# Effective Dairy Supply Chain Management in Big Cities

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**Abstract.** The purpose of this study was to develop recommendations to improve the efficiency of dairy products supply chain management in large cities. To achieve the study goal, a complex multi-stage research project was developed based on the analysis of primary information obtained by interviewing three main categories of dairy supply chain participants on the Internet: producers, intermediaries, and end consumers. At the same time, the survey of the three main categories was selected to obtain objective information throughout the entire supply chain - from producer to end consumer. The proposed methodology was tested for the supply chains of dairy products in Almaty (Kazakhstan) and Yekaterinburg (Russian Federation). The study resulted in recommendations to improve delivery management of short-life products requiring controlled storage and transportation temperatures during the COVID-19 pandemic, as well as key indicators to assess the effectiveness of dairy supply chain management. This article may be in demand by the real economy to ensure the sustainable development of dairy supply chains in large cities under the COVID-19 pandemic, as well as by academic researchers, primarily from the perspective of identifying new promising research areas.

**Keywords:** COVID-19 pandemic, dairy products, supply chain management, urban logistics

# 1. Introduction

## 1.1. Research Background and Significance

The problem of providing residents of big cities with fresh food of short shelf life emerged almost simultaneously with big cities, but at the beginning of the third decade of the 21st century this problem suddenly became especially pressing. In March 2020, the World Health Organization reported a new global threat, pandemic COVID-19, and called on all countries to counter the spread of the deadly virus. Temperature-sensitive, shelf-limited food supply chains have traditionally been considered some of the most expensive and most environmentally sensitive (Manning & Monaghan, 2019). However, it was the COVID-19 pandemic and the quarantine restrictions that most governments imposed to counter the pandemic that clearly demonstrated another critical characteristic of traditional perishable food supply chains: fragility. Supply chains for shelf-limited foods, including dairy products, were disrupted almost in the early days of the quarantine restrictions imposed to counter the pandemic, with serious negative consequences at all levels of the supply chain. A shortage of fresh dairy products was recorded from the first days of quarantine restrictions, while producers of dairy products had to dispose of them without being able to deliver them to consumers in a timely manner. The huge ($860 million) and growing (2% per year) dairy market (OECD, 2020) has faced one of the biggest challenges of the external environment, which has disrupted traditional supply chains and caused significant market structural changes, including a growing demand for cheaper dairy products with longer shelf life (de Sousa Jabbour et al., 2020; Queiroz et al., 2020). This has led to a dramatic increase in social demand for new methods of effective dairy supply chain management and an increased research interest in effective dairy supply chain management in large cities.

## 1.2. Research Framework

The research objectives of this article include summarizing previous research and developing recommendations to improve the efficiency of dairy supply chain management in large cities. Achievement of the research goals is realized through consistent solution of the following scientific tasks: (1) to study and summarize the experience of previous researchers regarding the effective management of dairy products supply chains in large cities; (2) develop a methodological research design, identify tools and sources of information; (3) test the study on the example of large cities of the Russian Federation and Kazakhstan; (4) develop recommendations to improve the efficiency of the supply chain of dairy products in large cities. The study results can provide effective management of sustainable supply chains of dairy products in large cities.

## 2. Literature Review

The enormous importance of supply chain management efficiency for products with limited shelf life and special storage and transportation conditions, primarily food and pharmaceutical products, has led to considerable research interest in this problem (Burinskiene, 2018; Ikechukwu, 2019; Nazifa & Ramachandran, 2019). Indeed, dairy supply chains are an important part of the agricultural industry in the EU and around the world. Today, the supply of dairy products to big cities is predominantly carried out by large agricultural holdings, and the importance of integration is reinforced by the need to effectively manage relationships between all stakeholders in the supply chain, develop partnerships and respond to consumer demand (Boichenko et al., 2022a; Mandych & Bykova, 2021).

It should be noted that modern food supply chain management faces a number of challenges, such as inadequate storage facilities, poor transportation, and insufficient quality control of transportation and storage (OECD/FAO, 2019; Rong et al., 2011; Siddh et al., 2017; Sweeney et al., 2018). According to current researchers, the bottlenecks in food supply chain management are (1) the high cost of technical support and temperature control; (2) the need to ensure the effective functioning of storage regimes for goods and various commodity groups (Beber et al., 2019; Mor et al., 2018; Nakandala & Lau, 2019); (3) seasonality and changes in demand: major losses in food supply chains are caused by mismatches between supply and demand (Raut et al., 2019); differences in standardization and certification across countries; transportation mismatches resulting in high transportation costs; multi-stage distribution.

