Electronic scientific and practical journal

INTELLECTUALIZATION OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT

#12 (2022)
April '22

WWW.SMART-SCM.ORG
ISSN 2708-3195
DOI.ORG/10.46783/SMART-SCM/2022-12

ISSN 2708-3195
9 772708 319005

Electronic scientific and practical collection
INTELLECTUALIZATION OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Electronic scientific and practical publication in economic sciences

ISSN 2708-3195
DOI: https://doi.org/10.46783/smart-scm/2022-12

Released 6 times a year

№ 12 (2022)
April 2022

Kyiv - 2022

Founder: Viold Limited Liability Company

The electronic scientific and practical journal is registered in international scientometric data bases, repositories and search engines. The main characteristic of the edition is the index of scientometric data bases, which reflects the importance and effectiveness of scientific publications using indicators such as quotation index, h-index and factor impact (the number of quotations within two years after publishing).

In 2020, the International Center for Periodicals (ISSN International Center, Paris) included the Electronic Scientific and Practical Edition "Intellectualization of Supply Chain Management" in the international register of periodicals and provided it with a numerical code of international identification: ISSN 2708-3195 (Online).

Recommended for dissemination on the Internet by the Academic Council of the Department of Logistics NAU (No. 7 of February 26, 2020). Released 6 times a year. Editions references are required. The view of the editorial board does not always coincide with that of the authors.

t.me/smart_scm
facebook.com/Smart.SCM.org
twitter.com/ScmSmart

DOI: https://doi.org/10.46783/smart-scm/2022-12
e-mail: support@smart-scm.org

тел.: (063) 593-30-41
https://smart-scm.org

Contents

INTRODUCTION 5

BUGAYKO D.O. PhD in Economics, Associate Professor, Vice - Director of International Cooperation and Education Institute, Instructor of ICAO Institute, Associate Professor of Logistics Dept. National Aviation University (Ukraine), **IERKOVSKA Y.M.** Lawyer (Ukraine), **BUGAYKO D.D.** Student of Logistics Dept. National Aviation University (Ukraine)
STRATEGIC MANAGEMENT OF AIRPORTS EFFICIENCY AND SAFETY IN THE PROCESS OF AIR AND MULTIMODAL LOGISTICS TRANSPORTATIONS DEVELOPMENT 6 – 17

HRYHORAK M.Yu. Doctor of Economics, Associate Professor, Senior Research Fellow in Institute of Cybernetics of the National Academy of Sciences of Ukraine (Ukraine), **ZALOZNOVA Yu.** Corresponding Member of the NAS of Ukraine, Doctor of Economics, Professor, Director (Head), Institute of Industrial Economics of the National Academy of Sciences of Ukraine (Ukraine), **TRUSHKINA N.V.** PhD (Economics), Senior Research, Senior Research Fellow, Department of Regulatory Policy and Entrepreneurship Development Institute of Industrial Economics of the National Academy of Sciences of Ukraine (Ukraine)
MODELING AS A TOOL OF STRATEGIC DEVELOPMENT OF THE REGIONAL LOGISTICS SYSTEM 18 – 35

GRITSENKO S.I. Doctor of Economics, Professor, Professor of Logistics Department of National Aviation University (Ukraine), **DOVGAN T.I.** Students of Logistics Department National Aviation University (Ukraine), **NINICH V.Z.** Students of Logistics Department National Aviation University (Ukraine)
CLUSTER PROSPECTS OF THE USE OF UNMANNED AERIAL SYSTEMS IN SUPPORTING THE LIVING ACTIVITY OF CRITICAL INDUSTRIES 36 – 44

KULIK V.A. PhD (Economics), Professor, Professor of Logistics Department National Aviation University, Honored Worker of National Education of Ukraine, Honorary employee of aviation transport of Ukraine (Ukraine), **MARCHUK V.Ye.** Doctor of Engineering, Professor, Professor of Logistics Department National Aviation University (Ukraine), **HARMASH O.M.** PhD (Economics), Associate Professor, Associate Professor of Logistics Department National Aviation University (Ukraine), **KARPUN O.V.** PhD (Economics), Associate Professor, Associate Professor of Logistics Department National Aviation University (Ukraine), **PEREDERII N.M.** PhD (Economics), Associate Professor, Associate Professor of Logistics Department National Aviation University (Ukraine)

SECURITY MANAGEMENT OF INTERMODAL TRANSPORTATION IN CONDITIONS OF SUSTAINABLE DEVELOPMENT OF GLOBAL SUPPLY CHAINS 45 – 56

INTRODUCTION

We are happy to invite you to get acquainted with the first issue of the new scientific and practical publication "Intellectualization of Logistics and Supply Chain Management".

We strongly believe that the launch of this magazine indicates the objective need to rethink a wide range of issues related to the development of theory and practice in logistics and supply chain management, awareness of the need to unite the scientific community and logistics practitioners, dissemination of modern knowledge and best practices for innovative development of the logistics services market.

The first issue of the magazine is published at a difficult time. The global coronavirus pandemic and the deep economic crisis have significantly worsened business activity in the world. Currently, global supply chains are collapsing, international trade is declining, and competition between global and regional logistics operators is intensifying. The most common thesis is that the world will never be the same again. Industry experts predict the emergence of new, more flexible and adaptive supply chain management strategies and approaches to logistics business process management. The trend towards collaborations, cooperation and unification of services is emerging, comprehensive proposals for clients are being developed. There is increasing talk about the need to build bimodal supply chains, which involves the development of different decision-making scenarios: the traditional approach - cost-effective efficiency, low risk, high predictability; a new approach "second mode" - rapid recognition of opportunities, adaptability, willingness to solve unexpected problems and look for new opportunities.

