a necessity. Eighty-nine percent (33 out of 35) of the addressed enterprises hold this certificate. Only four enterprises do not hold a certificate and fall into the category of small businesses. Of the food safety certificates (ISO 22000, standard BRC, and standard IFS), the most frequently used certificate was standard IFS when it was mentioned by 18 out of 35 (51%) enterprises contacted.

International standards for food safety management systems can be used as an essential tool for risk management in individual logistics processes of the entire agri-food chain [35] and certification of food safety systems affects the trust of individual links in the agri-food chain [36-38]. Hassan's study addresses the security of the milk supply chain and its failure factors, emphasizing the need to emphasize, inter alia, operational and transport management systems [39].

The second part is focused on the process of entry (purchase) of milk into the transformation process. The questions focused on importing raw materials and the selection and evaluation of suppliers. It was ascertained which criteria (location, quality, and price) they preferred for all the surveyed enterprises. At the same time, it was ascertained whether there were differences between the answers in the individual size groups of the addressed enterprises. Each addressed enterprise had the opportunity to determine the importance of individual criteria using the ranking method. To simplify the processing of the results, the first place was evaluated by three points, the second by two points, and the third by a single point. The best average point gain can be observed for all surveyed enterprises in the quality criterion (average = 2.46), followed by location (average = 2.14) and price (average = 1.4). Regarding the individual size categories, for small enterprises (up to 50 employees), there was an interesting agreement in all 15 addressed enterprises in this size category, where all enterprises are the most important criterion was chosen location (average = 3.00), followed by quality (average = 2.00) and then the price (average = 1.00). It is interesting to agree on the order of small businesses. However, a similar agreement has not been reached for medium-sized enterprises (up to 250 employees). In addition, there is a noticeable change in the order of the individual criteria. The best result can be observed for quality (average = 2.87), followed by price (average = 1.7) and last location (average = 1.40). For a small number of addressed large enterprises (over 250 employees), the resulting averages are more balanced; however, quality was determined as the most essential criterion (average = 2.60), followed by location (average = 1.80) and price (average = 1.60). It is clear from the results that for small enterprises, the location for the selection of suppliers is important; for other enterprises, it is mainly quality.

Due to the coronavirus pandemic and other external threats, flexibility in supply chains is being disrupted. Therefore, it is essential to have rules in selecting suppliers incorporated into the purchasing management system. As Rahman States, with the advancement of manufacturing technology and globalization of supply chains in the fourth-generation industrial revolution, manufacturing industries face significant pressure to improve customer satisfaction and maintain their position in the global market [40]. It is confirmed by the Pakula study that correctly defined criteria for the selection of suppliers of raw materials have the effect of reducing operational risks [41]. Only 5 out of 35 enterprises contacted do not require any standard or certificate from their suppliers. The HACCP law requires the remaining 30 enterprises (63.3%), followed by the IFS or BRC food safety certificate (43.3%), and 20% of enterprises request the ISO 9001 certificate. Only 3 out of 30 enterprises require more standards or certifications from their suppliers, equal to 3. Only one is enough for the remaining ones. Research confirms that international food safety standards are

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necessary for the agri-food chain. As further studies show [36-39]. 11 of the 15 small enterprises contacted (up to 50 employees) to import input materials through their suppliers. In comparison, medium-sized (51-250) and large enterprises (over 251 employees) use mainly external carriers. Together, 18 of the 20 enterprises contacted are used by external pages in this combined category. Combining the two largest size categories made it possible to examine the dependence using a four-field table, where the results confirmed the statistical dependence, where $X^2(1, N = 35) = 14.7261$, $p = 0.000124$. We can accept hypothesis H1: The mode of transport of input raw materials is affected by the size of the enterprises. Input raw materials are imported using suppliers' means of transportation more often in smaller enterprises than larger ones.

Thirdly, the research is concerned with the production process and the associated operational risks. As already established, the production process is harmonized with the requirements of international food safety standards at most dairies; regarding the use of the information system, 27 of the 35 enterprises contacted use an information system, which is about 77% of respondents. At the same time, there is a significant dependence between size categories. With the larger size of the enterprises, the greater the likelihood of using the logistics information system. For small enterprises, 60% of enterprises use the logistics information system, in the middle category, it is already 87%, and in the highest category of large enterprises the share is already 100%. By combining the two largest size categories, it was possible to examine the dependence using a four-field table, where the results confirmed the statistical dependence, where $X^2(1, N = 35) = 4375$, $p = 0.03647$. We can therefore accept hypothesis H2: The size of the enterprises affects the use of the logistics information system. The main benefit of introducing the logistics information system in 24 of the 27 enterprises is the traceability of the quality of milk/products and their batches from each order. Other frequent benefits are up-to-date data and time savings in administration.

