THE ACADEMY OF MANAGEMENT AND ADMINISTRATION IN OPOLE

SUPPLY CHAIN LOGISTICS SERVICE SYSTEM: METHODS AND MODELS OF ITS OPTIMIZATION

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PREFACE

The current stage of economic development is characterized by a radical change in the business model. High rates of growth in sales and profits, market power of suppliers, mergers and acquisitions, and low competition are being replaced by new economic conditions. Conditions in which power is concentrated in the hands of customers, barriers to entry for new players are reduced, differences between suppliers are becoming less obvious, and the issues of maintaining former market positions, finding new sources of growth, ways to preserve existing customers and attract new ones are becoming particularly acute. The more technologically simpler the composition of the material flow, the more substitute goods that have identical consumer properties, the further in the supply chain the firm is from the final link of product distribution, the more critical it becomes to find a method of differentiation of the enterprise in a highly competitive market.

Buyers' priorities are gradually shifting towards the service environment of the purchased product. This phenomenon determines the sensitivity of buyers to the service, which pushes enterprises to develop new and develop existing services in order to maintain their own market positions. Building a well-thought-out logistics service system allows companies to avoid making mistakes in this area of doing business, which include delivering goods to all customers on the day of the order, and implementing ill-conceived delivery schemes, and free delivery to all customers who express dissatisfaction and direct complaints to the company. Despite the significant progress achieved in logistics, problems related to real-time information management, optimal distribution of logistics resources, and construction of an optimal logistics service system remain unsolved. Under the traditional practice of logistics activities, in which a centralized and one-way service scheme is widely used, logistics companies have many typical problems, such as low efficiency in the management and distribution of logistics resources, low utilization rate of vehicles, and even errors in the supply logistics process.

Therefore, the marketing and logistics divisions play an increasingly leading role in the development and implementation of the logistics service system. The results of the interaction of these divisions, taking into account the types of economic utility they create, are the most significant for supply chains. It is considered that the area of responsibility of marketing is the elements of service before the agreement, while the area of responsibility of the units that make up the logistics system of the enterprise is the elements of service during and after the implementation of the agreement. Therefore, they are responsible for a significant share of service offers implemented by the logistics system of the supply chain.

In the scientific literature on logistics management, supply chain management and their modeling, the existence of the problem of determining the balance of the logistics service provided by the enterprise and the costs of its support is noted. The proposed methods of solving the specified problem are often conceptual in nature and lack proper systematicity and accuracy. Taking into account the possibility of quantitative measurement of logistics service using relevant indicators and the existence of a connection between logistics service indicators and financial indicators, the necessary balance of logistics service and costs can be established on the basis of the implementation of the integration economic-mathematical optimization model proposed by us in the study.

CHAPTER 1. THEORETICAL ASPECTS OF BUILDING A SUPPLY CHAIN LOGISTICS SERVICE SYSTEM

1.1 The genesis of development and management institutes in conditions of evolutionary change of paradigms in logistics

One of the most important components of freedom is the ability to move. It includes not only the personal movement of a person in space, according to his needs, desires and interests, but also the sending and receiving of various objects, services and information to the right place or from the right source. The possibility, ease, simplicity and cheapness of transport operations largely determine the content and quality of life of people in society, the degree of realization of their creative and consumer potentials. In addition, the efficiency of solving transportation tasks affects the competitiveness of the country, its productions and products. In economic activity, freedom of movement is of crucial importance, exerting a significant influence on all economic processes, enabling various economic operations inherent in post-industrial society.

The transition to a post-industrial society is marked by cardinal changeschanges that require the development of new methods and approaches in the functioning of society. Logistics as a field of human activity is also undergoing changes. Network, informational, cognitive features of the new economic formation determine approaches to managing processes and flows. New requirements appear, the requests of the end consumer become a priority, in connection with which the logistics of individual business processes are replaced by the concept of supply chain management. Accordingly, the process organization and institutional "design" of individual groups of logistics operations, the system of logistics management over a long historical period are permanently developing in the direction of increasing the degree of integration of supply chains.

As a result, at the current stage of scientific research, it is fundamentally important to focus on the mechanisms and factors of the long-term strategy of the behavior of supply chain participants, the updated composition of which should be characterized not only by a high level of their integration, but also by a parity distribution of market power and, accordingly, profit between them.

Consolidation of trade networks, expansion of tools for deepening the integration of suppliers into retailers' supply chains, actually formed a new object-process decomposition of the supply chain, from which the wholesale link is quite actively displaced. That is, trade networks, specializing in the performance of exchange functions, actually increase the requirements for logistics and supply management and transfer them to production links, bypassing intermediaries. This empirical trend corresponds quite well with the theoretical generalizations of scientists Bowersox and Kloss on the need to take into account the relationship between marketing and logistics when managing supply chains – the main argument for their division is the fullest use of the potential of specialization[1].

Under such conditions, one of the basic competitive advantages of any organization is the ability to quickly and qualitatively satisfy various requests of consumers or buyers (hereinafter, customers) in accordance with their requirements. The most important tool in the process of achieving this goal is the direction of the organization's activities as a whole, since it is the formation of an effectively functioning system of promoting goods along supply chains that allows the delivery of the goods needed by the client at the right place, time, in the required quantity, of the appropriate quality and with the lowest costs.

[1]Bowersox D. J., Kloss D. J. Logistics: an integrated supply chain / trans. with English N.N. Baryshnikova and B.S. Pinsker. M.: ZAO "Olymp-Business", 2008. R.433.

After all, cost and reliability remain the main drivers when designing supply chain operations.

In general, minimizing inventory and helping to expedite the flow of goods through the supply chain are two keys to achieving these dual goals.[2].

Distributor networks with different profiles of distribution and logistics centers create numerous opportunities to increase both profitability and efficiency of the supply chain. Therefore, M. Christopher and D. Tovill, in connection with the tendency of many markets towards instability and unpredictability, consider "efficiency in the management of supply chains to be the most priority area of the economy"[3].

However, a combination of unfavorable external factors, for example: wars, quarantine restrictions, price fluctuations, arbitrary increases in supply batches, deviations from planned dates and production volumes, lack of after-sales service, etc., can lead to disruptions or failures in the supply chain, and therefore to decrease in the reliability of supplies, increase in costs, and in some cases, the outflow of customers.

In addition, increasing the requirements for environmental friendliness of the economy and basic principlescircular economy requires the use of durable, renewable or reused materials in the production of goods. The most effective way to promote a circular economy is to extend the product life cycle, including logistics, by using durable materials and creating durable products that can be repaired and reused at the end of their life cycle.

Given the new economic conditions, an effectively functioning supply chain must meet all the requirements of the economy of a post-industrial society, including, in particular, a quick response to changes in demand, the application of innovations in all areas of logistics, the fulfillment of orders with high quality

[2]Baker P. The design and operation of distribution centers within agile supply chains. International Journal of Production Economics, 2008. 111, 27-41.

[3]Christopher M., Towill D. Developing market specific supply chain strategies. International Journal of Logistics Management. 2002. 13 (1), 1-14.

of service, and the extension of the life cycle of products. In this regard, during the construction of modern logistics systems, the policy of selling manufactured goods is replaced by the policy of production of goods or services that are sold; constant work is carried out to minimize the terms of passing products through the technological process, reducing the batch of resources and the batch of processing, reducing all types of downtime and irrational intra-production transportation. Organizations carry out their activities in a dynamic environment, within which there are rapid and constant changes in demand,

These changes directly affect the formation of characteristics that determine the competitiveness not only of production, but also of the entire logistics system of product promotion from the manufacturer to the client. Therefore, it can be confidently stated that the key to the successful functioning of an organization is not so much stability and stability as the ability to dynamically respond to the uncertainties of the external environment.

Accordingly, the development of traditional and most already functioning logistics systems is largely explained by the genesis of research concepts in the field of spatial economy, their interconnections with general and national patterns of economic development. A general idea of the genesis of the stages of logistics activity is given by the phasing of their development, presented by us in Table 1.1.

Thus, the principle of total costs became decisive first in the development of optimization of logistics solutions in wholesale and retail activities, and then in the entire structure of trade and industrial companies. In the 60s of the last century, the concept of business logistics was developed and widely used as an integral management tool in the developed countries of the world. Which is defined as "the art and science of management, techniques and technological activities that ensure the planning and application of means of movement for the implementation of planned operations and the achievement of the set goal"[4].

Table 1.1 – General characteristics of development stages logistics systems

Stages of development of logistics systems	Brief description of the stage
Stage 1 – the period of formation of logistics (late 1960s to 1980s)	The period is characterized by intensive development of theoretical foundations and organization of practical logistics. In developed countries, the philosophy of marketing in the field of logistics services is widely spread. Enterprises that carry out supply and sales activities solve the problems of finding reserves to reduce transport and procurement costs in order to reduce the cost of the work performed.
Stage 2 - the period of rapid development of logistics (beginning of the 1980s - until the end of the 20th century)	It is characterized by rapid development of logistics systems. The dominant practice of the rapid growth of logistics services is recognized as the practice of managing processes, which is developing, based on their maximum unification (integration), the unification of many types of logistics activities within the framework of large companies, covering the full cycle of fulfilling a customer's order: "purchase - production - distribution - sales - after-sales service" to achieve the ultimate goal of business with the optimal expenditure of resources

[4] Langley CJ. The Evolution of the Logistics Concept. Journal of Business Logistics. 1986. Vol. 7, No. 2. 1-13.

Stage 3 - the period of development of a new ideology of management of logistics systems - supply chains (at the turn of the 20th and 21st centuries)	The new ideology of managing logistics processes and business in general is developing on the basis of the methodology of supply chain management, which integrates the paradigms of logistics that existed before the beginning of the 21st century - functional and resource. The integration of logistics business processes, developed in the organizational management structures of leading companies, became the basis for the development of new functional responsibilities of companies, which are performed in the management of integral managers, coordinators and analysts, as well as top managers for planning and control of supply chains
4th stage - globalization (2000s).	The concept of logistics, the key point of which is the need for integration, has been recognized by most participants in the supply, production and distribution chains. There have been fundamental changes in the organization and management of market processes throughout the world economy. Companies began to carry out their activities not only at the regional or national levels, but also at the global level. The globalization of the world economy has begun.
Stage 5 – innovative development of logistics systems (from the early 2010s to the present)	With the improvement of logistics management methods, the formation and development of an innovative and digital ideology of logistics activity is taking place, which foresees the increase in the stability of integrated supply chains based on new information and digital technologies, which affect the reduction of the time of promotion of material and financial flows. Quality control and increased role of after sales service.

Source: compiled by the authors based on materials from scientific sources

Many researchers explain the "logical takeoff" in the 80s of the last century in the world economy with the development of personal computers and information technologies, on the basis of which the "integral concept of logistics" was implemented, which made it possible to control material flows in the online mode and in the mode remote access through information communication channels. It became possible to manage information within logistics activities.

However, the most significant is the modern stage of innovative development of logistics systems. We are talking about the fact that the different levels of development of individual market participants, wholesalers and trade networks, logistics and warehouse operators formed a special resulting configuration of the consumer market's commodity network. In the framework of its new decomposition, format retailing concentrates the performance of exchange functions as much as possible, while logistics is automatically transferred to suppliers. Not having the opportunity to organize supply to the network at a high level, producers actually stimulate the expansion of the range of auxiliary logistics functions implemented by other participants of distribution channels.

As a result of such differentiation of the position of individual participants in supply chains, the active growth of trade networks and the functional weakening of the distribution link, the term "integration potential" of a participant in the supply chain was introduced in modern logistics, which characterizes the degree of attractiveness of the participant for integration and the possibility of its influence on the efficiency of the processes taking place in chains Accordingly, this stage is characterized by an accelerated growth in the number of logistics companies that provide clients (industrial, service and trading firms) with complex logistics services in warehousing, cargo processing, transportation, customs clearance, inventory management, etc. These companies, mostly formed from transport and forwarding companies, general purpose warehouses, cargo terminals, began to be called logistics operators,

At the end of the 20th - at the beginning of the 21st century. a new type of intermediary companies appeared - 4PL-providers (system integrators of supply chains), the main functions of which are the development of logistics projects to the order of companies, the formation and management of integrated supply chains. More and more companies in the world have begun to transfer their logistics operations and functions to 3PL and 4PL providers, that is, to use a strategy of logistics outsourcing.

So, the distinctive features of the development of the world market of logistics services since the end of the 90s of the 20th century. to date are reflected by the following trends:

1. Logistics intermediaries have expanded the range of their competences in the field of integration and management of supply chains. This means that there is a growing desire to do business with a large participation of 3 and 4 PL providers.

2. Logistics operators have become more in demand to perform transactional activities, such as order processing.

3. The range of services is noticeably increasing and the technological capabilities of providers are becoming more developed.

4. Customer orientation of logistics companies is increasing. This is manifested in the implementation of integrated planning of the activities of client firms, in the understanding of the industry specifics of this activity.

5. Consolidation and consolidation of logistics operators is taking place.

6. Intermediaries have become more active, an increasing number of them enter the global market; their willingness to meet the specific needs of each of the local market segments increases; the validity period (duration) of contracts concluded by providers of logistics services with their clients increases.

International programs and projects that are being developed at this time and in which logistics are given a leading role should be noted separately. Thus, EU countries operate and implement programs aimed at creating international logistics centers for physical distribution, commodity flows and logistics infrastructure of pan-European and Eurasian transit corridors. To implement the principles of logistics in global supply chains in world economic trade relations, international communication information and computer systems developed under the auspices of the UN, TACIS and other international organizations and communities have been created.

Many scientific schools, known in the field of economic logistics, are recognized to a greater extent as national than general theoretical, and the goal of the development of logistics directions of the theory is increasingly becoming the modeling and optimization of logistics activities and the development of national and regional logistics systems. However, the majority of scientific schools develop within their initial concepts (paradigms), which determined certain areas of solutions to logistical tasks for the economy. In the evolution of scientific research in the field of logistics, three main paradigms can be traced, which in the process of development replace each other: functional, resource and innovative.

At the second stage of development, logistics paradigms are clearly divided according to the main types of outsourcing:

- resource outsourcing, in which enterprises transferring logistics functions to intermediaries give up their assets (resources), preferring to receive services from an intermediary - an outsourcing company;

- management outsourcing, in which the company engages a third-party outsourcing organization to manage its logistics infrastructure. At the same time, from the point of view of management in logistics, the most important concept is supply chain management, by which we mean "the organization, planning, control and execution of the product flow (from design and procurement through production and distribution to the end consumer in accordance with market requirements and cost efficiency), built on the principle of coordination (coordination of actions) with the features of partnership relations (coordination of interests)"[5].

The second direction of logistics, as a science of managing material flows and related information, financial and service flows, is considered in a certain micro-, meso- or macroeconomic system to achieve the goals set before it with the optimal expenditure of resources. Accordingly, the functioning of the transport and logistics system can be represented as a set of processes. In particular, the model of the processes performed in the enterprise's logistics system based on the SCOR methodology (Figure 1.1).

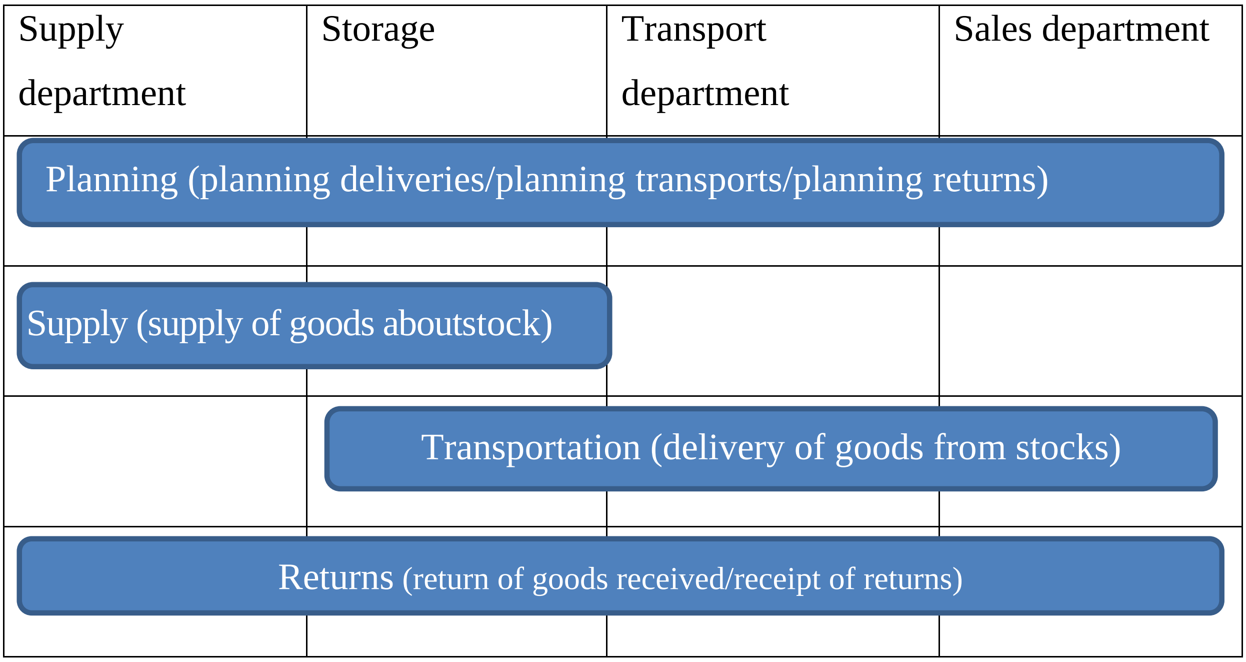

Fig. 1.1 – Model of supply chain flows

*Source:*compiled by the authors

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[5]Zagurskyi O.M. Supply chain management: education. manual Bila Tserkva: "Bilotserkivdruk" LLC, 2018. P 53.

At the same time, the flow is understood as the directed movement of an aggregate of something conditionally homogeneous (for example, products, information, finances, materials, raw materials, services, etc.).

Characteristics of flows in supply chains. The concept of material flow is key in logistics. Note that a unified approach to the concept of "material flow" has not yet been developed. Researchers[6] prefer to see as part of the material flow the object of logistics in relation to which the specific tasks of the study are set, most often it is the product and the logistics operations necessary for its promotion to the consumer. In this concept, the product can also be interpreted in different ways, depending on its spatial location and the specific stage of the logistics chain.

Material resources are usually considered as objects of logistics in the product flow. However, some authors include unfinished production along with finished products as material resources[7].

So, the material flow is unfinished and finished products that are considered in the process of applying to them various logistics operations (transportation, storage, and others) and assigned to a certain time interval. The dimensionality of the material flow is the ratio of the dimension of production (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. The material flow, which is considered for a given moment or period of time, becomes a material stock.

Material flow parameters can be: nomenclature, assortment, number of products, dimensional, weight, physical and chemical characteristics of cargo, characteristics of containers, packaging, conditions of purchase and sale,

[6] Laryna R.R., Pylyushenko V.L., Amitan V.N. Logistics in the management of organizational and economic systems. Monograph. Donetsk: Izd. VYK, 2003. 239; Gwynne Richards, Susan Grinsted The logistics and supply chain toolkit: 101 tools for transport, warehousing and inventory management. London: KoganPage, 2016. 261.; Kee-hungLai TCE Cheng Just-in-time logistics. Farnham, Surrey: Gower, 2016. 116.

[7] Dybskaya V.V., Zaitsev E.I., Sergeev V.I., Sterlygov A.N. Logistics. Integration and optimization of logistics business processes in supply chains: Moscow: Eksmo, 2014, P. 95.

transportation and insurance, financial characteristics, etc. At the same time, we note that the material flow is not able to advance within the logistics systems in isolation, it is accompanied by flows of finance, information and service.

The information flow reflects the dynamics of receiving, its transformation in relation to the change in the material flow. In other words, an information flow is a flow of various information messages during a certain period of time of the operation of the logistics system, which allows you to record the received data in a documentary, electronic form. Providing management of logistics activities with information on the basis of which management decisions are made is the main goal of forming information flows.

Depending on the nature of the information, methods of obtaining, collecting, processing and using it, information flows are classified according to different characteristics:

– in relation to logistics systems, logistics operations and functions;

- by type of media;

- by the time of occurrence and other criteria.

If the information flow is related to the multi-level organization of production and management, it is classified according to the levels of formation and use in the management system for the implementation of specific tasks.

The level representation of information flows is considered in the entire economic system, which allows to highlight information at the macro, meso, and micro levels. The presence of functioning global and national information resources and services allows for data exchange, serving various areas of state economic management, and creating various information platforms for branch activities, including for logistics systems of various levels.

The application of uniform requirements for the formation of information flows in logistics systems is used for the development of new information technologies that involve the automatic acquisition and collection of large databases, information storage using cloud technologies, control, exchange and transfer of information between management levels and its analytical interpretation for information support, specific management tasks.

The modern direction in the formation of models and methods of supply chain management is the integration of material and information flows, which was reflected in a number of scientific studies. According to them, information flows can be represented, in particular, in the form of documents, various devices (RFID scanners and sensors in warehouses), filled with data, the analysis of which is associated with relevant costs caused, including, by obtaining additional information about environment and making more accurate and reliable management decisions. As a result, the integration and synchronization of material and information flows leads to lower overall logistics costs, reduced costs related to shortages, and also ensures increased reliability of the supply chain.

The financial flow as a directed movement of funds is always related to the material flow and depends on the nature of the operations carried out in the supply chain with logistics objects, the scale of the logistics system, which united the intermediaries in the chain to perform the logistics operation.

In economic literature[8] traditionally allocated financial flows associated with the movement of cash and non-cash funds based on calculations in national or foreign currency units. The amount of financial flow, which is determined by the equivalent of cash funds reflected in settlement and other accompanying documents[9], is an object of management in the logistics system, on the one hand, and an object of logistics, on the other. It should be noted that until now, in the

[8]Lamzaouek H, Drissi H, El Haoud N. Cash Flow Bullwhip-Literature Review and Research Perspectives. Logistics. 2021; 5(1):8. URL https://doi.org/10.3390/logistics5010008; Sumets O.M., Kyzym M.O., Syromyatnikov PS, Kozureva, OV, Tsvirko O.O. Financial Flows In Logistics Systems Of Production Enterprises. Financial and Credit Activity: Problems of Theory and Practice, 2019, 3(30), 165-175.; Bals L., Tate W., Gelsomino L., Bals C. The Influence of Financial Flows on Sustainability. In Book of Abstracts: IPSERA Milan 2019: Art and Science of Procurement (pp. 53). [WP 152] International Purchasing & Supply Education & Research Association (IPSERA). URL http://www.ipsera2019.com/wp-content/uploads/2019/04/Book-of-Abstracts.pdf

[9]Zagurskyi O. M. Financial analysis: credit-module course. study guide. Kyiv: Center for Educational Literature, 2019. P. 24.

accounting system of organizations that carry out logistics activities independently and (or) that use intermediaries, funds and their movement as financial (or cash) flows are not separated separately either in the analytical accounting system or in the reporting forms.

Other opportunities have appeared in the conditions of widespread distribution of electronic payment systems, electronic (digital) money, the use of which allows subjects of logistics activity to manage financial flows based on new information and digital technologies. In our opinion, in the conditions of the digital economy, the financial flow should be combined with the information flow, since the movement of information and funds in calculations within logistics systems becomes a single complex object of management. At the same time, the information flow as an object of management in the logistics system does not lose its importance, but is the subject of constant scientific discussions and research[10] in various subject areas of science: analysis, statistics, econometrics and others.

In addition to material, information and financial flows, service flow is very important for supply chains, which is the number of services provided during a certain time interval. Let's dwell on it in more detail.

A service is a special type of activity that satisfies social 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

[10]Gu Y., Liu Q. Research on the application of the internet of things in reverse logistics information management. Journal of Industrial Engineering and Management, [Sl], 963-973, Oct. 2013. URL <https://www.jiem.org/index.php/jiem/article/view/793/511>;Chibba A., Rundquist J..Effective Information Flow in the Internal Supply Chain: Results from a Snowball Method to Map Information Flows,Journal of Information & Knowledge Management (JIKM), World Scientific Publishing Co. Pte. Ltd., 2009. vol. 8(04), 331-343; Rejeb A, Rejeb K, Abdollahi A, Zailani S, Iranmanesh M, Ghobakhloo M. Digitalization in Food Supply Chains: A Bibliometric Review and Key-Route Main Path Analysis. Sustainability. 2022; 14(1):83. urlhttps://doi.org/10.3390/su14010083; Wang G, Gunasekaran A, Ngai EWT, Papadopoulos T. Big data analytics in logistics and supply chain management: certain investigations for research and applications. Int J Prod Econ. 2016;176:98-110.;Awwad M., Kulkarni P., Bapna R., Marathe A. Big data analytics in supply chain: a literature review. In: Proceedings of the international conference on industrial engineering and operations management, 2018(SEP); 2018, 418-425.

or needs of organizations. The need to introduce the concept of the service flow of services is due to the growing importance and development of the service industry, and the concentration of an increasing number of companies and the population in it.

One of the many definitions of the service flow is given in the work of the author's team under the leadership of V.I. Sergeeva "Service flow - a flow of services (intangible activity, a special type of product or product) 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"[11]. The classification of service flows is given in Table 1.2.

Table 1.2 – Classification of service flows

Type of service flow	Service flow description
Pre-sale	Preparation of machines and equipment for sale; development of catalogs and price lists; preparation of technical documentation and operating instructions; provision of products in a commercial form after transportation to the destination (unpacking, re-conservation, installation, refueling, lubrication, regulation, etc.); demonstration of products; operation training.
After-sales (in warranty and post-warranty periods)	Diagnostics of machines and equipment; consultations on issues of operation and repair; supply of spare parts; replacement of defective parts (assemblies) with new ones; provision of tools, equipment, provision of consumables and accessories; provision of repair facilities for customers wishing to independently service

[11]Corporate logistics. 300 answers to the questions of professionals/ Ed. YOU. Sergeeva. INFRA-M, 2004. 976.

	their machines or equipment; preventive maintenance of works according to a special schedule, etc

Source: compiled by the authors based on materials from scientific sources

Together with you, we note that the very classification of flows contains the basis of their management, the management of flow processes, capable, using narrow branch terminology and the technique of formalizing connections, organizational and functional interactions between elements of the transport and logistics system, to reveal the optimal path of further logistical transformations.

Within the framework of the general fundamental theory of logistics, on the examples of real market practice, the mechanisms of managing economic flows are considered, practically taking into account the development of methods of managing flow processes aimed at high-quality transport and forwarding service of the consumer market.

Taking into account the multifacetedness, dynamism and multidirectional development trajectories of related industries, there are different approaches to managing flow processes, but the conceptual foundations of the logistics toolkit characterize the management process in supply chains as a linearly ordered set of participants (links, system elements) that perform the functions of transportation, warehousing, freight processing on the way of goods from the manufacturer to the consignee (Figure 1.2).

Management of flow processes, from the point of view of V.N. Stakhanov and V.B. Ukraintseva[12], is considered as a combination of strategic and operational management. In them, the flow management scheme consists of such basic aspects as targeting, design, management, planning, control and analysis.

[12]Stakhanov V.N., Ukraintsev V.B. Theoretical foundations of logistics. Rostov n/a: Phoenix, 2001. 159.

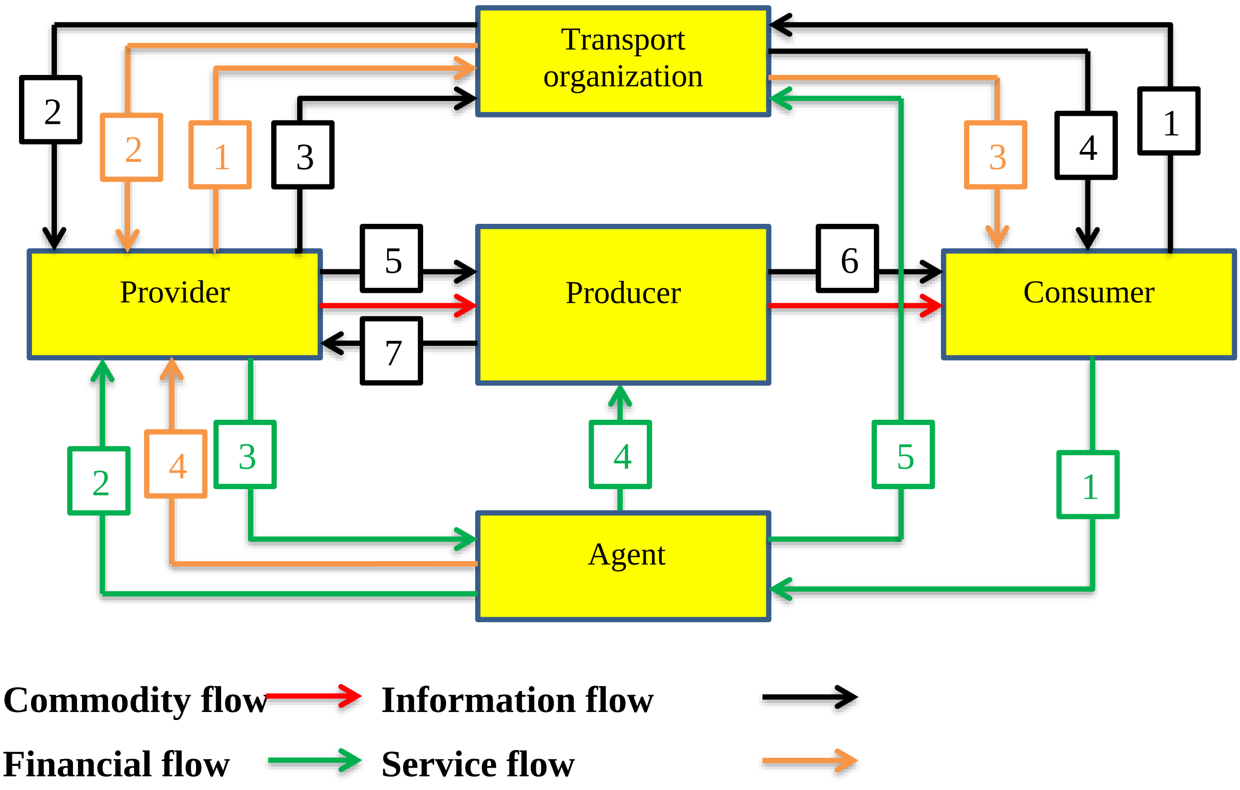

Fig. 1.2 – Scheme of intersection and overlap of flows in supply chains

Source: compiled by the authors

A number of other scientific and applied studies by domestic and foreign authors[13] devoted to issues of achieving stability of organizational and functional unity of flow processes in relation to their system optimization. In their view, the methodological significance of the formal adaptation of relationships within the transport and logistics system acquires a purposeful influence on the system as a whole. Accordingly, when conducting the analysis, it is necessary to find out from which specific group of reasons the instability of the system manifests itself.

[13]Laryna R.R., Pylyushenko V.L., Amitan V.N. Logistics in the management of organizational and economic systems. Monograph. Donetsk: Izd. VYK, 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. 2005. 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.

Having formally created an ideal model of the organization and functioning of flow processes, it is possible, assuming the influence of unforeseen market factors, to superimpose it on the actual one. Thus, the effectiveness of the system-analytical research is achieved, the points of intersection and overlapping of flows are formed, the impact on which provides the maximum economic effect.

Based on the principles of systematicity, dynamism, complexity, integration of processes and managerial influences, logistics has the property of quantitative, qualitative and functional universality. As a method or method of managing flow processes, it provides the possibility of preliminary calculation of the maximum quantitative indicators of the system at each level of its organization, which greatly simplifies and increases the efficiency of future functioning.

Flow process management methods are divided into three groups of principles.

1. Methodological principles, which include clear coherence and interaction of all functional nodes of the flow process management system to achieve the set 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 of time, computer support and modeling of the control system, as well as accounting for the costs of flow process management.

3. Situational principles, which include the timely receipt of reliable information about the movement of flows, the accuracy of planned cycles of purchase, production and sales, strict correspondence of order and sales

volumes, as well as the minimization of stocks[14]. And effective planning and controlling of all flows in chains supplies involves the use of metrics (Figure 1.3), which reveal the concept of "sustainability".

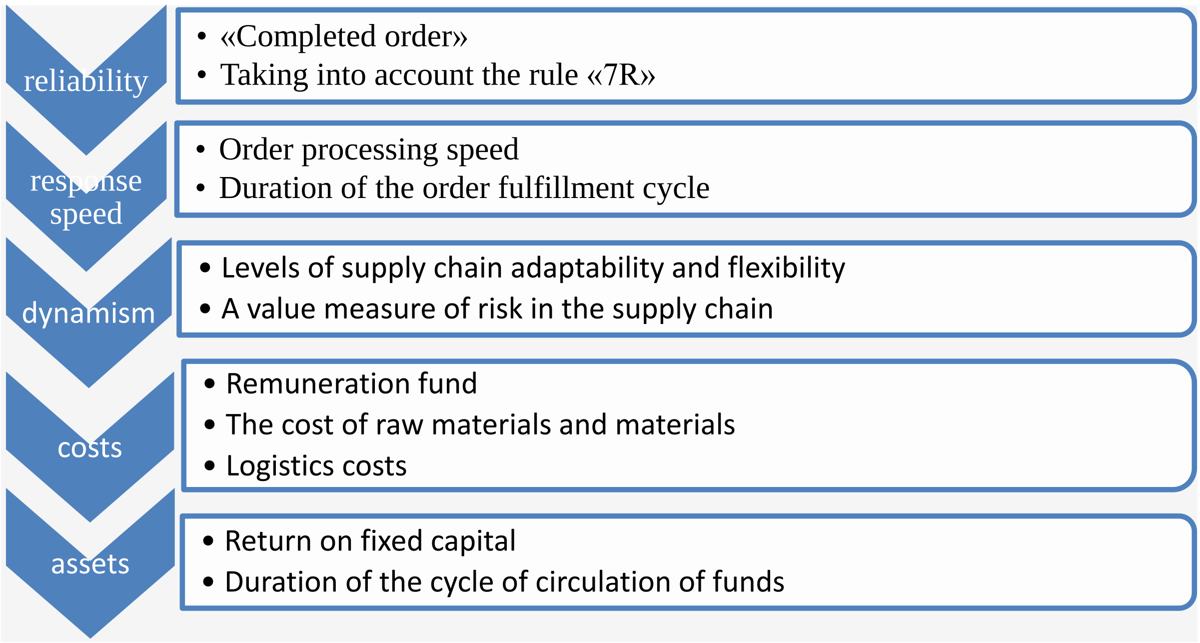

Fig. 1. 3 – Metrics of "sustainability" of the supply chain

Source: compiled by the authors

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

The influence of a certain link on a stream can be extremely diverse: streams can split, branch, converge, change their content, parameters, intensity, etc. In accordance with these characteristics, we offer the following basic diagram of the sequence of links of flows of the logistics chain:

1. Generators (sources) of material flows.

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

[14]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.

3. Transformation centers and points at production sites.

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

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

6. Destinations (consumers) of material flows.

Sources of material flow Consumers of material flow

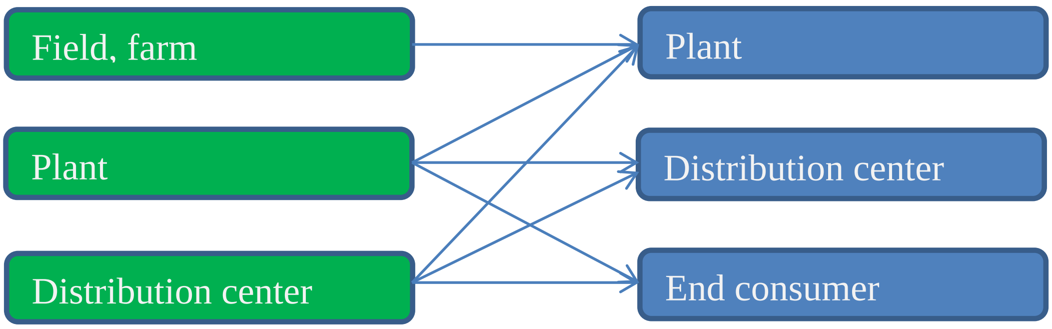

Fig. 1.4 – Variants of material flow entering the consumption system

Source: compiled by the authors

We note that the division of the main links into generating, transforming and absorbing does not contradict the logistic approach and can be applied to supply chains. At the same time, the elements of the logistics chain include suppliers, production units, intermediate, incoming and outgoing warehouses, transport companies, distribution networks, etc. In the links of the logistics chain, in accordance with the course of the technological process of transformation of the incoming material flow into the outgoing one, logistic operations are sequentially performed on the elements of the corresponding material, information, financial and service flows. Management of this subsystem, the necessity of which is the implementation of material flows, which is integral to the activity of the commercial structure, is also carried out with the help of four variables: temporal, spatial, quantitative and phase.