The perishable food logistics market depends on the size of the consumer industry. Therefore, the risks of doing business are associated with the production and imports of these products. Inflation and devaluation of national currencies increase the payback period and make it difficult to fulfill obligations under previous credit agreements.

Market entry barriers are high initial investments and longer payback periods. It creates a need to possess big warehouse facilities with the appropriate infrastructure (warehouses should be located near the main highways, have convenient entrance, a railway station nearby, communications infrastructure, own a boiler house, whole-house generators, etc.) (Nakandala & Lau, 2019; Vlajic et al., 2018).

The volume of the milk produced, the location of suppliers, and production seasonality are the main factors that affect the efficiency of the dairy supply chain. The dairy manufacturers cannot disregard these problems, but they can improve control over these areas using information technology (Roman, 2018).

A dairy manufacturer is the main stakeholder responsible for the efficiency of the dairy supply chain. Therefore, manufacturers' requirements for logistics service providers increase greatly. Logistics service providers have to ensure the quality and reliability of the supply store, and transportation of temperature-sensitive

products in controllable conditions. Primarily, this requirement applies to seasonal products (weekly, monthly, annual) and those items that deteriorate more quickly (Ferreira et al., 2020; Tan & Ngan, 2020).

Applying the best practices to the supply chain management, introducing innovations (such as blockchain, tracing, and QR-codes), and enhancing the productivity of each supply chain stage reduce waste, increase dairy products' quality, and bring economic benefits (Goyat et al., 2019). While discussing dairy supply chain management, sustainability is seen as the main factor affecting the industry's profitability in times of crisis (Pappa et al., 2019).

A logistics operator should rely on existing consumers and satisfy their needs by creating more value than the competitors create. The logistics service providers should also sustain the brand of the dairy manufacturer, increase sales, and ensure high profits. Therefore, it is important to build a supply chain in which the role of a logistics service provider is high. A logistics company and a manufacturer should work closely to deliver the best value (Ding et al., 2019).

In developed countries, the COVID-19 pandemic caused a supply shock to the food industry. The Just-in-Time strategy has failed to deliver the expected results (Garnett et al., 2020; Guritno, 2016).

Changes in supply chain management include (1) government support programs to reduce financial costs and improve warehousing; (2) government control of prices for essential foodstuffs (e.g., wheat); (3) diversification of the most important foodstuffs; (4) reduced overhead costs; (5) energy costs through better insulation, shorter door opening times, more nighttime deliveries to use lower temperatures; (6) increasing automation and monitoring of the fresh food supply chain.

As can be seen, the complex management strategies for managing dairy supply chains as part of the fresh supply chain have not been sufficiently studied. There is a need to develop an effective complex management strategy that takes into account the impact of COVID-19 on the food industry. Further research in this field is still required.

# 3. Research Methodology

## 3.1 Methodological Research Design

To achieve the study goals, a comprehensive multi-stage research project was developed and implemented. The main research stages are shown in Figure 1.
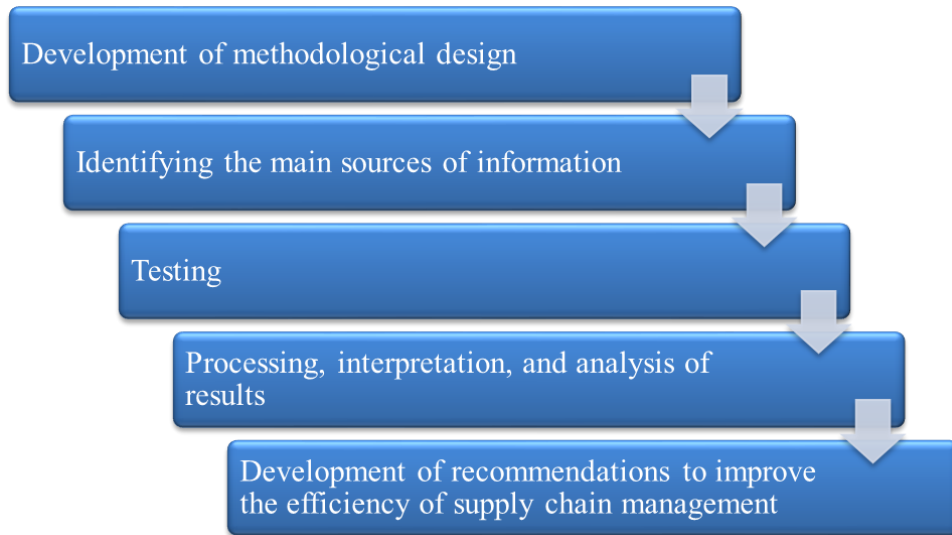