Aung and Chang emphasize that traceability is essential in ensuring food quality and safety [42]. Traceability is a tool for meeting quality and safety requirements throughout the food logistics chain. It is confirmed by Aworth's study that traceability has become an essential feature of the global food supply chain with the growing food safety concerns and the globalization of food production and distribution [35].

Digital technology can profoundly positively impact agriculture outcomes in developing countries by improving market transparency, enhancing farm productivity, improving rural households' food security, strengthening logistics and optimizing supply chain management, and improving food quality and safety [35]. Of the 35 enterprises contacted in this survey, 16 enterprises are considering or have already implemented complete digitization; the remaining 19 enterprises are

not considering full digitization even within five years. Two-thirds of the small businesses contacted (up to 50 employees) do not consider complete digitization within five years. On the contrary, the remaining third of the addressed enterprises have already implemented complete digitization (= 5). Two enterprises have fully implemented digitization for the medium-sized category, and seven medium-sized enterprises are considering complete digitization within five years. No enterprise already has complete digitization in place for large enterprises (over 250 employees). Two enterprises are considering complete digitization within five years. The remaining three enterprises are not considering complete digitization.

Risk mitigation is one of the essential aspects of supply chain risk management [43]; 24 of the 35 enterprises contacted to have a designated department or risk manager. All large enterprises have a risk department or employee in terms of size structure. It was observed in only 8 out of 15 enterprises and 11 out of 15 enterprises for smaller enterprises. A specific dependence can also be observed concerning a department or representative dealing with risks and the level of risk management in enterprises. Till 8 out of 11 enterprises that do not have a department or employee responsible for risk management address risks only by legal requirements. On the contrary, out of 24 enterprises with this responsibility, 15 enterprises have developed a risk register, and the remaining nine enterprises even have a set risk management system.

One of the things needed for risk-based management of food safety systems is understanding the risks and how they are generated in the food system [44]. Paillin et al. conducted research on risk assessment and mitigation throughout the food chain in social, environmental and economic dimensions [45]. In manufacturing, research on operational risks. Operational risk can be defined as the risk resulting from the shortcomings in information and internal control systems or external events such as fraud, resulting in unanticipated losses. Next, it could be the risk related to either human errors, system failures, and inefficient procedures that occur due to breakdown in internal control procedures, either in the front, middle or back-office activities, leading to unanticipated losses [46].

The frequency of operational risks was monitored at the surveyed enterprises in six primary areas:

- A. Low-quality raw materials at the entrance,
- B. Power failure,
- C. Machinery and equipment,
- D. Technology,
- E. Human error,
- F. Increase in operating cost.

The answers from the survey was evaluated according to a four-scaled evaluation of all six research questions A.x, B.x, C.x, D.x, E.x and F.x where $x = 1$ determines small-sized enterprises, $x = 2$ determines medium-sized enterprises, $x = 3$ determines large-sized enterprises and x

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= all determines all enterprises together. The individual grades of the rating scale of frequency are defined as follows: 1 – (Hardly) ever, 2 – Rarely, 3 – Sometimes, and 4 – Often.

Measures of the location of the cases were found by mode and median. Measures of variability were found by

discrete ordinal variance that was converted to the standardized form (NOR) for better comparison of indicators. All used statistical characteristics of collected data are presented in Table 1.

Table 1 Measures of location and variability of the cases A.-F

Cases	A.all	A.1	A.2	A.3	B.all	B.1	B.2	B.3	C.all	C.1	C.2	C.3
NOR	0.494	0.711	0.462	0.000	0.670	0.711	0.628	0.960	0.596	0.391	0.747	0.960
Mode	2	1	2	2	1	1	2	3	2	2	2	3
Median	2	1	2	2	2	1	2	3	2	2	3	3
Cases	D.all	D.1	D.2	D.3	E.all	E.1	E.2	E.3	F.all	F.1	F.2	F.3
NOR	0.647	0.782	0.687	0.000	0.431	0.711	0.308	0.000	0.522	0.332	0.664	0.000
Mode	2	2	3	1	3	2	3	3	3	3	3	3
Median	2	2	3	1	3	2	3	3	3	3	3	3