Radical transformations of the global and national markets for logistics services require appropriate scientific support. Logistics science has a special role to play in this process. Initiating the emergence of a new journal, we decided to focus on its coverage of problematic aspects of the formation and development of logistics systems at the micro, mezo and macro levels, supply chain management, digitization of logistics, methods and tools for optimizing processes in logistics and supply chains, sociopsychology relations and network interaction of enterprises using cloud technologies, artificial intelligence, e-learning, neural business process management systems, etc.

Therefore, we invite scientists, researchers and business representatives, as well as our colleagues from abroad, to cooperate and present the results of scientific research, to discus and debate on them, to work together to develop the scientific theory of logistics and promote mutual intellectual enrichment.

We hope that the new scientific publication will become a theoretical guide for young researchers and representatives of other fields.

HRYHORAK Mariia
Chief Editor

UDC 656.7.072 (045)
DOI: https://doi.org/10.46783/smart-scm/2022-12-1
JEL Classification: M12, M21, Q20.
Received: 10 March 2022

Bugayko D.O. PhD in Economics, Associate Professor, Vice - Director of International Cooperation and Education Institute, Instructor of ICAO Institute, Associate Professor of Logistics Dept. National Aviation University (Ukraine)

ORCID – 0000-0002-3240-2501
Researcher ID – ABF-5564-2021
Scopus author id: 57216582348

Ierkovska Y.M. Lawyer (Ukraine)

ORCID –
Researcher ID –
Scopus author id: –

Bugayko D.D. Student of Logistics Dept. National Aviation University (Ukraine)

ORCID –
Researcher ID –
Scopus author id: –

STRATEGIC MANAGEMENT OF AIRPORTS EFFICIENCY AND SAFETY IN THE PROCESS OF AIR AND MULTIMODAL LOGISTICS TRANSPORTATIONS DEVELOPMENT

Dmytro Bugayko, Yuliya Ierkovska, Danylo Bugayko. «Strategic management of airports efficiency and safety in the process of air and multimodal logistics transportations development». *The airport is a complex system that focuses on the intersection of the interests of different players in the transport market and different activities related to the performance of air transportation. The airport has an independent position in relation to partners and users of air transport. Therefore, the role of the airport, above all, is to unite the efforts of the air transport system and find a balance between their economic interests in order to maximize the efficient and safe use of air transport. In addition to effective cooperation with its partners, the airport must meet the requirements of international standards for aviation security, the appropriate state of infrastructure and efficiency of technological processes. States are also interested in developing, increasing the capacity of airports, expanding opportunities in the process of operation, as the airport contributes to the revival of ties between countries and the development of the global economy, tourism. Bringing the air transport infrastructure in line with international requirements is an important component of Ukraine's strategy aimed at ensuring the competitiveness of the national economy on the world market. Solving the problems of airport development is a nationwide problem that hinders the use of the high transit potential of the state. The complex and diverse challenges facing airports require rational, integrated and flexible solutions in business process management and active cooperation of air transport system participants, which is manifested in the coordination of strategic, tactical and operational decisions. The article is devoted to improving approaches to*

strategic management of airport efficiency and safety in the process of ensuring the implementation of international air and multimodal logistics services.

***Keywords**:* airport, air transport, security, multimodal transport, regulation, operation, infrastructure.

Дмитро Бугайко, Юлія Єрковська, Данило Бугайко. "Стратегічне управління ефективністю та безпекою аеропортів в процесі розвитку авіаційних та мультимодальних логістичних перевезень". *Аеропорт – це складна система, яка зосереджує місце перетинання інтересів різних суб'єктів транспортного ринку та різних видів діяльності, пов'язаних із виконанням авіаційних перевезень. Аеропорт займає незалежне становище відносно партнерів та користувачів авіаційним транспортом. Тому роль аеропорту, перш за все, полягає в тому, щоб об'єднати зусилля суб'єктів повітряної транспортної системи та знайти баланс між їхніми економічними інтересами з метою максимально ефективного та безпечного використання повітряного транспорту. Окрім ефективної взаємодії зі своїми партнерами, аеропорт має виконувати вимоги міжнародних стандартів щодо забезпечення авіаційної безпеки, відповідного стану інфраструктури та ефективності технологічних процесів. Держави також зацікавлені в розвитку, збільшенні потужностей аеропортів, розширенні можливостей у процесі експлуатації, оскільки аеропорт сприяє пожвавленню зв'язків між країнами та розвитку глобальної економіки, туризму. Приведення авіатранспортної інфраструктури у відповідність до міжнародних вимог є важливою складовою стратегії України, спрямованої на забезпечення конкурентоспроможності національної економіки на світовому ринку. Вирішення проблем розвитку аеропортів є загальнодержавною проблемою, яка стримує використання високого транзитного потенціалу держави. Складні та різноманітні завдання, які постають перед аеропортами, потребують раціональних, інтегрованих і гнучких рішень при управлінні бізнес-процесами та активної співпраці учасників повітряної транспортної системи, що проявляється в узгодженні стратегічних, тактичних й оперативних рішень. Статтю присвячено удосконаленню підходів щодо стратегічного управління ефективністю та безпекою аеропорту у процесі забезпечення виконання міжнародних авіаційних та мультимодальних логістичних перевезень.*

Ключові слова: аеропорт, авіаційний транспорт, безпека, мультимодальні перевезення, регулювання, експлуатація, інфраструктура.