To identify the material flow as an economic category, its relationship with financial and informational flows should be traced, which both at the stages of procurement and at the stages of implementation is manifested in the inseparability of these processes, that is, they are the basis for the emergence of each other and mutual means of calculation. After all, the distribution of products according to their functional purpose is an intermediate link between the production process and the consumption of material and technical resources. However, regardless of its intermediate status, it is distribution logistics that is responsible for the movement of the material flow from the manufacturer through intermediaries to the final customer. In the modern business environment, the client in the company's activities is defined "as the fundamental force that creates sales"[15].

The logistics system, like any other system, is managed. System management in the classic form is a complex of dynamically interconnected elements, which from the standpoint of cybernetics (the science of management and communications) is perceived as a certain type of regulation ("coercion"). It is possible to master the essence of the system, provided that the main connections between the elements and their dynamic interactions become the object of research.

In terms of logistics, systems for the study of all influences on some single object of logistics, this object must be considered a part of some subsystem (part of the flow). A system in dynamic mode, that is, a functioning logistics system, can change from one state to another during any time interval. Accordingly, decisions are events occurring in a chain that reflects the system and is amenable to description. This means that all events in a certain sense can

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

be "predicted" as reflected in terms of the information contained in the system and through the structure of connections. The accuracy of such a "prediction" allows us to talk about two main types of systems: deterministic and probabilistic.

A deterministic logistics system should be considered a system in which the components interact in a precisely predictable manner, and there is never any uncertainty in it (the system). If the previous state of the system is given and the information processing program is known, then, having determined the dynamic structure of the system, it is possible to accurately predict its next state.

For a probabilistic logistic system, on the contrary, it is not possible to make an exact detailed prediction. Such a system must be thoroughly investigated in order to establish with a high degree of probability how it will behave under any given conditions. Understanding that the logistics system is largely uncertain in nature, any "prediction" of the behavior of the system and the behavior of individual elements of the system will be formed within the logical framework of probabilistic categories by which this behavior can be described. Behavioral motivations of managers of logistics systems should be aimed not only at preserving the existence of systems in environmental conditions, but also at their development. For this, the system, regardless of its type and characteristics, is forced to adapt to the economic, financial, social and political environment.

At the same time, we note that the flow vision of logistics systems in the conditions of the digital economy changes the very idea of the systems, which allows for their local modernization. However, the formation and improvement of the efficiency of regional logistics systems, which arise at the meso-level of economic management, remains a problem.

Under such conditions, researchers identify the key areas of development and management of logistics activities[16] three directions of diversification:

- natural and industrial diversification based on existing advantages, their consolidation, deepening of processing of primary resources and involvement of more complex production factors in the export-oriented process;

– innovative diversification, based on the modernization of the export range in accordance with the requirements of the world market, the further development of national competitive advantages, the formation of new clusters and competitive industries;

– digital diversification, based on the transformation of functional areas of logistics for the formation and development of forward-looking logistics systems.

As for the first two directions, which are mostly related to the development of exports, it should be noted that the territory factor (size and geographical location) plays a big role here, as well as the possibility of increasing the volume of transit transportation and communications.

Regarding the third direction – digital diversification and the development of logistics systems of anticipatory development – it should be noted that there is not yet a sufficiently developed legal and methodological base in this direction. However, the organization of the management of the logistics system based on digital technologies allows the formation of new models of logistics activity with a different number of participants, logistics centers, oriented at the level of all types of flows, especially information. Digitization of the information flow with the help of new technologies for processing "big data" databases is a key factor in the creation of forward-looking logistics systems.

[16]Li X. Operations Management of Logistics and Supply Chain: Issues and Directions. Discrete Dynamics in Nature and Society, 2014, 1-7.; Gamboa-Bernal JP, Moreno-Mantilla CE, Orjuela-Castro JA Sustainable Supply Chains: Concepts, Optimization and Simulation Models, and Trends, Ingenier´ıa, 2020, vol. 25, no. 3, 355-377.

1.2 The role of marketing and logistics in development of supply chain logistics service system

The transition to a post-industrial society is marked by cardinal changeschanges that require mastering new methods and approaches in functioningsociety Logistics as a field of human activity is also undergoing changes. And as noted by A. Martel and V. Klibi[17] modern logistics management, which is a set of integrated logistics activities, including freight transportation, storage, inventory management, material handling and all related information processing, requires the movement of products through an efficient supply chain process. The purpose of such management is to facilitate the flow of information and the exchange of knowledge regarding the most effective approaches for the allocation of relevant logistics resources to different logistics functions. Network, informational, cognitive features of the new economic formation determine approaches to flow management. New requirements appear, the requests of the end consumer become a priority, in connection with which the logistics of individual business processes are replaced by the concept of supply chain management.

In the modern economy, one of the basic competitive advantages of any organization is the ability to quickly and efficiently satisfy the requests of consumers or buyers in accordance with their requirements. The most important tool in the process of achieving this goal is the direction of the organization's activities as a whole, since it is the formation of an effective system of promotion of goods along supply chains that allows the delivery of the goods needed by the consumer to the right place, time, in the required quantity, of the appropriate quality and with the lowest costs. Accordingly, the development of economic relations is characterized by a shift in the priorities of buyers towards

[17]Martel A., Klibi W. Supply chains: issues and opportunities, In: Designing Value-creating Supply Chain Networks. Springer International Publishing, 2016. 1-43.

the service provision of the goods they buy. This phenomenon determines the sensitivity of buyers to the service, which prompts enterprises to develop new and develop existing services that make up the service, in order to maintain market positions.

The marketing and logistics departments play a leading role in the development and implementation of the company's service strategy. The results of the interaction of these divisions, taking into account the types of economic utility they create, are the most significant for enterprises. It is considered that the area of responsibility of marketing is the elements of service before the agreement, while the area of responsibility of the units that make up the logistics system of the enterprise are the elements of service during and after the implementation of the agreement. Therefore, a significant share of service offers is implemented by the company's logistics system. Therefore, order management is considered much more broadly than just supplier-buyer relations.

Currently, the external integration of business participants, based on inter-firm cooperative relations and the creation of unified information channels with suppliers and customers, is gaining more and more importance. As noted by F. Kotler and K.L. Keller "A supply chain is a value delivery system in which each company is only a link in the total value generated into the total value"[18]. Accordingly, enterprise order management is part of the process of managing an integrated supply chain, in which relations with suppliers are of a long-term partnership nature, and special attention is paid to optimizing supply processes, improving the quality of procurement and information provision.

Various types of enterprise activities: production, sales, marketing and financial activities have become increasingly dependent on the state of material and technical supply. In a market economy, no enterprise can consider itself self-sufficient. They depend to varying degrees on the materials and services provided by other enterprises on contractual terms. The average statistical

[18]Kotler F., Keller K.L. Marketing - management. 12th ed., St. Petersburg., 2011. 816.

manufacturer spends 60% of funds on the purchase of materials, and even a seemingly insignificant optimization of this process can bring significant benefits to the enterprise. Therefore, order management is one of the key functions, for the performance of which enterprises create special departments or hire special managers.

Usually, their functions do not involve the direct movement of goods or materials, but only the organization of actions that combine the distribution logistics of suppliers with the production logistics of enterprises. In this case, supply logistics is more related to information processing and exchange of property rights to goods or materials. In a broad sense, an order can be described as a sequence of logically and chronologically related actions (activities) that form a business transaction and serve as a mechanism for coordinating the material flow between counterparties in the supply chain.

In order to meet the growing consumer requirements for quality, diversity and availability of products in conditions reducing the duration of production cycle,supply sends information about consumer preferences back through the logistics channel, and information about what suppliers can offer them forward. As a result, effective processes are formed that contribute to the coordination of activities for the formation of consumer demand, as well as its satisfaction.

A traditional order management system assumes that decisions are made independently by suppliers and consumers. Thus, the supplier accepts the order and processes it, the consumer deals with order transfer operations, as well as the issues of receiving products and placing them at warehouses that are under his direct control or a logistics intermediary connected to him by contractual relations.

In other words, the customer assumes responsibility immediately after the transfer of ownership and the entire distribution network is within his competence. And the supplier's area of responsibility includes the storage of raw materials and materials, production, work-in-progress, and the storage of finished products.

The material flow of the business process begins from the moment when raw materials and materials arrive at the manufacturer's warehouse from the supplier. Then these materials are used directly for production. Naturally, unfinished production appears in the production process. Finished products are sent to the warehouse and stored there until the customer's order arrives. Then buyers buy products for sale to end consumers. The information flow starts from the end consumer, based on it, the retailer forms a demand forecast and places an order with the supplier. Based on the received information, the supplier forms a production plan, then the manufacturer places an order for this category of materials with the supplier of raw materials and materials. Thus, only the order is the connecting link between the consumer and the supplier.

Cash flow follows a traditional pattern. The supplier and the consumer pay for what has become their property. The supplier pays for production, inventory and shortages in his warehouse. The consumer also pays for the products received from the supplier. Payment for this or that operation takes place only after it has been carried out. The storage fee is paid when the product is in the supplier's or customer's warehouse. When a shortage situation arises, the costs associated with it immediately arise. The supplier receives payment for the products only when they are in the customer's warehouse.

An alternative to the traditional system is the supplier's management of the customer's inventory. Within this system, the supplier makes ordering decisions and influences the customer's inventory holding costs. At the same time, the client is now responsible only for the distribution of products from the warehouse. A controversial point in this model is the question of when the ownership of products is transferred, and when the customer begins to feel the material burden from the stocks in his warehouse.

When choosing an order management strategy today, a decision-maker must be guided by many criteria at once. These include the reduction of costs related to the supply of goods or their storage, minimization of funds frozen in stocks, ensuring the necessary quality of products and/or logistics service, minimizing purchase prices, increasing the turnover of goods stock, improving the terms of payment from suppliers, observing the terms and cost of the supply of goods on composition, exact fulfillment of the application specification by suppliers, etc.

The main purpose of supplies is to provide the enterprise with raw materials or materials of the required quantity and appropriate quality in accordance with its production needs, from a reliable supplier, with a high level of service and at an acceptable price. With this in mind, the main tasks of supply logistics are:

- provision of a continuous flow of material resources (raw materials, components, auxiliary materials, etc.) necessary for the enterprise, for the needs of the operating room and other types of activities. The lack of material resources, or their untimely replenishment can lead to a decrease in production volumes (and in the worst case, to a stoppage of production) and, accordingly, to non-fulfillment of obligations under contracts within a specified period;

- warehouse maintenance (cargounloading platform) definedthe strategy of forming reserves of the required level of material resources. Ensuring the insurance stock of production resources guarantees the reliable operation of the organization in case of force majeure circumstances at suppliers, and the insurance stock of finished products in turn guarantees the fulfillment of the organization's obligations to consumers of its products;

- improvement of interactions with company divisions that use ordered material resources, construction of a general supply strategy. Close relations with production units contribute to the timely receipt of information about changes in requirements for raw materials and materials (quality, standards, etc.);

- search, close interaction and formation of mutually beneficial relations with the most competent suppliers. Especially in cases where long-term maintenance of purchased goods, their modification or renewal is necessary;

- constant support and improvement of requirements for the quality of purchased materials. Production of products must be carried out with the required level of quality at all stages of the supply chain, otherwise the final product will not be able to meet the accepted requirements, which will not give it the opportunity to be competitive in the market;

- maintaining the lowest total cost while maintaining the appropriate level of quality, quantity, delivery conditions and service. The optimal level of price, quality and after-sales service is the key to increasing the demand for products promoted by the supply chain;

- increasing competitiveness. It consists in controlling all costs of the supply chain, which allows you to identify operations that do not bring profit or their use requires additional time.

In addition, it should be noted that a properly formed order management system makes it possible to reduce to minimum values the time and number of operations from the moment the order was placed by the consumer to the moment it ends.

When developing an order management system at an enterprise, it is mandatory to pay attention to both their appearance and the efficiency of this logistics system. Orders can be classified by form and time of processing and by the subject and object of the order. The main role in this case is assigned to the subject of the order, that is, the consumer.

Customers can be:

– departments, shops or branches of companies ("internal" consumer);

– trading companies or production organizations, as well as private individuals ("external" consumer).

Let's consider in more detail the main logistics operations inherent in the functional cycle of orders (Figure 1.5).

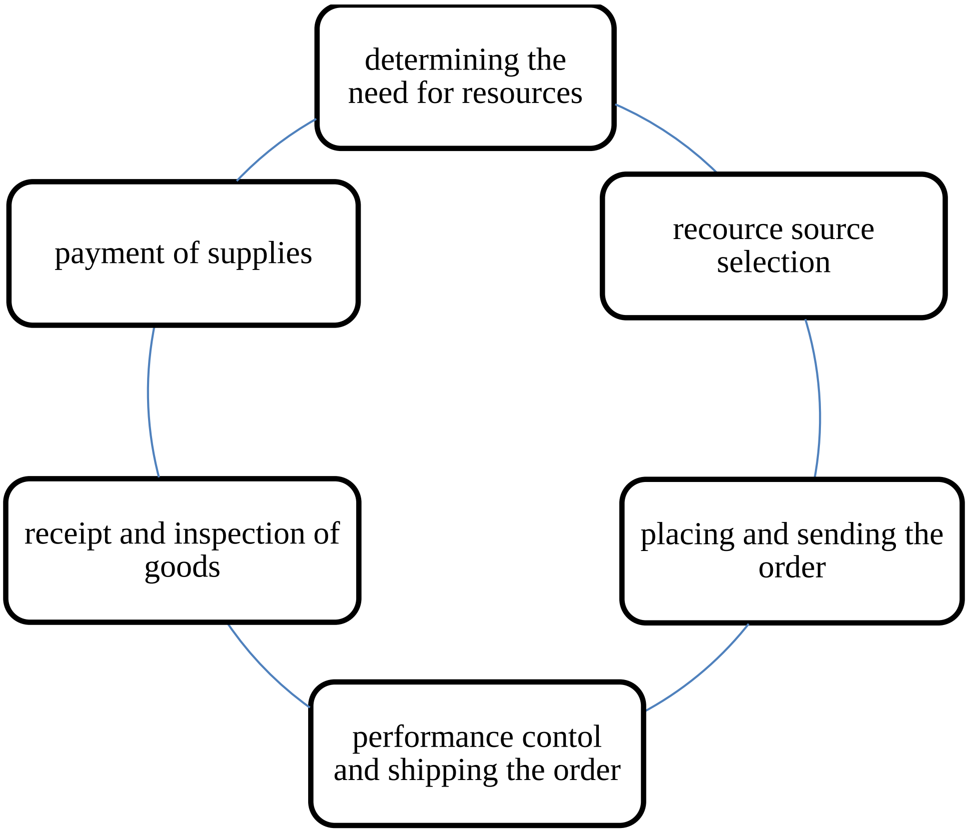

Fig. 1.5 – Functional order cycle

Source: compiled by the authors

The functional cycle of the order begins with the determination by the company's management of the need for material resources, i.e. what, how much and when must be put into production. The need for a specific material resource is understood as its necessary amount to ensure the life of the enterprise for a certain period of time (week, month, quarter, year). It consists of the need for resources for the main (production) process, the need for the creation and maintenance of temporary resource reserves, and the need for other types of economic activity of the enterprise.

$$G_{M.} = G_{M.b} + Z_{h,z} - Z_{m,f} \pm G_{m,h,n} + G_{m.e} \tag{1.1}$$

where $G_{M.b}$ – the material resource requirement of the main production process;

$Z_{h,z}$ – the standard of material resource stock is established;

$Z_{m,f}$ – the actual availability of a material resource;

$G_{m,h,n}$ – amount of material resource in work-in-progress;

$G_{m.e}$ – the need for material resources to perform repair, operational and other types of work.

Moreover, $G_{M.b}$ is calculated according to the formula:

$$G_{M.b} = \sum_{i=1}^{m} Q_i n_i \tag{1.2}$$

where Q_i – the output volume of each product name (pieces);

n_i – the rate of consumption of material resources per product unit, taking into account technological losses (natural units);

m – the number of names of products.

After the need for material resources has been determined, it is necessary to make a decision regarding the choice of the source of the resource, that is, on the independent production of the necessary material resources or their purchase from another enterprise. The essence of this choice lies in solving the question: what is more profitable – to produce semi-finished components yourself or to buy them from an external seller.

The process of making this decision is quite complex and includes consideration of both quantitative and qualitative factors. Quality factors include ensuring the quality of manufactured products and maintaining long-term business relations with the supplier. Quantitative factors are related to the cost of choosing one of the solutions. If the choice is made in favor of an external seller, then the second stage of determining the supplier comes.

Communication and interdependence of marketing and logistics. An understanding of the relationship between marketing and logistics can be achieved by analyzing the types of economic utility created as a result of performing these functions, such as utility of form, utility of ownership, utility of time, and utility of place. D.J. Bowersox and D.J. Klos note that the utility of form is created in the production process, the utility of ownership is created as a result of marketing activities, and the utility of time and place is created as a result of the implementation of logistics processes[19]. Possession utility represents the value added to a product by the fact that the consumer becomes its owner. The utility of place is understood as the value provided by the availability of a product for purchase or consumption in the right place, the utility of time is the value created due to the availability of the product at the right time[20]. So, the analyzed areas of activity are connected in the process of creating value for the consumer.

To determine the basis of the interdependence of marketing and logistics, we need to analyze the definition of marketing. So according to F. Kotler and K.L. Keller, marketing is a type of human activity aimed at meeting needs in the form of exchange[21]. The American Marketing Association defines marketing as the activity, set of institutions and processes for creating, communicating, and delivering value propositions to customers, buyers, partners, and society, as well as sharing them[22]. And according to the definition of the Royal Institute of Marketing, marketing is a management process aimed at identifying, forecasting and meeting the needs of customers with profit for the company[23]. The given

[19]Bowersox, D.D., Kloss, D.D. Logistics: an integrated supply chain. translated by N. N. Baryshnikova, B. S. Pinsker. - 2nd ed. Moscow: ZAO "Olymp-Business", 2008. P. 50.

[20]Stok D. R., Lambert D. M. Strategic logistics management - 4th ed. Moscow: INFRA-M, 2005. 797.

[21]Kotler F., Keller K.L. Marketing - management. 12th ed., St. Petersburg., 2011. 816.

[22]American Marketing Association (AMA) Dictionary Chicago, IL, 2015. URL: https://www.ama.org/resources/ Pages/Dictionary.aspx?dLetter=M

[23]Chartered Institute of Marketing (CIM) Glossary. Maidenhead, Berkshire, 2015. URL:http://www.cim.co.uk/Resources/ JargonBuster.aspx

definitions show that marketing activity has at least two orientations: meeting the needs of consumers and making a profit.

Satisfaction of consumer needs can be achieved as a result of providing the desired product or set of services. A significant contribution to the understanding of customer service was made by B.J. LaLonde et al. In them, "customer service is the process of creating significant benefits in the logistics chain, containing added value, while maintaining costs at an effective level"[24]. In which "three groups of service elements interact: elements before the transaction, elements during the transaction and elements after the transaction"[25]. Thus, the activities of marketing and logistics are aimed at serving consumers, with, as noted by D.J. Bowersox and D.J. Klos, logistics, optimizing the total costs, contributes to the achievement of the marketing goal of obtaining profit[26]. The positive impact of the results of logistics activities on the financial indicators of the enterprise due to the effectiveness of marketing is also confirmed by the research of K.V. Green, D. Witten and R.A. Inman[27].

It should also be noted the approach of V.I. Sergeev on the interaction of marketing and logistics, according to which each of the components of the marketing mix affects different aspects of the company's logistics. Given the amount of logistics costs, the level of which can be comparable to or exceed the costs incurred during the production of the product, the "price" component determines the range of possible methods of transportation and organization of storage, and even possible levels of stocks. The "product" component, which reflects the product assortment, determines the change in the distribution network, the amount of product stocks, methods of transportation and

[24]LaLonde BJ, Cooper MC, Noordewier TG Customer Service: A Management Perspective, Oak Brook, IL: The Council of Logistics Management, 1988. 162.

[25]LaLonde BJ, Zinszer PH Customer Service: Meaning and Measurement. Chicago, IL Physical Distribution Management, 1976. 492.

[26]Bowersox D. D., Kloss D. D. Logistics: an integrated supply chain. translated by N. N. Baryshnikova, B. S. Pinsker. - 2nd ed. Moscow: ZAO Olymp-Business, 2008. 640.

[27]Green KW, Whitten D., Inman RA The impact of logistics performance on organizational performance in a supply chain context. Supply Chain Management: An International Journal. 2008. No. 4 (13). 317-327.

technologies for warehouse processing of goods. The "place" component also affects decisions regarding the configuration of the distribution network and points of sale. The "promotion" component affects the decision on the amount of stocks of advertised products of the distribution network.

In turn, the logistics system, performing logistics processes, forms costs, the level of which affects the results of marketing strategy implementation[28]. V.I. Sergeev notes that marketing, when determining the level of service to consumers, often ignores the logistics costs associated with the implementation of such a level of service and declares the need for logistics to act as an "opponent" of marketing when evaluating logistics costs for the level of service set by marketing. D.J. Bowersox and D.J. Klos points out in confirmation: "Marketing dictates what logistics should be like. The most important strategic issue is to find such a combination of services and the level of service that would facilitate the conclusion of profitable deals"[29].

So we can conclude that, despite the allocation of logistics as an independent branch of activity in relation to marketing, these directions are connected in the process of creating value for the consumer. The activities of marketing and logistics are aimed at meeting the demands of consumers by means of service with profit for the enterprise.

Customer service is the result of the joint work of marketing and logistics[30], the priorities in the provision of services and the level of service are set by marketing, and the logistics system of the enterprise implements service. The interdependence of the spheres of activity under consideration is manifested in the search for a balance between the level of service and the total logistics costs caused by it. Therefore, for the logistics service of distribution channels, first of all, the degree of satisfaction of the client's needs with the order, which

[28]Corporate logistics. 300 answers to questions of professionals / Ed. V. I. Sergeeva. Moscow: INFRA-M, 2005. 976.

[29]Bowersox, D.D., Kloss, D.D. Logistics: an integrated supply chain. translated by N.N. Baryshnikova, B.S. Pinsker. - 2nd ed. Moscow: ZAO "Olymp-Business", 2008. P. 80.

[30]Stok D. R., Lambert D. M. Strategic logistics management - 4th ed. Moscow: INFRA-M, 2005. 797.

characterizes the concept of the quality of logistics service, should be taken into account. This is expressed in the proper execution of the client's orders, that is, in accordance with the consumer's standards, the client's ideas about the service and compliance with the terms of the contract. That is, the most important characteristic of the service flow is the given level of service.

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

The task of finding the maximum profit can be solved using a suitable optimization model. The conceptual model for determining the optimal level of logistics service under the condition of profit maximization is presented in the work of N.S. Burmistrova[32]

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

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

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

TC(CS) – a "cost/service level" function.

Where it proposes to make decisions about 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 values of logistics service indicators and the amounts of revenue

[31]Weihua Liu, Xinran Shen, Dong Xie, Decision method for the optimal number of logistics service providers with service quality guarantee and revenue fairness, Applied Mathematical Modelling, Volume 48, 2017, 53-69.; Ramos E.,Dien S.,Gonzales A.,Chavez M.,Hazen, B.Supply chain cost research: a bibliometric mapping perspective, Benchmarking: An International Journal, 2021, Vol. 28 No. 3, 1083-1100.

[32]Burmystrova N. S. The influence of logistics service on the company's revenue. Logistics and supply chain management. 2013. No. 5 (58). 60-68.

and costs[33]. Therefore, R. Ballou offers a number of methods for determining the dependence of revenue on the level of service, which allows overcoming the specified limitation[34]. The solutions to similar formulated 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 values of several indicators of the logistics service, reflecting the main ones, according to the ideas of D.J. Bowersox and D.J. Kloss[36], aspects of the logistics system such as availability, functionality and reliability.

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

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

2. The high cost of attracting a new customer - the costs of searching for and stimulating a new customer to order exceed the costs of re-ordering a loyal customer by 6-7 times[37].

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[33]Lukinsky V. S., Shulzhenko T. G. Methods of 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]Bowersox D. D., Kloss D. D. Logistics: an integrated supply chain. Translated by N.N. Baryshnikova, B.S. Pinskera. - 2-eizd. ZAO Olymp-Business, 2008. 640.

[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

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

4. Efficiency of investments in customer service: up to 50% of customers would pay more for a better level of service.

5. Synergistic effect: the increase in the turnover of loyal customers exceeds the amount of investment in customer service.

In a broad sense, the distribution of goods and services in the conditions of modern macro- and microeconomic changes can be characterized from the point of view of flexibility, globalization[38] and innovativeness.

Flexibility implies differentiated modes of functioning of markets and customers based on the creation of added value. Production and distribution refer not so much to the activities of individual firms as to networks of suppliers and subcontractors. Transport and logistics systems function on the basis of information, communication, cooperation and physical distribution of goods. Globalization means that the spatial framework of the functioning of the economy is expanded in the conditions of complex global economic integration and a developed network of global flows and hubs[39]. At the same time, we note that globalization is not only trade. It is also the ability of countries, companies, and now, during the Russian aggression in Ukraine, more and more often individuals to connect and act globally. People cannot do without communication, and modern technologies make it easier and more accessible.

Innovation in the conditions of fierce market competition, when the concepts of price and product quality become relative, provides the company with real tools for analyzing and optimizing the processes of selling goods. in additionvarious innovations in logistics introduce many new elements into the

[38]Dent D. Everything about distribution. trans. with English Zakharov A.V.: 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.

transportation system (Table 1.3), which are currently represented only to a very limited extent in freight transport models.

Table 1.3 – New elements of the transport system.

Innovations	New elements
Mass-customized logistics services	• The variety of logistics services is increasing: supply, demand, markets • Distribution channels • Crowdsourcing of services
Dynamics of globalization	•Global transport flows, networks and impacts • Production locations: offshoring of coastal streams
Network integration and synchronization	• Tactical and operational network planning • Shared networks (control towers, shared sources and flow scheduling) and their economics
Digitization of information and communication	• Availability and flows of information and data • Shared awareness of the situation • Information networks
Transport technologies (autonomy, engine)	• New modes and their attributes • The role and impact of vehicles • Energy systems

*Source:*Tavasszy LA Predicting the effects of logistics innovations on freight systems: Directions for research, Transport Policy, Volume 86, 2020, 1-6

Mass customized logistics services require redefining the current concept of supply and demand of goods in cargo models. The main goal of sales logistics is the reliable supply of goods needed by consumers in the right quantity and quality, to 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 the functional divisions of the enterprise, which participate in the process of order fulfillment and interaction with customers. So, the commercial division, the marketing department, or the logistics department are directly responsible for customer service. However, under modern conditions, a special role is played by the subsystem of after-sales service - the staff of employees or contractors responsible for service after the execution of 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 necessary to ensure the necessary level of logistics service. Distribution channels of supply chains are divided into two types:

- direct sales channel – directly from the producer to the consumer;
- a multi-level 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 focal company and consumers. They may include: distributors, dealers, commission agents, brokers.

At the same time, the main task for the focal company is for the participants of the sales channels to be clearly aware of their interdependence with each other and to build their activities on the basis of partnership, in which the willingness to eliminate significant individual differences and, most importantly, to share information is manifested.

The indicator of the quality of partnership is the price. If at the offer of the supplier to increase the price of the product, the intermediary refuses further cooperation, which means that the quality of partnership relations is doubtful. This is also indicated by the opposite situation, when the supplier raises the price without prior agreements and consultations with partners. True partnerships require formal procedures to resolve and agree on such issues.

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 the warehouse and transport support of the enterprise, namely the supply system (centralized, decentralized, combined), mobility, responsiveness to orders, and the possibility of maximum order fulfillment. The selected logistics technology, the level of optimization and automation of the logistics system, and the qualifications of personnel responsible for the logistics service function also play a major role.

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

- type of product and its purpose (industrial or consumer – long-term or short-term use, food products, etc.),

– its demand and method of purchase (pre-selected goods, goods in everyday demand, goods in high demand).

The assortment of the product portfolio, brand policy, the size of the delivery lot, delivery features, ensuring special conditions of transportation and storage also have an impact.

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

1.3 Factors impeding the implementation of logistics service system of supply chain and tools for their elimination

As a result of the interaction of marketing and logistics, in the ideal case, the optimal level of logistics service should be determined and established. However, in practice, the interaction of the marketing department and the departments that make up the logistics system of the enterprise is far from ideal due to the presence of a number of reasons for disagreements. Therefore, factors impeding the coordination of marketing and logistics should be considered in order to determine ways to overcome them.

Among the obstacles to organizational integration, H. Barki and A. Pinsonne single out both external and internal factors. They include political barriers to the first, and barriers related to the specialization of various areas of activity to the second. Scientists explain that political barriers are caused by the struggle for power and resources, specialization barriers are associated with differences in the goals of organizational units and the views of their representatives[40]. Instead, A.E. Ellinger, S.B. Keller and J.D. Hansen, the factors that hinder the coordination of marketing and logistics include purely internal factors of the supply chain, namely: insufficient knowledge of related functions, lack of communication, poor working relationships, conflicting goals and lack of attitude from the top management[41].

One of the reasons for the existence of these obstacles is the imperfection of traditional (functional) organizational structures. M. Christopher notes that functional organizational structures do not provide for the orientation of activities to the results and needs of customers[42]. D.J. Bowersox and D.J. Kloss

[40]Barki H., Pinsonneault A. A Model of Organizational Integration, Implementation Effort, and Performance. Organization Science. 2005. No. 2 (16). R. 170.

[41]Ellinger AE, Keller SB, Hansen JD Bridging the Divide Between Logistics and Marketing: Facilitating Collaborative Behavior. Journal of Business Logistics. 2006. No. 2 (27). 1-27.

[42]Christopher M. Logistics and supply chain management - 4th ed. Dorchester, Dorset: Financial Times/Prentice Hall, 2011. 288.

adds that such structures prevent the implementation of the concept of common costs[43].

An equally significant obstacle is the performance evaluation and reward systems formed at enterprises[44]. D.J. Bowersox and D.J. Klos emphasize the importance of evaluating logistics activities using indicators and the need for their correct selection and calculation of their values. It is noted that the disadvantage of the used performance indicator systems, which are based on organizational structures formed at enterprises, is the impossibility under such conditions of considering individual functions as parts of a single process, which leads to the optimization of private costs of individual functional units, and not the total costs of the logistics system[45]. Therefore, a number of scientists claim the need to use the method of costing in supply chain processes (Activity Based Costing – ABC). M. Christopher, being a supporter of using the specified method, notes the impossibility of estimating the cost of processes based on current accounting standards[46]. J. Shapiro emphasizes the importance of management accounting and the ABC method, in particular, when making decisions regarding the logistics activities of the enterprise[47].

Another obstacle to cross-functional coordination of these divisions is the quality of planning. The issue of planning is covered in the work of J.G. Shatta, where the goal of planning is given, which consists in the development of decisions related to the allocation of resources and the coordination of the actions of many participants in the process. Perfect planning, according to J.G. Shattu is the collection of information about current operations, establishing logical connections and making decisions about material flow management.

[43]Bowersox D. D., Kloss D. D. Logistics: an integrated supply chain. Translated by N.N. Baryshnikova, B.S. Pinskera. - 2-eizd. Moscow: ZAO Olymp-Business, 2008. 640.

[44]Ellinger AE Improving Marketing/Logistics Cross-Functional Collaboration in the Supply Chain Industrial Marketing Management. 2000. No. 1 (29). 85-96.

[45]Bowersox D. D., Kloss D. D. Logistics: an integrated supply chain. Translated by N.N. Baryshnikova, B.S. Pinskera. - 2-eizd. Moscow: ZAO Olymp-Business, 2008. 640.

[46]Christopher M. Logistics and supply chain management - 4th ed. Dorchester, Dorset : Financial Times/Prentice Hall, 2011. 288.

[47]Shapiro D. Modeling of the supply chain. Ed. V.S. Lukynsky St. Petersburg: Peter, 2006. 720.

Effective planning enables the enterprise to maintain supply and demand parity on an ongoing basis, meeting customer needs and keeping total costs and inventories low[48].

Thus, the necessary level of cross-functional coordination of the marketing unit and the units that make up the logistics system of the enterprise can be achieved under the condition of building a process-oriented organizational structure of the enterprise, forming a system of process efficiency indicators and general improvement of the quality of planning. However, these conditions cannot be fulfilled without prior definition (identification) of business processes as part of the enterprise's business architecture. Business processes can be determined by implementing a business process reengineering project, if necessary, and using reference process models[49]. Therefore, it is advisable to conduct a review of reference models of processes that are used for logistics systems of enterprises.

The first system-dynamic model of the supply chain was developed by J. Forrester[50], on the example of a simple production and sales system consisting of only two flows: a material flow and a flow of orders. Their interaction was determined on the basis of the rules for calculating the sizes of orders, which regulate purchases and inventories at the enterprise. The model also took into account organizational relationships between counterparties and delays occurring in the system. This was the first model of supply chains, later immortalized in the so-called "Beer Game" developed by J. Sterman[51] (Figures 1.6, 1.7).

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[48]Shutt D. G. Management of commodity flow: manual for optimization of logistics chains. Ed. A. N. Tarashkevich; translated by S. V. Kryvoshein. Minsk: Grevtsov Publisher, 2008. 352.

[49]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 2015. 161: 192-200.

[50]Haertfelder M., Lozovskaya E. Khanush B. Fundamental and technical analysis of the securities market St. Petersburg.: Peter, 2005.352.

[51]Sterman J. Business Dynamics – Systems Thinking and Modeling for a Complex World. McGraw-Hill Higher Education, 2000 982.

Unknown demand	weeks									
	1	2	3	4	5	6	7	8	9	10
Demand	**4**	**4**	**4**	**4**	**8**	**12**	**16**	**20**	**4**	**8**
Shop	6	8	6	6	10	12	12	8	4	2
Wholesale agent	5	9	6	6	8	14	thirteen	10	3	1
Producer	5	12	5	4	8	16	12	7	4	2
Provider	3	19	2	3	3	20	10	10	5	1
Initial supplier	3	19	0	2	4	20	12	8	4	1

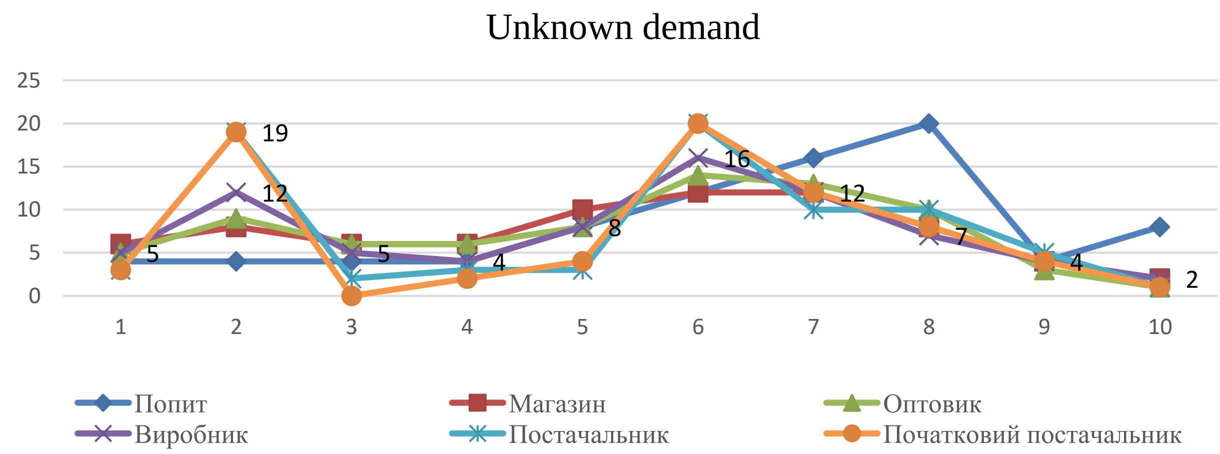

Fig. 1.6 – Example of calculations in the "Beer Game" with unknown demand

Source: compiled by the authors

Known demand	weeks									
	1	2	3	4	5	6	7	8	9	10
Demand	**4**	**4**	**4**	**4**	**8**	**12**	**16**	**20**	**4**	**8**
Shop	6	8	6	6	10	12	12	8	4	2
Wholesale agent	5	6	7	7	9	14	14	16	0	0
Producer	5	10	4	6	10	16	15	17	1	0
Provider	7	9	6	2	12	25	10	20	0	0
Initial supplier	5	8	8	3	12	30	15	15	0	0

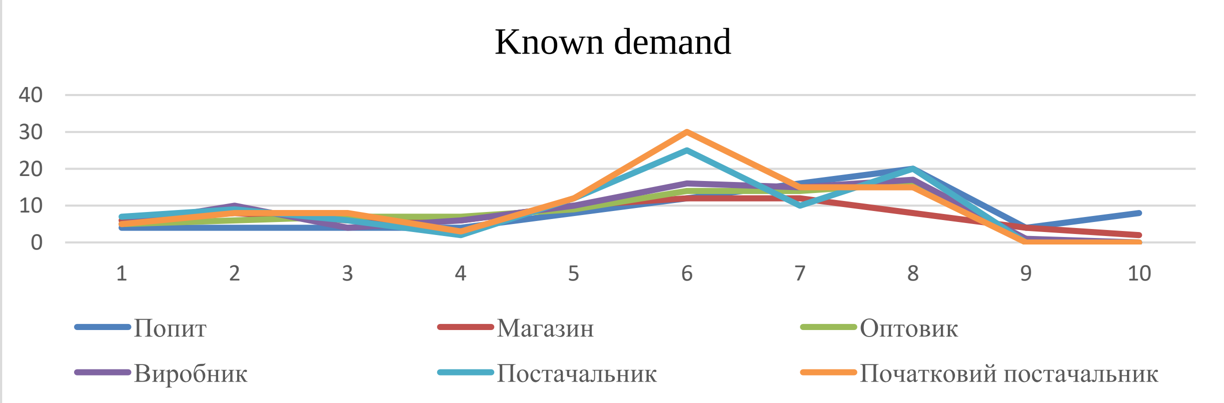

Fig. 1.7 – Example of calculations in the "Beer Game" with known demand

Source: compiled by the authors

The model made it possible to investigate possible fluctuations or instabilities in the behavior of the system caused by random changes in demand, which led to periodic fluctuations in inventory levels, arising from organizational relationships and management rules of the manufacturing enterprise, wholesale and retail trade, and the effect of delays in the flow of orders and materials.

