THE ACADEMY OF MANAGEMENT AND ADMINISTRATION IN OPOLE

# CURRENT TRENDS IN DEVELOPMENT OF TRANSPORT AND LOGISTICS SYSTEMS OF DELIVERY OF FAST PERISHABLE FOODSTUFFS

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## PREFACE

The need to feed the world's ever-growing population is prompting countries around the world to take measures to reduce the millions of tons of perishable waste that can be avoided throughout the food supply chain. A significant part of these losses is due to suboptimal processes and the provision of transport and logistics systems for the supply of perishable food products.

It should be noted that the problem of food losses at all stages of the transport and logistics chain is inherent in most economies and needs to be addressed both at the national level to improve the efficiency of the agricultural sector and the welfare of the population and internationally for development. addressing the complex issues of global food security and preventing hunger. After all, modern global transport and logistics systems of food supply face a variety of social problems that are constantly deepening. As a result, many of them work "below ideal", with the result that about one-third of the food produced for human consumption is lost. A key factor contributing to such a high level of waste is the inability to control and monitor the temperature in global food logistics systems.

Logistics, as a science and practice of managing material and related flows of finance, information and service is becoming increasingly needed in the agricultural sector. Of course, the need to use logistics tools in the process of logistics of agricultural production and marketing of agricultural products, ie in the field of agro-industrial complex, is especially relevant. The organization of resource provision of agricultural producers and promotion of their products on the market on the principles of logistics gives a significant economic, social and environmental effect. The efficiency of logistics support in the field of sales of agricultural products is higher, the more consistently and deeply the system approach penetrates into all parts of the logistics chain of goods movement.

Given the fact that a significant part of logistics operations on the movement of material flow from the primary source of raw materials to the final consumer is carried out using different modes of transport, and the cost of these operations is up to 50% of total logistics costs, it should be emphasized the need to develop theoretical and methodological provisions for the optimization of logistics costs in transportation, and the introduction of a process approach in the practice of transport and logistics systems of agriculture.

Implementation of the process approach to business process management of agricultural enterprises should be carried out taking into account the key areas of development of logistics concepts, which will quickly manage material, information, financial and service flows to improve the efficiency of food production.However, the supply of perishable food requires sufficient knowledge potential to take into account additional factors in transportation compared to the supply of other types of goods.

In the study, the typical components of the transport and logistics system of perishable food supplies include: marketing, customer service, forwarding, demand forecasting, communications, management, inventory management, cash flow management, material flow management, information flow management, order service, providing after-sales support, procurement, containerization, work with flows of goods, repair, disposal, transportation, processing and warehousing.

A large network of consumers of perishable food products, limited shelf life of products, certain time intervals of supply of goods and other factors give rise to a variety of different forms and methods of transport and logistics services in supply chains. Unsteady and uncertain behavior of participants in the supply chains of perishable food products leads to the need for flexible methods of planning and management of transportation using several optimization algorithms. Thus, the development of a methodology for transport and logistics services of perishable food supply chains and the construction of new conceptual models of their organization is an urgent task that requires careful study of the behavior of participants in order to apply the developed methodology in practice.

# CHAPTER 1. THEORETICAL AND METHODOLOGICAL FUNDAMENTALS OF DEVELOPMENT TRANSPORT AND LOGISTICS SYSTEMS

## 1.1 The concept and structure of the transport and logistics system

Improving welfarecountries of the world, the acceleration of trade and transport flows, the complexity of their composition significantly change the role of transport and logistics systems in the economic development of countries. Now more attention is paid to the optimization of business processes related to the sphere of circulation, ie the issues of formation and efficient operation of logistics systems. They are modern conditions play an integrative role, performing the functions not only of providing quality transport and logistics services, but also the functions of innovative development, conservation of resources, environmental protection and more.

Special attentionbusiness and scientific circles to logistics in recent years due to the fact that its importance as a real and effective means of maintaining and increasing the profitability of the company, the successful conduct of competition has increased. In most developed countries, corporate logistics costs and their share in gross national product are constantly growing. Yes, withthe total volume of the global logistics market in 2017 was almost 4 trillion. USD USA and is projected to grow 6.5% by 2021[1]. In this regard, all countries of the world develop national strategies for the development of logistics systems and conduct research on the possibilities of realizing the existing logistics potential in accordance with the strategic priorities of the national economy[2].

[1]Global Logistics Market 2017-2021 URL: https://www.technavio.com/report/global-logistics-market-2017-2021; Global 3PL Market Size Estimates Armstrong & Associates. URL: http://www.3plogistics.com/3pl-market-inforesources/3pl-market-information/global-3pl-market-size-estimates/

[2]Havenga JH, Simpson ZP, King D., de Bod A., Brown. M. Logistics Barometer South Africa 2016 Stellenbosch University, 2016. URL: http://www.sun.ac.za/english/faculty/economy/logistics/Documents/Logistics% 20Barometer / Logistics% 20Barometer% 202016% 20Report.pdf ;

The experience of Germany, Finland, the Netherlands, China, Singapore, Malaysia, shows that by building an efficient logistics system can significantly increase the efficiency of doing business in the country, as well as economic efficiency and competitiveness of the national economy[3]. However, it should be noted that building an efficient logistics system and settlementthe relationship of all stakeholders became possible through the theory of compromises. It is on its basis that the effect that suits the system as a whole is achieved. Today, in the management of trade, decisions are selected that will have a positive impact on reducing overall costs or increasing total profits. The whole complexity of the perception of logistics is that it has long ceased to exist within the narrow-profile application, ie has not become a narrow functional industry, but synthesizes scientific and methodological foundations for ensuring the supply of goods to consumers.

Thus, the modern concept of logistics management of goods to anywhere in the world from the standpoint of consumer service can be summarized as follows: "the right product of a given quality and quantity - at a given time and with minimal cost"4. Therefore, the perception of the scientific direction of logistics as a global service is quite legitimate, because the 21st century can rightly be considered the century of science and business, based on comprehensive support of trade and transport processes.

As a management approach, logistics has every reason to optimize the infrastructure of goods movement systems, without limiting its functional scope, which is determined by an extremely important stimulus and direction of

State of Logistics Indonesia 2013 Center of Logistics and Supply Chain Studies, 2013. URL: http://logisticscenter.itb.ac.id/wp-content/uploads/StateofLogisticsIndonesia2013.pdf;

Cebeci C., Yankova M. Analysis of the Logistics Systems in Bulgaria under the Requirements of the European Union. Research Journal of Applied Sciences, Engineering and Technology. 2013.Vol. 6, № 14. 2526-2534.

[3]Rantasila, K. Measuring logistics costs. Designing a generic model for assessing macro logistics costs in a global context with empirical evidence from the manufacturing and trading industries. Turun's shopping mall is open to the public. 2013. № A-8: 2013. URL: https://www.doria.fi/handle/10024/93317

[4] Sergeev VI, Kizim AA, Elyashevich PY Global logistics systems of St. Petersburg: Business Press, 2001. 218

development. It should be emphasized that distribution logistics is often identified with transport logistics, as these research areas intersect in organizational and functional unity, and intertwined in the implementation of a range of services, as goods on the way through distribution systems are accompanied by services related to transport and warehousing, following within the specified parameters of time, quantity and quality to the consumer. It is the use of system-analytical tools of modern logistics in the field of goods movement is able to adequately organize market realities and provide a system of distribution at the macro, meso and micro levels of logistics systems.

As an organizational and methodological basis for the movement of goods, distribution logistics is able to offer modern market players logistics management in the field of their own sales systems or a range of services for flow management, freight forwarding services for consumer market operators and more.

In order to fully define the place of the transport and logistics system, in logistics in particular and the economy in general, it is necessary to define the concepts of logistics and systems in the most general sense and narrow these definitions to a narrower specialization.

The etymology of the word "logistics" is ambiguous: the term "logistics" comes from the ancient Greek roots (logos - mind; logo - thinking; logismos - calculation, reflection, plan; logo - think, reason; logistea - the art of practical calculations) and French (loger - to live, place).

As science, logistics, develops scientific principles, methods, mathematical models to plan, control and manage transportation, warehousing and other tangible and intangible operations carried out in the process of promoting goods to the consumer, namely:

- bringing raw materials to the production plant;
- in-plant processing of raw materials and semi-finished products;

- bringing finished products to the consumer in accordance with his requirements;

- transmission, storage and processing of relevant information.

As an economic activity, logistics is the process of managing the movement and storage of raw materials, semi-finished products and finished products in economic turnover from the primary source of raw materials to the final consumer of finished products and related information. Logistics allows you to solve many different tasks of varying complexity and scale, namely:

- forecasting demand and determining the required stock on its basis;

- development of inventory management system;

- determination of the required production and transport capacity;

- organization of distribution of finished products;

- management of transshipment processes and transport and warehousing operations at points of production and consumption;

- modeling the operation of logistics systems;

- design of logistics systems;

- planning and implementation of supply, production, warehousing, marketing, transportation;

- coordination of goals and coordination of individual enterprises in the supply chain and various departments within the enterprise.

The American Association of Industrial Entrepreneurs proposes to consider logistics as a systematic approach to solving the problem of optimal management of material flows[5]. This definition of logistics reduces it to the task of optimizing only material flows and does not pay attention to such important flows as financial, information and service.

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[5]Larina RR, Pilyushenko VL, Amitan VN Logistics in the management of organizational and economic systems. Monograph. Donetsk: Ed. VIK, 2003. 239 p.

Researchers at the University of Economics in London believe that logistics should be considered from the standpoint of the implementation of key logistics coordination processes, including:

- management of activities in accordance with the operational calendar of supplies of raw materials and semi-finished products;

- transport and warehousing works with supply facilities;

- physical distribution activities in the production of products;

- in-house movement of materials, raw materials, spare parts and finished products;

- carrying out loading and unloading works;

- implementation of economic activity on the basis of marketing plan for product sales, demand forecasting, service, operational and calendar planning, processing of consumer orders[6].

According other foreign authors, representing the conventionally Asian approach to the organization of logistics, logistics should be understood as activities related to setting goals and objectives of the logistics system, maintaining relations between producers and the external environment, which allows all parties to achieve their goals.[7]. Such goals should correspond to the internal capabilities of the subjects of logistics activities and ensure sensitivity to environmental factors.

A peculiar definition of logistics is proposed by the Ukrainian scientist E. Krykavsky[8].

According to the Russian scientist Leontiev RG9., the most accurate wording of the definition of the term "logistics" was given by the US Logistics Management Council in 1985: the quality of products and services for the

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[6]Gwynne Richards, Susan Grinsted The logistics andsupplychaintoolkit: 101 tools for transport, warehousing and inventory management. London: KoganPage, 2016. 261.

[7]Kee-hungLai, TCE ChengJust-in-time logistics. Farnham, Surrey: Gower, 2016 116.

[8]Krykavsky E. Logistics of the enterprise: textbook. Lviv, Lviv Polytechnic State University, 1996. p.

[9]Leont'ev, RG Selected: monographic cycles (1984-2005) in 3 volumes - Vol. 2. Logistic paradigm. Khabarovsk: Izd-vo DVGUPS, 2006. 284 p.

management of material and (or) service flows, as well as the accompanying flows of information and financial resources. Based on this definition, certain elements of logistics are interpreted: operations, functions, links, systems, chains, channels, networks, etc. And all this is considered in the concept of macro-, micro-, megalogistics.

In accordance logistics can be understood as a tool that provides preparation, conduct and completion of commercial operations (sales agreements). At the same time, we must define the purchase agreement itself as a starting point, after which all relations are built on production management, purchasing and supply activities, which includes providing production with the necessary material resources, warehousing, inventory management and inventory management. sometimes the issuance of everything necessary for production to ensure its rhythm and quality manufacturing of finished products.

Regarding transport logistics, it is based on three main characteristics: quality, time and cost.The main tasks of transport logistics are:

- ensuring the transportation of goods;
- minimization of transport costs;
- finding optimal supply routes;
- creation of logistics schemes;
- search and selection of carriers, freight forwarders;
- supply planning;
- participation in the part of logistics in the preparation of contracts and in the conclusion of contracts for the purchase and sale of goods;
- passing customs formalities in the country of departure, destination and transit through third countries;
- ensuring a single controlled supply scheme for different carriers and modes of transport for mixed (intermodal) transportation;
- consolidation (unification) of goods in the supply process;
- coordination of shipment instructions with the sender and consignee.

The term "system" comes from the Greek. σύστημα - a whole composed of parts or compounds. Historically, it is used in literally all areas of human activity, and in both the exact and the humanities has almost the same understanding. Thus, L. Bertalanffy understands the system as "a set of elements that interact"[10]. A. Hall and R. Feidshin invest in this concept "many elements with a relationship between them and between their attributes"[11]. V.N. Toporov, considering the system in the framework of linguistics, understands the term "a set of elements organized in such a way that the change, exclusion or introduction of a new element is naturally reflected in other elements"[12].

Summarizing the above definitions, we can highlight the main properties of the system:

1) the system includes several components;

2) the components of the organized system are interconnected;

3) making any changes to the system naturally affects all its components.

From an institutional point of view, any system includes the following components:

- elements included in the system (subsystems, links, participants);
- structure (set of control, information, production and technological and other links between elements of the system);
- many permissible actions (restrictions and regulations);
- target functions (desires and aspirations of consumers);
- awareness and benefits of system elements[13].

The elements determine "who" is part of the system, the structure - "who interacts with whom, who is subordinate to whom", many permissible actions - "who can", target functions - "who wants what", awareness - "who knows what".

[10]Bertalanffy L. General systems theory - a critical review. Research on general systems theory: a collection. Moscow: Progress, 1969. 23- 82.

[11]*Hall AD, Fagin RE Definition of the concept of system /*Collection of translations from Polish and English. Moscow: Progress, 1969. 252-286.

[12]Toporov VN Some considerations in connection with the construction of theoretical toponymy // Sb. scientific tr. / Principles of toponymy, 1964. 3-22.

[13] Novikov DA Institutional Management of Organizational Systems Moscow: IPU RAS, 2004. 68.

Thus, the system is defined as a set of interacting elements that are in a relationship or relationship with each other, forming a integrity and organic unity[14]. Accordingly, the system can be represented as a set of essential properties that characterize its state at any given time

$$C = (m, H), \tag{1.1}$$

where m - the set of elements;

H - many connections between the elements of the system, through which the system exists as a whole.

Based on this, any object or process (technical, economic, social, biological, physical) can be analyzed and created as a system, ie a set of interconnected elements that works to achieve a common goal. Consequently, the process of transportation of goods can be considered as a system, ie as a set of interconnected elements, created to achieve a single goal of supplying goods to consumers.

The functioning of the system can be formalized on the basis of its presentation as a process of transition from one state to another. It is recommended to manage the system on the basis of dynamic economic-mathematical and information models that reflect the transitions of the system from one state to another in real time. As a rule, they use "Theory of Markov random processes", simulation of systems and components on a computer, information technology, computer programs to support management decisions based on modern mathematical methods.

In the process of functioning, the system interacts with the external environment. Therefore, when improving an object or process as a system, such interaction with the external environment should be provided, which will best contribute to the achievement of the goal of the system. The external environment in relation to the system may be other surrounding systems, the

[14]Large Economic Dictionary / ed. A. N. Azriliana. - 7th ed. Moscow: Institute of New Economy, 2008. 1472.

impact of which on the studied system consists in the mutual transmission of material and information flows. These flows are characterized by certain parameters and patterns (usually stochastic) and their impact on the behavior of the system can be analyzed using various mathematical methods.

If we consider the logistics system, the concept of "system" is narrowed to a specific industry – logistics. V. I. Sergeev notes the logistics system as "a set of links that are interconnected and united by a single management of the logistics process for the implementation of corporate strategy of business organization"[15]. E. V. Krykavsky and N. V. Chornopyska, as "specially organized integration of logistics elements (units) within a certain economic system to optimize the processes of material flow transformation"[16].

However, in foreign literature the concept of logistics system is used very rarely, more often this term (logistic system) is used as a synonym for a general understanding of logistics. Understanding is close to domestic terminology, foreign scholars invest in the terms "logistics chain" (logistic chain) or in the more commonly used concept of "supply chain" (supply chain). That is, foreign scholars tend to have a more specific definition: the definition often specifies the elements of the system/chain (raw material suppliers, manufacturer of products / services, distributors, carriers, warehouses, retail outlets, end consumer) and the links between the elements impact on the cost of the final product, its competitiveness, etc.).

In this sense, D. Benson and J. Whitehead define the logistics system as a relatively stable set of structural (functional) units of the company, as well as suppliers, consumers and logistics intermediaries, interdependent on the main and/or related flows and united by a single management to implement strategic

[15]Corporate logistics: 300 answers to questions from professionals [under common. and scientific ed. Sergeeva VI]. Moscow: INFRA-M, 2005. p. 28.

[16]Krykavsky EV, Chornopyska NV Logistic systems: textbook. manual. Lviv: Nat. Lviv Polytechnic University, 2009. p. 16.

(tactical) logistics plan[17]. A. R. Ganeshan, T. P. Harrison as a network of production facilities and distribution options, namely the functions of purchasing material, processing this material into intermediate and final product and distribution of this final product among consumers[18]. Or a single network of organizations, directly or indirectly interconnected and interdependent in serving a single customer or client (E. Frazelli[19]).

More broadly interprets the logistics system N. V. Burennikov "is not just an adaptive system with developed external and internal relations, which performs certain logistical functions, but a complex dynamic adaptive system with management and synergistic intra-system relations and relations with the external environment. This system requires measuring the consequences of its operation. Under the functioning of the logistics system, she suggests to understand the implementation of the system of certain functions, which are determined by resource, production, material, financial, social, economic, environmental, technological, logistics, institutional and other potentials (reserves)"[20].

Summarizing the views of domestic and foreign scientists, we can conclude that the logistics system is a system / network consisting of interconnected and interdependent elements / flows, each of which performs a specific logistics operation, which together implements a specific logistics function in a particular environment .

According to M. A. Aucklander[21], the logistics system environment consists of eight factors:

[17]Benson D., Whitehead J. Transportation and delivery of goods. / trans. with English Moscow: Transport, 1990. 279.

[18] Ganeshan, Ram, Harrison TR “An Introduction to Supply Chain Management,” Department of Management Sciences and Information Systems, 303 Beam Business Building, Penn State University, University Park, PA published at 1995 URL: http: // silmaril. smeal.psu.edu/supply_chain_intro.html

[19]Frazelli E. World standards of warehouse logistics / trans. with English Moscow: Alpina Publisher, 2013. 328.

[20]Burennikova NV, Yarmolenko VO Logistics systems: evaluating the effectiveness of functioning. Economy. Finances. Management: current issues of science and practice. No. 6. 2017. 94-102.

[21]Aucklander MA Contours of economic logistics: a monograph. Kiev: Scientific thought. 2000. p. 71

1. Competitive. Includes analysis of competitors' activities (price, profit, suppliers, consumers, etc.), which is important primarily to determine the minimum level of service that can satisfy consumers.

2. Georin market. Assumes that the effectiveness of logistics activities is directly proportional to the location of their participants.

3. Technical and technological. Takes into account the fact that robots, computers, video cameras, communications, warehousing, transportation, packaging, automated material flow management systems have a significant impact on the efficiency of the logistics system.

4. Fuel and energy. Takes into account the dependence of logistics operations on traditional, non-renewable energy sources, the number of which on the planet is declining, the cost is increasing, and the consequences of use have a detrimental effect on the quality of human habitat.

5. Socio-economic. Characterizes the state of banking, budget, tax, credit and financial systems, the level of real incomes, the degree of business activity of economic entities, pricing policy, lifestyle, traditions, customs, expectations and more.

6. The structure of the logistics chain. includes a variety of forms of supply and physical distribution, and the nature of the relationship between the participants in these processes adds a touch of character to the nature of the logistics system.

7. Trends in service development. Takes into account the flexibility inherent in the logistics system for the range of services provided to consumers. Due to increased competition and exacerbation of the problem of implementation, the amount of funds allocated for maintenance increases. This allows you to increase the variety and increase the volume of service.

8. Degree of state regulation. It assumes that the liberalization of economic processes in all parts of the logistics system affects the features and effectiveness of logistics activities.

Considering logistics systems in terms of functionality, it is customary to distinguish between functional and support subsystems.

1. Functional subsystems (functional areas of logistics) are supply, production and distribution.

2. Supply subsystems – organizational, economic, legal, staffing and logistics information system.

Traditionally, there are two levels of logistics systems: macro-logistics and micro-logistics systems.

1. Macrologistics system is a large system of material flow management, which includes enterprises and organizations of industry, intermediary, trade and transport organizations of different departments located in different regions of the country or in different countries.

2. Micrologistic systems are subsystems of macrologistic systems. These include various production and trade enterprises, territorial production complexes, etc.[22].

Starting from the basic logistics functions, the main subsystems are distinguished in the micrologistics system:

- procurement (raw materials, services, materials);

- warehousing activities (storage, accounting and packaging of materials and finished products; calculation of insurance stocks);

- production (processing of raw materials and intermediate products into the final product);

- sales and distribution (distribution of final products and their sale to the final consumer);

- management (forecasting, planning, organization, coordination, regulation, control);

- transport and logistics (warehousing, cargo processing, packaging and transportation, ymanagement of reverse material flows).

[22]Afonin AM Industrial logistics. Moscow: Forum, 2011. 302 p.

For the purposes of our study, we will focus in more detail on transport and logistics systems. First of all, we note that the transport and logistics system has all the features of the system:

1) integrity. The transport and logistics system can fulfill the set goal only if each of its elements works effectively;

2) the interconnectedness of the elements. The efficiency of the transport and logistics system is determined by the efficiency of each of its elements;

3) the organization of the set of elements. The transport and logistics system can be effective only if the potential of each element is realized through the use of organizational tools;

4) integrative qualities. Transport and logistics system owns qualities inherent in the system as a whole, but not inherent in any of its elements separately;

5) emergence. The transport and logistics system as a whole has such qualities and potentials that its individual elements do not have, ie the effect of the sum exceeds the sum of the effects. The system is able to perform a function that its elements will not be able to perform separately;

6) complexity. The transport and logistics system has a complex structure;

7) hierarchy. The transport and logistics system has a complex system of management and subordination;

8) structure. The presence of a large number of elements and connections, both within the system between its elements and with the external environment.

The transport and logistics system is formed by:

- goal – synchronization of flows and optimization of quantitative and qualitative parameters of the logistics business process;

- the subject of management – the consignor, consignee and carrier

- object of management: for the consignor – products and transport, for the carrier – transport for the consignee – cargo;

- management process – information flow from the subject to the object of management, which implements management functions (planning, organization, coordination, motivation, control, accounting and analysis) to achieve the goal of the transport and logistics system;

- function – ensuring interaction through coordination and synchronization of the component operations of the business process and management entities;

- catalyst – optimization of temporal and financial properties;

- equipment – labor, means of labor, objects of labor, necessary and sufficient to implement the function of the system.

The function of the transport and logistics system includes:

- integration of various functions and economic relations with the needs of both passenger and freight transportation;

- coordination of supply and transportation management processes;

- cooperation and integration of management of the movement of goods and cargo flows through the use of warehouses of different transport companies and firms of different sectors of the economy;

- development and improvement of management functions, as well as their rational distribution among all participants in the transport and logistics process;

- organization of software-defined transport and logistics systems, distribution of data transmission and management processes, centralization of process management with the help of unified software, virtualization of physical network and transport resources, etc.

The entrance to the transport and logistics system is labor, means of labor, objects of labor necessary for the functioning of the transport and logistics system. The way out of the transport and logistics system is the socio-economic result of functioning, expressed in the parameters of achieving the goal through obtaining a set of effects (integration, cooperation, coordination, unification).

It should be noted that the composition of subsystems, elements and connections that support the transport and logistics system is not constant, as it depends on a number of factors, such as:

- cyclical nature of the system;
- parameters of the control object;
- characteristics of the subject of management;
- the influence of the external environment;
- the difficulty of defining the boundaries of the transport and logistics system;
- the level of development of relations of sustainable interaction by technological redistribution;
- the level of self-organization of the subjects of management of the transport and logistics system;
- the level of development and formalization of the organizational and economic mechanism in general and its relevant tools for effective management.

Formed in theory and practice views on the use of technologies for transport services in logistics systems are based on the explanation and justification of the choice of modes of transport, mode of transport, carrier, as well as optimization of transport process parameters. According to experts, the cost of transportation carried out within the logistics systems can be up to 50% of the total cost of logistics[23]. However, the role of transportation in logistics is determined not only by a significant share of transport costs in the total logistics costs, but also by the fact that transportation determines the very existence of material flow in logistics systems.

The qualitative change in the role of transportation in logistics and in general the increasing importance of transport logistics in the economy is also evidenced by the increasing attention of the scientific community and

[23]Azimov PH Problems and prospects of transport and logistics activities in Central Asia (on the example of the Republic of Tajikistan)]: monograph. Chelyabinsk: SUSU, 2016. 171.

international research organizations to the organization of transport services. In particular, integrated indices are actively used to characterize the efficiency of the organization of transport services. For example, one of the first "transport" indices taken into account in international activities – "transport service index"[24]. This index characterizes the dynamics of the volume of transport services provided to organizations and the public.

The Freight Index measures the transport of goods by road, rail, inland waterway, pipeline and air (excluding maritime transport, courier and postal services). The index of passenger traffic characterizes the passenger turnover of urban public transport, intercity rail and air transport.

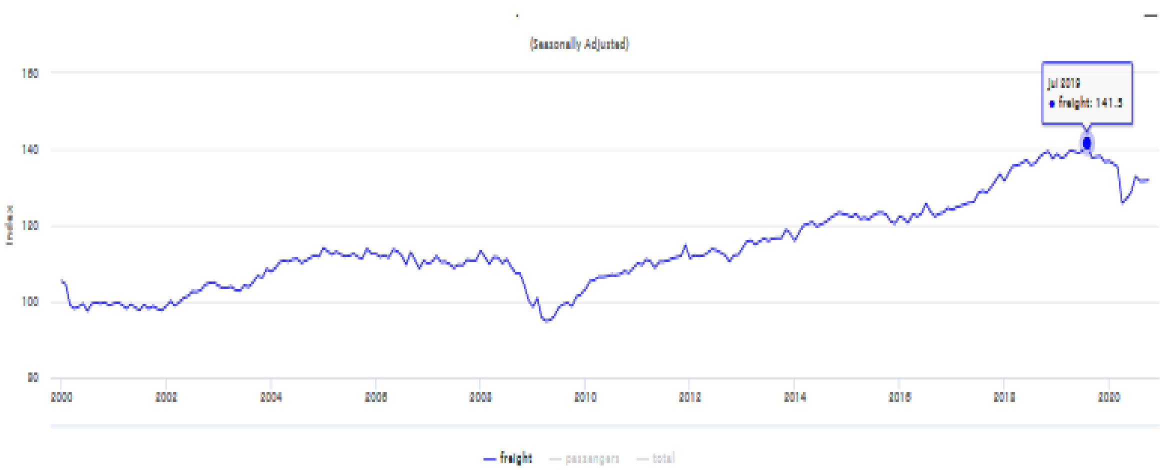


**Fig. 1.1** Indices of transport services (freight), 2000-2020, units

Source: Transportation Services Index URL. https://www.transtats.bts.gov/OSEA/TSI

Thus, the data in figure 1.1 show that in recent years (except for 2020 – due to the coronavirus pandemic) there has been a significant acceleration in the provision of freight services in the world. Which in the peak period (July 2019) reached 141.5 units of cargo per month.

Today, a significant number of other indices are also used to assess the efficiency of freight traffic. These include the index of freight traffic, which is

[24] Transportation Services Index URL.https://www.transtats.bts.gov/OSEA/TSI/ - officially used since 2000

calculated by the statistical office of the European Union. This index reflects the share of the cost of freight in the structure of GDP, including transport by transport such as road, rail and water. To assess the indicator, all freight traffic on the territory of the given state is taken into account, regardless of the nationality of the vehicle.[25]

However, transport and logistics systems cover more than just the transportation process. They, in general, decide the process of delivery of goods regardless of the modes of transport used, but taking into account the required volume, timing and quality of delivery. That is, they use the principles of building multi-level systems that provide the ability to manage material flows at different levels of operational management with access to common criteria for the effectiveness of transport and logistics systems. In this case, in transport and logistics systems, information control systems are essential, as only with their help it is possible to ensure coordination of management in a single information space of many entities.

As a rule, there are two components in transport and logistics systems: warehousing logistics and transport logistics.

Warehousing logistics is a set of interconnected operations implemented in the process of material flow transformation in warehousing. Its purpose is to organize an efficient warehousing system. Warehouse logistics is aimed at managing the flow of goods passing through the warehouse and the warehouse network in such a way as to ensure compliance of the characteristics of the outgoing flow (from the warehouse) with the incoming flow (to the warehouse) by optimizing all available resources in the warehouse: personnel and other factors. Thus, the warehouse, as an element of warehousing logistics, is also a complex technical system. Warehouses are found all the way through the flow

[25] Freight transport statistics. Eurostat URL. http://ec.europa.eu/eurostat/statistics-explained/index.php/Freight_transport_statistics

of material flows, from the warehouses of suppliers of raw materials and ending with the warehouses of the distribution system.

The warehousing policy and the activities of the enterprise are influenced by:

- place of warehouse in warehousing logistics;
- density of highways;
- feature of the industry and production;
- purpose and objectives of the business;
- product characteristics (weight, size, storage conditions, completeness, interchangeability, etc.);
- terms and requirements for storage;
- seasonality of demand for goods;
- level of development of logistics technologies and e-commerce.

Today, one of the systems that is quite active in economic practice and strengthens the competitive advantages of economic entities in the logistical aspect is the system of movement of goods JIT "just in time". It has a strong impact on all logistics areas, including warehousing, and therefore becomes widespread and has some success in the direction of "cross-docking" (the process of receiving and shipping goods and cargo through the warehouse directly, without placing in a long-term area storage).

According to their functional purpose, cross-docking warehouses, like traditional warehouses, can be classified into distribution warehouses, where consignments at the level of a cargo unit from wheels are reissued in batches according to customer requests, and sorting warehouses, where the cargo unit arrives at the warehouse disassembled. and is completed under the order to the consumer.

From the position of "cross-docking" the warehouse does not store cargo, but converts cargo flows, which in relation to the structure of warehouse space for "cross-docking" means: in the warehouse preference is given to areas for receiving and picking goods -2 days for stocks (in Merge-in-Transit warehouses - merger in transit), or completely absent (Flow Through warehouses). Accordingly, cargo handling becomes an important part of the logistics process in the warehouse.

Its main operations include:

- preparation of the warehouse for acceptance of products;
- unloading of transport;
- acceptance of products by quantity and quality;
- placement for storage (stacking of goods in racks, stacks);
- providing the necessary conditions to maintain the quality of cargo;
- selection of goods from places of storage, completion of orders and packing;
- release of goods;
- load in the vehicle.

An important aspect of cargo handling is packaging. One of the concepts of packaging related to storage and handling processes is the concept of a standardized cargo unit. The creation of an enlarged cargo unit is reduced to the physical association (consolidation) of individual industrial packaging into one standardized "package", convenient for transportation and cargo handling.

All forms of creation of consolidated cargo units - from a simple connection of two industrial packages to the consolidation of goods with the help of specialized transport equipment - are included in the concept of "containerization". All types of containerization have one goal - to increase the efficiency of cargo handling.

The task of warehousing management is to increase warehousing turnover, expand markets and create competitive advantage for the entire transport and logistics system. At the same time, the increase in warehouse space should not affect unit costs. The value of the total logistics costs is determined by the formula:

$$Z_p = \sum_{i=1}^{n} C_i + \frac{K}{T}\ , \qquad (1.2)$$

where $Z_p$ – the value of the total logistics costs;

n – the number of selected cost items;

$C_i$ – logistics costs, which include operating, transportation costs, costs of warehouse system management, inventory maintenance and other costs and losses associated with the operation of the logistics system, which are taken into account when deciding on the creation of a warehousing system;

K – full capital investments in construction and the equipment are resulted composition taking into account the discount rate;

T – the payback period of the option.

The largest share of costs in the structure of transport and logistics costs are transport. In this case, they can be divided into transport costs associated with the delivery of the batch from the supplier to the warehouse and supplies from the warehouse to customers.

In the case of centralized deliveries from the manufacturer or wholesaler (if the supply is made by the supplier), transport costs are included in the cost of production and become the costs of the supplier. The cost of delivery from the warehouse to the customer depends on the amount of cargo transported and the distance of the warehouse from the destination. Thus, the approach of the warehouse to the consumer and the integration of goods significantly reduce transport costs.

The following are warehousing costs. They are divided into conditionally constant, related to the maintenance of the warehouse building and its equipment, regardless of the volume and processes of cargo processing, and conditional variables, which directly depend on the intensity and volume of cargo processing. Conditional fixed costs include:

- salaries of warehouse staff;
- depreciation deductions;

- utility bills and communication services (subscription fee);
- taxes;
- maintenance and repair costs;
- security costs.

Conditionally variable costs include:

- order processing costs,
- packaging costs,
- loss of stocks during storage.

It should be borne in mind that the tasks of placing and increasing the warehouse network are optimization tasks. After all, on the one hand, the construction of new and reconstruction of existing warehouses increases capital costs, but on the other – it expands the range of functions of warehouses, brings their location closer to the consumer, thereby potentially reducing transport costs and increasing service speed. The choosing alternative projects for the construction and maintenance of warehouses, it is necessary, first of all, to conduct a comparative cost assessment, which will determine a more favorable option.

The role of transport in logistics processes is twofold: on the one hand it is a separate logistics system, with its own tasks and features; on the other hand, transport plays a connecting role between the other components of the system, ie it does not exist in isolation, but permeates other elements, uniting them into a single whole. Transport is the basis for the movement of material (freight) flow, and its products have specific features, namely:

1) transport products do not have a material form. Transport sells the production process itself, ie: transportation, movement of goods, products created in other sectors of the economy;

2) the peculiarity of the production process in transport implies that the means of production here do not contain raw materials;

3) the units of measurement of transport products are tonne-kilometers, passenger-kilometers, tons of cargo turnover and the number of passengers sent;

4) since the products here can not be accumulated or stored, the transport can not work without a reserve;

5) features of the functioning of the economy, its industries (seasonality, cyclicality) cause uneven use of vehicles during the year.

Accordingly, the main goal of transport logistics: to deliver the desired product, the appropriate quality and the specified quantity, to the right place with minimal costs. In essence, transport is the conductor of material flow in the supply chain, and the only reason for its movement at the inter-organizational level.

In market conditions, the availability of new services and forms of business relations between carriers and customers, as well as free pricing allow to achieve the most favorable combinations of transport service and prices that meet the goals of enterprises.

Today, there are far more ways to transport finished goods and materials than ever before. Businesses and organizations can make deliveries in person, can enter into contracts with hired carriers, or use the services of various transport service specialists.

Free competition in the market of transport services has created conditions for improving transport service. Today, in addition to timely delivery of goods, transport companies ensure the safety of goods and coordination of various modes of transport. Reducing transport tariffs, cargo insurance and preventing the risk of additional costs (for example, due to incorrectly completed documents) play an important role in the transport services market.

The technology of transportation and the organization of the general logistic process in supply chains have fundamentally changed. Now any cargo owner is looking for the cheapest, fastest and most reliable way to deliver cargo to the consumer. Therefore, the formation of options for the supply of goods becomes the most complex and diverse task of the transport and logistics system. After all, in most cases, long-distance deliveries use mixed (multimodal) transportation technologies, which involve two or more modes of transport.

Therefore, first, it is necessary to determine when and how many modes of transport will be used, where reloading will take place from one vehicle to another.

Secondly, the final decision is influenced by a large number of factors: from transport performance, availability of transportation in the required direction to legal aspects (customs legislation, rules of transportation, liability of the carrier of the transport, additional documents, approvals, licenses, etc.).

Third, any supply system, other than transportation, involves a large number of related operations that can be performed on their own or involve intermediaries. In this case, it is a matter of choosing not only the mode of transport, but also transport intermediaries (freight forwarders, customs brokers, loading and unloading operators, owners of terminal complexes, etc.), as increasing the distance will increase the number of entities interacting .

Within the production there are internal and external transport logistics: the first relates to the transportation of materials and products between warehouses and production sites of the enterprise, the second - covers the supply of goods to the enterprise or their removal from it. The main stages of transportation include:

1) loading, registration of all goods and transport and customs documents;

2) direct transportation: (possible organization of temporary storage at terminals and warehouses, reloading, etc.);

3) unloading of goods at the final place of delivery.

In the process of transporting goods to consumers in the logistics chain, the relevant processes take place, which depend not only on the properties of cargo, its volume and weight, but also on the type of packaging (pallets, containers, etc.), packaging and mode of transport. In this regard, the process of supplying products can be represented as a sequence of stages, which may be unrelated, as well as performed by different carriers. In this case, the optimization of the parameters of the specified space-time chain is a multilevel task.

Accordingly, the functions of transport in the distribution of goods are transport and forwarding. The latter includes:

- activities for planning, organizing and performing the supply of products from the place of its production to the places of consumption and providing additional services for the preparation of shipments;
- registration of necessary transport documents;
- concluding a contract for transportation with transport companies;
- calculation for transportation of goods;
- organization and carrying out of loading and unloading works;
- storage of products (packing, packaging, warehousing);
- consolidation of small and unbundling of large shipments;
- information support;
- insurance;
- financial and customs services using optimal methods and techniques provided that the needs of industrial and commercial enterprises in the efficient distribution of products are fully met.

The process of transportation of finished products has its own characteristics of the organization, which is expressed in the fact that supply as a process of continuous supply to consumers must be considered in the light of changes in demand from the buyer. This dictates the need for strict adherence to delivery deadlines, which are impossible without clear characteristics of the components of the system. Therefore, the construction of an integrated production and transport system, which will take into account the instability of the transport process and synchronize it with the production schedule, can be based on the use of Petri nets[26].

It should also be noted that the links and components of their transportation, as well as the characteristics of demand for transportation, have a high degree of uncertainty. Accordingly, the solution of transport problems in connection with the complexity and stochasticity of the transportation process requires the use of situational methods, logistical procedures for the analysis of situations arising from the design and implementation of the process of transportation of goods.

Of particular difficulty is the identification of places of risk, ie the location of gaps that result in losses. A typical example of the place of risk in transport are reloading processes that occur due to possible mismatch of transport and handling equipment, damage to containers and packaging, mismatch of vehicle capacity and power of mechanisms, which can lead to rupture or lengthening of the logistics chain. the cost of transporting products.

Thus, from the above we can conclude that transportation is a key logistics function (60%), which closes all the main operations related to the movement of material resources and delivery of finished products to the consumer. Transportation includes analysis and selection of modes of transport, models and modes of transportation and intermediaries.

At the same time, it is necessary to note the difference between the understanding of the transport system and the transport and logistics system. If the first aims at a high level of operation in isolation with other industries and the optimization of transport processes that should lead to lower transport costs, the second assesses the conditions of transportation and all related costs within the logistics system.

[26]Stetsenko IV, Boyko OV Petri net simulation system. Mathematical Machines and Systems, Kyiv, 2009. № 1. 117-124.

In other words, according to the concept of total costs, an increase in transport costs can lead to a significant reduction in other parts of the supply chain, which will reduce the final cost of the product. Or, for example, reducing transport costs will increase transit time, which will significantly reduce the productivity of the chain as a whole.

So summarizing all the above we will define ttransport and logistics systems as a set of objects and subjects of transport and logistics infrastructure together with material, financial and information flows between them, which performs the functions of transportation, storage, distribution of goods, as well as information and financial and service support of goods flows.

Optimal transport and logistics system is a system that provides maximum economic effect with a sufficient level of reliability and quality of services within the available resource constraints.

It should be noted that the efficiency of the transport and logistics system largely depends on the state of transport routes and the transport program implemented by the government. Today in Ukraine there are a number of problems in this area:

- structural transformations in transport are slow;

- trends in the aging of fixed assets have not been overcome; technical and technological levels of transport machinery and equipment require significant qualitative improvement;

- opportunities for interaction of transport with domestic transport engineering, petrochemistry, instrument making and communications are not fully realized;

- an integrated and systematic approach is slowly being implemented, especially in the management of the development and functioning of the transport system as a whole, as well as the coordination and interaction of different modes of transport;

- on passenger transportation by different modes of transport there are no effective mechanisms of financial compensation for transportation of privileged categories of passengers, which leads to significant losses of transport organizations and so on.

However, if we consider the fundamental basics of intensification of the development of macro, meso and micro transport and logistics systems, they do not look fully convincing without a description of the flows operating in them.

### 1.2 Characteristics of flows in transport and logistics systems

As noted above, the object of study of logistics as a science are material flows and their corresponding financial, information and service flows. Accordingly fthe functioning of the transport and logistics system can be represented as a set of processes. In particular, the model of processes performed in the logistics system of the enterprise on the basis of methodology SCOR (figure 1.2).

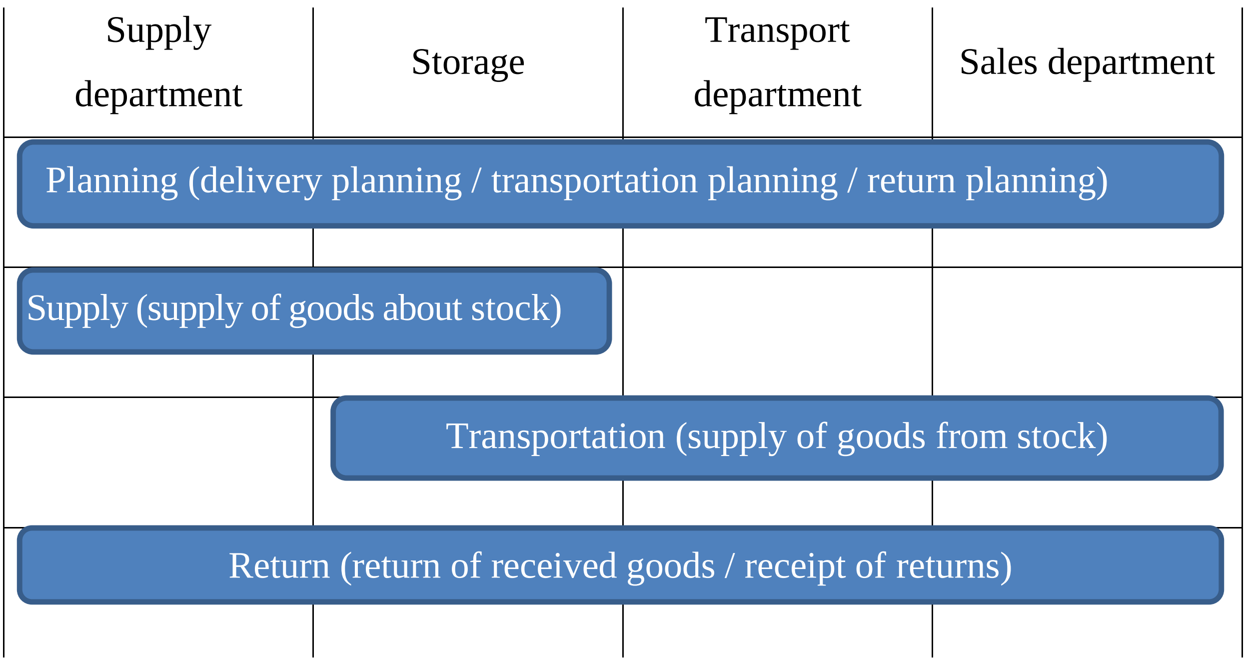


**Fig. 1.2** Model of flows of transport and logistics system of the enterprise

Source: compiled by the authors

In this case, the flow is understood as the directed movement of a set of something relatively homogeneous (for example, products, information, finance, materials, raw materials, services, etc.).

**Table 1.1**

Definition of flows in logistics as objects of study

| Stream type | Characteristics of the object |
|---|---|
| Material | As an object material resources (raw materials, components, semi-finished products), work in progress, finished products, etc. act. |
| Informative | As an object certain completed communications in language, documentary (paper and / or electronic) and other forms intended for management decisions are considered. |
| Financial | As an object there are financial resources in cash or non-cash forms that ensure the effective functioning of the system and its components in terms of commodity-money relations. |
| Service | As the object is a certain set of intangible benefits that the client receives in accordance with their needs. |

*Source*: compiled by the authors based on scientific sources

The concept of material flows is key in logistics. Material flow - work in progress, finished products, which are considered in the process of applying to them various logistics operations (transportation, warehousing, etc.) and attributed to a certain period of time. The dimension of material flow is the ratio of the dimension of products (units, tons, $m^3$) to the dimension of the time interval (day, month, year). This flow can be calculated for specific areas of the enterprise, for the enterprise as a whole, for individual cargo operations. A material flow that is considered for a given moment or period of time becomes a material stock.

The parameters of material flow can be: nomenclature, range, quantity of products, dimensions, weight, physical and chemical characteristics of cargo, packaging characteristics, packaging, terms of sale, transportation and insurance, financial characteristics and more.

Table 1.2 shows one of the possible classifications of material flows for the purposes of logistics optimization.

**Table 1.2**

Classification of material flows

| Sign of classification | Type of material flow | Description of material flow |
|---|---|---|
| 1 | 2 | 3 |
| Relation to the logistics system and its parts | External | It consists of goods that are relevant to a particular enterprise, but move in an external environment for the enterprise |
| | Internal | It is formed as a result of performing a logistics operation with cargo within the logistics system |
| | Input | Coming into the logistics system from the external environment |
| | Weekend | Coming from the logistics system to the external environment |
| Quantity of cargo | Mass | Occurs when transporting goods by a group of vehicles, such as a railway train, a convoy of vehicles, a caravan of ships, etc. |

Continuation of the table. 1.2

| 1 | 2 | 3 |
|---|---|---|
| Quantity of cargo | Large | Occurs during the transportation of goods by several cars, cars, ships. |
| | Average | Intermediate between large and small material flows (transported by single cars, cars) |
| | Small | Occurs for transportation so many of cargoes which does not allow to use fully loading capacity of the vehicle and demands combination with other cargoes at transportation |
| Specific weight of cargo | Heavy | IN process of its transportation provides full use of loading capacity of vehicles at smaller occupied volume, for example, metals |
| | Lightweight | It is formed loads that do not allow full use of the carrying capacity of the vehicle with full use of its volume, such as tobacco products |
| Degree compatibility | Incompatible | Such material flows cannot be transported together, such as household chemicals and food |
| | Compatible | They can to be transported together on one vehicle |
| Consistence cargo | Bulk | Transported without containers in specialized vehicles: open cars, on platforms, in containers, in cars. |

Continuation of the table. 1.2

| 1 | 2 | 3 |
|---|---|---|
| Consistence cargo | Bulk | Their main property - flowability (eg grain) |
| | Bulk | Transported without containers, some may freeze, agglomerate, sinter (eg coal, sand, salt) |
| | Container-artificial | Cargo in bags, containers, boxes, without containers, which can be listed |
| | Bulk | Transportedin tanks and bulk carriers. Requires special technical means for reloading, storage and other logistics operations |
| Certainty | Deterministic | All the parameters are fully known |
| | Stochastic | Although b one parameter is unknown or is a random variable |
| Continuity | Continuous | Flows of raw materials in continuous production (technological) closed-loop processes, such as flows of petroleum products, gas, transported by pipeline. |
| | Discrete | Material flows that are not continuous |

Source: compiled by the authors based on scientific sources

However, we note that the material the flow is not able to follow withinlogistics systems in isolation, it is accompanied by flows of information, finance and service. Therefore, we give their classification (tables 1.3-1.5).

In addition to the material, information and financial types of flows for transport and logistics systems is very important service flow, which is the number of services provided over a period of time. Let's dwell on it in more detail.

**Table 1.3**

Classification of financial flows

| Sign of classification | Type of financial flow |
|---|---|
| Relation to the logistics system and its parts | Internal, external, input, output |
| Appointment | Due to the procurement process, investment, the reproduction of labor, the formation of material costs in the production process, due to the process of selling products |
| The method of transferring the advanced value of goods | Concomitant movements of fixed assets due to the movement of working capital |
| Type of economic relations | Horizontal, vertical, diagonal |
| Form of calculation | Cash (cash), information and financial (non-cash), accounting and financial (in the formation of material costs in the production process) |

*Source*: compiled by the authors based on scientific sources

The service means a special type of activity that meets public and personal needs (transport services, customs services, wholesale and retail, consulting, information, etc.). Services can be provided by people and equipment in the presence of customers and in their absence, be aimed at meeting personal needs or the needs of organizations. The need to introduce the concept of service flow is due to the growing importance and development of the service industry, and the concentration in it of a growing number of companies and individuals.

**Table1.4**

Classification of information flows

| Sign of classification | Type of information flow |
|---|---|
| Relation to the logistics system and its parts | Internal, external, input, output |
| Type of media | On paper, on magnetic media, optical, digital, electronic |
| Frequency of use | Regular, periodic, operational |
| Purpose of information | Directives (managerial), normative-reference, accounting-analytical, auxiliary |
| Degree of openness | Open, closed, secret |
| Method of data transmission | Courier, mail, telephone, telegraph, teletype, e-mail, fax, telecommunication networks |
| Information exchange mode | online, offline |
| Focus on material flow | In the direct direction with the material flow, in the opposite direction with the material flow |
| Synchrony with material flow | Ahead, simultaneous, following |

*Source*: compiled by the authors based on scientific sources

One of the many definitions of service flow is given in the work of the author's team under the leadership of V. I. Sergeeva "Service flow - the flow of services (intangible activities, special products or goods) generated by the logistics system as a whole or its subsystem (link, element) in order to satisfy external or internal consumers of the business organization"[27].

[27]Corporate logistics. 300 answers to questions from professionals / Ed. YOU. Sergeeva. M .: INFRA-M, 2004. 976.

**Table 1.5**

Classification of service flows

| Type of service flow | Service flow description |
|---|---|
| Pre-sale | Preparationmachines and equipment for sale; development of catalogs and price lists; preparation of technical documentation and operating instructions; provision of marketable products after transportation to the destination (unpacking, reconservation, installation, refueling, lubrication, adjustment, etc.); product demonstration; operation training. |
| After sales (in warranty and post-warranty periods) | Diagnosismachines and equipment; consultations on operation and repair; supply of spare parts; replacement of defective parts (assemblies) with new ones; provision of tools, equipment, consumables and accessories; providing repair facilities for customers who want to maintain their own machines or equipment; carrying out prevention of works according to the special schedule, etc. |

*Source*: compiled by the authors based on scientific sources

Together with you we note that in itself classification of flows contains the basis of their management, management of flow processes, able, using narrow industry terminology and techniques of formalization of relations, organizational and functional interactions between elements of the transport and logistics system, to identify the optimal way of further logistics transformations.

Within the framework of the general fundamental theory of logistics on the examples of real market practice, the mechanisms of economic flow management are considered, practically taking into account the development of methods for managing flow processes aimed at high-quality freight forwarding services. Given the versatility, dynamism and diversity of trajectories of related industries, there are different approaches to flow management, but the conceptual foundations of logistics tools characterize the management process in transport and logistics systems as a linear set of participants (units, system elements) performing transport functions. warehousing, cargo processing on the way of passage of goods from the manufacturer to the consignee.

Management of flow processes, from the point of view of VN Stakhanov and V. B. Ukrainian[28], is considered as a set of strategic and operational management. In them, the flow management scheme consists of such basic aspects as focus, design, management, planning, control and analysis.