Дмитрий Бугайко, Юлия Ерковская, Данило Бугайко. «Стратегическое управление эффективностью и безопасностью аэропортов в процессе развития авиационных и мультимодальных логистических перевозок". *Аэропорт – это сложная система, сосредоточивающая место пересечения интересов разных субъектов транспортного рынка и разных видов деятельности, связанных с выполнением авиационных перевозок. Аэропорт занимает независимое положение по отношению к партнерам и пользователям авиационным транспортом. Поэтому роль аэропорта прежде всего состоит в том, чтобы объединить усилия субъектов воздушной транспортной системы и найти баланс между их экономическими интересами с целью максимально эффективного и безопасного использования воздушного транспорта. Кроме эффективного взаимодействия со своими партнерами аэропорт должен выполнять требования международных стандартов по обеспечению авиационной безопасности, соответствующего состояния инфраструктуры и эффективности технологических процессов. Государства также заинтересованы в развитии, увеличении мощностей аэропортов, расширении возможностей в процессе эксплуатации, поскольку аэропорт способствует оживлению связей между странами и развитию глобальной экономики, туризма. Приведение авиатранспортной инфраструктуры в соответствие с международными требованиями является важной составляющей стратегии*

Украины, направленной на обеспечение конкурентоспособности национальной экономики на мировом рынке. Решение проблем развития аэропортов является общегосударственной проблемой, сдерживающей использование высокого транзитного потенциала государства. Сложные и разнообразные задачи, стоящие перед аэропортами, нуждаются в рациональных, интегрированных и гибких решениях при управлении бизнес-процессами и активном сотрудничестве участников воздушной транспортной системы, что проявляется в согласовании стратегических, тактических и оперативных решений. Статья посвящена совершенствованию подходов к стратегическому управлению эффективностью и безопасностью аэропорта в процессе обеспечения выполнения международных авиационных и мультимодальных логистических перевозок.

Ключевые слова: аэропорт, авиационный транспорт, безопасность, мультимодальные перевозки, регулировка, эксплуатация, инфраструктура.

Introduction. The airport is a complex system that focuses on the intersection of the interests of different players in the transport market and different activities related to the performance of air transportation. Therefore, the role of the airport, above all, is to unite the efforts of the air transport system and find a balance between their economic interests in order to maximize the efficient and safe use of air transport.

States are also interested in developing, increasing the capacity of airports, expanding opportunities in the process of operation, as the airport contributes to the revival of ties between countries and the development of the global economy, tourism. Solving the problems of airport development is a nationwide problem that hinders the use of the high transit potential of the state. The complex and diverse challenges facing airports require rational, integrated and flexible solutions in business process management and active cooperation of air transport system participants, which is manifested in the coordination of strategic, tactical and operational decisions.

The study of the efficiency and safety aspects of airport operation is carried out on an ongoing basis by leading organizations in the field of aviation transport such as the International Civil Aviation Organization (ICAO) Secretary General, the Airports Council International (ACI), the Civil Air Navigation Services Organisation (CANSO), the International Air Transport Association (IATA) [1,2]. The article is a logical continuation of a number of publications devoted to the development of airports safety, effectiveness, regulations, operations and infrastructure aspects of Ukrainian scientists D. Bugayko [3 – 12], Y. Kharazishvili [3 – 5], M. Hryhorak [4, 10], Y. Ierkovska [6, 7], V. Lyashenko[5], V. Sokolovskiy [5], V Baranov[5], Anna Tereschenko [11, 12] and other, Polish scientist Z. Zamiar [4.10], Azerbaijan scientists F. Aliev [7,9] and scientists of other countries.

The purpose of the article is to provide structural analysis of contemporary approaches to strategic management of airport efficiency and safety in the process of ensuring the performance of international air and multimodal logistics transportations.

Presentation of the main results. *Logistic aspects of international airport development.*

In addition to its main functions, the airport must perform an additional function - to optimize the entire air transport system, to find a balance between the interests of different users, as well as between business and the environment. Given the global trends in the development of hub airports with heavy passenger and freight traffic, airports are trying to maximize the demand for transhipment operations and create a convenient schedule for transfer passengers and cargo.

The increase in air traffic is directly related to improving the economic efficiency of cargo and passenger complexes of airports. This can

be achieved through the use of the latest technologies to ensure the transportation process that meets modern requirements and high international standards. Currently, the world's leading airports use a logistical approach to organizing their activities to achieve the desired effect.

When using logistics, modern transport companies achieve greater stability, predictability, competitiveness, manufacturability in transportation, which is especially important in international transportation.

The main directions of development of world airports are shown in Fig. 1.

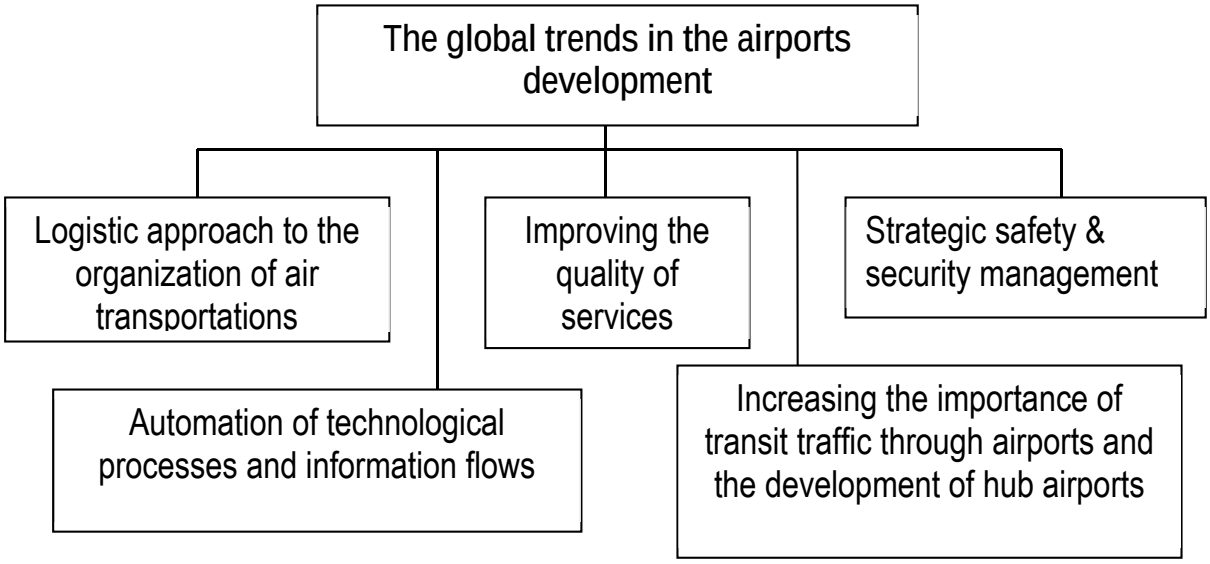

Figure 1 - The main trends in the development of airports around the world
Source: developed by the author.