Process decomposition of supply chains involves the selection of business processes, starting from end-to-end, up to the decomposition at the level of business processes of each individual enterprise in the supply chain. The relevance of process decomposition is due to the fact that the management of supply chains is built on the principles of process management. There is also a mixed decomposition, when different elements are distinguished at the same time: they can be objects, processes, flows, and management circuits. For ease of management, modeling of supply chains based on decomposition schemes is used.

Reference process models. There are a number of reference process models that apply to supply chains. Some of them only contain definitions of processes, others also include indicators and descriptions of best practices. The most developed models have the status of an inter-industry standard. The review included such reference models as Retail-H, Y-CIM model, Process Classification Framework, SCOR and Customer Chain Operations Reference (CCOR) models, as well as the Global Supply Chain Forum (GSCF) methodology – World Supply Chain Forum).

*Reference model Retail-H.*As the name suggests, the Retail-H reference model is designed for commercial enterprises. The structure of the model is graphically represented by the letter "H" (Figure 1.8).

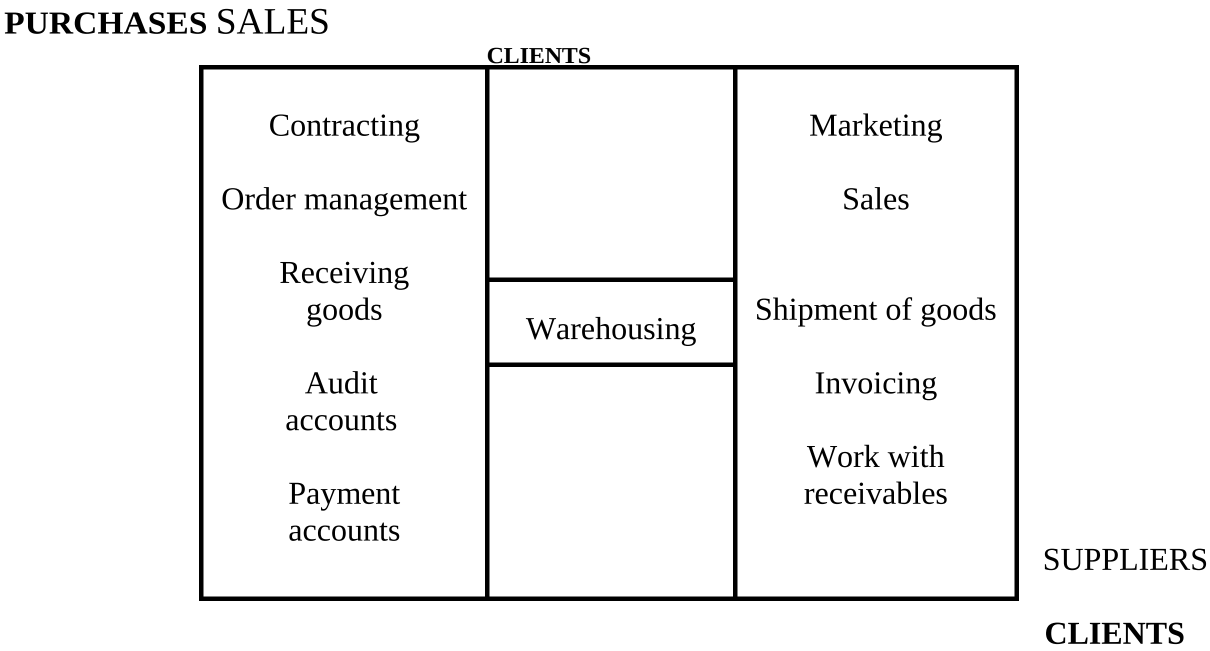

Fig. 1.8 – Retail-H model

Source: compiled by the authors

The model has three layers corresponding to the perspectives of different roles. The top layer, which has detailed descriptions of elements, consists of many functions standard for a trading company, but not processes. The second layer is the data layer, the third is the process layer.

Functions related to working with suppliers are located on the left side of the letter "H". This group includes the following functions: contracting, order management, receiving goods, checking invoices and paying invoices[52].

Functions on the right side of the model, such as marketing, sales, shipping, invoicing, and accounts receivable, are related to customer interactions. The function of the letter "H", which unites the left and right parts, is storage (storage). The warehousing function, which is related to the functions of receiving goods and shipping (of the left and right parts of the model, respectively), forms a group of logistics functions with them.

[52]Fettke P., Loos P. Reference modeling for business systems analysis. London [etc.] : Idea Group Publishing, 2007. 389.

The Retail-H model also defines strategic planning and control functions. In addition, the model has definitions of business administration functions such as accounting, asset management, cost accounting and personnel management. Thus, the core of the model consists of three groups of functions: procurement, distribution and logistics. The functions of these groups are implemented in accordance with strategic plans with the support of business administration functions.

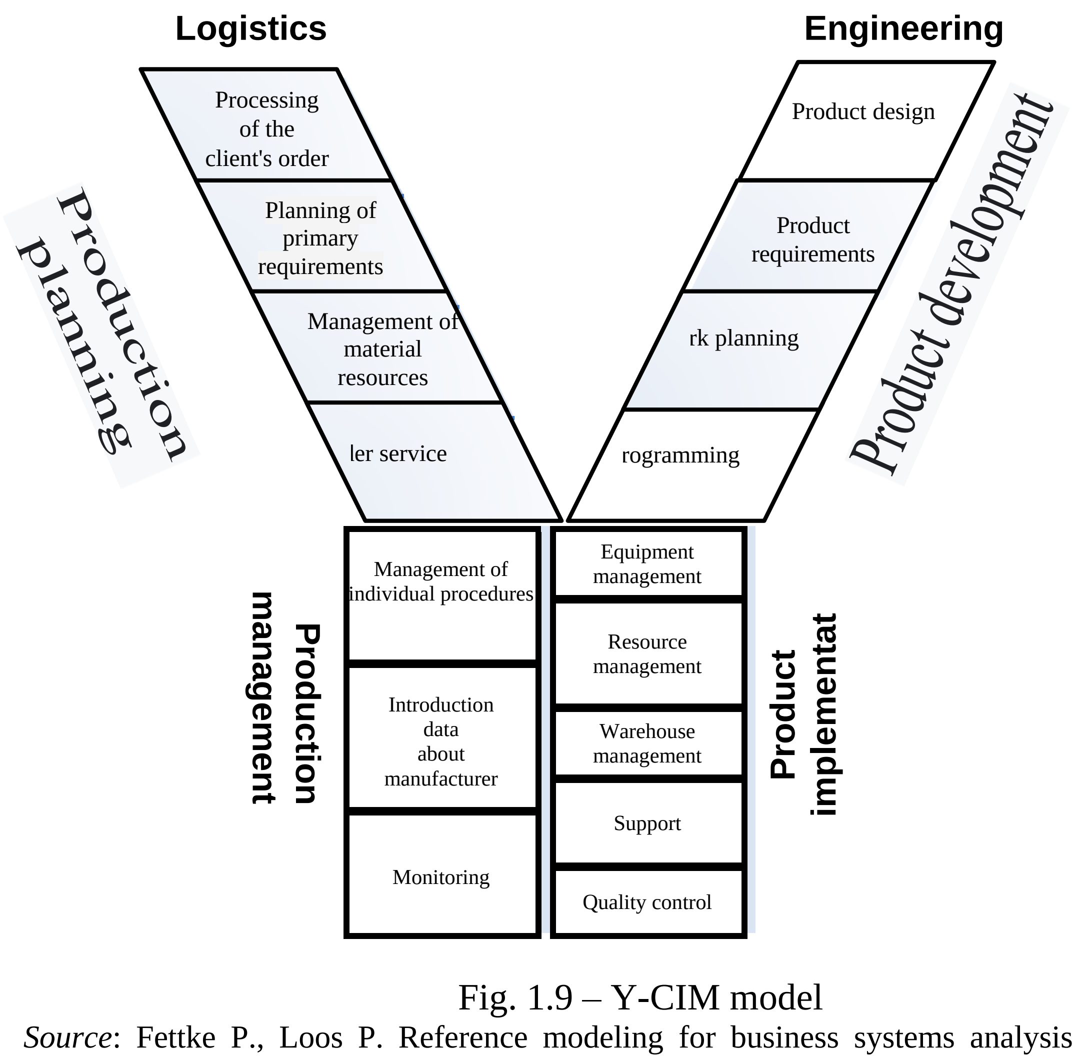

Fig. 1.9 – Y-CIM model

Source: Fettke P., Loos P. Reference modeling for business systems analysis IGI, 2007. 410.

Reference model Y-CIM. In contrast to the previous model, the Y-CIM model is based on the relationship between business and technical systems.

Technical and business processes develop in parallel at the planning stage and are combined at the production stage.

All processes are integrated taking into account information systems and cover the entire functionality of logistics. The left part of the Y-CIM model contains the main managerial and administrative functions related to planning and production management, and the right part contains technical-oriented functions related to the development and implementation of products. Planning functions are at the top of the Y, while management and implementation functions are at the bottom. (see Figure 1.9).

This model is extremely useful for any organization that develops its own products and services and is faced with the need to manage the order lifecycle together and in parallel with the lifecycles of their products and/or services.

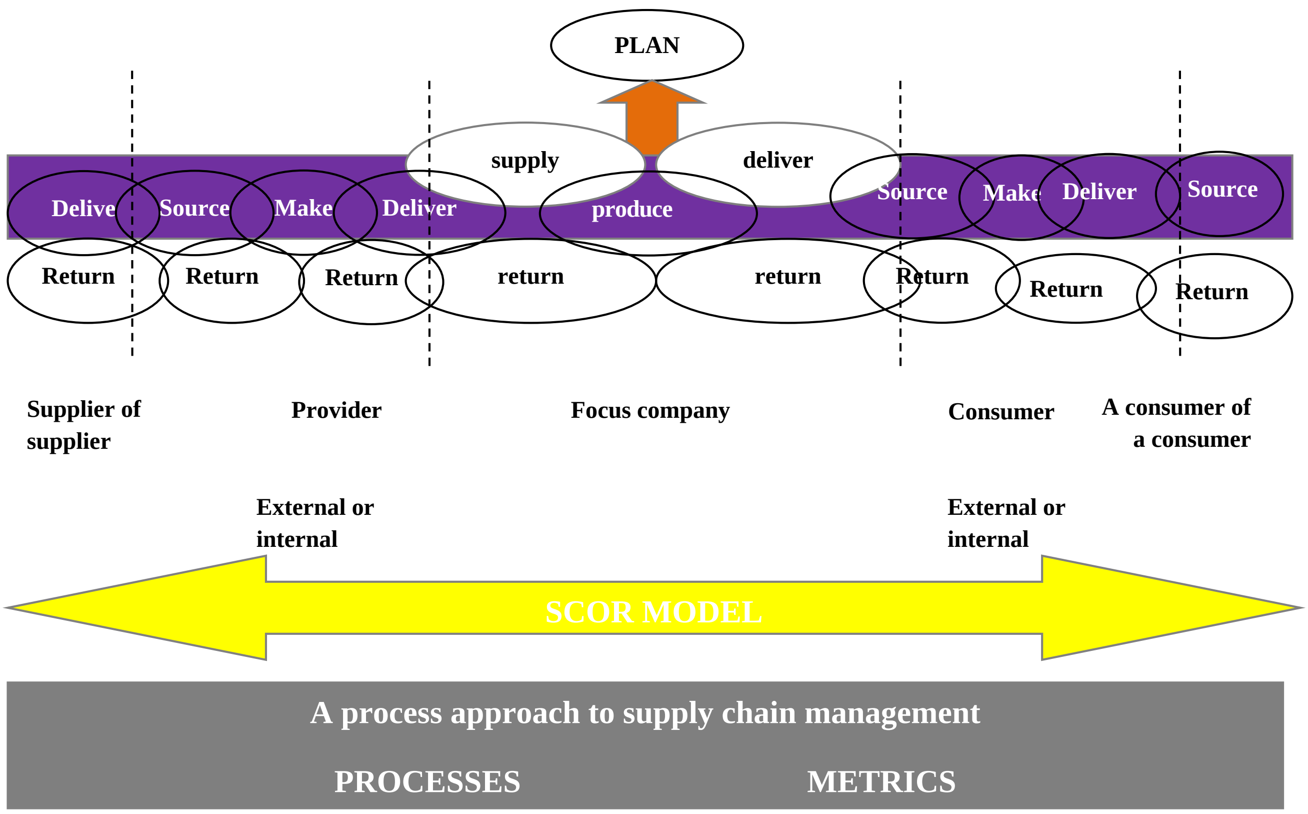

Fig. 1.10 – Scheme SCOR models in supply chains.

Source: composed on the basis of Huan SH, Sheoran SKand Wang G.A review and analysis of supply chain operations reference (SCOR) model,Supply Chain Management, 2004, Vol. 9 No. 1, 23-29

*SCOR and CCOR models.*The SCOR and CCOR reference models were developed by the Supply Chain Council. A widely known reference model for supply chain operations, the SCOR model, was first introduced in 1996. After 10 years, in 2006, the CCOR model was developed, which describes the processes related to sales and customer support. The SCOR model belongs to the class of process-oriented models, in which the activity of the modeling object is considered as a set of "end-to-end" (cross-functional) processes. The description of the SCOR methodology of the 11th version includes the following sections: "processes", "indicators", "practices" and "people". The process model at the first level of decomposition includes six types of processes, such as Plan, Source, Make, Deliver, Return, and Enable. (Figure 1.10).

It uses a system of standard business processes based on global best practices, a system of key performance indicators (KPI) of supply chain business processes, and a list of skills and competencies of employees aligned with the processes. The SCOR model describes both the interaction processes of supply chain participants and the internal processes of logistics systems of enterprises participating in the chain. The model considers the following processes: planning, supply, production, delivery and return.

The process structure of both models involves three levels of hierarchy: process types, process categories, and processes. The models also include recommended process metrics and descriptions of various practices used in supply chain management. The reference models under consideration combined concepts such as business process reengineering, benchmarking, process evaluation and organizational design into a single cross-functional methodology[53].

[53]The APICS SCC Frameworks Chicago, IL, 2016. URL:www.apics.org/sites/apics-supply-chain-council/frameworks/ apics-scc-frameworks

The structure of the SCOR model covers three quite popular management concepts: benchmarking, use of best practices, and reengineering of business processes and contains four levels of process detailing (Figure 1.11).

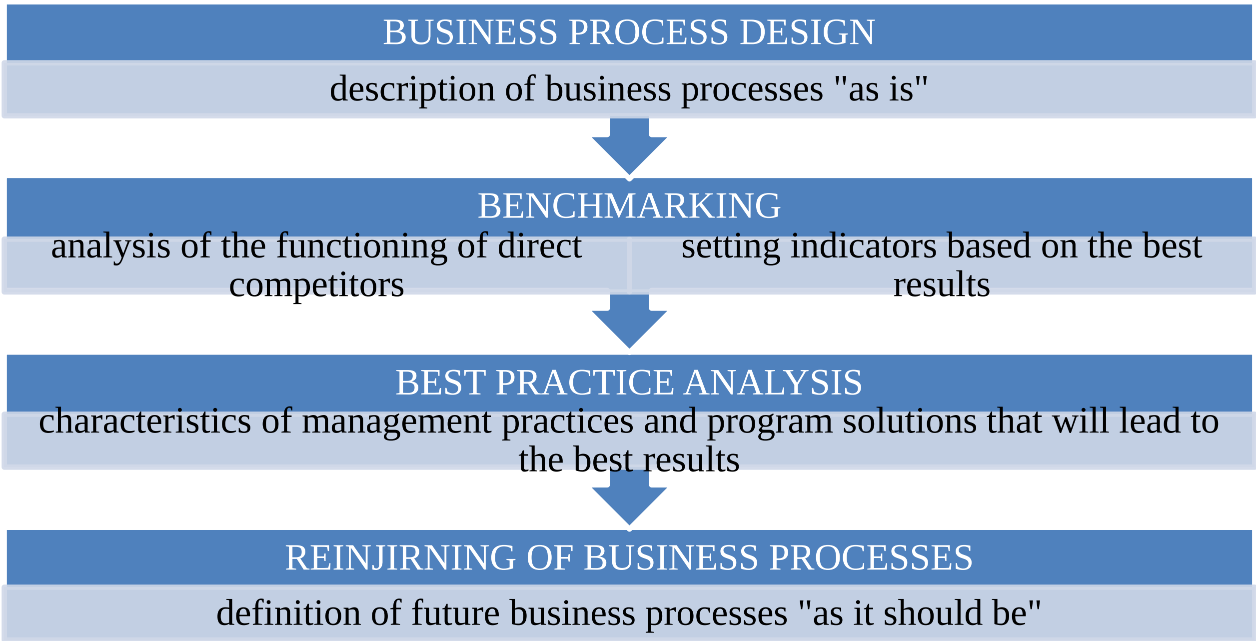

Fig. 1.11 – SCOR model design stages
Source: compiled by the authors

The first level is basic competitiveness. At this level, the company formulates competitive objectives and strategy for the supply chain. It includes six types of processes: planning, production, supply, delivery, return and support. The indicators are divided into five groups of indicators reflecting reliability, responsiveness, flexibility and costs in the supply chain, as well as the efficiency of asset management.

Groups of indicators contain the following indicators of the strategic level: the level of flawless execution of orders, the duration of the order fulfillment cycle, the flexibility of the supply chain, the adaptability of the supply chain in relation to suppliers and customers, the total value measure of risk, the total cost of service, the time of turnover of funds, the profitability of fixed assets, working capital capital The structure of indicators is similar to the structure of processes and has three levels of hierarchy. The practices section contains descriptions of recognized practices by which processes can be organized and performance targets achieved. Practices are divided into four groups: emerging, best, standard, and not recommended practices.

The second level is configuration. In accordance with the requirements of the strategy, taking into account the applied technologies, logistics principles and rules, the company designs the supply chain. This level includes indicators that help to diagnose the metrics of the first level in terms of the deviation of the planned values from the benchmarks included in the "benchmarking platform" (competitors, leaders).

The third level is efficiency, processes and practices, systems. The processes of each category are divided into elements, the combination of which will determine the competitiveness of the company. Here are the parameters and measures used to evaluate the performance of each element.

The fourth level is supply chain processes and implementation. At this level, elements of processes are divided into components of their work and operations.

The CCOR methodology is an extension of the SCOR model as a model of sales processes and its support. At the first level of process decomposition, the CCOR model defines five types of processes, such as Plan, Relate, Sell, Contract, Assist[54]. Among the 16 indicators of the first level, the following can be named: gross revenue, cost of sales, average profit per customer, response time of the customer service chain, flawless contracts. Thus, the considered models collectively cover both logistics processes and sales-related processes. It should also be noted the developed system of indicators of effectiveness and

[54]Supply Chain Council (SCC). CCOR model ver. 1.0 quick reference guide. Supply Chain Council (SCC). Washington, DC, 2008. URL: https://ru.scribd.com/document/112812799/CCOR-Quick-Reference.

efficiency of processes, which includes methods of calculating the values of indicators.

Reference process methodologies. Practice shows that it is possible to achieve significant improvements in the efficiency of the supply chain with the help of benchmarking, if you use a non-standard approach to the comparison process and look for ways, as a rule, that are not among the generally accepted ones in the industry.

Process Classification Framework methodology. In 1980, the American Productivity Center was founded to help companies create and improve productivity programs and measure productivity. In 1988, the organization was renamed the American Productivity & Quality Center. APQC's main areas of activity are knowledge management, process management and benchmarking. The APQC Cross-Industry Common Process Classifier is a high-level, context-agnostic business process model that enables organizations to view their business processes from a cross-industry perspective. The cross-industry classifier has been productively used by thousands of organizations around the world for over 20 years. This classifier is the foundation for the APQC (Open Standards Benchmarking®, OSB) database of publicly available benchmarking standards, and the work of the advisory board, which includes leading global companies, is also based on it. This classifier will be updated as new definitions, processes and indicators are added to the databases of publicly available benchmarking standards.

Process Classification Framework methodology offers definitions of general enterprise processes collected in the Cross Industry PCF (Cross Industry Process Classification Methodology) version and specific processes described in multiple industry versions of the PCF. Regardless of the version, the PCF methodology contains the definition of processes of two groups: operational processes and management and support services. According to the cross-industry process classification methodology (Cross Industry PCF version 7.0.5 -

Figure 1.12), operational processes include such categories as developing a vision and strategy, developing goods and services, selling goods and services, supplying goods, providing services, and service management customers.

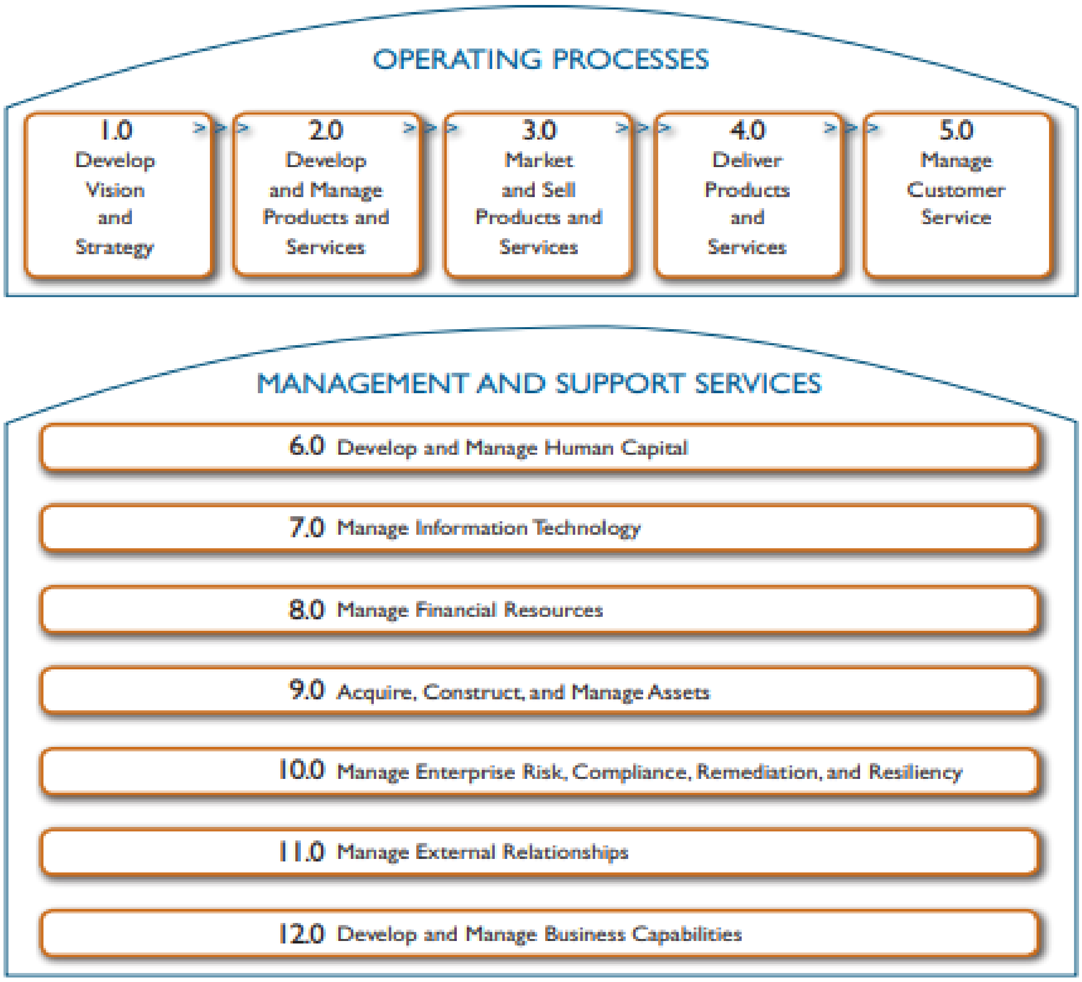

Fig. 1.12 – Cross Industry PCF version 7.0.5

Source: Ziemba E., Eisenbardt M. Examining Prosumers' Participation In Business Processes,Polish Journal of Management Studies, Czestochowa Technical University, Department of Management, 2015. vol. 12(1), 219-229.

The group of management and support services includes the following categories: human resources management and their development; information technology management; management of financial resources; acquisition, creation of assets and their management; risk management and enterprise stability; management of external relations; management of business competencies and their development. The PCF methodology uses five levels of process decomposition, namely: category, process group, process, action, task[55].

For commercial enterprises, the APQC organization offers an industry version of the PCF methodology - Retail PCF. Unlike the cross-industry version, the operational processes of the PCF methodology for companies operating in the retail sector include such categories as vision and strategy development, customer experience management and development, sales of goods and services, promotion of goods and services, supply of goods[56]. The management and support services of the analyzed version are similar to the cross-industry version. It can be concluded that Retail PCF describes the processes related to the development of distribution channels and retail sales points, marketing and logistics activities. In addition, APQC offers a set of key performance indicators for evaluating process performance.

Methodology of the Global Supply Chain Forum. In February 1996, the Global Supply Chain Forum presented a methodology of the same name. The GSCF methodology consists of three interdependent components: supply chain network structure, supply chain business processes, supply chain management components. The structure of the supply chain is the many organizations that create value for the customer and the relationships between them. Business processes are understood as specific actions, the result of which is customer value. Management components refer to management methods that ensure communication and execution of processes throughout the supply chain[57].

The GSCF model of supply chain management (Figure 1.13) reveals eight key cross-functional and cross-firm business processes:

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[55]American Productivity and Quality Center (APQC). Cross-industry Process Classification Framework ver. 7.0.5 overview. American Productivity and Quality Center (APQC). Houston, 2015. URL: https://www.apqc.org/knowledge-base/download/361282/Cross_Industry_v7.0.5.pdf.

[56]American Productivity and Quality Center (APQC). Retail Process Classification Framework ver. 6.1.1 overview. American Productivity and Quality Center (APQC). Houston, 2015. URL: https://www.apqc.org/knowledge-base/download/361283/K06444_PCF_Ver_6.1.1 RET.pdf.

[57]Tancrez, J.-S., Lange C., Semal P. A location-inventory model for large three-level supply chains. Transportation Research Part E: Logistics and Transportation Review. 2012. No. 2 (48). 485-502.

– management of relations with clients;

– customer service management;

– demand management;

– management of fulfillment of sales orders;

– production flow management;

– management of relationships with suppliers;

– management and release of products to the market;

– returns management.

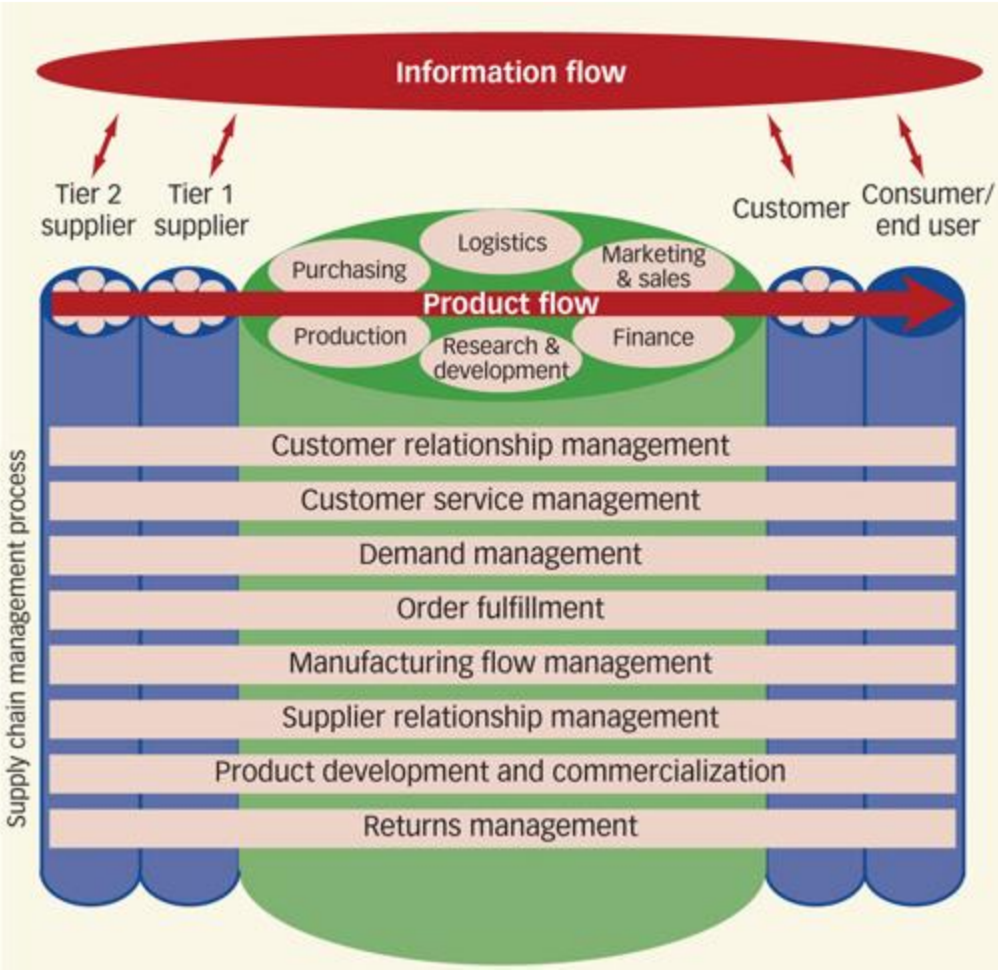

Fig. 1.13 – GSCF model

Source: Cooper MC, Lambert DM, Pagh, JD Supply Chain Management: More Than a New Name for Logistics, The International Journal of Logistics Management, 1997, Vol. 8 No. 1, 1-14.

Cross-functionality means that each of these business processes covers all functional areas within the supply chain, linking and integrating them. That is, "demand management" is not an autonomous process that only the marketing department deals with, but an end-to-end process that affects marketing, product development, and procurement. Cross-firm means that these processes can go beyond the scope of one company, being implemented within the framework of the entire supply chain.

The processes of managing relationships with suppliers and customers form the key links in the supply chain, the other six processes are coordinated through them. All processes are end-to-end both at the enterprise level and only at the supply chain level[58]. Each process has both strategic and operational sub-processes. Process management is carried out by cross-functional groups responsible for developing procedures at the strategic level and managing their implementation at the operational level. The methodology includes the following management components: "planning and control, work structure, organizational structure, material flow structure, information flow, management methods, power and leadership structure, risk and reward structure, culture and relationships"[59].

Supply chain management, according to this model, should encompass all business functions, providing a single, coherent view of the business. At the same time, it is especially important to imagine what exactly each of the functions can provide to each of the supply chain processes. The eight core processes listed above are then broken down into lower-level processes (sub-processes), providing a conceptual framework for putting the GSCF model into practice. Special attention in the GSCF model is paid to the processes of managing relationships with suppliers and customers, because it is these

[58]Lambert DM, García-Dastugue SJ, Croxton KL An evaluation of process-oriented supply chain management frameworks. Journal of Business Logistics. 2005. No. 1 (26). 25-51.

[59]Lambert DM, García-Dastugue SJ, Croxton KL An evaluation of process-oriented supply chain management frameworks. Journal of Business Logistics. 2005. No. 1 (26). R. 29.

processes that provide communication with third-party companies and coordination of the other six processes within the supply chain.

The goal of relationship management is to increase the profitability of each individual member of the supply chain by improving the efficiency of interaction, which should ultimately lead to increased work efficiency and, accordingly, the profitability of the entire supply chain. It is practically impossible to achieve this goal in working with all counterparties, so attention should be focused on key customers and suppliers. For this, within the framework of the GSCF model of supply chain management, an interaction model "Partnership model" (SCM partnership model) has been developed, which helps companies structure relationships with key counterparties. The interaction model has four components: factors, conditions, components and outcomes of the partnership.

Factors – these are convincing reasons for interaction, they should be investigated first of all before making a decision on the formation of partnership interactions.

Conditions – characteristics of two or more firms that help or hinder the development of partnership relations.

Components – administratively managed elements that must be implemented at a certain level depending on the type of partnership.

The results – represent an assessment of the extent to which each firm implemented its own factors/reasons for partnership in the process of interaction.

All four component models interact and influence each other. At the same time, the interaction model provides a framework for assessing factors and conditions, as well as a description of components depending on the type of partnership.

Key elements of the process evaluation system are reports on profitability and total costs. For wholesale businesses, supplier and customer profitability reports can be developed, while for manufacturing businesses, total cost reports are used[60]. These reports can be used to analyze value co-creation within the chain of seller and buyer organizations. The financial results of process improvements are measured using the Economic Value Added (EVA) indicator.

There are two main options for calculating EVA:

$$EVA = NOPAT - WACC \times Capital\ emploed \tag{1.4}$$

where: WACC – the weighted average cost of capital;

Capital employed – investment capital

or:

$$EVA = (ROI - WACC) \times Capital\ emploed \tag{1.5}$$

where: ROI – the rate of return on invested capital

The EVA indicator can be increased: due to an increase in income from sales and a decrease in the amount of expenses (economy and optimization of current expenses (reduction of unprofitable production, etc.)); due to the optimization of capital costs[61]. It can be seen that the GSCF methodology prioritizes financial indicators.In conclusion, using the GSCF model of supply chain management, the creation and regulation of all necessary coordination mechanisms for all functions should result in an effective supply chain.

Despite the differences in the levels of development of the considered methodologies, each of them is suitable for developing a model of processes in the supply chain. Determining the processes performed in the logistics system opens up the possibility for further transformations of enterprises, such as changing the organizational structure, the system of performance indicators and planning methods, aimed, in particular, at achieving the goal of interaction between the marketing division and the divisions that make up the logistics system of the enterprise, which consists in determining the optimal level of

[60]Supply Chain Management: Processes, Partnerships, Performance / ed. DM Lambert. - 4th ed. [Ponte Vedra Beach, FL] : Supply Chain Management Institute, 2014. 463.

[61]Zagurskyi O.M. Indicators of evaluation of supply chain efficiency. Mechanical engineering and energy. 2018 Vol. 9. No. 4. R. 100.

logistics service. It should be explained that the change in planning methods involves the transition to the use of a special mathematical apparatus for the coordination of marketing and logistics strategies and the determination of the rational level of logistics service of the supply chain.

CHAPTER 2. FORMATION OF SUPPLY CHAIN LOGISTICS SERVICE SYSTEM

2.1 Methodological aspects of supply chain logistics service management

The organization of logistics systems depends on the correct selection of logistics business processes in the supply chain. This is one of the main tasks of strategic logistics planning, for the implementation of which various methods can be applied:

- identification of logistics operations;
- simulation of logistics operations;
- reengineering of logistics business processes;
- definition of the functions of organizational structures allocated to the management of the logistics system.

However, the management of individual logistics business processes itself requires a high level of management of the entire system. Accordingly, the logistics business process is most often characterized as a certain set of interrelated operations and (or) functions that translate the company's resources (when managing commodity flows) into the result that was foreseen as part of the strategic planning of this logistics flow. Therefore, services related to logistics activities in the scientific environment are an independent subject of research with a wide range of proposed definitions, among which it is worth dividing by such concepts as "logistics service", "level of logistics service", "quality of logistics service" and "logistics service".