A number of other scientific and applied research by domestic and foreign authors[29] is devoted to the issues of achieving stability of organizational and functional unity of flow processes in relation to their system optimization. In their opinion, the methodological significance of the formal adaptation of relationships within the transport and logistics system acquires a purposeful impact on the system as a whole. Accordingly, conducting an analysis, it is necessary to identify for which specific group of reasons the instability of the system. Formally creating an ideal model of organization and functioning of flow processes, it is possible, assuming the influence of unforeseen market factors, to impose it on the real one. Thus, the effectiveness of systems-analytical research is achieved, the points of intersection and overlap of flows are formed, the impact on which provides the maximum economic effect.

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[28]Stakhanov VN, Ukraintsev VB Theoretical foundations of logistics. Rostov n / D: Phoenix, 2001. 159.

[29]Larina RR, Pilyushenko VL, Amitan VN Logistics in the management of organizational and economic systems. Monograph. Donetsk: Ed. VIK, 2003. 239;

Ala-Risku T., Kärkkäinen M. Material delivery problems in construction projects: A possible solution, International Journal of Production Economics, Volume 104, Issue 1, 2006, 19-29 .;

Hausman W. Financial Flows & Supply Chain Efficiency / Visa Commercial Solutions. URL:http://www.visa-asia.com/ap/sea/commercial/corporates/includes/uploads/Supply_Chain_ Management_Visa.pdf;

Oliver K., Webber M. Supply chain management: logistics catches up with strategy. Logistics: the strategic issues / ed. by M. Christopher. London; New York: Chapman & Hall, 1982. 360.

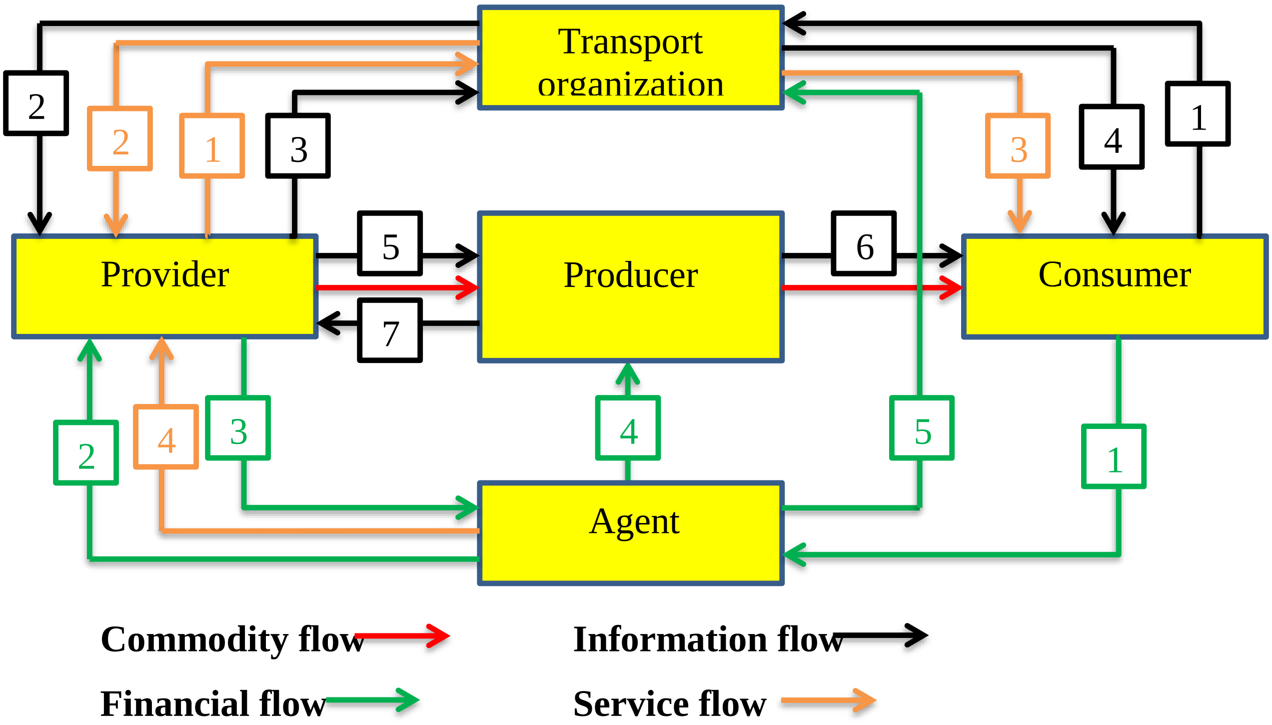


**Fig. 1.3** Scheme of crossing and overlapping flows in the transport and logistics system

Source: compiled by the authors

At the same time, the creation of any transport and logistics system should be directly combined with the organization of management, ie providing analysis and monitoring of the optimal combination of economic and scientific and applied efficiency. Stabilization of the existing transport and logistics system in its conceptual economic modeling, optimization of the combination of flow processes implies both in the theory of logistics and in real market practice the presence of certain reactions to changes in certain parameters or existing organizational and managerial influences.

Based on the principles of systematics, dynamism, complexity, integration of processes and managerial influences, logistics has the property of quantitative, qualitative and functional universality. As a method or technique of flow control, it provides the ability to pre-calculate the maximum quantitative indicators of the system at each level of its organization, which greatly simplifies and increases the efficiency of future operations. Methods of flow control are divided into three groups of principles.

1. Methodological principles, including strict coherence and interaction of all functional components of the flow control system to achieve this goal, as well as its stability, adaptability to changes in external factors, the ability to integrate with higher order systems, its continuous development.

2. Specific principles, which are based on the coordination and integration of all flow processes, the coordinated flow of flows in space time, computer support and modeling of the control system, as well as cost accounting of flow control processes.

3. Situational principles, which include the timely receipt of reliable information on the movement of flows, the accuracy of the planned cycles of procurement, production and marketing, strict compliance with the volume of orders and sales, as well as minimization of inventories.

It should be noted that the material flow, formed at the stage of production or operating in the distribution system, directly the final link of its path, always determines the sphere of consumption (figure 1.4).

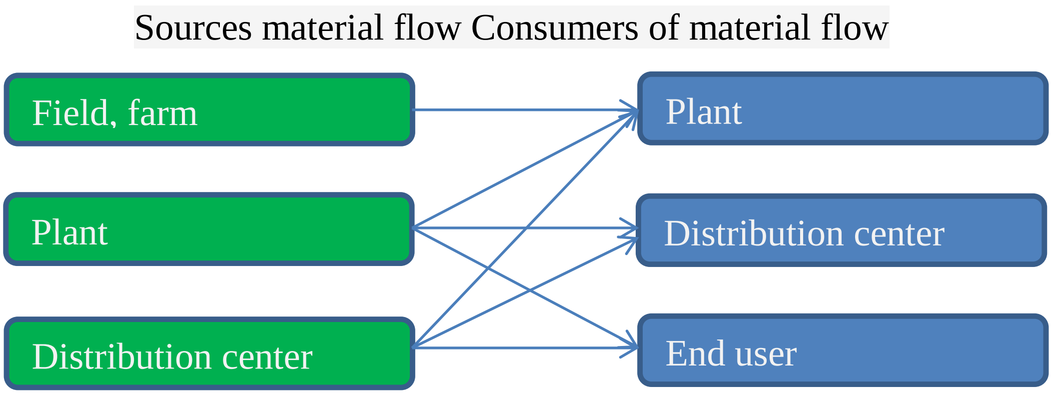


**Fig. 1.4** Options receipt of material flow into the consumption system

*Source*: compiled by the authors

The impact of a certain link on the flow can be extremely diverse: flows can be fragmented, branched, converge, change their content, parameters, intensity, and so on. According to these characteristics, we propose the following basic scheme of the sequence of links in the logistics chain:

1. Generators (sources) of material flows.

2. Transformation centers and points of trade, transport and other intermediary structures that convert material flows at the stage of purchase.

3. Transformation centers and points in places of production.

4. Transformation centers and points of physical distribution and dispatch of finished products.

5. Transformation centers and points of trade, transport and other intermediary structures that convert material flows on the way to supply finished products to consumers.

6. Destinations (consumers) of material flows.

Note that the division of the main links into generating, transforming and absorbing does not contradict the logistics approach and can be applied to transport and logistics systems. In this case, the elements of the logistics chain include suppliers, production units, intermediate, incoming and outgoing warehouses, transport companies, distribution networks and more. In the links of the logistics chain, in accordance with the course of the technological process of transformation of the input material flow into the output, logistic operations are consistently performed on the elements of the respective material and information flows.

The category of material flows, which contributes to the integration of individual elements of the movement of goods, establishing a relationship between them and providing end users with the necessary economic resources at the right time and in the right amount, is based on a system of principles that can be represented as a closed).

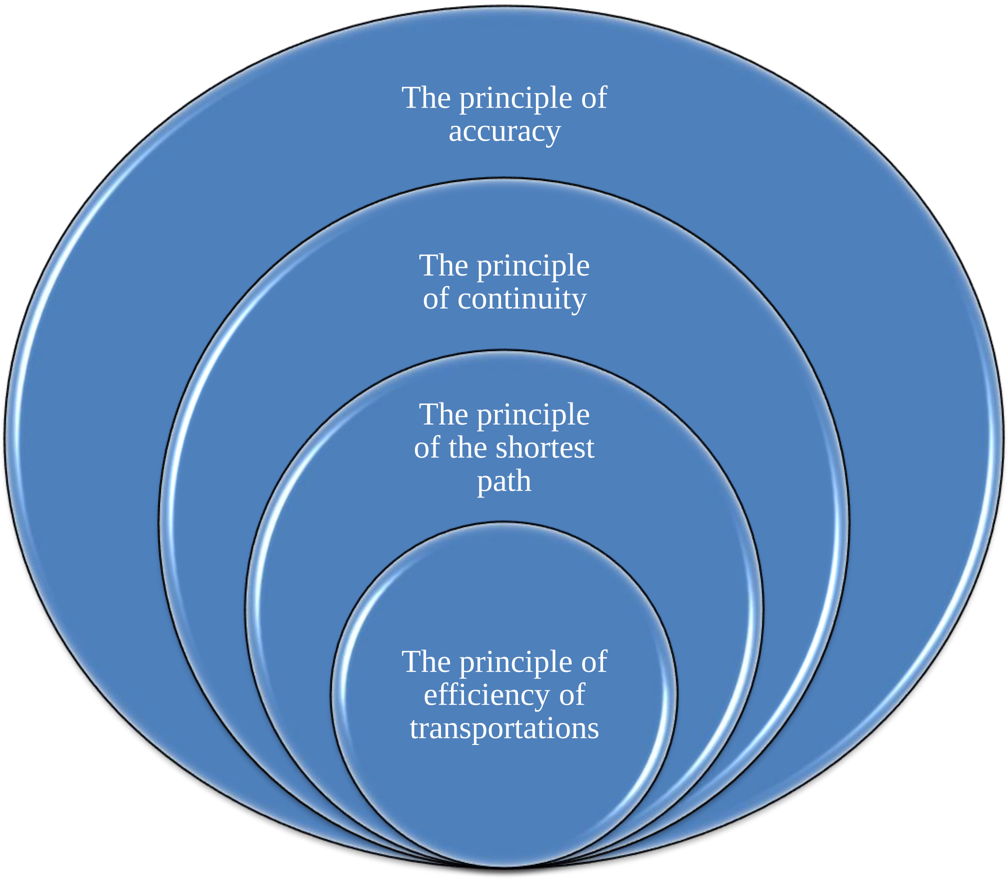


**Fig. 1.5** Principles of interconnection and movement of material flows

*Source*: compiled by the authors

The management of this subsystem, the need for which is the realization of material flows, inseparable from the activities of the commercial structure, is also carried out using four variables: temporal, spatial, quantitative and phase.

The effectiveness of management in this case can be determined by performing a number of management functions, which can be classified according to the following principle (figure 1.6).

To identify the material flow as an economic category should be traced its relationship with financial and information flows, which both at the stages of procurement and at the stage of implementation is manifested in the continuity of these processes, ie they are the basis for each other and mutual means of calculation. After all, pthe division of products by their functional purpose is an intermediate link between the production process and the consumption of material and technical resources.

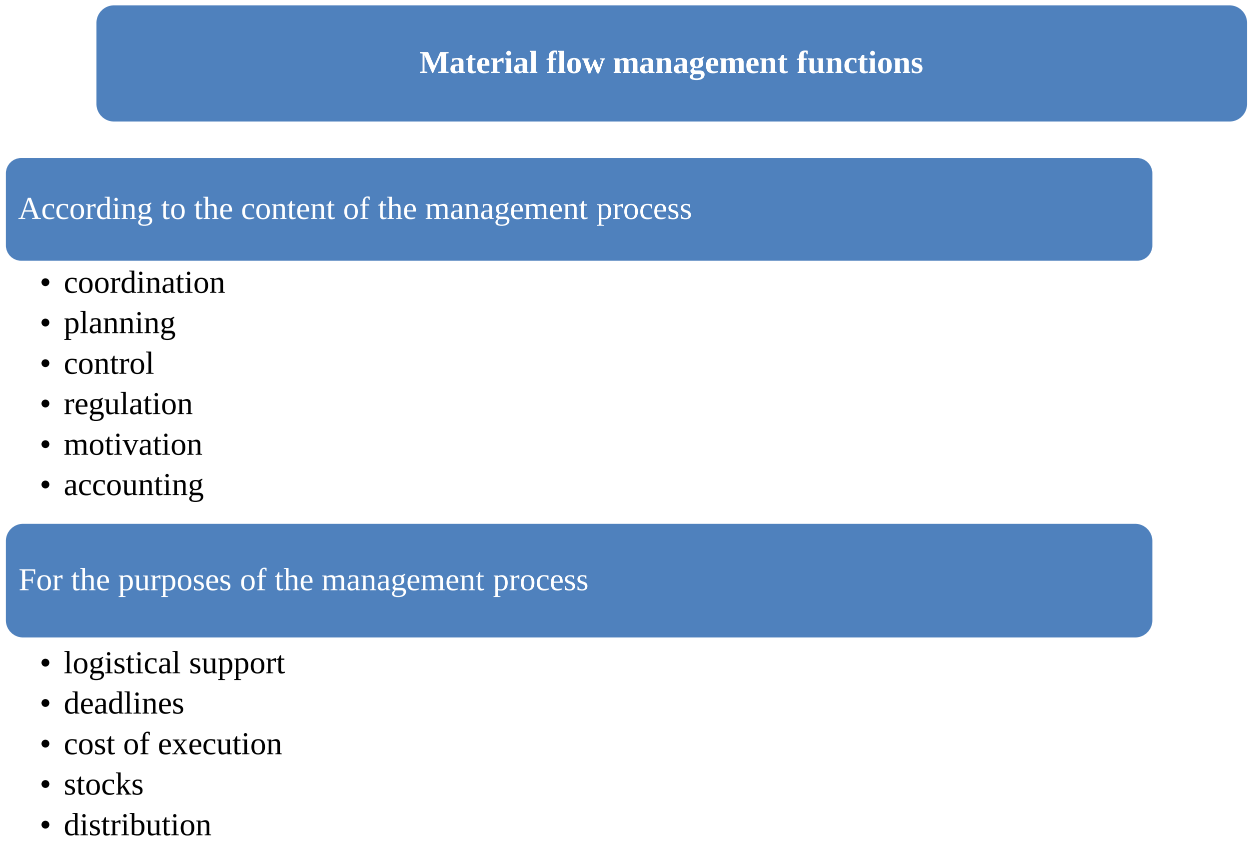


**Fig. 1.6** Schematic representation of the functions of material flow management

*Source*: compiled by the authors

However, regardless of its intermediate status, it is the distribution logistics that is responsible for the movement of material flow from the producer through intermediaries to the end customer. In today's business environment, the customer in the enterprise is defined as "the fundamental force that creates sales"[30].

[30]Christopher M. The Strategy of Customer Service. The Service Industries Journal. 1984. No. 3: Vol. 4. 205-213.

Therefore, in the logistics service of distribution channels should first take into account the degree of customer satisfaction with the order, which characterizes the concept of quality of logistics services. This is expressed in the proper execution of customer orders, ie in accordance with consumer standards, customer perceptions of the service and compliance with the terms of the contract. That is an important characteristic of the service flow is a given level of service.

The higher it is, the higher the satisfaction of the consumer, and with it the resulting total logistics costs. Ideally, as a result of the interaction of marketing and logistics, the optimal level of logistics service should be established, which is also called the cost / service balance [31]. The optimal level of logistics service means the level of service that ensures that the system achieves maximum profit, which is defined as the difference between revenue from product sales and total logistics costs.

The problem of finding the maximum profit can be solved using the appropriate optimization model. The conceptual model for determining the optimal level of logistics service in terms of profit maximization is presented in the work of NS Burmest[32]:

$$Pr\ (CS) = TR\ (CS) - (TC\ (CS) \rightarrow max \qquad (1.3)$$

where: Pr (CS) – level of logistics service (CS - customer service);

TR (CS) – function "revenue / level of service";

TC (CS) – cost / service level function.

Where it proposes to decide on the required level of logistics service based on the analysis of the elasticity of revenue and costs. However, a number of scientists note the difficulty of establishing reliable relationships between the

[31]Sergeev VI The problem of determining the balance of "costs / level of service" for the purposes of strategic logistics planning. Logistics and supply chain management. 2011. No 5 (46). 5-14.

[32]Burmistrova NS Influence of logistics service on the company's revenue. Logistics and supply chain management. 2013. No 5 (58). 60-68.

values of logistics service and the values of revenue and costs[33]. Therefore, R. Ballow offers a number of methods to determine the dependence of revenue on the level of service, which overcomes this limitation[34]. Solutions to similar problems are presented in the research results of a number of scientists[35]. In the models developed in them, the level of logistics service is expressed by the value of a single, sometimes integrated, indicator.

This circumstance complicates the development of a transparent service strategy for the logistics system. And since the logistics system has different characteristics, it seems appropriate to develop a model that takes into account the value of several indicators of logistics service, reflecting the main, according to the ideas of D.J. Bauersocks and D.J. Klossa[36], aspects of the logistics system, such as availability, functionality and reliability.

In the struggle for the consumer and reliable markets, the quality of service becomes an important and often decisive argument in determining the effectiveness of market activities of the enterprise. The most successful companies are those that not only "generate" customers, but also retain them due to the high level of service, which is due to the following reasons:

1. A loyal customer who is satisfied with the service can become a source of repeated (regular) orders.

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[33] Lukinsky VS, Shulzhenko TG Methods for determining the level of service in logistics systems. Logistics and supply chain management. 2011. No 1 (42). 70-86.

[34] Ballou RH Revenue estimation for logistics customer service offerings. International Journal of Logistics Management. 2006. No 1 (17). 21-37.

[35] Jeffery MM, Butler RJ, Malone LC Determining a cost-effective customer service level. Supply Chain Management: An International Journal. 2008. No 3 (13). 225-232.

Miranda PA, Garrido RA Inventory service-level optimization within distribution network design problem. International Journal of Production Economics. 2009. No 1 (122). 276-285.

[36] Bauersocks DD, Kloss DD Logistics: an integrated supply chain. Translated by NN Baryshnikova, BS Pinsker. - 2nd exit Moscow : CJSC "Olymp-Business", 2008. 640.

2. High cost of attracting a new customer - the cost of finding and incentives to order a new customer exceeds the cost of re-ordering a loyal customer in 6-7 times[37].

3. Higher profitability from working with regular customers, compared to new customers.

4. Efficiency of investment in customer service: up to 50% of customers would pay more for the best level of service.

5. Synergetic effect: the growth of loyal customers exceeds the amount of investment in customer service.

In a broad sense, the distribution of goods and services in today's macroeconomic and microeconomic changes can be characterized in terms of flexibility, globalization[38] and innovation.

Flexibility provides differentiated modes of operation of markets and customers based on value added. Production and distribution are not so much the activities of individual firms as the networks of suppliers and subcontractors. Transport and logistics systems operate on the basis of information, communication, cooperation and activities for the physical distribution of goods.

Globalization means that the spatial framework of the economy is expanded in the context of complex global economic integration and a developed network of global flows and hubs[39].

Innovation in the face of fierce market competition, when the concepts of price and quality of goods become relative, provides the company with real tools for analysis and optimization of sales processes.

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[37]Skok D. Startup Killer: the cost of customer acquisition. For Entrepreneurs 2013 URL:https://imh-holdings.com/wp-content/uploads/2013/01/Startup-Killer_-the-Cost-of-Customer-Acquisition-_-For-Entrepreneurs.pdf

[38]Dent D. All about distribution. lane with EnglishZakharov AVMoscow: Aquamarine. Book, 2011. 360.

[39]Zagurskiy O. Ohiienko M, Rogach S., Pokusa T., Rogovskii I., Titova L. Global supply chains in the context of a new model of economic growth // Conceptual bases and trends for development of social-economic processes. Monograph. Edited by Alona Ohiienko Tadeusz Pokusa Opole. The Academy of Management and Administration in Opole, 2019. 64-74.

The main goal of sales logistics is to reliably ensure the supply of goods needed by consumers in the right quantity and quality, in the right place and at the right time with optimal costs. Moreover, in the process of distribution, the supplier and consumer of products act as microsystems connected by a distribution channel and form the so-called logistics service system.

The latter is based on the organizational structure, in particular on the work of functional units of the enterprise involved in the process of order fulfillment and interaction with customers. Thus, the customer service department is directly responsible for the commercial department, marketing department, or logistics department. However, under modern conditions, a special role is played by the subsystem of after-sales service – staff or contractors responsible for service after the contract.

The components of the system also include suppliers, contractors and commercial partners: trade intermediaries directly involved in the distribution of goods, logistics intermediaries, as well as suppliers of goods and services needed to provide logistics services of the required level.

In practice, the final establishment of the structure of distribution channels is preceded by a long and painstaking process of planning and negotiations between the participants of the transport and logistics system.

In almost 100% of cases, the movement of goods (material flow) from producer to final consumer passes through a multilevel distribution channel. Typically, a typical distribution channel consists of: manufacturer – wholesaler (one or more) – retailer – consumer. Thus, high requirements for logistics services at each stage of the movement of goods contribute to the satisfaction of customer requests for a large number of channel levels (figure 1.7).

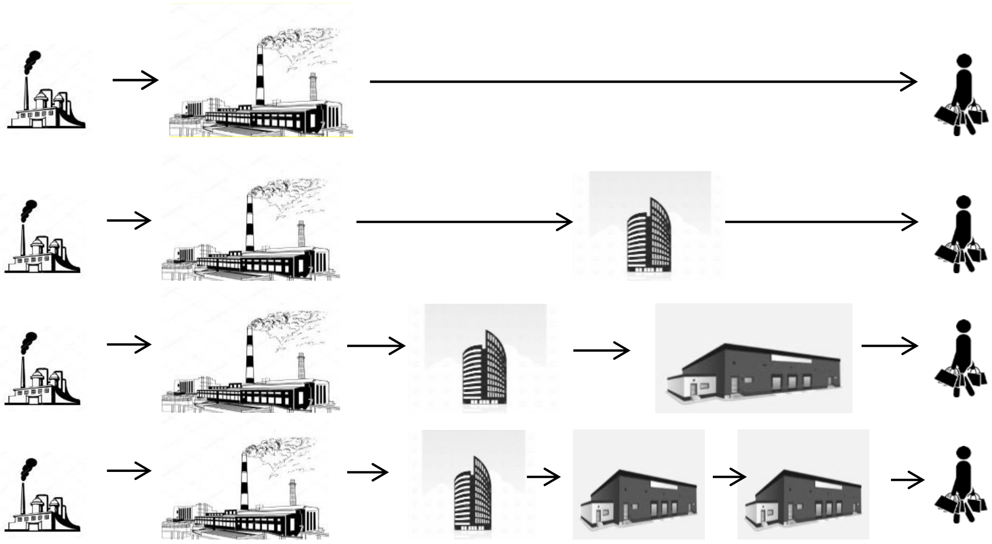

**Fig. 1.7** Types of distribution channels depending on the number of levels.
*Source*: compiled by the authors

Distribution channels of supply chains are divided into two types:

- direct sales channel – directly from the producer to the consumer;

- multilevel channel of indirect sales – from the producer through a number of intermediaries to the consumer.

In the case of indirect sales of products in the supply chain, intermediary organizations are formed between the focus company and consumers. They may include: distributors, dealers, commission agents, brokers (figure 1.8).

The main task for the focus company is that the participants of sales channels are clearly aware of their interdependence and build their activities on a partnership, which shows a willingness to eliminate significant individual differences and, most importantly, share information.

Partnership quality indicator – price. If, at the supplier's suggestion, the price of the goods is increased, the intermediary refuses to cooperate further, which means that the quality of the partnership is questionable. This is indicated by the opposite situation, when the supplier raises the price without prior agreement and consultation with partners. True partnerships require formal procedures to address and reconcile such issues.

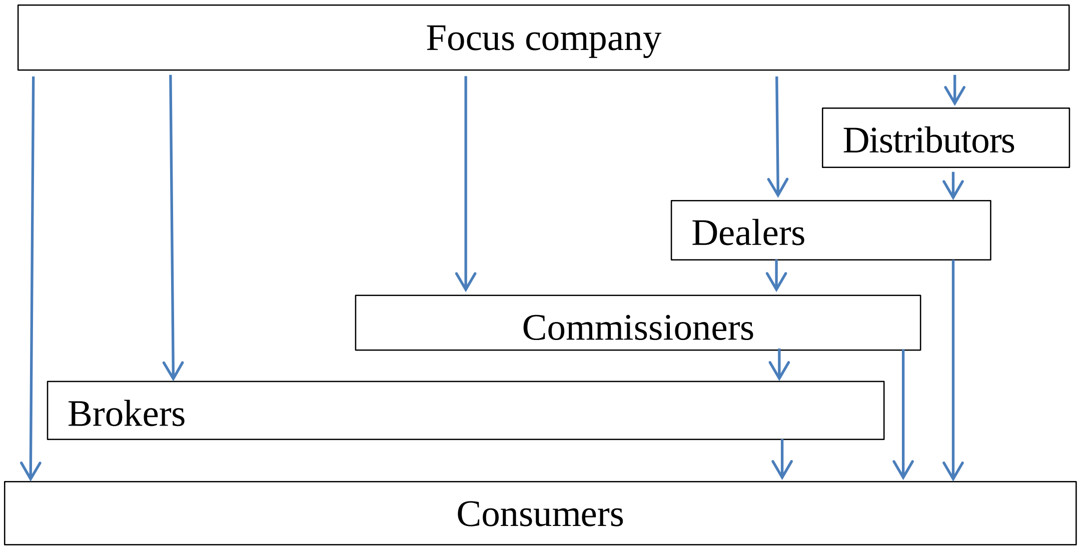


**Fig. 1.8** Scheme of formation of distribution channels of chains supplies.

*Source*: compiled by the authors

Regarding the logistics infrastructure of the enterprise as a whole, it is important to mention its "availability" for suppliers and buyers of goods in the distribution channel. In this context, a special place is given to warehousing and transportation of the enterprise, namely the supply system (centralized, decentralized, combined), mobility, efficiency of response to orders, the possibility of maximum order fulfillment. The chosen logistics technology, the level of optimization and automation of the logistics system and the qualification of the staff responsible for the functionality of logistics services also play an important role.

Note that the logistics infrastructure and the chosen logistics technology, in turn, depend on the characteristics and features of the proposed product:

- type of goods and their purpose (industrial or consumer – long-term or short-term use, food, etc.),

- its demand and method of purchase (goods of choice, goods of daily demand, goods of high demand).

The range of goods portfolio, brand policy, size of the supply lot, features of supplies, providing special conditions for transportation and storage also affect.

Accounting for these factors and features is implemented in the construction of the distribution system: the choice of sales region, the choice of distribution channels, the choice of intermediaries, their number. All this leaves its mark on the logistics operations associated with the material flow and, in turn, affects the formation and adaptation of the logistics service system in the supply chain.

### 1.3 Current trends in the development of transport and logistics systems

The latest stage of economic development, which experts call the "economy of interaction", or "competence economy", is directly associated with the spread of network structures and organizations. Improving their efficiency requires a new quality of interactions and management related to the integration of processes and organizations into a single whole.

Under such conditions, in research related to transport and logistics systems, analytical, technological and marketing paradigms are replaced by an integrated (logistics) paradigm, which goes beyond the problems of optimizing the business processes of individual enterprises and integrates individual enterprises into supply chains. thorough improvement of management processes and increase the overall efficiency of their business.

The main reference point for the development of modern transport and logistics systems is the integration of logistics with key elements of the management system: personnel, marketing, strategic vision and strategic development plans, finance, business processes.

The role of the integrated concept of transport and logistics system is not only to increase the efficiency of logistics activities at the level of enterprises-logistics centers, but also to intensify the processes of independent development of industries involved in providing services in transport logistics.

Among the main provisions of the integrated logistics concept are:

- transition to a single end-to-end flow as a space for the movement of tangible and intangible flows from the primary source to the final consumer;

- elimination or minimization of unnecessary information, financial and material flows in the end-to-end flow. For this purpose, the shipment of raw materials or finished products by the supplier is carried out in a predetermined volume and range, accompanied by information (documentation), including quantity, quality, legal characteristics of goods, etc.;

- minimization of the number of participants in the logistics chain. In this sense, the involvement of additional intermediaries between the consumer and the company, suppliers and the company requires economic justification, assessment of feasibility in terms of the cost of various resources of the company;

- the need to take into account the cost of time, labor and money to perform transport and logistics operations (loading, unloading, transport, warehousing and others) with material flows and their components from the primary supplier to the final consumer. It is also necessary to constantly identify and reduce the cost of labor-intensive work with cargo to minimize total logistics costs;

- use of modern universal logistics equipment capable of providing flexibility of production, flexibility of transport and logistics operations;

- ensuring the required level of service quality;

- prompt response of participants in the logistics chain to changes in consumer demand for raw materials, material and technical resources and finished products;

- ability to adapt integrated logistics to significant fluctuations in demand;

- joint responsibility of participants in logistics chains for the preservation of raw materials, semi-finished products, finished products, containers and packaging;

- involvement of specialists of different qualifications in the logistics processing of material and information flows;

- the need to create databases that include a complete set of information and information about manufacturers, carriers, intermediaries, consumers, all components of the material flow, range, quality, legal characteristics and hazards of goods transported to the environment.

Accordingly, the competitive advantages of logistics services, based only on price and consumer properties, in the context of globalization lose their leading importance, in the first place are flexibility, limited lead time, reliable and quality supplies, choice, and more.

From the producer market, the economy moves to the consumer market, where the ability of the producer to combine individual purchasing advantages with flexible production and a system of rapid delivery of goods becomes a decisive factor in competition. In the context of globalization, effective management of logistics and trade flows have become a central part of the competitiveness of almost any company that plans to work internationally. And the global trend of logistics of the modern economy is the rule "7R" whose main slogan is: the right product (Right product) of the required quality (Right quality) in the required quantity (Right quantity) must be delivered at the right time (Right time) and in the right place (Right place) to the right consumer (Right customer) with the required level of costs (Right cost)[40].

Failure to meet at least one of the seven conditions of R may result in loss of customers and, consequently, market share. In other words, in addition to its

[40] Bielecki M., Galinska V. Total logistics management concept and principles in manufacturing enterprise. Business Logistics in Modern Management, 2017, vol. 17, 93-107.

quality and price, the organization of fast deliveries is added to the factors that determine the competitiveness of a product, and this often becomes more important than the price. Only in compliance with these 7 rules provides a reduction in inventories and working capital, reduce lead time, increase production flexibility, accelerate capital turnover. As a result, improving the quality of supply leads to lower production costs – a decisive competitive advantage in market conditions.

Another global trend is the strengthening of environmental requirements or sustainable environmental logistics. The logistics industry is not only responsible for ensuring that the right product reaches the right place at the right time. It is also responsible for the impact of its processes on the environment. Therefore, every year in most developed countries, the environmental requirements for existing logistics systems of enterprises are increasing. Prohibitions on the use of vehicles that pollute the environment, create high noise levels, are not equipped with special systems that reduce the danger of movement and maneuver.

In recent years, environmental requirements for product packaging have risen sharply in the EU. Their purpose is to prevent pollution of the environment by used containers and substances released during its elimination, especially by incineration. For example, Deutsche Post DHL (DPDHL), a leading German logistics company, has identified the initiative as "on the road to green logistics"[41], highlighted the most anticipated in the future trends:

- logistics is not only the main catalyst for global trade and a key component in creating value – it is also a strategically important business in the transition to a low-carbon economy;

- technological change will be achieved as a result of certain actions of companies, financial institutions and governments. Given the high cost of new

[41] DHL Envirosolution (2017). DHL environmental solutions-Envirosolutions. DHL Group. URL. https://www.dpdhl.com/en/sustainability/environment-and-solutions.html

technologies, mutual support and long-term planning by all key players is important;

- cooperation will be seen to a greater extent as a factor that contributes to the achievement of environmental friendliness. Even former competitors will work more closely together. As reducing carbon emissions becomes a priority for suppliers, business customers and logistics companies, joint business models will expand both vertically and horizontally throughout the supply chain;

- business models of logistics companies will change as environmental innovations open up new opportunities;

- $CO_2$ labeling will become standardized. $CO_2$ labels will allow customers to identify "green" products. Transparency will help increase trust among logistics customers and end users in climate-friendly decisions;

- carbon emissions will come at a price. As carbon reduction is becoming increasingly important for companies, governments and consumers, this point will play a significant role in the business decision-making process;

- carrying out the cost of carbon emissions will lead to tighter measures to regulate them. Companies will accept such additional costs only if the government provides a level playing field for all business participants.

Today, much attention is paid to "green" fuel, as well as engineering developments that will help increase load capacity and reduce fuel consumption, such as increasing the length of the trailer or improving aerodynamics. The installation of solar panels on the roofs of the bodies is also being discussed.

An important modern global trend in the development of transport and logistics systems is the growing share of direct express deliveries from producer to consumer, bypassing intermediaries and intermediate storage. Direct delivery saves money by reducing inventory costs and costs in the supply chain, reducing lead times, helping consumers access a wide range directly from the manufacturer. Multinational express delivery companies such as FedEx, UPS, DHL, deliver small consignments to anywhere in the world in the shortest possible time.

The next trend in some ways contradicts the previous one and is more related to modern international logistics – the growth of outsourcing of transport and logistics services. It is associated with increasing the role of logistics intermediaries, which take responsibility for most of the operations related to the organization and management of the company's international logistics supply chains. Depending on the degree of involvement, such logistics operators 2PL (Second Party Logistics), 3PL (Third Party Logistics) and 4 PL (Fourth Party Logistics) are in growing demand for logistics services. They are most in demand in high technology (16%), industrial production (13%) and food production (13%), and the leaders in the use of 3PL-outsourcing are North America (29%) and Europe (27%).

The complexity of transport and logistics systems, increasing their dynamism, increasing the frequency of orders over time and reducing their volume determines the emergence of such a trend as multi-channel[42]. In the current conditions, the content of the consumer choice model is changing qualitatively, e-commerce stores are becoming more and more widespread, which puts forward new requirements for the logistics tools used. In this regard, there are a number of problematic issues related to determining the market mechanics of further development of the logistics market, the dynamics of consolidation of its operators, the accuracy of which will be measured by the resulting factors determining modern institutional and technological development of logistics business.

Therefore, the most important trend of modern times in transport and logistics systems is the rapid use of new technologies (especially information). Their implementation forces the evolution of not only logistics principles and

[42]Multichannel logistics. Amazon's answer. URL. http://www.oliverwyman.com/content/dam/oliverwyman/ europe/ru/files/Omnichannel%20logistics_Web_Russian.pdf

methods, but also the institutional environment of transport and logistics systems. The methodology of institutionalism is characterized by the so-called dichotomization, ie the separation from the system of social production of two more or less independent subjects of study that interact closely with each other. One of the subjects – "technology" – the achieved level of scientific and technical knowledge and intellectual experience embodied in the production of tools and machines, qualifications of manufacturers and management of production, services. The second "institution" – a real form of organization of behavior and motivation of economic agents that have developed in a particular society.

Based on this, institutionalists see the reason for all the contradictions of capitalism in the inconsistency of the institutional environment with the level and needs of the development of "technology". Thus, according to experts of the World Economic Forum, economic growth in innovation-active countries by 50% depends on the development of technology, 25% – on the efficiency of public institutions and 25% – on the quality of the microeconomic environment, which can also be considered an institutional structure.

In logistics markets, the institutional environment has transformed, moving towards a reconciliation between planned top-down approaches and private sector market development. In addition, encouraging public-private consortia has potentially facilitated the development of national corridors that can support new markets, while benefiting from both public and private benefits[43].

Institutional changes in the logistics market related to the processes of globalization and informatization of the economy and society have led to the fact that the main emphasis in the management of goods management today is on networks: IT technologies and multi-channel sales system. And if in the

[43]Monios J., Lambert B. The Heartland Intermodal Corridor: public private partnerships and the transformation of institutional settings, Journal of Transport Geography, 2013, Volume 27, p. 45.

traditional system of building a wholesale and retail link with thousands of products in the product matrix, hundreds of suppliers are unable to provide them with accurate information about consumer demand. That is, the structure of product supply is formed by intermediaries and it does not always coincide with real demand, and the existing deviation is offset by expanding marketing budgets, which are then transferred to the shoulders of buyers (laid in the price of goods). In the multi-channel (network) sales system, the product range is formed by the consumer and is close to the absolute maximum. The Internet makes any product offer equally accessible, regardless of its territorial origin. A new, more accessible and developed feedback with the consumer is being formed, the presence of which fundamentally changes the entire management system of the retail chain.

The multi-channel (network) sales system forms a completely new institutional environment. It opens up opportunities for consumer market participants that go beyond "the potential of today's best practices"[44]. At the heart of these capabilities is the virtualization of the market, where there are no distances or restrictions on the volume and speed of information processing, while management algorithms are unified and automated.

Moreover, this approach changes the very essence of supply chains. - the "need for a reliable central organization (focus company) that supports the entire system and coordinates and controls the continuous supply chain and transactions from raw materials to consumers" disappears[45]. After all, the powers and responsibilities in modern logistics systems are differentiated and distributed according to how the information flows themselves are distributed. Marketing and product policy remain in the management of producers, and sales

[44]Bauersocks D., Kloss D. Logistics: integrated supply chain; lane with English M . Olimp-Biznes, 2001. s. 539

[45] Zagurskiy O., Titova L. Problems and Prospects of Blockchain Technology Usage in Supply Chains. Journal of Automation and Information Sciences, 2019. Volume 11. pp. 71.

organization is implemented by external market operators who develop relevant competencies, technologies, infrastructure, etc.

Such fragmentation is also manifested in the system of virtual commerce, when some companies take out online stores for logistics outsourcing, leaving them only trade policy and marketing. Under such conditions, I thinkG. Bubnova, B. Levin "loses the relevance of the generally accepted in the theory of logistics economic criterion" minimum cost ", and comes to the fore" maximum economic effect, benefits, values"[46]. Therefore, for most small and medium-sized companies it is much easier to quickly and most importantly cost-effective to hire external freight forwarding companies, because this option eliminates unforeseen and additional costs, pays for actual trips, with a number of additional options for customers.

It should be noted that the vast majority of ways to solve problems of optimization of processes related to traffic management and material flows, belong to the field of virtual and digital logistics. Digital logistics in the era of globalization is not just tracking material and information flows based on the structure of the transport company. It is an integrated information system with a complex structure with control elements for real-time tracking and management, as well as simulation and virtualization of possible combinations of transport and logistics resources and tools based on intelligent and digital technologies.

Digital logistics provides the ability to manage the logistics process in real time with the optimal allocation of transport resources and rational allocation of available opportunities. In addition, digital logistics can effectively and comprehensively complement the concepts of virtual or digital economy, Internet business and e-commerce.

[46] Bubnova GV, Levin BA Digital logistics - an innovative mechanism for the development and efficient operation of transport and logistics systems and complexes // International Journal of Open Information Technologies. 2017, Vol. 5, № 3, p. 74.

Analysis of the development of intelligent information technologies in the field of organization and management of processes in the transport expedition[47] confirmed the absence or inadequate quality of intelligent models and mechanisms for planning transport, forwarding and intermediary functions and operations in transport and logistics systems.

To solve the problems of modern logistics, new business models of digital systems are needed, in which people will lose the functions of regulation, leaving only the ability to control their work. After creating and implementing a new business model of digital expedition, it will be able to successfully combine the classic functions of "offline" expedition and modern "online" technology. New business models based on digital technologies and focused on creating solutions and services with added value, in addition to reducing costs, lead to digital transformations in the transport industry, and ultimately to the full digitalization of its processes and service delivery methods.

The main task of the business model of modern logistics is not to use long-distance trains (trains), but the fastest method and cheapest way to deliver goods in the shortest possible time, with minimal costs and risks. Digital management of transport and logistics systems is a next-generation model that successfully combines automation with quality logistics service. It can be argued that over the next few years, the digital logistics chain will become the dominant business model, which will not only benefit businesses in terms of functionality,

[47] Dewan KK, Ahmad I. Carpooling: A Step To Reduce Congestion (A Case Study of Delhi) International MultiConference of Engineers & Computer Scientists. Newswood Limited, 2006. 408-413.

Jarašūnienė A, Batarlienė N., Vaičiūtė K. Application and Management of Information Technologies in Multimodal Transportation, Procedia Engineering, Volume 134, 2016, 309-315.

Shen L., Stopher P. Review of GPS Travel Survey and GPS DataProcessing Methods. Transport Reviews: A Transnational Transdisciplinary Journal. 2014. Vol. 34. No. 3. 316-334.

Schneider SA Concurrent and Real-Time Systems (the CSP Approach). Worldwide Series in Computer Science. Wiley, 2000. 507.

Stranner T., Ummenhofer P., Abl A. ETC-Based Traffic Telematics. Utilizing Electronic Toll Collection Systems as a Basis for Traffic Data Generation. Springer-Verlag Berlin Heidelberg 2010. 71-81 but also give them full predictability of trends and movements of goods from supplier to consumer.

However, it should be noted that the demand for modern business model of transport and logistics system depends not only on speed and flexibility, but also on the ability to monitor the quality of supply. With smartphones or tablets, consumers can track the shipment of goods from any place until it reaches its final destination. This form of service is very useful for consumers, providing them with accurate information about the delivery time of their goods. Until the 21st century, online payments were almost non-existent, and today e-commerce is the driving force behind sales. Therefore, ensuring the proper set and level of efforts and measures to carry out technological operations can be controlled more accurately with the use of modern information technology.

If you consider the process of production of services for the transportation of goods in terms of classical economic production function:

$$y = f(e) + \varepsilon \tag{1.4}$$

where: y – the level of transport services (expressed in the relevant units, for example, tonne-kilometers);

e – the level of effort to carry out the relevant technological operations;

*f* – production function, which is responsible for the causal link between the effort expended and the amount of services produced;

$\varepsilon$ – random component, which describes the impact on the transportation process of factors, accounting for which is either impossible or too costly for the optimal organization of the transport process.

Then you can track the overallfunctional dependence of the level of services on the level of effort expended. Among the usual characteristics of such dependence should be mentioned the growth of the function *f* (the level of freight forwarding services increases with increasing effort to provide them), while the growth slows down with increasing effort. Presumably, the influence of random factors, regardless of the effort expended, is distributed around zero, more precisely, "0" is the median of the distribution $\varepsilon$.

Thanin this case, the introduction of information technology can help? It is likely that information technology will be able to obtain, store and process other signals that carry relevant information about the effort expended. In other words, the introduction of information technology may mean the addition of additional observable values (more detailed data on how the transport process takes place).

Such dataprovide an opportunity to control all stages of the movement of goods, components and raw materials, which allows you to clearly and timely identify problem areas that lead to inefficiencies in existing schemes for managing cargo flows. In turn, the obtained data provide the necessary information and requirements for the development of new, more efficient ways of organizing and managing traffic flows.

In order to properly understand the basis of digitalization of transport processes requires a proper understanding of the properties and parameters of intelligent transport systems (ITS). Problems in understanding the process of operation and management of ITS depend on the tasks of automation, determining the role of digitalization and intellectualization in the management of transport systems. It should also be noted that not enough mistakes have been made in the creation of ITS, as the field of research is still actively developing, so the number of examples of successful implementation is not significant enough. Intelligent transport systems are formed on the border of intelligent information technologies and transport industry, and include modeling of transport flows, information systems, traffic control systems.

Understanding the essence of intelligent transport systems determines the key objectives for their development and implementation, which include:

- providing greater information and traffic safety;

- creation and provision of a fundamentally new level of digital intellectual interaction of all road users.

In order to to realize the goals set before ITS, ie to increase security, information and availability of transport and logistics support and synchronize the interaction of different modes of transport, it is necessary to conduct a functional decomposition, based on which you can move to the goals in the form of functional features of ITS.

At the same time, increasing demands on last mile logistics, permanent strengthening of industry supply standards (eg those related to consignment management, electronic data exchange with customers, packaging, etc.) stimulate closer cooperation between market participants and logistics providers, which is also accompanied by changes and replacements. their roles and functions.

Thus, the modern decentralized and autonomous organization of intelligent logistics facilities in service-oriented environments involves the storage of logistics information on RFID-tags, which are attached to the transported goods. This means that all the necessary information for logistics decisions is directly next to the product. Accordingly, the logistics facilities themselves have to choose the routes through the transport networks.

In addition, processes, methods and tools for managing them are also evolving within supply chains. There is a growing popularity of collaborative platforms that connect multiple buyers and suppliers with financial institutions, enabling them to conduct automated supply chain financing operations.

Thus, there is a replacement of utilitarian interpretation of logistics efficiency by minimizing the cost of increasing the usefulness of supply processes and greater customer satisfaction, which is associated with the breadth of changes affecting the technological level (new technologies of observation and control, new methods of supply and payment), and the institutional level (new models of consumer behavior, innovative business models that include elements of the sharing economy), new requirements for institutional intermediaries).

These changes are confirmed by Global Logistics Efficiency Rating (LPI 2018), which is based on a global survey of operators (global freight forwarders and express carriers) and combines in-depth knowledge of the countries in which they operate with qualitative assessments of other countries in which they trade and experience global logistics environment (table 1.6).

**Table 1.6**

World Bank Logistics Performance Index (LPI) rating in 2018

| № | Country | LPI Rank | LPI Score | Customs | | Infrastru-cture | | International shipments | | Logistics competence | | Tracking & tracing | | Timeliness | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Germany | 1 | 4.2 | 1 | 4.09 | 1 | 4.37 | 4 | 3.86 | 1 | 4.31 | 2 | 4.24 | 3 | 4.39 |
| 2 | Sweden | 2 | 4.05 | 2 | 4.05 | 3 | 4.24 | 2 | 3.92 | 10 | 3.98 | 17 | 3.88 | 7 | 4.28 |
| 3 | Belgium | 3 | 4.04 | 14 | 3.66 | 14 | 3.98 | 1 | 3.99 | 2 | 4.13 | 9 | 4.05 | 1 | 4.41 |
| 4 | Austria | 4 | 4.03 | 12 | 3.71 | 5 | 4.18 | 3 | 3.88 | 6 | 4.08 | 7 | 4.09 | 12 | 4.25 |
| 5 | Japan | 5 | 4.03 | 3 | 3.99 | 2 | 4.25 | 14 | 3.59 | 4 | 4.09 | 10 | 4.05 | 10 | 4.25 |
| 6 | Netherlands | 6 | 4.02 | 5 | 3.92 | 4 | 4.21 | 11 | 3.68 | 5 | 4.09 | 11 | 4.02 | 11 | 4.25 |
| 7 | Singapore | 7 | 4 | 6 | 3.89 | 6 | 4.06 | 15 | 3.58 | 3 | 4.1 | 8 | 4.08 | 6 | 4.32 |
| 8 | Denmark | 8 | 3.99 | 4 | 3.92 | 17 | 3.96 | 19 | 3.53 | 9 | 4.01 | 3 | 4.18 | 2 | 4.41 |
| 9 | United Kingdom | 9 | 3.99 | 11 | 3.77 | 8 | 4.03 | 13 | 3.67 | 7 | 4.05 | 4 | 4.11 | 5 | 4.33 |
| 10 | United Arab Emirates | 11 | 3.96 | 15 | 3.63 | 10 | 4.02 | 5 | 3.85 | 13 | 3.92 | 13 | 3.96 | 4 | 4.38 |
| | …… | | | | | | | | | | | | | | |
| 28 | Poland | 28 | 3.54 | 33 | 3.25 | 35 | 3.21 | 12 | 3.68 | 29 | 3.58 | 31 | 3.51 | 23 | 3.95 |
| 65 | Serbia | 65 | 2.84 | 78 | 2.6 | 74 | 2.6 | 57 | 2.97 | 80 | 2.7 | 76 | 2.79 | 62 | 3.33 |
| 66 | Ukraine | 66 | 2.83 | 89 | 2.49 | 119 | 2.22 | 68 | 2.83 | 61 | 2.84 | 52 | 3.11 | 56 | 3.42 |
| 67 | Egypt | 67 | 2.82 | 77 | 2.6 | 58 | 2.82 | 73 | 2.79 | 63 | 2.82 | 89 | 2.72 | 74 | 3.19 |
| | ….. | | | | | | | | | | | | | | |
| 160 | Afghanistan | 160 | 1.95 | 158 | 1.73 | 158 | 1.81 | 152 | 2.1 | 158 | 1.92 | 159 | 1.7 | 153 | 2.38 |

*Source:* Global Rankings 2018URL.https://lpi.worldbank.org/international/global

The first places in this ranking are traditionally occupied by technologically developed and institutionally stable countries of the European Union (Germany, Sweden, Belgium, Austria, the Netherlands, Great Britain), Asian countries (Japan, Singapore), UAE and USA. As for Poland, it has traditionally been at the top of the rankings for recent years and ranks 28th with 3.54 points. Ukraine scored 2.83 points, ranked 66th among 160 countries in the world (among post-Soviet countries 3 after Estonia (3.31 points and 36th place) and Lithuania (3.02 points and 54th place)) rising to 14 positions compared to the previous ranking in 2016.

If you look in detail at the Global Ranking of Logistics Efficiencyof the 6 criteria according to which the research was conducted – 3 contain technological features: international transportation of goods; cargo tracking; timeliness of delivery, and three institutional: customs procedures; infrastructure; logistical competence.

Moreover, the institutional environment, in our opinion, affects competitiveness and economic growth through the formation of individual and organizational incentives in logistics markets. These incentives initiate the processes of resource accumulation and modernization, development and dissemination of technologies; allocation, use and coordination of resources; interaction of buyers and sellers and internationalization of logistics activities.

T. Hamalainen in the work "National competitiveness and economic growth: the changing determinants of economic performance in the world economy" identifies five factors that have a decisive impact on economic growth through the process of technological innovation, four of these factors depend on existing institutional structures:

- market potential of innovation may be limited by institutional frameworks, such as monopoly rights, technological standards, tariffs and quotas, national differences in the regimes of regulation of specific sectors of the economy;

- the level of competition among producers directly affects the practical application of innovations, therefore, an important institutional factor in economic development is the predominant regime of antitrust regulation and competition;

- the regime of "guaranteeing" property rights (practical application) is an important factor in stimulating innovation;

- The institutional environment also influences the dissemination of new technologies[48].