However, to take full advantage of logistics we need:

1) to improve the legislative and regulatory framework - need to clarify and adjust transport and customs mechanisms and procedures for registration of goods when crossing borders, mechanisms to ensure optimal through tariffs, etc .;

2) make changes to the terminal technologies and technical base used in the service of modern international transport, in particular at airports. Airports should be considered as logistics centres;

3) strengthen operational control over the transportation process, which should involve modern electronic, communication and information technologies. Such technologies will increase the safety, reliability of transportation, possession of reliable information about the movement of goods on the route.

Logistics tasks should be considered in combination with a systematic approach. The system approach involves the coordination of information, resource characteristics and reliability characteristics in the interaction of all participants in the air system, which are related to a single goal - the organization of efficient air transportation. The fundamental difference between the logistical approach to the management of the transportation process from the traditional one is the integration of all participants in the transportation process and individual links in the transportation chain into a single system (Fig. 2). In the diagram, the airport acts as a transport hub or, in other words, a logistics center. The main processes at the airport are loading and unloading, passenger, luggage,

mail and cargo. All activities related to these processes must be performed quickly and in a timely manner to ensure a short waiting time and transfer, and to take place during the short stay of the aircraft on the ground, as well as to ensure the efficient operation of the entire transportation system. Airport operations services should coordinate and optimize the activities of various companies and organizations involved in the implementation of flights, as well as provide them with appropriate assistance. All organizations involved, although they can compete with each other, must work closely with each other to ensure a high standard of service quality.

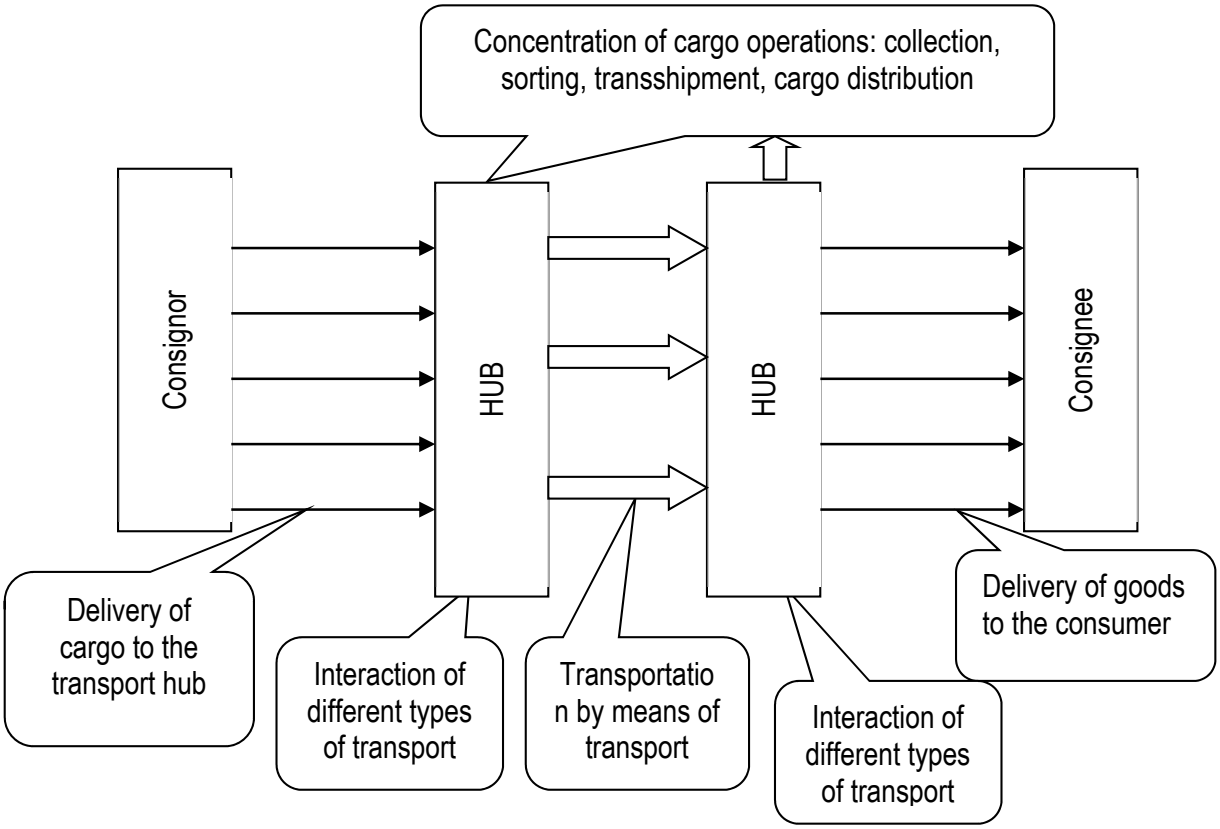

Figure 2 - Logistic approach to the cargo transportation organization
Source: developed by the authors.

Among the effective methods of solving problems of transport logistics should be singled out the method SCM (Supply Chain Management) - supply chain management. SCM is a highly interactive, integrated and systematic approach, which together with the information support system helps to solve the tasks of coordination, planning and management of processes of supply, warehousing and transportation.