Fig. 1: Main stages of the research project
*Source: developed by the authors*

Significant influence on forming the methodological research design had existing implementation limitations. In particular, the imperfection of the system of statistical information collection determined the impossibility of conducting a desk study and the need for a "field" stage to collect primary information. In addition, the limitations of the research budget and the limited study timeframe did not allow implementing monitoring studies and using a time-series model for the analysis. Thus, this study is based on the analysis of primary information and includes a "field" stage. Primary information was obtained through a survey using information technology (Internet survey).

## 3.2 Testing the Methodology

Three groups of participants took part in the survey to show the state of the dairy products supply chain at different levels (suppliers, intermediaries, end consumers). The survey was conducted among farmers, suppliers, and consumers to obtain the necessary data on dairy supply chains in major cities of the Russian Federation (Yekaterinburg) and Kazakhstan (Almaty). The main criteria for selecting cities were population size, geographic location, and lack of a capital status. The population of Almaty (Kazakhstan) (1.7 million people) is comparable to that of Yekaterinburg (Russian Federation) (1.4 million people). In addition, Almaty and

Yekaterinburg are the least distant from each other cities in Russia and Kazakhstan with a population above 1 million people, and both cities are not capitals.

Invitations to participate in the study and survey forms were sent through social networks (VKontakte, Odnoklassniki, and Facebook). Participants were assured of the voluntary and anonymous nature of the study. All participants who agreed to participate were divided into three groups: farmers, suppliers, and consumers. Each group received a link to fill in a survey form (Table 1 and 2).

Online surveys were conducted using Survey Monkey and a case study approach to determine the effectiveness of temperature-controlled dairy supply chains in big cities. The surveys had a multiple-choice question format.

Table 1: Number of participants in each group

| City | Yekaterinburg | Almaty |
|---|---|---|
| Farmers | 38 | 34 |
| Suppliers | 67 | 58 |
| Consumers | 129 | 135 |
| Total | 234 | 227 |

Table 2: Survey questions

| Group | Question |
|---|---|
| Farmers | What challenges did you face as an owner of a dairy business during the quarantine period? <br> How has the dairy supply chain changed during the quarantine period? |
| Suppliers | What challenges did you face as a dairy supplier during the quarantine period? <br> How has the dairy supply chain changed during the quarantine period? <br> What indicates the effectiveness of a supply chain during the quarantine period? <br> What measures could improve dairy supply chain management during the quarantine period? |
| Consumers | What challenges did you face as a dairy consumer during the quarantine period? <br> What changes did you notice in the supply of dairy products? |

Steps taken to ensure and maintain data quality: (1) survey data were compared to participant profiles; (2) participants could not participate in the study for a certain period (the study was conducted March-May 2020); (3) multiple registrations were rejected as duplicates; (4) data uniqueness was ensured. Data quality assurance measures resulted in a sampling error not exceeding 5%.

## 3.3 The Main Study Limitations

The main implementation limitations of the study, which influenced the formation of the methodological design, the choice of tools and sources of information were:

(1) the imperfection of the information subsystem that did not allow the use of statistical observations to analyze the supply chain of dairy products in large cities;

(2) the limitations of the research budget, which influenced the sample and the frequency of the survey; (3) the time frame of the study (March-May 2020), which influenced research frequency.

# 4. Results and Discussion

Farmers, suppliers, and consumers agree that dairy supply chain management in big cities during the COVID-19 pandemic depends upon social responsibility. Survey results are presented in Tables 3-5.