Thus, institutional changes contribute to the development of new technologies in the logistics sector and the digital transformation of supply chains in the consumer market, which involves a number of important changes, namely:

- change of processes of commodity-sales cooperation in supply chains of multichannel trade;

- change of approaches and models of formation of commodity supply of the modern consumer market;

- end-to-end change of all elements of the supply chain (CRM, ERP, WMS, TMS), Through the development of solutions in SaaS format, which allow to deploy new functionality based on the expertise that is formed with each new customer;

- expanding the intersection of logistics and marketing in multi-channel supply chains.

Examining trends and innovations in the field of logistics and supply chains in 2020, Transmetrics analysts identified 10 TOP-10 important innovative logistics trends of today and sorted them by importance.

1. Internet of Things (Fleet Management, Real-Time Supply Chain Visibility) – 17%.

2. Artificial Intelligence (Demand Forecasting, Process Optimization) – 14%.

[48] Hamalainen TJ National Competitiveness and Economic Growth: The Changing Determinants of Economic Performance in the World Economy: Edward Elgar Publishing, Cheltenham, UK, 2003, 380.

3. Robotics (Collaborative Robots Cobots work collaboratively with human workers, Robotic Process Automation) – 11%.

4. Last-Mile Delivery (Drones, Smart Lockers) – 11%.

5. Warehouse Automation (Automated Guided Vehicles, Automated Storage & Retrieval System) – 11%.

6. Blockchain (Smart Contracts, Freight Tracking) – 10%.

7. Big Data & Data Analytics (Performance Management, Prescriptive Analytics) – 9%.

8. Cloud Computing (Cloud Platform, Cloud TMS) – 8%.

9. Autonomous Vehicles (Autonomous Vehicle Fleet, Autonomous Vehicle Software) – 5%.

10. Elastic Logistics (On-Demand Warehousing, On-Demand Delivery Vehicles) – 4%.

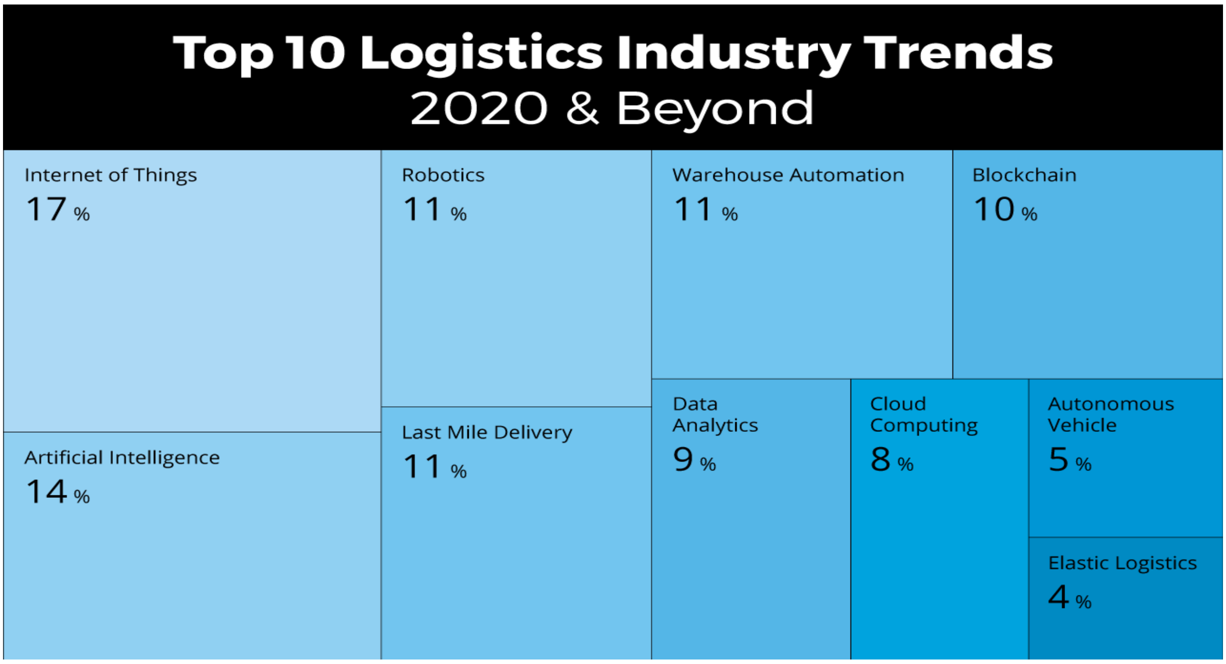


**Fig. 1.9** Top 10 Logistics Industry Trends & Innovations: 2020 & Beyond

*Source:* Transmetrics. URL. https://www.startus-insights.com/innovators-guide/logistics-industry-trends-10-innovations-that-will-impact-logistics-companies-in-2020-beyond

What does it mean? With customer expectations growing and interests shifting to a variety of products and personalized services, the logistics and supply chain sectors are facing increasing pressure. Rapid progress in the development of new technologies, such as the Internet of Things, modern mobile robots, artificial intelligence solutions and blockchain solutions, leaves companies facing a dilemma in choosing the most attractive technologies for investment.

Thus, the development of new technologies encourages changes in corporate governance strategies and patterns of consumer behavior, and the dominant type of institutional arrangements imposes certain restrictions on identifying needs, preferences and choice of agents, thereby stimulating the development of even more modern technologies.

Companies that use modern technologies in transport and logistics systems receive optimal solutions, namely: minimization of total logistics costs, reduction of all types of costs associated with material flow management, transportation costs, warehousing, order management, procurement and inventory, packaging, reducing logistics risks. The funds saved in this way allow companies to make additional investments in new production technologies and equipment to improve the efficiency of logistics activities.

However, current trends in logistics systems are also associated with "green" technologies, so the organization and management of transport processes is combined with the management of quality control of products supplied. The main factors influencing the transport process, and thus the cost of production, are time, quality and price. Three constituent factors that are interdependent. Information technologies are used for their control and forecasting (figure 1.10).

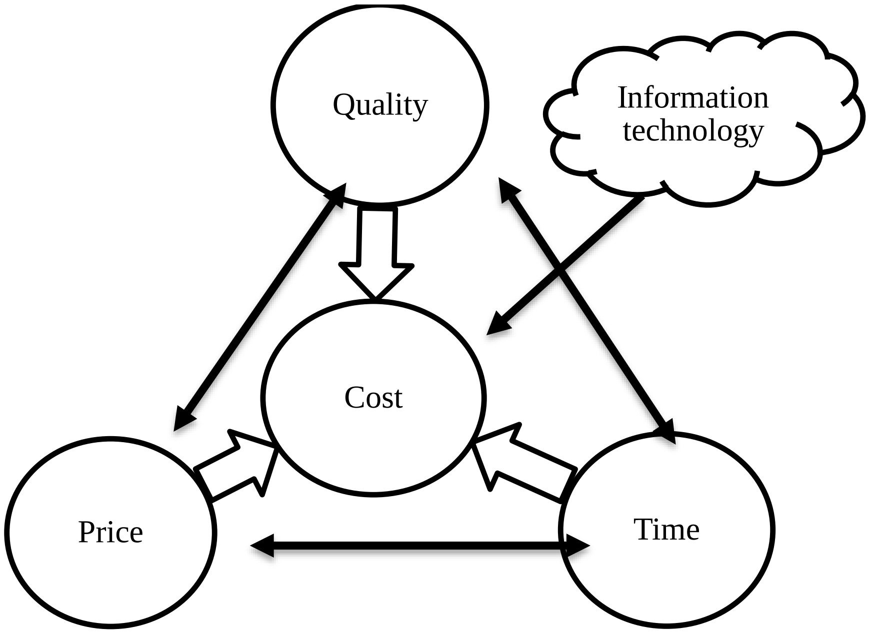


**Fig. 1.10** Cross-sectional model of the main factors of the transport process

*Source:* compiled by the authors

Effective traffic management involves solving two key tasks: the calculation of optimal routes and control of routes. Making a route manually requires a lot of time and knowledge of the area from the logistician, so this process can and should be automated. When using specialized programs, the formation of routes requires a few minutes and does not require special skills due to the intuitive interface of the program and the convenience of calculations. Here are the characteristics of some modern technologies of transport enterprise management.

Logistics technologies (systems of planning of routes of intra-city delivery; technology of management and modeling of logistic business processes) – combine possibilities of electronic cartography and databases. They are used to automatically select the optimal routes for delivery of goods and solve various transport problems (figure 1.11).

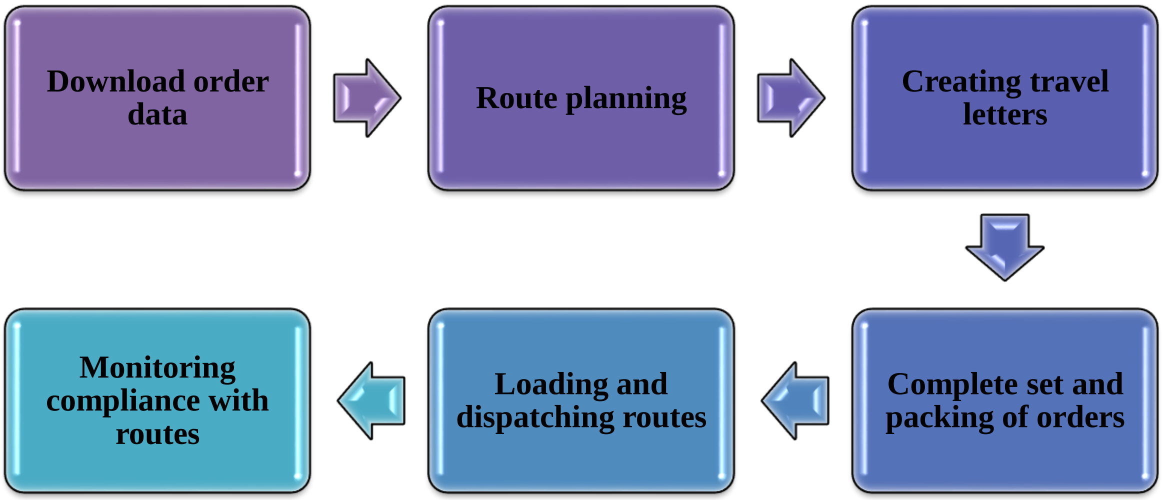


**Fig. 1.11** Supply route planning system

*Source:* compiled by the authors

Software and hardware systems for GPS-monitoring of the condition and location of vehicles. These are systems of tracking, communication and dispatching of transport on the basis of satellite navigation and communication systems that provide reliable two-way communication between individual structural units - the control center and distribution centers, stationary points and rolling stock.

The introduction of these technologies in the transportation process allows you to track and speed up transportation, control the location of cargo during transportation to avoid possible loss or delay. The use of this technology allows you to continuously obtain information about the time and coordinates of the location of the cargo. The scheme of operation of such a system is shown in figure 1.12.

Electronic Document Management (EDI) is a computer system for the electronic exchange of documents between users using a standard data format. They are often used in monitoring systems to control the movement of goods on the numbers of consignment notes via the Internet. Improved productivity is achieved through fast transmission and processing of information, data reliability – by reducing the number of paper documents and sharply reducing the possibility of data entry errors. Reduction of logistics costs is achieved by reducing the share of living labor and material costs associated with printing, mail, paperwork; reduction of telephone and facsimile communications; reduction of administrative and transaction costs. The scheme of work with electronic documents is shown in figure 1.13.

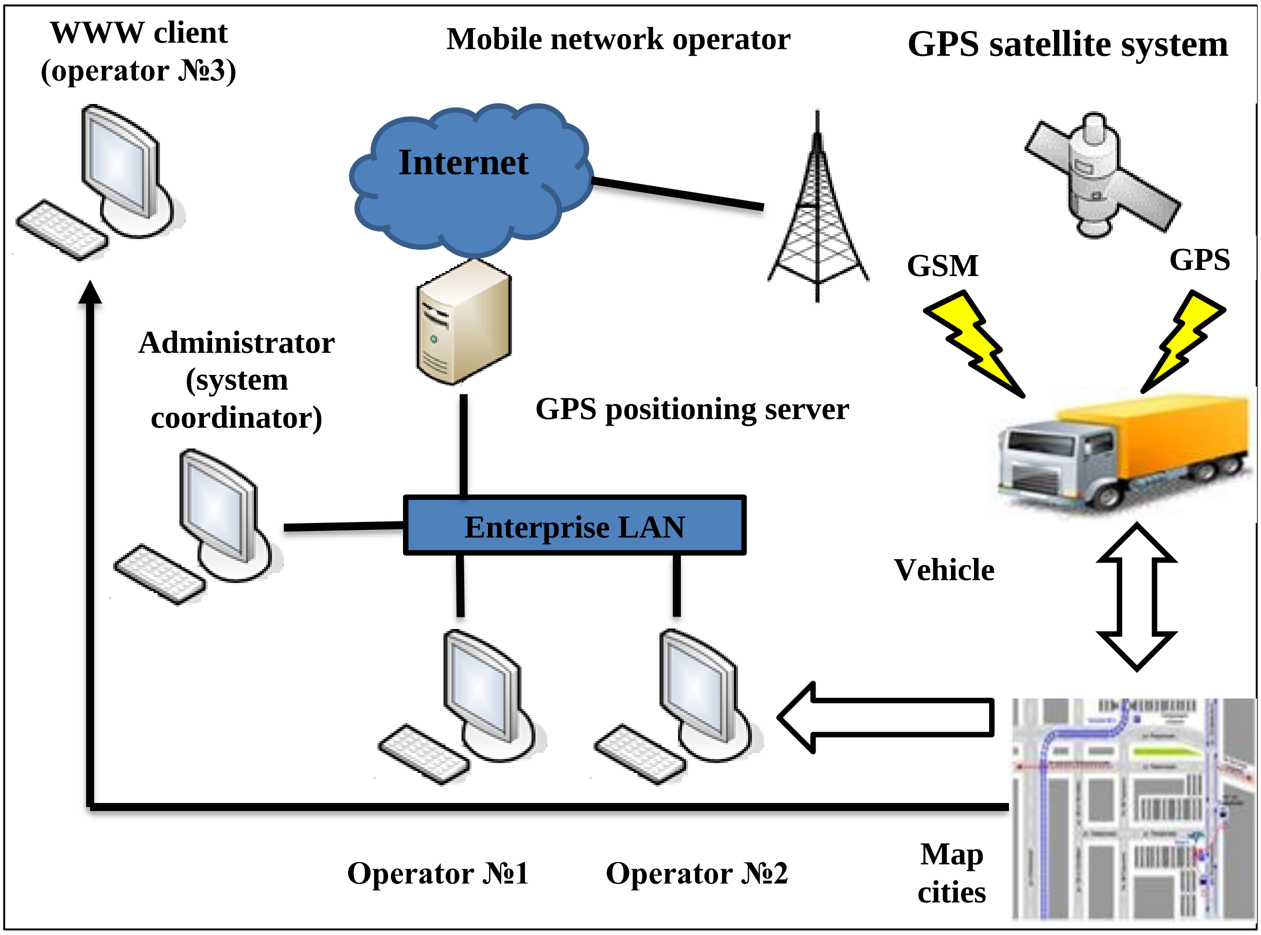


**Fig. 1.12** Scheme of the positioning system

*Source:* compiled by the authors

Note that the digitalization and intellectualization of information flows that accompany the cargo – at this stage of development is the most technically complex component of transport and logistics systems.

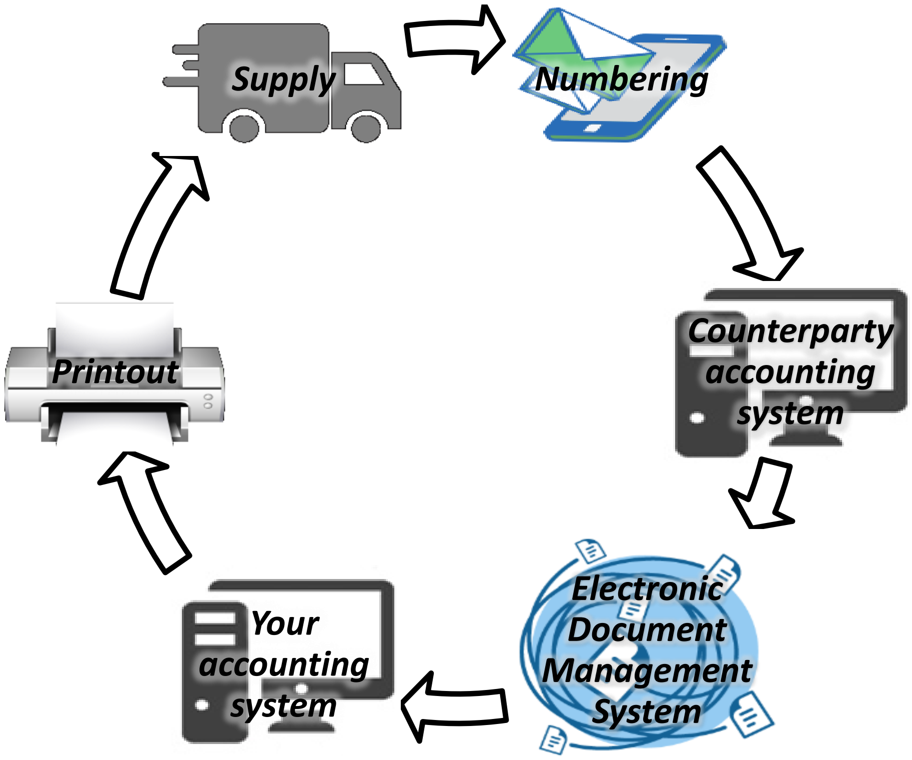


**Fig. 1.13** Scheme of work with electronic documents

*Source:* compiled by the authors

Modern approaches in the management of information flows is the replacement of paper transport documents with their electronic counterparts. But these improvements in the work with transport documents, although to simplify the accompanying processes are ineffective, because outdated technologies and methods of commercial work are implemented on the basis of new technical means of document automation.

Management and organization of logistics and forwarding transport systems should be built taking into account the dynamic changes that may occur during their operation. It is important that these changes do not have a destructive effect on its efficiency and integrity, and the system can continue to operate as a single transport mechanism aimed at achieving common goals and objectives for market compliance and improving the quality of services provided and comprehensive reduction of available costs.

Body loading optimization technologies. Designed to collect information about the availability of goods. The information is recorded in a database, with the help of software cargoes are grouped by the number of places by senders and recipients. As a result, information such as vehicle number, consignee name, shipment, department code, shipment amount and customer information is displayed.

Technologies for the analysis of the entire fleet and accounting for its operating costs; tracking and speeding up traffic. The purpose of the technology is information services for transport companies. Within the framework of this technological system, the recording of information on available vehicles and information on the supply of goods is managed.

Personnel management technologies. In order to ensure the efficiency of the enterprise, such modern recruitment technologies as screening, recruiting and headhunting are used.

Screening is a "superficial selection" of staff, which is carried out on formal grounds: education, age, work experience. On the basis of screening, vacancies that do not require appropriate qualifications and competencies are closed.

Recruitment is an "in-depth selection" of staff that takes into account the business qualities of the applicant and personal characteristics. This technology involves recruiting agencies to recruit mid-level professionals.

Headhunting is a way of finding and selecting staff of especially valuable specialists, both by profession and by the level of professionalism. The main method of selection is an active search for candidates in the companies of the customer's profile, among those applicants who have already proven that they are a qualified specialist in this field.

Marketing technologies (consumer segmentation, market strategy development, customer interaction management system, balanced scorecard). The use of marketing technologies provides increased management of both marketing activities and the activities of the enterprise as a whole through the development of accurate planning, organization, accounting, analysis and control of activities[49]. The advantages of using marketing technologies are shown in figure 1.14.

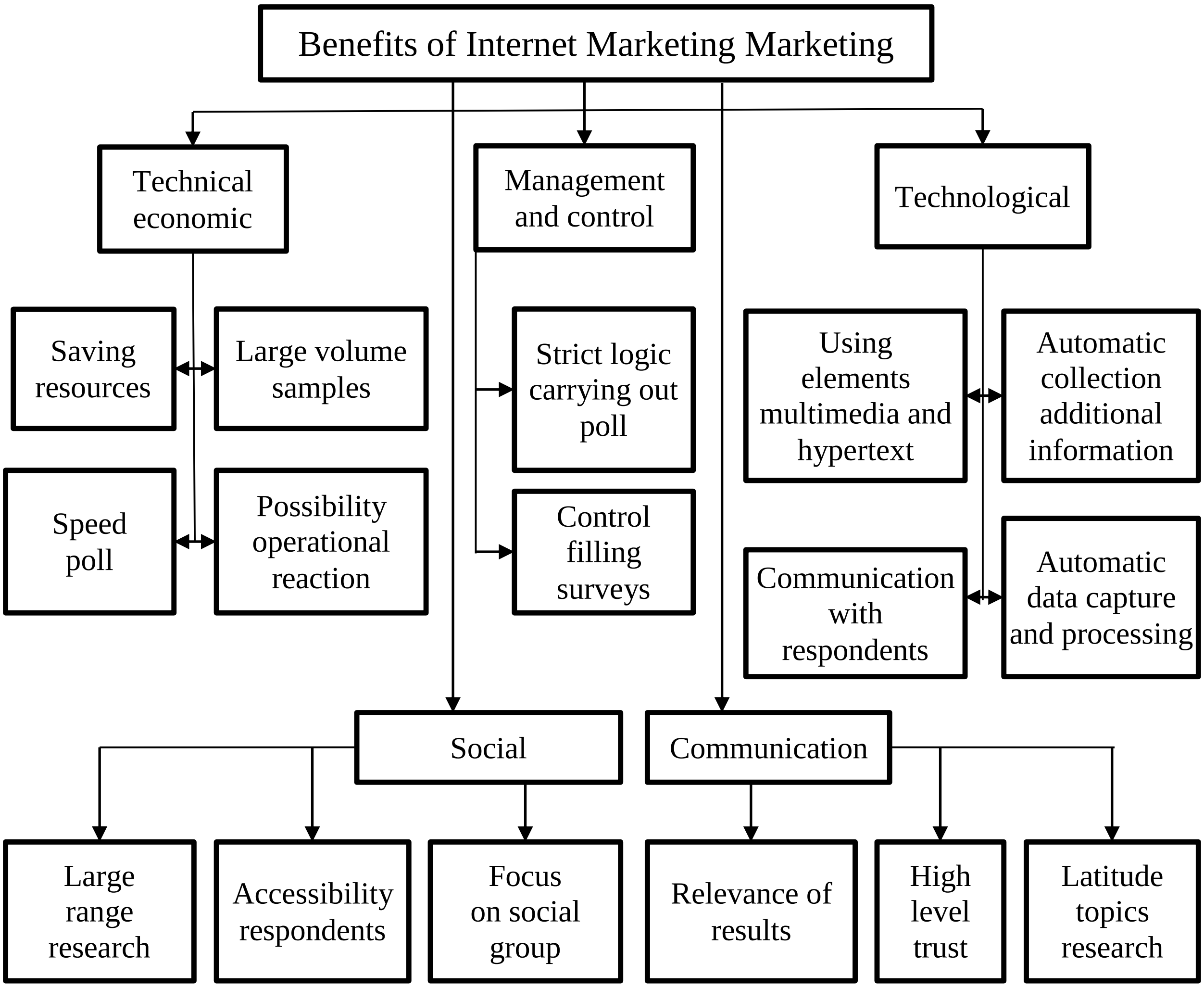


**Fig. 1.14** Advantages of marketing technologies

*Source:* compiled by the authors

At the same time, we note that the mutual influence of institutional and technological factors forms in the transport and logistics systems the specifics of

[49]Artemchuk VO, Navrotska TA Analysis of the effectiveness of transport enterprise management. Bulletin of the National Transport University. 2012. № 26 (1). 220-224.

the functioning of multi-channel supply networks, which are also becoming trends in the development of logistics systems. They have a fundamentally different more complex market mechanics, and also form a new institutional framework of trade and logistics infrastructure of multichannel supply of the modern consumer market – a system of socio-economic institutions that influence the directions and forms of economic agents in the structural modernization of logistics.

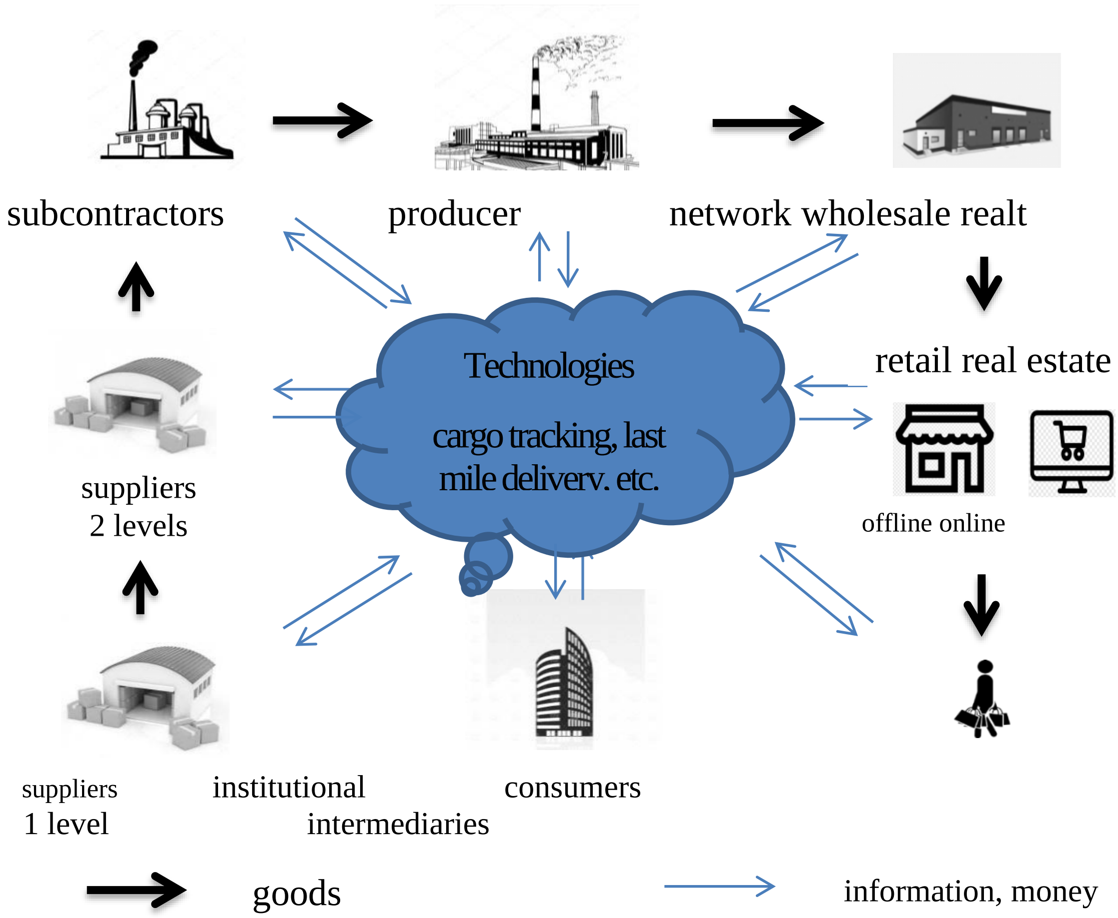


**Fig. 1.15** New supply chain model

*Source:* compiled by the authors

The latter can be defined as an institutional structure, which, in turn, shapes the institutional environment, conditions and models of future changes in logistics in particular and supply chains in general. In our opinion, the new supply chain model that meets the institutional needs of today may have a complex network structure both in the supply process and in the processes of financing management and especially the sale of goods (figure 1.15).

In contrast to traditional logistics, which are governed by the movement of inventories and data on commodity supply, the system of movement of goods of multi-channel trade is dominated by flows of payments and information on the state of consumer demand. This difference is basic. It creates operational advantages and high efficiency in the form of accelerated turnover, operational savings and a significant increase in the efficiency of supply of producers, which are achieved through technological innovation.

The development of e-commerce, the market of online aggregators, national and global trading platforms forms a fundamentally new configuration of the value chain where the dominant position is occupied by digital links, which without a product, solve the problem of attracting customer base, which allows them to retain a significant percentage added value. However, in itself the departure of retail is completely inonline is not a completely correct solution and a panacea for all problems, because in such a scenario a very important component is lost - personalized trust between seller and buyer. Therefore, in our opinion, it would be more correct to combine traditional offline methods with technological online methods into an innovative multi-channel sales model.

The formation of a multi-channel sales model creates a fundamentally new role of logistics, which in the current phase of online retail not only provides the opportunity to differentiate product and service offerings, but also creates an additional barrier to market entry, increasing retail monetization in digital sales channels. And the very combination of logistics and service in online retail is becoming the main catalyst for the development of the modern commodity market.

That is, there is not only a change in supply chains, but also a change in the entire transport, logistics and warehousing infrastructure, which must now be restructured and serve the multi-channel logistics of market supply. Institutional transformation of supply chains in turn is accompanied by profound technological changes in logistics.A new institutional and market direction in the development of supply chains and product distribution systems is being formed, which has important distinctive features:

1. The configuration of supply chains and methods of commodity-sales cooperation between producers and real estate is changing, which is becoming virtually autonomous.

2. The growing concentration of capital in the field of trade, its rapid infrastructural and technological development lead to sales autonomy, which in the long run eliminates the possibility of building vertically integrated value chains in the sense in which this concept is traditionally interpreted.

2. There are operationally and technologically more complex multi-channel supply chains, in which logistics acts as a de facto primary component of the supply of goods and services. It is possible that this is due to the immaturity of the initial stage of development of multi-channel sales, when many tasks in the context of radically new purchasing experience and behavior in different channels led to a number of logistics tasks to be solved within existing technologies and IT solutions.

Digital transformation of supply chains creates fundamentally new effects that have no analogy in the practice of logistics systems. In particular, the effects of over-scaling of the supply network in e-commerce are not typical for traditional retail. This allows us to identify new areas of scientific and practical development of logistics.

Optimization of logistics and freight management, cost reduction in the implementation of transport and logistics processes, the formation of adaptive work of the transport and logistics system capable of achieving scientific and technological progress, are the strategic objectives of any developing enterprise. And the use of modern advanced technologies and the implementation of innovative projects in logistics is necessary for the productive functioning of modern transport and logistics systems. An innovative direction in the development of transport and logistics activities will be the process of visualization and virtualization of transport and logistics functions around providing enterprises with cargo, raw materials, components and sales of finished products based on modern methods and business models of transport and logistics services.

The development of e-commerce creates new institutional conditions in which the bulk of profits will be received by companies that have access to the customer and encourages changes in corporate governance strategies and patterns of consumer behavior, and the dominant type of institutional agreements imposes certain restrictions on needs, benefits and election of agents thereby stimulating the development of even more modern technologies.

So, the market of transport and logistics services is in the stage of fundamental changes that significantly affect the role and scale of its subjects and the structure of their relations. Preliminary considerations allow us to highlight the following trends in the global transport and logistics industry, which will determine the priorities and prospects for the development of transport and logistics systems of the future:

- expansion and complication of distribution channels of raw materials, finished products;
- expansion of supply networks due to the globalization of the world economy;
- the use of technology "just in time", including through the impact on demand for transport and logistics services through the expansion of mechanisms for manufacturing products "to order" and reducing inventories;
- development of e-commerce, including the business-to-business (B2B), business-to-consumer (B2C) and business-to-business (B2G) sectors;

- continuation of the transfer of production and relocation of transport and logistics operations in the Asian bloc;
- development of logistics outsourcing;
- growth of cargo transportation in containers and concomitant growth of mixed transport and logistics services;
- increasing the requirements for quality indicators of international logistics;
- consolidation of the market of transport and logistics services;
- active dissemination of the concept of supply chain management;
- dissemination of "7R" principles
- increasing the role of logistics intermediaries in the market of transport and logistics services;
- innovative technologies become a key factor in the competitive advantages of transport and logistics companies;
- strengthening the environmental requirements of governments, which increases attention to the impact of logistics systems on the ecology of countries;
- new centers of integration of tangible and intangible flows are transport and logistics centers;
- development of markets for highly integrated logistics services, including 3PL and 4PL.

Future priorities for the development of transport and logistics systems are to eliminate the negative effects of the crisis, globalization, inefficient use of non-renewable resources.

# CHAPTER 2. FEATURES OF TRANSPORT AND LOGISTIC SYSTEMS OF SUPPLY OF FAST PERISHABLE FOODSTUFFS

## 2.1 Organizations of transport and logistics systems for the supply of perishable food products

Agricultural sector – one of the important areas of material production, which has a number specific, inherently unique to this industry, features, namely:

– the main means of production, an element of the productive forces is the land. The peculiarity of the agricultural sector is due to the fact that land is the subject of labor, and at the same time a means of labor. Therefore, land used in agricultural production, to maintain its productivity, quality and value requires constant reproduction. This necessitates its rational use (compliance with the rules of cultivation of crops, biologically and economically justified crop rotations, etc.), preservation and maintenance of soil fertility;

– in agriculture, both groups of objective laws interact – natural-biological and socio-economic. The action of natural and biological laws is spontaneous and unpredictable;

– the activities of agricultural enterprises are related to the production of basic, necessary and safe products that should be available to all social groups;

– labor productivity depends not only on the level of innovation of the used equipment and technologies, but mainly on natural processes, weather conditions, a number of biological factors, etc. This causes risk, instability in the functioning and development of the agricultural sector;

– the same amount of financial investments, the same amount and quality of work spent can give significantly different results;

– agricultural production is seasonal, and the rhythm of production depends on natural, climatic and weather conditions. This creates fluctuations in the use of capital resources (including technology), human resources, and, consequently, the supply of products on the market;

– the final amount of income is formed only after the sale of products;

– the level of concentration of production is largely determined by the available size of land, the intensity of their use, as well as the quality and productivity[1].

The presence of the above features distinguishes agriculture from other sectors of the economy; that is why it is important to take them into account when organizing transport and logistics systems in this industry.

High efficiency of the country's agro-industrial complex and its accelerated development should be ensured by a progressive system of construction of production processes, consisting of three interrelated parameters: equipment, technology and organization. Agricultural production is scattered over large areas and requires the movement of significant volumes of intermediate and final products, operational and auxiliary materials to ensure the continuity of the technological chain.

At what the vast majority of products produced by agricultural enterprises must be processed before being sent to the consumer. The function of processing, and, consequently, production in the agro-industrial complex is performed by the enterprises of food and processing industry.

For their normal functioning, the production infrastructure is necessary, which ensures the performance of production functions of enterprises: energy, water supply, logistics, road communications, information networks, trade, etc. In view of this, the agricultural sector of the economy is characterized by a certain autonomy and pronounced seasonality of production, as well as a strong dependence on natural, climatic and soil-biological conditions. In iteconomic

[1]Economic theory: Political Economy: a textbook / ed. VD Bazilevich; Kyiv. nat. University named after Т.Шевченка. 9th ed., Supplement. Kyiv: Knowledge, 2014. 710.

and natural processes of reproduction are closely intertwined, and the end result is the sum of the efforts of man and nature.

Agricultural production is specific and has a number of features:

Firstly, it is biological in nature, ie as a means of production here are used biological organisms, land and other natural resources, and therefore material flows in agrology, according to Levkin GG also have their own characteristics[2]:

– diversification – the ability to generate 2 or more streams that differ significantly from each other in their properties, ways of promotion and end user;

– seasonality – the need to store products in connection with seasonality;

– dualism – the ability of material flow at any stage to act as a raw material for the next stage and the final product;

– transformation – a significant change in material flow on the way to the final consumer, which in turn requires appropriate changes in the mode of storage and transportation;

– range – expansion of the range of material flow in the supply chain, which in turn requires increased efforts to maintain it.

Secondly, agricultural production is characterized by the lack of territorial localization of production processes. In addition, processing enterprises that use the products of agricultural enterprises are usually geographically distant from the sources of raw materials, which necessitates the physical movement of material flows, both in time and space.

Thus, the main losses in the agro-industrial complex are caused by:

- disunity of production processes by areas of activity;

- uncoordinated activities of commercial services (sales, contracts, marketing), technical services and suppliers;

[2]Levkin GG Logistics in the agro-industrial complex: a textbook. 2nd ed. Moscow: Berlin: Direct Media, 2014. 245.

- the lack of basic calculations of the insurance reserve, the cost of storage, the optimal size of the order,

- the movement of information about them.

The costs of this discrepancy are quite significant: in the final cost of goods, they reach about 70%.

Third, agricultural management is characterized by conservatism and inelasticity, which make it impossibleadequate response to market changes. Thus, with the growth of demand for agricultural products, the agricultural sector, given its peculiarities associated with significant terms of its production, can not increase production in a short time. Significant accumulation of certain types of food can lead to the fact that it will be impossible to sell even at low prices, because the physiological properties of man is not able to eat more than he needs, and shelf life of food.

Even the system of distribution of agricultural products differs from the distribution of other products, because moving along the supply chain to the final consumer, agricultural products are constantly changing. Due to this, the distribution, quality, usefulness and safety of agricultural products are paid much more attention than other goods.

Accordingly, the logistics system of agricultural distribution in the current global economy is the main topic of discussion in society and in the scientific literature, and food security is considered in close connection with the concept of sustainable economic development. Logistics, as a science and practice of management of material and related flows of financial resources and information is becoming increasingly popular in the agro-industrial complex.

It is clear that the need for the use of logistics tools in the process of logistics of agricultural production and marketing, ie in the field of agro-industrial complex and the creation of a new direction in logistics – agro-logistics. After all, the organization of resource provision of agricultural producers and the promotion of their products on the market on the principles of logistics gives significant economic, social and environmental effects.

OHM. Sumets defines "agrologistics" as a scientific and practical direction in the management system of agricultural entities, which allows to increase the economic efficiency of their activities by reducing intra-firm costs associated with logistics operations and processes in the production, storage and movement of agricultural products and information about it at a certain logistics site within the established time limits, and ensuring timely and quality customer service[3].

However, I amIf we consider the logistics system of agriculture from a functional approach, we can give the following definition: agrologistics - is the interaction of cyclical forecasting and planning of agricultural production, obtaining loans or funds, purchase or preparation for the season of machinery and equipment, procurement of materials, organization of production, processing of raw materials, delivery of finished products to consumers, receipt of proceeds to the accounts of enterprises.

If from the same process then – alogistics, is a form of optimal organization of flows of material and technical products between suppliers and consumers of these products in a market economy, as well as rational planning, regulation and management of financial, information, service and other flows in the field of agriculture.

Agrologistics is directly related to the distribution of agricultural products, and in a broader sense – with the creation of the most optimal system of movement of all types of agricultural products in the distribution network with high standards of service in the field of consumption. Accordingly, inmanagement of transport and logistics systems, the supply of agricultural

[3] Sumets OM Logistic activity of enterprises of oil and fat industry and evaluation of its efficiency: author's ref. dis. ... Dr. Econ. Science: 08.00.04; 2016. 43.

products should be primarily aimed at transforming the supply chain into a single, efficient system of customer service – the population.

**Table 2.1**

List of the main problematic issues of creating an effective transport and logistics system for the distribution of agricultural products and ways to solve them

| Problematic issues | Solutions |
|---|---|
| Infrastructure | Invest in joint logistics centers that will create a scale effect that will increase logistics efficiency by reducing routes, distances and transportation times |
| Information Technology | the implementation of information technology will help reduce losses and increase competitiveness. |
| Integrated logistics systems | Increase efficiency of agri-food supply chain management is aimed at uniting all participants in the supply chain into a single, efficient system |
| Qualified staff | Training of specialists in the field of logistics management and employees specializing in the finishing of products with a limited shelf life. |
| Specialized vehicles | Involvement of refrigeration equipment in the supply chain of agricultural products increases its quality and freshness and prolongs shelf life. |
| Services of logistics companies | Involvement logistics service operators. |
| Packaging | Improving packaging technologies that minimize losses and ensure appropriate product quality. |
| Monitoring and traceability | Improving monitoring of product identification and measures to maintain its proper quality |

*Source:* compiled by the authors on the basis of literature sources

ANDanalysis of literary sources[4] allows to form the main problematic issues on the way to the formation of an effective transport and logistics system of distribution of agricultural products and possible options for their solution (table 2.1).

Despite all the problems and shortcomings of the agro-industrial complex, cAccording to the World Bank, GDP growth, which is driven by agricultural growth, is at least twice as effective in reducing poverty as GDP growth in other sectors, and it is the innovative development of this sector that provides a large-scale reduction in rural poverty in recent years in many countries[5].

In addition, the calculations of scientists show that one percent of additional products produced in the agricultural sector, provides an increase in production of industrial infrastructure by 2.5%, respectively, manufacturing by 1.4%, transport services – by 0.33%, adequate trade – by 2.7%[6].

Therefore, accelerating the growth rate of agricultural production on the basis of increasing its competitiveness is a priority of economic policy[7]. If we add to this that the reduction of logistics costs by about 1% is equal to an increase in sales by 10%. It becomes clear that a well-built transport and logistics system at an agricultural enterprise can provide more income than the traditional extensive business development scheme.

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[4]Fonseca JM, Vergara N. Logistics Systems Need to Scale Up Reduction of Produce Losses in Latin America and the Caribbean Region.Proc. III rd Int. Conf. on Postharvest and Quality Management of Horticultural Products of Interest for Tropical Regions. 2014. P. 173-180.

Topics D. Food losses and waste in Ukraine. Regional Office for Europe and Central Asia Food and Agriculture Organization of the UN. 2013. URL: http://www.fao.org/europe/agrarian-structures-initiative/en

[5]New course: reforms in Ukraine 2010-2015: national report / [V. B. Averyanov, BM Azhnyuk, BM Bogdan, TP Borodin and others, for general. ed. VM Heitz and others]; NAS of Ukraine, Section susp. and humanitarian. Science. Kyiv: NVC NBUV, 2010. p. 135.

[6]The state of the world's land and water resources for food and agriculture (SOLAW) - Managing systems at risk. Food and Agriculture Organization of the United Nations, Rome and Earthscan, London. FAO. 2011. 285.

[7]Ulyanchenko Yu. O. Competitiveness of the agricultural sector of the economy: mechanisms of state regulation: monograph. Kharkiv: Publishing House of the Association of Doctors of Gauk from the state. Management, 2013. 368 p.

Modern development of agro-industrial complex with application of agrologistics will allow:

- reduce stocks along the entire path of material flow by 30-50%;

- reduce the time of movement of goods along the logistics chain 25-45% (according to scientists from the Institute of Agrarian Economics UAAS transportation of products by field roads, which are typical for most domestic transportation at grain producers, accompanied by annual losses of 1-2% of gross grain harvest)[8];

- reduce transport costs;

- reduce the cost of manual labor.

The above indicates the need to adapt the transport and logistics systems of the agro-industrial complex to the market model of management. The development of logistics in the agro-industrial complex will soon become more and more popular. Its colossal effectiveness in business development is proven by the results of the application of the logistics approach in the economies of developed countries and large agricultural vertically integrated firms.

So if we consider the transport and logistics systems of agriculture or agrocery supply chains should be noted that these are self-organizing systems that depend on the internal and external environment. Over time, some factors determine the evolutionary direction of the entire system. The self-organizing system has the initiative to adapt and choose parameters, which means that key companies can negotiate and actively cooperate, weakening and assimilating negative parameters, and vice versa, increasing and developing positive parameters.

As a result, synergies between key enterprises and synergies between supply chains and the environment can be created, and supply chain efficiencies can be improved. Under certain conditions, supply chain subsystems can form

[8]Formation and functioning of the market of agro-industrial products: a practical guide / ed. P.T. Sabluka. K . IAE, 2000. 556 p.

self-organizing structures and create new ordered connections through nonlinear interaction[9].

In the agri-food chain, access to the best customer (the one with the highest income) at the right level of quality, with the right shelf life and the right supply chain, is crucial for creating and maintaining a competitive advantage [10].

However, these requirements need to be expanded when we talk about sustainable development issues in strategic decision making. Since the ultimate goal of a sustainable agri-food chain is to meet the needs of consumers, it will be most appropriate to take into account the impact of operating activities on the environment and society. In his research, O. P. Velichko[11] and M. P. Butko emphasizes that in the conditions of transformation the concept of socially responsible business is gradually spreading. According to them, socially responsible enterprises get a positive result from their social activities aimed at both external and internal environment, which is manifested in improving productivity, increasing product quality, reducing the production cycle, as well as increasing the company's reputation, increasing volume sales and a positive attitude of the population to the company, which he proposes to perceive as a long-term unique competitive advantage of the firm.

At the same time, food products are special and so far irreplaceable goods of daily consumption. Their availability, quality and accessibility are the main conditions of human life and ability to work. However, despite the stable demand for food, the current market situation is characterized by certain difficulties:

1. Increasing customer requirements for product quality.

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[9] Dan T. Developing Agricultural Products Logistics in China from the Perspective of Green Supply Cain. International Journal of Business and Management. 2012. No 7. 106-111.

[10]Ahumada O., Villalobos JR Operational model for planning the harvest and distribution of perishable agricultural products. International Journal of Production Economics. 2011. No 133. 677-687.

[11]Velychko OP, Butko MP Management of distribution activity of food industry enterprises. Modern transformations of the organizational and economic mechanism of management and logistics of business entities in the system of economic security of Ukraine: a collective monograph / for general. ed. TV Grinko. Dnipro: Bila KO 2017, pp. 125-130.

2 The importance of maintaining sustainable results.

3 Unpredictable changes in the market.

4 Rising logistics costs[12].

With this in mind, companies in the food and processing industries need to maintain a balance in the supply chain to ensure the competitiveness of their products by providing optimal solutions that provide value to the company, namely:

- support of logistics costs at a reasonable level;
- efficiency of use of production equipment;
- differentiation of markets;
- providing opportunities for production growth;
- ensuring the reliability and sustainability of supplies of its products[13].

Along with the difficulties in managing business processes in food supply chains, there are also a number of problems in the development of the market for such products in general:

1. Constant changes in the formats of retail trade - the growth of forms of sales channels. Retailers seek to reach customers in different geographical locations, they create different store formats, which in turn requires an understanding of the business model for each store format and the orientation of logistics to this format;

2. Expansion and specialization of the range. Retailers use customer segmentation to more accurately identify their needs. However, most of them are unable to support the growth of the range, which affects the availability of goods on the shelf. Fulfillment of this requirement requires a reduction in the supply of individual items and a corresponding increase in logistics costs in general;

[12]Carter RH Stores Management and Related Operations. Second Ed., Macdonald & Evans. 1985 xii, 228.

[13]Gartner Research: Improving On-Shelf Availability for Retail Supply Chains Requires the Balance of Process and Technology. May 2011. URL. https://www.gartner.com/en/documents/1701615/improving-on-shelf-availability-for-retail-supply-chains

3. The growing importance of individual goods. Trademarks are a source of differentiation for retailers. Providing these items with stocks requires significant support for demand, which is difficult to obtain without sales statistics, which leads to both an increase in inventories and additional transportation costs. Accordingly, improving the quality of the forecast will increase the quality of forecasting parameters, which will affect the level of stocks in the supply chain. Reducing inventories in the supply chain will reduce the share of urgent supplies and, as a result, reduce logistics costs.

The presence of internal difficulties in the management of food supplies and external externalities of this market encourages the analysis of the supply chain and the technologies used in it.

If we consider in detail the process structure of the food supply chain, it usually includes all types of activities for growing and preparing raw materials, direct production of the final product and all post-production activities such as storage, transportation, sale (wholesale and retail) of finished products, its export and imports.

It should be noted that these activities have a number of specific characteristics such as the duration of the finished product, seasonality in production, limited shelf life, the need for air conditioning during transportation and storage.

In this regard, the food supply chains are subject to increased requirements related to their safety. Tight food safety regulations and growing consumer awareness of food safety are encouraging businesses to take steps to improve and modernize agri-food chains and are attracting increasing attention from researchers in food science, technology and supply chain management.

To ensure food safety, their quality must be carefully and continuously monitored and controlled at every stage of the supply chain. The International Organization for Standardization (ISO) provides the most popular definition of food quality "A set of properties and characteristics of products and services related to the ability to meet the established requirements or needs of the consumer"[14].

Therefore, in order to preserve the value and quality of food products and meet customer requirements, the freshness and safety of these products must be ensured at every stage of the logistics chain.

However, modern global transport and logistics systems of food supply face a variety of social problems that are constantly deepening. As a result, many of them are working "below ideal", with the result that about one-third of the food produced for human consumption is lost. A key factor contributing to such a high level of waste is the inability to control / monitor the temperature in global food logistics systems[15].

The problem of food losses at all stages of the transport and logistics chain is inherent in most economies of the world and needs to be addressed both at the national level to increase the efficiency of the agricultural sector andwelfarethe population of the country and internationally to address the complex issues of global food security and prevent hunger.

Thus, in the United States, Canada, Australia and New Zealand (in total) in 2011 (according to the Food and Agriculture Organization of the United Nations – FAO) the following losses were observed:

- grain products: 38% lost against 62% consumed;
- seafood: 50% lost versus 50% consumed;
- fruits and vegetables: 52% lost against 48% consumed;
- meat: 22% lost versus 78% consumed;
- milk: 20% lost versus 80% consumed[16].

[14] ISO 90000-1-94

[15] Badia-Melis R., Mc Carthy U., Ruiz-Garcia L., Garcia-Hierro J., Robla Villalba JI New trends in cold chain monitoring applications - A review, Food Control, Volume 86, 2018, 170-182.

[16]Gunders D. Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. NRDC Issue Paper 2012 Natural Resources Defense Council URL .:https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf

Moreover, food losses occur along the entire food production chain. Yes, the data pof the United Nations Office for Europe and Central Asia Food and Agriculture Organization (FAO) show that the average loss of perishable foodstuffs (cereals, potatoes, fruits and vegetables, meat, milk) is almost evenly distributed between supply chain operations (table 2.2).

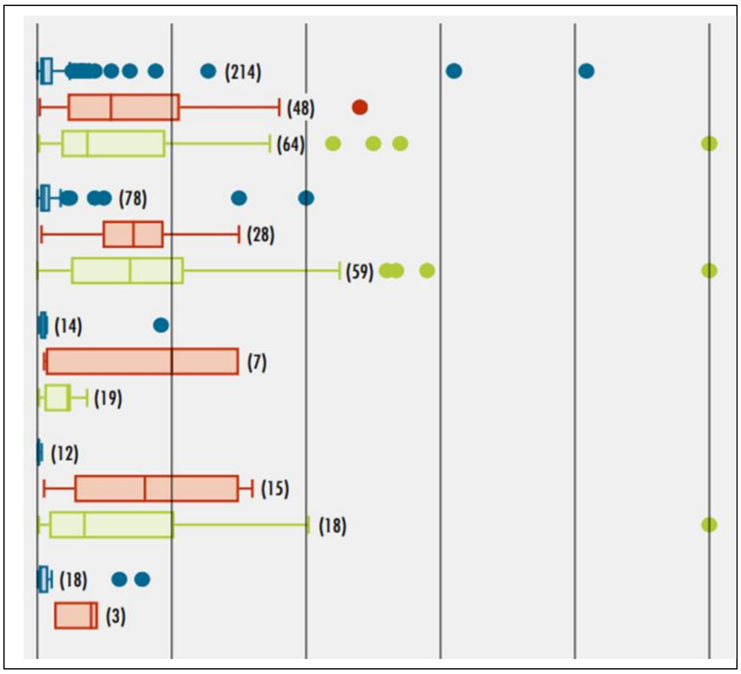
**Table 2.2**

Average level of losses of agricultural products along the supply chain,%.

| Product | Supply chain operations | | | | |
|---|---|---|---|---|---|
| | Production | Storage | Processing and packaging | Distribution | Consumption |
| Crops | 10-40 | 5-10 | 5-10 | 4-10 | 5-15 |
| Potato | 10-20 | 10-30 | 2-5 | 2-10 | 2-15 |
| Fruits and vegetables | 2-10 | 10-40 | 2-5 | 5-15 | 5-10 |
| Meat | 5-15 | 5-20 | 5-15 | 5-20 | 2-5 |
| Milk | 10-30 | 2-5 | 10-30 | 10-20 | 10-15 |

*Source:* Themen D. Food losses and waste in Ukraine [Electronic resource]. Regional Office for Europe and Central Asia Food and Agriculture Organization of the UN. 2013. URL: http://www.fao.org/europe/agrarian-structures-initiative/en

If we consider in more detail the places of origin and scale of losses and spoilage of food products at all stages of the food supply chain, for example for cereals and legumes (figure 2.1), then according to FAO studies in 2000-2017, conducted for countries in Asia and Africa, they were as follows.