The organization of transport and logistics processes within the SCM is based on the consideration of the entire supply chain, which unites several enterprises through information technology. The significant potential that different supply chain management options have today can also be used at airports. The systematic combination of all processes between enterprises in the value chain contains integrated information on all activities within the logistics chain - from forecasting the needs of shippers, distribution of orders and transportation [11].

The application of the supply chain management method involves the establishment of schedules of transportation. Customers (shippers) coordinate delivery schedules with freight forwarding companies;

freight forwarding companies coordinate their activities with airport terminal complexes, specifying the scope of loading and unloading operations, inform airlines about the planned amount of cargo, its type and properties.

Supply chain management allows satisfy the economic interests of all participants in the transportation process (Fig. 3).

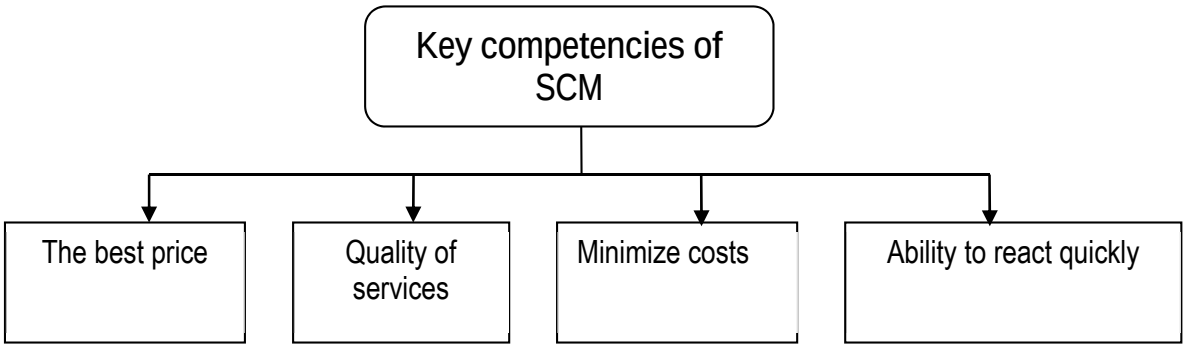

Figure 3 - Elements of the SCM method
Source: developed by the authors.

During transportation, the information flow passes through various subjects of the transport market (Fig. 4). The task of logistics is to ensure that the movement of information so that each entity has the necessary information to fully perform its functions.

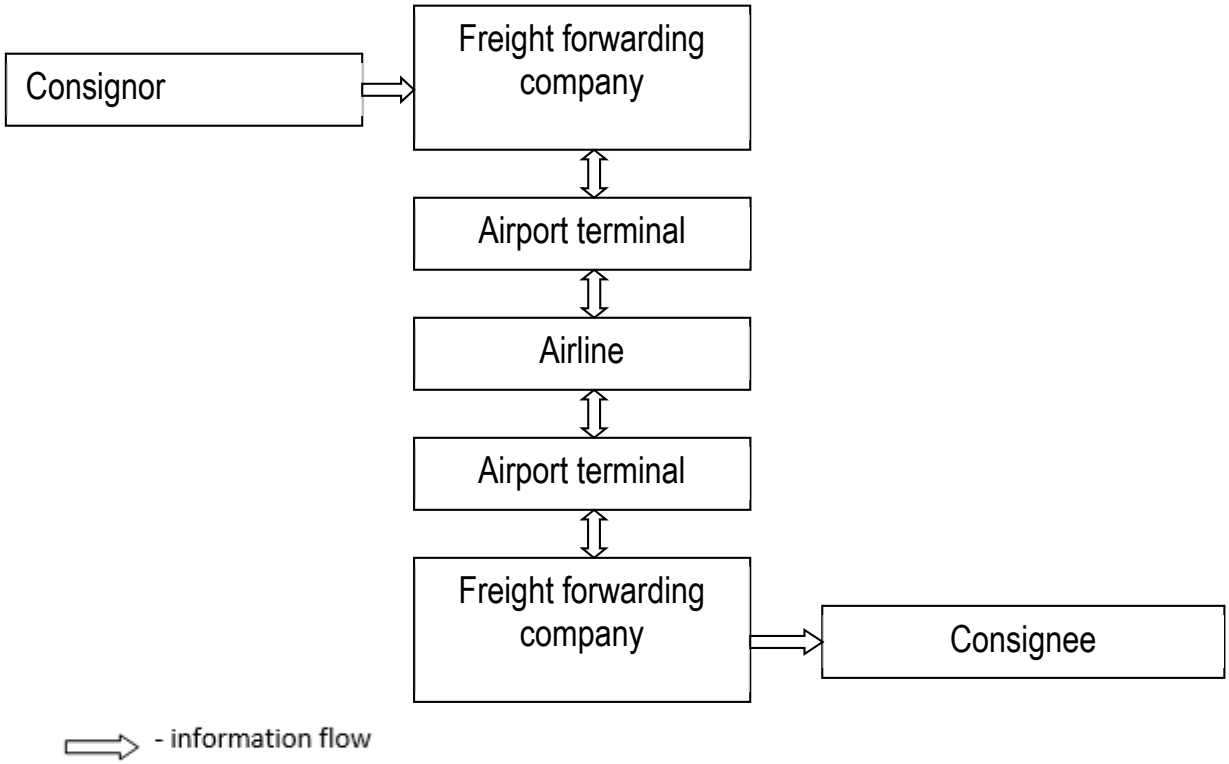

Figure 4 - Movement of information between transport market participants
Source: developed by the authors

SCM is used by airports and airlines for a large number of transfer services. In this case, it is extremely important to coordinate their activities to fully meet customer requirements. When organizing connecting flights, where efficiency, speed and coherence of actions are required, the use of SCM becomes necessary, as SCM allows considering and taking into account a large number of actions in the process of joint activities both within and outside the organization (Fig. 5). The transportation process at SCM is not divided into sections performed separately by the airline, separately by the airport, separately by land modes of transport, handling companies, but is considered as a single process.