Table 3: Farmer surveys

| Indicator | Yekaterinburg | Almaty |
|---|---|---|
| Farmers | | |
| What challenges did you face as an owner of a dairy business during the quarantine period? | | |
| Poor supply chain management | 25 | 27 |
| Delays in products and purchases | 18 | 17 |
| Inconsistency in storage and transportation | 11 | 8 |
| Inadequate forecasting and planning | 20 | 23 |
| Lack of government support | 29 | 27 |
| How has the dairy supply chain changed during the quarantine period? | | |
| Internet technology is now required for the dairy supply chains to perform effectively | 25 | 23 |
| Changes in demand | 31 | 13 |
| The increased need of interaction with suppliers | 27 | 25 |
| Changes in stock policy | 20 | 18 |

Table 4: Supplier surveys

| Indicator | Yekaterinburg | Almaty |
|---|---|---|
| Suppliers | | |
| What challenges did you face as a dairy supplier during the quarantine period? | | |
| Poor supply chain management | 53 | 49 |
| Delays in dairy products and purchases | 48 | 45 |
| Inconsistency in storage and transportation | 45 | 48 |
| Inadequate forecasting and planning | 51 | 53 |
| Lack of government support | 54 | 47 |
| Dairy products quality problems | 48 | 42 |
| How has the dairy supply chain changed during the quarantine period? | | |
| Shorter supply chains | 62 | 51 |
| Ecological issues are less important in supply chains | 62 | 48 |
| Changes in demand | 55 | 51 |
| The increased role of interaction with suppliers | 48 | 45 |

| | | |
|---|---|---|
| Changes in stock policy | 41 | 35 |
| No peak loads for goods ordered via the Internet | 52 | 48 |
| Hype when buying dairy at the initial stage of the quarantine period | 51 | 43 |
| What measures could improve dairy supply chain management during the quarantine period? | | |
| Use of information technology | 48 | 46 |
| Ability to react accordingly to any force majeure circumstances when the disease is spread among employees | 45 | 48 |
| New business relations should be developed | 51 | 47 |
| Updates in inventory and planning | 38 | 39 |
| Motivation to stop or start new dairy product lines | 47 | 42 |
| Development of consistency plans for logistics and capacity building, stress tests, and mitigation | 38 | 35 |
| Demand forecasting is problematic | 49 | 47 |

Table 5: Consumer surveys

| Indicator | Yekaterinburg | Almaty |
|---|---|---|
| Consumers | | |
| What challenges did you face as a dairy consumer during the quarantine period? | | |
| Poor supply chain management | 112 | 97 |
| An online ordering system is required | 87 | 57 |
| No clear deadlines for order delivery | 59 | 67 |

Most of the supply chains are *transitional*. They link rural businesses with urban consumers through a network of labor-intensive small and medium-sized enterprises. This supply chain contains more risks than the traditional one.

The survey results indicate that the following measures have been implemented to minimize risks:

(1) the physical delivery of dairy products has been optimized. Preference was given to farms that were as close to the city as possible, and the quality of dairy products was of secondary importance,

(2) the growing demand for cheaper dairy products and other similar products with longer shelf life led to a reduction in the importance of refrigeration and transportation and thus a decrease in supply chain pressure,

(3) importance of IT in supply chain and order management, significant increase in online ordering,

(4) more orders have been compensated by reducing peak loads and delivery times to end customers,

(5) increased role of IT in quality assurance of dairy products at any point in the supply chain,

(6) changes in inventory management: dividing dairy products into groups based on their importance for production; determining the minimum required level in each group and forming a general order, even if the stock has not reached the minimum level,

(7) increasing the importance of collaboration in the supply chain: poor collaboration in the supply chain has become a major factor in declining profits and sales,

(8) insufficient state support for business (tax incentives, loan vacations, etc.).

According to the study, the main problems caused by pandemic-imposed restrictions in the food supply chain in major cities are:

(1) lack of cooperation between suppliers, which makes it difficult to consolidate orders and deliver dairy products to the end consumer,

(2) inconvenient location of warehouses and loading and unloading facilities, inadequate network of routes around the city,

(3) inefficient use of transportation and courier services,

(4) loads on transport and courier services in the initial period of quarantine,

(5) lack of public awareness, which leads to impulse purchases of large quantities of food products and a rush demand for dairy products and requires control of storage and transportation temperatures.

Respondents considered the main methods to minimize the impact of pandemic constraints on food supply chain efficiency to be:

(1) implementing information technology in supply chain management,

(2) effective workforce planning and developing measures in case an employee is unable to work due to administrative constraints or has to be absent due to illness,

(3) minimizing risks associated with suppliers and developing new relationships,

(4) updating inventory, planning, and supply policies,

(5) transition from traditional to innovative production systems,

(6) developing alternative logistics and capacity building solutions, stress testing, and global scenario thinking,

(7) using a short-term supply and demand strategy,

(8) innovative changes in sales channels.