NOTE: the number of observations is given in parentheses. Dates (2000-2017) refer to the time of the measurements, but in cases where the survey dates were unknown or known inaccurately, the dates of their publication were used.

**Fig. 2.1** Locations and losses of cereals and legumes in Asia and Africa in 2000-2017- (%)

*Source:* FAO research data for 2000-2017

Such losses led to the fact that in 2010 the total volume of unsold goods increased by 3-5 billion US dollars compared to 2008[17]. The reasons for such deterioration can be divided into three categories.

First, reducing consumer tolerance for food quality.

Secondly, it is the potential lack or lack of control over the cargo, which can lead to the supply of unfit for sale, which, in turn, can pose a threat to consumer health. Product damage during distribution is a serious problem. About one-third of the world's food production is spoiled or lost – a total loss of

[17]Grunow M., Piramuthu S. RFID in highly perishable food supply chains - remaining shelf life to supplant expiry date? / Martin Grunow, International Journal of Production Economics 2013 Vol. 146 Issue 2, 2013. URL:https://proxy.library.spbu.ru:2069

1.3 billion tons per year[18]. Food losses in the United States alone are estimated at about 10% of the country's total food supply at the retail level[19].

Third, the difficulty is the urgent need to reduce high operating costs in transport and logistics systems and at the same time increase the efficiency of their work.

If we consider food products in terms of their transportation, they are classified into the following categories:

*1. Foods that are not perishable.* These products are able to maintain their consumer qualities for a long time (for example, cereals, pasta, sugar, salt, canned food, cigarettes, etc.). Transportation of these goods can be carried out on vehicles that do not have special equipment to maintain the desired temperature. Despite the fact that such goods have a long shelf life, their transportation imposes certain restrictions on climatic conditions - some goods require maintenance of the required humidity.

*2. Perishable foods.* This category includes foods that have a limited shelf life and need to maintain the required temperature and humidity to maintain it.

Considering them, we note that they are the main driver through which retail pitalers have the opportunity to create additional competitive advantages (in addition to pricing strategies) to attract customers.

Different terms such as perishable foodstuffs, foodstuffs or perishable goods are used in different literature sources for this category. In our work, we will use the term: perishable foods, ie products that without special measures (such as refrigeration) for a short time become unfit for their intended use. Such products include meat and meat products, seafood, dairy products, fruits and vegetables.

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[18]Zhang Y., Zhao L., Qian C. Modeling of an IoT-enabled supply chain for perishable food with two-echelon supply hubs / Y. Zhang, // Industrial Management & Data Systems, 2017.Vol. 117, Issue 9, 2017. URL.https://proxy.library.spbu.ru:2156

[19]Gunders D. Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. NRDC Issue Paper. 2012 Natural Resources Defense Council. URL.https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf

Stephen Namias[20] divides all perishable products on the basis of their shelf life into two groups:

1) products with a fixed expiration date, which have a specified expiration date;

2) products of arbitrary expiration date, for which there is no specified expiration date.

It is especially difficult to work with the first group of perishable foods precisely because of their limited shelf life, which must be taken into account when deciding on inventory and supply management policies. Therefore, overproduction and excessively long storage of such products is not recommended because they can be used only during their shelf life. It is not recommended to use the product after the expiration date, moreover, it must be disposed of.

Given this, the speed and conditions of supply often become determinants in the choice of methods of transportation of perishable foods. Their preservation affects not only the income of all participants in transport and logistics systems, but also human health, so transparency of the origin of perishable foods is a prerequisite for managing the supply chain of such products. Retailers of food products receive up to 40% of profits from the sale of perishable food products, but the losses of this category of goods caused by failures in transport and logistics systems sometimes reach 65% and more[21]. It is possible to reduce the share of losses of perishable food products by reducing the delivery time of products and prolonging their life cycle on the store shelves.

Modern digital technologies are successfully used to manage the supply chains of many types of consumer goods (clothing, electronics, household

[20] Nahmias S. Perishable Inventory Theory: A Review 1982 Operations Research30 (4): 680-708.Nahmias S. Perishable Inventory Systems New York, NY, United States 2011. 80

[21] Kienzlen M. Sales and shrink by department Where is My Shrink. URL: http://wheresmyshrink.com/shrinkbydepartment.html

appliances, etc.), but these technologies do not allow to manage transport and logistics systems of perishable food products just as effectively.

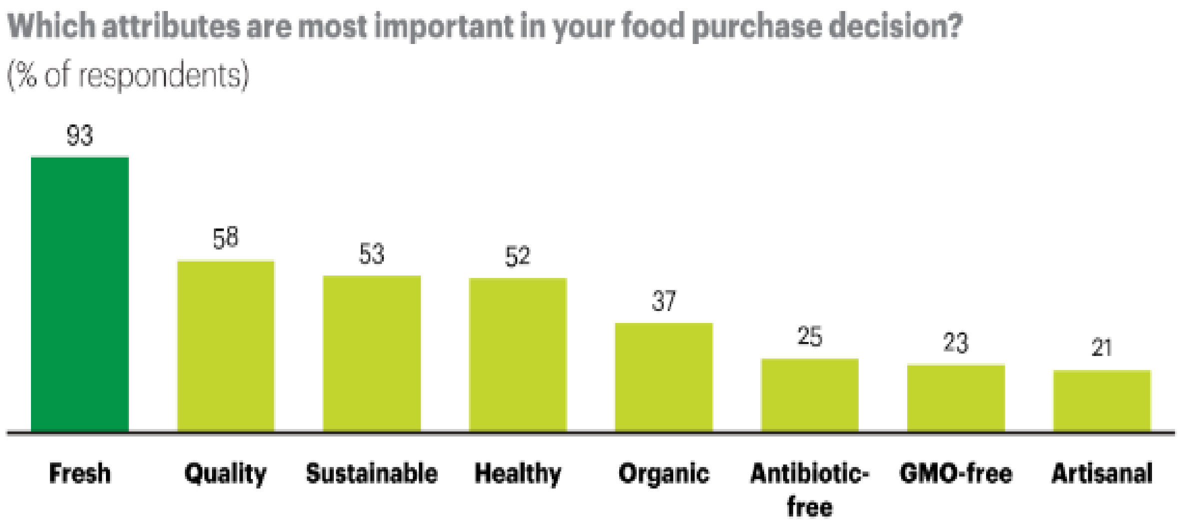


**Fig. 2.2** Factors influencing consumer choice when buying perishable foods

*Source:* A fresh look: perishable supply chains go digital.Kearney.URL: https://www.de.kearney.com/ operations- performance- transformation/article?/a/a-fresh-look-perishable-supply-chains-go-digital

Thus, according to the consulting company AT Kearney (figure 2.2) for 93% of consumers surveyed freshness is the main factor in choosing perishable foods. He is a lot ahead of the next largest attribute - quality, which was chosen by 58% of consumers. No less important factor in choosing products for customers is the availability of reliable information about the origin of goods, which increases the requirements for transparency and tracking of goods in transport and logistics systems.

To date, there is no single universal solution for the management of transport and logistics systems of perishable foods, but this mechanism is in demand by the market and all participants in the supply chain, so commercial companies offer a number of technological tools to manage individual stages of perishable food supplies (figure 2.3).

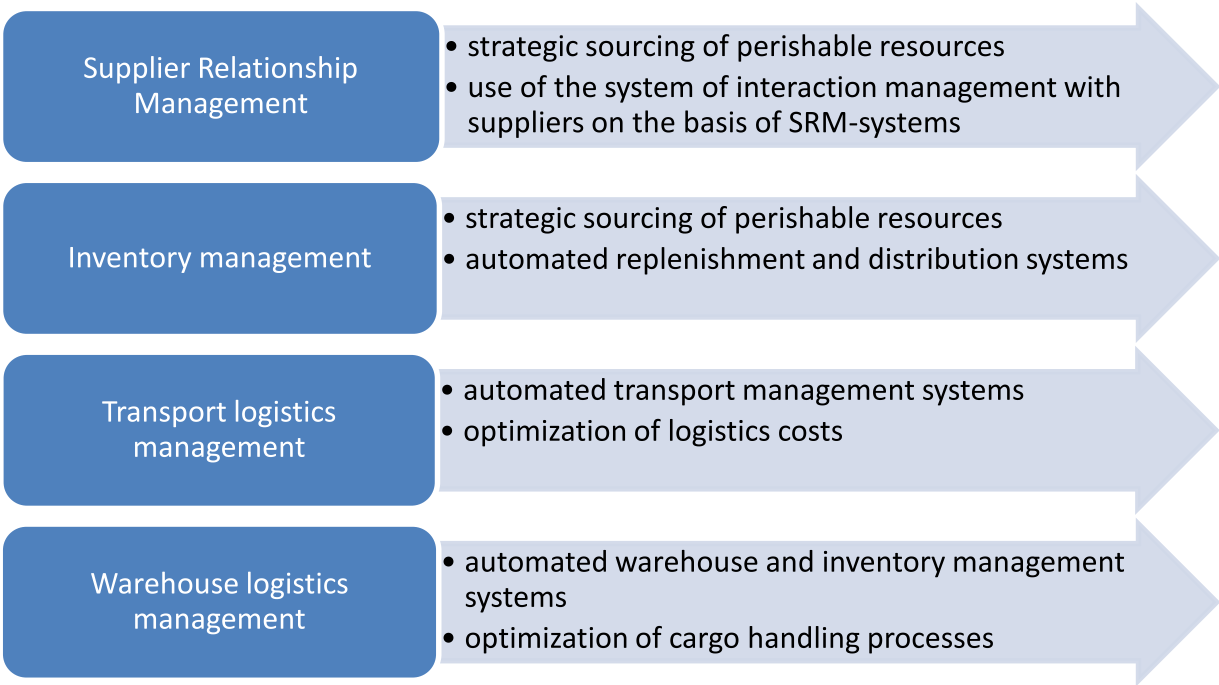


**Fig. 2.3** Tools used to manage perishable food supply chains

*Source:* Hagen C. A fresh look: perishable supply chain go digital. AT Kearney. URL: https://www.atkearney.com/operations-performance-transformation/article?/a/a-fresh-look-perishable-supply-chains-go-digital

The complexity of the organization of transport and logistics systems for the supply of perishable food products is due, on the one hand, the participation of a large number of links in the chain, and on the other hand – the features of perishable goods, namely:

- scattering of perishable food production points;
- seasonality of freight flows;
- the complexity of coordination of loading and unloading processes on interacting modes of transport;
- indeterminate arrival of rolling stock at transshipment points (transport hubs);
- indeterminate mode of transportation of perishable goods to wholesale collection points;
- forced the need for reverse empty run of rolling stock;

- the need to pass phytosanitary and veterinary control when crossing state borders, which delays cargo at terminals of departure and destination, often not adapted for storage of perishable products.

In addition, the preservation of consumer properties for the supply of perishable food is influenced by a large number of parameters that must be controlled at each stage of the transport and logistics system:

- quality condition of the goods at the time of dispatch;
- preparation of cargo for storage and transportation;
- conditions of cargo retention during transshipment between different modes of transport in transport nodes;
- used packaging and wrapping;
- temperature mode of storage and transportation;
- the level of humidity in the place of storage and transportation of goods;
- the presence of air circulation and ventilation in the place of storage and transportation of goods;
- clean air and sanitary condition of the chambers and the cargo volume of the vehicle;
- ways of placing products in the vehicle;
- term of storage and transportation[22].

Accordingly, the management of transport and logistics systems for the supply of perishable food products requires a highly efficient network of business relations, which helps to increase efficiency by eliminating duplicate and unproductive work. Thus, profitable companies are increasingly paying attention to operations in the supply chains of perishable food products, which are known as the system "Farm-to-fork / farm-to-table".

The Farm-to-fork / farm-to-table system displays the sequence of stages involved in growing, processing and consuming food; an integrated product

[22] Chaudhuri A.,Dukovska-Popovska I., Subramanian N., Chan H., Bai R. Decision-making in cold chain logistics using data analytics: a literature re-view. International Journal of Logistics Management. 2018. Vol. 29, no. 3. 839-861.

quality control system that can be traced at all stages of production and supply (from the local farm to your table). These operations are designed to meet huge market demand and expand market share, including agriculture (eg agriculture and crop production), processing, inspection, packaging, warehousing, transportation, and distribution and marketing. However, the productivity of the perishable logistics chain often deteriorates due to the characteristics of perishable food, as well as the difficulties of interregional logistics.

For A clearer understanding of the difference between the traditional logistics chain and the perishable food supply chain, as well as to more accurately reveal the key performance indicators of transport and logistics perishable food supply systems, are summarized in table 2.3.

**Table 2.3**

Differences between the traditional logistics chain and the supply chain of perishable food products

| Comparison criterion | Traditional logistics chain | Perishable food supply chain |
|---|---|---|
| Design (design) of the logistics chain | - development logistics chain design and selection of the appropriate type of transportation for a particular product;<br>- optimization product supply routes and technologies (logistics chain design review) to minimize time and financial costs. | - development efficient supply chain design to reduce the cost of delivery to the end user and maintain the quality of perishable products;<br>- carefully supply chain modeling to meet both logistics objectives (such as costs and delivery requirements) and to ensure delivery of products of a certain quality to the right place and time. |

Continuation of table 2.3

| Comparison criterion | Traditional logistics chain | Perishable food supply chain |
|---|---|---|
| 1 | 2 | 3 |
| Inventory management | - definition the exact level of reserve reserves;<br>- accounting and control over the current level of stocks;<br>- calculation order size (EOQ);<br>- definition inventory management systems (with fixed order time and with fixed quantity: t-system and q-system respectively). All that significantly affects the reduction of financial costs | - determination of the critical level of reserve stocks, as a higher level will lead to more expired products;<br>- determination of the strategy of work with inventory (FIFO, FPFO, FEFO or LIFO, which significantly reduces the number of damaged goods issued for transportation).<br>- control over the expiration date of products to determine at what point in time or in what place it is advisable to withdraw the product from the general flow of goods;<br>- calculation of the frequency and location of expiration control (manufacturer's warehouses, distribution centers or retail outlets) to obtain up-to-date and timely information on the expiration date of the product, which will later be transferred to distribution centers and production forecasting departments. |

Continuation of table 2.3

| 1 | 2 | 3 |
|---|---|---|
| Time cargo delivery | time supply is an important factor, time delays can lead to additional financial costs. | perishable foodshave a certain period of time within which they must reach the consumer. Delays, at least, lead to products not being the freshest when they are in stores, and this can negatively affect sales. In the worst case, perishable products that do not reach the store on time are sent immediately to the landfill. |
| Costs for cargo handling and delivery | - standard processing cargo;<br>- correct mounting in the vehicle. | - previous product processing, as well as measures taken to preserve the product for a longer period of time (for example, product cooling);<br>- choice a special type (or several types) of transport that maintains the temperature at a certain level;<br>- costs on special equipment for real-time product control; |
| Risks arising during delivery | - analysis external environment and risk assessment.<br>- trace pay attention to political, economic, legal, technical and technological, social and environmental risks. | additional specific risks, such as:<br>- risks associated with demand (pronounced "whip effect");<br>- risks, related to the environment (influence of weather conditions). |

*Source:* compiled by the authors

Taking into account the full range of tasks that arise in the organization of transport and logistics supply systems perishable foods. Food and processing companies need to review current supply chain models and systems and modernize their management methods so that the logistics system can better cope with unforeseen situations and consistently meet food quality requirements. After all, "the distinguishing feature of logistics systems for perishable products is the maintenance of product quality, which depends on the length of delivery and temperature variations throughout the supply chain."[23].

Thus, according to N. Ndraha, H. Hsiao, J. Vlajic, M. Yang, H. Lin «…number food waste can be reduced through better temperature control in food supply chains»[24]. Supporting this view R. Badia-Melis, U. Mc Carthy, L. Ruiz-Garcia, J. Garcia-Hierro, J.I. Robla Villalba emphasize that in global food supply networks focus on, and therefore technology, focus on maintaining temperatures at the required level throughout the supply chain[25].

Instead, R. Montanari more broadly approaches the problems of organization of supply chains of perishable agricultural products and notes that minimization of logistics costs of promotion in the supply chain of perishable food products needseffective and efficient monitoring of the conditions of their transportation, technical and managerial solutions are available for this, but there are no methods for selecting the most suitable ones. Based on this, heoffers the greatest attention to control time and temperature[26].

V. Lakshmil and S. Vijayakumar take the same view, saying that "the only reliable way to verify the true integrity of a perishable food supply chain is to monitor the temperature of the products during their distribution, as

[23]Zhang, G., Habenicht, W., & Spie, WEL (2003). Improving the structure of deep frozen and chilled food chain with taboo search procedure. Journal of Food Engineering, 60 (1), 67-79

[24] Ndraha N., Hsiao H., Vlajic J., Yang M, Hong-Ting Victor Lin Time-temperature abuse in the food cold chain: Review of issues, challenges, and recommendations, Food Control, Volume 89, 2018, 12-21.

[25] Badia-Melis R., Mc Carthy U., Ruiz-Garcia L., Garcia-Hierro J., Robla Villalba JI, New trends in cold chain monitoring applications - A review, Food Control, Volume 86, 2018, 170-182.

[26] Montanari R. Cold chain tracking: a managerial perspective, Trends in Food Science & Technology, Volume 19, Issue 8, 2008, 425-431.

products may experience transient conditions during loading or even throughout the transport process with a high risk to the integrity of the goods"[27].

J. Kuo and M. Chen consider the identified problem even more broadly, proposing the use of the following logistics technologies in relation to different groups of consumers and logistics sales channels:

- cold logistics;
- logistics of ambient temperature;
- express delivery;
- home delivery;
- regular transfer, etc.[28].

Researchers have contributed to the development of practical tools to ensure the quality of perishable food supplies, which are reflected in a number of standards and certification schemes of the Global Food Safety Initiative (GFSI).

To date, GFSI has recognized the following regulations and certification schemes:

- FSSC 22000 (Food Safety System Certification) – "Certificate of certification of food safety management systems";
- IFS Food, Version 6, updated version April 2014 – "International Standard for Food Manufacturers";
- IFS Logistics, Version 2.1 – "International Standard for Transportation and Warehousing";
- IFS Cash & Carry – "International Standard for Wholesale Stores";
- IFS Broker – "International Standard for Brokerage Companies";
- IFS Paskaging – "International Standard for Packaging";

[27] Lakshmil VR, Vijayakumar S. Wireless Sensor Network based Alert System for Cold Chain Management, Procedia Engineering, Volume 38, 2012, 537-543

[28] Kuo J., Chen M., Developing an advanced Multi-Temperature Joint Distribution System for the food cold chain, Food Control, Volume 21, Issue 4, 2010, p. 561.

- BRC Global Standard – Food. (British Retail Consortium Global Standard – Food. Version 6) – "Global Standard of the British Retail Consortium. Food products ";

- BRC Global Standard – Food Packaging and other Packaging Materials Version 4 – "BRC General Standard for Food Packaging";

- BRC Global Standard – Food Storage and Distribution – "BRC General Standard for Food Storage and Distribution".

**2.2 Features of transportation of perishable food products**

Transportation perishable foodoccupies a special position in the list of transportation services. The main difference between such cargoes is the limited shelf life, as well as the special climatic conditions of storage and transportation, which are presented to ensure the longest shelf life of food. Restrictions in the form of shelf life of the goods also affect the logistics processes - the lower the shelf life, the more often the goods are produced and transported.

Modern experience shows the need to ensure unity in transport and logistics systems of food supply. This is especially true of perishable goods, the acceleration of delivery times which directly affects their safety and quality.The use of proven routes will avoid the occurrence of unforeseen circumstances on the road that can affect the course of supplyperishable food products.Yes, the developments of scientists at the University of California ledto create a strategy for the promotion of perishable goods in order to minimize the time of their delivery. In them, food shipments were grouped by location so that each group was served by only one route. That is, the optimal service areas were identified and the sequence of cargo flows was determined.

The solution of these problems in the organization of supply of goods to consumers led to the inclusion in the transport and logistics system of intermediaries – freight forwarding companies (TEC). Despite the fact that the services of freight forwarders increase the cost of supply of products, in a market economy, they are necessarily present in the food market, occupying a certain niche. Moreover, with the development of intermodal transportation and mass containerization and packaging, the number of forwarding companies is constantly growing.

The need for the services of freight forwarding companies appears with the growth and complexity of economic ties in the economy, the intensification of production and other macroeconomic processes taking place in market economies. Under such conditions, food producers promote them on the market through intermediaries that interact with transport organizations and companies. When choosing a fuel and energy complex, customers focus on the company's compliance with a number of requirements.

The following is a set of parameters that determine the quality of food supply and the priority of customer requirements for energy services:

1 Assistance in the customs clearance procedure (today about 200 documents are processed for international transportation) – 78%,

2. Observance of term of delivery – 70%,

3. Preservation of cargo during transportation and storage – 69%,

4. Minimum supply costs – 65%;

5. Provision of additional services – 55%,

6. High image of the carrier – 52%,

7. Flexibility in the form of payment – 40%[29].

The process of supplying perishable food products can be presented as a system characterized by internal construction and interacts with the external environment. In accordance with the conditions of the transport and logistics system makes it possible to achieve the required level of customer service while reducing costs, which allows you to gain a competitive advantage.

[29] Alphonse S., Etsibach K. Effective cargo and vehicle storage in distribution centers: a case study of Copenhagen Malmö. Port *World Maritime University*, Malmö, 2002, 113.

The study of the supply of perishable foodstuffs on the principles of transport logistics allows:

- to consider the nature of interaction and relationships between manufacturers, warehouses, transport;

- to establish optimal conditions for perishable goods during packaging, storage and transportation;

- find "bottlenecks" that prevent the movement of goods from producer to consumer;

- to organize scientifically substantiated transport and technological processes taking into account both the needs of individual parts of the logistics chain and the system as a whole;

- to improve the management structure, legal, informational and documentary support necessary for the optimal course of processes in transport and logistics systems;

- take measures to automate the system of supply management of perishable goods.

In this case, technological lines, as a rule, form the technical basis of transport and production processes. The connecting link of the technological line, which largely determines the mode of its operation, is transport.

For perishable goods, the important criteria for choosing a particular mode of transport are economic feasibility and technical ability to ensure the transportation of goods on time and without losses. However, different modes of transport are interchangeable, and it all depends on the choice of cargo owner.

Transportation of goods by road is a convenient and economical way of delivery different food groups products, so trucking continues to be the most popular among suppliers of perishable goods worldwide.

The advantages of this type of food supply are high maneuverability and efficiency, regularity of supply, less stringent requirements for packaging of goods, compared to the requirements for other modes of transport. The main disadvantage of road transport is the relatively high cost of transportation, and the transportation fee is charged for the maximum possible load capacity of the car.

Thus, the transportation of food is a responsible process that requires consideration of numerous factors that ensure their safety. The supply of this group of goods is always associated with a number of risks, as throughout the transport requires the creation of special conditions around it that meet the standards of its storage. For example, ensuring proper temperature control or humidity control in Fresh Logistics technology is "fresh" logistics, which promotes perishable goods, the market of procurement and distribution of which is characterized by short shelf life, different product quality, significant fluctuations in supply and demand.

Considering the basic technologies of transportation of perishable food products, it should be noted that regardless of whether they are transported around the country or an international supply, the set of factors and conditions is approximately the same:

- temperature regime;
- shelf life or delivery time;
- packing and marking according to the type of cargo transported;
- reliable mechanical fixing using pallets, belts, film, etc.

At the same time, ensuring full compliance with transport conditions throughout the journey is a much more difficult task than maintaining the same conditions in the middle of ordinary warehouses.

In this regard, we need a quality organization of transportation, which provides for unforeseen circumstances and is able to protect the cargo from their destructive effects. That is, the competent use of specific to each group of goods technology of transportation and use of technical means, understanding the peculiarities of their work, including those that arise during movement. After all, as part of the technological complex of the transport and logistics system, transport has its own production process, which is called transport. It consists of a certain technological system of transportation, which has its own specifics for perishable food cargo.

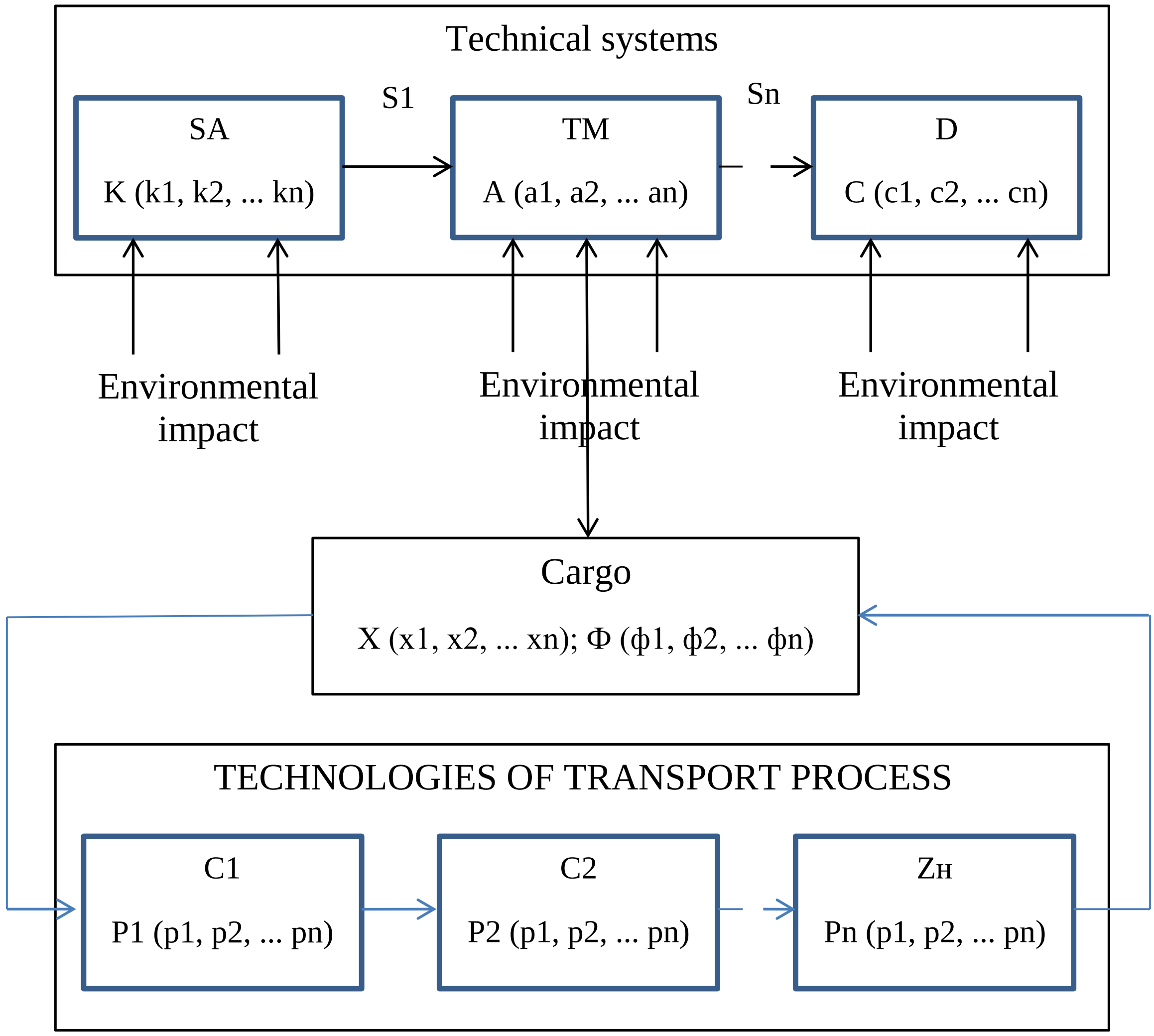


**Fig. 2.4** Graphic model of construction of technological system of perishable food cargo transportation

*Source:* compiled by the authors

Figure 2.4 shows a graphical model of this system. It involves technical systems of assembly (SA) or distribution (D) and transport machines (TM), which interact with each other to maintain the required climatic regime. They have their technological parameters: respectively K (k1, k2, ... kn), C (c1, c2, ...

cn), A (a1, a2, ... an). The suitability or conformity of these machines to each other is characterized by the indicator S. Technical systems are affected by the environment P (t) – weather, D (t) – road conditions and so on.

The list of loads X (x1, x2, ... xn) with their technological properties Φ (ф1, ф2, ... фn) is presented as an argument of the operation, and in the process of transportation changes not only their location in space, but also their properties and the technologies applied to them.

Moreover, the technology of the transport process consists of many transport cycles C (c1, c2, ... cn), each of which is a function of its parameters. The following technological system of perishable food transportation can be described by a mathematical model:

$$\begin{cases} S = f(К, A, C); \\ У_M = f\left[К(k_1, k_2, ..., k_n), A(a_1, a_2, ..., a_n), C(c_1, c_2, ..., c_n)\right]; \\ П_K = f\left[M(t), D(t)\right], П_A = f\left[M(t), D(t)\right], П_C = \left[M(t), D(t)\right]; \\ П_A = f\left[X(x_1, x_2, ..., x_n), Ф(ф_1, ф_2, ..., ф_n)\right]; \\ У_{ТП} = \sum Ц_i(p_j). \end{cases} \tag{2.1}$$

This model takes into account:

- compatibility (adaptability) of transport machines (TM) with agricultural machines (SA, D) – the first equation;

- technological parameters of technical systems - the second equation;

- adaptability (adaptability) of technical systems to environmental conditions and technological properties of perishable foodstuffs – the third and fourth equations;

- parameters of transport-technological cycles – the fifth equation.

Therefore, the model takes into account all the most important factors of technological conditions. In order to carry out the transport process as part of the technological complex of the transport and logistics system of perishable food supplies, in addition to moving the cargo, it is necessary not only to load it at the required location of the technological chain, but also to unload at the destination adhering to certain indicators of temperature, humidity, etc.

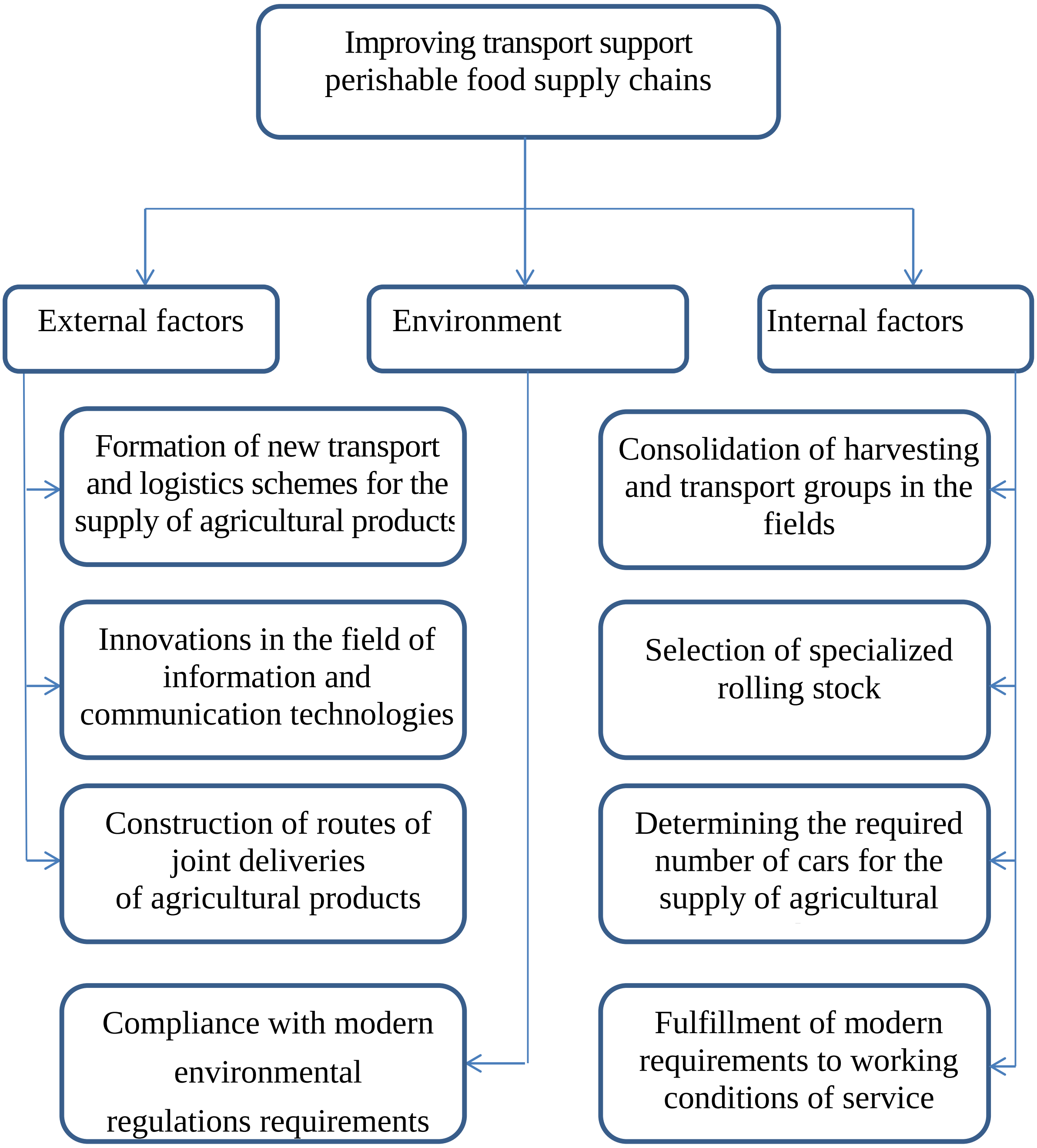


**Fig. 2.5** Means of improving transport support perishable foods

*Source: compiled by the author*

Thus, the completed technological cycle of the transport process consists of the supply of the vehicle under load, loading, moving cargo (transportation) and unloading. And in order to improve transport provision in the delivery of perishable foodstuffs, external, internal and environmental factors must be analyzed and taken into account (figure 2.5).

The use of certain tools in the organization of transport and logistics systems for the supply of perishable food products will minimize the mutual influence of environmental factors and cargoon top of each other and will help preserve more products of the required quality for consumers and customers of agriculture.

If from the transport process of deliveryperishable food to distinguish only the process of transportation of goodsit will also have its own features related to the use of specialized rolling stock, technological vehicles used in transportation to reduce the likelihood of damage to the cargo during transportation and reduce the impact of cargo and transport process on the environment.

In this regard, we note that the transportation of perishable food products occupies a special position in the list of transportation services. After all (we emphasize again) their main difference from other types of cargo is a limited shelf life, as well as special climatic conditions of storage and transportation, which are presented to ensure the longest shelf life of this type of cargo. All perishable foods require certain storage conditions. If one is enough to maintain the temperature in the range of 5-18° C (for example, fresh berries, fruits, vegetables, dairy products in a tetrapack), others need negative indicators (frozen semi-finished products, fish, seafood, etc.).

To meet the needs of any customer, vehicles for the transport of perishable food products are equipped with special thermal systems with the ability to maintain within the cargo compartment set parameters (from -25° C up to +25° C). Yes, transportation of perishable goods is carried out on special transport -heat-insulated vans, the design of which allows you to maintain a clearly defined temperature inside. They can be made on the basis of a car, trailer or semi-trailer. In addition, there are special models of containers that also allow you to adjust the humidity level, as well as monitor the air condition[30].

By their design, heat-insulated vans are divided into:

- isothermal vehicle constructively built on the principle of a thermos. Isothermal vehicles transport products that are pre-cooled to the required temperature. They are usually used to deliver perishable products over short distances.

- the glacier vehicle lowers the temperature inside the empty body and then maintains it at an average outdoor temperature of 30 °C, using a cold source (natural ice with or without salt; dry ice with a device that regulates its sublimation, or without it; eutectic plates, liquefied gases with or without a device for regulating evaporation), which is not a mechanical or "absorption" device.

- the refrigerated vehicle is equipped with a freezer, which allows to significantly increase the range of available temperatures and the distance to which the cargo can be delivered. International transportation of perishable food is almost always carried out using refrigerators.

- heated vehicle is a vehicle that has a special heating system that allows you to raise the temperature inside the empty body and then maintain it without additional heat for at least 12 hours at almost constant levels of not less than 12 °C[31].

The difference between the first two categories and the other two is the lack of a refrigerator and heating devices.

[30]Olkhova M., Davidich Yu., Roslavtsev D., Davidich N. The efficiency of transporting perishable goods by road and rail. Transport Problems, 2017 Volume 12 Issue 4. 37-50.

[31]Demin OA, Zagursky OM Freight: A textbook. Kyiv: Comprint Publishing House, 2020. 604 p.

However, not all foods require individual storage rules throughout the transportation period.

Today there are uniform rules of transportation products of food and processing industry road transport, which allow you to decide what products and how to transport.

Among perishable foodstuffs are:

- food products of plant origin (berries, fruits, vegetables);
- food products of animal origin (meat, poultry, fish, milk, eggs, caviar, etc.);
- processed products (sausages, cheeses, dairy products, confectionery and bakery products).

In addition, perishable goods are divided into:

- fresh vegetables, fruits, berries that have not been subjected to heat treatment);
- chilled (-5 to 6 degrees: milk and dairy products, live fish, egg sausages);
- frozen (from -6 to -18 degrees: frozen meat, poultry, fish, meat and cooking fats);
- deep freezing (temperature less than 18 degrees: ice cream, butter);

Accordingly, the temperature conditions of transportation of products of each category have their own characteristics, namely:

1) Meat and meat products - supplied mainly in frozen or chilled form. To do this, make batches in dense stacks to avoid shrinkage and thawing on the road, and refrigerators are used for transportation. Temperature for deep-freezing objects - 18°C, travel time up to 20 days. For chilled - 5° C for the duration of transportation not more than 12 days.

2) Dairy products and milk are carefully packaged. Tanks are used for milk, wooden boxes for cheese and butter, open shelves. Ice cream and butter

are moved at a temperature of -18°C; yogurts, sour cream, cheese, milk - up to +4°C.

3) Fish and fish products are transported depending on the type of freezing or cooking method. The optimal temperature is chosen for their transportation. So for the transportation of live fish Fr. the optimum water temperature for heat-loving fish species should be 10-12 °C in summer, 5-6 °C in winter and autumn, and 6-8 °C and 3-5 °C for cold-loving fish species.

In winter, all species of fish can be transported at a water temperature of 1-2 °C. Transportation of processed fish is allowed at temperatures from 6 to 18°C. Cold smoked fish up to 5°C. The goods are packed in boxes, barrels, cardboard boxes, etc.

4) Vegetables and fruits – goods that spoil quickly, so they require special packaging and prompt delivery. In addition to maintaining the temperature regime for the transportation of such goods, it is necessary to maintain the optimum humidity in the body of the vehicle.

The peculiarity of the transportation of this group of food products is that different types of fruits and vegetables are stored at different temperatures and humidity, which must be taken into account when forming consignments or choosing a vehicle. We should also not forget about the duration of delivery, according to which different types of fruits and vegetables also differ.

5) Eggs – a fragile cargo that is delivered only in a closed body (van), at a constant temperature. Changes in temperature during transportation are not allowed. Also during the transportation of eggs, sanitary norms must be strictly observed and no foreign odors must be present.

To transport eggs, the temperature in the refrigerator must be zero degrees. All boxes are packed in wood chips so that the eggs stay fresh when you arrive at the store. The required speed of the refrigerator should not be higher than 30 km/h off-road and 50 km/h on an asphalt road. In addition, the refrigerator must be equipped with a special air suspension that dampens shocks from potholes and potholes on the roads.

6) Bread and bakery products, if they are made from natural ingredients and do not contain preservatives, are also perishable goods, because improper transportation they can develop mold or microorganisms, or overdue bread can harden.

In this regard, the organization of transportation of bakery products to carriers have certain requirements:

- transportation of bakery products is carried out only in the presence of a special transport permit, which is issued for a period of six months. At the end of the permit there is a new inspection of the vehicle;

- for the transportation of bread or bakery products in specialized transport, it must be specially marked "Bread";

- the car body, as well as the packaging in which the bakery products are transported, must be subjected to regular wet cleaning and disinfection. Inside the van, the trays in which they are transported must be securely fastened to prevent the bakery products from tipping over during movement;

- in vehicles intended for the transport of bread and bakery products, it is prohibited to transport any other products, even other food products.

In addition, there are special rules for the transportation of bread and bakery products, namely:

- bread made from wheat and rye flour must be delivered to the consumer in no more than 14 hours (and not less than 1 hour);

- products made of wheat or rye flour must be delivered in no more than 10 hours (and not less than 1 hour), and pastries weighing less than 200 g – not more than 6 hours.

- bread and bakery products are placed on trays in one row in height, and the number of products on the tray and in the body is determined by the technical standards established for each vehicle.

Delivery of bakery products to the trade network is carried out according to pre-drawn up and agreed schedules and schedules. As a rule, three parties take part in their compilation: the consignor, the consignee, the trucking company.

Perishable products should be transported only in special isothermal containers and other similar equipment that creates special conditions. Climatic conditions in the car body must meet the requirements of transportation for each type of product. Thus, perishable goods must be transported in a closed body on a vehicle equipped with special refrigeration units capable of maintaining a certain climatic regime.

Before submitting the vehicle for loading, the internal temperature regime must comply with the standards of transportation of the category of cargo being transported, as well as compliance with sanitary and hygienic standards of cleanliness of the body. At the end of the loading, the vehicle must be sealed if the transported cargo does not contain its own sealed container or packaging.

In addition, it should be borne in mind that the basic human need for food is provided daily through the sale of products in stores. The availability of a product on grocery shelves depends on the regularity of deliveries. The presence of the expiration date of the product requires its fastest arrival from the place of production to the point of its sale.

The optimal speed of food transportation is achieved only by the interaction of a number of factors:

- a large fleet that allows you to submit a car at any time;
- a network of routes established and tested by the transport company;
- conformity of the vehicle for transportation of perishable foodstuffs.

Restrictions in the form of the shelf life of the goods also affect the logistics processes: the lower the shelf life, the more often the goods are produced and transported. The use of proven routes will avoid unforeseen circumstances on the road, which can affect the course of supplyproducts of food and processing industry[32].

It should be remembered that the transportation of food requires not only special knowledge, but also special transport and a permit for this type of activity. All special vehicles have letter markings in the form of large Latin letters of dark blue color on a white background. The height of the letters must be at least 100 mm for classification marks and at least 50 mm for expiration dates.

Classification and expiry date markings shall be applied from the outside, at least on two sides in the upper corners near the front. Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for Such Carriage the provided letter designations are shown in table 2.4.

If the vehicle is equipped with removable or non-autonomous thermal equipment, or if special operating conditions are provided for the thermal equipment, the corresponding or appropriate distinguishing letters must be supplemented by the letter "X".

**Table 2.4**

Classification of special vehicles carrying perishable goods food

| Vehicle | Marking |
|---|---|
| Isothermal with normal insulation | IN |
| Isothermal with reinforced insulation | IR |
| Class A glacier with normal insulation | RNA |
| Class A glacier with reinforced insulation | RRA |

[32]Zagurskiy OM, Zhurakovska TS Optimization of transport processes in supply chains of epicenter hypermarket network. Machinery & Energetics. Journal of Rural Production Research. Kyiv. Ukraine. 2020, Vol. 11, No. 3, p. 58.

| | |
|---|---|
| Class B glacier with reinforced insulation | RRB |
| Class C glacier with reinforced insulation | RRC |
| Class D glacier with normal insulation | RND |
| Class D glacier with reinforced insulation | RRD |
| Class A refrigerator with normal insulation | FNA |
| Class A refrigerator with reinforced insulation | FRA |
| Class B refrigerator with normal insulation | FNB |
| Class B refrigerator with reinforced insulation | FRB |
| Class C refrigerator with normal insulation | FNC |
| Class C refrigerator with reinforced insulation | FRC |
| Class D refrigerator with normal insulation | FND |
| Class D refrigerator with reinforced insulation | FRD |
| E-class refrigerator with normal insulation | FNE |
| E-class refrigerator with reinforced insulation | FRE |
| F-class refrigerator with normal insulation | FNF |
| F-class refrigerator with reinforced insulation | FRF |
| Heated vehicle A class with normal insulation | CNA |
| Heated vehicle A class with reinforced insulation | CRA |
| Heated vehicle B class with reinforced insulation | CRB |

*Source:* ANDgreement on the international carriage of perishable foodstuffs and on the special equipment to be used for such carriage (atp). URL. https://unece.org/DAM/trans/main/wp11/ATP_publication/ATP-2016e_-def-web.pdf

A special group also includes food bulk cargoes - various vegetable oils, molasses, juice concentrates, dairy products, wine, water, etc. Bulk (liquid) cargo is a special cargo, for the supply of which in most cases no packaging is used. They are supplied by road with special bodies - tank trucks, which are usually made of stainless steel, which protects the product being transported from corrosion.

Accordingly, the requirements for vehicles used for the transport of such goods relate not only to the perfect cleanliness inside the tanks and the sterile condition of the pumps for pumping, but also to compliance with safety, environmental and safety standards.

One of the features of the supply of liquid food products is the process of preparation of the vehicle for transportation and sanitation after it. All food tanks before operation are subject to mandatory testing for cleanliness and the absence of foreign substances. In case of compliance, a document is issued that allows the loading of food bulk cargo in this vehicle.

In addition, all vehicles involved in the supply of liquid cargo to the food and processing industries must comply with sanitary standards. Be technically sound, clean and free of foreign odors. The inner surface of the tank intended for the transport of liquid food must be covered with a special hygienic material that is easy to clean and disinfect.

Before the next loading the tank should be cleared inside and outside of the remains of the last cargo, and if necessary additional disinfection should be carried out. Sanitation of the vehicle intended for delivery of liquid food cargoes is carried out in the specially equipped washing rooms connected to a water supply and the sewerage and provided with special stock and chemicals.

Tanks used for the transport of liquid food must have a sanitary passport, which is issued for no more than 6 months, and tanks for the transport of perishable liquid food - no more than 3 months.

Business entities for transportation products of the food and processing industries haveadhere to the hygienic requirements for vehicles. According to Art. 44 of the Law of Ukraine "On Basic Principles and Requirements for Food Safety and Quality" they can use only vehicles that meet the following requirements:

- vehicles and / or containers used for the transport of foodstuffs are clean, kept in a proper condition to protect foodstuffs from contamination and have a design which ensures effective cleaning and / or disinfection;

- if the use of vehicles and / or containers for the transport of non-food products may lead to contamination of the foodstuff, for the transport of which they may then be used, they shall be used only for the transport of foodstuffs;

- in the case of the simultaneous use of vehicles and / or containers for the transport of food and non-food products or in the case of the simultaneous transport of different food products, such separation of products shall be ensured that prevents their contamination. To avoid the risk of contamination, effective cleaning of these vehicles and / or containers is ensured before each subsequent loading;

- transportation of liquid, granular, powdered food products is carried out in containers and / or containers / tankers intended for transportation of food products only. These containers and / or containers / tankers are clearly marked in the state language, indicating their use exclusively for the transport of foodstuffs, or are marked “for foodstuffs only”;

- foodstuffs are placed in vehicles and / or containers in such a way as to minimize the risk of contamination.

On machines designed for transportation products of food and processing industrythere must be a special label ("bread", "milk", "fish", etc.). The driver (forwarder) must have a medical book with a note on the passage of the medical commission.

The body of the vehicle intended for transportation products of food and processing industrymust be clean. Therefore, special attention is paid to the procedure of its washing before transportation of food, as well as after it (requirements for water temperature and detergents, washing time, control after disinfection).

Only specialized accredited organizations have the right to wash the body of a car intended for the transportation of food products, which are obliged to provide the necessary documents on the relevant procedure of cleaning and disinfection at the first request.

Different substances are used to clean the car body. For example, for tanks that carry edible oil, one wash with hot water is not enough. Instead, "steaming" is carried out - treatment of the tank walls with hot steam (up to 170-180 degrees) for a certain time (up to 6-7 hours) to completely remove the remnants of the substanceus.

Sanitary treatment of transport intended for transportation of perishable food products should be carried out in specially equipped washing units or on special sites. Disinfection of vehicles is carried out as needed, but at least once every 10 days.

### 2.3 Basic technologies for the supply of perishable food products

Taking into account the views of scientists and practitioners in the field of management of transport and logistics systems for perishable food and our previous research, we propose, considering the methods, techniques and techniques of their organization, all transport and logistics technologies are divided into three main groups:

1. Cold Chain technology.
2. Internet of Things technology.
3. Technology of optimal routes.

Consider each of these technologies in more detail:

*1. Cold Chain technology.*

In recent years, a special type of supply chain management, so-called Cold Chain Management, has been created in the logistics of perishable products that are sensitive to changes in temperature. And as noted by EV Krykavsky and TV Nakonechna[33] The impetus for the organization of cold supply chains can occur for three reasons:

- the initiator is the retail network, which should provide the customer with quality, inexpensive products, because today retailers refuse to supply products directly to stores, preferring to organize logistics centers for chilled and frozen products;

- a successful market company will work, the main task of which will be to consolidate the volume of cold logistics, while declaring the level of rates lower than the costs of producers. However, the company will consciously take risks because it will not make a profit for long enough;

- a successful company will work, which will be able to play the role of the main logistics provider and consolidate logistics volumes, based partly on its own products, partly on the products of other manufacturers.

If we consider the cold chain, it is a supply chain that provides a smooth series of stages of promotion of perishable foods at controlled temperatures from the factory to the consumer. At the same time, refrigeration units are used not only at enterprises that manufacture or store products, but also in the processes of transportation and during loading / unloading of goods.

From the point of view of transport logistics, the requirements for the temperature regime of transportation in the cold supply chain are provided primarily by the correct choice of car body (van), refrigeration unit, compliance

[33] Krykavsky EV, Nakonechna TV From cold logistics to cold supply chains Bulletin of the National University "Lviv Polytechnic". Series: Logistics. Lviv: Lviv Polytechnic National University, 2016. № 846. 79-84.

with the rules of cargo placement in the body and organizational measures using temperature monitoring systems[34].