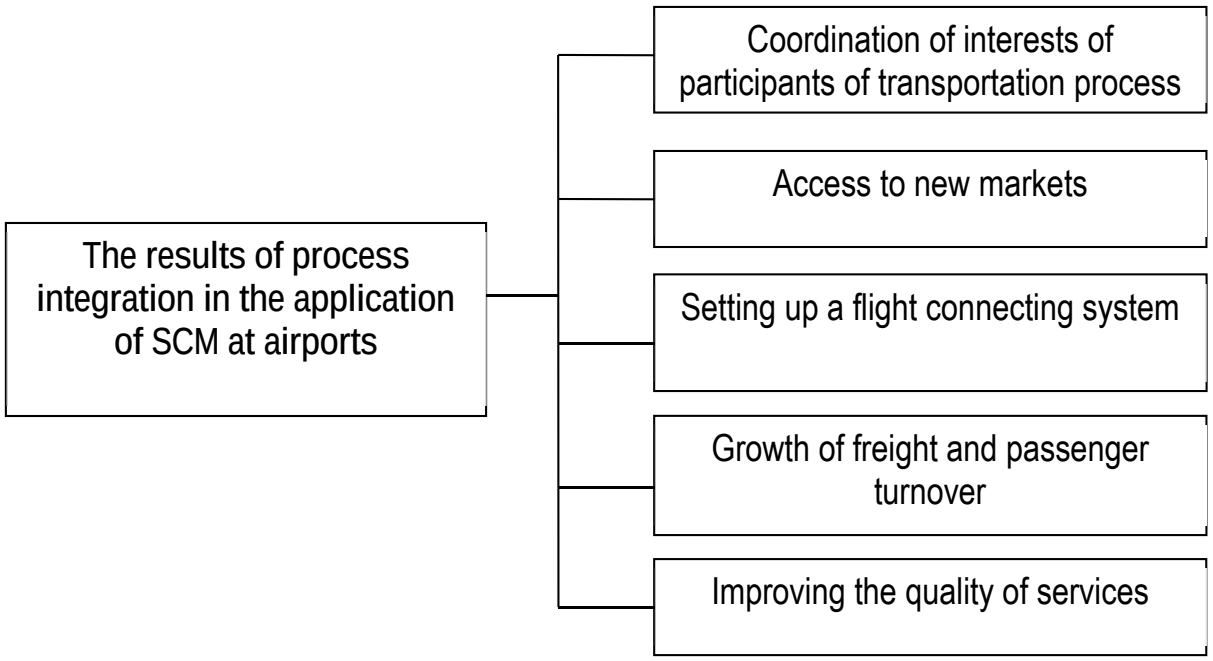

Figure 5 - Results of SCM principles application
Source: developed by the authors

The main results of SCM application:

1) a single focus on the process of planning and managing all flows (information, transport, material, financial) throughout the value chain;

2) integration of all partners in the chain and creation of common strategic objectives;

3) elimination of information barriers between the agreed areas of planning, management and creation of tools for modern information and communication systems (networks) to ensure uninterrupted and end-to-end movement of information flow in accordance with market needs.

SCM implementation involves identifying the supply chain participants with whom it is important to establish links, the processes to be associated with each key actor, and the types or levels of integration for each process. SCM's goal is to achieve maximum competitiveness and profitability of the company, including the end user. That is, the integration and reengineering of supply chain processes should be aimed at improving the efficiency of all participants in the system.

Thus, air supply chain management is the integration of key business processes that cover the transportation process. The use of SCM is especially effective not only in the organization of airports or airlines - within one

company, but by all participants in the transport. In order to use SCM technologies and successfully implement them in the system of cooperation of transport market participants, it is necessary to determine the general goals and potential of enterprises, to build a system of mutual enterprise.

Reconciling the interests of transport market participants in the process of air transportations

Different types of transport that participate in the transportation process, interact and complement each other. Execution of the transportation process is based on the coordinated work of all participants in the transportation process, including both transport organizations and shippers, consignees and reduce downtime at transshipment points. The transport process includes not only the movement of goods from sender to recipient, but also the performance of loading and unloading and forwarding services. According to the classic firm, the key economic interests of enterprises are associated with maximization or profit (from the theory of income of the time factor - net income). Economic interest is manifested in increasing profits and (or) guaranteeing a stable position in the market (in uncertain conditions of survival) when considering the long term, in the short term it can be supplemented (replaced) by the volume of work.

The relationship between transport organizations, shippers, consignees and intermediaries should be used from the standpoint of the logistics system, as a complex organizational economic system consisting of interdependent elements, the set of which, boundaries and objectives are combined internal and external purposes. Elements of the logistics system are: airlines, airports, airline agents and partners, partner organizations of airlines and service airports, freight forwarders, customs brokers and service providers. The various elements of the logistics system affect the growth of the variety and complexity of the relationship between them and the content of their economic interests. But it should be aimed at a single global goal - the implementation of the entire system for the client with minimal time and minimal financial costs [11].

Legal regulation of the interaction of enterprises involved in the transportation and trade of goods carried out at the national and international levels. At the national level, it is state regulation. These include: licensing and certification of airlines, airline sales agents, issuing licenses for brokerage and warehousing activities, etc.

At the international level - bilateral conditions between the relevant agencies of the contracting states, the provisions of international air and trade law, the recommendations of various intergovernmental and international non-governmental organizations.

