



## **THEORETICAL FOUNDATIONS OF “COLD CHAIN” INFRASTRUCTURE AND ITS ROLE IN THE VALUE CHAIN**

Saidova Gulnoza Tulkunovna

Doctoral Student of Karshi State Technical University

E-mail: gulnoz0410@gmail.com, ORCID: 0009-0001-5436-2344

### **Abstract**

This article analyzes the theoretical foundations of cold chain infrastructure and its functional significance in the economic system, particularly in the value chain. The study explores the role of temperature control in the processing of perishable products, from production to delivery to the end consumer. It also substantiates the role of cold chain systems in creating added value, reducing losses, and expanding export opportunities.

**Keywords:** Cold chain, value chain, agricultural sector, added value, infrastructure.

### **Introduction**

## **ТЕОРЕТИЧЕСКИЕ ОСНОВЫ ИНФРАСТРУКТУРЫ ХОЛОДОВОЙ ЦЕПИ И ЕЁ РОЛЬ В ЦЕПОЧКЕ СОЗДАНИЯ СТОИМОСТИ**

Саидова Гульноза Тулкуновна

Докторант Каршинского государственного технического университета

E-mail: gulnoz0410@gmail.com, ORCID: 0009-0001-5436-2344

### **Аннотация:**

В данной статье анализируются теоретические основы инфраструктуры «холодовой цепи» и ее функциональное значение в экономической системе, в частности, в цепочке создания стоимости. Исследование выявляет роль контроля температуры в процессах обработки скоропортящихся продуктов, от производства до доставки конечному потребителю. Также обосновывается роль системы холодной цепи в создании добавленной стоимости, снижении потерь и расширении экспортных возможностей.



---

**Ключевые слова:** холодовая цепь, цепочка создания стоимости, сельскохозяйственный сектор, добавленная стоимость, инфраструктура.

## **INTRODUCTION**

In the context of deepening globalization processes and the increasing relevance of ensuring food security, cold chain infrastructure is becoming highly important. In particular, the cold chain system plays a crucial role in the production, storage, and delivery of perishable agricultural products.

The transportation and storage of temperature-sensitive products in refrigerated conditions dates back to the 18th century, when fishermen used ice and salt to preserve fish at sea. In the 19th century, with the emergence of the ice trade from New England to the Caribbean, Latin America, and Asia, refrigerated transport became increasingly widespread. Wood shavings were used as a form of insulation. Later, in the 20th century, with the invention of refrigeration systems, refrigerated ships and cargo became increasingly common. France began importing frozen meat from South America; the United Kingdom started importing frozen meat from Australia and New Zealand; and North America began importing tropical fruits from Central America. Subsequently, globalization in the late 20th century further accelerated the development of refrigerated cold chain containers.

Today, one of the most pressing issues is maintaining product quality and minimizing losses throughout the process from production to delivery to the consumer. From this perspective, the development of cold chain infrastructure can significantly improve the efficiency of the value chain.

## **LITERATURE REVIEW**

The issue of cold chain infrastructure and its role in the value chain is widely studied in the field of agricultural economics. Research conducted in this area focuses on highlighting the importance of the cold chain system in preserving product quality and increasing added value.

In recent years, the importance of cold chain infrastructure in the storage and delivery of food products has significantly increased. This system is a key factor in maintaining product quality, ensuring safety, and reducing losses. A number of foreign scholars have conducted research in this field.



In particular, studies by R. Badia-Melis have substantiated the use of sensor technologies in controlling the quality of food products. The author demonstrates that the implementation of real-time monitoring systems can improve the efficiency of the cold chain[1].

Nada Jabbour Al Maalouf, on the other hand, has studied the improvement of logistics processes and ensuring safety in food supply chains. Her work emphasizes the importance of using information technologies in managing cold chain infrastructure[2].

Additionally, Tianran Ren has examined the possibilities of optimizing product storage and transportation processes through the use of artificial intelligence and data analytics within smart agricultural systems[3].

In the CIS countries as well, a number of scientific studies have been conducted on cold chain infrastructure, logistics systems, and supply chain optimization.