The most general among the knowledge selected for study is the concept of "logistics service" of customers, which is also defined as "the process of coordination of logistics operations"[1], and as "a set of actions invested in the buyer"[2], and as "a set of functions and activities of all enterprise systems"[3], and as "a complex of actions covering and combining areas of logistics activity"[4], and as "information supply and exchange services"[5], "logistics services affecting customer service"[6], and as part of the "general customer service policy"[7], and as "the relationship between the value and the provision of services to customers offered by the firm"[8], and as "a set of actions invested in the buyer"[9], and as a "result of logistics"[10].

Each of the above points of view on the definition of the concept of "customer service" has the right to exist, because it reflects the different limits of this concept and shows the dynamics of awareness of its complexity[11]: from presenting it as a set of separate actions to recognizing it as a company philosophy. Regarding the structure of customer service, the three-component structure of customer service with the designation of elements for each component is becoming the most widespread. Customer service elements reflect the state of the company's system, and even the company's actions in relation to customers.

[1]Ballou R. Business logistics/supply chain management. fifth ed Pearson Education India; 5th edition; Upper Saddle River, NJ: 2007. 820.

[2]Coyle JJ, Bardi EJ, Langley JC The management of business logistics A Supply Chain Perspective - 7th edition. Canada, Quebec: Transcontinental Louseville, 2003. P. 86.

[3]Ellinger AE, Daugherty PJ, Gustin CM The relationship between integrated logistics and customer service, Transportation Research Part E: Logistics and Transportation Review, Volume 33, Issue 2, 1997, 129-138.

[4]E. Krykavskyi. Logistics management: textbook. Lviv: Vidvo nats. Lviv Polytechnic University, 2005. 684.

[5]Lotfi Z., Mukhtar M., Sahran S., Zadeh A. Information Sharing in Supply Chain Management, Procedia Technology, Volume 11, 2013, 298-304

[6]Jonsson P. Logistics and Supply Chain Management - UK: The McGraw-Hill Companies, Inc., 2008. 491.

[7]Daniela-Tatiana Agheorghiesei Corodeanu, Consumer's Protection from the Generation Y's Perspective. A Research Based on Scenarios, Procedia Economics and Finance, Volume 20, 2015, 8-18.

[8]Sarder MD Logistics customer services. Logistics Transportation Systems. 2021; 197-217.

[9]Coyle JJ, Bardi EJ, Langley JC The management of business logistics A Supply Chain Perspective - 7th edition. Canada, Quebec: Transcontinental Louseville, 2003. P. 86.

[10]Farahani R., Rezapour S., Kardar L. Logistics Operations and Management: Concepts and Models.Elsevier, 2011. 475.

[11]Cichosz M.,Wallenburg CM, Knemeyer AMDigital transformation at logistics service providers: barriers, success factors and leading practices,The International Journal of Logistics Management, 2020. Vol. 31 No. 2, 209-238.

That is, from a logistics perspective, customer service is the result of all logistics activities or supply chain processes. In which the corresponding expenses for the logistics system and income from logisticsservices determine the company's profit. This profit largely depends on the level of customer service that the company offers. Therefore, perhaps the most successful definition"logistics service"was provided by B. LaLonde and P. Zinser: "...actions that occur at the interface between the customer and the corporation that improve or facilitate the sale and use of the corporation's products and services, which include all that the manufacturer does for the customer in moving the product from him to the client"[12].

At the same time, it should be noted that the desire to fix on "logistics service" the set of functions and types of activity of all systems of the enterprise, which ensure the connection "enterprise - consumer" in terms of each material, financial, information or service flow according to a number of indicators, threatens to be one-sided consideration of the organization's activities: the desire to transfer all authority and transfer all responsibility for customer service to one functional area of the company. This will contribute to inter-functional conflicts and suboptimal managerial decisions.

The most rational, in our opinion, is to consider customer service as an interaction between the client and the supplier on terms of mutual benefit, or "win-win" relations. The appearance of a third party (logistics service provider) in this relationship will depend on the logistics strategy used by the provider (insourcing or outsourcing of logistics activities). After all, logistics service is essential, but only a part of the general service policy, in which commercial and financial services and other divisions of the enterprise have their own role.

Sodespite the identified differences in the positions of scientists, their undeniable unity in the issue of logistics service is manifested in two aspects. First,

[12]LaLonde BJ, Zinser P. Customer Service: Meaning and Measurement. Chicago, 111.: The Council of Logistics Management, 1976. 492.

the client's needs are recognized as the main regulatory mechanism of the enterprise's activities in relation to logistics services. Secondly, it is emphasized that the client should receive clear benefits from the logistics activities of the supplier company: his requirements should be taken into account and satisfied with the resources available at the supplier company.

Logistics service is the basis of logistics service.

Majorityre searchers are united in the understanding of logistics service as a set or complex of logistics services. The difference lies in the number of logistics services that are included in this concept and are determined by moments of interaction with consumers. Yes, P. Johnsson[13]offers to consider the list of logistics services related to the management of the customer order cycle. While T. Dudar and R.Voloshin[14] expand the boundaries, including "further service of products", and A. Galkin, K. Dolya, N. Davidych[15], on the contrary, limit logistics services to "direct delivery to consumers". From the position of the result, the logistics service is considered as a reflection of the efficiency of the logistics system "from the point of view of the usefulness of the time and place of each product"[16], or how the participants of the logistics system receive "tangible additional benefits of the supply chain"[17].

Taking into account the views highlighted above, it is possible to define the logistics service as the result of the activity of the supply chain, which reflects its efficiency in terms of the usefulness of time and place of each product.

The level of logistics service and the quality of logistics service are two concepts so closely related that in a number of cases, logistics researchers

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[13]Jonsson P. Logistics and Supply Chain Management - UK: The McGraw-Hill Companies, Inc., 2008. 491.

[14]Dudar T.G., Voloshyn R.V. Basics of logistics. Education manual K.: Center of Educational Literature, 2012. 176.

[15]Galkin A., Dolia C., Davidich N. The Role of Consumers in Logistics Systems, Transportation Research Proceedings, Volume 27, 2017, 1187-1194.

[16]Mentzer JT, Flint DJ, Hult GTM Logistics Service Quality as a Segment-Customized Process. Journal of Marketing. 2001. Vol. 65: Iss. 4. R. 82-83.

[17]Stock D. R., Lambert D. M. Strategic logistics management - 4th ed. M.: INFRA-M, 2005. P. 90.

combine them into "the level of quality of logistics service", the expediency of which, in our opinion, is very questionable. Most often under the level of logistics service, which is found as "service level"[18], and as "supply service level"[19], and as "level of service"[20], and as "order fulfillment degree"[21], is understood as the ratio of two quantities given by the author's logic, which gives this definition. Usually, this indicator differs from one another among different authors, but there is a general deep unity in the desire to numerically compare the fact obtained from the results of logistics customer service with the plan or with the promise made to the client, fixed by the terms of the contract.

The quality of logistics service quantitatively or qualitatively determines the degree of compliance of logistics services with customer requirements[22]. Many scientists[23] evaluate the quality of the logistics service through the degree of satisfaction with the logistics provider's performance of the main logistics operations in the supply chain, however, some recognize that in view of the concept of supply chain management, the most appropriate for evaluating the quality of the logistics service is the customer's point of view[24], and in the models of A. Parasuraman, V.A. Zaythmala, L.L. Berry[25], as well as in the developments of Mentzer, Flint and Hult[26], the quality of the logistics service is suggested to be evaluated in relation to customer expectations, especially in the

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[18]Wills G. Customer Service. A Tool of Marketing? Industrial Management & Data Systems. 1982. No.10: Vol.82, Iss.9. P. 7.

[19]Christofides N., Watson-Gandy CDT Improving Profits with Distribution Services. International Journal of Physical Distribution. 1973. No. 3: Iss. 5. R. 324.

[20]Stock D. R., Lambert D. M. Strategic logistics management - 4th ed. Moscow: INFRA-M, 2005. 797.R. 89.

[21]Schreibfeder J. Effective stock management; trans. with Eng.. 3rd ed. Moscow: Alpina Business Books, 2008. P. 301.

[22]Sergeev V.I. Logistics service quality management. Logistics today. 2008. No. 5. R. 272.

[23]Haydabrus N.V. Evaluation of the quality of the level of logistics service. Innovative economy. 2013. No. 6. 246-251.; Gulc A. Models and Methods of Measuring the Quality of Logistic Service, Procedia Engineering, Volume 182, 2017, 255-264.; Limbourg S., Giang N., Cools M. Logistics Service Quality: The Case of Da Nang City, Procedia Engineering, Volume 142, 2016, 124-130.; Ovcharenko A.H. Evaluation of the quality of logistics service for consumers. Economy of the transport complex. 2020. No. 35. 160-176.

[24]JohnsonJCWoodDFContemporary Logistics 6th EditionPrentice Hall College Div, 6th edition. 1996. 622.

[25]Parasuraman A., Zeithaml V. A, Leonard L. Berry A. Conceptual Model of Service Quality and Its Implications for Future Research The Journal of Marketing, Vol. 49, No. 4 (Autumn, 1985), 41-50.

[26]Mentzer JT, Flint DJ, Hult T. M. Logistics Service Quality as a Segment-Customized Process The Journal of Marketing. 2001. 65 (4). 82-104.

case of the desire to achieve the maximum satisfaction of the needs of the customer.

In our study, "logistics service" will be understood as part of the customer service policy, which covers the interaction between the customer and the supplier regarding the movement of the material flow, as well as the accompanying information, financial and service flows, an interaction that provides benefits to each of the parties involved and is able to satisfy the requirements the client in the conditions of the available capabilities of the supplier.

Under "logistics service" – a set (set, complex) of logistics services, which are implemented in the management of customer orders, as well as in the logistics support of requests and warranty service of purchased goods, in the process of interaction between the customer and the supplier and which provides clear benefits to each party – meeting the client's requirements and accounting for the supplier's available capabilities.

The "level of logistics service" will be called the indicator of the conformity of the actual value of each individual logistics service, which is included in the totality (set, complex) of logistics services, with the values guaranteed to customers (in the contract, when concluding an agreement orally or in another way).

"Logistics service quality" will reflect the presence and magnitude of the gap between the actual value of each logistics service provided and the value that was promised to the client (in the contract, verbal agreement, or otherwise), and will signal the need for corrective actions.

The strategic role and importance of a high-quality logistics service will have a direct impact on both the market share of the logistics integrator and the reduction of its total costs due to the growth of the image, which will attract a larger number of customers (scale effect), and accordingly, these components will increase the overall profitability of the company in as a whole.

A logistics integrator, when providing logistics services for supply chain management, uses a wide arsenal of management methods, such as:

– logical and formalized management decision-making methods at the stage of idea generation, evaluation and selection of alternatives for the client in relation to the necessary logistics service, in relation to a new international sales contract, etc.;

– informalized methods in the form of the experience of the integrator's logistics managers and their experiences;

– methods of economic analysis that help to compare different options for organizing supply chains, as well as to determine the necessary logistics service for the client. Comparison methods help to choose the most popular variants of a complex of services and to create a logistics service demanded by clients, as well as to subsequently offer the client the most optimal supplier for him and to offer different variants of the logistics service in comparison with its cost;

– forecasting methods for managing the demand and supply of customers' products, which helps to avoid a shortage or surplus of products in the future and prevent unnecessary costs related to reordering products or, conversely, their disposal;

– game-theoretic methods, for example, the method of scenarios, which suggests the discovery of logic in the sequence of events of the past in order to further develop on this basis the options for designing the supply chain for the client, or the decision tree, which helps to develop different solutions in the case of "if", the best option for leveling most external factors affecting the organization and management of the logistics service integrator.

Searching for optimal solution options together allows the logistics integrator to retain the leading role in decision-making indirectly, i.e., due to his own knowledge and considerable experience, to present the most optimal option for everyone in a more profitable world to the client. Moreover, such a collective decision of the client with the logistics operator leads to mutually beneficial and optimal cooperation.

The parameters of logistics service depend on a number of factors identified in scientific works[27], which can be grouped by the source of their origin into external and internal environments.

In the external environment, the primary importance is given to the characteristics of the customer base – their number, geographical distance and density, customer requirements for their service from the point of view of logistics, and parameters of activities in the field of logistics. It is also important to understand who the customer is in a particular consideration of the supply chain and what are the specifics of its activity. The increase in the number of competitors on the market determines the ability of customers to switch to competing products or substitute products. This translates competition in the field of product assortment into the field of services provided to customers. The list, quality and cost of services provided by competitors will determine the competitiveness of the enterprise's logistics service.

The infrastructure of the region, primarily the network of roads of various purposes, together with the development of the logistics services market, have a significant impact on the formation and subsequent offers of logistics services to consumers by the supplier company. Transport availability and the availability of storage facilities, supported by the presence of logistics intermediaries in the region, expand the capabilities of the supplier company to manage the resources at its disposal.

Significant adjustments in logistics service are made by other external factors, among which it is worth noting legislative restrictions and orders, financial and tax burden, inflation rate, etc.

[27]Christopher M. The Strategy of Customer Service. The Service Industries Journal. 1984. No. 3: Vol. 4. R. 211; Jonsson P. Logistics and Supply Chain Management - UK: The McGraw-Hill Companies, Inc., 2008. P. 331-333.; Christofides N., Watson-Gandy CDT Improving Profits with Distribution Services. International Journal of Physical Distribution. 1973. No. 3: Iss. 5. R. 324.

The influence of internal environmental factors on the logistics service of the supplier company is determined, first of all, by the type of its activity and product specialization, which set corporate goals and objectives. The corporate strategy for achieving the set goals and objectives is reflected in the functional strategies and is adjusted depending on the financial capabilities and scale of activity.

Logistics service vectors are set by the enterprise's commercial goals, which are expressed in the choice of the sales region, sales policy, in the determination of the most acceptable sales channels, which leave their mark on the implementation of the final logistics operations in the supply chain. Instead, commercial activity limits potential logistics offers, on the one hand, and on the other, it takes into account logistics costs in the pricing policy. If we talk about the most important factors influencing logistics service, which are concentrated in the activities of the enterprise itself, then it is worth noting the characteristics of the logistics infrastructure: its composition, quantitative parameters, location in relation to customers and suppliers.

A significant role in customer service is assigned to the company's warehouse infrastructure, the use of which depends on the implemented form of supply of goods to customers (warehouse or transit), and the customer supply system (centralized or decentralized) used, and flexibility in servicing unplanned orders, and supply capabilities , and the customer service radius.

The quality of the logistics service depends on the rationality and logic of the technology of the process of processing and moving the cargo flow, its flexibility and mobility, where employees (both directly involved in the implementation of technological operations and those managing these processes), their structural composition, professionalism and motivation to perform play an important role assigned tasks. Effective use of resources is determined by the availability of necessary and sufficient information for making management decisions.

However, it is worth noting that the choice of technology and the method of its application for the implementation of logistics services in specific conditions will largely be determined and determined by the nature and features of the material flow:

– category and type of product;

– the availability and behavior of demand;

– the variety of the assortment and the size of the consignment;

– the need to ensure special conditions of supply, etc.

The above factors make it possible to talk about the need for a differentiated attitude to the logistics service, i.e. the selection of sets of services in its composition according to some characteristics that are essential for the purposes of management (that is, for the supplier company) or consumption (that is, for the client company).

However, for management purposes, knowledge of the conceptual apparatus with the allocation of various types of logistics services will not be enough: it is also necessary to control and manage the logistics service of consumers. This means that it is necessary to carry out calculations and assessments, that is, to actively use the indicators of the logistics service of the

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When such indicators are determined, all recommendations are reduced to the general principles of logistics service evaluation, methods and principles of data collection for indicators, requirements for the indicators themselves, and those results that result from the results of their measurement, namely:

1. Indicators must be objective, measurable and equally understandable for all interested parties:

28Linders M., Firon H. Supply and stock management. Logistics, St. Petersburg: Victoria plus, 2006. 768.

– the quality limits of the logistics service must be clearly defined;

– the accuracy of the measurement of indicators is specified and the compared units of measurement are selected or the method of data comparison is provided.

2. The principles of calculating indicators must be documented:

– agreements are agreed upon by interested parties;

– agreements are fixed in the agreement.

3. Indicators are determined from the most important aspects of logistics activity for clients: the significance of indicators for the client is revealed.

4. The method of collecting information on aspects of the logistics service is chosen, which should reflect the position of customers as much as possible (questionnaires, interviews, document verification, etc.).

5. Indicators should be measured and analyzed with a certain periodicity:

– along with detailed statistics collected at certain time intervals,

– it is necessary to provide a simple method of evaluating the logistics service, which is measured at each interaction of the parties.

6. Indicators should reflect the current situation, and not reflect the past (dynamics of the logistics process at the current moment).

7. Indicators according to their characteristics should be different:

– valuable and temporary;

– quantitative and qualitative;

– absolute and relative.

8. Indicators should evaluate independent characteristics (comprehensively describe logistics services).

9. Indicators should evaluate different limits of logistics service:

– indicators determined by customer requirements;

– indicators that control the process of providing logistics services within the supplier company;

– indicators that have a logical connection between themselves

– indicators that are decomposed "from top to bottom" according to the organizational structure of management.

10. According to the results of the monitoring of the logistics service, a report must be submitted, in which it is necessary to show:

– the current state (including analytics on resource utilization during the provision of services, the actual performance of the provider);

– target value;

– long-term trends;

– causes of deviations.

11. A hierarchy of losses at the logistics service level should be developed:

– it is necessary to clearly indicate the source of problems (the area of responsibility of the company or the area of responsibility of a source outside the company;

– main areas/causes of problems;

– a responsible employee capable of influencing their elimination.

In a systematized form, these recommendations are presented in Figure 2.1.

General principles of development of logistic service evaluation indicators		
indicators should be objective, measurable and equally understandable for everyone interested parties	calculation logic there should be indicators Documentary fixed	indicators are determined based on the most important ones for consumers aspects logistics activity

Methods and principles of data collection for logistics service evaluation indicators	
a method or methods must be selected collection of information about logistics service	it is necessary to carry out measurements and analysis with a certain periodicity

Requirements for logistics service evaluation indicators			
indicators should	indicators for	indicators should	indicators should

display current the situation, not be a reflection of the past	his own characteristics should be different	rate the most independent of each other one characteristics	evaluate various faces logistic service

Results of measurement of logistics service evaluation indicators	
according to the results of logistic monitoring reporting must be made to the service	a loss hierarchy should be developed logistics service

Fig. 2.1 – Recommendations for the development of evaluation indicators logistics service

Source: compiled by the authors

The number of groups of logistics service evaluation indicators depends on the number of selected criteria. Such criteria, for example, can be:

– indicators evaluating the temporal characteristics of the logistics service. The indicators of this group evaluate the absolute value of the cycle time of the client's order when providing a logistics service (or a separate logistics service) as a whole or its various stages in some database. These indicators are convenient for evaluating the efficiency of the logistics system according to the time parameter;

– reliability of logistics service. The indicators of this group evaluate the ability of the company providing the logistics service to withstand the parameters of the provision of each logistics service in the range of values discussed with the client;

– flexibility of logistics service. The indicators of this group evaluate the ability of the logistics system to adapt to the needs of the client;

– policy in the field of inventory management when providing logistics services to customers. This group of indicators is aimed at a comprehensive assessment of the company's policy in the field of inventory management;

– parameters of logistics services. This group of indicators is aimed at evaluating the list and structure of logistics services as a whole, as well as in warehousing, transportation, container and equipment management, characterizing the company's ability to provide informational support for the process of fulfilling customer orders and evaluate the level and quality of logistics service;

– degree of fulfillment of customer orders. This group of indicators evaluates the method of placing an order by the client, the completeness, error-free, accuracy and quality of the execution of his order, the preservation of goods and the causes of complaints that arise;

- productivity and resource efficiency of logistics infrastructure and labor. this group of indicators evaluates the effectiveness of the use of the available (or engaged by) logistics infrastructure and the company's personnel involved in the provision of logistics services;

– pricing policy for the provision of logistics services: this group of indicators evaluates the company's pricing policy for logistics services - price level, payment method, availability of product credit, as well as discount program;

– logistics costs caused by the provision of logistics services: The indicators of this group measure costs related to logistics activities both in general and for individual logistics functions, their absolute and relative values;

– efficiency of logistics service provision. The indicators of this group evaluate the overall effectiveness of customer service, measuring the latter's reaction to the logistics services received - satisfaction and the nature of the relationship, as well as the obtained economic and non-economic effects.

One of the options for using the defined criteria is offered by CustomerXM specialists, who compiled the top 10 indicators for measuring the level of logistics service for customers in supply chains.

1. Customer satisfaction (CSAT – Customer Satisfaction) is a key performance indicator designed to track how satisfied customers are with an organization's products and/or services. As an experience indicator, CSAT uses a survey consisting of several questions that focus on specific moments of the customer's experience in cooperation with the company. For example, these questions could be: "How would you rate your overall satisfaction with the service you received?", or "how satisfied were you with the delivery experience." The customer is then asked to give their rating on a scale of 1 to 5.

To determine the percentage of satisfied customers: the number of satisfied customers [those who answered 4 and 5] is divided by the total number of answers and multiplied by 100. Only answers 4 (satisfied) and 5 (very satisfied) are included in the calculation, since using the two highest values in surveys with feedback is the most accurate measure of customer retention. As a rule of thumb customer satisfaction occurs after each interaction between a service agent and a customer. These measurements can also be taken over time to analyze how certain agents or teams are performing.

2. Indicator of the client's efforts (CES – Customer Effort Score) is a one-item experience score that measures the customer's effort to solve a problem (complete a request, purchase/return a product) or get an answer to a question. The idea is that the customer will be more loyal to brands that are easier to do business with. Focusing on reducing customer effort creates a better customer experience. Customer surveys ask questions that can be answered with help numerical information, and then the average score is calculated.

3. Pure customer loyalty rating (NPS – Net Promoter Score) is an experience metric used in customer service programs. It is often considered the gold standard of customer experience. NPS scores are measured using a one-question survey scored from 0 to 10, with a higher score preferred. Clients are divided into promoters (score 9 or 10), passive (score 8 or 9) and negative

(grade 0-6). This distribution allows you to get a broader picture of customer loyalty to the company.

To determine NPS, the percentage of detractors is subtracted from the percentage of promoters. The result is an NPS score. For example, if 10% of respondents are detractors, 20% are passive, and 70% are promoters, the NPS score would be 70-10 = 60. This is good, but there are some areas for improvement.

4. Monitoring of social networks is a set of experience metrics that allow you to not only know when to respond to a customer, but also understand what kind of feedback customers prefer, so you can create better systems for solving customer problems and maintain those systems that do. work well

The effectiveness elements of this group include: mentions of the brand over time; negative comments; technical or account issues; the number of questions that could be answered with other supporting materials. To determine the value of social network monitoring indicators, you need to record the above criteria on a monthly basis, and then analyze their changes and understand general directions and trends.

5. Customer outflow is an indicator of the experience of evaluating the number of customers who have decided to stop using the company's products or services. This indicator is more difficult to measure, since there is no single forecast of customer churn.

When measuring it, you need to pay attention to operational statistics (for example, a decrease in repeat purchases, a decrease in the amount of purchases). For example, a customer who has abandoned recent visits and shows a lower NPS after their last delivery experience may be more likely to stop using the company's products or services. When measuring this indicator, the factors that can cause customer churn are determined, and then their value is measured every month.

6. First response time is an indicator of the company's appreciation of the client's time. According to Forrester research[29], 77% of consumers say valuing time is the most important thing a company can do to provide a great customer experience. When a customer comes up with a question or problem, they want a quick response, so measuring the first response time can be a useful operational metric to ensure that customer queries are resolved quickly. And while it's beneficial to send an automated response to show that a customer's request has been registered, what really matters is how quickly and easily the company's employees respond to that request.

Leading companies, when responding to customer requests or problems, usually use the following benchmarks as a starting point: e-mail or online form - 24 hours; social networks – 60 minutes; telephone - 3 minutes; live chat and instant messaging. The indicator is calculated as the difference between the time of the client's request and the time of the first response.

7. The overall coefficient of the ability to solve the client's problems – this is an indicator of the company's commitment to solving customer problems. When a customer has a question or complaint, the main goal of the company close the question and solve the problem. If the company is unresponsive or unable to provide adequate support, the customer may not want to do business with the company in the future. An increase in this indicator may indicate the effectiveness of the customer support service. Calculated by dividing the number of resolved requests by the total number of requests.

8. The speed of solving the first contact – the indicator determines how many cases require only one contact from the client. Customers don't like being bounced around from agent to agent and want their issues resolved on the first

[29]Leggett K. Consumer Expectations For Customer Service Don't Match What Companies Deliver. 2015. url. https://www.forrester.com/blogs/consumer-expectations-for-customer-service-dont-match-what-companies-deliver.

contact. A high first-contact resolution rate is likely to correlate with CES – the customer will exert less effort if they only have to contact the organization once. To determine the first contact resolution rate, you need to calculate the number of incidents resolved during the first contact and divide them by the total number of incidents.

9. Volume of customer requests for support is an indicator of the experience of the problem solving and customer support system. While it's good that customers are interacting with the company and that the company has a customer support system available, too many inquiries can indicate a problem. Tracking this operational metric will help you catch this problem before it becomes a real problem. To determine the value of the indicator, you need to compare the amount of support costs month by month or week by week, especially if the number of such costs increases after the release of a new product or feature.

10. Average time for processing customer support requests is the amount of time an agent actually spends working on one case. The shorter the time, the more efficient the team's work. When measuring this indicator, you need to track the time to service customer support requests and compare it to the average time for the week and month, as well as compare its dynamics with the data of the previous year to see if long-term changes have occurred.

Regarding the methodical approaches of logistics service management, it should be noted that they are based on customer service developments, which are divided into two large classes based on the type of information used: 1) approaches based on information available from the customer service provider; 2) approaches based on information received from various sources (from customers, from competitors, from markets, etc.).

Comparing approaches to customer service (especially the 2nd group) is somewhat difficult due to the variety of principles laid down by the developers in each of them, as well as due to differences in the terminology used. For example, a meaningful analysis of approaches focused on the development of a customer service strategy and on the development of a customer service policy by various authors (see, for example, D. Stock, D. Lambert[30]; P. Jonsson[31]; M. Christopher[32]), did not allow to clearly identify that characteristic or element/step of the approach that unambiguously drew the line between approaches and variants of their name.

Approaches to customer service based on the information available to the company are, on the one hand, very convenient to use, as they involve the analysis of retrospective data, on the other hand, they are problematic for business use, as they operate with incomplete information for decision-making. So, for example, the method of assessing the consumer's reaction to a shortage situation proposed by D. Stock. and D. Lambert, aimed at estimating the maximum time the consumer is willing to wait for the required product. This method is based on the relationship established in the scientific literature between the level of inventory maintained by the supplier and the level of customer service reliability (Figure 2.2).

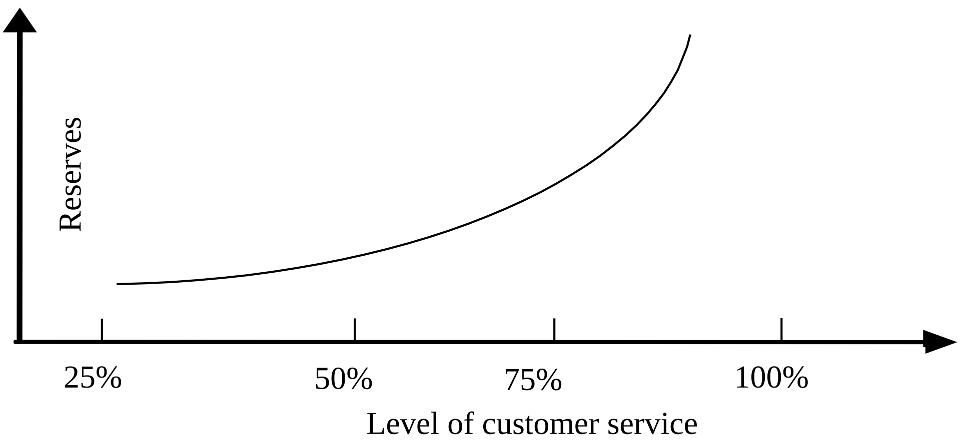


Fig. 2.2 – The relationship between the level of stocks and the level of customer service

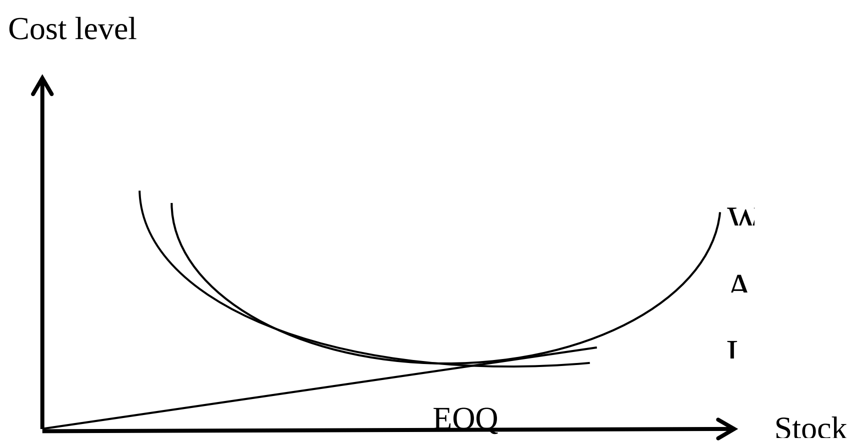
[30]Stock D. R., Lambert D. M. Strategic logistics management - 4th ed. Moscow: INFRA-M, 2005. R. 94-117.

[31]Jonsson P. Logistics and Supply Chain Management UK: The McGraw-Hill Companies, Inc., 2008. P. 91-96.

[32]Christopher M. Logistics and supply chain management - 4th ed. Dorchester, Dorset : Financial Times/Prentice Hall, 2011. P. 36-42.

Source: Stock D. R., Lambert D. M. Strategic logistics management - 4th ed. Moscow: INFRA-M, 2005. 797.

J.J. Coyle, E.J. Bardy, S.J. The Langleys emphasize the importance and duration of the complete order cycle, which can encourage the company of the supplier, serving the customer, to increase the level of inventory, since the increase in duration is diametrically opposite to the level of inventory of the supplier (seller of goods) and the consumer (buyer of goods) [33] (Figure 2.3).



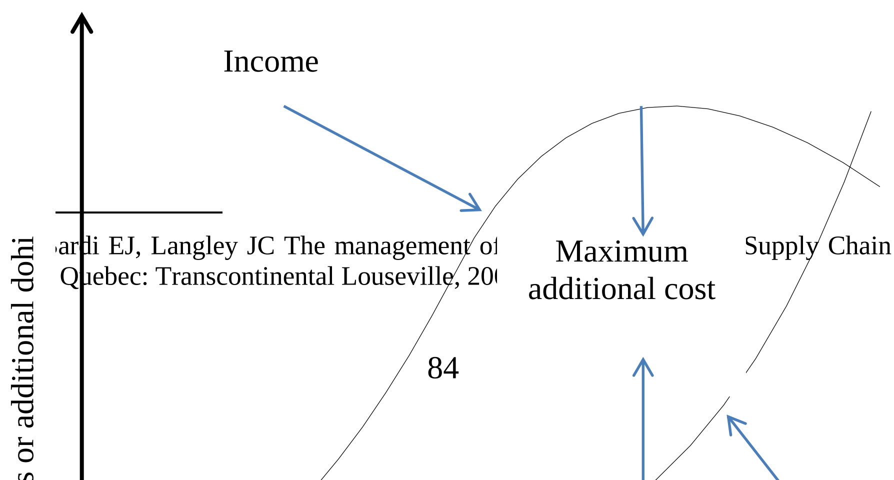
where A is storage costs; B – order costs; C - total costs.

Fig. 2.3 – Dependence of the level of expenses on the volume of merchandise stocks.

Fig. 2.3

Source: Coyle JJ, Bardi EJ, Langley JC The management of business logistics: A Supply Chain Perspective. - 7th edition. Canada, Quebec: Transcontinental Louseville, 2003. 707.

The analytical method of interpretation (Figure 2.4) is proposed by D. Stock and D. Lambert.



[33]Coyl ardi EJ, Langley JC The management of Supply Chain Perspective. - 7th edition. C Quebec: Transcontinental Louseville, 20

Fig. 2.4 – Impact of superior customer service on revenue, logistics costs and profit

Source: Stock D. R., Lambert D. M. Strategic logistics management - 4th ed. Moscow: INFRA-M, 2005. 797.

In it, they used the definition of the relationship between expenses, which is understood as the cost of maintaining stocks, and income, which is understood as profit.

The ABC method of analysis (Figure 2.5) and its variants are aimed at assessing the contribution of various customers and products to the company's profitability. The disadvantage of this method is an overestimation of the importance of customers and goods that have a significant contribution to the company's income, with insufficient attention to other groups of customers and goods.

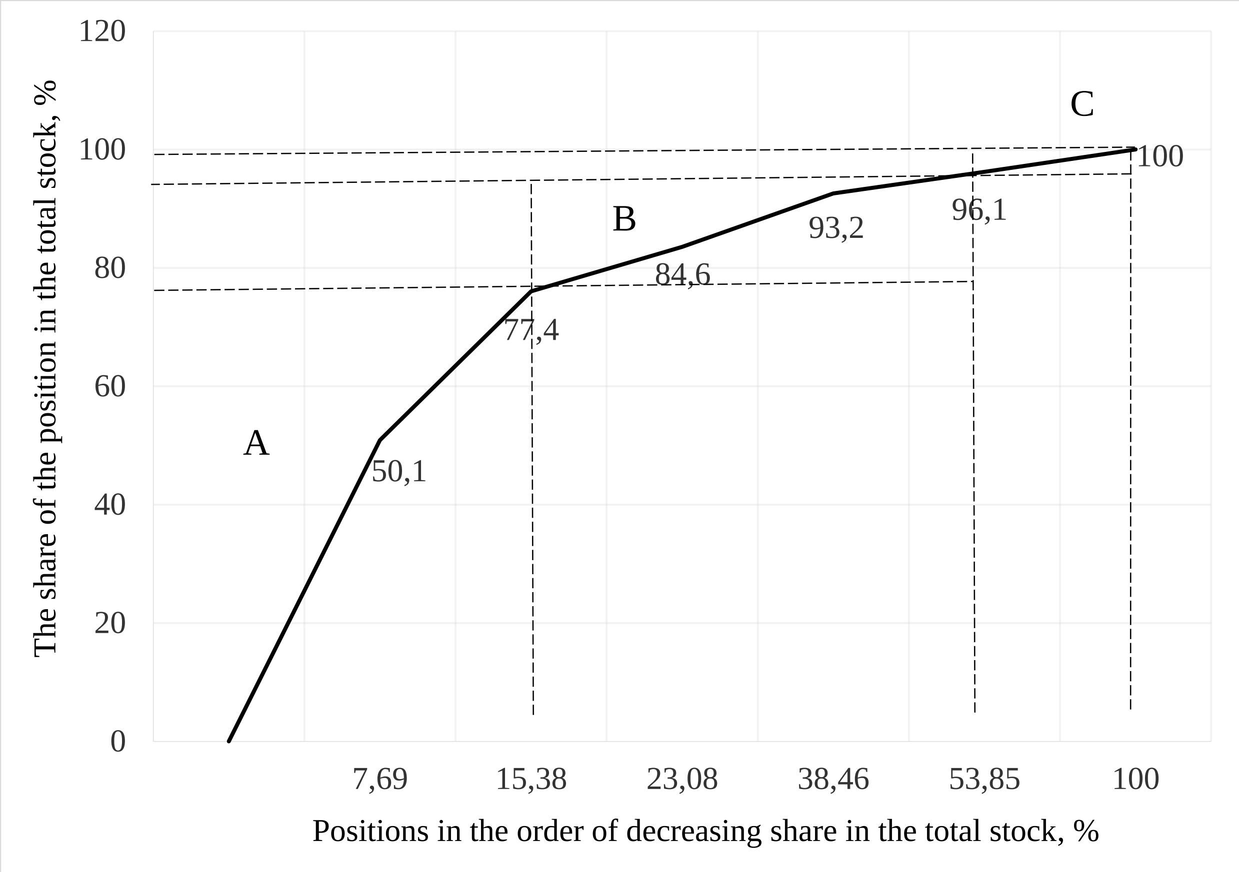


Fig. 2.5 – Cumulative curve "ABS" analysis of reserves

Source: Douissa MR, Jabeur K., A New Model for Multi-criteria ABC Inventory Classification: PROAFTN Method, Procedia Computer Science, Volume 96, 2016, 550-559.

Despite the fact that, in general, in the foreign and domestic logistics literature, the final states of the logistics system do not coincide, the methods of accounting for uncertainty and decision-making under risk conditions are identical.