Relations between airports and airlines, airlines and intermediaries of economic companies and intermediaries are regulated by bilateral commercial international agencies that provide the opportunity to sell transportation, the system city for mutually provided services, liability of the parties and dispute resolution. At the same level, relations with the freight clientele are regulated.

Economic factors influencing the interaction of transport market participants:

managed - market demand, competition, machinery and technology, general air transport infrastructure;

unmanageable - the state of the world air transport market, the state of macroeconomics, the level of scientific and technological progress in all fields, demographic factors, natural and geographical features of countries and regions, socio-economic level of development of individual countries, military and social conflict, natural disasters [11].

The state is not a direct participant in the transportation process, but requires effective organization of transportation. The state not

only sets requirements for transportation, but can also stimulate and encourage participation in the transportation process (for example, by reducing toll airports).

Interests of the state: meeting the needs for quality air transport services; protection of trade and economic interests of the country (tariff and non-tariff regulation, customs regulation); increase in budget revenues due to cash deductions and tax deductions; ensuring the development of a competitive situation in the air transportation market and protection of the population of the air transportation market; ensuring the country's competitiveness in the world economy, economic and other security of the country; creation of stable conditions for the development of enterprises in the aviation industry and air transport.

Satisfied customer interests are of the utmost concern to all participants in transportation. The main interests of clients: establishment of the economic substantiation of tariffs for air transportation at guaranteed maintenance of safety of transportation; minimization of costs of delivery time of cargo at maintenance of its full safety; guarantees of compensation for losses in case of delay or relocation of flights due to various reasons; in case of damage or lack of cargo when reloading it from one mode of transport to another; reduction of persons of documents which are issued; simplification of the procedure of tariff and non-tariff regulation, reduction of customs and other duties; providing real-time download information.

Interests of airlines: meeting market needs, conquering new markets as a result of increasing carrying capacity; brand strengthening and development; increase in profits, including through the development of a separate service; providing information support along the entire route of the cargo; reduction of operating costs; observance of safety norms and control of the accepted cargo on danger; simplification of document circulation with the use of acceleration of cargo handling at transit points; development of e-commerce.

Interests of airports: increase of efficiency of processing of cargoes with use of minimization of expenses and increase of profit; compliance with safety requirements; compliance with the requirements of state bodies when crossing the border and joint planning of the transport process with the warehousing process; ensuring the technological unity of the transport and warehousing process and the definition of rational delivery routes [11].

Interests of warehousing complexes: increase of capacity according to efficiency of cargo processing with use of minimization of expenses and increase of profit; introduction of modern means of automation of warehousing processes; introduction of cargo handling and tracking systems; introduction of services such as repackaging, labeling, etc.

Interests of customs brokers: access to information; transition to electronic document management; reduction and increase of profit; simplification of formalities at customs posts.

Interests of forwarding agencies: development of end-to-end service (door-to-door delivery) and establishment of a partner network; increase increase in orders; strengthening the brand and conquering new markets; simplification of document flow and development of a single information field within the logistics system; increase profits and reduce operating costs; reduction of transit time of cargo passage; risk reduction deficiency.

Moving the load of the logistics system is the result of making some of our decisions and performing a set of technological operations. The effectiveness of a set of real business processes depends on the degree of coordination of the interests of transportation

participants. Reconciliation of interests is a process of coordination, combination of actions of subjects that provides support of stability of logistic system and achievement of the maximum effect. The creation of a logistics center and strengthen the process of reconciling the interests of transport market participants create conditions for the effective realization of interests (Fig. 6).