Accordingly, vehicles transporting perishable, temperature-dependent goods must meet certain thermal requirements, which are mainly related to thermal insulation and refrigeration capacity. But according to V. Lakshmil, S. Vijayakumar "even compliance with vehicle requirements does not always ensure product quality due to unpredictable conditions that may occur during transportation and the cue can cause a significant change in product temperature."[35].

The only reliable way to test the efficiency and safety of a cold supply chain is to constantly monitor the temperature of the products during their distribution throughout the chain. Yes, in researchG. Prakash, A. Pravin Renold, B. Venkatalakshmi main focus is dedicated to temperature monitoring and control using a combination of RFID tag readers and iButton Thermochron.

Connectedwith the iButton thermochron reader is initiated by the lower and upper product temperature limits. If the temperature value exceeds the limit value, the administrator is automatically notified[36]. Accordingly, such constant temperature control will provide a multiple level of warning in the event of undesirable conditions in the products, including warning messages transmitted to the driver of the vehicle and the manufacturer of the product.

Recently, Cold Chain Management technology has singled out the so-called Fresh logistics – "fresh" logistics, which "deals with the movement of perishable goods, the market of procurement and distribution of which is

[34]Krykavsky EV, Nakonechna TV From cold logistics to cold supply chains. Bulletin of the National University "Lviv Polytechnic". Logistics. 2016. № 846. pp. 79–84. URL: http://nbuv.gov.ua/UJRN/VNULPL_2016_846_16.

[35] Lakshmil VR, Vijayakumar S. Wireless Sensor Network based Alert System for Cold Chain Management, Procedia Engineering, Volume 38, 2012, 537-543

[36] Prakash G., Pravin Renold A., Venkatalakshmi B., RFID based Mobile Cold Chain Management System for Warehousing, Procedia Engineering, Volume 38, 2012, 964-969.

characterized by short shelf life, different product quality, significant fluctuations in supply and demand."[37].

Accordingly, Fresh logistics can be defined as the process of planning, implementing and controlling the efficient and effective flow and storage of perishable products, related services and information from one or more points of origin to points of production, distribution and consumption to meet customer needs worldwide. That is, it is a temperature logistics system that combines individual logistics operations with perishable products into an existing business process to create consumer value.

In the cold supply chain "any change in time – distance or temperature can lead to increased costs and, accordingly, reduced value added throughout the supply chain"[38].

Accordingly, the transport and logistics system of such a supply chain has features and distinctive features that are strikingly different from the general logistics of transportation[39]. First of all, these are features that are related to the control and monitoring of temperature or time delays in the supply chain.

Based on these features in the economically developed countries of the world established safety rules for food:

- regulation of product temperature throughout the logistics chain;

- mandatory registration of air and product temperature in vehicles, production centers and places of loading-overload-unloading;

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[37] Yiyan Qin, Jianjun Wang, Caimin Wei, Joint pricing and inventory control for fresh produce and foods with quality and physical quantity deteriorating simultaneously, International Journal of Production Economics, Volume 152, 2014, 42-48,

[38]Bogataj M., Bogataj L., & Vodopivec R. Stability of perishable goods in cold logistics chains. International Journal of Production Economics, 2005, 93/94 (8), 345-356.

**[39]**Fedorova TF, Shiryaeva AM, Petrenko KA Features of the functioning of the logistics chain for the delivery of perishable goods by road. Bulletin of the East Ukrainian National University. In Dahl, 2011. № 5 (159) Part 1, 203-207.

- availability of standardized equipment at all stages of promotion of perishable products, which passes all necessary inspections and has special certificates[40].

Than designing cold logistics chains, a number of factors must be considered, such as the location and composition of the cold logistics chain, the suitability of the equipment used at each stage, the formation of effective transport interaction in the distribution process, information support and more[41].

Cold chain maintenance is a specific type of activity for continuous operation of the system of organizational and practical measures that provide optimal temperature during storage and transportation of perishable or frozen goods that require special temperature conditions for transportation and storage and ensure safety of cargo within the established time limit. when delivered to the consumer. Cold chain logistics includes the following operations:

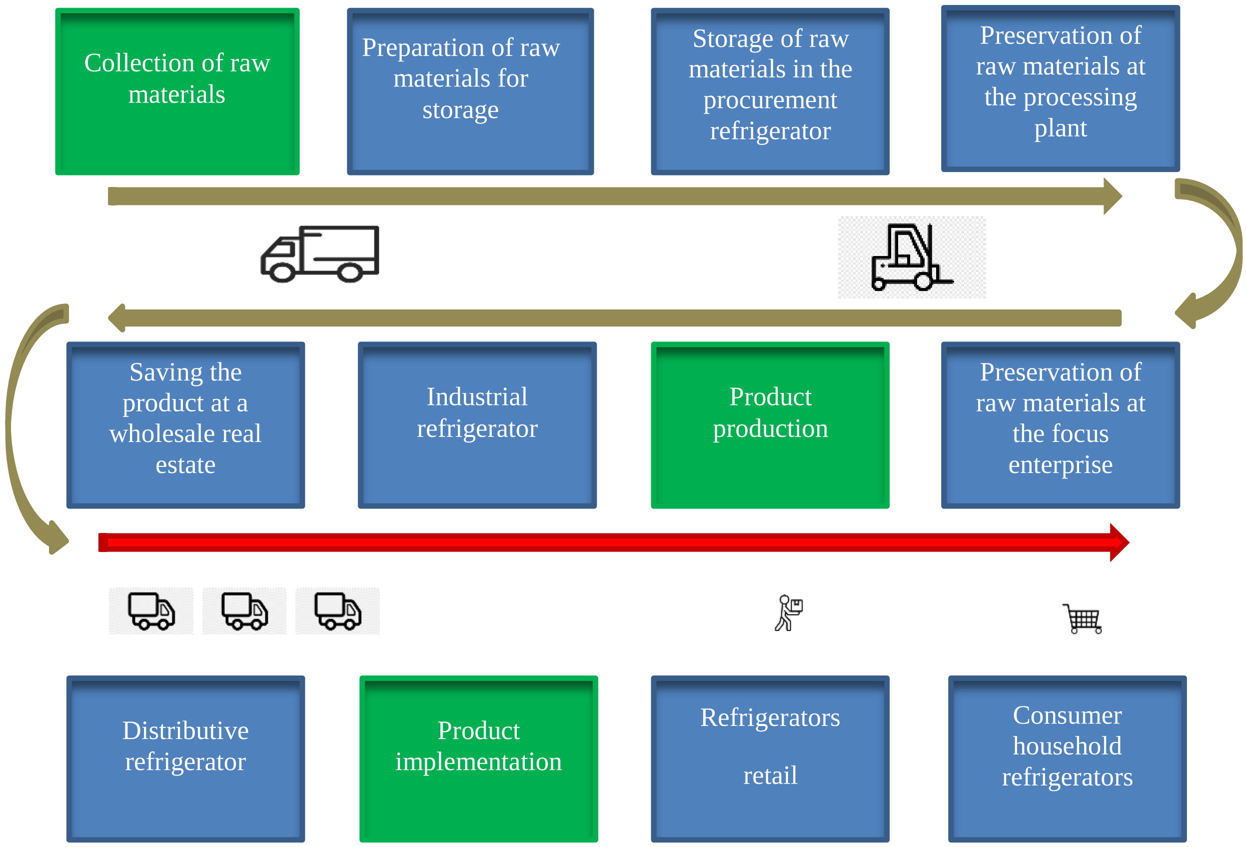
- ensuring the maintenance of constant temperatures during stationary storage and transportation of all participants in the supply chain;
- constant temperature regime in the processes of overloading and manipulation of goods at allowable (minimum) costs;
- movement of goods using the minimum required amount of transport capacity, with minimal time costs, but with constant maintenance of a stable temperature;
- separation and isolation of the processes of receipt and sale of goods, which contributes to the rational use of refrigerated storage capacity and maintaining stable temperatures;
- ensuring a uniform flow of goods with the support and maintenance of standardized information and production flows.

[40]Bogataj M. Stability of perishable goods in cold logistic chains 2005. URL. https://proxy.library.spbu.ru:2069

[41]Yashin AA, Ryashko ML Logistics. Fundamentals of planning and evaluating the effectiveness of logistics systems: a textbook. Ekaterinburg: Ural Publishing House. University, 2014. 52.

As can be seen from figure 2.6 the main supply chain includes all major production and logistics processes, the latter having a greater impact on maintaining the quality of perishable food products.

Therefore, effective management of the cold supply chain should optimize all processes in it, help ensure the freshness of food and their safety for the consumer




| | |
|---|---|
| Logistics activities | Operations in which the temperature is controlled |
| Operational activity | Operations in which it is not controlled temperature regime |

**Fig. 2.6** Scheme cold supply chain

Source: compiled by the authors

E. Gogou, G. Katsaros, E. Derens, G. Alvarez, PS Taoukis give an example when in the framework of the European project FRISBEE[42] a web platform was developed to collect data on temperature conditions throughout the supply chain of chilled and frozen foods. It has accumulated a wealth of information on temperature during all stages of the cold chain (industry, distributors, retailers and consumers). This large database, containing more than 14,000 time-temperature profiles (t - T), can be a valuable tool for cold chain management. The user can determine the sequence of stages of the cold chain for selected foods.

Cold Chain Forecasting (CCP) program, based on the Cold Chain Database (CCD), which allows you to calculate the shelf life status of a product at different stages of the cold chain based on existing or user-defined kinetic data[43]. And according reduce losses and improve service quality through better product quality monitoring, biological shelf life modeling and adjustment FEFO.

FEFO (First Expire, First Out) is one of the options for cargo rotation used in modern logistics.The main criterion for its application is to establish the shelf life of products. If the product is currently in stock and the shelf life of the product remains short, it is shipped first.

A key advantage of FEFO-supported cold supply chains is the provision of consistent quality for all stakeholders, which also improves the accuracy of forecasting and profits of all participants in the transport and logistics supply chain of perishable food products. After all, different companies may have different priorities, such as offering high-quality / expensive or low-quality / inexpensive perishable products, depending on customer needs. In this case, the logistical parameters of the FEFO can be adjusted to take into account both

[42]URL. http://frisbee-project.eu

[43] Gogou E. Katsaros G., Derens E., Alvarez G., Taoukis PS Cold chain database development and application as a tool for cold chain management and food quality evaluation, International Journal of Refrigeration, Volume 52, 2015, 109-121.

types of priorities, which is only possible by accurately predicting the shelf life of the food to be distributed.

However, experts note that the large-scale implementation of technologies that support FEFO in the food industry has its drawbacks, as business management is always careful about the initial cost of hardware and software such as RFID readers and tags[44]. In addition, stakeholders, such as farmers, suppliers and distributors, are generally reluctant to allow the free exchange of temperature records when storing or transporting products, fearing that they may be used against them in lawsuits or other forms of litigation. disputes.

*2. Internet of Things technology*.

The Internet of Things (IoT) is a concept of a computer network of physical objects, for the use of which special technologies are built that interact between objects or with the external environment. The introduction of the Internet of Things in transport and logistics systems for the supply of perishable food products allows its participants to visualize, plan, control and optimize business processes in real time. Its use can lead to significant cost reductions, as it will help to avoid damage to the product through constant monitoring of the cargo, active temperature monitoring during storage and transportation, as well as reducing delivery time.

In addition, according to X. Zou, the use of the Internet of Things for tracking also allows "to control and avoid fraud in the supply of food"[45].

So, Gupta & Rakesh[46] developed a simple and effective IoT system for monitoring food impurities. It can be used by several participants in the transport and logistics system of food supply (for example, farmers, consumers

[44]Jedermann, R., M. Nicometo, I. Uysal, and W. Lang. "Reducing Food Losses by Intelligent Food Logistics." Philosophical Transactions of the Royal Society a: Mathematical, Physical and Engineering Sciences 2014. 372 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4006167/

[45]Zou X. Design and realization of pork anti-counterfeiting and traceability IoT system Acta Technica CSAV (Ceskoslovensk Akademie Ved), 61 (4) (2016) . 281-289

[46]Gupta K., Rakesh N. IoT based solution for food adulteration Smart innovation, systems and technologies, Vol. 79 (2018). 9-18

and authorities) to detect falsification of the product. The system contains various sensors of temperature, oil, humidity, salt, metal, color, and viscosity.

Another IoT system that prevents food fraud and can be used to monitor the quality of food in general, but can also be adapted to specific foods, developed S.Nirenjena et al[47].

Several sensors were used in the study to measure temperature, humidity, and GPS location and to detect food degradation due to non-compliance with established requirements.

And Smiljkovikj & Gavrilovska[48], developed the SmartWine cloud system to monitor the wine supply chain.

They integrated several sensors to collect data on air temperature, humidity, atmospheric pressure, solar radiation, ultraviolet radiation, wind speed, wind direction, leaf moisture, soil temperature and soil water pressure.

Research scientists[49] show that the ability to monitor and track the process of transportation of goods online using IoT technologies is especially relevant in the organization of transport and logistics systems for the supply of perishable food products.

It is possible to estimate the nearest prospects of application of IoT technologies in the logistics industry on the basis of data of development of the IoT market in the world (table 2.5).

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[47] Nirenjena S., Lubin Bala Subramanian D., Monisha M. Advancement in monitoring the food supply chain management using IoT International Journal of Pure and Applied Mathematics, 119 (14) 2018. 1193-1196.

[48] Smiljkovikj K., Gavrilovska L. Smart Wine: Intelligent end-to-end cloud-based monitoring system Wireless Personal Communications, 78 (3) 2014, 1777-1788

[49]Jedermann R, Nicometo M, Uysal I, Lang W. Reducing food losses by intelligent food logistics. Philos Trans A Math Phys Eng Sci. 2014; 372.

Накандала, Д.,Lau, H.andZhang, J.(2016), "Cost-optimization modeling for fresh food quality and transportation",Industrial Management & Data Systems, Vol. 116 No. 3, 564-583.URL.https://doi.org/10.1108/IMDS-04-2015-0151

Kumar, S., Tiwari, P. & Zymbler, M. The Internet of Things is a revolutionary approach for future technology enhancement: a review. J Big Data 6, 111 (2019).URL.https://doi.org/10.1186/s40537-019-0268-2

In Lee, Kyoochun Lee, The Internet of Things (IoT): Applications, investments, and challenges for enterprises, Business Horizons, Volume 58, Issue 4, 2015, 431-440,

**Table 2.5**

Dynamics of costs for IoT devices by segments economy

| Year | B2C | | B2B | | | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Billion USD | Part of c general to him volume, % | Inter-loose segment | Galu-yawn seg-moment | Total y segmental those billion USD | Part of c general to him volume, % | Billion USD | Tempo increased melting, % |
| 2015 | 257 | 27.4 | 115 | 567 | 682 | 72.6 | 939 | |
| 2016 | 416 | 35.2 | 155 | 612 | 767 | 64.8 | 1183 | 126 |
| 2017 | 533 | 38.6 | 212 | 635 | 847 | 61.4 | 1380 | 117 |
| 2018 | 726 | 43.0 | 280 | 684 | 964 | 57.0 | 1690 | 122 |
| 2019 | 985 | 47.0 | 373 | 737 | 1110 | 53.0 | 2095 | 124 |
| 2020 | 1494 | 51.1 | 568 | 864 | 1432 | 48.9 | 2926 | 140 |

Note: B2C - IoT of consumer goods; B2B - intersectoral segment of IoT industrial goods.

*Source*: built on the basis of Internet of Things endpoint spending worldwide by category from 2014 to 2020 (in billion US dollars) URL: https://www.statista.com/statistics/485252/iot-endpoint-spending-by-category-worldwide

Yes, according to analysts Statista[50], the cost of IoT devices during 2015-2020 is growing steadily – annually by an average of 26%. Even in a global pandemic, when investment in many sectors of the economy is significantly reduced, and some businesses are closed altogether, global IoT spending in 2020 will be reduced by only 2.7%[51].

However, we note that the use of IoT in food safety is a relatively new approach. The first article describing its application appeared in the scientific literature only in 2011 and since then their number is growing rapidly. Most of

[50] Statista is a German company specializing in market and consumer data. According to the company, its platform contains more than 1,000,000 statistics from more than 80,000 topics from more than 22,500 sources and 170 different industries.

[51] Oracle Innovation Manifests in a New Generation of Cloud Applications URL. https://idcdocserv.com/US46799319

these studies were conducted by Chinese universities[52], and the main reports on the use of IoT in transport and logistics supply systems concerned food, namely the ability to monitor their safety and quality. The authors of these studies used sensors to monitor the temperature, humidity and location of the vehicle.

But even with the growing body of research in most of them, the proposed IoT architecture had a theoretical structure without any real application, which means that the implementation of IoT in practice in the field of food safety is rare. Only S.W. Shih, CH Wang[53] note about some examples of real implementation of IoT in the field of food safety, in which they developed a system for monitoring the cold supply chain. The system has been successfully implemented, and the authors report that this system has led to increased annual sales, increased turnover, new jobs, and reduced energy consumption.

In general, IoT technology can be seen as a global network infrastructure consisting of many connected devices that use sensor, communication, network and information technology. The most commonly used communication technologies are the Internet, radio frequency identification (RFID) and wireless sensor networks (WSN).[54].

The main technology for the Internet of Things is RFID technology, which allows the microchip to transmit identification information to readers via wireless communication. With RFID readers, people can identify, track and monitor any objects that are automatically connected using RFID tags.

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[52]Shih, CW, Wang, CH. Integrating wireless sensor networks with statistical quality control to develop a cold chain system in food industries. Computer Standards & Interfaces, 2016, 45, 62-78;

Xu G., Yu G. On convergence analysis of particle swarm optimization algorithm. Journal of Computational and Applied Mathematics 2018 URL .:https://proxy.library.spbu.ru:2069,

Ndraha N., Hsiao N., Vlajic J., Yang M., Hong-Ting Victor Lin, Time-temperature abuse in the food cold chain: Review of issues, challenges, and recommendations, Food Control, Volume 89, 2018, 12 -21.,

Qi L., Xu M., Fu Z., Mira T., Zhang H., C2SLDS: A WSN-based perishable food shelf-life prediction and LSFO strategy decision support system in cold chain logistics, Food Control, 2014, Volume 38 , 19-29.

Dai J., Che W., Lim JJ, Shou Y. Service innovation of cold chain logistics service providers: A multiple-case study in China, Industrial Marketing Management, 2020, Volume 89, 143-156.

[53] Shih CW, Wang CH Integrating wireless sensor networks with statistical quality control to develop a cold chain system in food industries Computer Standards & Interfaces, 2016, 45, 62-78.

[54] Bouzembrak Y, Klüche M., Gavai A., Marvin N., Internet of Things in food safety: Literature review and a bibliometric analysis, Trends in Food Science & Technology, 2019. Volume 94, 54-64.

RFID technology is widely used in production, warehouse management, transport logistics and measurement of product authenticity, etc. For example, IBM and Colombian logistics operator AOS have implemented a platform that uses IoT to track and obtain information about each vehicle carrying goods. IBM Blockchain, Watson IoT and IBM Cloud technologies were used to develop the system. AOS trucks are equipped with special IoT sensors for assigning RFID tags. Each label contains information about the carrier, the cargo, the location at a certain time, as well as the availability of space in the truck. The necessary information is recorded on the blockchain, which allows the company to receive it quickly, while providing reliable protection against unauthorized access[55].

The second technology for IoT is wireless sensor networks (WSNs), which mainly use interoperable intelligent sensors (sensors) for collaboration and monitoring. In general, WSNIs a distributed, self-organized network of many sensors (sensors, motes - from the English. "Mote" – a powder, so named because of the tendency to miniaturization) and actuators, interconnected by radio. The coverage area of such a network can be from several meters to several kilometers due to the ability to relay messages from one element to another.

The motors usually include autonomous microcomputers (controllers) powered by batteries and receivers, which allows them to self-organize into specialized networks, communicating with each other and exchanging data via radio. Their scope of application includes environmental monitoring, production control, traffic monitoring, etc.

Accordingly, the implementation of transport and logistics systems for the supply of perishable food products tInternet of Things technology will help improve their key aspects, namely:

[55]How the IoT is Improving Transportation and Logistics. Retrieved from https://ardas-it.com/how-the-iot-is-improving-transportation-and-logistics

1) opportunities tracking the origin, movement, location and condition of products;

2) transparency of the supply process for all participantstransport and logistics system;

3) continuous product monitoring throughouttransport and logistics system.

1) Tracking is the ability to assess the origin, movement, location and condition of products at all stages of supply (processing, production and distribution) in the chain. An effective system should allow you to track products down or up the supply chain and answer the question of where the product you are interested in is and where it came from, ie determine the origin of the product.

The key components of tracking are tracking and tracing[56]. Tracking of movement and location (tracking) is a set of measures that allows you to identify products throughout the supply chain by one or more criteria (eg, batch number or expiration date). Tracking makes it possible to track the route of movement of the desired product and / or batch of products as they move "down" in the supply chain. Tracking is used to determine the availability of goods, inventory management and logistics.

Tracking allows you to use several search criteria to determine the place of origin and related characteristics of a particular product at any point in the transport and logistics system of perishable food supplies. So by batch number, you can find out what raw materials were used to produce this product and the nature of its origin.

Tracing is used to identify the origin of goods and any problems related to product quality. In other words, tracing provides the ability to identify the origin of the product in the direction "up" in the supply chain on the records made in

[56]Sergeev VI, Sergeev IV Development of methodology of control and monitoring of supply chains of network retail enterprises // Economic relations. 2019. Volume 9. № 2. 1463-1486.

the previous stages of its movement. Tracking is a procedure for continuous monitoring of the progress of perishable food products in PKTCHLS in real time. Information and telecommunication tracking technologies operate on the basis of processing large arrays of structured and unstructured data, inter-organizational interactions and logistical coordination between supply chain contractors, as well as the use of modern digital technologies that allow automatic, fast and secure processing of customer orders.

Yes, blockchain technology offers solutions for a reliable single source of information distribution with improved accuracy and efficiency of information, which gives asset managers more opportunities to scale and use resources[57]. It marks the beginning of a new era and is an innovative innovation in decentralized information technology, the main thesis of which for digital security is "trust, authentication, accounting of supply chain data associated with each movement of global freight"[58].

The advantages of using blockchain technologies in transport and logistics systems for the supply of perishable food products is:

- autonomy – independence from third parties in concluding a contract and conducting negotiations;

- reliability of data – all transactions are encrypted with cryptographic code in a common distributed database, documents can not be lost and they can not be edited;

- security – no possibility of hacking the database;

- data transfer speed – data transfer is carried out instantly with the possibility of automating the process of electronic document processing;

[57]Zagursky OM Basic principles of application of blockchain technology in supply chains. Computer technology and mechatronics. Collection of scientific works. Kharkiv, KhNADU, 2020. 5-8.

[58]Smith J. Blockfreight block the blockchain for global freight. Version: Public Release 2016. v 1.0.1 URL.http://blockchainlab.com/pdf/BlockfreightWhitepaperFinalDraft.pdf

- reduction of the amount of transmitted information – by reducing the use of EDI (electronic data interchange) by replacing the encoded information in blocks;

- the possibility of multifaceted use of data in the supply chain / network – reduces the number of errors and allows you to synchronize changes.

Accordingly, today, according to average estimates, 6 out of 10 companies are looking for opportunities to use blockchain technologies in their activities, as they have great potential for food security control in logistics and supply chain management[59]. Major retailers such as Walmart, Unilever, and Nestle are working with IBM to develop technology for tracking the origin of products throughout the supply chain and controlling foodborne illness. This technology allows not only to accurately identify infected products, but also to exclude suppliers of such resources from the supply chain.

The World Health Organization estimates that every tenth person in the world is infected with food every year and about 420,000 people die[60]. Outbreaks appear to be exacerbated during the outbreak of foodborne illness and in companies. When it is not possible to pinpoint the manufacturer of contaminated products, the government advises not to consume all products produced in a particular area. This leads to huge losses for all participants in the supply chain.

The introduction of transparent technology for tracking the origin of goods in the supply chain will simplify and reduce the time of removal from the supply chain only of contaminated products. So together with Unilever, Nestle and Walmart, seven more companies joined the project: meat producer Tyson Foods, supermarket chain Kroger Co, fruit and vegetable producer Dole,

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Ratul A., Megat FZ, Nazmus S. Enhanced Blockchain transaction: a case of food supply chain management. Journal of Engineering and Applied Sciences. 2020. Vol. 15, iss. 1. 99-106

[60] Food safety. World Health Organization. URL. https://www.who.int/news-room/fact-sheets/detail/food-safety

condiment maker McCormick & Company, food supplier Golden State Foods, fresh berry seller Driscoll's and trucking operator McLane Co[61].

Walmart has been testing the blockchain platform from IBM since October 2016. The research was based on the example of tracing mango supply chains in the United States and pork supply chains in China. As a result of such cooperation was published press releases about the supply of these products, when after scanning the product barcode with the help of the program, employees can find out information about the farm where they were grown and the warehouse where they were stored before getting on the store shelf.

A Walmart test showed that the time required to track the path taken by packing mangoes was significantly reduced (from six days, 18 hours and 26 minutes using traditional methods to 2.2 seconds using blockchain technology)[62]. Research conducted in pork supply chains has allowed to download certificates of conformity of products into the system to verify its origin[63].

According to Walmart, one review of spoiled products can cost a company tens of thousands to millions of dollars in lost sales. As a result of research, Walmart was able to track the origin of 25 products (mangoes, strawberries, fresh herbs, meat, poultry, dairy products and even multicomponent products) supplied by five suppliers. This technology is based on the open source Hyperledger Fabric enterprise system. To create it, it was necessary to define the attributes of standard barcodes and markings for loading into the system. Walmart plans to expand its product range for the supply chains

[61]IBM, "IBM announces major blockchain collaboration with Dole, Driscoll's, Golden State Foods, Kroger, McCormick and Company, McLane Company, Nestlé, Tyson Foods, and Unilever, and Walmart to address food safety worldwide," press release, IBM.com, August 22, 2017. URL. www-03.ibm.com/press/ us / en / pressrelease / 53013.wss.

[62]Blockchain disruption in transport are you decentralized yet? Concept paper. (2018) URL:https://s3-eu-west-1.amazonaws.com/media.ts.catapult/wp-content/uploads/2018/06/06105742/Blockchain-Disruption-in-Transport-Concept-Paper.pdf

[63] Walmart, "Walmart invites global collaboration on food safety in China," press release,www.wal-martchina.com, October 19, 2016. www.wal-martchina.com/english/news/2016/20161130-4.htm.

where this technology will be used. Mandatory monitoring of fresh green supply chains (lettuce, spinach, etc.) has already been announced[64].

Today, there are three main types of blockchain platforms – public, private and consortium.

- Public blockchains are decentralized structures that allow any interested participant to log in, review information, make transactions, transfer assets and participate in the consensus process, usually without any special permission. Public blockchains, such as Ethereum, do not have a central administrator or control, and the information is available to everyone.

- private blockchains are centralized structures, the entry of which, and accordingly the implementation of operations is allowed only to a pre-approved set of participants. Therefore, they include members who know each other or their identity has been verified and it meets certain pre-defined criteria. Control in private chains of blocks is distributed only to participants and no information is available to the public.

- Blockchain consortia are a hybrid of public and private platforms. They include the decentralized nature of public blockchains and the leisure capabilities of private blockchains. Here, the entire network, along with the organization's validation rules and policies, is defined and regulated by members / nodes that can control every aspect of the blockchain, including transaction validation, node addition, node privilege management, smart contracts, chain code deployment, and more. In them, the identity of the members usually has to be verified before they can join the network, and some information about them has to be made public. Such blockchains are configured depending on the use case, including information that each member has access to and information that the member can add.

[64]Case Study: how Walmart brought unprecedented transparency to the food supply chain with Hyperledger Fabric / blockchain. Hyperledger. URL: https://www.hyperledger.org/wp-content/uploads/2019/02/Hyperledger_CaseStudy_Walmart_ Printable_V4.pdf

Private or hybrid blockchains are more likely to be used than public ones for the use of blockchain technology in perishable food transport and logistics systems.

2) Transparency is a level at which all stakeholders have a common understanding and access to the product information they request, without loss, delay or distortion. In the area of perishable foods, transparency can be useful for a variety of needs. According to J. Trienekens, "in addition to improving market efficiency, improved information exchange throughout the supply chain, as well as the quality of food that is constantly maintained, product differentiation, logistics and process optimization can help with operational management."[65].

Moreover, to ensure transparency and controllability in the transport and logistics systems of perishable food products, information must be transmitted between customers and suppliers in real time. Therefore, modern technologies such as sensors, radio frequency identification (RFID) and wireless networks are key components to ensure the visibility of each product throughout its life cycle.[66]. Transparency and tracking of the transport and logistics system are especially important for the supply of perishable food products, where the quality and quantity of the product of the required level at the final link is maintained by temperature control in both production and transportation. As demand for organic agricultural products increases, companies can increase customer confidence by enabling them to track the origin of a product. Transparency also facilitates inventory management, reduces operating costs and speeds up delivery times. The Internet of Things helps identify vulnerabilitiestransport and logistics system, which allows you to make the necessary changes in accordance with accepted standards.

[65]Trienekens J. Transparency in complex dynamic food supply chains r, 2012 URL. https://proxy.library.spbu.ru:2069

[66]Aung M., Chang Y. Temperature management for the quality assurance of a perishable food supply chain. Food Control. Elsevier, 2014. 40. 198-207.

Such procedures are becoming increasingly important as the global market for perishables and ready-to-eat foods expands rapidly as a result of globalization and integration processes, continuous improvements in transport infrastructure and the development of communication and information technologies.

However, the ever-growing trade in perishable products, which is affected by various negative factors in the form of temporary delays and temperature deviations, requires strict quality control. And since the mutual influence of these factors can seriously reduce the quality of perishable products to such a level that the product will pose a threat to consumer health, it is important to constantly monitor such products.

3) Monitoring technologies include a number of technologies related to tracking various factors influencing perishable food product (such as temperature or humidity) and tracking the location of the product in transport and logistics system.

This is primarily necessary to ensure the delivery of goods before the expiration date and thus increase the efficiency of the entire supply chain. For the transportation of perishable food products, it is necessary to implement monitoring and warning system for the critical condition of products (for example, those associated with unacceptable temperatures), as well as to inform all participants about compliance with regulatory requirements.

In recent years, advances in Internet of Things technologies, such as radio frequency identification (RFID), sensor technology, communication modules, microprocessors and special sensors, have expanded the range of applications of the Internet of Things. This trend is especially evident in the use of sensor technology, which can be used for intelligent control of temperature and humidity during transportation of products. For example, a company can monitor the temperature of its products and track them throughout the supply chain, instead of the traditional approach, in which basic processes are performed separately using a temperature recorder, barcode scanner and documents. Also, technologies such as RFID tags will allow you to control the expiration date of the product as in large industrial warehouses.

It should be noted that the development of information and communication technologies (ICT) is constantly changing the devices used in the IoT, so the sensors are replaced by tags of radio frequency identification of animals and food (RFID), actuators and even smart packaging (IP)[67].

Considering the staggered device, we note that Food packaging plays a very important role, both in maintaining the quality of the product and in ensuring its safety for the consumer.

Traditional packaging preferably performs only the first function and is intended only to protect food from changes in the environment, such as temperature, humidity, light, gaseous emissions or microbes.

Active packaging systems (APS) contain special additives (gas and moisture absorbers, flavors, antimicrobials, enzymes, etc.) that have an interactive link between the food packed in them and the packaging environment to regulate the microbiological balance inside and ensure protection and continuation shelf life of products. With the help of active components APS protects packaged foods by releasing or absorbing the necessary substances in / out of the product. They help to improve the appearance and preserve the organoleptic properties of food, ie signs that affect the human senses.

Intelligent (smart) packaging systems (IPS), unlike APS, do not contain active ingredients, but they have intelligent devices that "communicate" with observers or consumers about the quality of the current state of food[68].

Smart packaging devices are divided into two types. The first type is storage media such as barcode labels and radio frequency identification (RFID)

[67] Fang, Z., Zhao Y., Warner, R. Johnson, S. Active and intelligent packaging in the meat industry. Trends in Food Science and Technology. 2017. 60-71.

[68] Biji KB, Ravishankar CN, Mohan CO, Gopal TKS "Smart packaging systems for food applications: a review," J Food Sci Technol, 2015. vol. 52, 6125-6135.

tags. The second type includes batch indicators used to monitor the environment (indicators of time, temperature and gas indicators, etc.). Such systems analyze the impact of the environment on the state of the product and inform the consumer about this state. For example, beer may indicate its temperature by the color of the label.

Thus, the consumer receives information about the expiration date of the product or non-compliance with the requirements of the conditions of its storage or transportation. In addition, consumers using smartphones can get more detailed information about the packaging that is already indicated on it (for example, ingredients, allergens or nutritional value of the product), as well as information about product quality, freshness, origin or whether pesticides were used in its production. In addition to consumers, retail retailers can also benefit from this system by predicting the shelf life of products and comparing it with the actual shelf life to improve their logistics.

In the future, IoT is expected to grow rapidly towards the development of wireless sensor networks for contextual data collection. For example, such as the Coach2O cover, which helps consumers monitor their water consumption and set goals for its consumption with the accompanying application, based on their unique benefits and health requirements. According to Mordor Intelligence research, the smart packaging market alone will reach $ 42.75 billion by 2023, with an average annual growth rate of 4.15% over the forecast period 2018-2023[69].

However, experts note that today, due to the lack of standardized communication protocols, data received by IoT devices is difficult to interpret, transmit and share. In the future, as more and more IoT devices adhere to the Fair Trade Guidelines (FAIR), the Internet of Data and services that help data

[69] Worldwide Markets for Smart Packaging 2018-2023 - Oxygen Scavenger Technology Expected to Lead the Market. URL. https://www.financialbuzz.com/worldwide-markets-for-smart-packaging-oxygen-scavenger-technology-expected-to-lead-the-market-1266026/

and algorithms will be available for sharing by all participants in transport and logistics systems for perishable food supplies[70].

*3. Technology of optimal routes.*

The modern market environment, along with the optimization of costs, puts before the participants of commodity-money relations more and more requirements related to the speed of customer service and increase the efficiency and productivity of transport activities. Therefore, one of the main characteristics of any logistics system is the timeliness of deliveries, ie the time parameter.

The most common causes of delays in the practice of modern logistics companies include:

1) violation of the planned time for transportation - shifts the work in other areas, which, in turn, may lead to arrival at the point of unloading (transshipment, customs control, port, etc.) during non-working hours;

2) intentional violation by the carrier of delivery deadlines (example for hourly payment);

3) lack of mobile navigation system;

4) road accident, speeding violation, etc.

Each of the identified causes can be determined both objectively and subjectively, because it depends on many factors. However, given that the modern market has increased requirements for compliance with all contract conditions, including delivery times and quality of goods, when building transport and logistics systems for perishable food supplies, it is advisable to use the concept of just-in-time (JIT).

The ELA Glossary defines JIT as "the delivery of goods (or consignments of goods) to the right place at the exact time when they are needed"[71]. The JIT

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[70]Wittenburg, P, et al. The FAIR Funder pilot program to make it easy for funders to require and for grantees to produce FAIR. 2019. Data. archive: 1902.11162. URL:http://arxiv.org/abs/1902.11162

[71]English-Russian explanatory dictionary of logistic terms http://ocean.mstu.edu.ru/docs/files/20120202_1412-2.pdf

concept is based on the synchronization of supply volumes and quality according to the operational needs of production. It is based on the decentralized principle of material flow management, when instructions to start production come directly from the warehouse or sales system of the enterprise, and the key elements are integrated information processing, segmentation of production and supply, synchronized with production. Accordingly, having an accurate calculation of the duration of shipments is one of the basic ideas of the JIT concept, especially when it comes to perishable food supply chains and related transportation.

On these principles W. Soto-Silva, M. González-Araya, M. Oliva-Fernández, L. Plà-Aragonés developed an integrated supply model that provides a common solution for the purchase, transportation and storage of fresh food. The application of the model at the apple processing plant in the Moulles region of Chile resulted in an average saving of about 8% relative to the real costs of purchasing, storing and transporting fresh produce during the processing period[72].

The following algorithms can be used as the main tools for optimal supply routing in the JIT concept:

1. Combining LIFO / FIFO strategies taking into account the level of service. Application of FIFO strategy in case of high level of service, and, on the contrary, application of LIFO strategy in case of low level of service. However, in practice, the use of a hybrid strategy of LIFO and FIFO is often observed. Such strategies help to level the "whip effect" and the high level of variability of logistics chains.

2. Particle Swarm Optimization method. This method is a population algorithm for stochastic optimization. This algorithm was based on the modeling of transport and logistics systems on the example of the behavior of birds when

[72] Wladimir E. Soto-Silva, Marcela C. González-Araya, Marcos A. Oliva-Fernández, Lluís M. Plà-Aragonés, Optimizing fresh food logistics for processing: Application for a large Chilean apple supply chain, Computers and Electronics in Agriculture, Volume 136, 2017, 42-57.

they gather in flocks. The use of this method in logistics chains helps reduce costs, as well as more effectively plan production and distribution.

3. Ant algorithm. This algorithm contributes to the efficient design of routes and the rational use of different types of vehicles. The algorithm is based on the behavior of the ant colony when the ants find the best route from the colony to the food source. This algorithm, which can be used to determine the optimal path, has a number of advantages: it is easily combined with other algorithms, can be distributed computing, and includes intelligent search and has strong stability compared to other similar algorithms.

In addition, the ant optimization algorithm not only has the advantage of high speed and high accuracy, but it can also be used to find a quasi-optimal solution. In solving simple problems, the use of this algorithm is not necessary, and is unlikely to have a significant advantage over other algorithms. On average, this algorithm shows greater efficiency when applied to relatively complex tasks[73].

4. Genetic algorithms[74]. Such optimization algorithms can help in the development and planning of the schedule of vehicles for the transportation of perishable products. Figure 2.7 shows the scheme of the algorithm proposed by X. Wang et al[75].

5. Lagrangian relaxation algorithm. The application of this algorithm helps to optimize the decision on the location of the warehouse, routing and inventory management in the transport and logistics system of perishable food supplies in conditions of uncertainty.

[73]Ning J. A best-path-updating information-guided ant colony optimization, 2018 URL. https://proxy.library.spbu.ru:2069 (access date: 22.04.2018).

[74] In the scientific literature, the algorithm is involved in Priority-Based-Genetic Algorithm (PB-GA) and Traditional genetic algorithm (T-GA).

[75]Wang X., Sun H., 1 Dong J., Wang M., Ruan J. Optimizing terminal delivery of perishable products considering customer satisfaction. Mathematical Problems in Engineering. 2017. URL. http://downloads.hindawi.com/journals/mpe/2017/8696910.pdf

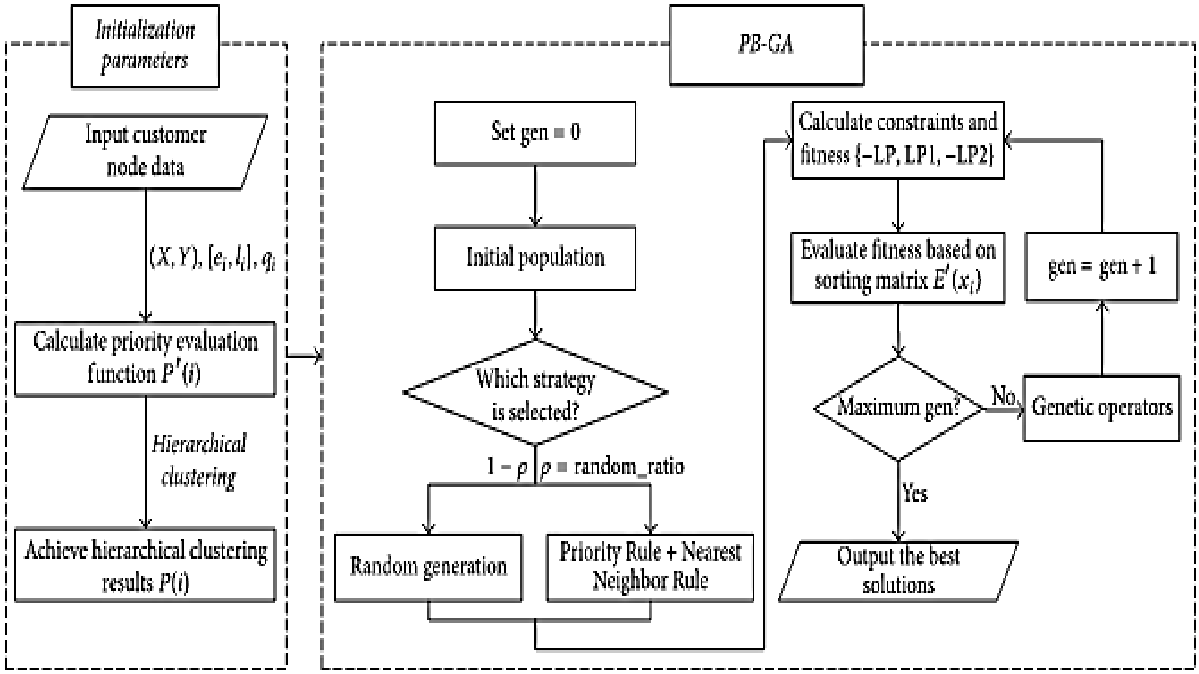


**Fig. 2.7** The scheme of the genetic algorithm is based on priorities (PB-GA)

*Source:* Wang X., Sun H., 1 Dong J., Wang M., Ruan J. Optimizing terminal delivery of perishable products considering customer satisfaction. Mathematical Problems in Engineering. 2017 http://downloads.hindawi.com/journals/mpe/2017/8696910.pdf

The main idea of this algorithm is that complex constraints are relaxed (removed) and passed to the object function. Weakened objective value is considered as the lower limit (in minimization problems) for the optimal objective value of the problem to be solved[76].

However, it should be noted that the real socio-economic conditions radically change any trends, concepts or principles. Thus, the global coronavirus pandemic has significantly disrupted traditional logistics chains and led to the need to store many times more perishable foods. Today, there is a shortage of refrigerators for perishable food on a global scale. Lineage Logistics, the largest company in the EU, announced the almost complete filling of its own warehouses with temperature control in the EU. Its president of international

[76] Rafie-Majd Z. Modeling and solving the integrated inventory-location-routing problem in a multi-period and multi-perishable product supply chain with uncertainty: Lagrangian relaxation algorithm, 2018 URL: https://proxy.library.spbu.ru: 2069 /

operations Mike McClendon said 15 facilities in the UK are over 90% full[77]. Accordingly, it is almost impossible to find free capacity for storing meat and vegetables. This situation is due to the sharp decline in international food supplies around the world due to quarantine measures.

Covid-19 once again demonstrated the vulnerability of the international system of economic and food security, built on a continuous algorithm of supply-intermediate storage-transportation-shipment of products. The suspension or partial restriction of export shipments has halted this well-functioning process and requires the development of new approaches and algorithms.

[77]World's Biggest Cold Storage Supplier Could Reach Full UK Capacity in Three Weeks. By Reuters, Wire Service Content April 24, 2020URL. https://money.usnews.com/investing/news/articles/2020-04-24/worlds-biggest-cold-storage-supplier-could-reach-full-uk-capacity-in-three-weeks

# CHAPTER 3. WAYS TO IMPROVE TRANSPORT AND LOGISTICS SUPPLY SYSTEMS OF QUICK-FOOD

## 3.1 Construction of an integrated transport and logistics system for the supply of perishable food products – a constantly controlled temperature and time logistics system

The use of any of the above technologies in transport and logistics systems of perishable food supplies has both advantages and disadvantages, it is important to understand that there is no single "ready" or correct solution, due to the fact that the product composition, route, climate conditions, method of logistics and efficiency of the transport process are very different for different products in different countries.

Each individual technology is limited in scope and has problems both in terms of functionality and in terms of productivity. However, when shared or combined, these technologies significantly increase management efficiency transport and logistics systems for the supply of perishable food products.

Based on this, we propose to combine certain technologies into a single constantly managed temperature-time logistics system (PKTCHLS), which will contribute to greater efficiency in maintaining the quality of perishable food products throughout the supply chain.

From our previous research, we were able to see that in most cases, modern logistics management of perishable food supply systems involves temperature control and regulation, which focuses on simply tracking product temperature in the logistics chain rather than processing multiple channels and managing each one individually. of them.

To overcome the above shortcomings, we propose to use a system based on the architecture of the Internet of Things (IoT) and the International Standard for Food Safety TV (ISO 22000) (figure 3.1).

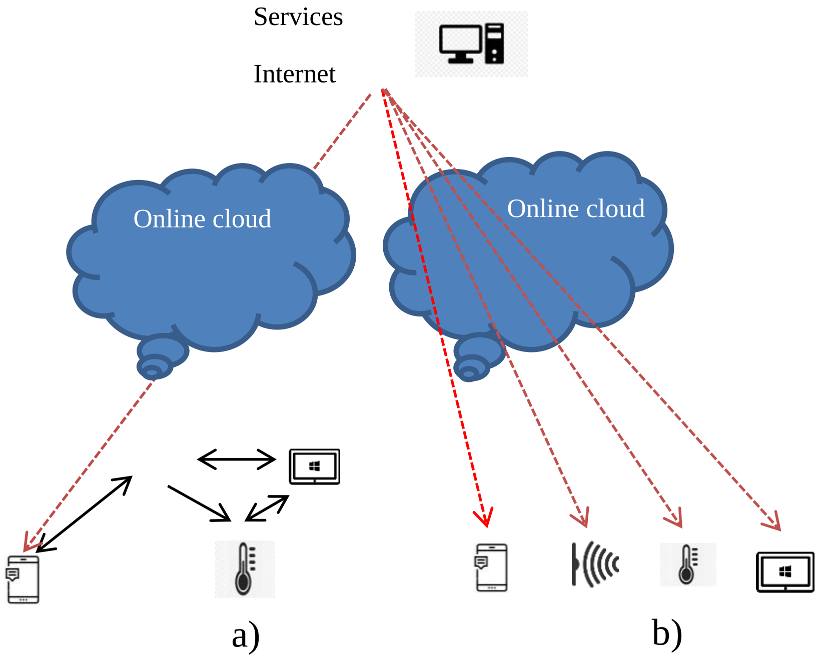


**Fig. 3.1** Scheme of organization of tracking the process of transportation of goods using IoT technology built on the basis of temperature-time indicator (TCHI): a) collection of temperature data; b) criteria for critical control points.

*Source*: built by the authors

It is based on a temperature-time indicator (TCHI), which uses wireless sensors to collect temperature data throughout the supply chain (from refrigerated storage to retail) (Figure 3.1a) and implements the criteria for critical quality control checkpoints ) during the supply process (figure 3.1b).

Based on the results of constant and careful monitoring of food temperature, control charts are created for each process point, which allows to transfer some products from frozen storage to refrigerated, to overcome the shortcomings associated with frozen storage (high energy consumption, deteriorating taste, limited sales).

Also how we mentioned earlier that the management of perishable food supply chains is related to temperature monitoring at each stage: during production, storage and transportation at the internal and interoperable levels.

And since there is a direct dependence of changes in quality on changes in temperature conditions, it is important not only to monitor the temperature regime, but also to monitor changes in product quality over time. Therefore, we propose to take the concept of "constantly managed temperature-time logistics system PKTCHLS "Controlled Quality Logistics"(QCL), proposed by Van der Worst and colleagues[1]. In it, they hypothesize that if the quality of perishable food at each stage of the supply chain can be predicted in advance, the flow of goods can be proactively controlled and better logistics chain schemes can be created to maintain quality, increase product availability and reduce losses. According to this hypothesis, they built a structure consisting of six elements that contribute to the successful implementation of QCL:

1. Consumer preferences and the period of acceptance of product quality attributes.

2. Critical Quality Scores (CQP).

3. Measurement and forecasting of product quality.

4. Logging and information exchange.

5. Local dynamic / adaptive logistics and quality control.

6. Supply Chain Management (SCM).

Under this structure, the model of constantly controlled temperature-time logistics system PKTCHLS, will havetwo starting points (figure 3.2).

On the one hand, the transport and logistics system of perishable food supplies, starting from the field (farm) where there is a product with a set of certain characteristics (quality characteristics, shelf life, volume and location), information about which comes directly to all participants in the supply chain. Theoretically, this is described as the registration and exchange of information

[1]Van der Vorst, J., Van Kooten, O., & Luning, P. Towards a diagnostic instrument to identify improvement opportunities for quality controlled logistics in agrifood supply chain networks. International Journal on Food System Dynamics, 2011. 2 (1), 94-105. URL. http://centmapress.ilb.uni-bonn.de/ojs/index.php/fsd/article/view/119

(I) passing from the field to the consumer through the producer, seller and transport company (T).

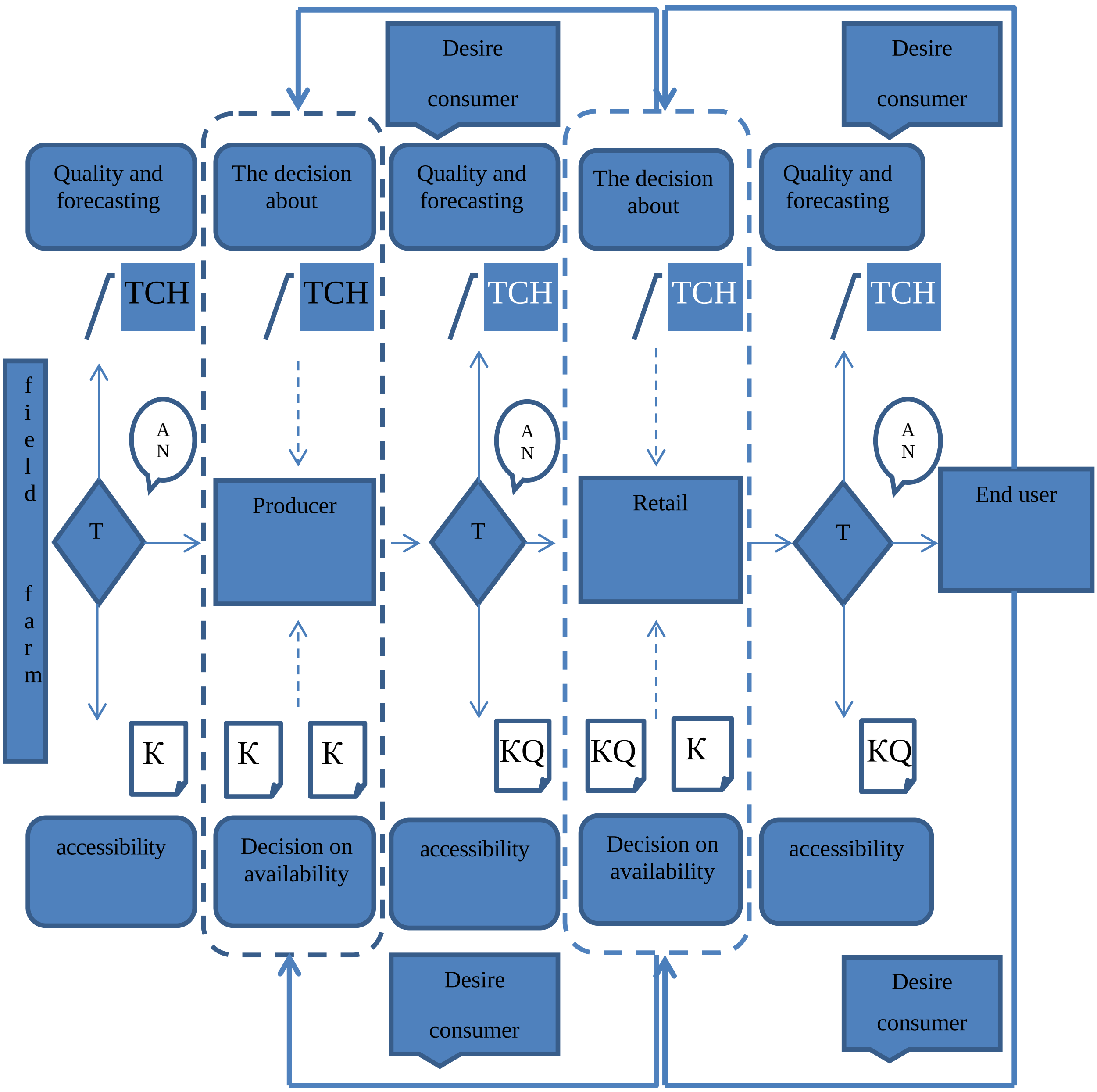


**Fig. 3.2** Application of QCL structure in PKTCHLS model

*Source:* built by the authors on the basisVan der Vorst, J., Van Kooten, O., & Luning, P. Towards a diagnostic instrument to identify improvement opportunities for quality controlled logistics in agrifood supply chain networks. International Journal on Food System Dynamics, 2011. 2 (1), 94-105. URL. http://centmapress.ilb.uni-bonn.de/ojs/index.php/fsd/article/view/119

On the other hand, the end consumer, who shares with the seller his desires for the quality characteristics of the product, which are theoretically defined as consumer preferences that form the main attributes of the product. These consumer requirements are passed from link to link in the supply chain. Therefore, all its participants have information about the characteristics of the product and customer requirements.