In support of the above, we will consider the classification of models and methods for accounting for uncertainty for decision-making in conditions of uncertainty during the planning of processes in supply chains (Table 2.1).

Table 2.1 – Correspondence of decision-making methods to the company's planning horizons

Planning level	Solutions	Planning horizon	Planning period unit	Classification problems	Target	Modeling and applied decision-making methods
(A) Strategic planning	The number and location of divisions, the volume of warehouse stocks, the distribution of demand	Long-term planning (3-5 years)	One-period (3-5 years)	The problem of determining the location of network points and the problem of network location	Network description, cost minimization, profit maximization	Partial-integer programming
(B) Tactical planning	Implementation period, service level, insurance reserves	Long-term and/or short-term (week, day)	Multiperiod (every week, day)	The problem of modeling the system of echelon supply	Defining the order fulfillment policy, managing the flow of raw materials and materials, controlling the whiplash effect	Dynamic and simulation modeling

(C) Operational	(A) + distribution of demand between retailers and distributors	Short-term planning	Multiperiod (every week, day)	A dynamic model for determining the location of network points	Planning the needs of the logistics system	Partial-integer programming and simulation modeling

Source: compiled by the authors based on literary sources

Accordingly, today, when great emphasis is placed on the quality and high level of provided logistics services, the application of optimization models and methods in logistics activities is a necessity. Optimization methods are more and more often used to manage logistics chains, as their results make it possible to apply effective solutions to improve supply chain business processes.

Advantages of optimization models and methods include cost reductions in transportation costs, storage or production processes. In addition to economic advantages, as noted by L. Pecheny, P. Meshko, R. Kampf, Y. Gasparik[34] the optimization process also reduces the time needed to perform logistics operations.

In the matter of profit maximization, according to J. Shapiro[35], the application of solutions related to demand management and supply chain management is of paramount importance. The scientist explains that descriptive models used in marketing and logistics should be embedded in optimization models reflecting the connection of decisions in the specified spheres of activity. Obviously, the task of determining the optimal level of logistics service can be presented in the form of an optimization model.

[34]Pečený L., Meško P., Kampf R., Gašparík J. Optimization in Transport and Logistic Processes, Transportation Research Procedia, Volume 44, 2020, 15-22.

[35]Shapiro D. Modeling of the supply chain. Ed. V. S. Lukynskyi. St. Petersburg.: Peter, 2006. 720.

2.2 Customer-oriented behavior as a form of improvement of logistics service

The growing interest in the study of customer orientation arose at the very beginning of the 21st century, when customer orientation was finally separated from the concept of market orientation as an independent field of research. The main works on market orientation, which marked the beginning of the client-oriented approach, should be considered the work of A. Kolli and B. Yavorski[36], as well as J. Narver and S. Claytor[37]. Thus, A. Kolli and B. Yavorski believe that market orientation is the company-wide generation of knowledge about the market, relevant to current and future customer needs, the dissemination of knowledge among all divisions and the company-wide response to them, and J. Narver and S. Claytor singles out three groups of market orientation characteristics: customer orientation, competitor orientation, and cross-functional coordination. The authors see the concept of marketing as a special organizational culture, norms and values shared within the company, in which the consumer becomes the center of the organization's activity.

Thus, a salesperson with customer-oriented behavior should increase customer satisfaction in the long run and avoid actions that may cause dissatisfaction, even if they could increase sales in the short run[38]. We note that the study of scientific constructs of customer-oriented behavior is distinguished by individual, organizational and system factors. First, personal factors influence: the seller's gender, sales experience, and the client's emotional situation[39]. Second, organizational factors, such as delegating authority to solve

[36]Kohli A., Jaworski B. Market Orientation: The construct, Research Propositions, and Managerial Implication. Journal of Marketing. 1990, Vol. 54, 1-18.

[37]Narver J., Slater S. The effect of a Market Orientation on Business Profitability. Journal of Marketing. 1990, Vol. 56 (October), 20-35.

[38]Saxe R., Weitz BA The SOCO Scale: A measure of the customer orientation of salespeople. J. Mark. Res. 1982, 19, 82-113.

[39]Shu L., Wei H., Peng L. Making the customer orientation of salespeople unsustainable-The moderating effect of emotional exhaustion. Sustainability 2019, 11, 735.

a client problem or creating an environment for collaboration between colleagues[40], ethical education[41], creating an environment that stimulates organizational culture and motivation[42]. Third, systems of factors that include behavioral control[43].

Accordingly, models of business implementation under the influence of forces both inside the company and from the outside have recently undergone significant changes. Modern trends include business models[44]:

– business does not work because of money, but because of an "inspired" mission, the implementation of which is entrusted to a "working" business model;

– the business processes of the company, which are built and function in clear accordance with the vertical of power, are replaced by horizontally oriented ones;

– increasing attention to the process and organizational flexibility of the company;

– employees are trusted more and therefore given wide powers;

– there is a need to develop methods, approaches and decision support systems that work in real time;

– there is a need to coordinate processes in geographically distant places;

– interactions of supply chain participants cross the borders of one state, moving to the international level of cooperation;

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[40]Parasuraman A. Customer-oriented corporate cultures are crucial to services marketing success. J. Serv. Mark. 1987, 1, 39-46.

[41]Honeycutt ED, Siguaw JA; Hunt TG Business ethics and job-related constructs: A cross-cultural comparison of automotive salespeople. J. Bus. Ethics. 1995, 14, 235-248.

[42]Kelley SW Developing customer orientation among service employees. J. Acad. Mark. Sci. 1992, 20, 27-36.

[43]Anderson E., Oliver RL Perspectives on behavior-based versus outcome-based sales force control systems. J. Mark. 1987, 51, 76-88.

[44]Zagurskyi O. M. System-evolutionary approach in market research. Economic magazine - XXI, 2014. No. 11-12 8-11.; Kovalkov V.A. The system for measuring the level of logistics service. Logistics and supply chain management. 2009. No. 6. 33-39.; Christopher, M. Logistics and supply chain management. Under general editor V.S. Lukinsokho. St. Petersburg: Peter, 2004. 316.; Christopher, M. The Strategy of Customer Service. The Service Industries Journal. 1984. No. 3: Vol. 4. 205-213.; Dobbs R., Manyik J., Woetzel J. The four global forces breaking all the trends. Book Excerpt, McKinsey Global Institute, Public Affairs2015.288.

– changes in technologies, primarily in the field of high technologies, undermine the existing postulates of conducting business, leading to the widespread use of information technologies and an increase in the speed of changes in all spheres of human life, including in the business environment;

– the availability of information increases, where Internet resources play a predominant role, as well as the mass use of various gadgets (mobile phones, smartphones, tablets, etc.);

– the exchange of information between the participants of supply chains increases;

– the amount of information available to customers and companies is increasing dramatically (the problem of managing large databases): more and more users of instant and unlimited information are appearing;

– the time for making strategically important decisions, including the allocation of resources for further business development, is shortened;

– the interrelationship of counterparties in the supply chain through "flows" is increasingly strengthened: the spread of modern technologies deepens the processes of globalization, at the same time providing unlimited opportunities, and leading to an unpredictable degree of variability in the economic processes of counterparties;

– pressure from competitors increases due to the faster introduction of new goods and services to the market;

– substitute goods are becoming more common due to the tendency to level technical differences between goods as such;

– services expand companies' offers, contributing to the development of their spectrum and their inclusion in the package of commercial offers;

– companies focus on customers;

– the company's processes are becoming more complex, oriented to the needs of customers;

– customers demand a faster response to their needs, preferring the "utility of place and time" of goods and services purchased;

– clients seek to receive services in a complex, evaluating the provider's service package as a whole.

All this contributes to shifting the focus of strategic development of companies from an orientation only on profit maximization towards profit maximization through increased customer satisfaction[45]. Under the power of customers, barriers to entry for new players are lowered, differences between suppliers become less obvious, and the issues of maintaining former market positions, finding new sources of growth, ways to preserve existing customers and attract new ones become especially acute. The more technologically simpler the composition of the material flow, the more substitute goods that have identical consumer properties, the further from the supply chain the firm is from the final link of product distribution, the more critical is the search for a method of enterprise differentiation in a highly competitive market.

Considering these trends, a number of scientists believe that customer service is aimed at achieving several global goals[46]:

1) maintaining the maximum possible number of regular customers satisfied with the service;

2) obtaining competitive advantages in the fight for market share;

3) creation of a "buyer network": connection of the company's customers with specific employees of the given company, directly involved in the customer service process, who in turn act as customers of employees from the same or adjacent divisions, providing service support, and so on during entire supply chain.

[45]Seth N., Geshmukh SG, Vrat P. Service quality model: a review. International Journal of Quality and Reliability Management. 2005. No. 9: Vol. 22. 913-949.

[46]Avery GC Altruistic strategy: doing better by doing good, Strategy & Leadership, 2018, Vol. 46 Issue: 4, 50-51.; Hook M. The Trillion Dollar Shift: Achieving the Sustainable Development Goals, Business for Good is Good Business. Routledge, 2018. 430.

Moreover, customer service affects not only whether a company "keeps existing customers, but also how many of its potential customers become actual customers."[47]. In connection with such a significant role of customers for the success of business, their service is considered as one of the strategic perspectives when building a strategic map of the company, on par with "finances", "processes" and other perspectives, and in distribution logistics, it is one of the strategies.

Customer-oriented behavior in the company's activities is recognized as fundamental for conducting business: "consumers create sales, and the most successful companies are those that create customers and keep them"[48]. And as noted by J.R. Stock and D.M. Lambert[49], as well as a number of other researchers[50], there are at least four reasons for paying close attention to customers:

1) the need to maintain customers loyal to the company, who can become a source of repeat purchases;

2) higher profitability of interaction with loyal customers compared to engaged ones;

3) the high cost of "creating" a client: a 5-fold increase in the cost of attracting a client compared to keeping it;

4) multiplicative effect of negative interaction with the client.

Moreover, according to the Accenture global customer satisfaction report[51] price is not the main reason for customer churn; it's actually due to the overall poor quality of customer service.

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[47]Christopher, M. Logistics and supply chain management. Under general editor V.S. Lukinsokho. St. Petersburg.: Peter, 2004. 316.

[48]Christopher, M. The Strategy of Customer Service. The Service Industries Journal. 1984. No. 3: Vol. 4. R. 205.

[49]Stock D. R., Lambert D. M. Strategic logistics management - 4th ed. M.: INFRA-M, 2005. P. 608.

[50]Pokrovskaya L., Dolotova N. Scientific and Practical Recommendations for Outsourcing of Logistics Activities. In Proceedings of the 2nd International Scientific Conference on Innovations in Digital Economy. Association for Computing Machinery, New York, NY, USA, Article 2020. 27, 1-5.

[51]15 Statistics That Should Change The Business World – But Haven't ByColin Shawon June 10, 2013 URL: https://beyondphilosophy.com/15-statistics-that-should-change-the-business-world-but-havent/

Customer behavior	7 out of 10 satisfied customers will spend 13% more on their next visit	9 out of 10 satisfied customers will recommend the company to 15 of their friends	5 out of 10 customers dissatisfied with the service will refuse the company's services,	9 out of 10 customers will dissuade 24 of their friends from contacting a disappointing company
The result for the company	+ 8.5% to the average check of regular customers	+ 14% potential customers	- 55% of total revenue from the number of dissatisfied customers	- 23 potential customers
	The client is satisfied		The client is not satisfied	

Fig. 2.6 – The influence of consumer satisfaction on the retail sales process

Source: built by the authors on the basis; Customer-centricity: metrics, practices, facts. Specialized scientific and practical journal. URL:http://logistika-prim.ru/press-releases/tsci-enter-«klientotsentrichnost-metriki-praktiki-fakty»

Moreover, customer loyalty is no longer based on brands, products and prices. It depends much more on the services they receive, the work experience and the level of satisfaction, which is confirmed by statistical studies Customer Service Stats for 2020 (Table 2.2).

At the same time, scientists determine that attracting and retaining customers by any means and at any price is also an irrational step, so in a number of sources[52] the issue of finding a balance between their service and the amount of resources spent on it is raised: and distortions in either direction are recognized as unacceptable. And the clients themselves, demanding from the provider the provision of services with greater added value, expect to receive a clear explanation for the higher price for goods/services[53].

[52]Christopher M. The Strategy of Customer Service. The Service Industries Journal. 1984. No. 3: Vol. 4. 205-213.; Fotis J. The Use of social media and its impacts on consumer behavior: the context of holiday travel. 2015. 405. Rihova I., Buhalis D., Gouthro M., Moital M., Customer-to-customer co-creation practices in tourism: lessons from Customer-Dominant logic, Tourism Management, 2018. Vol. 67, 362-375.

[53]Stok D. R., Lambert D. M. Strategic logistics management - 4th ed. Moscow: INFRA-Moscow 2005. R. 607-608.

Table 2.2 – Customer service, satisfaction and experience statistics and suggestions

Interest	Characteristics of information	Source of information
54%	customers have higher expectations for customer service today than they did a year ago. This percentage rises to 66% for consumers between the ages of 18 and 34.	Microsoft
89%	companies are expected to compete primarily on customer experience.	Gartner
more than 50%	organizations will redirect their investments to innovations in the field of customer service.	Gartner
67%	people believe that customer service in general is improving.	Microsoft
64%	of Americans have turned to some form of customer service.	Statista
52%	people around the world believe that companies should take action based on the feedback provided by their customers.	Microsoft
96%	consumers say that customer service is an important factor in choosing brand loyalty.	Microsoft
85%	consumers put "the best customer service" in the first place on the question that affects their level of trust in the company.	Zendesk
70%	have already made a choice to support a company that provides excellent customer service.	American Express
62%	Consumers believe that understanding and	American

	knowledge of services is also key to a good experience.	Express
52%	of consumers say they made an additional purchase from a company after a positive customer service experience.	Zendesk
90%	customers are subject to positive feedback when purchasing a product.	Zendesk
89%	companies will compete mainly for the experience of working with clients	Gartner
99%	of customer experience and success leaders believe experience management has a positive impact on their business.	Lumoa
87%	organizations agree that the traditional experience no longer satisfies customers.	Accenture
over 40%	all data analytics projects will involve some aspect of customer service. Gartner	Gartner

Source: built by the authors based on: Customer Service Stats for 2020 URL: https://www.customerthermometer.com/customer-service/customer-service-and-satisfaction-statistics-for-2020.

The level of logistics customer service directly affects the company's market share, its total logistics costs and ultimately profitability, determining not only the loyalty of existing customers, but also the number of potential customers.

Usually, three main areas of logistics service improvement are considered: improving the use of resources, efficiency and differentiation.

Improving the use of resources is the provision of logistics services that allow reducing consumer costs, i.e. reduce logistics costs throughout the supply chain. A direct consequence of this is a reduction in the price of goods and related services compared to competitors.

Efficiency of logistics is the best satisfaction of consumer requirements for the quality of goods and services based on such indicators as guaranteed product quality upon delivery, availability of the necessary product stock at the right place, order fulfillment time, ease of use of the product, after-sales service, service innovations, market position (image).

Differentiation is an increase in the market share (number of buyers) with the help of logistics service. An example of such a service is the use of the concept of value added logistics.

So, the logistics service as a complex of interrelated operations and functions ensures uninterrupted operation of the system of procurement, supply, storage and delivery of products to the consumer. This complex operates in the appropriate logistics infrastructure. The following main components are distinguished in the logistics service management system:

– general issues of creation, development and management of logistics infrastructure;

– management of the rolling stock fleet of own or hired vehicles;

– use of transport and storage equipment;

– development of a network of trunk and auxiliary roads;

– increasing the efficiency of warehouse operations, including warehouse buildings and premises, warehouse, production and communication equipment;

– management of the work of rolling stock on the line (dispatching and routing of transports).

The elements of the logistics service are:

1) material base – a set of technical means of various types of transport, handling and storage equipment with an optimal ratio of parameters, used for the delivery of individual or similar cargoes in terms of transport and physical properties;

2) economic, commercial, legal and organizational unity of various links;

3) automation and complex mechanization of basic labor processes; elimination of heavy manual labor;

4) reduction of socially necessary transport costs due to the economic efficiency of the functioning of transport systems;

5) a single agreed technology for the delivery of cargo from the consignor to the consignee.

An important role in the design of the logistics service network will be played by such factors as the determination of the required number of logistics service facilities of each type, geographical location and economic functions of each of them. Therefore, all service units should be considered as integrated elements of the logistics system in the supply chain management process. The logistics service infrastructure should become a kind of framework for the movement of goods along it. Logistics infrastructure should include transport and information facilities, as well as production departments, warehouses, loading and unloading terminals, retail outlets, etc. It is clear that for the proper functioning of the entire logistics service system, it is necessary to consider the services of all divisions, starting from procurement logistics and ending with the logistics of return flows.

It should be emphasized that logistics service is a balance between the priority of high-quality customer service and associated costs. After all, the lack of a resource necessary for production at the right time can cause the closure of the enterprise, and significant costs associated with fines, a reduction in the volume of sales, or even the loss of a good client. All this can cause significant losses for all participants in the supply chain. Conversely, a two-day delivery delay to restock is likely to have minimal or no impact on profits, judging by the company's overall performance. In most cases, the impact of disruptions in a company's logistics system on its costs/benefits directly depends on the importance its customers attach to the quality of service.

Among the types of service, the following are distinguished:

1. Consumer demand satisfaction service, which represents a complex characteristic of the level of customer service.

2. The service of providing services for production purposes, which covers the totality of the proposed types of product service, i.e. a set of services provided to the client from the moment of concluding the purchase contract to the delivery of products.

3. After-sales service, which includes a set of provided services necessary to ensure the effective functioning of products in existing economic conditions throughout the entire expected life cycle of products. After-sales service is provided both before and after the sale of products and includes the following main activities:

– determination of requirements for after-sales service of products at the stage of its development together with the consumer;

– definition of services provided to the consumer after the sale of products;

– establishing the procedure for after-sales service of products in the process of discussing the terms of its supply;

– training of personnel for operational and repair work, preparation and release of the necessary technical documentation;

– organization of provision of spare parts and tools necessary for after-sales service;

– management of after-sales service of products;

– preparation of the necessary infrastructure to provide after-sales service;

– development of a system of replacing products with their modern modifications and disposal of old products.

4. Information service. which is characterized by a set of information provided to the consumer about products and their service, methods and

principles, as well as technical means used for processing and transmitting information.

5. Financial and credit service, which includes a set of various payment options for products, a system of discounts and benefits provided to consumers. Here you need to consider different forms of credit:

– depending on the borrowed value (commodity, money and mixed);

– depending on who is the creditor: banking, commercial, state, international, civil, production, consumer structure;

– in some cases, it is necessary to consider the following forms of credit (direct, indirect, explicit, hidden, old, new, basic, additional, development, non-development, etc.).

Regarding the issue of forming a list of minimum necessary indicators for evaluating customer service, the "basic" level of service in logistics is evaluated according to the following indicators:

1) availability;

2) functionality;

3) reliability.

This means the availability of stocks for uninterrupted satisfaction of customers' needs for material resources or finished products. According to the traditional model, the higher the degree of inventory availability, the greater the amount of investment it requires. The development of technologies has opened new ways to ensure high availability of stocks without accompanying large capital investments, but the latest global world events related to the pandemic and the war in Ukraine significantly adjust them and require the formation of over-rationalized stocks for "just in case".

The functionality of logistics is also determined by the time that passes from the moment of receiving the order to its execution, that is, the supply of resources or goods to consumers. This general indicator consists of two elements: speed and uninterrupted supply. Most consumers, of course, prefer fast delivery. However, fast deliveries are of very limited value if they are uneven. Usually, companies strive to conduct their operations evenly, because of this, they try to achieve, first of all, the continuity of the service process, and then - an increase in the speed of deliveries[54].

There are other equally important features of logistics service functionality. In particular, it can be measured by the level of flexibility with which the firm responds to unusual or unexpected customer requests. Another significant indicator is the level of "defects" and the elimination of deficiencies, which reflects the probability of unforeseen failures in logistics – in particular, the supply of unsuitable or defective products, errors in the selection of the assortment or incorrect processing of documents. If something similar happened, that is, the supply of defective products was still allowed, then the company's activity is evaluated by the length of time it takes to eliminate the defects (ie, restore the given level of service). Logistics functionality reflects all aspects of a firm's day-to-day satisfaction of consumer requests, including failures and service deficiencies.

Service reliability is a quality characteristic of logistics. A key quality factor in this case is an accurate and thorough assessment of accessibility and functionality. Only such a comprehensive assessment can determine whether the supply chain provides the desired level of customer service. The reliability of the service depends on whether the firm has clear measures of stock availability and order fulfillment functionality.

In order for the logistics system to be constantly ready to meet the needs of customers, company managers must adhere to a policy of continuous improvement. Quality in logistics is not easy to achieve: careful planning, supported by professional training, a comprehensive system of evaluation of results and constant changes for the better. To improve the level of service, companies must set goals for themselves on an electoral basis. For example,

[54]Shaul D. First class service as a competitive advantage. Moscow: Alpina Publisher, 2013. 344.

some products have a more important role than others because of the importance that consumers place on them and the contribution they make to the firm's bottom line.

Realistic requirements should be made for the basic level of service, based on the requests and expectations of consumers. Often, companies face the fact that their customers have different purchasing power, or some of them require unique services. And managers must realize that consumers are heterogeneous and that the services described by them must be coordinated with their individual preferences and purchasing power. As a rule, companies are very optimistic about their ability to serve consumers at an average or basic level. But if the company has set itself an unrealistically high target level of service, then the inability to constantly adhere to it can cause more serious problems both in the main activity and in relations with customers, than simply the inevitable lowering of the "bar". In addition, due to the unrealistic high general standards of service set for itself by the company, it may lose promising customers without being able to satisfy their specific requests. Of course, logistics service is not the only source of joint economic success of enterprises in the supply chain, but it plays a key role in serving consumers. After all, the impact of logistics on competitiveness often depends on how logistics "fits" into the marketing activities of the supply chain. This activity determines the degree of satisfaction of customer needs. As a rule, the desired degree of satisfaction of such needs changes over time. logistics service is not the only source of joint economic success of enterprises in the supply chain, but it plays a key role in serving consumers. After all, the impact of logistics on competitiveness often depends on how logistics "fits" into the marketing activities of the supply chain. This activity determines the degree of satisfaction of customer needs. As a rule, the desired degree of satisfaction of such needs changes over time. logistics service is not the only source of joint economic success of enterprises in the supply chain, but it plays a key role in serving consumers. After all, the impact of logistics on competitiveness often depends on how logistics "fits" into the marketing activities of the supply chain. This activity determines the degree of satisfaction of customer needs. As a rule, the desired degree of satisfaction of such needs changes over time.

Due to the wide variety of indicators, as well as problems with their calculation methods, working with metrics is very difficult. Therefore, it would be more useful for practitioners to collect existing theoretical developments in the field of customer service evaluation indicators, group and systematize them according to some principle, and provide recommendations for the use of one or another indicator. Thus, practicing specialists in the field of customer service should be offered a decision-making tool for choosing the necessary list of indicators with the conditions of their application. In this regard, the view of P. Johnson is interesting, who suggests considering customer service as a process (Figure 2.7), which is implemented in four time intervals that create added value for the consumer[55].

It is worth noting that the author presents the process of customer service not as a set of service evaluation indicators, but as services provided in one or another period of time.

Based on the results of the analysis mentioned in the first section of scientific sources, we have formed a set of indicators that are proposed to be used to evaluate customer service. To simplify perception, all indicators were divided into 10 groups. Each of the groups covers one aspect of customer service that must be evaluated and analyzed by the company in one way or another:

1. Indicators evaluating the (comprehensive) service result customers (efficiency of customer service; efficiency of customer service; share of new

[55]Jonsson P. Logistics and Supply Chain Management : The McGraw-Hill Companies, Inc., 2008.. P. 84-85.

customers in the company's customer base; long-term customer value; customer satisfaction index).

Indicators of evaluation of services provided before placing an order

- Acceptability of the terms of placing an order by the client
- Clear and detailed information about the conditions of placing an order (for example, delivery time, current stock level, etc.)

Indicators of assessment of services provided from the moment of placing the order to the moment of delivery

- Ease of placing an order by the client
- Adaptability and flexibility of the process of placing an order by the customer (informing about delays, the ability to work with changing customer requirements)

Indicators of assessment of services provided in the process of delivery

- Delivery time
- The extent to which the promised delivery time meets the actual delivery date

Indicators of assessment of services provided after delivery

- The possibility of tracking the origin of the product and the details included in its composition
- Availability of necessary spare parts
- Dealing with customer complaints and returns
- Processing and recycling of used goods and packaging

Fig. 2.7 – Process of customer service over time

Source: constructed by the authors based on: Jonsson, P. Logistics and Supply Chain Management : The McGraw-Hill Companies, Inc., 2008. 491.

2. Indicators evaluating the level of fulfillment of customer orders (the number of requests from customers; the number of responses to requests per employee; the convenience of placing an order by a customer; the number of problems associated with placing a customer order; the number of received customer orders in electronic form; accuracy in filling out the customer's order by the supplier; the quality of the documentation prepared by the supplier ; the number of processed orders; the completeness of order fulfillment by the supplier; the accuracy of the order fulfillment by the supplier in time; the probable assessment of the failure-free execution of the accepted order in terms of time and/or quantity/quality; the share of orders with errors from the total number of orders processed by the system; quality of supply (absence of violation of the product appearance, absence of errors in the assortment)).

3. Indicators evaluating the time parameters of customer service(time of the complete cycle of the order; time of response to customer requests; time of making the order; time of placing the order; time of processing the order; time of assembling the order; time of packing the order; time of delivery of the order).

4. Indicators evaluating the flexibility of order fulfillment the ability to handle specialized cargo; the ability to process transit cargo; availability of vehicles for the delivery of dangerous goods; availability of a safety program for dangerous goods).

5. Indicators evaluating customer after-sales service (the number of after-sales services; the possibility of receiving technical advice; the speed of response to the after-sales service request; the availability of spare parts).

6. Indicators evaluating the work with complaints, claims, reclamations, deviations on the order of the client (the number of complaints from customers; the number of negative events in the distribution system; the volume of product returns in physical terms; the volume of returns in monetary terms; processing of order deviations; speed of response to complaints).

7. Indicators evaluating the flow of goods and materials (inventories) and services logistics costs for customer service by service stages and service components; inventory shortage costs; ease of use; cargo safety, technical specifications).

8. Indicators evaluating the information provision of the customer service process (availability of information about the progress of the order; openness and availability of information exchange channels; reliability of the information provided; quality of information transmission to the client; deviation of the information formation time from the average market value of time; the price of information services in comparison with the average market prices; timeliness of notifying the client about a change service conditions; providing information about a change in the size of a delivery lot or errors in customer service; providing information about a shipment delay and the nature of the delay; providing information about the duration of the cycle of fulfillment of delayed orders; providing information about delayed orders; providing information about outdated orders; providing management assistance stocks; the use of a global data integration system; the amount of advertising in newspapers and magazines).

9. The indicators evaluate the financial conditions of customer service (convenience of the calculation procedure; ratio of the number of types and forms of payment for products provided by the company; deviation of the time of providing options and forms of payment from the moment of receipt of the application to the moment of conclusion of the contract from the average market indicator; fee (in percentage) for financial and credit services in comparison with average market prices; providing credit to customers; acceptance by the supplier of costs for returned goods; acceptability of the invoice format for the supplier and the customer; timeliness of delivery of invoices for payment).

10. Indicators evaluating the social aspect of customer service (the general reputation of the supplier; the presence of a sales representative; the availability of personnel for customers; the awareness of sales department employees; the sensitivity and courtesy of sales department representatives; individual approach to customers; the quality of workers; understanding with the customer; the presence of work standards for employees in the warehouse; long-term contractual relations with customers ; ease of interaction with the supplier; ease of use of the purchased goods; preferences for a special category of product users; availability of technical specialists; training programs offered by the supplier; holding seminars on sales techniques).

This advanced approach to measuring indicators of supply chain logistics service makes it possible to comprehensively assess the effectiveness of working with clients. After all, it is aimed not only at the overall result of customer service (the first group of indicators), but also at the efficiency of the execution of customer orders, where special attention should be paid to consideration of various types of deviations in order execution, as well as services implemented after the sale (the second, fourth and the fifth group of indicators); not only the time parameters of customer service (the third group of indicators), but also their variability or stability, that is, the company's ability to adapt to customer needs, which is expressed in the flexibility of fulfilling customer orders (the sixth group of indicators); it is both material, information and financial flows,

2.3 Review of modern models and methods of optimization of logistics service

In developed economies, the goals and principles of "optimality", "absolute safety" or, in other words, "zero risk", which have been used for many years in economic and technical systems, have today given way to the principles of "acceptable risk" or "suboptimality" ". Accordingly, in Western studies, in connection with the need to define certain forms of supply chain management, that is, structures and processes designed to coordinate and unify the management of supplies of various volumes, sustainable logistics systems were proposed. In them, management represents structures and processes by means of which elements of logistics systems distribute power, and also determine individual and collective actions. Nevertheless, despite the interest shown by Western researchers to bringing logistics systems to a stable state, there is a clear lack of research on the peculiarities of managing logistics systems after the latter have been brought to the mentioned stable state. Or, in other words, how management should change so that the system continues its sustainable development. From these positions, R. Manzyna, R. and M. Bortolini define supply chains as complex and interconnected socio-ecological systems of people and institutions, and the concept of sustainability in supply chains as a combination of previous principles of sustainability with studies of the sensitivity of supply chains, defined as "unexpected deviations from the norm and their negative consequences"[56]. That is, sensitivity can be measured and expressed in numerical values from the position of "risk", as a combination of the probability of an event and its potential severity.

Research in the field of logistics from both a theoretical and a practical point of view has already reached a level where the use of mathematical methods has become a necessity. Modeling of such systems in order to further facilitate their management is the tool that ensures the systematicity of logistics processes and their effectiveness, which means the effectiveness of production and commercial activities. When a decision-maker is faced with the task of organizing the passage of a material flow from its beginning to its final point and doing it with minimal costs, then in order to make an optimal management decision, he desperately needs a model of the controlled process.

The possibility of modeling individual logistics processes by participants of logistics systems is based on the justified choice and application of statistical and economic-mathematical methods and forecasting tools. The forecasting toolkit is especially important for organizing the activities of regional logistic systems of anticipatory development, taking into account the peculiarities and regional interests of the territory.

Modeling has a centuries-old history and for a long time in the scientific literature, despite its development within the framework of the synergistic use of

[56]Manzini R., Bortolini M. A Supporting Tool for the Integrated Planning of a Logistic Network. Supply Chain, Theory and Applications 2008, No. 4 276-294.

the results of the scientific disciplines of economics and mathematics, there was no unified terminology for this process. Thus, we can recall examples of economic and mathematical modeling, on the basis of which separate provisions of the works of Luca Pacioli were built ("Treatise on accounts and records", 1494)[57], Francois Quenet ("Economic Tables", 1758)[58], Adam Smith (classical macroeconomic model 1776)[59], by David Ricardo ("Model of International Trade" 1817)[60] and other. However, the very appearance of the concept of "economic-mathematical methods and models" can be attributed to the 20th century, when a number of fundamental works of famous economists - Nobel laureates in the field of economics V. Leontiev appeared[61], D. Hicks[62], R. Solow[63].

Later, the term "model" began to be used quite often to denote standards, images, exemplary examples of products, a type or type of construction of a product, etc. This is where the target settings of modeling originate (understanding, qualities, laws of system development, methods of managing the system with given goals and criteria, forecasting consequences). In the subsequent works of economists and mathematicians, there are approaches to structuring the modeling process, the general scheme of which includes a number of stages:

1) construction of models of the original object;

2) analysis of models as an independent object of research;

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[57] *Pacioli, L. Treatise on Accounts and Records. Translated by N. M. Tkachenko. Kyiv: Alerta, 2021. 180.*

[58] Quesnay F. Œuvres économiques completes et autres textes. C. Théré, L. Charles and J.-C. Perrot (eds.) Paris: Institut National d'Etudes Démographiques. 2005.

[59] Smith A. Welfare of Nations. An Inquiry into the Nature and Causes of the Welfare of Nations; trans. from English O. Vasiliev [etc.] ; of science ed. E. Lytvyn. ate : Port-Royal, 2001. 594.

[60] Ricardo, D. Writings: [in 2 volumes] . T. II: Beginnings of political economy and taxation. Moscow: Ogiz: Socekgiz, 1935. XXXX, 296.

[61] Leontief W., 'Structural Change,' in Leontief et. al., Studies in the Structure of the American Economy, New York, 1953.

[62] Hicks JR Value and Capital: An Inquiry into some Fundamental Principles of Economic Theory,OUP Catalogue, Oxford University Press, 1975, edition 2, number 9780198282693.

[63] Linear Programming and Economic Analysis. Front Cover. Robert Dorfman, Paul Anthony Samuelson, Robert M. Solow. McGraw-Hill, 1958 Economics. 527.

3) transferring the accumulated knowledge obtained at the second stage from the "models" to the "original";

4) verification of knowledge obtained with the help of models for theoretical conclusions with possible transformation for purposes and further management.

Note that from the last stage, if necessary, you can easily return to the first one to adjust the original model (object). Thus, the structuring of the modeling process indicates its cyclic nature.

Theoretically, different types of modeling are distinguished:

– material, based on physical modeling, study of the main functional characteristics of the object;

– ideal, which is most often used in economics and is used when using two classes of tools: iconic (symbols, models, graphs, etc.) and intuitive (when modeling risk situations);

– computer, based on mathematical modeling, widely used in economic research.

Let's try to present an algorithm for building a model for solving one or another problem in logistics, the solution of which will be carried out with the help of mathematical modeling:

1) it is necessary to determine in which of the elements of the logistics system a problematic situation arose;

2) it is necessary to determine the characteristic features of the problematic situation that has arisen;

3) it is necessary to determine whether this problematic situation entails losses;

4) identify goals for solving this problematic situation;

5) determine the task that contributes to solving the problem situation;

6) build a model based on all previously obtained data about the problem situation;

7) analyze the model and determine the method of solving the given problem;

8) solve the problem based on the chosen method;

9) make a decision based on the data obtained during the solution of the problem;

10) bring the received decision to a management decision to influence the problematic situation of the logistics system;

11) get a result;

12) analyze the obtained result.

The analysis of the obtained results determines the degree of adequacy of the model and the effectiveness of its solution methods. Based on this analysis, certain adjustments are made to the model and method. Regardless of the level of modeling complexity, the main stages of modeling can be traced: "situation - model - method - result".

Such an algorithm, generally speaking, is universal for modeling any process, situation or system in general. The main difficulty in such a process is to correctly define the problematic element, and then choose the most effective method of modeling this element. Despite such versatility, when it comes to the modeling of logistics activities, economic or even commercial components are involved in the consideration, therefore, in many models, the solution is cost optimization for various processes of the logistics system.

Economic-mathematical models in regional analysis are traditionally a formalized description of a process or phenomenon to establish the regularity of relationships between individual internal processes and phenomena in the system. It is clear that such a model is an abstract reflection of reality, since it is quite difficult to take into account with high accuracy all the processes taking place in the economic system of the region and the relationships between them. However, such models make it possible to determine the main economic parameters of the system (for example, availability of resources, consumption, development of transport infrastructure, peculiarities of price formation of enterprises – large suppliers, inflation rate, employment rate, etc.).

Regional level models have a certain feature - they are formed using two types of variables: exogenous (the values of which are formed outside the model, are independent or autonomous) and endogenous (the values of which are formed inside the model, are dependent). In essence, such models reflect the extent to which the values of endogenous variables depend on changes in exogenous variables. Moreover, the same variable in different models can be both exogenous and endogenous. Therefore, all functional relationships between variables in scientific research acquire different characteristics: behavioral, institutional or technological. Each logistics company that is a member of the logistics chain develops its logistics strategy, which includes a set of decisions and plans focused on the tasks of supply chain management. When developing such a strategy, one should take into account factors that affect logistics operations, but which the company cannot control for various objective reasons. As for controlled factors, they most often include interaction with suppliers, personnel management, marketing policy, and technology applications.

Based on the goal of logistics – to ensure the availability of the right product in the right place at the right time and at the lowest cost, which is achieved by reducing order fulfillment time, production time, transportation time, inventory control, improving the quality of products and goods that are objects of logistics, specific methods, models and algorithms of logistics are determined. Such methods include:

– methods in the field of production placement: weighing method, placement method taking into account total costs, gravity method, cost calculation method;

– methods of placing logistics service objects;

– methods of determining the shortest path of the logistics flow;

– methods of building a logistic chain of minimum length;

– methods of determining the maximum logistics flow and others.