Poor input raw materials are perceived as a potentially small operational risk and are often not addressed by businesses. For small enterprises, it is possible to identify a larger degree of dispersion; however, the mode and median are equal to 1. Medium and large enterprises address the poor quality of input materials much more often than smaller enterprises. Still, the risk is not perceived as large because the median and mode are equal to 2, and the variance rates are quite small. Differences in responses can be traced to a power outage. With the enterprises growing in size, enterprises address energy issues much more often, at least based on mode and median. However, some ambiguity can be seen in the variance rates, which are quite high. The operational risks related to machinery and equipment are also not perceived as large, but their frequency and position increase with the enterprise's size. Technology-based operational risks are an unexpected outcome. In this category, risks occur most frequently in medium-sized enterprises, less frequently in small enterprises, and least (barely sometimes) in large enterprises. The last two research areas (human error and

growth in operating costs) reach the highest median and mode values across size categories (human error in smaller enterprises to a lesser extent). Therefore, it is possible to label them as the most important and the riskiest due to the relatively frequent frequency and importance in operation. Like the first six areas of operational risk, methods for identifying operational risks were also examined:

- G. based on experience and estimates,
- H. brainstorming in a team,
- I. Check-list,
- J. Ishikawa Diagram,
- K. What-if,
- L. HAZOP,
- M. FMEA.

The same methodology was used as in the previous case. The four-point range of responses remained unchanged, mode, median, and normalized variance were determined and compared. The change occurred only in the designation of individual examined areas.

Table 2 Measures of location and variability of the cases G.-M.

Cases	G.all	G.1	G.2	G.3	H.all	H.1	H.2	H.3	I.all	I.1	I.2	I.3
NOR	0.522	0.521	0.540	0.320	0.488	0.512	0.308	0.320	0.705	0.569	0.770	0.000
Mode	4	3	4	4	3	3	3	4	3	3	3	4
Median	3	3	4	4	3	3	3	4	3	3	3	4
Cases	J.all	J.1	J.2	J.3	K.all	K.1	K.2	K.3	L.all	L.1	L.2	L.3
NOR	0.516	0.474	0.415	0.640	0.466	0.581	0.154	0.000	0.135	0.154	0.154	0.000
Mode	1	2	1	1	1	1	1	2	1	1	1	1
Median	1	2	1	1	1	2	1	2	1	1	1	1
Cases	M.all	M.1	M.2	M.3	-	-	-	-	-	-	-	-
NOR	0.261	0.154	.0415	0.000	-	-	-	-	-	-	-	-
Mode	1	1	1	1	-	-	-	-	-	-	-	-
Median	1	1	1	1	-	-	-	-	-	-	-	-

Operational risk identification based on own experience and estimates is more often used in medium and large enterprises, to a lesser extent in small. On the

contrary, the brainstorming method is widely used, especially in large enterprises. We observe relatively consistent responses in this area due to smaller variances.

The outputs of using the checklist method also look similar. It is also widely used for large enterprises, even in this size category of enterprises, even with zero variance. Ishikawa's cause and effect diagram is very rarely used in monitored enterprises and, if so, in small enterprises. The remaining methods, i.e., What-If, HAZOP, and FMEA, are rarely used. With the exception of the What-IF method, the frequency is very small, and no major disproportions were observed between the size categories of the enterprises surveyed.

4 Conclusion

Food safety and quality are essential aspects of the competitiveness of every food business. The dairy industry is the third most efficient food production branch in the Czech Republic. A whole range of legislative regulations affects dairy products' production and logistics. In addition, dairies can implement food safety standards that help them identify and manage risks that arise throughout the processing process. The research goal was to identify which risks this type of business encounters most often and which tools it uses to manage them. The research confirmed that businesses use voluntary risk management tools in connection with food safety, up to 89%. Companies eliminate entry risks by requiring these certificates from their suppliers. Within the processing process itself, traceability is a crucial factor. This is related to using an information system that eliminates the risk of losing traceability. The research confirmed the hypothesis that the company's size is related to implementing an information system for managing production logistics chains. Digitalization helps improve the traceability process. Research has shown that large and medium-sized enterprises are implementing digitization. While small dairies do not consider digitization in the five-year horizon. The research confirmed the hypothesis that the size of the dairy enterprise has an influence on the method of transport of input raw materials. Small businesses use supply means, large and medium-sized businesses use external carriers. The most severe operational risks for businesses in the dairy industry are human error, rising operating costs, and technological risk. The risk of low-quality raw material at the input is perceived as low. It is more common in medium and large dairies. Technological risk is also more common in medium-sized enterprises. The results were compared with the results of foreign studies. Further research will be expanded to include elements of reverse logistics and sustainability of food chains as stated by Fidlerová [47].

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Review process

Single-blind peer review process.