Exchange of information received from the temperature-time indicator (TCHI), in our proposed model PKTCHLS carried out in two directions:

1) between participants in the supply chain (thick arrows). This information influences decisions on product quality control (status for a specific period of time) and decisions on general logistics (storage temperature, required volumes and places of delivery);

2) the participants in the supply chain (thin arrows). This information influences decisions on quality control (solid lines) and local or dynamic logistics (dotted lines) – schedules and delivery times, transfer of products from frozen to refrigerated storage or vice versa, which can be done at each stage PKTCHLS perishable foods.

Finally, each participant in the process of promoting the product in the supply chain changes it and releases its final product, which is also characterized by its quality and availability. Accordingly, critical quality control points (QCs) should be distributed at all stages of supply. They may be at the reception of raw materials, during processing and/or before shipment. And because product quality is understood as a dynamic variable, batch flow is not linear, as shown in figure 3.2, it changes as we measure the quality of the product and predict its shelf life (figure 3.3).

Therefore, the relationship between temperature and food quality is extremely important for the control system.

<table>
<tr><td>Elements PKTLS</td><td colspan="3">Passive</td><td colspan="2">Combined</td><td colspan="3">Active</td></tr>
<tr><td>Transport</td><td colspan="2">Delivery time planning and control</td><td>Isothermal</td><td colspan="2" rowspan="2">Pre-cooling, additional cooling elements (dry ice, eutectic plates, etc.)</td><td colspan="2">Maintaining the required temperature in the body</td><td>Refrigerator</td></tr>
<tr><td>Transport packing</td><td colspan="2">Temperature screening</td><td>Isothermal</td><td colspan="2">Maintaining the required temperature product</td><td>Isothermal with active cooling</td></tr>
<tr><td rowspan="2">Control of parameters</td><td colspan="4">Disposable color-changing indicators</td><td colspan="4">Local temperature control and regulation</td></tr>
<tr><td colspan="4">Sensors with active alert</td><td colspan="4">Remote control and regulation of temperature</td></tr>
<tr><td>Monitoring of movements</td><td colspan="2">Monitoring the route at checkpoints</td><td>Recording the route in the GPS module memory</td><td colspan="2">GPS route control in real time</td><td colspan="3">Real-time route control</td></tr>
<tr><td rowspan="3">Data storage and processing</td><td colspan="8">Data collection and storage systems</td></tr>
<tr><td colspan="8">Software for data storage and processing</td></tr>
<tr><td colspan="8">Data security systems</td></tr>
<tr><td colspan="9"></td></tr>
<tr><td colspan="2">Transport management system</td><td colspan="2">Quality management system</td><td colspan="3">Risk management system</td><td colspan="2">Warehouse management system</td></tr>
</table>

**Fig. 3.3** General scheme constantly controlled temperature-time logistics system

*Source:* compiled by the authors

In general, the degree and rate of deterioration of products during storage (or transportation) depends on the storage time, storage temperature and various constants (eg, activation energy or gas constant). It is also necessary to monitor products throughout their life cycle to determine real-time quality status. To achieve these goals, M. Aung proposed the following scheme, called Smart Cold Chain Management (SCCM), shown in figure 3.4.

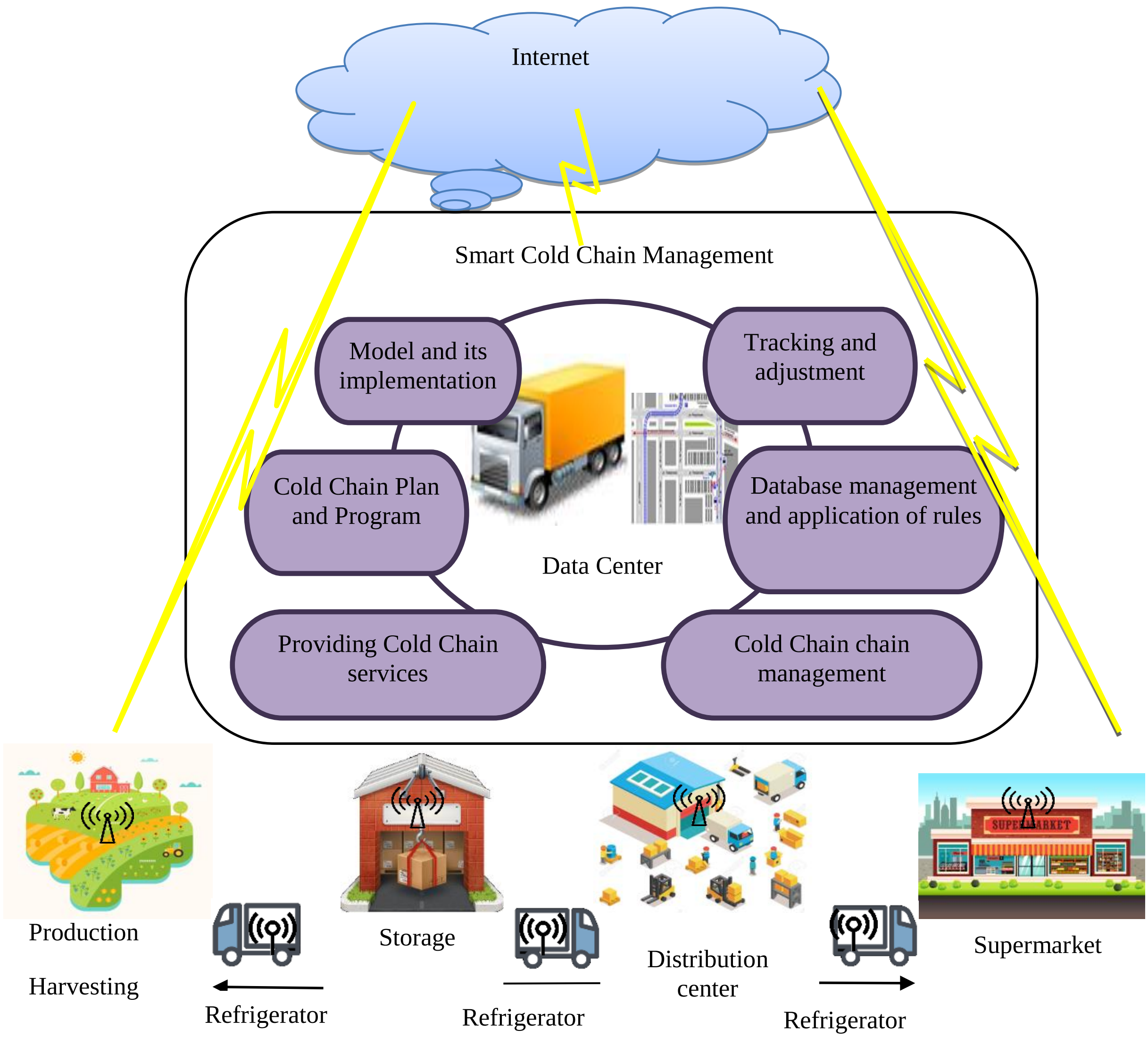


**Fig. 3.4** Smart Cold Chain Management Scheme (SCCM)

*Source:* Aung M., Chang Y. Temperature management for the quality assurance of a perishable food supply chain. Food Control. Elsevier, 2014. 40. 198-207.

According to this scheme, each unit of product has an RFID tag attached to it, and a wireless sensor network is applied to each object of the Cold Chain chain (for example, in a container, warehouse, refrigerator, etc.). The SCCM system needs to integrate product information from the RFID system and related data collected from the network. Therefore, all monitoring data is stored in a central database in the Data Center for processing and obtaining any product information at each stage of the network via the Internet.

Because all participants are responsible for maintaining quality and value in the supply chain, the SCCM system must support all operations required for a sustainable Cold Chain chain, from planning to final delivery of the product to operators and customers. Using this structure, tracking and recording temperature history and related product quality information can be achieved both online and offline.

Inclusion of the scheme Smart Cold Chain Management (SCCM) to our offerconstantly controlled temperature and time logistics system PKTCHLS Nwill provide an opportunity to build an integrated decision support system for shelf life of perishable foods based on wireless sensor network (WSN).

Such a system will be implemented based on a combination of WSN functions, temperature-time indicator (TCI), critical quality control point (QC) systems, route optimization devices and specialized vehicles. Compared to traditional cold chain management methods previously used, PKTCHLS not only bridges the information gap between different companies in the stages of promotion of perishable food products in the supply chain and provides a continuous flow of information on it, but also allows companies involved in such a chain. Supplies predict the shelf life of perishable products and helps develop a smart strategy to reduce losses and economic losses.

However, the logistics of distribution of perishable food products due to the constraints associated with perishable characteristics, a priori has a lower efficiency than the logistics of distribution in general. And as we noted in previous sections, a large amount of fresh food does not reach the end user, either because of the actual spoilage or because of its imperfect condition.

in addition for food the more attractive to consumers, the less time has passed since the date of their production. In other words, people often prefer "fresh" foods to "dependent" ones. In such circumstances, the ideal logistical principle would not be "JIT - just in time ", and" as quickly as possible "at all stages of supply of perishable food products.

Applying this principle, stocks of products are transferred from assets to liabilities and all efforts are focused on their faster advancement in the chain to the final consumer and sales. Thus, the size of the stock should be determined only by the current needs of retailers. This principle will not tolerate production errors, requires additional costs to ensure the rhythm of supply, production and sales, but increasing product quality will have a positive impact on sales and ultimately be able to bring the supply chain above competitors with a reputation as a reliable company.

However, the consumer is the final link PKTCHLS and formsbasic product attributes in addition to basic consumer characteristics has and economic characteristics, namely consumer capacity. Therefore, when choosing a product, in addition to quality characteristics, always take into account the price, and for the same quality will always give preference to a product with a lower price (especially for countries with low living standards). Therefore, the organization of transport and logistics systems for the supply of perishable food products is a natural compromise between efficiency and freshness.

And given that the deterioration process is unique to each type of product, the joint use of several types of products during transportation is not yet possible, at least quite difficult. After all, fortransportation of groupage consignments, they can have different temperatures from - 20 °C to + 20 °C. Most refrigeration devices on refrigerated vehicles are designed only to maintain the temperature in the range of +2 ... + 4 °C and are not able to cool «warm» goods. Accordingly, it is necessary to separate such goods or special insulated partitions, or transported in separate rolling stock, which in turn increases the cost of goods.

Next, for example, we will consider the problems associated with the organization of supply of dairy products, most of the names of which require strict temperature from + 4 °C to + 6 °C at all stages of product promotion in the supply chain from farm to end consumer. However, there are some for which this interval is not critical and they can be stored at a temperature of + 20 °C, such as ultra-pasteurized milk, condensed milk with sugar and the like.

In accordance Customers when ordering, to reduce the cost of the transport component, often require the supply of a variety of products, including all categories of dairy products by temperature. This means that in the future, both refrigerated and unrefrigerated goods will be loaded into one refrigerator car. And because most refrigerators only have enough power to keep the body temperature low, they can't cope with the heat from uncooled products, resulting in heating of air and products that require cooling. When accepting such a consignment of goods in the customer's warehouse there are problems, as the temperature of delivery is violated, respectively, the goods may not be accepted and the car will be sent back to the manufacturer.

Even if the results of the examination of this batch are then satisfactory at the enterprise, in the future this batch may be difficult to implement, because the implementation period remaining after all measures is too short.

Given this, we offer for supply of dairy and similar products over long distances in PKTCHLS use intermediate cooling warehouses on the way of the car to reduce the temperature of the product. Then during the movement of the refrigerator the temperature in the body can rise from the minimum allowable value of + 2 °C to the maximum + 6 °C. At a certain place, the refrigerator arrives at the intermediate cooling warehouse, the products are unloaded, cooled back to + 2 °C and then reloaded on the refrigerator and the further movement of the vehicle continues.In this way, it is possible to reduce the cost of transportation, as it will be possible to transport prefabricated consignments of perishable foodstuffs that have different temperatures and use the car's cooling device not at full capacity.

The pattern that allows you to assess the feasibility of using intermediate compounds is as follows:

$$\Sigma C = L \cdot M \cdot S_{km} + \frac{L}{V_T} \cdot S_o(N) + N \cdot M \cdot C_p + N \cdot M \cdot t_{sr} \cdot S_{zb} + N \cdot M \cdot S_N + \\ + M \cdot (S_{pr} + L \cdot S_{km}) \cdot D(T_d) \quad (3.1)$$

where ∑C – total costs;

L – the distance between the manufacturer and the realtor;

M –weight of the consignment;

$S_{km}$ – the cost of 1 t.km of rolling stock;

$V_T$ – technical speed;

$S_o(N)$ – the cost of 1 hour of operation of the cooling device at a given capacity, inversely proportional to the number of intermediate compositions;

N – quantity intermediate warehouses on the way supply;

$C_p$ – the cost of unloading and Talman services 1 ton of products;

$t_{sr}$ – average time of cargo stay in the intermediate warehouse;

$S_{zb}$ – the cost of 1 hour of cargo storage;

$S_N$ – the cost of loading and preparatory work 1 ton of cargo;

$S_{pr}$ – the average cost of 1 ton of products in the party;

$D(T_d)$ – function of the dependence of the share of unsold products on the total delivery time. Here, the increase in the number of intermediate warehouses entails an increase in delivery time, and with it the share of unsold products.

The decision on the expediency of using this technology should be made according to the transport and logistics system of supply of each specific perishable food product.

Therefore, applying all the technologies we have previously defined, we will take into account a number of key factors when choosing the configuration of the permanently controlled temperature and logistics system PKTCHLS:

1) time and routes of deliveries;

2) volumes of cargo;

3) sensitivity of the product to changes in temperature;

4) the cost of risks of promotion of goods in the supply chain.

And given the fact that the elements of ensuring and controlling the modes of transportation of the cold supply chain of perishable food products are divided into three types: passive, active and combined systems, the general schemeconstantly controlled temperature-time logistics system can be, nfor example, such as shown in figure 3.5).

Elect for example passive profile PKTCHLS has significant limitations, he canbe used only on short supply routes of perishable food and only in the cold season, but it also has a number of advantages, such as minimal costs and no equipment requirements. As the profile becomes more complicated PKTCHLS (application active profile) transportation costs will increase, but this increase will be justified by improving the quality of transportation and reducing the risk of product damage.

In addition, we propose to use in the PKTCHLS to work with a unified blockchain platform, a system of "smart contracts" (Smart contract), which provides for the coding of the transaction only if it is approved by all participants by using the "signature share". In this case, to access the block, it is necessary to register all marked keys that have "signature shares" of this transaction[2].

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[2]Stathakopoulous C. and Cachin, C. Threshold signatures for Blockchain sys-tems. IBM Research. Zurich: Swiss Federal Institute of Technology, 2017. 42.

Christidis K. and Devetsikiotis, M. Blockchains and smart contracts for the in-ternet of things. Ieee Access, 2016. vol. 4, 2292–2303.

| Factors | Passive circuit PKTLS | | | |
|---|---|---|---|---|
| Sensitivity of cargo to the mode of transportation | Low | Average | High | |
| Volume of cargo | Box | Pallet | Not fully loaded | Full download |
| Delivery time | Not long | Average | Long | |
| The cost of risks of loss of product quality | Low | Average | High | |
| Vehicle type | Standard | Isothermal | Refrigerator | |
| Routing | Direct delivery | Cross-docking | Multimodal supply | Intermediate cooling compositions |
| Transport packing | Standard | Isothermal | Passive cooling | Active cooling |
| Control system | Missing | Disposable indicators on the package | Sensors in the middle of the body | Online monitoring |
| Supply chain reliability | Low | Average | High | |
| Supply chain costs | Low | Medium | High | |

**Fig. 3.5** Profil passive constantly controlled temperature-time logistics system

*Source:* compiled by the authors

A smart contract is a computer protocol designed to facilitate the verification, negotiation or execution of contracts in digital form without the involvement of third parties, such as a notary, broker, etc.[3]. Its application automatically ensures the fulfillment of obligations under the contract[4]. For example, a smart contract can automatically send a payment to the supplier immediately upon receipt of the shipment.

At the same time, the ability of the blockchain to guarantee the reliability, tracking and authenticity of information means a serious rethinking of the essence of supply chains and their management. In our opinion, the application of blockchain technologies and reasonable contracts in transport and logistics systems of perishable food supplies allows to identify and detail at least five key aspects of the product:

- character (what it is);
- quality (as it is);
- quantity (how many there are);
- location (where it is);
- property rights (to whom it currently belongs).

Thus, the blockchain eliminates the need for a reliable central organization (focus company) that supports this system and checks and monitors the continuous supply chain and transactions from raw materials to consumers[5].

Based on this, we propose for the SCTC to use a model of the perishable food supply chain, which includes blockchain technology to coordinate product tracking and "smart contracts" for fast and secure execution.

Its essence and difference is a special network configuration. Yes, the traditional supply chain model is usually linear. It starts with suppliers, subcontractors and manufacturers who manufacture and promote their products

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[3]Rosic A. Smart contracts: the Blockchain technology that will replace lawyers. Blockgeeks. 2017 URL: https://blockgeeks.com/guides/smart-contracts/

[4]Ream J., Chu Y. and Schatsky D. Upgrading Blockchains: smart contract use cases in industry. Deloltte Univercity Press, 2016, №. 02 (04), 1−11.

[5] Zagurskiy O., Titova L. «Problems and Prospects of Blockchain Technology Usage in Supply Chains» Journal of Automation and Information Sciences, 2019. Volume 11. 63-74. URL. http://www.dl.begellhouse.com/ru/journals/2b6239406278e43e,5c564c68149f41e1

and data to the next level of the chain. At the last level are retailers who sell products directly to consumers.

The main disadvantage of this model is that the data is centralized in each of the elements of the supply chain and other elements can not see either the transactions occurring in it or the state of the product at different links in the chain, much less affect them. Accordingly, the consumer is not able to verify the accuracy of information about the goods he buys (origin, storage, transportation, etc.).

With the addition of blockchain technology in the PKTCHLS of perishable food supplies (Figure 3.6), the model changes from linear to network. Now all participants store all their transactions using blockchain technology, which on the one hand improves transparency and confidentiality, and on the other hand increases their security. This model corrects the shortcomings of the traditional supply chain. In it, all data is decentralized and each participant can get important information in the blockchain. For example, the manufacturer may view information about the quality of the supplier's products or take information about the reliability of the carrier. In addition tocombined with Internet of Things (IoT) technology and smart contracts sothe technology can be efficient enough to manage international perishable food supply chains. In this case, Blockchain technology will not only be a means of tracking and controlling supply chains, but also full management[6].

The advantage of this model over the linear one is that all products are closely monitored using blockchain technology, and this can give end consumers confidence in their origin, whether they are recycled or used for the first time. Using blockchain technology, the participants of the PKTCHLS of perishable food supplies seem to hint that they are running a legitimate business and meet certain quality standards that consumers expect from them.

[6]Xu L., Chen L., Gao Z., Chang Y., Iakovou E., Shi W. Binding the physical and cyber worlds: a Blockchain approach for cargo supply chain security enhancement. IEEE International Symposium on Technologies for Homeland Security (HST), Woburn. 2018. 1-5.

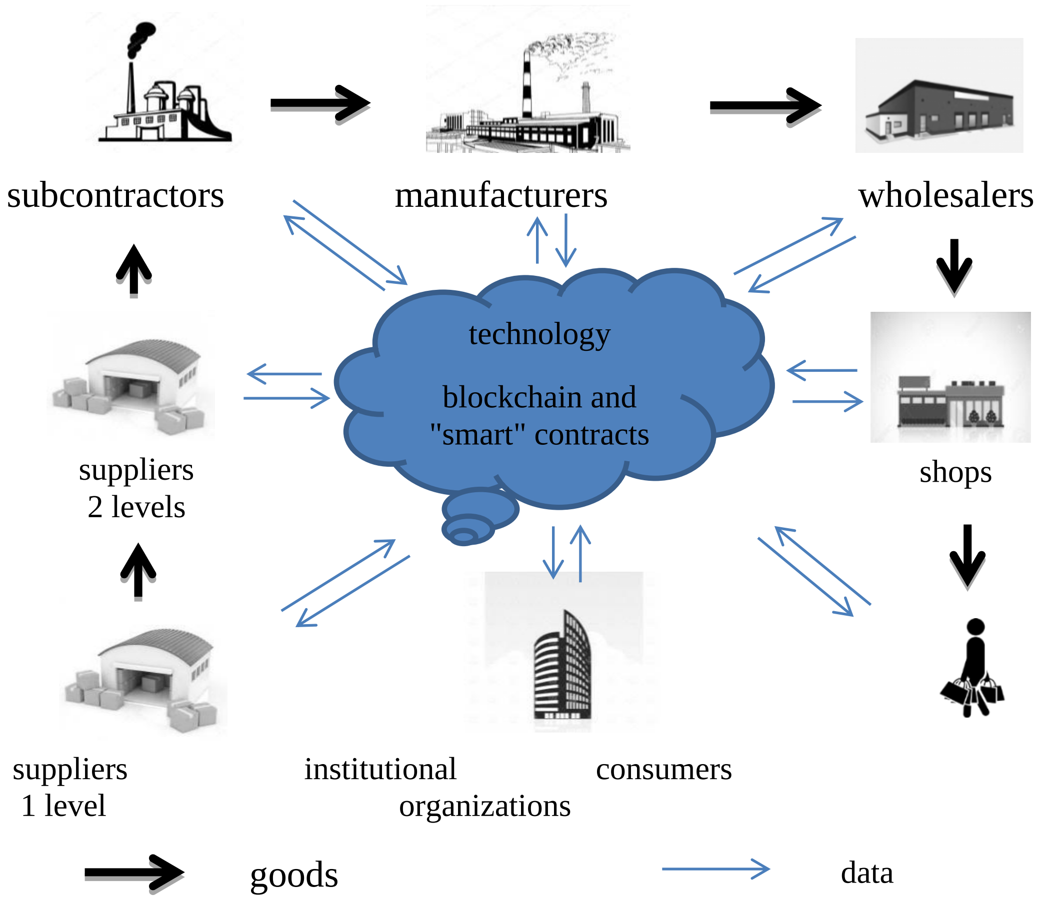


**Fig. 3.6** Scheme of work PKTCHLS with the inclusion of blockchain technology

*Source*: built by the authors

The ability to track the history of a transaction from sender to consumer throughout the supply chain is crucial, especially when there is a problem with trust[7]. Accordingly, the use of blockchain technology can increase competitive advantage and reduce risk by increasing the reliability of information about the participants in the supply chain, especially when two entities carry out such an operation for the first time.

[7]Zagurskiy O., Zahurska S., Titova L., Rogovskii I. Of blockchain-technology usage in supply chains / Socio-economic development of the regions in conditions of transformation. Monograph. Opole: The Academy of Management and Administration in Opole, 2020. 13-22.

### 3.2 Modeling of routes of transport and logistics system of perishable food supplies

The second most important indicator that affects the quality characteristics of perishable foodsthere is time in the model of constantly controlled temperature-time logistics system (PKTCHLS). Therefore, in this section attention will be paid to the improvement of transport technologies according to this criterion.

From the point of view of preserving the quality of perishable food, one of the important transport concepts is "Routing and Vehicle Planning (VRSP)", ie finding the most optimal routes and vehicles for transporting this group of goods. But as noted by Spliet R.Gabor A., Dekker R. VRSP conceptit's not just about finding the best routes - it is more a search for a new timetable for a group of vehicles that not only minimizes the overall transport costs of the supply chain, but also minimizes the cost of deviating from the original transport schedule[8].

For her, the process of optimizing supply chains can be presented as finding the best option for the functioning of the transport and logistics system from the many possible resources available. And for the process of optimizing the transport and logistics system of perishable food supplies to take place, it is necessary to clearly understand what and how to achieve in the end. After all, such optimizationcan help reduce overall transportation costs by about 2.7%[9].

That is, the "ideal" model should be set, which has already been created and tested in the management of other transport and logistics systems (methods of using best practices) or designed in "laboratory" conditions, to achieve the parameters of which must be sought. This "ideal" model of transport and

[8] Spliet R. Gabor A., Dekker R. The vehicle rescheduling problem, Computers & Operations Research, Volume 43, 2014, 129-136

[9] Marques A., Soares R., Santos MJ & Amorim P. 2020. "Integrated planning of inbound and outbound logistics with a Rich Vehicle Routing Problem with backhauls, "Omega, vol. 92 (C). URL. https://www.sciencedirect.com/science/article/pii/S0305048319300350

logistics system of perishable food products requires a single information system that manages orders in the expectation that:

- the time of the order execution cycle should be minimal due to deviations from the terms stated by the customer (ideally zero);

- the number of stocks in the transport and logistics system should be minimal (ideally zero);

- the impact of the human factor should be minimal;

- the use of environmentally efficient transportation technologies should be maximized.

Depending on the desired results, each optimization has its own goals. In the example shown in figure 3.7, the transport process is optimized so that there is a symbiosis of efficient, economic and environmental transportation of products.

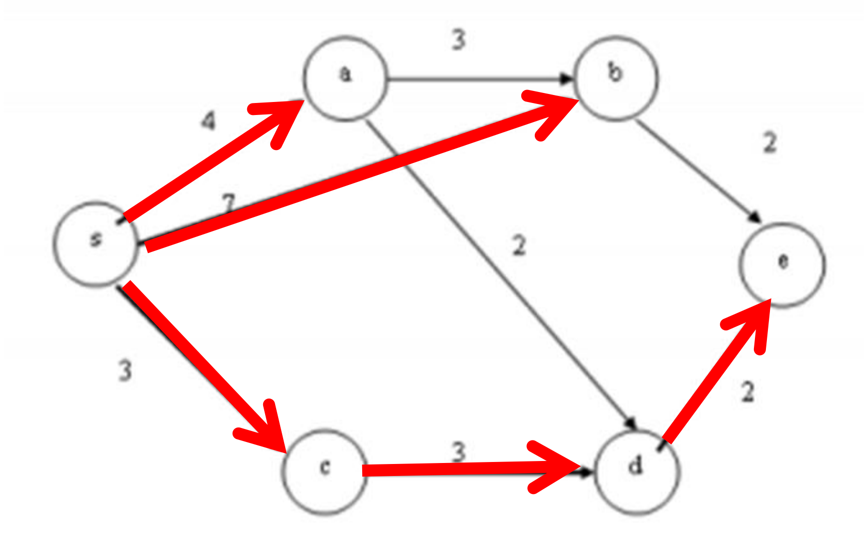


**Fig. 3.7** Optimized schedule of deliveries of goods

*Source*: compiled by the authors

It should be noted that the shortest path is the only one if the algorithm never has ambiguity in the choice of arcs. In this example, such ambiguity has arisen and accordingly there is an alternative solution:

$$(s, e) = \{(s, a), (a, d), (d, e)\} \tag{3.2}$$

That is, to fully implement the "ideal" model in practice is quite difficult, because in most cases it can not take into account all the real, and constantly changing, parameters of the external and internal business environment. Therefore, in order to get as close as possible to the parameters of the desired "ideal" model of transport and logistics system, it is necessary to be able to quickly and efficiently respond to increasingly complex consumer demands, but not lose the idea of balancing economic efficiency andquality transportation.

However, the problem of routing and vehicle planning (VRSP) is not just about determining routes and schedules for the fleet. Reducing the total distance traveled will in itself undoubtedly provide benefits by reducing fuel consumption and transportation time. However, the link between routing and vehicle emissions is less clear. For example, time spent in traffic jams by a vehicle will have a significant impact on the quality of perishable goods. Therefore, as L. Gurch notes, "the basis for solving the problems of optimizing the transport process is the development of a logistic concept of freight forwarding services, which is based on the routing of traffic"[10].

It is to determine the optimal (or suboptimal - not worse) solutions for which at constant (or close to them) costs, to maintain the quality of food transported.

These include:

- consolidation of cargo, especially for the transportation of goods in small batches ("Less-Than-Truckload" (LTL);

- exclusion from the transport system of intermediate transshipment points;

- routing associated with the calculation of the time spent on the road to avoid traffic jams and congestion.

[10] Gurch L.M. Transportation routing using the latest technologies. Bulletin of the National University "Lviv Polytechnic". Logistics. 2016. № 846. 48–53.

Let us dwell in more detail on the most significant of them.

Consolidation, for Less-Than-Truckload (LTL).

With this technology, small loads are combined with larger ones to achieve scale efficiency for long-distance transportation. The disadvantage of such transportation is that it takes time to consolidate cargo, which means that it is more difficult to plan such operations on time in terms of the availability of the necessary equipment and vehicles. But last but not least, there is the strategic choice of perishable delivery time, where the fastest choice is faster transport (such as air, not car) and reduced consolidation (ie waiting for another load). In fact, the fastest type of delivery is one courier, which accompanies a unique cargo, but it is also the most expensive, so it is unlikely (except for some of the most expensive foods – caviar, seafood.

Express carriers also specialize in reliable (guaranteed) transport time. Guaranteed delivery time can be achieved only by performing the planned work on schedule. Within the express business, there is a difference between B2B business for business and B2C business for customer. The latter are more complex, especially in the last mile delivery phase, which is essentially more costly as customers may not be at home and the address may be harder to find. T. Kull, K. Boyer[11] researching last mile supply – the part of the supply chain that directly supplies products to the end customer – proposes to apply consolidation concepts to last mile transport. For example, delivery of packages in city centers (post offices, retail stores, etc.), where customers can pick up their package using a unique PIN code. This avoids repeated attempts at delivery, which consumers do not have at home and, accordingly, product losses from exceeding the delivery time.

Instead, X. Cai, J. Chen, Y. Xiao, X. Xu, G. Yu are advised to include 3PL suppliers in the supply chain in order to maintain the quality of perishable

[11]Kull, TJ, Boyer, K., 2007. Last-mile supply chain efficiency: an analysis of learning curves in online ordering. International Journal of Operations & Production Management 27, 409.

food products. According to the authors, the increase in the efficiency of such a chain will be through the incentive scheme for coordination.

In them, the supply scheme consists of two contracts, including a wholesale market clearance contract (WMC) between the manufacturer and the distributor and a wholesale price and discount distribution contract (WDS) between the manufacturer and the 3PL supplier. The proposed contracts could eliminate the two sources of "double marginalization" that exist in the three-tier supply chain and encourage the three parties to act in a coordinated manner[12].

Thus, intermediate transport concepts are returning to the urban logistics of perishable goods, where they have a number of advantages. First of all, urban transport requires other vehicles (smaller and less polluting, such as electric) than mainstream transport, as large trucks are more cost-effective and less environmentally friendly. In addition, improving the efficiency of consolidation can also be achieved by combining shipments from different suppliers to neighboring stores.

Another concept that to some extent contradicts the previous concept of consolidation cargo, but by reducing the delivery time significantly affects the preservation of the quality and safety of perishable food, there is a concept exclusion from the transport system of intermediate transshipment points.

It involves the use of direct deliveries (pendulum routes) versus complex deliveries (ring routes) in which several customers are served by one route.

Complex deliveries are usually more efficient in the case of small customer orders located close to each other. Shipments can be combined and increased, so more efficient transport units can be used. This also creates some inefficiencies, as the cargo usually travels longer before reaching its destination. Planning direct traffic is easier than indirect, because in the latter schedules must be agreed to ensure uninterrupted communication.

[12] Xiaoqiang Cai, Jian Chen, Yongbo Xiao, Xiaolin Xu, Gang Yu, Fresh-product supply chain management with logistics outsourcing, Omega, Volume 41, Issue 4, 2013, 752-765

Taking into account certain concepts and methods, we will build an economic-mathematical model of routing constantly controlled temperature-time logistics system (PKTCHLS) in time. In herthe task of building a model of transportation is the optimal routing of the fleet of vehicles of fixed capacity for the supply of consolidated goods in a certain period of time.

Such optimization is determined by finding a solution that minimizes the number of used cars and the total travel time. Travel time is calculated by knowing the time of departure and an accurate estimate of the average speed of the car when driving on a certain route (arc). Thus minimizing the total travel time, the resulting solutions will direct vehicles to roads where they can move quickly instead of standing in traffic jams.

This problem can be solved by building efficient routes in the transport and logistics system. According to the principle formulated by Wardrop13any transport system over time comes into equilibrium, and the travel time on all selected routes is the same for all road users and less time spent by any road user changing their route. Accordingly, in each transport and logistics system, independently of the others, a decision is made on the route chosen in order to reduce transportation costs. The distribution of flow over a network that satisfies this principle is called competitive equilibrium. The desired equilibrium is achieved when none of the competing transport and logistics systems can reduce their costs of moving goods.

A convenient apparatus for building models of transport and logistics systems is graph theory, which allows the use of modern techniques in setting tasks for optimizing the processes of their operation and development. However, in In the process of compiling network graphics models, a situation may arise when the original graph of the model with the maximum level of detail of vertices and edges is very cumbersome and is described by a large matrix.

[13] Wardrop JG Some Theoretical Aspects of Road Traffic Research. Proceedings of the Institution of Civil Engineers, 1952. Part II, Volume I, 325-362.

Therefore, we at building an economic and mathematical model routing constantly controlled temperature-time logistics system (PKTCHLS) in time subsets of vertices and edges will be distinguished that are quite closely related to each other and have a limited number of connections with other subsets.

Based on this, we present the transport network in the form of an oriented graph (figure 3.8):

$$G = (V; E) \tag{3.3}$$

where: V – the set of sequentially numbered nodes of the graph;

E – the set of consecutively numbered arcs of the graph

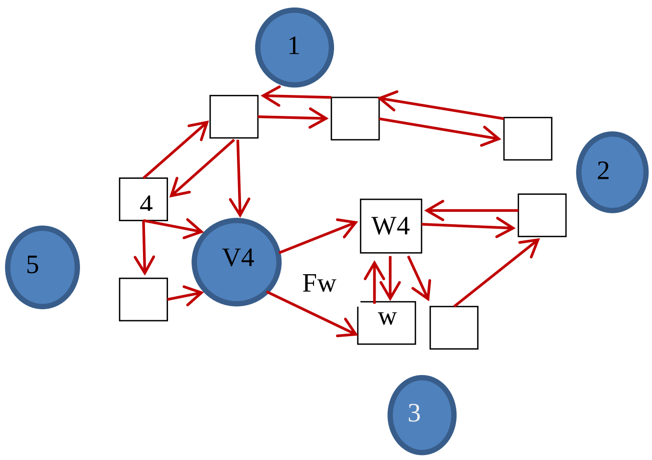


**Fig. 3.8** Oriented graph G of the transport network

*Source:* compiled by the authors

Let's denote by *W*many pairs of areas of departure / arrival of cargo. Then Rw is the set of routes between the pair w; he - transport flow along the arc e ϵ E; te (he) - time of advance along the arc e ϵ E. The traffic flow along the route r ϵ Rw is denoted by $\int_r^w$ , and aggregate transport demand between w ϵ W - Fw.

We derive a Boolean function that will show whether the edge e of the route r ϵ Rw

$$\delta_{e.r}^{w} = \begin{cases} 1, if\ \ curver\ e \text{ part of the route } R^{w} \\ 0, if\ \ not. \end{cases} \quad (3.4)$$

Mathematical formalization of the first principleWardrop is possible in the form of a mimicry problem with limitations

$$\sum_{r \in R^{w}} \oint_{r}^{w} = F^{w}, \ \ \forall_{w} \in W, \quad (3.5)$$

$$\oint_{r}^{w} \geq 0, \ \ \forall_{\kappa} \in R^{w}, \ \ w \in W, \quad (3.6)$$

by

$$x_{e} = \sum_{w \in W} \sum_{r \in R^{w}} \oint_{r}^{w} \delta_{e,r}^{w}, \ \ \forall_{e} \in E. \quad (3.7)$$

The target function, which corresponds to the competitive balance on the network, is as follows.

$$\min_{x} \sum_{e \in E} \int_{0}^{x_{e}} t_{e}(u) du, \quad (3.8)$$

where $t_e$ – the delay function of the volume flow xe on the edge e ϵ E. As the delay function we choose the BPR function[14].

$$t_{e}(x_{e}) = t_{e}^{0}(1 + \alpha_{e}(\frac{x_{e}}{c_{e}})^{\beta_{e}}), \quad (3.9)$$

where $t_{e}^{0}$ – time of free movement on the edge e;

$c_e$ – rib capacity e.

The problem of mimicry under the constraints of (3.5), (3.6) has the form:

$$T(\oint\ \ ) = \min_{x} \sum_{t \in E} \int_{0}^{x_{e}} t_{e}^{0}(1 + \alpha_{e}(\frac{u}{c_{e}})^{\beta_{e}}) du. \quad (3.10)$$

Solving such an optimization problem, we obtain the vector x distribution of traffic flows along the edges of the oriented graph G. Using the delay functions given on the edges of the graph, we can calculate the travel time on

[14] Wardrop JG Some Theoretical Aspects of Road Traffic Research. Proceedings of the Institution of Civil Engineers, 1952. Part II, Volume I, 325-362.

any of the edges e ϵ E. Next, we apply the Dijkstra[15] by which we find the shortest paths from one vertex of the graph to all the others.

The main goal of such optimization is to find a route plan for cars (ie many routes for each vehicle involved in the supply chain), which meets the requirements and demand of customers and does not violate the restrictions imposed on variables. At the same time, the total time spent by all cars on the road should be minimal.

Next we will carry out routing constantly controlled temperature-time logistics system (PKTCHLS), which is associated with the calculation of the time spent on the road, to avoid traffic jams and congestion.

For a comprehensive solution to this problem, an approach based on the methods of dynamic programming and simulation is usually used.

In the column (figure 3.9), the vertices (marked by circles) represent the objects (neighborhoods of the city) to which perishable food products will be supplied. They have an internal structure, enough are closely related to each other and have a limited number of connections with others. The parameters of these objects determine the level of traffic between them and, accordingly, the traffic load on the highways. Each such object has its own system of inputs and outputs, and the total incoming traffic is not equal to the outgoing.

The second type of vertex, marked with squares, specifies the function of traffic management and routing. The red solid lines indicate the existing transport connections, and the black dotted lines indicate those that are proposed to be established to reduce the load on the city center. The sum of traffic at all entrances and exits of such peaks, for a certain period of time – T (management period), should be zero.

[15] Dijkstra EWA note on two problems in connection with graphs. Number. Math.Springer-Verlag, 1959. Vol. 1, Iss. 1. 269-271.

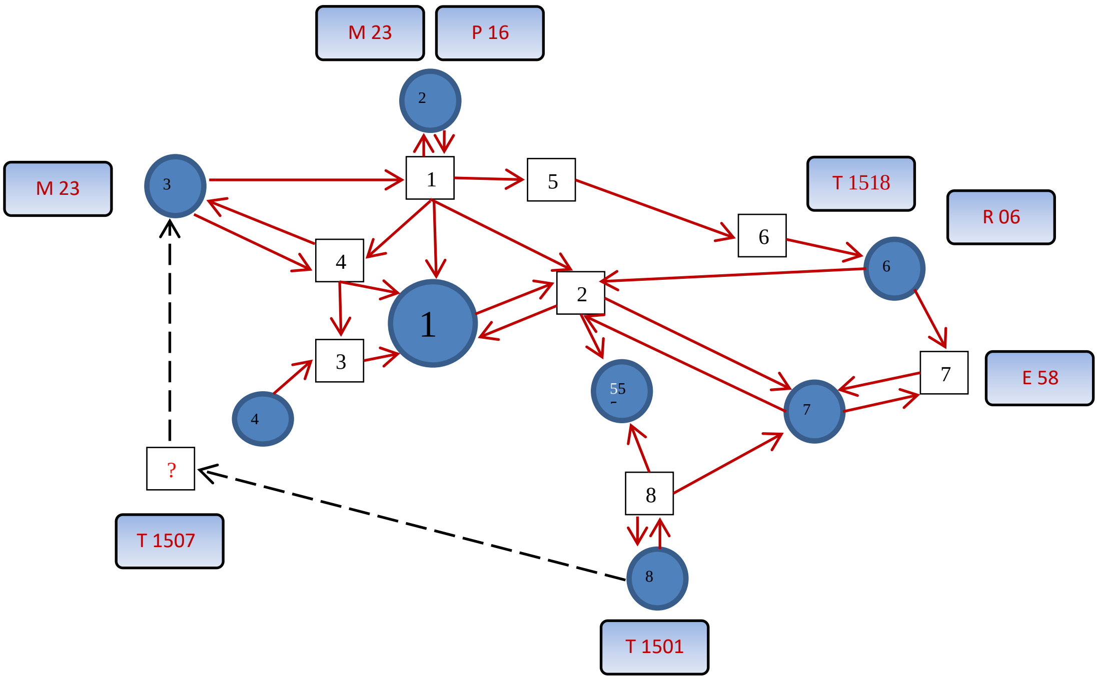


**Fig. 3.9** Example of a graph of the city transport network

*Source:* compiled by the authors

Each such vertex is given by a control function, which is ideally periodic in time, but in the general case, the control period can be a discrete function of time. The topology is given by the system matrix of connectivity.

$$K = \sum_{i=1}^{n} m_i + M \qquad (3.11)$$

where n – the number of cluster vertices;

$m_i$ – the degree of the vertex;

M – the number of routing nodes

In the considered model, the edges of the graph are sections (races) of roads (streets) of city, district or regional significance, which do not contain intersections, traffic lights and entrances and exits. It is assumed that the movement in these areas is limited only by the properties of the vertices, which are connected by this edge and the parameters of the highway.

That is, we will assume that the weight parameters of the edges in this interval do not change. Let's go on, vector $\vec{R}_{ij}$ a set of independent parameters of the highway between the vertices (i, j). Under the system of independent parameters we will understand a set of such characteristics of an edge which cannot be expressed through others.

Thus, with respect to the graph (figure 3.9), the components of the vector $\vec{R}_{ij}$ will be a set of matrices, the dimension of which is determined by the dimension of the connectivity matrix. Then to describe the transport-distributed system of the city, this vector can be represented as follows:

$$R_{ij} = R(L_{ij}, P_{ij}, V_{ij}) \tag{3.12}$$

where $L_{ij}$ – matrix of lengths of sections (races) between the vertices (i, j);

$P_{ij}$ – a matrix that characterizes the capacity of the highway from the vertex i to the vertex j;

$V_{ij}$ – a matrix of speed limits on a given section of road.

These parameters are basic for this model in the sense that they can be considered constant over a significant period of time. With their help, the limit characteristics for compiling constraint matrices can be calculated. For example, the minimum time interval of the vehicle on the highway (i, j) can be calculated by the formula:

$$t_{ij} = {L_{ij}}/{V_{ij}}\,. \tag{3.13}$$

Also, certain parameters will help in choosing the manufacturers that provide the best price-time-distance combination for purchase.

If we further enter the parameters of filling the road with vehicles, we will be able to calculate the maximum number of vehicles that can be on the track at the same time. To do this, suppose that $l_k, k = 1,..., r$ a set of dimensions of vehicles moving in the village. AND $r_{ij}^k$ – the probability that a vehicle moving in the direction (i, j) has dimensions $l_k$. Then the average length of the vehicle, taking into account the interval of movement $\Delta$, in the direction (i, j) can be calculated by the formula:

$$\bar{l}_{ij} = \frac{1}{r}\sum_{k=1}^{r} r_{ij}^{k} l_k + \Delta \,. \tag{3.14}$$

Accordingly, the maximum number of vehicles that can be on the highway at the same time (i, j):

$$g_{ij} = L_{ij} P_{ij} / \bar{l}_{ij} \,. \tag{3.15}$$

Similarly, you can enter many other parameters needed to solve a specific problem in the transport and logistics system of perishable food supplies.

However, as we noted in previous sections, the difficulty of building an effective model of transport and logistics system of perishable food supplies is to find the best option for its operation from the many possible, given that: the order cycle time the number of stocks in the transport and logistics system must be the minimum allowable.

The task is to combine the optimal logistics processes with the optimal number of products the size of which is determined by the current needs of retail customers, ie in balancing the cost of supply with the cost of storage.

Optimization of the proportions between these two groups of costs according to Wilson's formula[16] is achieved at the optimal average volume of the supply party.

$$EOQ = \sqrt{\frac{2 \times D \times C}{Z_{xp}^{1}}}\,, \tag{3.16}$$

where EOQ – the optimal average volume of the supply of raw materials, materials, etc.;

*D* – volume of production consumption of raw materials for the period;

*C* – the average cost of placing one order for the supply of raw materials;

$Z_{xp}^{1}$ – the average cost of storage of a unit of inventory for the period.

[16]Wilson, RHA Scientific Routine for Stock Control. Harvard Business Review. 1934. 13: 116-128.

The disadvantage of this model is a rather rigid system of input prerequisites, in particular, the following assumptions are made: demand for products is known, uniform and constant; shortage of products is not allowed; receipt of goods is instantaneous[17]. These assumptions are not so critical for practice, and they can be bypassed if desired, without developing special modifications.

But in addition to them, the classical model has another significant drawback due to the fact that a number of variables that it takes into account is too small and does not meet modern business requirements. However, this shortcoming has been offset by repeated modifications of the EOQ model by various authors, in order to take into account many additional factors due to market development. And corporations with large supply chains and high variable costs use this algorithm in their computer software to determine the optimal economic size of the order. Moreover, there are already some modifications of EOQ models[18], which allow to take into account the factors of carrying capacity / carrying capacity of vehicles and discounts on the organization of deliveries depending on the size of the container when calculating the parameters of the economic size of the order.

Therefore, in addition to the characteristics defined in the basic model of the optimal economic size of the order EOQ, a significant impact on the process of formation and delivery of the order have other indicators of transportation, namely: cost and productivity.

The cost is related to the route and the number of rides. It shows the effectiveness of using different models of rolling stock. Cost-effective and the best rolling stock in which this value will be minimal. The full cost of road

[17]Zagursky OM Supply chain management: textbook. way. Bila Tserkva: Belotserkivdruk LLC, 2018. 416.

[18]Knowlts TW, Panturnsinchai P. All-Units Discounts for Standard Container Sizes. Decision Sciences. 988. Vol. 19. N. 4. 848-857.
Lee, Chung-Yee The Economic Order Quantity for Freight Discount Costs IIE Transactions. 986. Vol. 3. 18-32.

transport includes the cost of transportation St, which are taken into account by trucking companies, the implementation of freight forwarding services Se, loading and unloading work Snr and road component Sa:

$$SP = St + Se + Snp + Sa \tag{3.17}$$

The cost of transportation St consists of the costs associated with the movement of the car and its downtime at the points of loading / unloading. can be written as:

$$S_T = \frac{\sum C_{v\ 1\ i}}{P_{iz}\,(W_{iz})}, \tag{3.18}$$

where $\sum C_{v\ 1\ i}$ – the amount of travel expenses;

$P_{iz}\,(W_{iz})$ – the volume of traffic or transport work performed per ride.

The amount of travel expenses consists of variable and fixed costs.

$$\sum C_{v\ 1\ i} = \sum Cz + \sum Cp. \tag{3.19}$$

$C_z$ and $C_p$ depend on the load capacity of the car. These dependencies are linear and have the form:

$$Cz = az + bz \times q \times \gamma_{CT}; \tag{3.20}$$

$$Cp = ap + bp \times q \times \gamma_{CT}. \tag{3.21}$$

where: az and ap – constant coefficients (parameters) of dependence Change = f (qγct);

*bz and bp* – constant coefficients (parameters) of dependence Spost = f (qγct);

*q* – load capacity of a motor vehicle, t;

$\gamma_{CT}$ – static capacity utilization factor of a motor vehicle.

Productivity, on the other hand, includes technical parameters of the route and is represented by such indicators as the average loading / unloading time, load capacity of vehicles, etc. It is calculated by the formula:

$$p = \frac{q_a \times y_c \times \beta \times V_{TA}}{L_{CA} + \beta \times V_{TA} \times t_{н/р}} \tag{3.22}$$

where: $q_a$ – load capacity of the car, t;

$y_s$ – coefficient of statistical load capacity;

β – mileage utilization factor (<= 1);

$V_{TA}$ – technical speed of the car, km / h;

$L_{CA}$ – planned distance of transportation, km;

$t_{n/p}$ – time of loading / unloading of the car, h.

Accordingly, if you know the type of goods, its volume and load capacity of the vehicle, you can calculate the average speed – $V_{TA}$ and loading / unloading time – $t_{n/p}$. Based on these data, you can estimate the delivery time (T) of one order

$$T = L / V_{TA} + t_{n/p} \qquad (3.23)$$

Based on the time of delivery, we obtain the size of the transport tariff in UAH. per hour. It should be noted that when transporting long distances, the transport component is especially important, as it can significantly exceed other components of the total cost of the supply chain (in some cases up to 50% of the cost of the product). Therefore, if the average cost of placing a single order for the supply of raw materials can be represented as the sum of the average operating costs of placing an order and the average logistics costs of transporting V, as a group of costs that are an integral part of any order, then the optimal batch size ( model EOQ) can be found by the formula:

$$EOQ = \sqrt{\frac{2 \times D \times (C_0 + C_m)}{Z^1_{xp}}}\ , \qquad (3.24)$$

The proposed approach allows to connect the components of the models of efficiency of management of perishable food stocks, in supply chains in particular the EOQ model with the productivity of the transport process and as a consequence to include in them the parameters of technical transportation:

$$C_m = 2y \times (\frac{L}{V_{cp}} + t_{н/p}) \times g = \frac{kygL}{V_{cp}} + kygt_{н/p} \qquad (3.25)$$

where y – mileage utilization factor;

k – number of rides per route;

g – tariff, UAH / year

The indicator Cm includes the product of transport work and transport tariff, which allows you to move to the economic and cost expression of the result. Transport work, in turn, is represented by such indicators as the average loading / unloading time and load capacity of vehicles. Thus, the formula for calculating transport costs (Cm) includes significant transportation parameters of a technical nature, which must be taken into account when planning the transport and logistics system and determining the optimal size of the order. Then when substituting formula 3.25 in formula 3.24 we obtain:

$$EOQ = \sqrt{\frac{2D(C_0 + \frac{kygL}{V_{cp}} + kegt_{н/р}}{Z^1_{xp}}} \qquad (3.26)$$

The resulting formula allows you to link transport costs with other types of costs, and in turn, the components of transport costs are reflected in the EOQ model.