Optimization models. In works[64] well-known models of decision-making related to transportation and inventory management, as well as determining the locations of storage facilities are given. A significant number of studies[65] was aimed at the development of these models. At the same time, we note that although transport models and inventory optimization models achieve the goals of their implementation, their application can lead to the optimization of partial indicators of any subsystem of the logistics system, but will not achieve the overall optimality of the functioning of the supply chain. Integrated optimization models, the purpose of which is to optimize the operation of several subsystems of the logistics system, lack this drawback.

Such models of production and transportation optimization are offered by O. Kaya, D. Kubali, and L. Ormeki[66]; joint optimization of distribution of production and transportation of customer orders - M. Aydinela, T. Soulatib, K. Serda, E. Kopea, M. Gershman[67] and C. Archettia, L. Peiranob, M. Grazia

[64]Bowersox, D. D., D. D. Kloss, D. D. Logistics: the integrated supply chain. translated by N. N. Baryshnikova, B. S. Pinsker. - 2nd ed. M.: ZAO "Olymp-Business", 2008. 640; Waters D. Logistics. Supply chain management Moscow: UNITY-DANA, 2003. 503.; Dolgui A., Ould-Louly M. Optimization of supply chain planning under uncertainty, IFAC Proceedings Volumes, Volume 33, Issue 20, 2000, 303-307.; Gamboa-Bernal JP, Moreno-Mantilla CE , Orjuela-Castro JA, Sustainable Supply Chains: Concepts, Optimization and Simulation Models, and Trends, Ingenier´ıa, 2020. vol. 25, no. 3, 355-377.

[65]Bhattacharya A., Kumar SA, Tiwar MK i, Talluri S. An intermodal freight transport system for optimal supply chain logistics, Transportation Research Part C: Emerging Technologies, Volume 38, 2014, 73-84.; Güner AR, Murat A., Chinnam RB Dynamic routing under recurrent and non-recurrent congestion using real-time ITS information. Computers & Operations Research. 2012. No. 2 (39). 358-373.; Lai M. et al. Cyber-physical logistics system based vehicle routing optimization. Journal of Industrial and Management Optimization, 2013, vol. 10, no. 3, 701-715.; Moncayo-Martínez LA, Reséndiz-Flores EO, Mercado D., Sánchez-Ramírez C. Placing Safety Stock in Logistic Networks under Guaranteed-Service Time Inventory Models: An Application to the Automotive Industry, Journal of Applied Research and Technology, Volume 12, Issue 3, 2014, 538-550; Nidhi MB, Anil B. A cost optimization strategy for a single warehouse multi-distributor vehicle routing system in stochastic scenario. International Journal of Logistics Systems and Management. 2011. No. 1 (10). 110-121.;Rahman MA; Hossain AA; Debnath B.; Zefat ZM; Morshed MS, Adnan ZH Intelligent Vehicle Scheduling and Routing for a Chain of Retail Stores: A Case Study of Dhaka, Bangladesh.*Logistics*2021,*5*, 63. URL:https://doi.org/10.3390/logistics5030063;

[66]Kaya O., Kubali D., Örmeci L. Stochastic models for the coordinated production and shipment problem in a supply chain. Computers & Industrial Engineering. 2013. No. 3 (64). 838-849.

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Speranzab[68]; minimization of inventory and transportation costs – E. Kutanoglu and D. Lohia[69]. And K.H. Zhao, S. Chen, and K.K. Zang adds the costs of order fulfillment to the mentioned costs[70]. In addition, the extended model of optimization of total costs, which includes the costs of maintenance and replenishment of stocks and transport costs, formulated in the work of B.K. Lee, K.H. Kana and E.H. Lee[71], and S. Park, T-E. Lee and Ch.S. Sung[72] a decision-making model was developed regarding the number and location of suppliers and distribution centers, the assignment of each distribution center to retailers, and inventory control in order to minimize the amount of setup, transportation, and cash and insurance costs. The model presented by E. Ponce-Cueto and M.M. Muelas[73], notable for the fact that it takes into account logistics costs associated with both direct and reverse material flow.

The considered models allow to some extent to avoid sub-optimization of the values of the indicators of the logistics system. At the same time, their significant drawback is the absence of logistics service indicators, or insufficient emphasis on them. However, there are models that include such indicators as the main elements. An example of a model that takes into account the level of service in the insurance reserve indicator is the model developed by E. Gebennini, R. Gamberini and R. Mancini[74]. Similar ideas about the level of stocks as the main indicator of the level of service can be seen in the work of

[68]Archetti C., Peirano L., M. Speranza G. Optimization in multimodal freight transportation problems: A Survey, European Journal of Operational Research, Volume 299, Issue 1, 2022, 1-20.

[69]Kutanoglu ED Lohiya Integrated inventory and transportation mode selection: A service parts logistics system Transportation Research Part E: Logistics and Transportation Review. 2008. No. 5 (44). 665-683.

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[71]Lee BK, Kang KH, Lee YH Decomposition heuristic to minimize total cost in a multi-level supply chain network. Computers & Industrial Engineering. 2008. No. 4 (54). 945-959.

[72]Park S., Lee T.-E., Sung CS. A three-level supply chain network design model with risk-pooling and lead times. Transportation Research Part E: Logistics and Transportation Review. 2010. No. 5 (46). 563-581.

[73]Ponce-Cueto E., Muelas MM Integrating forward and reverse logistics network for commercial goods management. An integer linear programming model proposal. International Journal of Production Management & Engineering. 2015. No. 1 (3). 25-32.

[74]Gebennini E., Gamberini R., Manzini R. An integrated production–distribution model for the dynamic location and allocation problem with safety stock optimization. International Journal of Production Economics. 2009. No. 1 (122). 286-304.

P.A. Miranda and R.A. Garrido[75]. A two-objective model for optimizing logistics costs and service level, where the first objective function minimizes the sum of order costs, transportation costs, and inventory holding, and the second (service function) minimizes the number of undelivered goods and surpluses, formulated in the work of R.Z. Farahani and M. Elahipana[76]. A multi-purpose model that takes into account, in addition to the level of stocks, such indicators as the number of delivered and returnable goods was proposed by D. Ivanov, A. Pavlov and B. Sokolov[77]. The model presented in the work of O.Kh. Ibarra-Rojas, R. Giessen and J. Ríos-Solisa, ensures simultaneously the maximization of transported passengers and the minimization of costs for the used transport[78]. Recognizing the level of customer service as one of the main factors affecting the efficiency of supply chains, A. Hafezalkotob and D. Khalili-Damkhani develop a multi-objective model for cost and service optimization[79]. In them, the cost function consists of several parts and takes into account the range of costs associated with the purchase of raw materials, production and distribution of goods. The service function has two parts, where the first takes into account the deviation of the delivery time from the appointed date, and the second – the number of unfulfilled orders.

At the same time, practical activity quite often takes place under conditions of uncertainty caused by inaccuracy or incompleteness of information about demand, supply, temporary delays of ordered goods, spoilage of products and other parameters of the logistics system, which require the search for an

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

[76]Farahani RZ, Elahipanah M. A genetic algorithm to optimize the total cost and service level for just-in-time distribution in a supply chain. International Journal of Production Economics. 2008. No. 2 (111). 229-243.

[77]Ivanov D., Pavlov A., Sokolov B. Optimal distribution (re)planning in a centralized multi-stage supply network under conditions of the ripple effect and structure dynamics. European Journal of Operational Research. 2014. No. 2 (237). 758-770.

[78]Ibarra-Rojas OJ, Giesen R., Rios-Solis YA An integrated approach for timetabling and vehicle scheduling problems to analyze the trade-off between level of service and operating costs of transit networks. Transportation Research Part B: Methodological. 2014. Vol. 70. 35-46.

[79]Hafezalkotob A., Khalili-Damghani K. Development of a multi-period model to minimize logistic costs and maximize service level in a three-echelon multi-product supply chain considering back orders. International Journal of Applied Decision Sciences. 2015. No. 2 (8). 145-163.

effective mechanism for managing stocks and transportation in conditions of uncertainty of various nature. Stochastic models can be used as such tools.

Stochastic uncertainty is uncertainty that can be treated as a random entity. A random object can be a random value or a random process, and methods of probability theory and mathematical statistics can be used to study it. Accordingly, the peculiarity of stochastic uncertainty is that an uncertain factor, phenomenon or event can be considered or interpreted as a stochastic object. Stochastic uncertainty can be represented by a random variable or a random process. Complete uncertainty is not perceived as a random object in principle. The type of uncertainty determines the choice of mathematical models. According to the level of complexity, models can be arranged in the following order: models under conditions of complete uncertainty are much more complex than stochastic ones,

To solve problems with a priori uncertainty, in the modern literature on inventory management, the approaches of set theory, scenario modeling, an approach based on the concept of "unknown but limited" (unknown demand belongs to a given set) are proposed. Recently, the rapid development of the method of simulation modeling and its application to a wide range of tasks is associated with the progress of computer technologies, for example in publications[80]simulation programming is used to study and optimize warehouse systems. At work[81]the use of interval analysis methods is proposed for the purpose of calculating the basic parameters of the stock management policy in systems with incomplete information about demand. In these works, analytical statements of the interval values of the limit stock, point, and order volume were

[80]Gallego-García, S., García-García, M. Market-Oriented Procurement Planning Leading to a Higher Service Level and Cost Optimization. Appl. Sci. 2020, 10, 8734; Ran H. Construction and optimization of inventory management via cloud-edge collaborative computing in supply chain environment in the Internet of Things era. PloS one, 2021. 16(11), e0259284; Wang M.,Asian S.,Wood LC,Wang B., Logistics innovation capability and its impacts on the supply chain risks in the Industry 4.0 era,Modern Supply Chain Research and Applications, 2020. Vol. 2 No. 2, 83-98.

[81]Botha A. A system dynamics simulation for strategic inventory management in the South African automotive industry, PhD Thesis, University of Pretoria, Pretoria, 2017. URL http://hdl.handle.net/2263/66223.

obtained for the corresponding cost interval in a single-nomenclature inventory management system with continuous control, interval-specified demand intensity and instant deliveries (interval generalization of the Wilson model), as well as deliveries of the interval generalization of the model with fine

In publications[82] two single-product models with random parameters (delay and demand) were considered. In the first model, the reorder point and the order moment are fixed. In the second, there is a fixed time between moments of adjacent orders. The order quantity is defined as the difference between the fixed stock level and the quantity of the product at the time of the order. The considered models are investigated using analytical and simulation methods.

The study of the stochastic model of inventory management, taking into account the possibility of their deterioration, is presented in the paper[83]. The authors obtained optimal management characteristics for expected costs per unit of time under the condition that the demand in each period until the stock is replenished forms a regenerating process.

At work[84] the results of modeling the inventory management of the trading activity of an intermediary firm are presented, the purpose of which is to find the optimal strategy of behavior from the point of view of obtaining the highest guaranteed profit for a given level of service, the characteristics of its consumers, suppliers and the market. In the researched stochastic inventory management system with periodic control of the demand level, the demand is random, non-stationary, the distribution of supplies depends on the amount of

[82]Kopytov E., Greenglaz L., Muravyov A., Puzinkevich E. Modeling of two strategies in inventory control system with random lead time and demand. Computer Modeling and New Technologies. 2007. Vl 1. No. 1. 21-30.; Kopytov E., Muravjov A, Greenglaz L., Burakov G. Investigation of two strategies in inventory control system with random parameters. Proceedings of the 21st European Conference on Modeling and Simulation (ECMS 2007). June 4-6, 2007. Prague, Czech Republic: Thomas Bata University in Zlin, 2007. 566-571.

[83]Aggoun L., Benkherouf L., Tadj L. On a stochastic inventory model with deteriorating items. IJMMS. 2001. Vol. 25. No. 3. 197-203.

[84]Baradel N., Bouchard B., Evangelista D., Othmane Mounjid. Optimal inventory management and order book modeling. ESAIM: Proceedings and Surveys, EDP Sciences, 2019, 65. 145-181.

the order submitted to the corresponding source of stock replenishment. The optimal order size of the model with a decrease in the delivery delay and a decrease in the price when a shortage is formed under conditions of random demand in the study[85].

In the model with continuous control, the optimal order point is investigated. The delivery delay time is considered controllable, during the formation of a deficit in the system, a discount of the product price and partial sales losses are provided. The control parameters are the delivery delay time, the order size, the discount value and the system reliability factor. As a function - expected annual costs. The distribution of demand is unknown. To find the optimal solution, the author uses an algorithm based on the minimax approach, with a detailed numerical example.

Authors of studies[86] offer an approach to creating an effective management system of a motor transport enterprise based on regulatory and descriptive models of regional transportation. The economic-mathematical model and methods presented in these works take into account the descriptive aspects of cargo transportation, which ensures consideration of the risk of dependence on external conditions and more adequate decision-making in conditions of uncertainty associated with the organization of transportation.

Various studies of stochastic inventory management models can also be found in logistics publications. For example, Y. Tan, MX Weng[87] investigated the conditions for the successful operation of a two-level order system with

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[85]Lo M. Economic ordering quantity model with lead time reduction and backorder price discount for stochastic demand. American Journal of Applied Sciences. 2009. Y. 6. No. 3. 387-392.

[86]Junyi C., Weng Z., Liu. W. Behavioral Decision Making in Normative and Descriptive Views: A Critical Review of Literature. Journal of Risk and Financial Management 2021. 14: 490.; Thaller C., Niemann F., Dahmen B. Uwe Clausen, Bert Leerkamp, Describing and explaining urban freight transport by System Dynamics, Transportation Research Procedia, Volume 25, 2017, 1075-1094.; Zhangyuan H. Future Sustainable Urban Freight Network Design in the Large Cities and Megacities, 1st ed. 2021. Wiesbaden: Springer Fachmedien Wiesbaden, 2021. 200.

[87]Tan Y., Weng MX Optimal stochastic inventory control with deterioration and partial backlogging/service-level constraints. International Journal of Operational Research (IJOR). 2013. Vol. 16, No. 2. 241-261.

random demand. M.J. Alkheder, M.A. Darvish, A. R. Alenezi[88] developed a stochastic inventory management model with an objective functioncost minimization and normal distribution of demand. Together with S.K. Goyal presented the (Q,R) model[89] to determine the optimal order size and order point with the probabilistic nature of demand.

So, after getting acquainted with a number of sources of research on stochastic models of inventory management, it is possible to single out certain features characteristic of most works:

– in most of the considered models, numerical methods are used to find a solution, rather than analytical ones;

– to describe the random characteristics of almost all models, given distribution laws are used, not arbitrary ones;

– most often, product consumption is a Poisson process;

– the minimization of the average total costs or the maximization of the expected total profit is most often chosen as the objective function;

- only some of the above studies take into account the concept of time value of money.

The analysis of studies of the main models of logistics service optimization shows that the optimization models have different economic and mathematical properties, the search for a solution is carried out using different methods, which have their strengths and weaknesses.

Optimization methods. Multi-criteria decision-making (Multiple-criteria decision analysis – MCDM) is a branch of operations research. Decision-making often involves imprecision and uncertainty, which can be effectively handled by fuzzy sets and fuzzy decision-making methods. In recent years, a large amount of research has been carried out on the theoretical and applied aspects of

[88]Alkhedher MJ, Darwish MA, Alenezi AR Stochastic inventory model for imperfect production processes. Logistics Systems and Management. 2013. Vol. 15, No. 1. 3246.

[89]Darwish MA, Goyal SK, Alenezi AR Stochastic inventory model with finite production rate and partial backorders. International Journal of Logistics Systems and Management (IJLSM). 2014. Vol. 17, No. 3. 289-302.

MCDM and fuzzy MCDM[90]. These approaches have been proposed for various real-world problems that need to be considered as a multi-criteria tool for decision makers to improve and solve problems in various fields of mathematical optimization, informatics, and computer engineering.

At the same time, it should be noted that the search for an optimal (sometimes suboptimal) solution based on several optimality criteria at the same time, which is carried out by the method of multicriteria optimization[91] has a certain drawback. Namely, the main drawback of this method is the subjective nature of the weighting factors used in the process of narrowing down the criteria, which are often established by the method of expert evaluations. Thus, the research of scientists shows that currently known methods of finding solutions to problems can lead to a decision different from the one desired by the person making the decision, despite taking into account the subjective coefficients of importance determined by him[92]. However, despite the noted drawback, the application of the method of the importance of criteria significantly reduces the Pareto set (the set of best solutions), which opens up

[90]Barfod MB, Salling KB A new composite decision support framework for strategic and sustainable transport appraisals, Transportation Research Part A: Policy and Practice 2015. 72: 1-15.; Belton V.; Stewart TJ Multiple Criteria Decision Analysis: an Integrated Approach. Springer. 2002. 372.; Hanaoka S.; Kunadhamraks P. Multiple criteria and fuzzy based evaluation of logistics performance for intermodal transportation, Journal of Advanced Transportation 2009. 43(2): 123-153; He T., Ho W., Man CLK, Xu X. A fuzzy AHP based integer linear programming model for the multi-criteria transshipment problem, The International Journal of Logistics Management 2012. 23(1): 159-179.; Mardani et al. Multiple criteria decision-making techniques in transportation systems: a systematic review ...REVIEW PAPER Ho, C.; Mulley, C. 2015. Intra-household interactions in transport research: a review, Transport Reviews 35(1): 33-55.; Liou JJH; Tzeng G.-H. A non-additive model for evaluating airline service quality, Journal of Air Transport Management 2007. 13(3): 131-138.; Zagurskiy O. System of evaluation of performance indicators of supply chains. Machinery & Energetics. Journal of Rural Production Research. Kyiv. Ukraine. . 2019 Vol. 10. No. 3. 103-109;

[91]Jugovic TP, Jugovic, A. Zelenika R. Multicriteria optimization in logistics forwarder activities. Promet-traffic & Transportation. 2007. No. 3 (19). 145-153.; Hojda M., Żak J., Filcek G. Multiple Criteria Optimization of the Joint Vehicle and Transportation Jobs Selection and Vehicle Routing Problems for a Small Road Freight Transportation Fleet, Transportation Research Procedia, 2018, Volume 30, 178-187.

[92]Lee JH, Jiao L. Finding Efficient Solutions for Multicriteria Optimization Problems with SOS-convex Polynomials. Taiwanese J. Math. 2019. 23 (6) 1535-1550.; Ferreira JC, Fonseca CM, Denysiuk R, Gaspar-Cunha A. Methodology to select solutions for multiobjective optimization problems: Weighted stress function method. J Multi-Crit Decis Anal. 2017; 24: 103-120.

the possibility of reducing many optimal solutions to one solution, which greatly facilitates the selection of parameters in the design of a mechanical object[93].

Therefore, at the current stage, scientists continue to develop new optimization methods in logistics based on multi-criteria decision-making. So M.R. Bartolaci, L.J. LeBlanc, Y. Caicchi, and T.A. Grossman,[94] systematize information about the models being developed and applied methods and means of solving optimization tasks in logistics with the allocation of decision-making levels. Examples of a combination of linear programming models, as well as partial-integer programming and simulation models for solving problems of the tactical management level are given. Among the methods of finding solutions, the method of branches and boundaries, as well as heuristic methods are distinguished. The detailed models and methods are considered in the work of J. Jones[95], D.R. Morrison, Sh.Kh. Jacobson, D. J. Saupp, E. S. Sewell[96], L. Borba, M. Rita[97] and others. S. Lee, Y. Chong, Y. Lee, L. Wang, Hee Wang[98] propose a dynamic optimization method based on real-time information for smart vehicles and logistics tasks of efficient use of resources and achieving a sustainable balance between the economic, environmental and social goals of the dynamic optimization strategy. It is also necessary to note non-linear methods aimed at finding the optimal ratio of costs and logistics service[99].

[93]Misyurin S, Kreynin G, Nelyubin A, Nosova N. Multicriteria Optimization of a Dynamic System by Methods of the Theories of Similarity and Criteria Importance. Mathematics. 2021; 9(22):2854.

[94]Bartolacci MR, LeBlanc LJ, Kayikci Y., Grossman TA Optimization modeling for logistics: Options and implementations. Journal of Business Logistics, 2012. 33(2), 118-127.

[95]Geunes J. Operations Planning: Mixed Integer Optimization Models. Boca Raton, FL : CRC Press, 2015. 213.

[96]Morrison DR, Jacobson SH, Sauppe JJ, Sewell EC, Branch-and-bound algorithms: A survey of recent advances in searching, branching, and pruning, Discrete Optimization, Volume 19, 2016, 79-102.

[97]Borb L., Ritt M. A heuristic and a branch-and-bound algorithm for the Assembly Line Worker Assignment and Balancing Problem, Computers & Operations Research, 2014, Volume 45, 87-96.

[98]Liu S., Zhang Y., Liu Y., Wang L., Wang Xi V. An Internet of Things' enabled dynamic optimization method for smart vehicles and logistics tasks, Journal of Cleaner Production, 2019. 215, 806-820.

[99]Moncayo-Martínez LA, Zhang DZ Optimizing safety stock placement and lead time in an assembly supply chain using bi-objective MAX-MIN ant system. International Journal of Production Economics. 2013. No. 1 (141). 18-28.; Sarrafha K., Rahmati SH, Niaki ST, & ZaretalabA. A bi-objective integrated procurement, production, and distribution problem of a multi-echelon supply chain network design: A new tuned MOEA. Comput. Oper. Res., 2015. 54, 35-51.; Roy M., Gupta RK, Dasgupta T. A technique for determining the optimum mix of logistics service providers of a make-to-order supply chain by formulating and solving a constrained nonlinear cost optimization problem. Decision Science Letters. 2013. No. 2 (2). 95-108.

Nonlinear methods are able to more accurately reflect the relationships of the real system, but at the same time, the procedures for finding solutions to nonlinear optimization problems are much more complicated than those used when solving linear optimization problems. Among the methods of solving similar problems, the method of Lagrange multipliers and the method of piecewise linear approximation can be distinguished[100], applied in supply chains in works[101], as well as heuristic methods used in works[102].

Based on the results of the review of mathematical models and methods used to determine the optimal level of logistics service, it can be concluded that the models belonging to the classes of partial-integer, integer and linear programming with Boolean variables, as well as dynamic programming, are promising, taking into account on the availability of effective methods and means of finding globally optimal solutions.

When developing the model, it is necessary to take into account a number of factors that contribute to the further successful practical implementation of the mathematical model. It is important to take into account that the overall optimality of the functioning of the logistics system of the supply chain can be achieved under the condition of identifying the processes performed in it, based on the application of the reference model of the processes and the development of their model. The definition of processes opens up the possibility of transition from indicators of functional units of the supply chain to indicators of processes and taking into account their values in the optimization model. The development

[100]Shang Y., Guo S. and Jiang X. A New Lagrangian Multiplier Method on Constrained Optimization, Applied Mathematics, Vol. 3 No. 10A, 2012, 1409-1414.

[101]Adelman D. Price-Directed Control of a Closed Logistics Queuing Network. Operations Research. 2007. No. 6 (55). 1022-1038.; Park S., Lee TE, Sung CS A three-level supply chain network design model with risk-pooling and lead times. Transportation Research Part E: Logistics and Transportation Review. 2010. No. 5 (46). 563-581.

[102]Miranda PA, Garrido RA Inventory service-level optimization within distribution network design problem. International Journal of Production Economics. 2009. No. 1 (122). 276-285.; Tancrez J.-S., Lange J.-C., Semal P. A location-inventory model for large three-level supply chains. Transportation Research Part E: Logistics and Transportation Review. 2012. No. 2 (48). 485–502.; Wang S., Sarker BR Optimal models for a multi-stage supply chain system controlled by kanban under just-in-time philosophy. European Journal of Operational Research. 2006. No. 1 (172). 179-200.

of the process model enables the construction of a process-oriented organizational structure of the supply chain, which contributes to the implementation of the optimal solution found with the help of the optimization model.

The analysis of the developed models showed that despite the sufficient number of models that take into account the service component, the possibilities of their practical application are limited. In many cases, the level of logistics service is associated with the level of inventory established at the enterprise, less often with the time of order fulfillment, sometimes identified with the level of the ideal order. It is obvious that taking into account only one indicator of the logistics service is not enough for the development of an effective model for the formation and implementation of the service strategy of the supply chain.

Thus, the need to develop an integrated model of logistics service optimization, which takes into account a set of indicators, the entire range of logistics processes and costs associated with their implementation, and also takes into account the impact of logistics service on the profit of the supply chain, was revealed.

A review of mathematical methods used in logistics and supply chain management showed that the method of multi-criteria optimization, which is appropriate taking into account a number of indicators whose values need to be optimized, has significant shortcomings. In addition to the weighting coefficients, the accuracy of which may be insufficient, the possibility of adapting the optimal solution to the views and beliefs of a specific decision-maker limits the possibility of applying this method. Nonlinear optimization models, which have certain advantages over linear ones, which consist in the possibility of a more plausible description of the regularities of real processes, are also not without disadvantages. Finding the optimal solution using nonlinear models is often complicated by the lack of effective algorithms for finding a solution, which forces researchers to resort to the use of heuristic methods. The results obtained using such methods may be unsatisfactory. In this regard, it is appropriate to develop models belonging to the classes of partial-integer, integer and linear programming with zero variables, as well as dynamic programming models when it is necessary to decompose the original task into several sub-tasks (steps of the solution), taking into account the availability of effective methods finding the optimal solution, as well as the availability of means of finding a solution.

CHAPTER 3. DEVELOPMENT OF INTEGRATED MODEL OF OPTIMIZATION OF LOGISTICS SERVICE OF SUPPLY CHAIN

3.1 Model of optimization of total supply chain logistics costs

Logistics costs are a significant part of the total costs for any company. Surveys conducted in Germany showed a high share of logistics costs in the total costs of both manufacturing (21.4%) and trading (11.3%) companies[1]. However, a significant number of managers underestimate the importance of calculating logistics costs. They are often included in manufacturing, supply or sales overhead, and in many cases only overhead. And sometimes neither company owners nor managers at all levels of control know about them.

Therefore, one of the main concepts of our research, which needs an extended review, is the concept of total logistics costs. In general, total logistics costs are understood as total costs associated with the movement and storage of goods and material values, starting from the choice of a supplier and ending with the delivery of finished products and customer service[2]. It is clear from the definition that total costs have a complex structure, as they contain a number of components (cost items) that mutually influence each other. In the most general sense, all components of supply chain logistics costs can be reduced to three main categories: inventory management costs, transportation costs, and administrative costs. Thus, the statistical data of the developed countries of the world show that they prevail among other aggregate logistics costs (expenses for

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[1] Pernica, P.; Mosolf, HJ Partnership in Logistics. Praha: Radix, 2000. P. 18.; Elsweier M.; Nickel R. Logistic controlling in SME - results of a study and need for action. Productivity Management 2010. 15(2): 50-53.

[2] Oklander M. A. Logistics: Textbook Kyiv: Center for Educational Literature, 2008. 346.

inventory management (20-40%), transport costs (15-35%), costs of administrative and management functions (9-14%)[3].

However, in modern scientific developments, the list of items of logistics costs is wider, scientists and specialists consider it necessary to comprehensively consider all components of general logistics costs. Thus, J. Toiley and co-authors believe that total logistics costs consist of six separate components - transportation, warehousing, inventory, administration, packaging and indirect logistics costs[4]. E.Z. Zen and K. Rossetti support this classification of logistics costs, however, add to it articles related to international transportation. Thus, their classification includes the following cost items: transportation, inventory maintenance, administration, customs duties, risk and loss, as well as goods handling and packaging[5]. According to J. Engblom et al., total logistics costs include costs for transportation, warehousing, inventory maintenance, logistics administration, packaging, and indirect logistics costs[6]]. T. Solakivi, Y. Toili and L. Oyala use a similar classification, but instead of indirect costs, they allocate "other logistics costs"[7]. P. Pudlo and S. Sabo already identify a larger number of logistics cost items, there are seven of them: "transportation costs, costs for maintaining material stocks, costs for storing raw materials, materials, semi-finished products, costs for maintaining stocks of finished products, logistics administration, storage of finished products, management costs associated with logistics processes, opportunity costs"[8]. An even broader

[3]Bowersox D. D., Kloss D. D. Logistics: an integrated supply chain. translated by N. N. Baryshnikova, B. S. Pinsker. - 2nd ed. M.: ZAO "Olymp-Business", 2008. 640.,

[4]Logistics and financial performance: An analysis of 424 Finnish small and medium-sized enterprises / J. Töyli [et al.] International Journal of Physical Distribution & Logistics Management. 2008. No. 1 (38). 57-80.

[5]Zeng AZ, Rossetti C. Developing a framework for evaluating the logistics costs in global 136 sourcing processes: An implementation and insights. International Journal of Physical Distribution & Logistics Management. 2003. No. 9 (33). 785-803.

[6]Multiple-method analysis of logistics costs / J. Engblom [et al.] International Journal of Production Economics. 2012. No. 1 (137). 29-35.

[7]Solakivi T., Töyli J., Ojala L. Logistics outsourcing, its motives and the level of logistics costs in manufacturing and trading companies operating in Finland. Production Planning & Control. 2013. No. 4/5 (24). R. 395.

[8]Pudło P., Szabo S. Logistic costs of quality and their impact on degree of operation level. Journal of Applied Economic Sciences. 2014. No. 3 (9). R. 472.

classification of logistics costs is provided by A. Gunasekaran, C. Patel, and E. Tirtiroglu, who consider a variety of performance indicators, the most significant of which in the context of this review are cost indicators. Scientists distinguish general transportation costs, production costs, information maintenance costs, and inventory maintenance costs[9]. The latest opinions of scientists include the following costs: opportunity costs, which include capital and storage costs; costs related to inventories in transit, inflow of goods, and work in progress; maintenance costs, including costs related to inventory management and insurance; costs associated with the risks of theft, deterioration and damage to goods; costs related to waste and recycling; lost sales[10]. And Rushton and others define among the items of logistics costs: transportation costs, storage costs, transportation costs, packaging costs, consolidation costs, inventory costs, information, as well as control costs, which are components of logistics costs[11].

And T.F.G. Silva, A.T.P. Gonsalves and M.S.A. In his study, Leite presented an overview of approaches to determining items of logistics costs. According to the results, the commonly recognized items of logistics costs are: storage, transportation, packaging, inventory maintenance, order processing and information technology, taxes and logistics administration. It should be noted that storage costs include costs related to physical space and handling of materials and goods, while inventory maintenance costs include opportunity costs and the cumulative risk associated with inventory[12].

However, in order to effectively manage the costs of the supply chain, it is necessary to systematize them from the standpoint of financial management. After all, enterprises entering the supply chain need various expenditures of

[9]Gunasekaran A., Patel C., Tirtiroglu E. Performance measures and metrics in a supply chain environment. International Journal of Operations and Production Management. 2001. No. 1/2 (21). R. 84.

[10]In the same place, 81

[11]Rushton A., Croucher P., Baker P. The Handbook of Logistics and Distribution Management, 3rd ed.; Kogan Page Limited: London, UK, 2007.721.

[12]Silva TFG, Gonçalves ATP, Leite MSA Logistics cost management: insights on tools and operations. International Journal of Logistics Systems and Management. 2014. No. 3 (19). 329-334.

material, labor and financial resources for the implementation of their current (operational) activities. Therefore, from the point of view of the formation of unified approaches to the understanding of cost classifications by all participants of the supply chain, it is important to observe the principles and standards of the international financial reporting system.

In this regard, it is appropriate to list the fundamental principles of International Accounting Standards:

– monetary dimension;

– a separate (autonomous) enterprise;

– operating enterprise;

– cost accounting;

– double accounting;

– accounting period;

– conservatism (caution regarding assessment);

– implementation;

– consistency of income with expenses;

– sequences;

– materiality or materiality.

The listed basic accounting principles (concepts) formed the basis of generally accepted accounting principles, which, in combination with accounting standards used throughout the world, are used for accounting and reporting in supply chains. Accordingly, for management purposes, the enterprise included in the supply chain has the right to organize accounting by cost items. It establishes the list of such articles independently.

To form the financial result of the enterprise's work, the full cost of goods sold (products, works, services) is determined from ordinary activities. It is formed on the basis of expenses received both in the reporting year and in past reporting periods, and transitional costs related to the receipt of income in subsequent reporting periods. The full costs of the company's production and sales of products are reflected in the estimate (budget), which is formed in the following sequence: material costs (by types); labor costs (by types); deduction for social needs (by types); depreciation deductions; Other expenses; together expenses for production; debited to non-production accounts; change in work-in-progress balances; production cost of products; commercial expenses; management costs; full production cost; revenue (net) from sales; profit from sale; operating expenses balance; the balance of non-realization expenses; accounting profit.

Therefore, the analysis of literary and normative sources proved that there are different approaches to the structuring of logistics costs[13], which make it possible to identify the most significant items of costs in logistics systems.Evaluation of the efficiency of supply chains or logistics processes in them at the international level is directly related to the evaluation of costs arising during the functioning of counterparties. The logistics component of costs in the supply chain is quite large, but its evaluation and comparison, both in terms of structure and calculation of individual groups of costs, is still very difficult.

The company (supply chain) tries to estimate the cost of logistics processes within the framework of the financial accounting and reporting system adopted for each country, and thereby find an objective indicator of logistics efficiency. Currently, the problem of analyzing the international practice of accounting and classifying logistics costs in supply chains is very relevant in terms of comparing different approaches and finding best practices. Thus, it is important to consider and compare the existing international systems for

[13]Alkema V.G., Kyrychenko O.S., Filatov S.A. Logistics consulting: Study guide. Kyiv: KROC University of Economics and Law, 2020. 344..; Gunasekaran A., Patel C., Tirtiroglu E. Performance measures and metrics in a supply chain environment. International Journal of Operations and Production Management. 2001. No. 1/2 (21). 71-87.; Multiple-method analysis of logistics costs / J. Engblom [et al.]. International Journal of Production Economics. 2012. No. 1 (137). 29-35.; Silva TFG, Gonçalves ATP, Leite MSA Logistics cost management: insights on tools and operations. International Journal of Logistics Systems and Management. 2014. No. 3 (19). 329-334.; Ramos E.,Dien S.,Gonzales A.,Chavez M.,Hazen, B. Supply chain cost research: a bibliometric mapping perspective, Benchmarking: An International Journal, 2021. Vol. 28 No. 3, 1083-1100.

estimating logistics costs, as the main indicator of the efficiency of processes in supply chains.

Table 3.1 – Logistics Performance Index – 20018

Country	Year	LPI Rank	LPI Score	Customs	Infrastructure	International shipments	Logistics competence	Tracking & tracing	Timeliness
Germany	2018	1	4.20	4.09	4.37	3.86	4.31	4.24	4.39
Sweden	2018	2	4.05	4.05	4.24	3.92	3.98	3.88	4.28
Belgium	2018	3	4.04	3.66	3.98	3.99	4.13	4.05	4.41
Austria	2018	4	4.03	3.71	4.18	3.88	4.08	4.09	4.25
Japan	2018	5	4.03	3.99	4.25	3.59	4.09	4.05	4.25
…………									
Poland	2018	28	3.54	3.25	3.21	3.68	3.58	3.51	3.95
…………									
Ukraine	2018	66	2.83	2.49	2.22	2.83	2.84	3.11	3.42
…………									
Belarus	2018	103	2.57	2.35	2.44	2.31	2.64	2.54	3.18

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

The growing interest in the analysis of logistics costs leads to the appearance of new and new ratings and reports containing indicators of logistics costs and their classification taking into account the peculiarities of one or another national economy. One of the attempts to account for and compare logistics costs is the Logistics Performance Index (LPI) – 20018.

It was in this version of the report that the first step towards the analysis of logistics costs in the countries of the world was made. However, later this indicator was removed from consideration as a component of LPI due to the lack of a unified international approach to the classification and assessment of logistics costs. Therefore, let's focus separately on the problems of estimating the components of total logistics costs in supply chains by types of costs that are characteristic of many countries of the world.

Operating expenses.

1. Lack of management accounting and reporting of enterprises on logistics costs.

2. Aggregation of accounting. Lack of differentiation of accounting and management accounting by factors/parameters/objects.

3. Weak use of ABC (FVA) – analysis.

4. The problem of identifying hidden operating costs in the supply chain.

5. The problem of rationing and benchmarking in estimating the amount of costs. The need to create and maintain databases for operational logistics costs.

Transaction costs. It should be noted that today there is practically no allocation of a separate group of transaction costs in accounting and reporting systems for logistics (which may become the subject of further research). Among them, we note the main ones:

– costs of decision-making, planning and organization of future logistics activities, negotiations on its content and conditions, when two or more participants in the supply chain enter into business relations;

– expenses for changing plans, reviewing the terms of the agreement (logistics outsourcing) and resolving disputed issues, when this is dictated by changed circumstances;

– costs caused by compliance with the agreements reached by all participants (contractors) of the supply chain.

Transaction costs should also include any losses arising from:

– ineffectiveness of joint decisions, plans, concluded contracts and created logistics structures in the supply chain;

– ineffective reactions to changed conditions in terms of logistics;

– ineffective protection of logistics agreements (contracts).