In particular, the works of G.A. Belozarov[4] and G.Yu. Yurov explore the organization of logistics processes in cold chain systems and the optimization of product storage conditions. These studies emphasize the importance of maintaining a stable temperature regime during transportation and storage stages[5].

A.V. Medvedeva and A.A. Medvedev have also conducted research on preserving food quality and reducing losses in logistics processes. Their work is aimed at improving the economic efficiency of the cold chain[6].

In the Republic of Uzbekistan, a number of scholars have also carried out important scientific research on cold chain infrastructure, logistics systems, and the storage of agricultural products.

In particular, the works of R.X. Ergashev[7] and B.T. Salimov study the improvement of storage and transportation processes of agricultural sector products, as well as increasing the efficiency of the cold chain system[8].

In his scientific research, B.A. Abdusattorov analyzes technologies for preserving food product quality and methods for reducing losses in logistics processes[9].

The above studies highlight various aspects of cold chain infrastructure, including product quality control, optimization of logistics processes, and the use of information technologies. However, the issues of comprehensively assessing the role of the cold chain system in the value chain and its economic efficiency have not been sufficiently explored in these works.



Therefore, this study focuses on a deeper examination of the theoretical foundations of cold chain infrastructure and pays special attention to determining its role in the value chain.

## **RESEARCH METHODOLOGY**

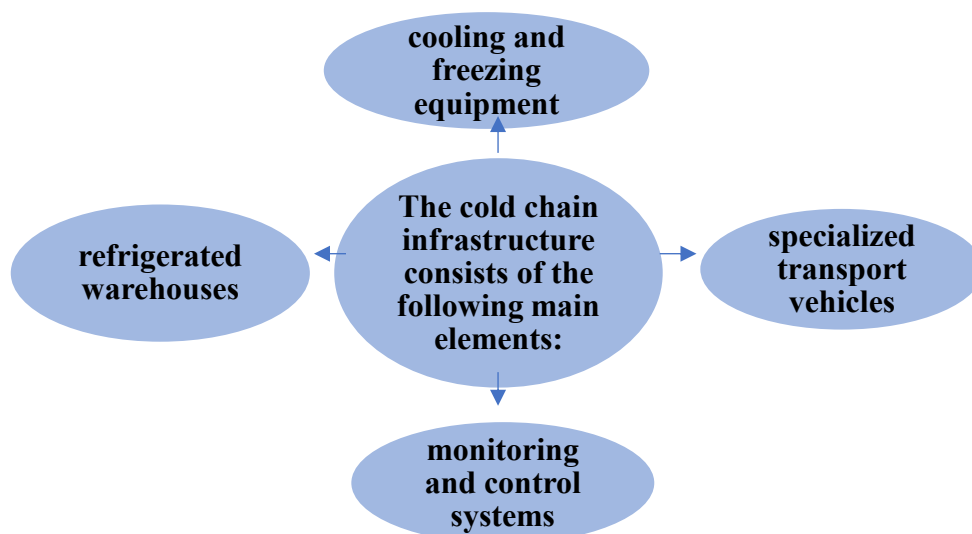
The study employs methods of systems analysis, comparative analysis, classification, generalization, scientific abstraction, and modeling. Existing scientific approaches to cold chain infrastructure have been systematized, and their advantages and disadvantages have been identified.

In addition, the impact of the cold chain system on the value chain in the agricultural sector, as well as its efficiency, has been evaluated based on comparative analysis.

## **ANALYSIS AND RESULTS**

The cold chain is a logistics system that includes the processes of producing, storing, transporting, and distributing products under a specified low-temperature regime. This system is primarily used for food products, pharmaceuticals, and biological products.

From a theoretical perspective, the cold chain is a component of the logistics system and is considered within the framework of supply chain management. Its main function is to preserve product quality and reduce losses during delivery to the consumer.



**Figure 1. Main elements of the cold chain infrastructure**



---

Value chain is the sum of processes that create added value for a product. This concept includes all stages from production to final consumption.

Main stages of the value chain:

- raw material production;
- processing;
- storage and logistics;
- marketing and sales.