It is evident that there is a need to develop a new model of supply chain management to reduce costs, improve inventory management, and ensure the effective use of assets. The COVID-19 pandemic revealed that many companies did not understand how vulnerable their supply chains were. Therefore, the traditional linear supply chain model is transformed into digital supply networks (DSN), where functional connections are broken up and the dairy businesses are connected to the entire supply network to ensure end-to-end visibility, collaboration, flexibility, and optimization.

Traditional supply chain management practices are not sufficiently effective during a pandemic, and do not ensure the sustainability of dairy supply chains in

large cities, as the survey results showed. According to the survey, traditional measures of supply chain performance are not effective during the pandemic-induced quarantine. Issues such as fresh logistics and recycling become less crucial, while sales volumes and market coverage become a priority in a dairy supply chain. Supply chain management helps food businesses to generate profits and ensure effective relations with all stakeholders within the dairy supply chain.

The key performance indicators for supply chain management are inventory turnover (an indicator showing how effectively a business uses its assets for profits optimization) and response to changes in markets (an indicator of how quickly information about demand is transferred into a new product). The synergy of the proposed criteria will provide a comprehensive assessment of the effectiveness of the dairy supply chains. The main task is to assess supply chain effectiveness and its structure in general and in dairy production.

The efficient interaction within the supply chain is the main precondition for effective supply chain management. The supply chain flexibility can be explained as the ability of all stakeholders, including suppliers, manufacturers, functional intermediaries, and traders, to overcome internal and external barriers with a high level of competitiveness and high-cost efficiency.

In today's environment, the main forms of effective relationships between stakeholders in the supply chain are:

(1) logistics outsourcing by suppliers, manufacturers, and distributors,

(2) partnerships between supply chain actors combining supply, production, distribution, and transportation to maintain desired inventory levels,

(3) development of a system of logistics services (high availability, low cost, individual approach).

For dairy supply chain businesses, the primary activities to ensure supply chain sustainability should be (1) improving demand forecasting to minimize risk in sales and operations planning (S&OP); (2) using advanced statistical demand forecasting tools; and providing predictive monitoring for rapid response.

Big cities depend on effective logistics, which influence businesses and help them to meet the consumers' needs. Therefore, urban logistics and supply chain management are based on an innovative component of the city management system. It involves a complex of actions that manage the movement of goods, people, energy, and information. Cost and benefit are important elements of the supply chain efficiency, however, consumer service (resident, passenger, road user, etc.) is the primary factor.

The study results indirectly confirm the results of previous scientific work regarding the improvement of logistics systems in large cities in Europe and the world (Guan et al., 2020; Queiroz et al., 2020), including the consolidation of cargo in logistics clusters, urban centers, logistics centers, aggregation of flows to different recipients in a particular area (e.g., shopping centers, hospitals, business

centers, etc.). The study results are also consistent with the views of predecessors, who viewed the main direction for improving supply chain efficiency in the consolidation of urban supply chains linking logistics and non-logistics services (e.g., retail, service, healthcare, etc.) into a "smart grid" that optimizes supply and demand in cities (e.g., Binnenstadservice in the Netherlands) (Chudzik, 2006), as well as integration of enterprise development (Boichenko et al., 2022b). At the same time, the study results suggest that, due to the specifics of the industry, a number of proposals developed by the predecessors will not be sufficiently effective for dairy supply chains, including: the use of urban infrastructure for additional logistical purposes (e.g., the use of closed parking lots for storage and distribution at night; use of public transport to transport products) or automation of storage with extended functionality (Singh et al., 2021; Wawrosz et al., 2019).

In addition, respondents emphasized the critical importance of government involvement in food supply chain management to ensure food security for residents of major cities, which confirms the views of predecessors who proposed various strategies to improve logistics systems with active government involvement (Singh et al., 2021).