Losses from the immobilization of funds in stocks. Losses from the immobilization of funds in stocks are indirect costs associated with the diversion and freezing of financial funds invested in stocks. In other words, this is the unearned income from the possible use of funds frozen in stocks for the investment of supply chain counterparties.

Currently, this component of the total logistics costs is very rarely controlled and taken into account by the logistics service, since in many companies it is attributed to the prerogatives of the financial departments. A common option for calculating losses from the immobilization of funds in stocks is formula (3.1).

$$V_{i.k} = \frac{TZ_s \times i_s}{100} \tag{3.1}$$

where TZ_s – the average volume of stocks for the period, UAH.

i_s – weighted average bank interest rate

Instead of the bank interest rate, you can take the supply chain refinancing rate or use the rate of return on capital that could be obtained by investing capital in another business. In some cases, when calculating costs for frozen capital, a minimum rate of return is used, which is determined for each specific enterprise separately.

Losses from logistic risks. These are costs for compensation (elimination) of logistics risks (cargo insurance, carrier/forwarder liability insurance, stock insurance, losses from a shortage of goods at the consumer, related to logistics, for example, potential loss of sales due to the absence of goods on the store shelves - losses from "out - of-stock" or "out-of-shelf").

Calculating losses from logistics risks, in particular losses from lost sales, is often a complex analytical task that requires processing a large amount of information and a fairly advanced methodology. In absolute terms, lost sales can be calculated using the formula[14] (3.2).

$$Lost\ sales_t = Demand_t - Sales_t, \tag{3.2}$$

where $Lost\ sales_t$ – lost sales in period t, UAH.

$Demand_t$ – the solvent demand presented by customers, which must be satisfied in period t, hryvnias. (in the simplest case, these are orders placed by customers, the promised term of which falls within time t);

$Sales_t$ – actual sales in period t, UAH.

Since the absolute value of the demand presented by customers can change from period to period, and, therefore, lost sales can become more or less under the influence of this external factor, it is more convenient to use the relative indicator of lost sales.

$$Lost\ sales_t = (Demand_t – Sales_t) / Demand_t * 100\% \tag{3.3}$$

The results of the assessment, as a rule, make it possible to make an effective decision in the future on measures to compensate for logistical risks, which are based on existing and constantly improving methods. Including:

1. Diversification – the distribution of invested funds between different objects of capital investments that are not directly interconnected,

2. Risk sharing – assigning a certain share of responsibility for the risk to that partner in the supply chain who is able to control it better than others.

[14]de KokAG Approximations for a Lost-Sales Production/Inventory Control Model with Service Level Constraints. Management Science. 1985. 31(6):729-737.

3. Limiting – limitation of flows (cash, goods, credit, investment) directed to the external (relative to the enterprise) environment, setting limits on expenses, sales, loans, etc.

4. Insurance – transfer or distribution of risks arising from one person to several persons.

5. Risk reduction – reduction of the probability and volume of losses.

6. Risk avoidance – avoidance of a certain measure burdened with excessive (catastrophic) risk, or elimination of certain risk-related measures[15].

Therefore, effective management of logistics requires the use of the principle of total costs. In other words, for a given level of customer service, logistics companies should learn to minimize total logistics costs, and not try to reduce costs only for certain types of activities. The main disadvantage of a non-integrated approach to the analysis and minimization of logistics costs is the disparity of actions when trying to reduce cost items in individual logistics functions/operations, which, in the end, may turn out to be a suboptimal option for the supply chain as a whole, as it often leads to an increase in total costs.

In the monograph J.R. Stok and D.M. Lambert's "Strategic Logistics Management" states that the analysis of total logistics costs is the key to managing logistics functions[16]. Accordingly, in order to build a model of effective management of logistics activities of the supply chain, we need a detailed analysis of the formation and optimization of general costs in the logistics system, and not individual logistics costs. However, establishing ratios that reflect the mutual influence of individual logistics costs forming the total logistics costs is a rather difficult task. Therefore, we propose to establish the relationship of logistics costs through the value of the indicators of the logistics service. In this way, the limitation of ignoring the service component in the development of cost optimization models should be eliminated.

[15]Zagurskyi O.M. Risk management: textbook Kyiv: University "Ukraine", 2016. R. 134-140.
[16]Stok D. R., Lambert D. M. Strategic logistics management - 4th ed. M.: INFRA-M, 2005.R. 576

Table 3.2 – Compliance of processes and diagnostic metrics TCS indicator

Types of processes	Categories of processes	Processes	CO.1.001 Total cost (TCS)					
			CO.2.001 Planning costs	CO.2.002 Supply costs	CO.2.003 Costs of materials /goods	CO.2.005 Administrati on costs orders	CO.2.006 Implementatio n costs no orders	CO.2.007 Return costs goods
sP Planning	sP2 Planning software	-	CO.3.001 CO.3.002 CO.3.003 CO.3.004	-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-
	sP4 Planning supplies	-	CO.3.001 CO.3.002 CO.3.003 CO.3.004	-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-
	sP5 Planning returns	-	CO.3.001 CO.3.002 CO.3.003 CO.3.004	-	-	-	-	-
				-	-	-	-	-
				-	-	-	-	-
sS Provision	sS1 Provision goods in stock	-	-	CO.3.005 CO.3.006 CO.3.007 CO.3.008	CO.3.009 CO.3.010 CO.3.011 CO.3.012	-	-	-
			-			-	-	-
			-			-	-	-
sD Supply	sD1 Supply goods from stock	sD1.1	-	-	-	CO.3.018	-	-
		sD1.2	-	-	-	-	-	-
		sD1.3	-	-	-	-	-	-
		sD1.4	-	-	-	CO.3.018	CO.3.022	-
		sD1.5	-	-	-	CO.3.018	CO.3.022	-
		sD1.6	-	-	-	CO.3.018	CO.3.022	-
		sD1.7	-	-	-	CO.3.018	CO.3.022	-
		sD1.8	-	-	-	-	CO.3.024	-
		sD1.9	-	-	-	-	CO.3.024	-
		sD1.10	-	-	-	-	CO.3.024	-
		sD1.11	-	-	-	-	CO.3.024	-
		sD1.12	-	-	-	-	CO.3.022 CO.3.024	-
		sD1.13	-	-	-	-	-	-
		sD1.14	-	-	-	-	-	-

		sD1.15	-	-	-	CO.3.018	-	-
sR Return	sSR1 Return received goods	sSR1.1	-	-	-	-	-	-
		sSR1.2	-	-	-	-	-	CO.3.029
		sSR1.3	-	-	-	-	-	-
		sSR1.4	-	-	-	-	-	-
		sSR1.5	-	-	-	-	CO.3.022	-
	sDR1 Receiving returns	sDR1.1	-	-	-	-	-	CO.3.028 CO.3.029
		sDR1.2	-	-	-	-	-	-
		sDR1.3	-	-	-	-	-	-
		sDR1.4	-	-	-	-	-	-

*Source:*Supply Chain Council (SCC). Supply Chain Operations Reference Model Revision 11.0 / Supply Chain Council (SCC). [Pittsburgh] : Supply Chain Council, 2012. 976.

We also note that despite the significant number of developed optimization models, the cost structures underlying them are not uniform[17]and are often limited by costs associated with transportation and inventory holding[18], which also does not contribute to their application. In addition, optimization models developed for supply chains cannot always be adapted to optimize costs in an enterprise's internal logistics system. The solution to the problem can be the use of reference models that contain descriptions of universal processes and indicators that reflect both the level of logistics service and logistics costs, as well as the methods of calculating their values.

Correlation of SCOR indicators and methods of calculating their values. Logistics service indicators can be regarded as cost factors, since a change in their values entails a change in the values of cost indicators. Logistics cost indicators are accordingly dependent on cost factors through POF and OFCT

[17]Gebennini E., Gamberini R., Manzini R. An integrated production–distribution model for the dynamic location and allocation problem with safety stock optimization. International Journal of Production Economics. 2009. No. 1 (122). 286-304.; Nidhi MB, Anil B. A cost optimization strategy for a single warehouse multi-distributor vehicle routing system in stochastic scenario. International Journal of Logistics Systems and Management. 2011. No. 1 (10). 110-121.

[18]Lee BK, Kang KH, Lee YH Decomposition heuristic to minimize total cost in a multi-level supply chain network. Computers & Industrial Engineering. 2008. No. 4 (54). 945-995.; Zhao QH, Chen S., Zang CX Model and algorithm for inventory/routing decision in a three-echelon logistics system. European Journal of Operational Research. 2008. No. 3 (191). 623-635.; Davulis G., Šadžius L. Modeling and optimization of transportation costs. Intellectual economics 1. 2010. 18-29.; Archetti C., Peirano L., M. Speranza G., Optimization in multimodal freight transportation problems: A Survey, European Journal of Operational Research, Volume 299, Issue 1, 2022, 1-20.

performance indicators, which are cost factors reflecting service requirements for processes.

The TCS indicator is an indicator of the total cost of logistics processes.

$$TCS = TCS_s + TCS_d \quad (3.4)$$

where TCS – general (variable) logistics costs;

$TCSs$ – costs for the execution of the processsoftware;

$TCSd$ – costs of the delivery process.

At the same time, according to the data in Table 3.5, the total costs for the provision and delivery processes can be expressed as:

$$TCS_s = CO.\,2.002 + CO.\,2.003 \quad (3.5)$$

where $CO.$ 2.002 – supply costs;

$CO.$ 2.003 – costs of materials/goods.

$$TCS_d = CO.\,2.005 + CO.\,2.006 \quad (3.6)$$

where $CO.$ 2.005 – costs for administration of orders;

$CO.$ 2.006 – costs for order fulfillment.

Flawless execution of orders corresponds to the level of flawless execution of the supply process. According to the SCOR methodology, the total order fulfillment rate is equal to the ratio of the number of perfectly executed orders to the total number of orders multiplied by 100%. To calculate the number of flawlessly executed orders, the value of diagnostic indicators (second-level SCOR metric) for each order is taken as a basis. The diagnostic indicator takes the value 1 if the execution of the order is recognized as perfect in one of the aspects, and 0 otherwise. If all four diagnostic metrics take the value equal to 1 for the same order, then the execution of the order is recognized as flawless[19].

Identification of logistics costs. To develop an economic-mathematical model, it is also necessary to determine the main components - logistics costs.

[19]Šitova I., Pecherska J.A Concept of Simulation-based SC Performance Analysis Using SCOR Metrics, Information Technology and Management Science, 2017, 20, issue 1, 85-90.

The composition of components is partially determined taking into account equation (3.4). However, in order to unambiguously determine the content of each component, SCOR metrics reflecting logistics costs were matched with generally recognized items of logistics costs (Table 3.3).

Table 3.3 – Correspondence of Functional Units, SCOR Cost-Reflective Metrics, and Commonly Recognized Items logistics costs

SCOR metrics	Articles of expenditure
CO.2.002 Supply costs	Warehouse processing of goods Storage Administration
CO.2.003 Costs of materials/goods	Stock support Transportation Customs fees
CO.2.005 Order administration costs	Personnel Automation tools Order processing
CO.2.006 Costs of fulfilling orders	Storage Warehouse processing of goods Packaging Transportation

Source: Supply Chain Council (SCC). Supply Chain Operations Reference Model Revision 11.0 / Supply Chain Council (SCC). [Pittsburgh] : Supply Chain Council, 2012. 976.

According to the SCOR methodology, supply costs (CO.2.002) are costs for managing the process of organizing supply, receiving, checking and storing goods. Costs of materials/goods (CO.2.003) include the costs of purchasing goods, their transportation, insurance, and taxes and customs duties.

Order administration costs (CO.2.005) are the costs of personnel (working with customers), automation tools and equipment used to respond to customer requests, enter and store orders, create delivery schedules, determine the location of orders and track their movement , supply, installation and billing. Order fulfillment costs (CO.2.006) related to warehouse processing of goods (storage, picking, packing, shipping) and transportation include personnel costs (mainly warehouse and transportation department), automation equipment, asset value, and overhead costs[20].

In a number of modern studies[21] the need to consider indirect costs as part of the total logistics costs is emphasized. Among them, costs associated with the immobilization of funds in stocks and lost sales are highlighted. Costs associated with the immobilization of funds in stocks, costs caused by the diversion of funds invested in stocks. Lost sales are costs associated with the loss of revenue due to the provision of a logistics service that does not meet the consumer's requirements.

Based on the content of the POF and OFCT metrics, their values affect the costs of indirect cost items. Therefore, the specified indirect costs can be taken into account in the optimization model. However, their values should be taken into account separately, since they depend on the values of the logistics service indicators for the logistics system as a whole, and not on the values of the logistics service indicators of individual processes.

3.2 Model of supply chain logistics service optimization

As established in the previous sections, the interdependence of marketing and logistics is manifested in the establishment of the level of logistics service provided in the supply chain at the time of conclusion of the agreement, as well

[20]Supply Chain Council (SCC). Supply Chain Operations Reference Model Revision 11.0 / Supply Chain Council (SCC). [Pittsburgh] : Supply Chain Council, 2012. P.111-134.

[21]Multiple-method analysis of logistics costs / J. Engblom [et al.] // International Journal of Production Economics. 2012. No. 1 (137). 29-35.; Rybakov DS Total cost optimization model for logistics systems of trading companies Published in: International journal of logistics systems and management. Olney : Inderscience, 2017, Vol. 27, 3, 318-342.

as after its completion. Marketing sets the value of a number of logistics service indicators characterizing its level. The given level of service is implemented by the enterprise's logistics system; whose divisions are responsible for achieving the target values of the indicators. The higher the given level of logistics service, the higher the total logistics costs caused by it.

In an ideal case, as a result of the interaction of marketing and logistics, the optimal level of logistics service should be established.

The development of an optimization model requires the construction of a conceptual model, which is a formulation of the task in terms of the subject area, and the construction of a structural mathematical model that reflects the connections and relationships of its components.

Formulation of the problem. Logistics service is characterized by the values of a number of service indicators. Each indicator of a logistics service can acquire a single value from many possible ones. Each value of each indicator of the logistics service is matched with coefficients reflecting the impact of the values of these indicators on revenue and total logistics costs. Values of revenue and total logistics costs when implementing logistics services at the basic level (base values of revenue and total costs, respectively) are given. The basic level of logistics service is the level of service that can be provided to all customers of the company. The coefficients at the basic values of the logistics service indicators are equal to one.

It is necessary to find a combination of values of the indicators of the logistics service, which ensure that the supply chain achieves maximum profit. Profit is calculated by subtracting total logistics costs from revenue.

It should be clarified that in our study, total or total logistics costs mean the total operating costs of the supply chain, which are limited by the value of the maximum allowable costs. A graphic representation of the conceptual problem in the form of a "black box" model showing input and output data and impacts is presented in Fig. 3.1, which demonstrates the transformation of input indicators into output using certain mathematical ratios, the establishment of which requires further detailing of the connections of the model components.

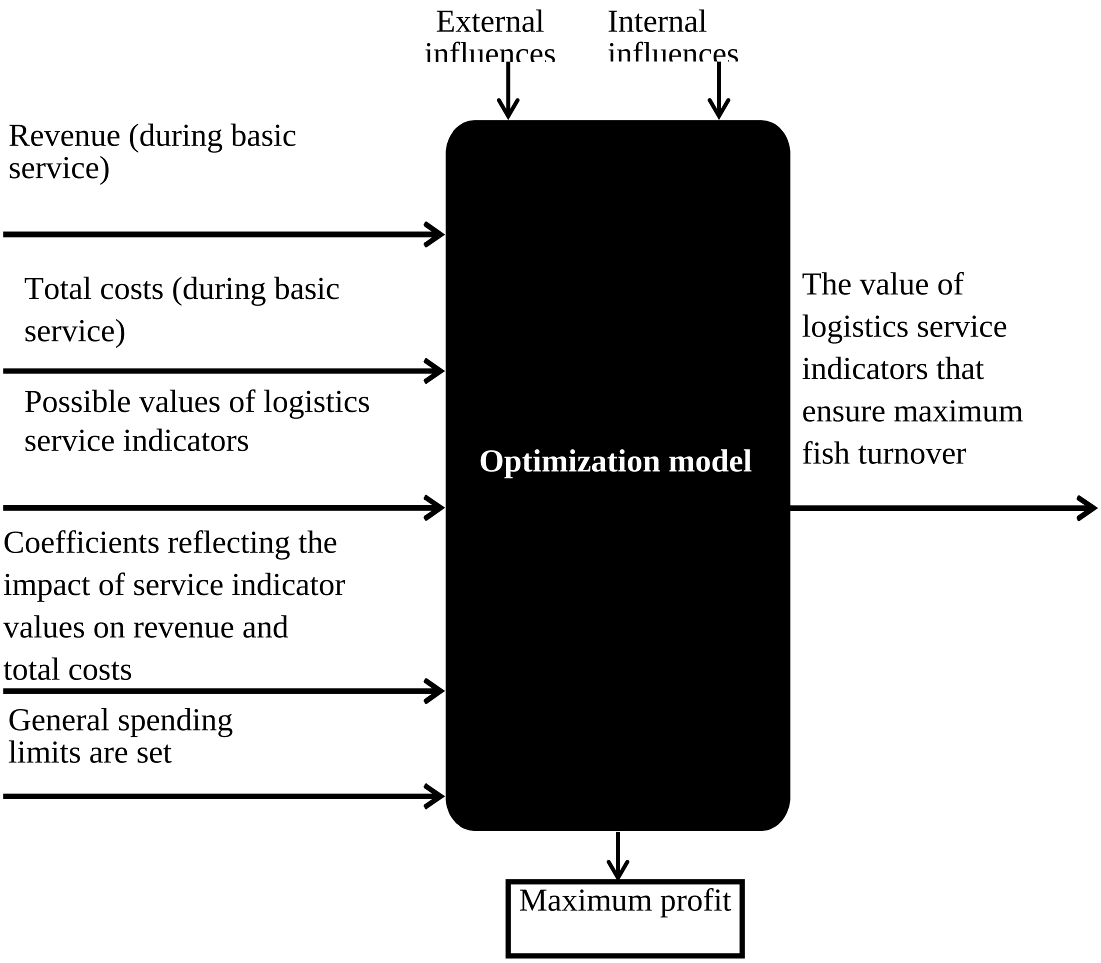

Fig. 3.1 – The "black box" model of the conceptual formulation of the problem

Source: compiled by the authors

In order to display the multitude of components of the optimization model, as well as to determine the connections and relationships between them, the diagram of the influence of the components of the optimization model presented in Fig. 3.2 was developed.

Limits of application of models. It is assumed that the coefficients that reflect the influence of the values of the logistics service indicators on the revenue and the total logistics costs of the supply chain are given. It can be assumed that the input data may be incomplete or unknown at all. However, these data can be found based on regression analysis[22].

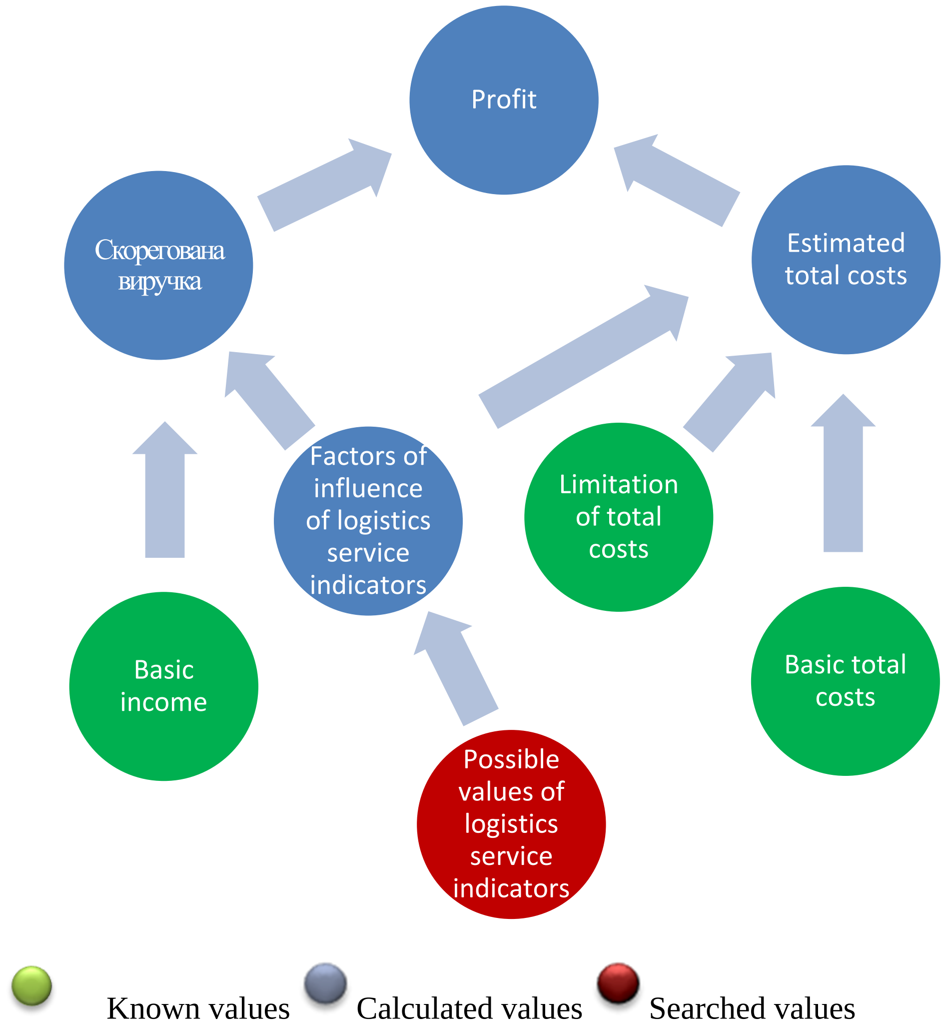

Fig. 3.2 – Diagram of influence of optimization model components

Source: compiled by the authors

In the case of incomplete data, the missing data can be found by interpolation. In addition, it is assumed that the values of logistics service

[22]Jeffery MM, Butler RJ, Malone LC Determining a cost-effective customer service level / MM Jeffery, Supply Chain Management: An International 132 Journal. 2008. No. 3 (13). 225-232.; Peng C.-YJ, Lee, KL, & Ingersoll, GM An introduction to logistic regression analysis and reporting. The Journal of Educational Research, 2002, 96(1), 3-14.

indicators affect the value of revenue and total logistics costs independently of each other. At the same time, the possible synergistic effect of the influence of the values of the logistics service indicators is not taken into account. A consequence of this assumption is the linearity of the objective functions of the models. The positive side of the linearity of models is the relative simplicity of finding a solution.

Construction of models. The procedure for finding the optimal solution involves choosing (from many possible) values of logistics service indicators that ensure the formation of maximum profit while observing the established restrictions. Alternative profit values, as mentioned above, are calculated by subtracting the corresponding values of estimated total costs from the estimated revenue values. Values of revenue and total logistics costs are calculated by adding to the base values of the specified indicators the values of the increase, which are calculated using coefficients dependent on the values of the indicators of the logistics service. The establishment of interrelationships between the components of the optimization task opened an opportunity for the development of a mathematical model for the optimization of the logistics service of the supply chain.

Linear mathematical model of logistics service optimization. Using the conceptual formulation of the problem and the structural model, a linear mathematical model of logistics service optimization is formulated. Formulas for calculating the values of its main components are presented below. Yes, the formula for calculating the profit of a trading company:

$$TP = TR - TS \tag{3.7}$$

where TP – the profit value of the supply chain;

TR – value of supply chain revenue;

TS – the value of the total logistics costs of the supply chain.

The value of revenue, taking into account its increase from the level of logistics service, is calculated according to the formula:

$$TR = Rb + \Delta R, \tag{3.8}$$

where Rb – the value of the revenue from the implementation of the logistics service at the basic level;

ΔR – the total increase in revenue caused by the salelogistics servicedifferent from the base level.

Revenue growth provided by any value of any of the analyzedlogistics service indicators can be calculated as follows:

$$\Delta R_{ij}(S_{ij}) = Rb \times (Kr_{ij}(S_{ij}) - 1),\ Kr_{ij} > 0, \forall i \in \{1, \ldots, n\}, \forall J \in \{1, \ldots, m\}, \tag{3.9}$$

where i – the number of the logistics service indicator;

j – the number of the possible value of the logistics service indicator;

ΔR_{ij} – revenue growth provided by the j-th value of the i-th indicatorlogistics service;

S_{ij} – the jth value of the i-th indicatorlogistics service;

Kr_{ij} – a coefficient that reflects the influence of the jth value of the ith indicatorlogistics service for revenue;

n – the number of logistics service indicators;

m – the number of possible values of logistics service indicators.

The total increase in revenue depends on the choice of value for each of the indicators of the logistics service:

$$\Delta R(x_{ij}) = \sum_{i=1}^{n} \sum_{j=1}^{m} \Delta R_{ij}(S_{ij}) \times x_{ij},\ x_{ij} \epsilon \{0,1\} \tag{3.10}$$

wherex_{ij} – a Boolean variable reflecting the decision to accept or reject the j-th value of the i-th indicator of the logistics service.

The value of total logistics costs is calculated as follows:

$$TC = TCb + \Delta TC, \tag{3.11}$$

where TCb – the value of the total logistics costs for the implementation of the logistics service at the basic level;

ΔTC – the total increase in total costs caused by the implementation of the actual logistics service from the base level.

Based on this, the increase in total costs caused by any value of any of the analyzed logistics service indicators can be calculated as follows:

$$\Delta TC_{ij}(S_{ij}) = TCb \times (Kc_{ij}(S_{ij}) - 1),\ Kc_{ij} > 0,\ \forall\ i \in \{1, . . , n\},\ \forall\ j \in \{1, . . , m\}, \quad (3.12)$$

where ΔTC_{ij} – the increase in total costs caused by the jth value of the i-th indicatorlogistics service;

Kc_{ij} – a coefficient reflecting the influence of the jth value$i$-th indicatorlogistics service for general expenses.

What are the coefficients Kr_{ij} and Kc_{ij}, which are used in the development of the logistics service optimization model, acquire a value greater than 1 if the value of the logistics service indicator provides an increase in the value of the financial indicator (revenue or total costs), and is in the range from 0 to 1 otherwise.The basic values of logistics service indicators correspond to coefficients of 1.

The total increase in total costs depends on the choice of value for each of the logistics service indicators:

$$\Delta TC(x_{ij}) = \sum_{i=1}^{n} \sum_{j=1}^{m} \Delta TC_{ij}(S_{ij}) \times x_{ij},\ x_{ij} \epsilon \{0,1\} \quad (3.13)$$

The expression for calculating the value of the maximum allowable increase in total costs has the following form:

$$TC_{max} = TC_{max} - TCb,\ 0 < TCb < TC_{max} \quad (3.14)$$

where $\Delta TCmax$ – the maximum permissible increase in total logistics costs;

$TCmax$ – the value of the maximum allowable total logistics costs of the supply chain.

The integration of the components discussed above allows for the development of a mathematical model for optimizing the values of logistics service indicators. The objective function in its expanded form is as follows:

$$TP(x_{ij}) = Rb + \sum_{i=1}^{n} \sum_{j=1}^{m} Rb \times (Kr_{ij}(S_{ij}) - 1) \times x_{ij}\ -$$

$$-(TCb+\sum_{i=1}^{n}\sum_{j=1}^{m}TCb\times(Kc_{ij}(S_{ij})-1)\times x_{ij})\rightarrow\max \tag{3.15}$$

or in an abbreviated and reduced to profit growth form:

$$\Delta TP(x_{ij})=\sum_{i=1}^{n}\sum_{j=1}^{m}(\Delta R_{ij}(S_{ij})-\Delta TC_{ij}(S_{ij}))\times 1)\times x_{ij}\rightarrow\max \tag{3.16}$$

where ΔTP – increase in supply chain profits.

Limitation:

1) limiting the values of variables

$$x\text{ij}\in\{0,1\},\ \text{i}\in\{1,...,n\},\ \text{j}\in\{1,...,m\}; \tag{3.17}$$

2) limiting the choice of only one of the possible values for each indicator of the logistics service

$$\sum_{j=1}^{m}x_{ij}=1,\quad \forall i\varepsilon\{1,...,n\} \tag{3.18}$$

3) limiting the growth of total costs

$$\sum_{i=1}^{n}\sum_{j=1}^{m}\Delta TC_{ij}(S_{ij})\times x_{ij}\leq\Delta TC_{\max},\Delta TC_{\max}\geq 0 \tag{3.19}$$

The developed model is a deterministic linear static model with Boolean variables. If it is necessary to take alternate (staged) consideration of logistics service indicators, the optimization problem can be presented in the form of a dynamic programming model, and the solution is found using recurrent equations.

Model of dynamic programming of logistics service.

The development of a dynamic programming model requires a transformation of the input data. The increase in profit caused by any value of any of the analyzed indicators of the logistics service is calculated according to the formula:

$$\Delta TP_{\text{ij}}(S_{\text{ij}})=\Delta R_{\text{ij}}(S_{\text{ij}})-\Delta TC_{\text{ij}}(S_{\text{ij}}),\ \forall\ \text{i}\in\{1,...,n\},\ \forall\text{j}\in\{1,...,m\} \tag{3.20}$$

where ΔTP_{ij} – profit growth provided by the j-th value of the i-th indicatorlogistics service.

Many values of indicators of logistics service, increase in total costs and increase in profit can be set as follows:

$$S_i^{set} = \{S_{i1}, S_{i2}, \ldots, S_{im}\}, \ i \in \{1, \ldots, n\} \tag{3.21}$$

where S_i^{set} – set of possible values of the i-th indicatorlogistics service, consisting of melements;

$$\Delta TC_i^{set}=\{\Delta TC_{i1}, \Delta TC_{i2}, \ldots, \Delta TC_{im}\}, \ i \in \{1, \ldots, n\} \tag{3.22}$$

where ΔTC_i^{set} – a set of values of the increase in total costs corresponding to the possible values of the i-th indicatorlogistics service, which consists of m elements;

$$\Delta TP_i^{set}=\{\Delta TP_{i1}, \Delta TP_{i2}, \ldots, \Delta TP_{im}\}, \ i \in \{1, \ldots, n\} \tag{3.23}$$

where TP_i^{set} – set of values of profit growth corresponding to the possible values of the i-th indicator of the logistics service, which consists of m elements.

Then the possible values of the i-th indicator of the logistics service are known $S_i \in S_i^{set}$ and their corresponding values of the increase in total costs $\Delta TC_i \in \Delta TC_i^{set}$ and growth profit $\Delta TP_i \in \Delta TP_i^{set}$.

Since the found values of revenue growth and growth of total logistics costs depend on the values of logistics service indicators, it can be concluded that the value of profit growth also depends on the values of logistics service indicators. Then the necessary formulations of the dependence model can be expressed as follows:

$$\Delta TC_i=c_i(S_i), \ i\in\{1, \ldots, n\} \tag{3.24}$$

where c_i is a function reflecting the dependence of the increase in total costs on the value *i*-th indicator of logistics service;

$$\Delta TP_i=p_i(S_i), \ i\in\{1, \ldots, n\} \tag{3.25}$$

where p_i is a function reflecting the dependence of profit growth on the value of the i-th indicatorlogistics service.

The objective function of the mathematical optimization model is as follows:

$$\Delta TP(S_i) = \sum_{i=1}^{n} p_i(S_i) \to \max \tag{3.26}$$

1) limiting the growth of total costs

$$\sum_{i=1}^{n} c_i(S_i) \le \Delta TC_{\max}, \ \ \Delta TC_{\max} \ge 0 \tag{3.27}$$

2) limiting the increase in total costs from the value of the i-th indicator of the logistics service

$$c_i(S_i) \ge 0, \forall i \in \{1, \ldots, n\}. \tag{3.28}$$

To solve dynamic programming problems, Bellman's basic functional equation is used, on the basis of which recurrent relations are derived[23].

Recurrent the ratio for solving the given problem by the method of direct running is presented below:

$$\int_i^{''}(\Delta TC_{sum_i^{''}}) = \max_{S_i \varepsilon S_i^{set}}\{p_i(S_i) + \int_{s-1}^{''}(\Delta TC_{sum_i^{''}} - c_i(S_i)\},$$

$$0 \le c_i(S_i) \le \Delta TC_{sum_i^{''}} \ i \in \{1, \ldots, n\}. \tag{3.29}$$

where $\Delta TCsum_i'$ – increase in costs associated with a change in the values of the indicatorslogistics serviceat the i-th and all previous stages;

$f'_{i-1}(\Delta TCsum_i')$ – the maximum increase in profit received in the amount on the i-thand all previous stages.

The results of solving such a problem by means of a direct run are reflected in the works of A. Lois and A. Ziliaskopoulos[24]and V. Shmid[25]. However, in our opinion, the reverse sweep algorithm is applied in the works of S. Iwamoto[26] and P. Ch. Popa, K.-M. Pintea, K. P. Sitar, M. Haidu-Meselaru[27] in terms of ease of use, it is more effective. In connection with this, the NPM also

[23]Bellman R. Dynamic programming / translated from English under the editorship. N. N. Vorobyev. Moscow: Publishing House of Foreign Literature, 1960. 400.

[24]Lois A., Ziliaskopoulos A. Online algorithm for dynamic dial a ride problem and its metrics, Transportation Research Procedia, Volume 24, 2017, 377-384.

[25]Schmid V. Solving the dynamic ambulance relocation and dispatching problem using approximate dynamic programming, European Journal of Operational Research, Volume 219, Issue 3, 2012, 611-621.

[26]Iwamoto S. Reverse function, reverse program, and reverse theorem in mathematical programming, Journal of Mathematical Analysis and Applications, Volume 95, Issue 1, 1983, 1-19.

[27]Pop PC, Pintea CM, Sitar CP, Hajdu-Măcelaru M. An efficient Reverse Distribution System for solving sustainable supply chain network design problem, Journal of Applied Logic, Volume 13, Issue 2, Part A, 2015, 105-113.

formulated a recurrence relation for solving the problem by the method of backward sweep, which has the following form:

$$\int_i (\Delta TC_{sum_i}) = \max_{S_i \varepsilon S_i^{set}} \{ p_i(S_i) + \int_{s+1}^{"} (\Delta TC_{sum_i} - c_i(S_i)\},$$

$$0 \le c_i(S_i) \le \Delta TC_{sum_i} \ \mathrm{i} \in \{1, \ldots, n\}. \qquad (3.30)$$

where $\Delta TCsum_i$ – increase in costs associated with the change in the values of logistics service indicators at the i-th and all subsequent stages;

$f_i(\Delta TCsum_i)$ is the maximum increase in profit obtained in the amount of i-this and all subsequent stages.

Consequences of using models. The proposed models allow taking into account the values of a number of logistics service indicators, which distinguishes them from those developed earlier. However, regardless of the type of optimization model, accurate input data, especially regarding actual logistics costs, are required to obtain a reliable solution. The formation of logistics costs takes place in the logistics system, which combines several interconnected subsystems, in connection with which a comprehensive analysis of logistics costs and the mechanism of their formation is necessary in order to develop a model for optimizing the total costs of the supply chain. Such an optimization model can be used independently and as a component of developed models.

3.3 Integration model of supply chain logistic service optimization

Models of logistics service optimization and total costs, the stages of development of which are presented in the previous sections, take into account the values of logistics service indicators, which opens up the possibility of their integration. An integration optimization model means a model that combines several independent optimization models, which must be involved in the process of finding the optimal solution, and provides for the exchange of optimization results between them in accordance with a certain algorithm.

As a result, the formulated integration model should determine the value of logistics service indicators that ensure the formation of maximum profit. The latter is defined as the difference between revenue and total logistics costs. The complexity of the structure of total costs and the connections of their individual components determined the need for further detailed analysis of the formation of total costs and the development of a model for their optimization.

The formulation of the integration model of the optimization of total costs made it possible to calculate the value of the minimum total costs and to determine the value of the indicators of the logistics service and the costs of individual logistics processes that ensure the achievement of the optimum. It is assumed that the combination of models of logistics service optimization and total costs will give the integration model a degree of adequacy that will surpass the characteristics of each of the mentioned models separately. The basis for the assumption is an increase in the accuracy of the display of elements, connections and relationships between them, models being simulated, logistics systems, caused by the use of the optimization model of total costs to determine the values of total costs used in the calculations of the optimization model of the logistics service.

Algorithm for finding the optimal solution. The analysis of the procedure presented in Figure 3.3 shows that the determination of the optimal level of logistics support using the integration model is significantly more difficult than the one implemented when using the optimization model of logistics support. Thus, the application of the logistic support optimization model does not involve the execution of operations numbered 2, 4, 5 and 6, which are the operations of the process of determining the optimal total costs of the total costs optimization model.