According to the JIT concept, the calculation of the time to find the total duration of the voyage (taking into account the relevant operations: travel time, accumulation, loading and unloading, etc.) is carried out according to the formula:

$$T_0 = \sum_{r=1}^{N} \sum_{i=1}^{A} t_{r,i} + \sum_{r=1}^{N} \sum_{j=1}^{B} \tau_{r,j} + \sum_{r=1}^{N} \sum_{k=1}^{C} \theta_{r,k} + \sum_{r=1}^{N} \sum_{l=1}^{D} \varphi_{r,l} + \sum_{m=1}^{E} \psi_m + \sum_{n=1}^{F} \eta_n \qquad (3.27)$$

where: $t_{,\, i+1}$ – travel time between the i-th and (i + 1) -th points;

$\tau_j$ – time of registration of customs documents in the j-th point (within the country and at border crossings);

$\theta_k$ – time of loading, unloading and warehousing in the k-th point;

A, B, C – the number of sections of the vehicle and loading / unloading points, respectively;

$\varphi_l$ – random component that reflects the increase in flight time for maintenance work;

$\psi_m$ – a random component that reflects the restrictions associated with the mode of operation and rest of the crew;

$\eta_n$ – random component that reflects prohibitions on the movement of vehicles along the route (weekends, accidents, malfunctions, etc.);

D, E, F – the number of cases of vehicle downtime, taking into account the above reasons, respectively;

r – an index that reflects a certain type of transport for multimodal transport (for example, when using the route simultaneously road, rail and sea transport N = 3).

Given that in a particular model one of the components $\psi_m$ related to the peculiarities of the regime of work and rest of drivers (accumulation of time of the driver during the ride, which is a limitation for each day of movement of the vehicle during the flight), in our opinion, it should be limited by inequality

$$\sum t_{i,i+1} \le T_{up} \ . \qquad (3.28)$$

where $T_{up}$ – normalized duration of driving a vehicle per day ($T_{up}$ = 9 hours).

In addition, we must introduce restrictions on the duration of daily rest Tweed

$$\sum t_{i,i+1} + \tau_i + \theta_\kappa + \varphi_l + \eta_n \le 24 - T_{cd} \qquad (3.29)$$

In which the statistical parameters of the cycle – time and standard deviation – are determined by the formulas:

$$\bar{T} = \sum_{i=1}^{N} \bar{T_i} \ , \qquad (3.30)$$

$$\sigma_T = \sqrt{\sum_{i=1}^{N} \sigma_i^2 + 2\sum_{i \le j} r_{ij}\sigma_i\sigma_j} \ , \qquad (3.31)$$

where $\bar{T}$ – the average value of the operation time of the i-th cycle;

$\sigma_T$ – root mean square deviation of the operation time of the i-th cycle;

$r_{ij}$ – correlation coefficient between the i-th and j-th operations of the cycle.

Our refinements for the model of estimating the performance of transport operations according to the JIT allow us to obtain more accurate data on the total total time of transportation of perishable food products; probabilities of delivery or delivery time with a given probability. And the model built in this way allows to take into account all the variety of factors that affect the duration of transportation, which allows managers at the planning stage to assess all the threats and risks that could potentially face their designed transport and logistics system.

The extended model of determining the time of transportation for several modes of transport allows for an analytical assessment of the key indicator of transportation, namely the duration of logistics cycles and to make a competent decision based on calculations. Which in turn will allow to obtain probabilistic estimates of transport operations in accordance with the concepts of JIT. This model differs from the existing empirical approach in that it allows the decomposition of the transportation process into individual components, and describe them as independent elements using statistical parameters that can be monitored and predicted and adjusted in real time to preserve the quality of perishable foods.

## 3.3 Risk management in transport and logistics systems of perishable food supplies

The last impact indicatoron the efficiency of the constantly managed temperature-time logistics system (PKTCHLS) of perishable food supplies, which we will consider will be a risk. And the risk of loss is not onlyqualitative characteristics of perishable food products, or themselves in the process of advancing in the supply chain, as well as the risk of loss of health by consumers as a result of their use.

After all, the supply chaincharacteristics of perishable food products is a complex system, which operates in a dynamic and changing environment associated with uncertainty due to various factors (consumer preferences, fluctuations in demand for products, untimely and inaccurate transfer of information, changes in political, economic or natural conditions, etc.).

Thus, according to the American economist F. Knight, "we live in a world prone to change, in the realm of uncertainty. … We are not in complete ignorance, but we do not have complete and perfect information, and we have only partial knowledge"[19]. F. Knight regarded uncertainty as probabilityoccurrence of an event and suggested using the term "risk" to distinguish between measurable and immeasurable uncertainty. Risk applies to those cases where the distribution of results in the group is known through the study of statistics of previous experience or calculations.

There are a number of serious risks when dealing with perishable foods that can affect the entire logistics chain in some way. Therefore, it is important to focus on risk management to avoid or minimize the impact of risks on the supply chain. Thus, in a scientific article by G. Behzadi, M. O'Sullivan et al[20]. Two main types of risk strategies were discussed: rigid and flexible strategies.

A rigid strategy helps to avoid breaking the supply chain, while a flexible strategy helps to recover quickly in the event of a breakdown. However, these strategies are not interchangeable, and the design of SCTCs should be based on both rigid and flexible risk management planning strategies. The combination of flexible and rigid strategies is most effective in mitigating the risks associated with supplier actions.

[19]Knight F. H. Risk, uncertainty and profit trans. with English M : Delo, 2003., p. 195.

[20] Behzadi, O'Sullivan et al .: "Robust and resilient strategies for managing supply disruption in an agribusiness supply chain", International Journal of Production Economics, Elsevier, 2017. vol. 191 (C), pp. 207-220.

Therefore, to minimize the risk of perishable food supplies, the following solutions can be used, based on a combination of both strategies:

1. Reserve supplies – a flexible strategy that provides the ability to obtain supplies from one or more sources in the event of a chain failure. Backup supplies are used only in case of chain failure and failure.

2. Reducing the likelihood of failure is a tough strategy that reduces the likelihood of failure at vulnerable nodes in the supply chain. An example is a greenhouse in which high-tech planting and irrigation systems are installed in order to reduce the likelihood of product destruction by severe weather conditions.

3. Number of suppliers – a tough strategy that can reduce the risk of failure by using multiple suppliers or expanding the supply base to attract new suppliers to the logistics chain. In the event of a failure in the main supply hub, market demand can still be partially met by other suppliers.

4. Risk acceptance – a combination strategy that involves taking any action to mitigate the risks of chain failure and involves accepting the consequences of the risk. Such a strategy can be effective when implementing measures to avoid or reduce risks is more costly than the size of losses from the consequences of failures in perishable food supply chains.

The basic factors that characterize an integrated approach to risk management of transport and logistics systems include:

- basic structure of the management system;
- viability;
- stability;
- adaptation based on multilevel (multilayer risk).

The identified factors have a decisive influence on maintaining the working condition of the transport and logistics system and the possibility of its recovery after the violation of the regime of sustainable operation. We have studied them in detail in our previous work[21] so let's focus on the specific type of risk to a greater extent inherent transport and logistics systems for the supply of perishable food products, namely reputational risk, or the risk of loss of business reputation by a company (a group of companies included in the transport and logistics system).

First of all, we note that withame means the concept of pEputation is complex because each group of corporate audiences may have their own criteria for evaluating the activities of the organization. Thus, according to G. Dowling, "The organization does not have a single image or reputation - it has many"[22]. Accordingly, reputation is a variable characteristic of the organization's behavior, which as a result of its activities is formed in the public consciousness over a long period, especially in the food group, because their poor quality consumers have the most unpleasant risks associated with health loss.

Analysis of the scientific literature on the study of business reputation allows us to identify 3 key approaches to understanding it:

- reputation as an asset of the company (Goldberg[23], Mahon[24]);

- reputation as a set of valuation judgments (Dowling[25], Fombrun[26];

- reputation as a result of perception (a set of ideas and associations of stakeholders about the company) - Griffin[27], Stewart[28].

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[21]Zagurskyi O., Ohiienko M., Pokusa T., Zagurska S., Pokusa F., Titova L., Rogovskii I. Study of efficiency of transport processes of supply chains management under uncertainty. Monograph. Opole: The Academy of Management and Administration in Opole, 2020. 162.

[22]Dowling G. Reputation of the firm: creation, management and evaluation of efficiency. Moscow: Image-Contact Consulting Group: INFRA-M, 2003., p. 29.

[23]Goldberg AI, Cohen G., Fiegenbaum A. Reputation Building: Small Business Strategies for Successful Venture Development. Journal of Small Business Management, 2003, 41 (2), 168-187.

[24]Mahon JF Corporate Reputation: A Research Agenda Using Strategy and Stakeholder Literature. Business & Society, 41 (4), 2002, 415-446.

[25]Dowling G. Reputation of the firm: creation, management and evaluation of efficiency. Moscow: Image-Contact Consulting Group: INFRA-M, 2003. 368 p.

[26]Fombrun CJ, Cees BM van Riel Fame and Fortune: How Successful Companies Build Winning Reputation. 2004. New Jersey: Pearson Education. 304 p.

[27]Griffin E. Reputation risk management: Strategic campaign: lane. with English Moscow: Alpina Business Books, 2009. 237.

Noting that withname action, not communication, builds a strong business reputation transport and logistics system, in our opinion, the latter approach is more rational.

Business reputation largely depends on how ambitious the intentions of the organizers transport and logistics system / supply chain, predictability of its behavior and the probability of meeting the expectations of stakeholders in its activities. In this regard, G. Honey[29]notes that in the event of deviations of the actual state and actions of the organization from those expected by stakeholders there is a specific reputational risk. It is associated with potential mthe possibility of a loss of trust, authority, respect and loyalty to the organization by its stakeholders. Reputational risk accompanies the organization throughout its life cycle and is expressed in any action (inaction), event or circumstance that may damage the reputationorganizations. In essence "Reputational risk related to stakeholder relations management"[30].

The occurrence of reputational risk is due to the influence of internal and external factors. The first include the actions of the organization itself related to:

- non-compliance with current legislation;
- inconsistency of business practices with ethical norms accepted in society;
- violation of the principles of professional ethics;
- non-fulfillment of contractual obligations;
- lack of formalized mechanisms to avoid conflicts of interest between shareholders, managers and other stakeholders;
- shortcomings in personnel policy, which cause disloyalty of staff, low level of professionalism of employees, etc.

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[28]Stuart Toby E. Interorganizational Alliances and The performance of Firms: A Study of Growth and Innovation Rates In a High-technology Industry. Strategic Management journal, 2008, 21 (8), 791-801.

[29] Honey G. A Short Guide to Reputation Risk. Farnham: Gower Publishing. 2009, 119.

[30]Zaman A. Reputational risk: value management. Moscow Olymp-Business, 2008., p. 117.

The second are socio-economic and organizational relations due to:

- introduction of trade restrictions and sanctions;

- change of political and economic regimes;

- opportunistic actions of certain groups of stakeholders that create obstacles for the organization in the process of production and supply of products that are most attractive to consumers in terms of price and non-price characteristics.

These factors make it possible to characterize the reputational risk of the transport and logistics system / supply chain of perishable foods not only as a separate risk, but as a set of risks arising from the relationship of its member organizations with stakeholders and exacerbated by violations food products, first of all, these violations are related to non-compliance with the declared quality of the product), which may affect their economic interests.

On the one hand, reputational risks arise due to the occurrence of a certain event that is directly related to a group of risks (political, economic, environmental, price, quality, etc.). On the other hand, reputational risks lead to other types of risk (solvency, liquidity, etc.). This means that the interests of a certain group of partners did not receive timely attention and grew into reputational losses for this group. And given that modern web communications and social media provide organizations and individuals with unprecedented tools to learn more about a particular business organization, the threat of losing their reputation is only accelerating. After all, the idea of organization is formed regardless of anyone's will.

Accordingly, in the new communication field, the old operational risk, which arose due to imperfections (negligence) in the work of processes, people or systems, today becomes a reputational risk of the entire supply chain of the product, the price of which is much higher. Thus, according to American Banker, the negative information provided about the business practices of the supply chain is the root cause of reputational risk because it:

- first, determines the methods of influencing the organizations that are part of it and forms the experience of the subjects;

- secondly, in the process of monitoring the activities of companies and identifying the discrepancy between experience and the real state of affairs, it can significantly affect the business reputation, and through it - to increase reputational risk;

- thirdly, it forms the judgments and perceptions of the subjects about the organizations, which without combination with experience and monitoring are independent sources of reputational risk of the supply chain[31].

Given the above, reputationalthe risk of transport and logistics systems for the supply of perishable food is determined by us primarily as a specific property of the network system: the organization-society. It should be seen as a gap between reality and perception and as a potential threat to changes in the perception and evaluation of the product promoted by key stakeholder groups (especially consumers), recognizing that this process can and should be managed by the organization.

The survey was conducted by The Economist[32], whether reputational risk is a separate type of risk or a consequence of other types of risk that have not received due attention, showed that most risk managers are inclined to the second approach. The results of the study show that the threat of reducing the stability of the organization's relations with each group of stakeholders exists continuously, and reputational risk has its own characteristics at each stage of development.

However, the distribution of developments related to reputational risk transport and logistics systems for the supply of perishable food is quite conditional. And the manifestation of reputational risk occurs when significant

[31]Reputation risk. American Banker Glossary. URL.http://www.americanbanker.com/glossary/r.html

[32]Economist Intelligence Unit. Reputation: Risk of risks. 2005. URL.http://www.eiu.com/report_dl.asp?mode=fi&fi=1552294140.PDF&rf=0

quality indicators do not meet the expectations of stakeholders - consumers of the product. It is clear that due to information asymmetry, certain events can never be expected. Therefore, in the event of a risk situation that was not expected, there are three main scenarios:

- stakeholders consider it insignificant;

- the risk situation will affect the relationship of stakeholder groups with the organization;

- Stakeholders will assess the impact of existing reputation as changing the vision of the organization's prospects and stop working with it.

In the second and third cases, reputational losses may occur due to non-compliance with the expectations of stakeholders, up to the seizure of products of inadequate quality by state and public authorities, lawsuits, fines and complete disregard for the goods by consumers.

It should be noted that initially "reputation management" was related to public relations, but the development of computer technology, the Internet and social media has made the reputation dependent on the results of search information. Of course, this term is sometimes used in a negative context, implying the creation of fake reviews, negative feedback or the use of CEO techniques.[33]to influence search results. For example, in 2007, researchers at the University of Berkeley found that some eBay sellers, in order to gain an advantage over other sellers, managed their reputation by selling goods at a discount in exchange for positive reviews of their activities.[34].

However, in most cases, reputation management is ethical and positively reflected in response to customer complaints, negotiating with site administrations to remove incorrect information, and using feedback to improve supply chain products. Therefore, the main task for the company to manage its

[33] Actions aimed at improving the visibility of the site in the topics to which it really corresponds in the eyes of the user, in terms of search engine algorithms.

[34]Mills E., Study: eBay sellers gaming the reputation system? URL.http://news.cnet.com/8301-10784_3-6149491-7.html

reputation is to reduce the number and pessimism[35]negative information about her and her products in search results. In other words, reputation management is an attempt to bridge the gap between how a company positions itself and how others see it.

The effectiveness of reputation management depends on how it forces various information about the company and its actions to increase its "weight" in the minds of "necessary" target audiences. And this information can come from two sides:

1) from the company itself in the form of press releases, management statements, public events, etc.

2) from external sources, which may include stock market analytical reports, independent journalistic publications, public statements of politicians, consumer feedback on social networks and more.

In the first case, the company's influence on the composition and quality of information preparation is maximum. In the second case, the company is no longer so free to control the information that is published - as a rule, in such cases, the company remains only reactive measures.

In order to increase the effectiveness of the company's reputation risk management, it is necessary to constantly increase the transparency of reporting, which allows to strengthen the trust of stakeholders by providing reliable, timely and representative information about the company's business. However, numerous studies show that, despite growing disclosure requirements, stakeholders still do not value corporate reporting as a sufficient source to meet their information needs.

The biggest uncertainties for stakeholders are the reporting sections on risks, forecasts and prospects, strategy description and social and environmental responsibility. At the same time, most public companies issue a report according to GRI standards, where the above sections are present in the annual report. The

[35] reducing the position of the site in the search engine (artificial reduction of the relevance of the query)

main reason is hidden in the unrepresentativeness of such information. Disclosure of additional information helps to increase stakeholder confidence only if such information logically complements the information in the financial statements and is consistent with each other. Otherwise, this disclosure does not increase user confidence and increase the value of the company.

Thus, the main means of managing the company's reputational risk is to fill corporate reporting with timely and representative information. However, market participants, forming their ideas and expectations about the company's prospects, are never limited to information disclosed by management. In addition, without full information, they cannot accurately estimate whether information about a particular event will enter the market, which does not allow investors to fully base their estimates on corporate reporting. Accordingly, the presence of uncontrolled elements of the information field (opinions of other market participants) increases the need to manage reputational risk, which is achieved by monitoring changes in the expectations of such participants. Thus, in relation to reputational risks, there are two main functions of corporate reporting:

Given the limited methods of assessing reputational risks and the need to combine quantitative and qualitative methods, the most acceptable approach is to use them in combination, combining expert assessments and statistical information on losses (losses), as well as modeling causation .

The best solution to this problem can be facilitated by building causal models, in particular, the use of Bayesian trust networks[36]. Bayesian networks are graph models of probabilistic and causal relationships between variables in

[36] Jensen FV, Nielsen T. Bayesian Networks and Decision Graphs: SpringerVerlag Berlin Heidelberg NewYork Hong Kong London Milan Paris Paris Tokyo, 2007.447;

Klewes J., Wreschniok R. Reputation Capital: Building and Maintaining Springer, 2009. URL. https://download.e-bookshelf.de/download/0000/0138/38/LG-0000013838-0002370668.pdf .;

Mills E., Study: eBay sellers gaming the reputation system? URL.http://news.cnet.com/8301-10784_3-6149491-7.html statistical information modeling, combining empirical frequencies of different values of variables, subjective estimates of "expectations" and theoretical ideas about the mathematical probabilities of certain consequences from a priori information.

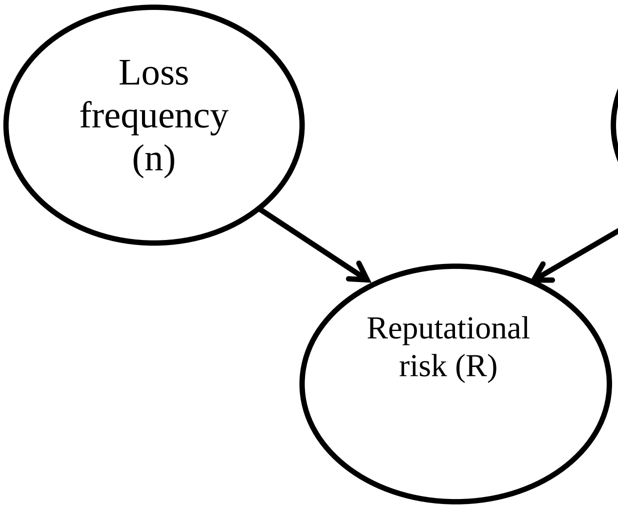


**Fig. 3.10** One-tier Bayesian network of trust in reputational risk assessment

*Source:* compiled by the authors

Thus, in the network shown in figure 3.10, the probability of the vertex R in different states (Rk) depends on the states (ni, Sj) of the vertices n and S and is determined by the equation:

$$p(R_k) = \sum_i \sum_j p \frac{R_k}{n_i; S_j} \times p \frac{n_i}{S_j} \, . \qquad (3.32)$$

where: p ($R_k$ / $n_i$; $S_j$) – the probability of being in the state Rk depending on the states $n_i$, $S_j$.

Since the events represented by the vertices n and S are independent, then:

$$p \frac{R_k}{n_i; S_j} = p(n_i) \times p(S_j) \, . \qquad (3.33)$$

In turn, the frequency of losses will be affected by the frequency of reputational threats, which depends on the level of control (area controlled by reputational risk) and the power of these threats, which is often uncontrollable, while the amount of reputational losses – the value of reputational assets and degree their vulnerabilities (figure 3.11).

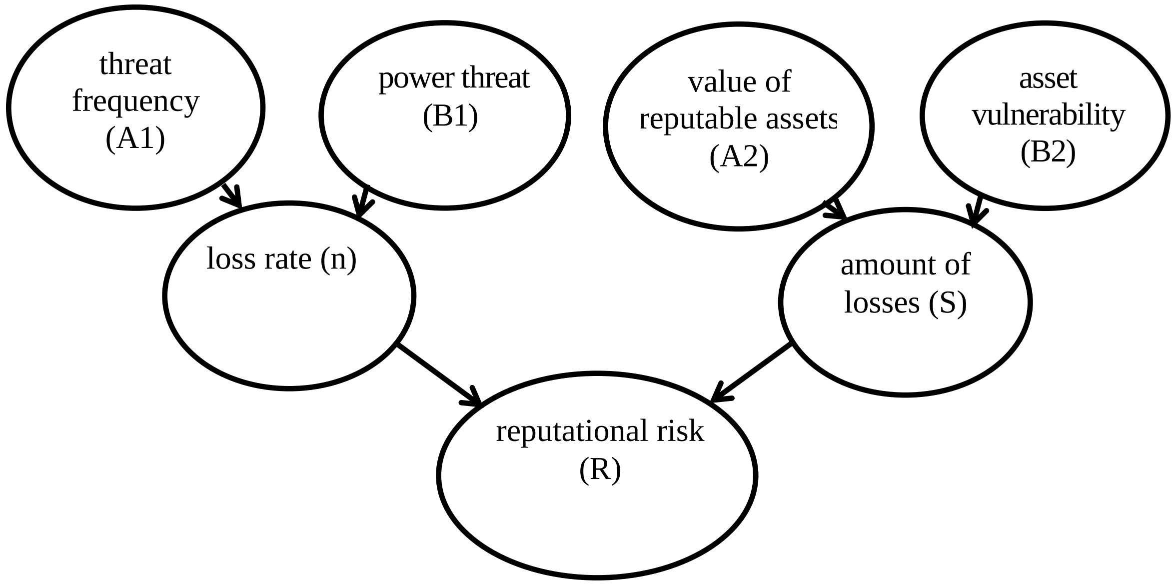


**Fig. 3.11** Two-tier Bayesian trust network in reputational risk assessment

*Source:* compiled by the authors

In this case, figure 3.11 illustrates the conditional independence of events n and S. Therefore, to estimate the vertices n and S, the same calculations are used as for the calculation of p (Rk), then:

$$p(n_i) = \sum_m \sum_n p \frac{n_i}{A_{1m}; B_{1n}} \times p(A_{1m}) \times p(B_{1n}) . \quad (3.34)$$

$$p(S_j) = \sum_m \sum_n p \frac{S_j}{A_{2m}; B_{2n}} \times p(A_{2m}) \times p(B_{2n}) . \quad (3.35)$$

Also, the vertex R does not depend on the vertices A1, A2, B1, B2, because there are no arrows that would directly connect these vertices. Accordingly, the directed acyclic graph has the following properties:

- each vertex is an event that is described by a random variable that can have several states;

- all vertices associated with the "parent" can be determined using conditional probability tables or conditional probability functions;

- for vertices not related to "parent", the probability of states is unconditional[37].

Thus, the vertices are represented by random variables, and the arcs are represented by probability dependencies, which are determined using a table of conditional probabilities. The calculation of the probability of losses from the realization of reputational risks in the transport and logistics system can be done using the Monte Carlo simulation of the Microsoft Excel editor. The histogram obtained from the Monte Carlo simulation is shown in figure 3.12.

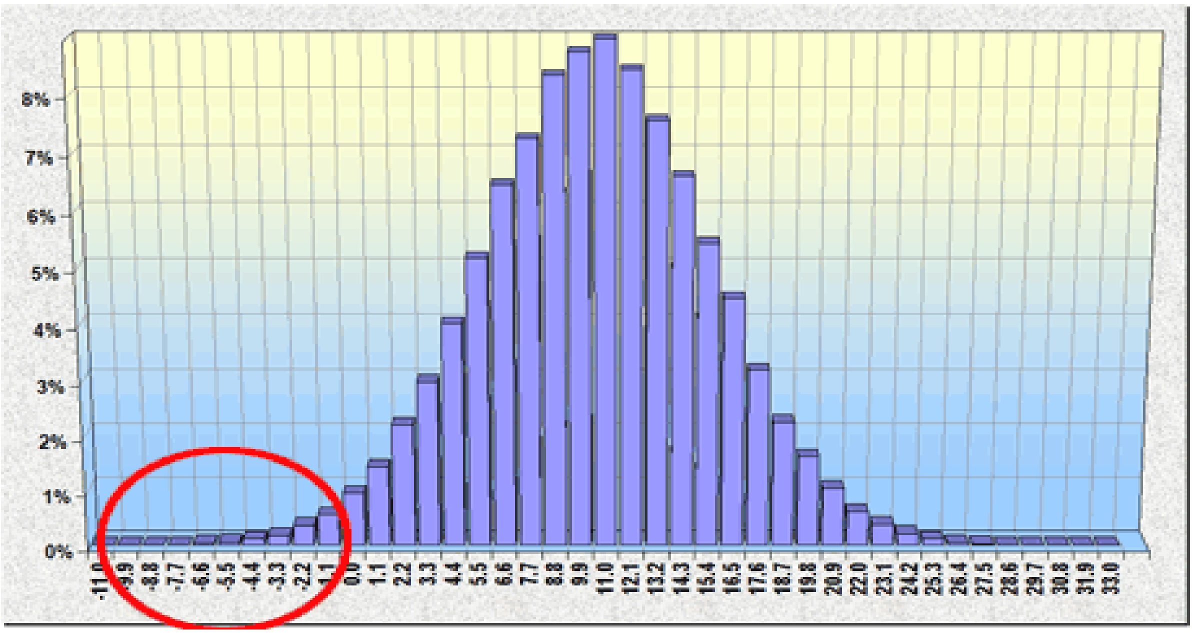


**Fig. 3.12** Histogram of Monte Carlo simulation results

*Source:* compiled by the authors

After construction of the directed graph the estimation of the concepts included in it is carried out: for risk events the probability of their realization and, further, the size of the losses connected with them is estimated.

[37]Heckerman D. A Tutorial on Learning with Bayesian Networks. In Learning in Graphical Models, M. Jordan, ed. MIT Press, Cambridge, MA, 1999. URL. https://www.cis.upenn.edu/~mkearns/papers/barbados/heckerman.pdf

The probability of realization of events can be specified in the Bayesian network in the form of a continuous distribution function or in the form of a table of probabilities (table 3.1), ie in the form of discrete probabilities.

**Table 3.1**

Estimates of the probability of events

| | A | B |
|---|---|---|
| 1 | Values | Probabilities |
| 2 | -10 | 35% |
| 3 | 10 | 45% |
| 3 | 15 | 15% |
| 4 | 50 | 5% |

*Source:* compiled by the authors

Since continuous distribution functions can be obtained only in rare cases due to insufficient empirical data, it is most acceptable to use discrete distributions. For concepts that do not have input arrows on the graph, such as events that are risk factors, the absolute probability of each of the possible outcomes of the event should be indicated. For those concepts that are influenced by others, the conditional probability is indicated for each combination of related concepts.

It is possible to improve the constructed model with the help of fuzzy set theory[38]. To do this, on the two-level Bayesian network of trust, built by us above (figure 3.13), we impose a system of relative advantages F:

$$F = \{S1\} = n;\ B2\} = A2;\ B1\} = A1\} \qquad (3.36)$$

in which "} =" indicates superiority, and "≈" indifference.

[38] Zadeh L. Toward a theory of fuzzy information granulation and its centrality in human reasoning and fuzzy logic. Fuzzy sets and systems, 1997. Vol. 90, no. 2. 111-127.

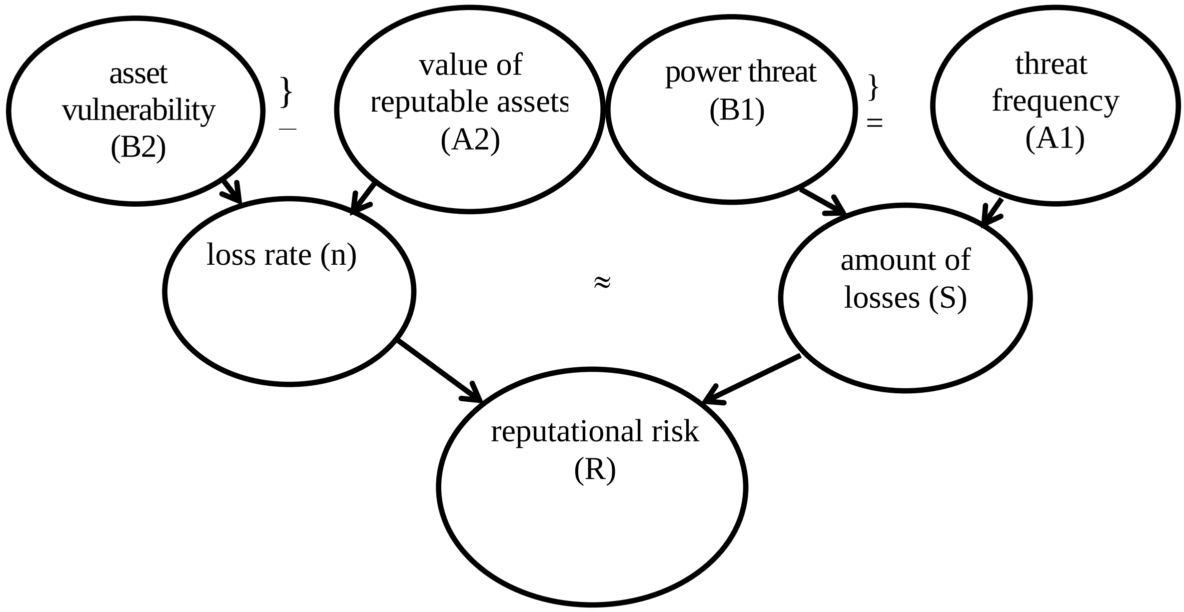


**Fig. 3.13** Hierarchy R with superimposed system F

*Source:* compiled by the authors

In this case, to assess the reputational risk quantitatively and qualitatively, the aggregation of data displayed within a defined hierarchy; while aggregation is performed in the direction of the arcs of the graph. Jager's OWA operator is used for aggregation[39], according to which the measurement of the degree of aggregation is defined as:

$$orntss(W) = \frac{1}{n-1}\sum_{i=1}^{n}(n-i)\times w_i \qquad (3.37)$$

where for any W orness (W)∈ [0,1], and Fishburn coefficients act as weights at folding[40].

$$p_i = \frac{2(N-i+1)}{(N-1)N}. \qquad (3.38)$$

where: $p_i$ – the Fishburne weighting factor for index $x_i$;

N – the total number of indicators in the hierarchy, N> 0;

[39] Yager R. Families of OWA Operators Fuzzy Sets and Systems, 59, 1993. 125-148.

[40] Fombrun CJ Reputation: Realizing Value from the Corporate Image Harvard Business School Press, 1996. 441.

i – the ordinal number of indicator $x_i$ in the group.

In the system of indifferent to each other N alternatives – a set of equal weights is equal to:

$$p_i = N\text{-}1 \tag{3.39}$$

If the system includes only the relationship of preference, then:

$$N = 1,\ ri\text{-}1 = ri + 1,\ K = 1 + 2 + ... + N = N (N + 1) / 2 \tag{3.40}$$

where: $r_i$ – numerators of recursive fractions;

K – the sum of the obtained numerators or the common denominator of Fishburne fractions.

That is

$$pi = ri / K \tag{3.41}$$

In this case, the membership function of the value of the deviation of the consequence factor is given by a fuzzy set:

$$\mu_{[0;1]}(X_s^r) = \{X_{s_1}^r / V_1, X_{s_2}^r / V_2, ...., X_{s_n}^r / V_n\}. \tag{3.42}$$

where: $X_{s_1}^r, ..., X_{s_n}^r$ – the value of the factor after the increase,

$V_1$, ..., $V_n$ – subjective assessments of the possibility of corresponding increases in the factor-consequence at a given increase in the factor-cause.

The values of some concepts included in the R hierarchy can be quantified, for example, after processing the collected statistics. However, in most cases, the numerical determination of factor values is carried out by the method of expert assessments. Experts' assessments are usually verbal. Therefore, to formalize the information received from the expert, it is proposed to introduce a linguistic variable with a term set of values: QL = {Low (H); Below average (NA); Average. (WITH); Above average (VS); High (B)}.

To move to a quantitative description of this term set, it is advisable to match the five-level classifier, in which the membership functions (F) of fuzzy numbers given on the segment [0; 1], there are trapezoids:

"H" (0; 0; 0.15; 0.25); "NS" (0.15; 0.25; 0.35; 0.45); "C" (0.35; 0.45; 0.55; 0.65); "BC" (0.55; 0.65; 0.75; 0.85); "B" (0.75; 0.85; 1; 1)}.

Therefore, if for each indicator (X * 1 ... X * N) at the selected level of the hierarchy known linguistic estimates, as well as a certain system of Fishburne scales based on the system of advantages F, then linguistic estimates are determined from the relations of membership functions:

1; $0 \leq x < 0.15$

OH: μ1 (x) = 10 (0.25 - x); $0.15 \leq x < 0.25$ (3.43)

0; $0.25 \leq x < 1$

0; $0 \leq x < 0.15$

10 (x - 0.25); $0.15 \leq x < 0.25$

H: μ2 (x) = 1; $0.15 \leq x < 0.35$ (3.44)

10 (0.45 - x); $0.35 \leq x < 0.45$

0; $0.45 \leq x \leq 1$

0; $0 \leq x < 0.35$

10 (x - 0.35); $0.35 \leq x < 0.45$

C: μ3 (x) = 1; $0.45 \leq x < 0.55$ (3.45)

10 (0.65 - x); $0.55 \leq x < 0.65$

0; $0.65 \leq x \leq 1$

0; $0 \leq x < 0.55$

10 (x - 0.55); $0.55 \leq x < 0.65$

B: μ4 (x) = 1; $0.65 \leq x < 0.75$ (3.46)

10 (0.85 - x); $0.75 \leq x < 0.85$

0; $0.85 \leq x \leq 1$

0; $0 \leq x < 0.75$

OJ: μ5 (x) = 10 (x - 0.75); $0.75 \leq x < 0.85$ (3.47)

0; $0.85 \leq x < 1$

If, in addition to the factors assessed qualitatively ("fuzzy"), there are concepts whose values are quantified ("clearly"), it is advisable to use the method proposed by the Basel Committee to share quantitative and qualitative information[41], which involves the calculation of the normalized value $\bar{F_i}$ quantitatively measurable factor $F_i$ according to the formula

$$\bar{F_i} = \frac{F_i - F_{\min}}{F_{\max} - F_{\min}} \tag{3.48}$$

where: $F_{max}$ and $F_{min}$ – the maximum and minimum values of $F_i$, respectively.

Heterogeneous rationing parameters leads to a single interval [0; 1].

Then the estimate of the factor is a fuzzy number

$$X\ (a1, a2, a3, a4), (a1 = a2 = a3 = a4 = \bar{P_i}) \tag{3.49}$$

If $\bar{P_i}$ contains an error $\delta$ then a1 = a2 - $\delta$; a2 = a3 = $\bar{P_i}$; a4 = a3 + $\delta$. Thus, the normalized clear value of the factor is represented as a special case of fuzzy sets.

However, the level of risk tolerance for transport and logistics systems of perishable food products, due to its features, primarily related to limited shelf life, is a complex indicator that reflects the probability of occurrence and severity of an adverse event (risk event). At the same time, the impact on the occurrence of a risk event is exerted by a significant number of external and internal environmental factors, expressed in the aggregate of certain indicators. The significance of these indicators, as well as the vector of the strength of their influence, are unique to each individual factor.

However, the indicators of the influence of transport factors on the risk of transport and logistics systems for the supply of perishable food products are of the greatest importance and a certain uniqueness. The importance of the problem of logistical risks is difficult to overestimate. Yes, according to a study

[41]International Convergence of Capital Measurement and Capital Standards Basel Committee on Banking Supervision. 2006 URL.https://www.bis.org/publ/bcbs128.pdf

conducted at the initiative of Oracle[42] more (77%) of the respondent companies suffer from unforeseen failures in the "value chains". Thus, to determine the systems of factors influencing the level of acceptability of the logistical risk of transportation, in PKTCHLS it is necessary to conduct theoretical and empirical analysis in terms of types of these risks.

It should be noted that risk management in transport and logistics systems (SCRM) is a new area of research in the context of the overall supply chain management strategy (SCM). And most SCRM researchers view risk as a situation that involves two main elements: the incident and the uncertainty of the possible consequences.[43], accordingly, decisions to reduce the level of risk are associated with the assessment of levels and the nature of uncertainty.

R. Joshi, D. Banwet, R. Shankar conduct a broader risk analysis of perishable food supply chains. The methodology of their analysis is based on Delphi-AHP-TOPSIS and includes three stages.

The first step is the Delphi method, which identifies, synthesizes and prioritizes key risk factors, and develops a new harmonized measurement scale.

The second stage is to assess the effectiveness of the cold chain of the selected company in comparison with its competitors based on the process of analytical hierarchy (AHP).

The third stage is the evaluation of possible alternatives for continuous improvement of the cold chain companies based on the method of order preference for similarity with the ideal solution (TOPSIS). According to the authors, their proposed scheme can help managers understand the current

[42]Oracle Managing the Value Chain in Turbulent Times. Dynamic Markets Limited. Independent Market Research Report Commissioned by Oracle 2013 URL. https://www.oracle.com/corporate/analyst-reports.html

[43]Bandaly D., Satir A., Shanker L. Integrated Supply Chain Risk Management via Operational Methods and Financial Instruments, International Journal of Production Research 52 (7). 2014. 2007-2025;

Nooraie SV, Parast MM “A Multi-Objective Approach to Supply Chain Risk Management: Integrating Visibility with Supply and Demand Risk”, International Journal of Production Economics 161. 2015. 192-200 .;

Vilko J., Ritala P., Edelmann J. On Uncertainty in Supply Chain Risk Management, The International Journal of Logistics Management 25 (1). 2014. 3-19.

strengths and weaknesses of their supply chain, as well as identify weaknesses based on current working conditions and company strategy[44].

However, given that in today's chaotic and very dynamic market environment, any transport and logistics system for the supply of perishable foodstuffs is susceptible to devastating consequences[45]. According to experts, it is necessary to develop a comprehensive strategy that meets the following needs. First, these are strategies that help companies minimize costs and increase customer satisfaction. Second, these strategies, which should enable companies to operate during and after the incident[46].

With this in mind, we propose to develop a system of factors expressed in indicative indicators that reflect the impact of internal and external environment on the level of risk of the process of transportation of perishable agricultural products.

Usually the risk management system is built in the form of a cycle of Deming (or Deming – Schuhart) – PDCA-cycle (from the words: plan (plan), perform (do), check (check study), action (act))[47]. Therefore, the risk management cycle in the transport and logistics system for the supply of perishable food products can be represented as follows (figure 3.14).

Risk situation analysis identifies three interrelated conditions:

- the presence of uncertainty;

- analysis of possible development alternatives;

- the choice of the ability to assess the likelihood of implementing the selected risk management options.

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[44] Rohit Joshi DK Banwet, Ravi Shankar A Delphi-AHP-TOPSIS based benchmarking framework for performance improvement of a cold chain, Expert Systems with Applications, Volume 38, Issue 8, 2011, 10170-10182

[45]Knemeyer AM, Zinn W., Eroglu C. Proactive Planning for Catastrophic Events in Supply Chains. Journal of Operations Management 27 (2). 2009. 141-153.

[46]Tang O., Musa SN Identifying Risk Issues and Research Advancements in Supply Chain Risk Management. International Journal of Production Economics 133 (1). 2011. 25-34.

[47]Niv GR Space Dr. Deming: The Principles of Sustainable Business Harvard Business Review, 2005. 370.

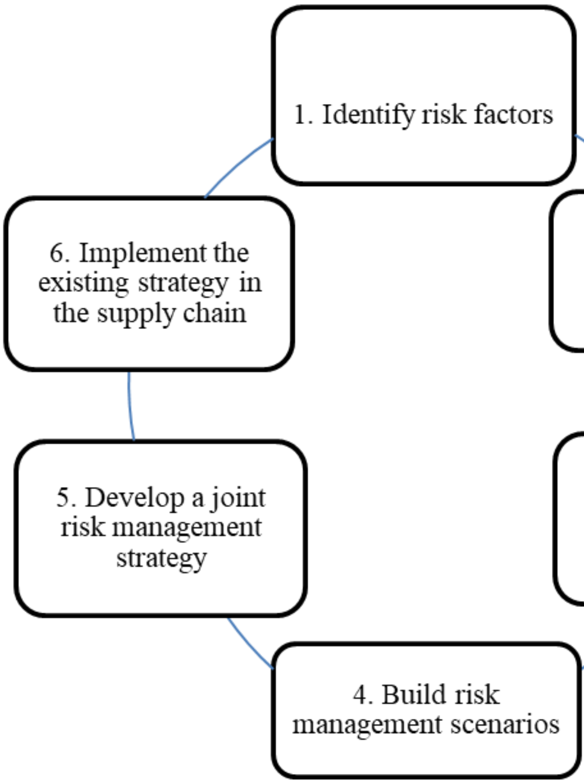


**Fig. 3.14** Risk management cycle in the transport and logistics system of perishable food supply

*Source:* compiled by the authors

It should be noted that in this case only the process of transport logistics of perishable agricultural products is studied, and therefore the choice of a particular option for its transportation. To this end, the most important groups of risk factors associated with this stage of the supply chain will be considered, namely: material, operational and social risks.

Consider the following group data:

Material risks. These risks characterize the cumulative adverse effect on the quantitative and / or qualitative integrity of the cargo being transported. The following factors can be identified as factors influencing the level of these risks:

1. Availability of control staff. The presence of specially trained personnel who are able to respond in a timely manner to violations of the conditions of transportation of perishable goods contributes to a significant reduction in

potential damage and the likelihood of a risky situation. The effect of this factor is inverse in relation to the level of risk. The level of influence of this factor can be assessed using the following indicators:

a. Number of control staff. Symbol – Fr / m-1. Units of measurement – people. Measured statistically. An increase in this indicator leads to an increase in the influence of the factor.

b. Qualification of supervisory staff. Symbol – Fr / m-2. Units of measurement – points. Measured expertly. An increase in this indicator leads to an increase in the influence of the factor.

2. Length and specificity of the path. With increasing path length, the probability of quantitative and / or qualitative damage to the cargo increases significantly. The impact of this factor is direct to the level of risk. The level of influence of this factor can be assessed using the following indicators:

a. Total path length. Symbol – Fr / m-3. Units of measurement – km.Measured statistically. An increase in this indicator leads to an increase in the influence of the factor.

b. The number of traffic accidents committed on the road in the last 2 years according to the statistics of the Ministry of Internal Affairs. Symbol – Fr / m-4. Units of measurement – pcs. Measured statistically. An increase in this indicator leads to an increase in the influence of the factor.

3. Weather conditions. Deterioration of weather conditions can lead to violations of the integrity of transport packaging, as well as to the deterioration of the ability to control the transportation process. The effect of this factor is inverse in relation to the level of risk. The level of influence of this factor can be estimated using the indicator:

a. Qualitative assessment of weather forecast results. Symbol – Fr / m-5. Units of measurement – point. Measured expertly. An increase in this indicator leads to a decrease in the influence of the factor.

Operational risks. These risks characterize the cumulative adverse effects of external and internal environmental factors on the operation of freight rolling stock. The realization of these risks can lead to the realization of environmental risks. At the same time, these risks are largely technical. The following factors can be identified as factors influencing the level of operational risks:

1. Wear of rolling stock. This factor is crucial in ensuring the continuity of the transportation process. The impact of this factor is direct to the level of risk. The level of influence of this factor can be assessed using the following indicators:

a. Rolling stock wear factor. This indicator is calculated as the accumulated depreciation to the initial cost of rolling stock. Symbol - Fr / e-1. Units of measurement - %. Measured statistically. An increase in this indicator leads to an increase in the influence of the factor.

b. The share of regulatory time that has elapsed since the last scheduled maintenance of rolling stock. This indicator is calculated as the ratio of time remaining until the next scheduled maintenance and the standard time between scheduled maintenance. Symbol - Fr / e-2. Units of measurement - %. Measured statistically. A decrease in this indicator leads to an increase in the influence of the factor.

2. Load on the roadway. This factor is purely technical. Its impact has a clearly defined vector and is direct in relation to the level of risk. The level of influence of this factor can be assessed using the following indicators:

a. Exceeding the permissible axle load level. The calculation of this indicator is carried out by dividing the current level of load on the axle to its standard value. Symbol - Fr / e-3. Units of measurement - %. Measured statistically. An increase in this indicator leads to an increase in the influence of the factor.

b. Exceeding the permissible load level by 1 meter of the road surface. The calculation of this indicator is carried out in accordance with the calculation of the indicator Fr / e-3. Symbol - Fr / e-4. Units of measurement - %. Measured statistically. An increase in this indicator leads to an increase in the influence of the factor.

2. Wear of the road surface. This factor is exclusively external to the transport company. The impact of this factor is direct to the level of risk. The level of influence of this factor can be estimated using the following indicator:

a. The share of regulatory time that has elapsed since the repair of the road. This indicator is calculated as the ratio of time remaining until the next scheduled maintenance and the standard time between scheduled maintenance. Symbol - Fr / e-5. Units of measurement - %. Measured statistically. A decrease in this indicator leads to an increase in the influence of the factor.

Social risks. These risks combine a set of adverse events, the source of which is the "human factor". The realization of social risks can lead to operational risks, which in turn can lead to environmental risks. The following factors can be identified as factors influencing the level of these risks:

1. Sufficiency of staff. This factor is decisive in the possibility of realizing social risks. The impact of this factor is direct to the level of risk. The level of influence of this factor can be estimated using the following indicator:

a. staffing of the enterprise. This indicator is calculated by the ratio of staff available at the enterprise to the number needed to perform tasks. Symbol - Fr / s-1. Units of measurement - %. Measured statistically. A decrease in this indicator leads to an increase in the influence of the factor.

2. Qualification of staff. The impact of this factor is inversely related to the level of risk. The level of influence of this factor can be estimated using the following indicator:

a. Average level of staff qualifications. This indicator is calculated as the ratio of the sum of qualification assessments (expressed in points) and the total number of assessed personnel. Symbol - Fr / s-2. Units of measurement - point /

person. Measured expertly. An increase in this indicator leads to an increase in the influence of the factor.

3. Experience of staff. The combined experience of work allows to form in the worker practical skills on algorithms of elimination of consequences in the conditions of realization of risk. The nature of the influence of this factor on the integrated result is comparable to the nature of the influence of the previous factor. The level of influence of this factor can be estimated using the following indicator:

a. Average experience of the staff involved. The calculation of this indicator is consistent with the indicator Fr / s-2. Symbol - Fr / s-3. Units of measurement - point / person. Measured statistically. An increase in this indicator leads to an increase in the influence of the factor.

The current system of indicators is quite heterogeneous. The degree of influence of each factor on the integrated indicator and each individual indicator on the influence of the factor differs. Thus, it makes sense to build a balanced system of indicators (figure 3.15).

Assignment of weight to each of the selected indicators can be done using a combined approach, which involves both expert weight distribution and weight distribution according to Fishburne's law. For these purposes, the factors were ranked by experts according to the degree of influence on the final result. The weight distribution within the groups themselves is made evenly to prevent weight gain of those factors that are assessed by several indicators.

The assessment of the acceptability of all selected risk groups cannot be performed on the basis of classical risk assessment methods. First of all, this is due to the need to use both statistical (formalized) and expert (informal) indicators that characterize the level of risk. Moreover, the complexity of the object of study determines the need for fuzzy assessment intervals, as well as characterized by the level of confidence of the expert in the conclusions.

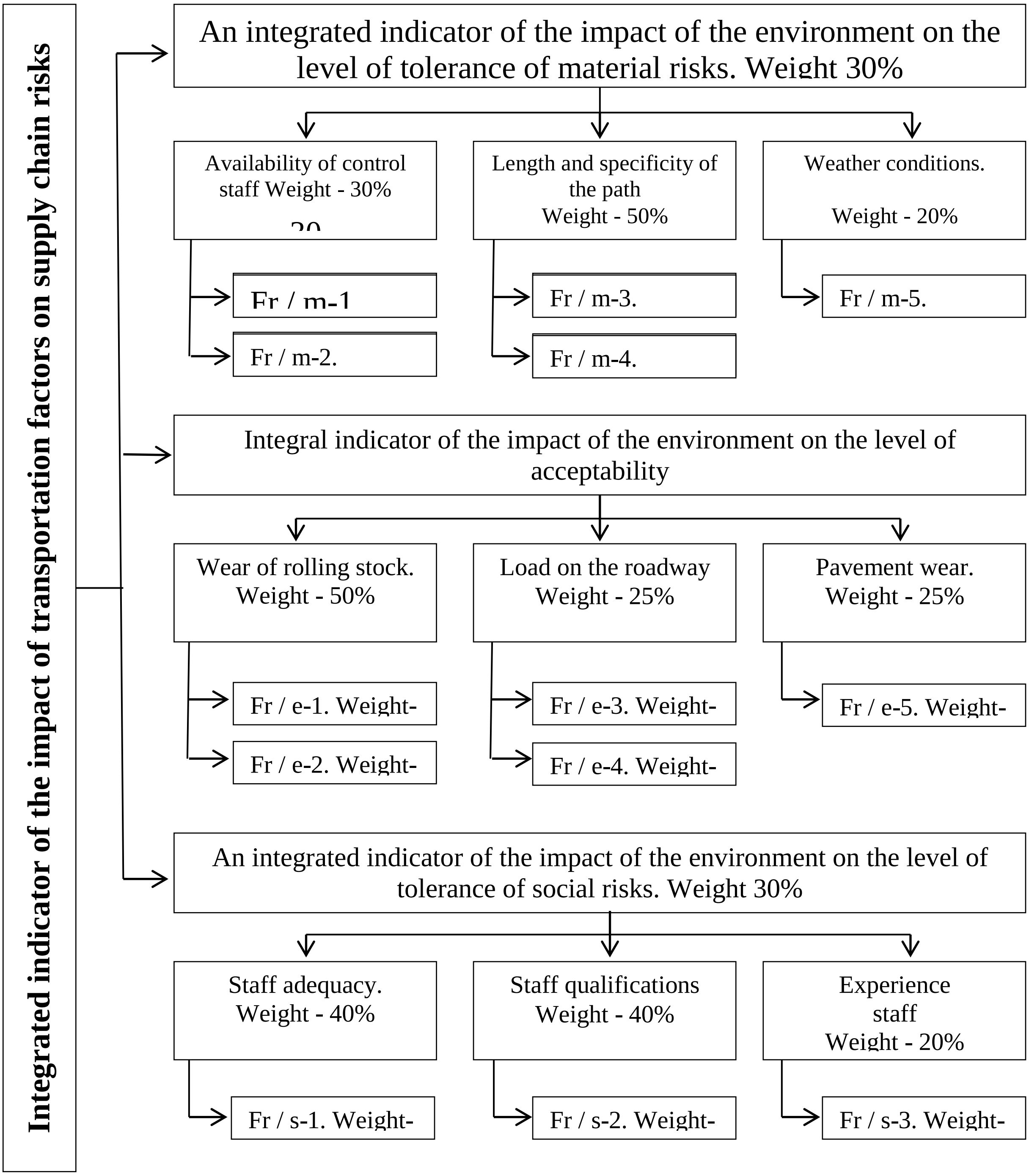


**Fig. 3.15** Distribution of weights of the integrated impact model on the level of risk tolerance of the transportation process

*Source:* compiled by the authors

Thus, one of the most suitable for building a model for assessing the level of acceptability of logistical risks of the process of transportation of perishable agar products is the fuzzy-multiple approach.