New planning models, reducing risks caused by the last-mile delivery, improving flexibility, speed, and quality of logistics services will benefit consumers. Threats can be caused by a lack of funding to rebuild urban infrastructure, limited public sector funding of innovations, the complexity of stakeholders' engagement with the city authorities, and a lack of cooperation efforts within the logistics sector (Figure 2).
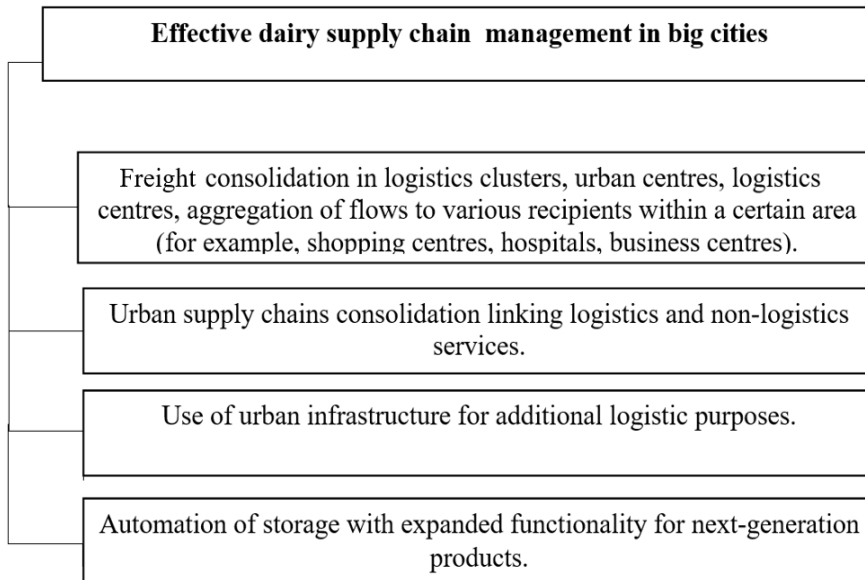


Fig. 2: Food supply chain management in big cities under the pandemic induced restrictions
Source: developed by the authors

Thus, at the current stage of development, the main challenge of improving the efficiency of dairy supply chain management in large cities remains to ensure sustainable supply chain development in the context of the ongoing pandemic to maximize consumer demand for dairy products and ensure food security in large cities. The main directions for improving the efficiency of dairy supply chain management in these conditions should be considered the introduction of innovative logistics technologies, the development of a system of monitoring observations to implement early risk management, increased automation of logistics processes and improved personnel management to prevent supply chain failures associated with the instability of the "human factor" in a pandemic.

The study results not only confirm and deepen the results of previous studies (Ikechukwu, 2019; Singh et al., 2021; Wawrosz et al., 2019), but also contain the main directions for improving the effectiveness of dairy supply chain management, developed based on current information on the supply chains of dairy products of major cities in Kazakhstan and Russia. In addition, the study results may be in demand among academic researchers, primarily due to the formation of new promising areas of further research.

# 5. Conclusions

The COVID-19 pandemic has changed supply chains and business environments around the globe. The primary objective for many dairy suppliers is to ensure sales volumes of products. Thus, fresh supply chain management is less important. The strategy of supply chain management for dairy products can be seen as the strategy of individualization of supply chains with the increased use of digital technologies and risk mitigation strategies.

The importance of interaction between all stakeholders in the supply chain is evident. There is a decrease in the dairy supply chain, changes in product quality, increased risks, changes in demand, an increased need for online orders, and a lack of support from business authorities. The traditional linear model of the supply chain is transformed into Digital Supply Networks (DSN), where functional connections are broken up and dairy suppliers are connected to the entire supply network to ensure end-to-end visibility, collaboration, flexibility, and optimization.

The article creates recommendations for food businesses operating in big cities to improve the strength and efficiency of the dairy supply chain. The most efficient supply chains enable dairy businesses to deliver high-quality products as quickly and cost-effectively as possible. Good relationships with suppliers and the ability to forecast and prepare while keeping an eye on costs are all essential to ensuring the smooth operation of the dairy supply chain. Therefore, contingency management for force majeure circumstances, minimization of risks, updates to inventory policy, a transition from old to new production, development of the alternative solutions for logistics and capacity building, conducting stress tests, and introduction of the

global scenario thinking are of vital importance for dairy businesses. Effective supply chain management relies on being able to ensure effective suppliers' performance to have a system in place to monitor and report on the service provided by suppliers.

The article proposes a strategy to improve the delivery of short shelf-life products requiring controlled storage and transportation temperature monitoring in big cities. The findings suggest that dairy supply chain management should improve freight consolidation in logistics clusters, urban centers, urban supply chains linking logistics and non-logistics services, using urban infrastructure for complementary logistics purposes.

The study results can be used by the real sector of the economy to improve the efficiency of managing the existing supply chains of dairy products in large cities, as well as by academic researchers to further develop recommendations to ensure the sustainable development of dairy supply chains and preserve food security for the residents of large cities.

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## Conflict of Interest

This research has no conflict of interests.

## Availability of Data and Materials

Data will be available on request.

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