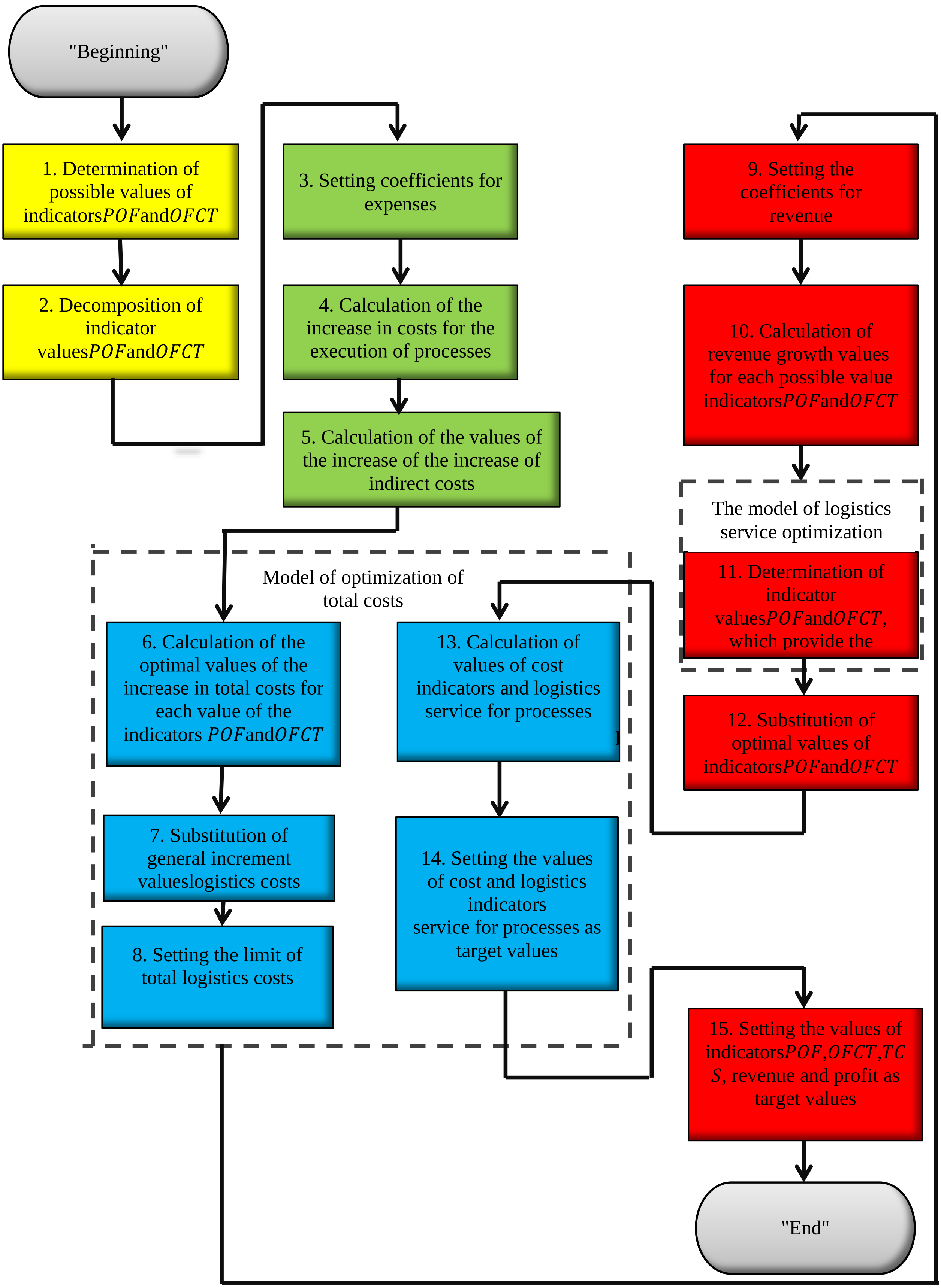

Fig. 3.3 – Algorithm for finding the optimal solution

Source: compiled by the authors

The absence of these operations in the procedure of finding the optimal solution excludes the possibility of performing operations under numbers 7, 12, 13 and 14.

Supplementing the logistics service optimization model with a sub-model for optimizing total costs, which involves the inclusion in the procedure of finding the optimal solution of the set of mentioned costs, forms an integration model for optimizing the logistics service.

As mentioned above, the integration model is characterized by the possibility of exchanging calculation results obtained at various stages of the search for the optimal solution between the models that make it up. The developed procedure provides for the transfer of the results of the optimization of total costs, which is implemented during the implementation of logistic support. At the 12th stage, there is a reverse transfer of data, optimal values of logistics support indicators (POF and OFCT), from the logistic support optimization model to the overall costs optimization model in order to determine the optimal values of process indicators, the finding of which is realized at the 13th stage of finding a solution.

As a result of performing the presented modeling stages, the optimization task was formulated, the connection of the model components and the set of data to be exchanged between the models were determined, the procedure for data transfer and finding the optimal solution to the problem based on the integration model was developed, which opens the possibility of developing a mathematical optimization model.

Mathematical model of optimization. Total logistics costs can be expressed as the sum of logistics costs when implementing the basic level of logistics service and the increase in costs caused by the implementation of a logistics service different from the basic level:

$$TCS = TCS^b + \Delta TCS, \tag{3.31}$$

where TCS is the total logistics costs of the supply chain;

TCS^b – general costs for the implementation of the basic level of logistics service (basic costs);

ΔTCS – the increase in total costs to basic costs caused by implementationlogistics servicedifferent from the base level.

The total costs for the implementation of the basic level of logistics service are calculated as the sum of direct and indirect basic costs:

$$TCS^b = \sum_{p=1}^{P} Cd_p^b + \sum_{n=1}^{N} Cin_n^b \tag{3.32}$$

where p is the item number of expenses for the implementation of the logistics process (equal to the process number), p$\in\{1, \ldots, P\}$;

P – the number of cost items for the execution of processes (equal to the number of analyzed processes);

Cd_p^b – amount of basic costs for the execution of the process p;

n – item number of indirect costs, n $\in\{1, \ldots, N\}$;

N – the number of items of indirect costs;

Cin_n^b – the amount of basic costs for the nth item of indirect costs.

In general, the increase in total costs is calculated according to the following formula:

$$\Delta TCS = \sum_{p=1}^{P} \sum_{i=1}^{I} \Delta Cd_{pi} + \sum_{n=1}^{N}\sum_{i=1}^{I} Cin_{ni} \tag{3.33}$$

where i – the number of the logistics service indicator, i$\in\{1, \ldots, I\}$;

I – the number of logistics service indicators;

ΔCdp_i – increase in costs for the execution of process p from the value of the i-th indicatorlogistics service;

$\Delta Cinn_i$ – the increase in costs for the nth item of indirect costs from the i-th value indicator of logistics service.

The increase in direct costs caused by any value of any logistics service indicator for any process can be calculated as follows:

$$\Delta Cdp_{iv}(S'_{piv}) = Cdb \times (kCdp_{iv}(S'_{piv}) - 1), \tag{3.34}$$

$$kCdp_{iv} > 0, \forall\, p \in\{1, \ldots, P\}, \forall i \in\{1, \ldots, I\}, \forall\, v \in\{1, \ldots, V\},$$

where v – the number of the possible value of the logistics service indicator for the process,$v \in \{1, . . . ,V\}$;

V – the number of possible values of logistics service indicators for processes;

ΔCdp_{iv} – the increase in costs for the execution of the process p caused by the value of the i-th indicatorlogistics serviceunder number v;

S'_{piv} – the value of the logistic service indicator under number v_i of process p;

kCd_{piv} – the coefficient reflecting the influence of the value of the i-th indicatorlogistics serviceunder the number v for the costs associated with the execution of the process p.

Similarly, the increase in costs for any item of indirect costs, caused by any value of any indicator of the logistics service, is calculated.

$$\Delta Cinn_{i}j(Sn_{ij}) = Cinb_{n} \times (kC^{inn}_{ij}(Sn_{ij}) - 1), \tag{3.35}$$

$$kC^{inn}_{i}J > 0, \forall\ n \in \{1, . . . ,N\}, \forall i \in \{1, . . . ,I\}, \forall J \in \{1, . . . ,J\},$$

where j – the number of the possible value of the logistics service indicator for the logistics system in general, $j \in \{1, . . . ,J\}$;

J – the number of possible values of logistics service indicators for the logistics system in general;

$\Delta Cinn_{ij}$ – the increase in costs for the nth item of indirect costs, caused by the value of the i-th indicatorlogistics serviceunder number j for the logistics system as a whole;

Sn_{ij} – the value under number j of the indicator of logistics service i, which affects the costs of the nth article of indirect costs;

kC^{inn}_{ij} – the coefficient reflecting the influence of the value of the i-th indicatorlogistics serviceunder number j for costs under item n of indirect costs.

It should be explained that the coefficients k (with different indices) used in the development of the integration mathematical model for the optimization of the logistics service acquire a value greater than 1, if the value of the logistics service indicator provides an increase in the value of the financial indicator (revenues or costs), and is greater than 0, but less 1 otherwise. The basic values of logistics service indicators correspond to coefficients of 1.

Value of cost growth ΔCdp_i and $\Delta Cinn_i$ depend on the choice of one of the possible values of the logistics service indicators and the corresponding values of cost growth and are calculated using the following formulas:

$$\Delta Cdp_i(\mathrm{in}p_{iv}) = \sum^{V} v{=}1 \Delta Cdp_{iv}(S'_{piv}) \text{ x} yp_{iv}, \qquad (3.36)$$

$$yp_{iv} \in \{0,1\}, \forall\, p \in \{1, \ldots, P\}, \forall i \in \{1, \ldots, I\},$$

where yp_{iv} is a Boolean variable that means acceptance or rejection of the value for the i-th indicatorlogistics serviceunder number v of process p;

$$\Delta Cinn_i(zn_{ij}) = \sum^{J}{}_{j=1} \Delta Cinn_{ij}(Sn_{ij}) \text{ x} zn_{ij}, \qquad (3.37)$$

$$zn_{ij} \in \{0,1\}, \forall\, n \in \{1, \ldots, N\}, \forall i \in \{1, \ldots, I\},$$

where zn_{ij} is a Boolean variable, which means acceptance or rejection of the value for the i-th indicator of the logistics service under number j, which causes a change in the amount of costs by item n of indirect costs.

Since there is a component in the structure of total costs that does not depend on the values of logistics service indicators, total costs when implementing the basic level of logistics service, the task of optimizing costs can be reduced to optimizing the values of cost growth, the sum of which is calculated as follows:

$$\Delta TC(y_{piv} z_{nij}) = \sum^{P}{}_{p=1} \sum^{I}{}_{i=1} \sum^{V}{}_{v=1} C_p{}^{b} \times (k^{Cd}{}_{pivj}(S'_{piv}) - 1) \times y_{piv} +$$

$$+ \sum^{N}{}_{n=1} \sum^{I}{}_{i=1} \sum^{J}{}_{j=11} Cin_n{}^{b} \times (\, k^{cin}{}_{nij}(S_{nij}) - 1) \times z_{nij}$$

$$y_{piv} \in \{0.1\}, z_{nij}, \in \{0.1\} \qquad (3.38)$$

In order to determine the vectors of the values of the increase in total costs for each indicator of the logistics service that is taken into account, it is necessary to express the increase in the total costs for each possible value of each indicator of the logistics service.

However, for this, first of all, it is necessary to clarify the relationship between the values of the logistics service indicators considered in the optimization models of total costs and logistics service. Since the indirect costs of the general cost optimization model depend on the values of the logistics service indicators for the logistics system as a whole, the indirect costs are formed from the same vectors of indicator values used in the logistics service optimization model. In addition, the values of cost growth for each item of indirect costs are formed from the logistics service. Then, in the general case, equality holds:

$$S_{ij}=S_{1ij}=S_{2ij}= \ldots =SN_{ij}, \forall i\in\{1, \ldots ,I\}, \forall J\in\{1, \ldots ,J\}, \quad (3.39)$$

where S_{ij} – j-th value of the i-th indicatorlogistics service, which is taken into account in the optimization modellogistics service.

Given the equality of the values and numbers of the values of the logistics service indicators of the logistics service optimization model and those taken into account when calculating indirect costs in the optimization model of total costs, the values Sn_{ij} can be replaced by S_{ij}. Considering the need to find the optimal value of the increase in total costs for each possible value of each indicator of the logistics service, the need to choose the value$S_{ij}$and the corresponding value of the increase in indirect costs $Cinbn\times (kC^{inn}{}_{ij}(S_{ij}) - 1)$ using a Boolean variable $z\ _{nij}$ in the process of solving each individual task is absent. Then the total increase in costs for indirect cost items is added to expression (3.38) as a value determined by the value of the logistics service indicator, for which the rational value of the increase in total costs is searched. Taking into account the changes, the expression for calculating the increase in total costs for each value of each indicator of the logistics service takes the following form:

$$\Delta TCS_{ij}(y_{piv},S_{ij})=\sum\nolimits^{P}{}_{p=1}\sum\nolimits^{V}{}_{v=1}Cd_{p}{}^{b}\times(k^{Cd}{}_{pivj}(S'_{piv})-1)\times y_{piv}+\sum\nolimits^{N}{}_{n=1}Cin_{n}{}^{b}\times(C^{cin}{}_{nij}(S_{nij})-1)$$

$$y_{piv}\in\{0.1\}, \forall\ i\in\{1, \ldots , I\}, \forall\ j\in\{1, \ldots , J\} \quad (3.40)$$

where $\Delta TSSij$ – the value of the increase in total costs for the j-th value of the i-th indicator of the logistics service.

It is necessary to verify the validity of formula (3.40) when considering various indicators of logistics service. Given the fact that such cost factors as order cycle time (OFCT) and the level of perfect order fulfillment (POF) were identified for the costs of the processes of the analyzed logistics system, and they were taken into account in the development of the optimization model of total costs, the relationship between the values of the mentioned indicators for the processes and the logistics system should be considered in detail. Thus, the duration of the order fulfillment cycle is equal to the sum of the duration values of all analyzed processes (order fulfillment and delivery). Therefore, the following expression is valid:

$$OFCT = \sum P \; OFCTp, \tag{3.41}$$

where $OFCT$ – duration of the order fulfillment cycle;

$OFCTp$ – the duration of the process execution p.

Expression (3.41) defines the constraint of the integrated optimization model, which, using the notation of the model being developed, can be written as follows:

$$\sum\nolimits^{P}{}_{p=1}\sum\nolimits^{V}{}_{v=1}(S'_{piv}-1)\times y_{piv} \leq S_{ij},\ i=t,\ y_{piv} \in \{0.1\}, \forall\ i \in \{1, \ldots, J\} \tag{3.42}$$

where t – the number of the indicator of the logistics service corresponding to the indicator of the OFCT, $t \in \{1, \ldots, I\}$.

Since the value of the POF indicator is a factor of the costs of the supply process and only, the calculation of the values of the increase in the costs of the supply process and indirect costs is carried out from the same vector of the values of the POF indicator, and the value of the analyzed indicator for the supply process is equal to the value of the POF indicator for the logistics systems in general. The following expressions reflect the equality of values:

$$POF = POFd, d \in \{1, \ldots, P\}, \tag{3.43}$$

where POF – the value of the indicator of the level of flawless execution of orders;

d – delivery process number;

$POFd$ – the value of the indicator of the level of flawless execution of the supply process;

$$S'_{pij}=S_{ij}=S_{1ij}=S_{2ij}= ... =SN_{ij}, p=d, \text{ i }=r, \forall J\in\{1, ... ,J\}, \quad (3.44)$$

where r is the number of the logistics service indicator corresponding to the POF indicator, $r \in\{1, ... ,I\}$.

Taking into account equality (3.47), formula (3.40) for calculating the increase in total costs from the values of the POF indicator takes the form:

$$\Delta TCS_{ij}(S_{ij})=Cd_p{}^b\times(k^{Cd}{}_{pivj}(S'_{ij})-1)+ \sum^N{}_{n=1}Cin_n{}^b\times(K^{cin}{}_{nij}(S_{ij})-1,)$$

$$p=d,\ i=r,\ \forall j \in\{1, ... , J\} \quad (3.45)$$

Let's pay attention to the fact that, if i=r, the solution of the optimization problem is not required, and the search for the "optimal" value of the increase in total costs is reduced to the calculation of a simple sum of the values of the increase in costs for each of the considered cost items. It is also necessary to note the assumption that the values of logistics service indicators affect the value of cost growth for any of the cost items in isolation from each other. In this regard, solving the optimization problem for each possible combination of values of the logistics service indicators is not necessary, and the number of tasks to be solved in turn is equal to (i −1) × j, taking into account the fact that when i= r solution of optimization problems is not required. Taking into account the considered relations of the values of the logistics service indicators, an integration model of optimization was formulated.

$$\Delta TCS_{ij}{}^{opt}\ (y_{piv},S_{ij})=\sum^P{}_{p=1}\sum^V{}_{v=1}Cd_p{}^b\times(k^{Cd}{}_{piv}(S^1{}_{piv})-1)\times y_{piv}$$

$$+\sum^N{}_{n=1}Cin_n{}^b\times(K_{nij}{}^{cin}\ (S_{ij})-1)\rightarrow min$$

$$\text{i}\in\{1, ... ,I\}\setminus \{\text{r}\}, \text{ j}\in\{1, ... ,J\} \quad (3.46)$$

where $\Delta TSSijopt$ – the optimal value of the increase in total costs for the jth value*i*-th indicator of logistics service.

Subject to restrictions:

1) Limitation of variable values

$$yp_{iv} \in\{0,1\}, p \in\{1, ... ,P\},\ i\in\{1, ... ,I\} \setminus\{r\}, v \in\{1, ... ,V\} \quad (3.47)$$

2) Limiting the choice of only one of the possible values of the logistics service indicators

$$\sum_{v=1}^{V} yp_{iv} = 1, \forall p \in \{1, . . . , P\}, \forall i \in \{1, . . . , I\} \setminus \{r\} \quad (3.48)$$

3) Limitation of the total duration of execution of all investigated processes by the duration of the order fulfillment cycle

$$\sum_{p=1}^{P} \sum_{v=1}^{V} S'_{piv} \times y_{piv,} \leq Sij,\ i = t,\ \forall j \in \{1, . . . , J\} \quad (3.49)$$

According to the procedure presented in Fig. 3.3, the value $\Delta TSSijopt$, found for each value of the POF and OFCT indicators, are substituted into the logistics service optimization model. The limit of total costs is also set and the maximum allowable increase in total logistics costs is calculated.

The maximum allowable increase in total costs is calculated according to the following formula:

$$\Delta TCS_{max} = TCS_{max} - TCS_b,\ 0 < TCS_b < d \quad (3.50)$$

where $\Delta TCSmax$ – the maximum allowable increase in total costs;

$TCSmax$ – the maximum allowable value of total costs.

A number of expressions were formulated on the basis of formulas (3.6) – (3.9).

Supply chain profit is expressed as:

$$TP = TR - TCS, \quad (3.51)$$

where TP – the profit of the supply chain;

TR – revenue from the implementation of the supply chain.

The value of revenue, taking into account its increase from the implementation of a logistics service different from the basic level, is calculated according to the following formula:

$$TR = R^b + \Delta R, \quad (3.52)$$

where R^b – revenue from the implementation of the basic levellogistics service;

ΔR – the total increase in revenue provided by the implementation of a logistics service different from the basic level.

Expression for calculation growthrevenue provided by any value of any logistics service indicator has the following form:

$$\Delta R_{ij}(S_{ij}) = R^b \times (k^R_{ij}\,(S_{ij}) - 1),\ k^R_{ij} > 0,\ \forall i \in \{1, . . . , I\},\ \forall j \in \{1, . . . , J\}, \quad (3.53)$$

where ΔR_{ij} – revenue growth provided by the j-th value of the i-th indicatorlogistics service;

kR_{ij} – a coefficient reflecting the influence of the jth value of the ith indicatorlogistics serviceon revenue

The total increase in revenue depends on the selection of the values of the logistics service indicators and the corresponding values of the revenue increase:

$$\Delta R(x_{ij}) = \sum^{I}_{i=1} \sum^{j}_{j=1}\ \Delta R_{ij}(S_{ij}) \times x_{ij},\ x_{ij} \in \{0,1\}, \quad (3.54)$$

where x_{ij} – a Boolean variable that means accepting or rejecting the jth value$i$-th indicator of logistics service.

Considering that for each value of ΔR_{ij} the calculated value of Δ is matched $TCS_{ijo}{}^{pt}$, then profit growth can be calculated. Since the following relationship holds:

$$TP = R^b + \Delta R - TCSb - \Delta TCS, \quad (3.55)$$

with

$$R^{b - TCSb} = TPb, \quad (3.56)$$

where TPb – profit for the implementation of the basic levellogistics service,

but

$$TP - TP^b = \Delta TP, \quad (3.57)$$

where ΔTP – profit growth provided by a change in levellogistics service, then the expression will be valid:

$$\Delta TP = \Delta R - \Delta TCS. \quad (3.58)$$

Thus, the task of profit maximization can be reduced to the maximization of profit growth provided by the values of logistics service indicators. And the objective function of the supply chain logistics service optimization model looks like this:

$$\Delta TP(x_{ij}) = \sum^{I}_{i=1} \sum_{jj=1}\ (\Delta R_{ij}\,(S_{ij}) - \Delta TCS^{opt*}{}_{ij}\,(S_{ij})) \times x_{ij} \rightarrow max. \quad (3.59)$$

subject to restrictions:

1) Limitation of variable values

$$x_{ij} \in \{0,1\}, i \in \{1, \ldots, I\}, j \in \{1, \ldots, J\}. \quad (3.60)$$

2) Limiting the selection of only one of the possible values for each indicator of the logistics service

$$\sum_{j=1}^{j} x_{ij} = 1, \forall i \in \{1, \ldots, I\}. \quad (3.61)$$

3) Limiting the growth of total costs

$$\sum_{i=1}^{I} \sum_{j=1}^{j} \Delta TCS^{opt*}_{ij}(S_{ij})) \times x_{ij} \leq \Delta TCS_{max}, \ \Delta TCS_{max} > 0 \quad (3.62)$$

As a result of logistics service optimization, a combination of values of logistics service indicators is determined ($OFCT^{opt}$ and POF^{opt}), which ensures the formation of the maximum profit of the supply chain. Next, the values from the combination of the found optimal values of the logistics service indicators should be fed into the general cost optimization model, i.e. substituted as input data of the general cost optimization model, in order to calculate the values of the logistics service indicators for individual processes and costs for each of the considered cost items. Final operations of the procedure presented in Fig. 3.3, provide for setting the found optimal values as targets.

Therefore, the model of optimization of total costs proposed by us was developed as a response to the need to detail the process of formation of total costs in the logistics system. The optimization model is based on the SCOR model of supply chain processes. Evaluation of processes is carried out using indicators of logistics service and costs, also proposed by the SCOR methodology. It is significant that the cost indicators of the SCOR model reflect all widely recognized items of logistics costs. The developed model takes into account both direct costs associated with the execution of processes and indirect costs arising in the logistics system. As a result of the optimization, the values of the logistics service indicators are determined, which ensure the formation of such costs for individual cost items, which in total form the minimum total logistics costs of the supply chain.

CONCLUSIONS

In the monograph, a theoretical generalization of the process approach to the management of supply chains and the development of a mathematical apparatus for optimizing the operation of logistics systems was carried out, methodological principles for determining the optimal level of logistics service were formulated, and a complex of mathematical models for the optimization of logistics service was developed, aimed at increasing the efficiency of the operation of the supply chain.

The conducted research gives grounds for drawing the following theoretical and scientific-practical conclusions:

1. In view of the new economic conditions, an effectively operating supply chain must meet all the requirements of the economy of a post-industrial society, in particular, a quick response to changes in demand, the application of innovations in all areas of logistics activity, the fulfillment of orders with high quality of service and the extension of the life cycle of products. In this regard, during the construction of modern logistics systems, the policy of selling manufactured goods is replaced by the policy of production of goods or services that are sold; constant work is carried out to minimize the terms of passing products through the technological process, reducing the batch of resources and the batch of processing, reducing all types of downtime and irrational intra-production transportation.

Any "prediction" of the behavior of the system and the behavior of individual elements of the system will be formed within the logical framework of probabilistic categories by which this behavior can be described. Behavioral motivations of managers of logistics systems should be aimed not only at preserving the existence of systems in environmental conditions, but also at their development. For this, the system, regardless of its type and characteristics, is forced to adapt to the economic, financial, social and political environment, especially in the conditions of global challenges and crisis situations and the restrictions in the entrepreneurial activity of the subjects of logistics activity related to them.

2. Despite the separation of logistics into an independent branch of activity in relation to marketing, these directions are connected in the process of creating value for the consumer. The activities of marketing and logistics are aimed at meeting the demands of consumers by means of service with profit for the enterprise. Customer service is the result of the joint work of marketing and logistics. The interdependence of marketing and logistics is manifested in the search for a balance between the level of the provided logistics service and the total logistics costs associated with its support. The necessary level of logistics service is established by marketing, and implemented by the logistics system of the enterprise, as a result of which general logistics costs are formed, which affect the profit of the supply chain. Formulated methods of determining the "cost/service" balance are conceptual in nature and do not guarantee the optimality of the balance. Determining the optimal level of logistics service is possible by developing an appropriate model and applying effective optimization methods.

3. The necessary level of cross-functional coordination of the marketing department and the departments that make up the logistics system of the enterprise can be achieved under the condition of building a process-oriented organizational structure of the enterprise, forming a system of process efficiency indicators and general improvement of the quality of planning. However, these conditions cannot be fulfilled without prior definition (identification) of business processes as part of the enterprise's business architecture.

Despite the differences in the development levels of reference process models and methodologies used for supply chains, each of them is an effective tool for eliminating obstacles to the implementation of the supply chain logistics service system. Determining the processes performed in the logistics system opens up the possibility for further transformations of enterprises, such as changing the organizational structure, the system of performance indicators and planning methods, aimed, in particular, at achieving the goal of interaction between the marketing division and the divisions that make up the logistics system of the enterprise, which consists in determining the optimal level of logistics service.

4. Methodical approaches to logistics service management are based on customer service developments, which are divided into two large classes based on the type of information used: 1) approaches based on information available from the customer service provider; 2) approaches based on information received from various sources (from customers, from competitors, from markets, etc.).

The analysis of scientific approaches to the definition of the categories "logistics service", "logistics service level", "logistics service quality" and "logistics service" made it possible to systematize and generalize them. It is proposed that "logistics service" will be understood as part of the customer service policy, which covers the interaction between the customer and the supplier regarding the movement of the material flow, as well as the accompanying information, financial and service flows, the interaction which provides benefits to each of the parties involved and is able to satisfy the customer's requirements in the conditions available capabilities of the supplier. "logistics service" means a set (set, complex) of logistics services that are implemented in the management of customer orders, as well as in the logistics support of requests and warranty service of purchased goods, in the process of interaction between the client and the supplier and which provides clear benefits to each party - compliance with the client's requirements and accounting for the available capabilities of the supplier. The "level of logistics service" will be called the indicator of the conformity of the actual value of each individual logistics service, which is included in the totality (set, complex) of logistics services, with the values guaranteed to customers (in the contract, when concluding an agreement orally or in another way). "Logistics service quality" will reflect the presence and magnitude of the gap between the actual value of each logistics service provided and the value that was promised to the client (in the contract, verbal agreement, or otherwise), and will signal the need for corrective actions. The "level of logistics service" will be called the indicator of the conformity of the actual value of each individual logistics service, which is included in the totality (set, complex) of logistics services, with the values guaranteed to customers (in the contract, when concluding an agreement orally or in another way). "Logistics service quality" will reflect the presence and magnitude of the gap between the actual value of each logistics service provided and the value that was promised to the client (in the contract, verbal agreement, or otherwise), and will signal the need for corrective actions. The "level of logistics service" will be called the indicator of the conformity of the actual value of each individual logistics service, which is included in the totality (set, complex) of logistics services, with the values guaranteed to customers (in the contract, when concluding an agreement orally or in another way). "Logistics service quality" will reflect the presence and magnitude of the gap between the actual value of each logistics service provided and the value that was promised to the client (in the contract, verbal agreement, or otherwise), and will signal the need for corrective actions.

5. In connection with the significant role of customers for the success of business, their service is considered as one of the strategic perspectives in the construction of the company's strategic map on a par with "finances", "processes" and other perspectives, and in distribution logistics is one of the strategies, which contributes to shifting the focus of strategic development of companies from an orientation only on profit maximization towards profit maximization through increased customer satisfaction.

An extended approach to measuring indicators of supply chain logistics service is proposed, which makes it possible to comprehensively assess the effectiveness of working with clients. After all, it is aimed not only at the overall result of customer service (the first group of indicators), but also at the efficiency of the execution of customer orders, where special attention should be paid to consideration of various types of deviations in order execution, as well as services implemented after the sale (the second, fourth and the fifth group of indicators); not only the time parameters of customer service (the third group of indicators), but also their variability or stability, that is, the company's ability to adapt to customer needs, which is expressed in the flexibility of fulfilling customer orders (the sixth group of indicators); it is both material, information and financial flows,

6. The possibility of modeling individual logistics processes by the participants of logistics systems is based on the justified choice and application of statistical and economic-mathematical methods and forecasting tools. The forecasting toolkit is especially important for organizing the activities of regional logistic systems of anticipatory development, taking into account the peculiarities and regional interests of the territory. The analysis of studies of the main models of logistics service optimization shows that the optimization models have different economic and mathematical properties, the search for a solution is carried out using different methods, which have their strengths and weaknesses. In many cases, the level of logistics service is associated with the level of inventory established at the enterprise, less often with the time of order fulfillment, sometimes identified with the level of the ideal order. Obviously, that taking into account only one indicator of the logistics service is not enough for the development of an effective model for the formation and implementation of the service strategy of the supply chain. Thus, the need to develop an integrated model of logistics service optimization, which takes into account a set of indicators, the entire range of logistics processes and costs associated with

their implementation, and also takes into account the impact of logistics service on the profit of the supply chain, was revealed.

7. Evaluation of the efficiency of supply chains or logistics processes in them is directly related to the evaluation of costs arising during the functioning of counterparties. The company (supply chain) tries to estimate the cost of logistics processes within the framework of the financial accounting and reporting system adopted for each country, and thereby find an objective indicator of logistics efficiency. Currently, the problem of analyzing the international practice of accounting and classifying logistics costs in supply chains is very relevant in terms of comparing different approaches and finding best practices.

Effective logistics management requires the use of the principle of total costs when, for a given level of customer service, logisticians of companies must learn to minimize total logistics costs, and not try to reduce costs only for certain types of activities. The main disadvantage of a non-integrated approach to the analysis and minimization of logistics costs is the disparity of actions when trying to reduce cost items in individual logistics functions/operations, which, in the end, may turn out to be a suboptimal option for the supply chain as a whole, as it often leads to an increase in total costs.

8. The development of an optimization model requires the construction of a conceptual model, which is a formulation of the task in terms of the subject area, and the construction of a structural mathematical model that reflects the connections and relationships of its components. The procedure for finding the optimal solution involves choosing (from many possible) values of logistics service indicators that ensure the formation of maximum profit while observing the established restrictions. Alternative profit values are calculated by subtracting the corresponding values of estimated total costs from the estimated revenue values. Values of revenue and total logistics costs are calculated by adding to the base values of the specified indicators the values of the increase,

which are calculated using coefficients dependent on the values of the indicators of the logistics service. Establishing relationships

The proposed models allow taking into account the values of a number of logistics service indicators, which distinguishes them from those developed earlier. However, regardless of the type of optimization model, accurate input data, especially regarding actual logistics costs, are required to obtain a reliable solution. The formation of logistics costs takes place in the logistics system, which combines several interconnected subsystems, in connection with which a comprehensive analysis of logistics costs and the mechanism of their formation is necessary in order to develop a model for optimizing the total costs of the supply chain.

9. The formulation of the integration model of the optimization of total costs made it possible to calculate the values of the minimum total costs and to determine the values of the indicators of the logistics service and the costs of individual logistics processes that ensure the achievement of the optimum. The model of optimization of total costs was developed as a response to the need to detail the process of formation of total costs in the logistics system of a trading enterprise. The optimization model is based on the model of SCOR processes of a trading company. Evaluation of processes is carried out using indicators of logistics service and costs, also proposed by the SCOR methodology. It is significant that the cost indicators of the SCOR model reflect all widely recognized items of logistics costs. The developed model takes into account both direct costs associated with the execution of processes and indirect costs, arising in the logistics system. As a result of the optimization, the values of the logistics service indicators are determined, which ensure the formation of such costs for individual cost items, which in total form the minimum total logistics costs of the supply chain.

10. On the basis of models of logistics service optimization and total costs, an integrated model of logistics service optimization was developed,

which uses the second model as a sub-model of the first. The search for the optimal solution is regulated by the developed procedure. According to the procedure, a series of tasks aimed at determining the optimal values of the increase in total costs are first solved, which ensures finding the input data of the logistics service optimization model that belong to the effective limit. Further, with the help of the logistics service optimization model, the values of the logistics service indicators, as well as the financial indicators belonging to the logistics system in general, which ensure the formation of the maximum profit of the supply chain, are determined.

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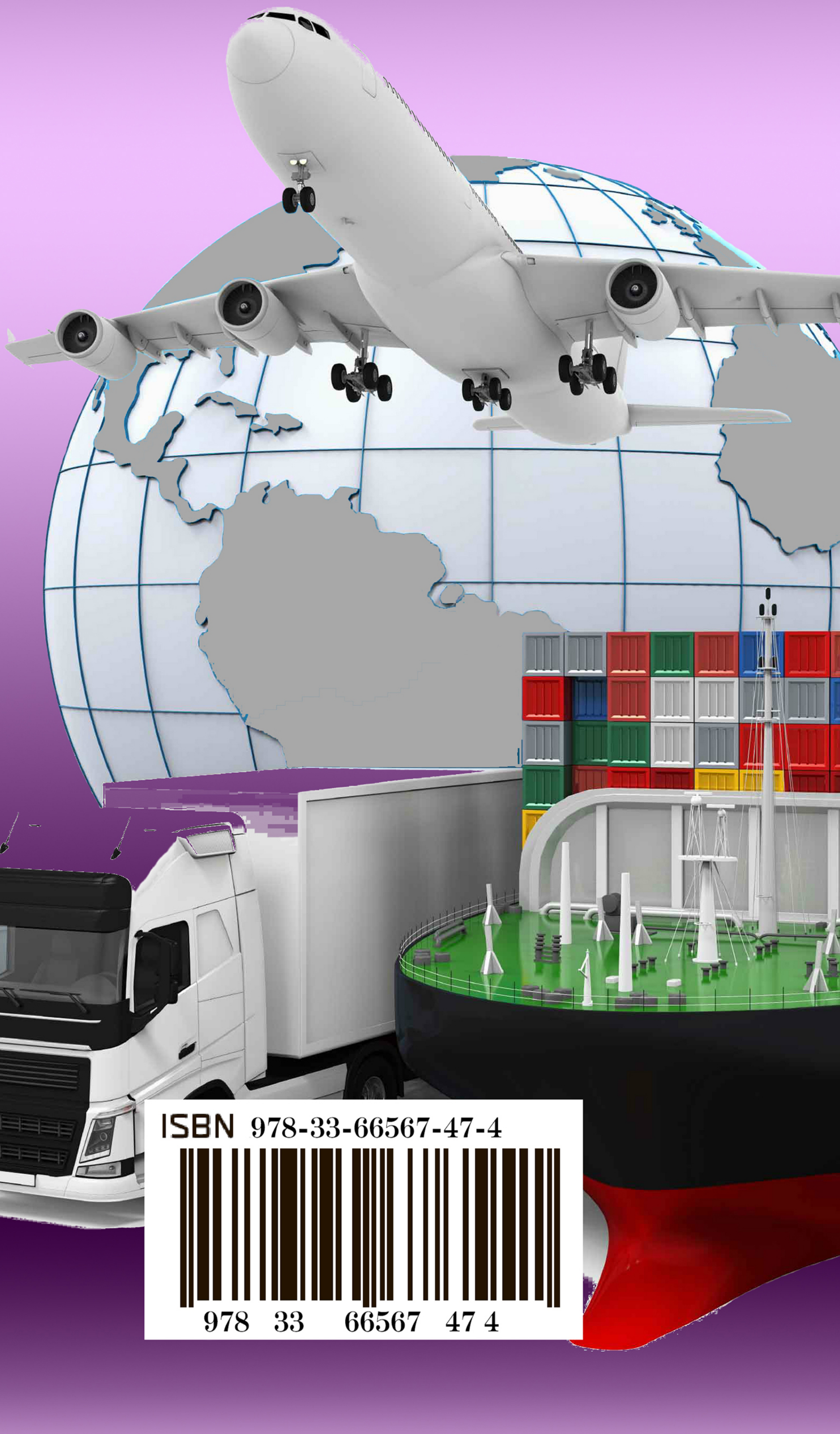

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