Building an evaluation model using fuzzy logic includes the following steps:

1. Independent variables, consequence factors that affect the value of the dependent variable are selected.

2. Fuzzy sets of values for independent and dependent variables are described. Linguistic terms are used instead of numerical values.

3. Describe the rules of withdrawal. Each rule is written as "if" (independent variable is equal to value), "then" (dependent variable is equal to value). Linguistic terms described in item 2 are used as "values".

4. Fuzzy sets of the dependent variable are generated on the basis of independent variables and output rules. Software tools are usually used to implement this step.

5. The result is then used to make informed decisions.

The obtained results are characterized by two components: linguistic interpretation of the level of a risk and the degree of reliability of the obtained result (table 3.2).

First of all, consider the linguistic interpretation of the obtained result: experts have established that the borderline state is state №3 - conditionally acceptable level of risk "medium risk". In that case, if the transportation scenario exceeds this state, and goes to state №4 - unacceptable level of risk "high risk" - it is automatically rejected. However, as these variables are fuzzy, the level of reliability of the classification should be taken into account. Therefore, the rules of acceptable reliability should be established. The threshold of reliability, in the case of material risks is set at 50%, as they have only 1 level of consequences of implementation. At the same time, operational and social risks have 2 and 3 levels of consequences, respectively. As a result, experts set a limit of 40% for them. This is primarily due to the fact that.

**Table 3.2**

Classification of selected indicators

| Nameindicator | Criterion of division into subsets | | | | |
|---|---|---|---|---|---|
| | extremely low risk | the risk is insignificant | the risk is medium | the risk is high | extremely high risk |
| The system of fuzzy-multiple classifiers of indicators that characterize the level of tolerance of material risks | | | | | |
| Fr / m-1 | (1; 1; 3; 5) | (3; 5; 6; 8) | (6; 8; 10; 12) | (10; 12; 13; 15) | (13; 15; + ∞; + ∞) |
| Fr / m-2 | (1; 1; 2; 3) | (2; 3; 4; 5) | (4; 5; 6; 7) | (6; 7; 8; 10) | (8; 10; 10; 10) |
| Fr / m-3 | (0; 0; 300; 1400) | (300; 1400; 2500; 3600) | 2500; 3600; 4700; 5800) | (4700; 5800; 6900; 8000) | (9100; 10200; + ∞; + ∞) |
| Fr / m-4 | (0; 0; 2; 4) | (2; 4; 6; 9) | (6; 9; 11; 13) | (11; 13; 15; 17) | (15; 17; + ∞; + ∞) |
| Fr / m-5 | (1; 1; 2; 3) | (2; 3; 4; 5) | (4; 5; 6; 7) | (6; 7; 8; 10) | (8; 10; 10; 10) |
| A system of fuzzy-multiple classifiers of indicators that characterize the level of tolerance of operational risks | | | | | |
| Fr / e-1 | (0; 0; 8; 16) | (8; 16; 24; 32) | (24; 32; 40; 48) | (40; 48; 56; 64) | (56; 64; 100; 100) |
| Fr / e-2 | (0; 0; 11; 23) | (11; 23; 34; 45) | (34; 45; 56; 68) | (56; 68; 79; 90) | (79; 90; 100; 100) |
| Fr / e-3 | (0; 0; 5; 10) | (5; 10; 15; 20) | (15; 20; 25; 30) | (25; 30; 35; 40) | (35; 40; + ∞; + ∞) |
| Fr / e-4 | (0; 0; 4; 8) | (4; 8; 11; 15) | (11; 15; 19; 23) | (19; 23; 26; 30) | (26; 30; + ∞; + ∞) |
| Fr / e-5 | (0; 0; 12; 25) | (12; 25; 37; 49) | (37; 49; 61; 74) | (61; 74; 86; 98) | (86; 98; 100; 100) |
| The system of fuzzy-multiple classifiers of indicators that characterize the level of tolerance of social risks | | | | | |
| Fr / e-1 | (70; 80; 100; 100) | (50; 60; 70; 80) | (30; 40; 50; 60) | (10; 20; 30; 40) | (0; 0; 10; 20) |
| Fr / e-2 | (1; 1; 2; 3) | (2; 3; 4; 5) | (4; 5; 6; 7) | (6; 7; 8; 10) | (8; 10; 10; 10) |
| Ft / e-3 | (1; 1; 2; 3) | (2; 3; 4; 5) | (4; 5; 6; 7) | (6; 7; 8; 10) | (8; 10; 10; 10) |

*Source:* compiled by the authors on the basis of fuzzy-plural approach.

Therefore, we have proposed a system of factors expressed in indicative indicators that reflect the impact of internal and external environment on the level of a risk group in the process of transportation of perishable agricultural products. Based on the defined system of indicative indicators, a fuzzy-multiple model of estimating the level of acceptability of the proposed groups of logistic risks was formed.

According to the defined approach, it is proposed first of all, regardless of economic indicators, to assess the level of eligibility of all accepted for the possible implementation of transportation scenarios. A scenario that does not meet the normative values of the level of logistical risk, should be automatically excluded from the list of possible for implementation, regardless of its level of economic attractiveness.

# CONCLUSIONS

The monograph provides a theoretical generalization of the impact of global information trends on the development of transport and logistics systems of perishable food supplies and proposes a new solution to the scientific and practical problem of maintaining food quality in the supply chain from producer to consumer. The study gives grounds to draw the following conclusions of theoretical and scientific-practical direction:

1. Analysis of the main domestic and foreign concepts and approaches regarding the development of logistics systems makes it possible to define them as systems / networks consisting of interconnected and interdependent elements / flows, each of which performs a specific logistics operation, which together implements a specific logistics function in a specific environment. Transportation is a key logistics function of these systems, which closes all major operations related to the movement of material resources and delivery of finished products to consumers. However, it is impossible not to note the difference in approaches to understanding the transport system and the transport and logistics system. If the first goal is a high level of functioning in isolation with other industries and the optimization of transport processes, which should lead to lower transport costs,

Accordingly, transport and logisticssystem is a set of objects and subjects of transport and logistics infrastructure together with material, financial and information flows between them, which performs the functions of transportation, storage, distribution of goods, as well as information and financial and service support of goods flows. And the optimal transport and logistics system is a system that provides maximum economic effect with a sufficient level of reliability and quality of services within the existing resource constraints.

2. The creation of a transport and logistics system should be directly combined with the organization of management, ie providing analysis and monitoring of the optimal combination of economic and scientific and applied efficiency. Stabilization of the existing transport and logistics system in its conceptual mathematical and economic modeling, optimization of the combination of flow processes involves both in the theory of logistics and in real market practice the presence of certain reactions to changes in certain parameters or existing organizational and managerial influences.

The logistics infrastructure and the chosen logistics technology, in turn, depend on the characteristics and features of the proposed product:

- type of goods and their purpose (industrial or consumer - long-term or short-term use, food, etc.),

- its demand and method of purchase (goods of choice, goods of daily demand, goods of high demand).

Accounting for these factors and features is implemented in the construction of the distribution system: the choice of sales region, the choice of distribution channels, the choice of intermediaries, their number. All this leaves its mark on logistics operations related to material flow and affects the formation and adaptation of the logistics service system in the supply chain.

3. In the context of globalization, the competitive advantages of logistics services, based only on price and consumer properties, lose their leading importance, and in the first place are flexibility, limited lead time, reliable and quality supplies, choice, and so on.

From the producer market, the economy moves to the consumer market, where the ability of the producer to combine individual purchasing advantages with flexible production and a system of rapid delivery of goods becomes a decisive factor in competition. In the context of globalization, effective management of logistics and trade flows have become a central part of the competitiveness of almost any company that plans to work internationally. And the global trend of logistics of the modern economy is the rule "7R" whose main slogan is: the right product - the right quality - in the right quantity - must be delivered - at the right time - and in the right place - the right consumer - at the right cost.

4. Important modern world trends in the development of transport and logistics systems are:

- strengthening of environmental requirements or sustainable environmental logistics, which is responsible for the impact of its processes on the environment. INElika pays attention to "green" fuel, as well as engineering developments that will help increase load capacity and reduce fuel consumption;

- increasing the share of direct express deliveries from producer to consumer, bypassing intermediaries and intermediate storage. Direct delivery saves by reducing inventory and supply costs in the supply chain, reducing lead times, helping consumers access a wide range directly from the manufacturer;

- application of new technologies (primarily information). The main emphasis in commodity management technologies today is on networks: IT technologies and multi-channel product sales system.

5. Development of e-commerce, market entry of online aggregators, national and global trading platforms forms a fundamentally new configuration of the value chain where the dominant position is occupied by digital links, which without a product, solve the problem of attracting customer base that allows them to keep a significant percentage of value added.

The formation of a multi-channel sales model creates a fundamentally new role of logistics, which in the current phase of online retail not only provides the opportunity to differentiate product and service offerings, but also creates an additional barrier to market entry, increasing retail monetization in digital sales channels. And the very combination of logistics and service in online retail is becoming the main catalyst for the development of the modern commodity market.

6.The complexity of the organization of transport and logistics systems for the supply of perishable food is due, on the one hand, the participation of a large number of links in the chain, and on the other hand – the features of perishable goods, namely: scattering of perishable food production points; seasonality of freight flows; the complexity of coordination of loading and unloading processes on interacting modes of transport; indeterminate arrival of rolling stock at transshipment points (transport hubs); indeterminate mode of transportation of perishable goods to wholesale collection points; forced the need for reverse empty run of rolling stock; the need to pass phytosanitary and veterinary control when crossing state borders, which delays cargo at terminals of departure and destination, often not adapted for storage of perishable products.

7. Transport support of transport and logistics supply systemsperishable foodsinextricably linked to the use of specialized rolling stock to reduce the likelihood of damage to cargo during transportation and reduce the impact of cargo and the transport process on the environment. Among the methods, techniques and techniques of organization of transport and logistics systems, in science and practice there are three main groups of logistics technologies:

- Cold Chain Technology;
- Internet of Things Technology;
- Technology of Optimal Routes.

8. Cold Chain – the process of planning, implementing and controlling the efficient and effective flow and storage of perishable products, related services and information from one or more points of origin to points of production, distribution and consumption to meet customer needs worldwide. That is, it is a temperature logistics system that combines individual logistics operations with perishable products into an existing business process to create consumer value. Cold chain maintenance is a specific type of activity for continuous operation of the system of organizational and practical measures that provide optimal temperature for storage and transportation of perishable or frozen goods that

require special temperature conditions for transportation and storage and ensure safety of cargo quality within the established time limit. when delivered to the consumer.

9. The introduction of the Internet of Things in transport and logistics systems for the supply of perishable food products allows its participants to visualize, plan, control and optimize business processes in real time. Its use can lead to significant cost reductions, as it will help to avoid damage to the product through constant monitoring of the cargo, active temperature monitoring during storage and transportation, as well as reducing delivery time.

Internet of Things technology contributes to the improvement of key aspects transport and logistics supply systemsperishable food products, namely: 1) the ability to track the origin, movement, location and condition of products; 2) transparency of the supply process for all participantstransport and logistics system; 3) continuous product monitoring throughouttransport and logistics system.

10. One of the main characteristics of any transport and logistics system is the timeliness of deliveries, ie the time parameter. The JIT concept is based on the synchronization of supply volumes and quality according to the operational needs of production. It is based on the decentralized principle of material flow management, when instructions to start production come directly from the warehouse or sales system of the enterprise, and the key elements are integrated information processing, segmentation of production and supply, synchronized with production. At the same time, real socio-economic conditions radically change any trends, concepts or principles. Thus, the global coronavirus pandemic has significantly disrupted traditional logistics chains and led to the need to store many times more perishable foods. Today, there is a shortage of refrigerators for perishable food on a global scale. Covid-19 once again demonstrated the vulnerability of the international system of economic and food security, built on a continuous algorithm of supply-intermediate storage-

transportation-shipment of products. The suspension or partial restriction of export shipments has halted this well-established process and requires the development of new approaches and algorithms.

11. To improve the efficiency of transport and logistics supply systems of perishable food products in the work it is proposed to introduce a constantly controlled temperature-time logistics system (PKTCHLS), which combinesInternet of Things Architecture (IoT), International Food Safety and Quality Standards (ISO 22000), the concept of "controlled quality of logistics "(QCL), schemesSmart Cold Chain Management (SCCM) andsystem of "smart contracts" (Smart contract) on the platformblockchain.

Such a system will be implemented based on a combination of WSN functions, temperature-time indicator (TCI), critical quality control point (QC) systems, route optimization devices and specialized vehicles. Compared to traditional cold chain management methods previously used, PKTCHLS not only bridges the information gap between different enterprises in the stages of promotion of perishable food products in the supply chain and provides a continuous flow of information on it, but also allows companies involved in such a chain. supplies predict the shelf life of perishable products and helps develop a smart strategy to reduce physical product losses and economic losses.

12. With the addition of blockchain technology in the PKTCHLS of perishable food supplies, the model is changing from linear to network. Now all participants store all their transactions using blockchain technology, which on the one hand improves transparency and confidentiality, and on the other hand increases their security. This model corrects the shortcomings of the traditional supply chain. In it, all data is decentralized and each participant can get important information in the blockchain.

The advantage of this model over the linear one is that all products are closely monitored using blockchain technology, and this can give end consumers confidence in their origin, whether they are recycled or used for the first time. By using blockchain technology, the participants of the PKTCHLS supply of perishable food products ensure that they run a legitimate business and meet certain quality standards that consumers expect from them.

12. In the economic and mathematical model of routing PKTCHLS on time the task of building a model of transportation is the optimal routing of the fleet of vehicles of fixed capacity for the supply of consolidated goods in a certain period of time. Such optimization is determined by finding a solution that minimizes the number of used cars and the total travel time.

The proposed refinements for the model of estimating the performance of transport operations according to the JIT allow to obtain more accurate data on the total total time of transportation of perishable food products; probabilities of delivery or delivery time with a given probability. Advanced model of determining the time of transportation for several modes of transport allows analytical analysis of key indicators of transportation, namely the duration of logistics cycles and make a competent decision based on calculations. Which in turn will allow to obtain probabilistic estimates of transport operations in accordance with the concepts of JIT. This model differs from the existing empirical approach in that it allows the decomposition of the transport process into individual components, and describe them as independent elements using statistical parameters,

13. No less important indicator of impact. There is a risk to the efficiency of the constantly managed temperature-time logistics system (PKTCHLS) for the supply of perishable food products. And the risk of loss is not onlyqualitative characteristics of perishable food products, or themselves in the process of advancing in the supply chain, as well as the risk of loss of health by consumers due to the use of expired products.

The paper focuses on the specific type of risks to a greater extent inherent transport and logistics systems for the supply of perishable food products, namely reputational risk, or the risk of loss of goodwill by a company (a group of companies included in the transport and logistics system) thatlargely depends on how ambitious the intentions of the organizers transport and logistics system, predictability of its behavior and the probability of meeting the expectations of stakeholders in its activities.

The occurrence of reputational risk is due to the influence of internal and external factors, which factors allow to characterize the reputational risk of the transport and logistics system of perishable food not only as a separate risk but as a set of risks arising from relationships between stakeholders and stakeholders. are exacerbated by the detection of violations (in the case of perishable food products, in the first place these violations are related to non-compliance with the declared quality of the product), which may affect their economic interests.

14. The level of risk tolerance for transport and logistics systems of perishable food supplies, due to its features, primarily related to limited shelf life, is a complex indicator that shows the probability and severity of an adverse event (risk event). At the same time, the impact on the occurrence of a risk event is exerted by a significant number of external and internal environmental factors, expressed in the aggregate of certain indicators. The significance of these indicators, as well as the vector of the strength of their impact, are unique to each individual factor. To determine the systems of factors influencing the level of acceptability of the logistical risk of transportation, the PKTCHLS conducted a theoretical and empirical analysis in terms of types of these risks.

The paper proposes a system of factors expressed in indicative indicators that reflect the impact of internal and external environment on the level of a risk group for the transportation of perishable foods. Based on the defined system of indicative indicators, a fuzzy-multiple model of estimating the level of acceptability of the proposed groups of logistic risks was formed. According to the defined approach, it is proposed first of all, regardless of economic indicators, to assess the level of eligibility of all accepted for the possible implementation of transportation scenarios. A scenario that does not meet the normative values of the level of logistical risk, should be automatically excluded from the list of possible for implementation, regardless of its level of economic attractiveness.

## REFERENCES

1. Azimov PH Problems and prospects of transport and logistics activities in Central Asia (on the example of the Republic of Tajikistan)]: monograph. Chelyabinsk: SUSU, 2016. 171.
2. English-Russian explanatory dictionary of logistic terms http://ocean.mstu.edu.ru/docs/files/20120202_1412-2.pdf
3. Artemchuk VO, Navrotska TA Analysis of the effectiveness of transport enterprise management. Bulletin of the National Transport University. 2012. № 26 (1). 220-224.
4. Afonin AM Industrial logistics. Moscow: Forum, 2011. 302.
5. Bauersocks DD, Kloss DD Logistics: an integrated supply chain. Translated by NN Baryshnikova, BS Pinsker. - 2nd exit Moscow: CJSC "Olymp-Business", 2008. 640.
6. Benson D., Whitehead J. Transportation and delivery of goods. / trans. with English Moscow: Transport, 1990. 279 p.
7. Bertalanffy L. General systems theory - a critical review. Research on general systems theory: a collection. Moscow: Progress, 1969. 23-82.
8. Large Economic Dictionary / ed. A. N. Azriliana. -7th ed. Moscow: Institute of New Economy, 2008. 1472.
9. Bubnova GV, Levin BA Digital logistics - an innovative mechanism for the development and efficient operation of transport and logistics systems and complexes // International Journal of Open Information Technologies. 2017, Vol. 5, № 3, 72-78.
10. Burennikova NV, Yarmolenko VO Logistics systems: evaluating the effectiveness of functioning. Economy. Finances. Management: current issues of science and practice. No. 6. 2017. 94-102.

11. Burmistrova NS Influence of logistics service on the company's revenue. Logistics and supply chain management. 2013. No 5 (58). 60-68.

12. Velychko OP, Butko MP Management of distribution activity of food industry enterprises. Modern transformations of the organizational and economic mechanism of management and logistics of business entities in the system of economic security of Ukraine: a collective monograph / for general. ed. TV Grinko. Dnipro: Bila KO 2017. 487 s, pp. 125-130.

13. Griffin E. Reputation risk management: Strategic campaign: lane. with English Moscow: Alpina Business Books, 2009. 237.

14. Gurch L.M. Transportation routing using the latest technologies. Bulletin of the National University "Lviv Polytechnic". Logistics. 2016. № 846. 48–53.

15. Dowling G. Reputation of the firm: creation, management and evaluation of efficiency. M .: Consulting group "Image-Contact": INFRA-M, 2003. 368 p.

16. Dent D. All about distribution. lane with English Zakharov AV Moscow: Aquamarine. Book, 2011. 360.

17. Demin OA, Zagursky OM Freight: A textbook. Kyiv: Comprint Publishing House, 2020. 604 p.

18. Economic theory: Political Economy: a textbook / ed. VD Bazilevich; Kyiv. nat. University named after Т.Шевченка. 9th ed., Supplement. Kyiv: Knowledge, 2014.710.

19. Zagursky OM Analysis of the efficiency of transport processes in supply chains. Mechanical engineering and energy. 2018 T. 9. № 4. 43-48.

20. Zagursky OM Estimation of social and ecological efficiency of motor transport enterprises taking into account transaction costs. Management and Entrepreneurship: Development Trends, 2019, (07), 120-129.

21. Zagursky OM Basic principles of application of blockchain technology in supply chains. Computer technology and mechatronics. Collection of scientific works. Kharkiv, KhNADU, 2020. 5-8.

22. Zagursky OM Supply chain management: textbook. way. Bila Tserkva: Belotserkivdruk LLC, 2018. 416.

23. Zagursky OM Risk management: a textbook. Kyiv University "Ukraine", 2016. 243.

24. Zaman A. Reputational risk: value management. Moscow Olympus Business, 2008. 416.

25. Corporate logistics: 300 answers to questions from professionals [under common. and scientific ed. Sergeeva VI]. Moscow: INFRA-M, 2005. 976.

26. Krykavsky E. Logistics of the enterprise: textbook. Lviv, Lviv Polytechnic State University, 1996. 160.

27. Krykavsky EV, Nakonechna TV From cold logistics to cold supply chains. Bulletin of the National University "Lviv Polytechnic". Series: Logistics. Lviv: Lviv Polytechnic National University, 2016. № 846. 79-84.

28. Krykavsky EV, Chornopyska NV Logistic systems: textbook. manual. Lviv: Nat. Lviv Polytechnic University, 2009. 264.

29. Larina RR, Pilyushenko VL, Amitan VN Logistics in the management of organizational and economic systems. Monograph. Donetsk: Ed. VIK, 2003. 239 p.

30. Levkin GG Logistics in the agro-industrial complex: a textbook. 2nd ed. Moscow: Berlin: Direct Media, 2014. 245.

31. Leont'ev, RG Selected: monographic cycles (1984-2005) in 3 volumes - Vol. 2. Logistic paradigm. Khabarovsk: Izd-vo DVGUPS, 2006. 284.

32. Lukinsky VS, Shulzhenko TG Methods for determining the level of service in logistics systems. Logistics and supply chain management. 2011. No 1 (42). 70-86.

33. Multichannel logistics. Amazon's answer. URL.http://www.oliverwyman.com/content/dam/oliverwyman/europe/ru/files/Omnichannel%20logistics_Web_Russian.pdf

34. Knight F. H. Risk, uncertainty and profit .. trans. with English Moscow Case, 2003. 360 p.

35. New course: reforms in Ukraine 2010-2015: national report / [V. B. Averyanov, BM Azhnyuk, BM Bogdan, TP Borodin and others, for general. ed. VM Heitz and others]; NAS of Ukraine, Section susp. and humanitarian. Science. Kyiv: NVC NBUV, 2010. 222 p.

36. Novikov, DA Institutional Management of Organizational Systems Moscow: IPU RAS, 2004. 68.

37. Aucklander MA Contours of economic logistics: a monograph. Kiev: Scientific thought. 2000. 176.

38. Sergeev VI, Kizim AA, Elyashevich PY Global logistics systems of St. Petersburg: Business Press, 2001. 218.

39. Sergeev VI The problem of determining the balance of "costs / level of service" for the purposes of strategic logistics planning. Logistics and supply chain management. 2011. No 5 (46). 5-14.

40. Sergeev VI, Sergeev IV Development of methodology of control and monitoring of supply chains of network retail enterprises // Economic relations. 2019. Volume 9. № 2. 1463-1486.

41. Stakhanov VN, Ukraintsev VB Theoretical foundations of logistics. Rostov n / D: Phoenix, 2001. 159.

42. Stetsenko IV, Boyko OV Petri net simulation system. Mathematical Machines and Systems, Kyiv, 2009. № 1. 117-124.

43. Sumets OM Logistic activity of enterprises of oil and fat industry and evaluation of its efficiency: author's ref. dis. ... Dr. Econ. Science: 08.00.04; НУХТ. К., 2016. 43.

44. Toporov VN Some considerations in connection with the construction of theoretical toponymy // Sb. scientific tr. / Principles of toponymy, 1964. 3-22.

45. Ulyanchenko Yu. O. Competitiveness of the agricultural sector of the economy: mechanisms of state regulation: monograph. Kharkiv: Publishing House of the Association of Doctors of Gauk from the state. Management, 2013. 368.

46. Fedorova TF, Shiryaeva AM, Petrenko KA Features of the functioning of the logistics chain for the delivery of perishable goods by road. Bulletin of the East Ukrainian National University. In Dahl, 2011. № 5 (159) Part 1, 203-207.

47. Formation and functioning of the market of agro-industrial products: a practical guide / ed. P.T. Sabluka. K.: IAE, 2000. 556.

48. Frazelli E. World standards of warehouse logistics / trans. with English Moscow: Alpina Publisher, 2013. 328.

49. Hall A.D., Fagin R.I. Definition of the concept of system / Collection of translations from Polish and English. Moscow: Progress, 1969. 252-286.

50. Yashin AA, Ryashko ML Logistics. Fundamentals of planning and evaluating the effectiveness of logistics systems: a textbook. Ekaterinburg: Ural Publishing House. University, 2014. 52 p

51. A fresh look: perishable supply chains go digital. Kearney. URL:https://www.de.kearney.com/operations-performance-transformation/article?/a/a-fresh-look-perishable-supply-chains-go-digital

52. ANDgreement on the international carriage of perishable foodstuffs and on the special equipment to be used for such carriage (atp). URL. https://unece.org/DAM/trans/main/wp11/ATP_publication/ATP-2016e_-def-web.pdf

53. Ahumada O., Villalobos JR Operational model for planning the harvest and distribution of perishable agricultural products. International Journal of Production Economics. 2011. No 133. P. 677–687.

54. Ala-Risku T., Kärkkäinen M. Material delivery problems in construction projects: A possible solution, International Journal of Production Economics, Volume 104, Issue 1, 2006, 19-29.

55. Alphonse S., Etsibach K. Effective cargo and vehicle storage in distribution centers: a case study of Copenhagen Malmö. Port *World Maritime University*, Malmö, 2002, 113.

56. Aung M., Chang Y. Temperature management for the quality assurance of a perishable food supply chain. Food Control. Elsevier, 2014. 40. 198-207.

57. Badia-Melis R., Mc Carthy U., Ruiz-Garcia L., Garcia-Hierro J., Robla Villalba JI New trends in cold chain monitoring applications - A review, Food Control, Volume 86, 2018, 170-182.

58. Bandaly D., Satir A., Shanker L. Integrated Supply Chain Risk Management via Operational Methods and Financial Instruments, International Journal of Production Research 52 (7). 2014. 2007-2025;

59. Ballou RH Revenue estimation for logistics customer service offerings. International Journal of Logistics Management. 2006. No 1 (17). 21-37.

60. Behzadi O'Sullivan et al .: Robust and resilient strategies for managing supply disruption in an agribusiness supply chain, International Journal of Production Economics, 2017. vol. 191 (C), pp. 207-220.

61. Bielecki M., Galinska V. Total logistics management concept and principles in manufacturing enterprise. Business Logistics in Modern Management, 2017, vol. 17, 93-107.

62. Biji KB, Ravishankar CN, Mohan CO, Gopal TKS Smart packaging systems for food applications: a review, J Food Sci Technol, 2015. vol. 52, 6125-6135.

63. Bogataj M., Bogataj L., Vodopivec R. Stability of perishable goods in cold logistics chains. International Journal of Production Economics, 2005, 93/94 (8), 345-356.

64. Bogataj M. Stability of perishable goods in cold logistic chains 2005. URL. https://proxy.library.spbu.ru:2069

65. Bouzembrak Y., Klüche M., Gavai A., Marvin N., Internet of Things in food safety: Literature review and a bibliometric analysis, Trends in Food Science & Technology, 2019. Volume 94, 54-64.

66. Cai H., Chen J., Xiao Y., Xu H., Yu G. Fresh-product supply chain management with logistics outsourcing, Omega, Volume 41, Issue 4, 2013, 752-765.

67. Carter RH Stores Management and Related Operations. Second Ed., Macdonald & Evans. 1985 xii, 228.

68. Case Study: how Walmart brought unprecedented transparency to the food supply chain with Hyperledger Fabric / blockchain. Hyperledger. URL: https://www.hyperledger.org/wp-content/uploads/2019/02/Hyperledger_CaseStudy_Walmart_ Printable_V4.pdf

69. Cebeci C., Yankova M. Analysis of the Logistics Systems in Bulgaria under the Requirements of the European Union. Research Journal of Applied Sciences, Engineering and Technology. 2013.Vol. 6, № 14. 2526-2534.

70. Chaudhuri A., Dukovska-Popovska I., Subramanian N., Chan H., Bai R. Decision-making in cold chain logistics using data analytics: a literature re-view. International Journal of Logistics Management. 2018. Vol. 29, no. 3. 839-861.

71. Christidis K., Devetsikiotis, M. Blockchains and smart contracts for the in-ternet of things. Ieee Access, 2016. vol. 4, 2292-2303.

72. Christopher M. The Strategy of Customer Service. The Service Industries Journal. 1984. No. 3: Vol. 4. 205-213.

73. Gupta K., Rakesh N. IoT based solution for food adulteration Smart innovation, systems and technologies, Vol. 79, 2018, 9-18.

74. Dai J., Che W., Lim JJ, Shou Y. Service innovation of cold chain logistics service providers: A multiple-case study in China, Industrial Marketing Management, 2020, Volume 89, 143-156.

75. Dan T. Developing Agricultural Products Logistics in China from the Perspective of Green Supply Cain. International Journal of Business and Management. 2012. No 7. P. 106–111.

76. Dewan KK, Ahmad I. Carpooling: A Step To Reduce Congestion (A Case Study of Delhi) International MultiConference of Engineers & Computer Scientists. Newswood Limited, 2006. 408-413.

77. DHL Envirosolution (2017). DHL environmental solutions-Envirosolutions. DHL Group. URL.https:/ /www. dpdhl. com/ en/ sustainability/environment-and-solutions.html

78. Dijkstra EWA note on two problems in connection with graphs. Number. Math.Springer-Verlag, 1959. Vol. 1, Iss. 1. 269-271.

79. Economist Intelligence Unit. Reputation: Risk of risks. 2005. URL.http://www.eiu.com/report_dl.asp?mode=fi&fi=1552294140.PDF&rf=0

80. Fang Z., Zhao Y., Warner, R. Johnson, S. Active and intelligent packaging in the meat industry. Trends in Food Science and Technology. 2017. 60-71.

81. Fombrun CJ, Cees BM van Riel Fame and Fortune: How Successful Companies Build Winning Reputation. 2004. New Jersey: Pearson Education. 304.

82. Fombrun CJ Reputation: Realizing Value from the Corporate Image Harvard Business School Press, 1996. 441.

83. Fonseca JM, Vergara N. Logistics Systems Need to Scale Up Reduction of Produce Losses in Latin America and the Caribbean Region.Proc.

III rd Int. Conf. on Postharvest and Quality Management of Horticultural Products of Interest for Tropical Regions. 2014. P. 173-180.

84. Food safety. World Health Organization. URL. https://www.who.int/news-room/fact-sheets/detail/food-safety

85. Freight transport statistics. Eurostat URL. http://ec.europa.eu/eurostat/statistics-explained/index.php/Freight_transport_statistics

86. Ganeshan Ram, Harrison T.R. An Introduction to Supply Chain Management, Department of Management Sciences and Information Systems, 303 Beam Business Building, Penn State University, University Park, PA published at1995 URL:http://silmaril.smeal.psu.edu/supply_chain_intro.html

87. Gartner Research: Improving On-Shelf Availability for Retail Supply Chains Requires the Balance of Process and Technology. May 2011. URL. https://www.gartner.com/en/documents/1701615/ improving-on-shelf-availability-for-retail-supply-chains

88. Global Logistics Market 2017-2021 URL: https://www.technavio.com/report/global-logistics-market-2017-2021;

89. Global 3PL Market Size Estimates Armstrong & Associates. URL:http://www.3plogistics.com/3pl-market-inforesources/3pl-market-information/global-3pl-market-size-estimates/

90. Global Rankings 2018 URL.https://lpi.worldbank. org/ international/global

91. Gogou E., Katsaros G., Derens E., Alvarez G., Taoukis PS Cold chain database development and application as a tool for cold chain management and food quality evaluation, International Journal of Refrigeration, Volume 52, 2015, 109-121.

92. Goldberg AI, Cohen G., Fiegenbaum A. Reputation Building: Small Business Strategies for Successful Venture Development. Journal of Small Business Management, 2003, 41 (2), 168-187.

93. Grunow M., Piramuthu S. RFID in highly perishable food supply chains - remaining shelf life to supplant expiry date? International Journal of Production Economics 2013 Vol. 146 Issue 2, 2013 URL:https://proxy.library.spbu.ru:2069

94. Gunders D. Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. NRDC Issue Paper 2012 Natural Resources Defense Council URL .:https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf

95. Gwynne R., Susan G. The logistics andsupplychaintoolkit: 101 tools for transport, warehousing and inventory management. London: KoganPage, 2016. 261.

96. Hagen C. A fresh look: perishable supply chain go digital. AT Kearney. URL: https://www.atkearney.com/operations-performance-transformation/article? / a / a-fresh-look-perishable-supply-chains-go-digital

97. Hamalainen TJNational Competitiveness and Economic Growth: The Changing Determinants of Economic Performance in the World Economy: Edward Elgar Publishing, Cheltenham, UK, 2003, 380.

98. Hausman W. Financial Flows & Supply Chain Efficiency / Visa Commercial Solutions. URL:http://www.visa-asia.com/ap/sea/commercial / corporates / includes / uploads / Supply_Chain_ Management_Visa.pdf;

99. Havenga JH, Simpson ZP, King D., de Bod A., Brown. M. Logistics Barometer South Africa 2016 Stellenbosch University, 2016. URL: http://www.sun.ac.za/english/faculty/economy/logistics/Documents/Log istics% 20Barometer / Logistics% 20Barometer% 202016% 20Report.pdf

100. Heckerman D. A Tutorial on Learning with Bayesian Networks. In Learning in Graphical Models, M. Jordan, ed. MIT Press, Cambridge, MA, 1999. URL. https://www.cis.upenn.edu/~mkearns/ papers/barbados/ heckerman.pdf

101. Honey G. A Short Guide to Reputation Risk. Farnham: Gower Publishing. 2009, 119.

102. How the IoT is Improving Transportation and Logistics. Retrieved fromhttps://ardas-it.com/how-the-iot-is-improving-transportation-and-logistics

103. IBM, “IBM announces major blockchain collaboration with Dole, Driscoll’s, Golden State Foods, Kroger, McCormick and Company, McLane Company, Nestlé, Tyson Foods, and Unilever, and Walmart to address food safety worldwide,” press release, IBM.com, August 22, 2017. www-03.ibm.com/press/ us / en / pressrelease / 53013.wss.

104. International Convergence of Capital Measurement and Capital Standards Basel Committee on Banking Supervision. 2006 URL.https://www.bis.org/publ/bcbs128.pdf

105. Jarašūnienė A, Batarlienė N., Vaičiūtė K. Application and Management of Information Technologies in Multimodal Transportation, Procedia Engineering, Volume 134, 2016, 309-315.

106. Jedermann R., M. Nicometo I. Uysal W. Lang. Reducing Food Losses by Intelligent Food Logistics. Philosophical Transactions of the Royal Society a: Mathematical, Physical and Engineering Sciences 2014. 372 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4006167/

107. Jeffery MM, Butler RJ, Malone LC Determining a cost-effective customer service level. Supply Chain Management: An International Journal. 2008. No 3 (13). 225-232.

108. Jensen FV, Nielsen T. Bayesian Networks and Decision Graphs: SpringerVerlag Berlin Heidelberg NewYork Hong Kong London Milan Paris Paris Tokyo, 2007.447.

109. Kee-hungLai TCE ChengJust-in-time logistics. Farnham, Surrey: Gower, 2016 116.

110. Kienzlen M. Sales and shrink by department Where is My Shrink. URL: http://wheresmyshrink.com/shrinkbydepartment.html

111. Klewes J., Wreschniok R. Reputation Capital: Building and Maintaining Springer, 2009. URLhttps://download.e-bookshelf.de/download/0000/0138/38/LG-0000013838-0002370668.pdf

112. Knemeyer AM, Zinn W., Eroglu C. Proactive Planning for Catastrophic Events in Supply Chains. Journal of Operations Management 27 (2). 2009. 141-153.

113. Knowlts TW, Panturnsinchai P. All-Units Discounts for Standard Container Sizes. Decision Sciences. 1988. Vol. 19. N. 4. 848-857.

114. Kull, TJ, Boyer, K., Last-mile supply chain efficiency: an analysis of learning curves in online ordering. International Journal of Operations & Production Management 27, 2007, 409.

115. Kumar S., Tiwari, P., Zymbler M. The Internet of Things is a revolutionary approach for future technology enhancement: a review. J Big Data 6, 111, 2019.URL.https://doi.org/10.1186/s40537-019-0268-2

116. Kuo J., Chen M., Developing an advanced Multi-Temperature Joint Distribution System for the food cold chain, Food Control, Volume 21, Issue 4, 2010, 559-566.

117. Lakshmil VR, Vijayakumar S. Wireless Sensor Network based Alert System for Cold Chain Management, Procedia Engineering, Volume 38, 2012, 537-543.

118. Lee C.-Y. The Economic Order Quantity for Freight Discount Costs IIE Transactions. 1986. Vol. 3. 18-32.

119. Lee I., Lee K. The Internet of Things (IoT): Applications, investments, and challenges for enterprises, Business Horizons, Volume 58, Issue 4, 2015, 431-440.

120. Mahon JF Corporate Reputation: A Research Agenda Using Strategy and Stakeholder Literature. Business & Society, 41 (4), 2002, 415-446.

121. Marques A., Soares R., Santos MJ & Amorim P. 2020. Integrated planning of inbound and outbound logistics with a Rich Vehicle Routing

Problem with backhauls,Omega, vol. 92 (C). URL.https://www.sciencedirect.com/science/article/pii/S0305048319300350

122. Mills E., Study: eBay sellers gaming the reputation system? URL:http://news.cnet.com/8301-10784_3-6149491-7.html

123. Miranda PA, Garrido RA Inventory service-level optimization within distribution network design problem. International Journal of Production Economics. 2009. No 1 (122). 276-285.

124. Monios J., Lambert B. The Heartland Intermodal Corridor: public private partnerships and the transformation of institutional settings, Journal of Transport Geography, 2013, Volume 27, 36-45.

125. Montanari R. Cold chain tracking: a managerial perspective, Trends in Food Science & Technology, Volume 19, Issue 8, 2008, 425-431.

126. Nahmias S. Perishable Inventory Systems New York, NY, United States 2011. 80.

127. Nahmias S. Perishable Inventory Theory: A Review 1982 Operations Research30 (4): 680-708.

128. Lau, H. and Zhang, J. Cost-optimization modeling for fresh food quality and transportation, Industrial Management & Data Systems, 2016, Vol. 116 No. 3, 564-583.URL.https://doi.org/10.1108/IMDS-04-2015-0151

129. Ndraha N., Hsiao H., Vlajic J., Yang M, Hong-Ting Victor Lin Time-temperature abuse in the food cold chain: Review of issues, challenges, and recommendations, Food Control, Volume 89, 2018, 12-21 .

130. Ning J. A best-path-updating information-guided ant colony optimization, 2018, URL. https://proxy.library.spbu.ru:2069

131. Nirenjena S., Lubin Bala Subramanian D., Monisha M. Advancement in monitoring the food supply chain management using IoT International Journal of Pure and Applied Mathematics, 119 (14) 2018. 1193-1196.

132. Niv GR Space Dr. Deming: The Principles of Sustainable Business Harvard Business Review, 2005. 370.

133. Nooraie SV, Parast MM "A Multi-Objective Approach to Supply Chain Risk Management: Integrating Visibility with Supply and Demand Risk", International Journal of Production Economics 161. 2015. 192-200.

134. Oliver K., Webber M. Supply chain management: logistics catches up with strategy. Logistics: the strategic issues / ed. by M. Christopher. London; New York: Chapman & Hall, 1982. 360.

135. Olkhova M., Davidich Yu., Roslavtsev D., Davidich N. The efficiency of transporting perishable goods by road and rail. Transport Problems, 2017 Volume 12 Issue 4. 37-50.

136. Oracle Innovation Manifests in a New Generation of Cloud Applications URL.https://idcdocserv.com/US46799319

137. Oracle Managing the Value Chain in Turbulent Times. Dynamic Markets Limited. Independent Market Research Report Commissioned by Oracle 2013URL.https://www.oracle.com/corporate/analyst-reports.html

138. Prakash G., Pravin Renold A., Venkatalakshmi B., RFID based Mobile Cold Chain Management System for Warehousing, Procedia Engineering, Volume 38, 2012, 964-969.

139. Qi L., Xu M., Fu Z., Mira T., Zhang H., C2SLDS: A WSN-based perishable food shelf-life prediction and LSFO strategy decision support system in cold chain logistics, Food Control, 2014, Volume 38 , 19-29.

140. Rafie-Majd Z. Modeling and solving the integrated inventory-location-routing problem in a multi-period and multi-perishable product supply chain with uncertainty: Lagrangian relaxation algorithm, 2018 URL: https://proxy.library.spbu.ru: 2069 /

141. Rantasila, K. Measuring logistics costs. Designing a generic model for assessing macro logistics costs in a global context with empirical evidence

from the manufacturing and trading industries. Turun's shopping mall is open to the public. 2013. № A-8: 2013. URL:https://www.doria.fi/handle/10024/93317

142. Ratul A., Megat FZ, Nazmus S. Enhanced Blockchain transaction: a case of food supply chain management. Journal of Engineering and Applied Sciences. 2020. Vol. 15, iss. 1. 99-106.

143. Ream J., Chu Y., Schatsky D. Upgrading Blockchains: smart contract use cases in industry. Deloltte Univercity Press, 2016, №. 02 (04), 1-11.

144. Reputation risk. American Banker Glossary. URL.http://www.americanbanker.com/glossary/r.html

145. Rohit Joshi DK Banwet, Ravi Shankar A Delphi-AHP-TOPSIS based benchmarking framework for performance improvement of a cold chain, Expert Systems with Applications, Volume 38, Issue 8, 2011, Pages 10170-10182

146. Rosic A. Smart contracts: the Blockchain technology that will replace lawyers. Blockgeeks. 2017 URL: https://blockgeeks.com/guides/smart-contracts

147. Schneider SA Concurrent and Real-Time Systems (the CSP Approach). Worldwide Series in Computer Science. Wiley, 2000. 507.

148. Shen L., Stopher P. Review of GPS Travel Survey and GPS DataProcessing Methods. Transport Reviews: A Transnational Transdisciplinary Journal. 2014. Vol. 34. No. 3. 316-334.

149. Shih CW, Wang CH,. Integrating wireless sensor networks with statistical quality control to develop a cold chain system in food industries. Computer Standards & Interfaces, 2016, 45, 62-78

150. Skok D. Startup Killer: the cost of customer acquisition. For Entrepreneurs 2013 URL:https://imh-holdings.com/wp-content/uploads/2013/01/Startup-Killer_-the-Cost-of-Customer-Acquisition-_-For-Entrepreneurs.pdf

151. Smiljkovikj K., Gavrilovska L. Smart Wine: Intelligent end-to-end cloud-based monitoring system Wireless Personal Communications, 78 (3) 2014, 1777-1788.

152. Smith J. Blockfreight block the blockchain for global freight. Version: Public Release 2016. v 1.0.1 URL.http://blockchainlab.com/pdf/ BlockfreightWhitepaperFinalDraft.pdf

153. Spliet R. Gabor A., Dekker R. The vehicle rescheduling problem, Computers & Operations Research, Volume 43, 2014, 129-136.

154. State of Logistics Indonesia 2013 Center of Logistics and Supply Chain Studies, 2013. URL:http://logisticscenter.itb.ac.id/wp-content/uploads/StateofLogisticsIndonesia2013.pdf

155. Stranner T., Ummenhofer P., Abl A. ETC-Based Traffic Telematics. Utilizing Electronic Toll Collection Systems as a Basis for Traffic Data Generation. Springer-Verlag Berlin Heidelberg 2010. 71-81.

156. Stathakopoulous C., Cachin, C. Threshold signatures for Blockchain systems. IBM Research. Zurich: Swiss Federal Institute of Technology, 2017. 42.

157. Stuart Toby E. Interorganizational Alliances and The performance of Firms: A Study of Growth and Innovation Rates In a High-technology Industry. Strategic Management journal, 2008, 21 (8), 791-801.

158. Tang O., Musa SN Identifying Risk Issues and Research Advancements in Supply Chain Risk Management. International Journal of Production Economics 133 (1). 2011. 25-34.

159. Themen D. Food losses and waste in Ukraine [Electronic resource]. Regional Office for Europe and Central Asia Food and Agriculture Organization of the UN. 2013. URL:http://www.fao.org/europe/agrarian-structures-initiative/en

160. The state of the world's land and water resources for food and agriculture (SOLAW) - Managing systems at risk. Food and Agriculture

Organization of the United Nations, Rome and Earthscan, London. FAO. 2011. 285.

161. Transmetrics. URL. https://www.startus-insights.com/innovators-guide/ logistics-industry-trends-10-innovations-that-will-impact-logistics-companies-in-2020-beyond /

162. Transportation Services Index URL.https://www.transtats.bts.gov/OSEA/TSI/

163. Trienekens J. Transparency in complex dynamic food supply chains, 2012 URL.https://proxy.library.spbu.ru:2069

164. Van der Vorst, J., Van Kooten, O., Luning, P. Towards a diagnostic instrument to identify improvement opportunities for quality controlled logistics in agrifood supply chain networks. International Journal on Food System Dynamics, 2011. 2 (1), 94-105. URL.http://centmapress.ilb.uni-bonn.de/ojs/index.php/fsd/article/view/119

165. Vilko J., Ritala P., Edelmann J. On Uncertainty in Supply Chain Risk Management, The International Journal of Logistics Management 25 (1). 2014. 3-19.

166. Walmart, “Walmart invites global collaboration on food safety in China,” press release,www.wal-martchina.com

167. Wang X., Sun H., 1 Dong J., Wang M., Ruan J. Optimizing terminal delivery of perishable products considering customer satisfaction. Mathematical Problems in Engineering. 2017http://downloads.hindawi.com/journals/mpe/2017/8696910.pdf

168. Wardrop JG Some Theoretical Aspects of Road Traffic Research. Proceedings of the Institution of Civil Engineers, 1952. Part II, Volume I, 325-362.

169. Wittenburg, P, et al. The FAIR Funder pilot program to make it easy for funders to require and for grantees to produce FAIR. 2019. Data. archive: 1902.11162. URL:http://arxiv.org/abs/1902.11162

170. Wilson, RHA Scientific Routine for Stock Control. Harvard Business Review. 1934. 13: 116-128.

171. Wladimir E. Soto-Silva, Marcela C. González-Araya, Marcos A. Oliva-Fernández, Lluís M. Plà-Aragonés, Optimizing fresh food logistics for processing: Application for a large Chilean apple supply chain, Computers and Electronics in Agriculture, Volume 136, 2017, 42-57.

172. World's Biggest Cold Storage Supplier Could Reach Full UK Capacity in Three Weeks. ByReuters, Wire Service Content April 24, 2020URL. https://money.usnews.com/investing/news/articles/2020-04-24/worlds-biggest-cold-storage-supplier-could-reach-full-uk-capacity-in-three-weeks

173. Worldwide Markets for Smart Packaging 2018-2023 - Oxygen Scavenger Technology Expected to Lead the Market. URL. https://www.financialbuzz.com/worldwide-markets-for-smart-packaging-oxygen-scavenger-technology-expected-to-lead-the-market-1266026/

174. Xu G., Yu G. On convergence analysis of particle swarm optimization algorithm. Journal of Computational and Applied Mathematics 2018 URL .:https://proxy.library.spbu.ru:2069

175. Xu L., Chen L., Gao Z., Chang Y., Iakovou E., Shi W. Binding the physical and cyber worlds: a Blockchain approach for cargo supply chain security enhancement. IEEE International Symposium on Technologies for Homeland Security (HST), Woburn. 2018. 1-5.

176. Yager R. Families of OWA Operators Fuzzy Sets and Systems, 59, 1993. 125-148.

177. Yiyan Qin, Jianjun Wang, Caimin Wei, Joint pricing and inventory control for fresh produce and foods with quality and physical quantity deteriorating simultaneously, International Journal of Production Economics, Volume 152, 2014, 42-48.

178. Zadeh L. Toward a theory of fuzzy information granulation and its centrality in human reasoning and fuzzy logic. Fuzzy sets and systems, 1997. Vol. 90, no. 2. 111-127.

179. Zagurskyi O., Ohiienko M., Pokusa T., Zagurska S., Pokusa F., Titova L., Rogovskii I. Study of efficiency of transport processes of supply chains management under uncertainty. Monograph. Opole: The Academy of Management and Administration in Opole, 2020. 162 p.

180. Zagurskiy O. Ohiienko M, Rogach S., Pokusa T., Rogovskii I., Titova L. Global supply chains in the context of a new model of economic growth // Conceptual bases and trends for development of social-economic processes. Monograph. Edited by Alona Ohiienko Tadeusz Pokusa Opole. The Academy of Management and Administration in Opole, 2019. 64-74.

181. Zagurskiy O., Titova L. Problems and Prospects of Blockchain Technology Usage in Supply Chains. Journal of Automation and Information Sciences, 2019. Volume 11. 63-74.

182. Zagurskiy O., Rogach S., Titova L., Rogovskii I., Pokusa T. «Green» supply chain as a path to sustainable development // Mechanisms of stimulation of socio-economic development of regions in conditions of transformation. Monograph. Opole: The Academy of Management and Administration in Opole, 2019. 199-213.

183. Zagurskiy O., Zahurska S., Titova L., Rogovskii I. Of blockchain-technology usage in supply chains / Socio-economic development of the regions in conditions of transformation. Monograph. Opole: The Academy of Management and Administration in Opole, 2020. 13-22.

184. Zagurskiy OM, Zhurakovska TS Optimization of transport processes in supply chains of epicenter hypermarket network. Machinery & Energetics. Journal of Rural Production Research. Kyiv. Ukraine. 2020, Vol. 11, No. 3, 55-60.

185. Zhang G., Habenicht W., Spie WEL Improving the structure of deep frozen and chilled food chain with taboo search procedure. Journal of Food Engineering, 2003, 60 (1), 67-79.

186. Zhang Y., Qian C. Modeling of an IoT-enabled supply chain for perishable food with two-echelon supply hubs. Industrial Management & Data Systems 2017.Vol. 117, Issue 9. URL.https://proxy.library.spbu.ru:2156

187. Zou X. Design and realization of pork anti-counterfeiting and traceability IoT system Acta Technica CSAV (Ceskoslovensk Akademie Ved), 61 (4), 2016, 281-289.

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