In the agricultural sector, the value chain has distinct characteristics, where the perishability and seasonality of products are important factors. Therefore, logistics—especially the “cold chain” system—plays a crucial role.

The cold chain infrastructure plays an important role at all stages of the value chain. It provides the following economic benefits:

- preservation of product quality: maintaining temperature conditions helps preserve the product’s consumer properties;
- reduction of losses: spoilage during logistics processes is minimized;
- increase in added value: high-quality products can be sold at higher prices;
- increase in export potential: it enables the delivery of products that meet international standards.

In addition, when the cold chain system operates effectively, economic relations between producers, intermediaries, and consumers are strengthened.

In the context of Uzbekistan, the “cold chain” infrastructure is still not fully developed; in particular, there is a shortage of refrigerated storage facilities and specialized transport in rural areas. As a result, a significant portion of fruits and vegetables is lost.

At the same time, in recent years, a number of investment projects have been implemented to build logistics centers and refrigerated warehouses. This is helping to improve the efficiency of the value chain.

## **CONCLUSION AND RECOMMENDATIONS**

In conclusion, “cold chain” infrastructure plays a vital role in the modern economy, especially in the agricultural sector. It is an important tool for improving value chain efficiency, preserving product quality, and reducing economic losses.

To develop cold chain infrastructure, it is necessary to increase the volume of investments allocated by both the public and private sectors. This will enable the



---

expansion of modern storage facilities, cooling systems, and transport infrastructure. Through investments, it is possible to reduce product losses and increase export potential.

The introduction of energy-efficient and automated cooling systems is of great importance. Using sensors, IoT technologies, and real-time monitoring systems ensures continuous temperature control of products. This, in turn, significantly improves product quality preservation.

Establishing modern logistics and distribution centers in different regions helps create a fast and efficient delivery system. These centers ensure the continuous operation of the cold chain and strengthen the connection between producers and consumers.

Strengthening public–private partnerships is essential for developing cold chain infrastructure. If the government provides incentives and support mechanisms, it will accelerate the attraction of private investment and the implementation of innovative projects.

It is also necessary to improve the training system for qualified specialists in cold chain logistics. Universities and training centers should introduce specialized programs in modern logistics, cooling technologies, and digital monitoring systems. Expanding practical internships is also important to enhance professional skills and experience.

Implementation of the above recommendations will improve the efficiency of the cold chain infrastructure, ensure food safety, and enhance competitiveness in both domestic and international markets.

## **REFERENCES**

1. Badia-Melis, R. (2018). New trends in cold chain monitoring applications – A review. *Food Control*, 86, 170–182.
2. Al Maalouf, N. J. va boshqalar. (2024). Sustainable practices and their impact on the operations of fresh fruits and vegetables market in the cold chain. *Cleaner Logistics and Supply Chain*, 13, 100196. <https://doi.org/10.1016/j.clscn.2024.100196>
3. Ren, Tianran. (2024). Research on Cold Chain Packaging Risk Management Based on Fuzzy Bayesian Network and TOPSIS. Liverpool John Moores University PhD thesis, p.12.



- 
4. Belozеров, G. A. (2012). Scientific and practical aspects of the development of the refrigeration technological chain for processing, storage and transportation of food products of animal origin. Abstract of dissertation, Moscow, pp. 3–5.
  5. Yurov, G. Y. (2014). Development of the agro-food market and improvement of methods for its protection. Candidate dissertation, Moscow.
  6. Medvedeva, A. V., Medvedev, A. A., & Kireychenkov, N. S. (2024). Implementation of RPA bots in cold chain logistics supply systems. *Computational Nanotechnology*, 11(2), 34.
  7. Ergashev, R. Kh. (2025). Issues of developing cooperation in fruit and vegetable production. “Green Economy and Development” Journal, Vol. 3, No. 2.
  8. Salimov, B. T. (2015). Directions of state support for fruit and vegetable production and export in Uzbekistan. *Journal of Economics and Innovative Technologies*, No. 4.
  9. Abdusattorov, B. A. (2024). The importance and specific features of the value chain in fruit and vegetable production. *Journal of Healthcare and Life-Science Research*, 3(12).