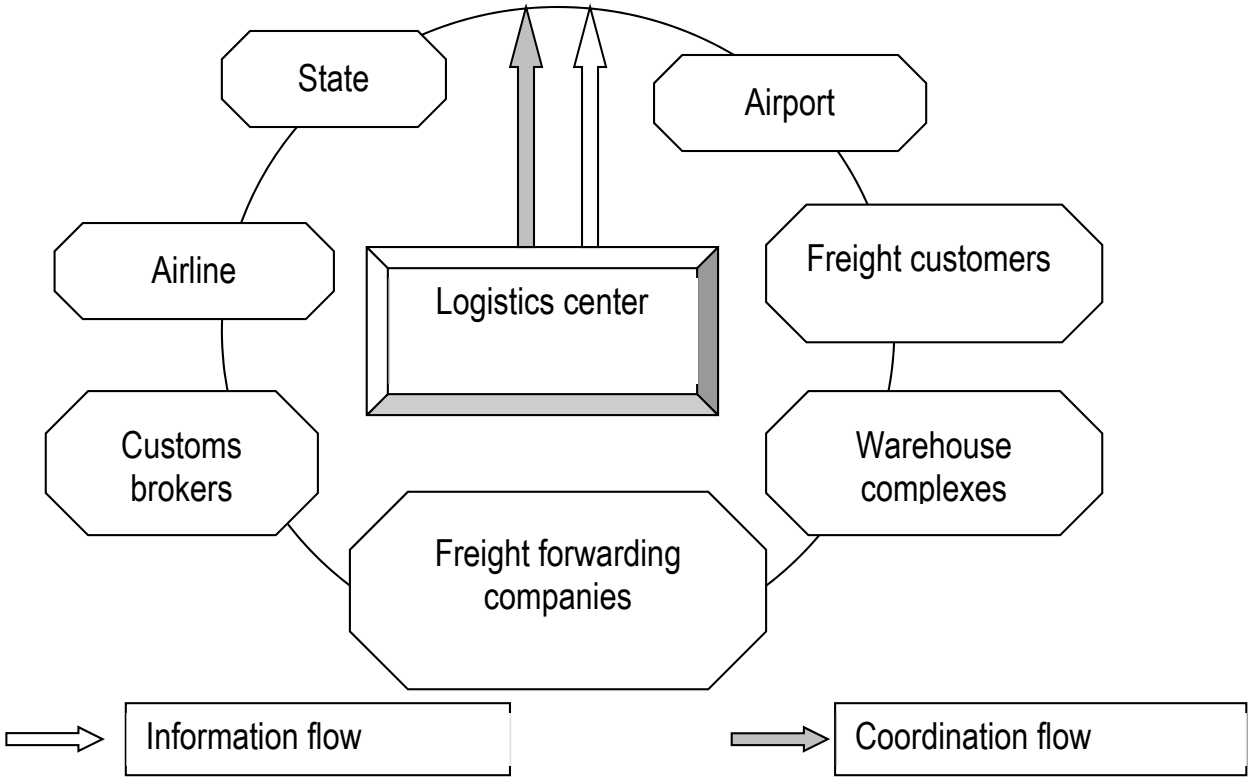

Figure 6 - The place of the logistics center in the coordination of economic interests
Source: developed by the authors

The creation of a logistics hub on the basis of the airport will allow to ship goods over long distances and to develop multimodal transportation of passengers and cargo using air transport.

The main functions of the logistics center: coordination of the elements of the logistics system in order to ensure a single technological process in the node; coordination of economic interests; information flow management; formation of harmonious and productive relations between all participants in the transport process.

An effective mechanism for reconciling economic interests should include the following elements:

– cooperation and integration to achieve a common goal;

– development of an effective mechanism for resolving disputes;

– creation of a managing logistics center;

– equal access to information and transition to a single information field (electronic document management, standardization of data transmission);

– creation of effective state and international governance with regulatory procedures and mechanisms for resolving market access issues, disputes and conflicts;

– development of the transport industry in accordance with the trends of the world economy;

– ensuring the feasibility of interaction, based in part on the material interest of all participants in an effective incentive mechanism, which provides for the optimal distribution of the effects of interaction.

An important condition in satisfying their own interests and the interests of partners is to maintain the quality of transport services (Fig. 7).

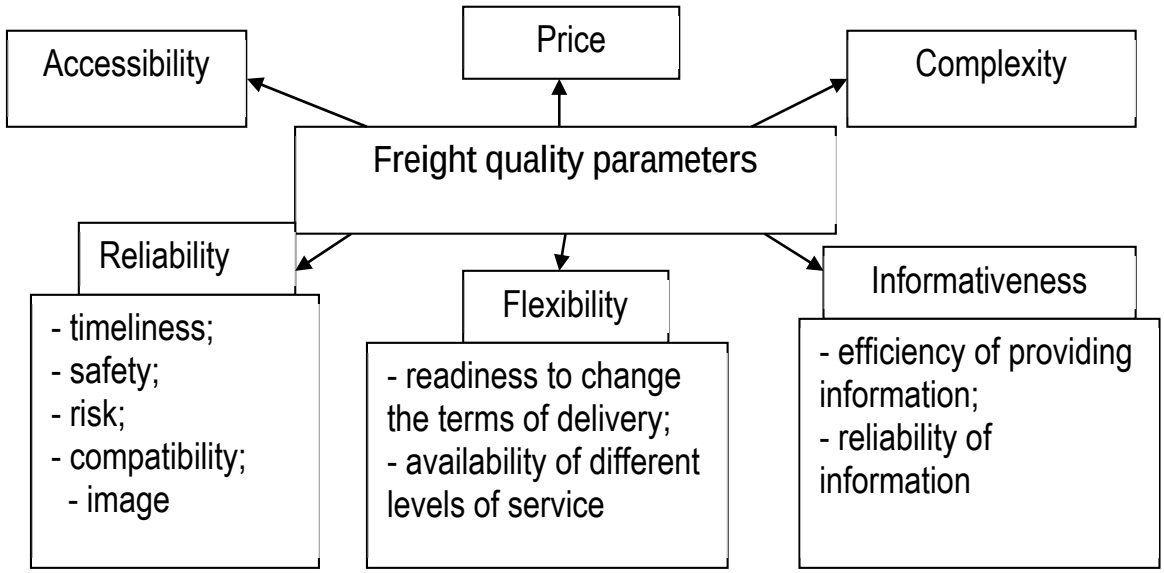

Figure 7 - Components of the quality of freight
Source: developed by the author

Quality is a set of properties and characteristics of services that provide the ability to meet specified requirements and needs. The quality of the delivery system depends not only on the level of quality of each of its participants, but also on the degree of synchronization of their interaction in the customer service process. Under the interaction of participants in the delivery system should be understood as the presence of certain types of connections that are found in the implementation of the function of the system.

Conclusions. Strategic management of airport efficiency and safety in the process of ensuring the implementation of international air and multimodal logistics is one of the main components of sustainable development of the air transport industry. The study of theoretical aspects of interaction of transport market participants allowed to determine the main directions and principles of interaction of airports with their partners, based on a systematic approach, anticipation, adaptation, continuous improvement of interaction technologies. The system approach involves the harmonization of information, resource characteristics and reliability characteristics in the interaction of all participants in the air system, which are related to a single goal - the organization of efficient and safe air transportation. Cooperation of transport market participants, as well as any other enterprises, is based on economic interest, which is formed as a result of joint activities.

References

1. Aviation Benefits Report 2019. The Industry High Level Group (IHLG). 2019. 76 p. URL: https://www.icao.int/sustainability/Documents/AVIATION-BENEFITS-2019-web.pdf.

2. IATA. WATS World Air Transport Statistics 2021. URL: https://www.iata.org/contentassets/a686ff624550453e8bf0c9b3f7f0ab26/wats-2021-mediakit.pdf.

3. D. Bugayko, Yu. Kharazishvili. Theoretical principles of strategic aviation safety management in the context of ensuring sustainable development of the national economy. Bulletin of Economic Science of Ukraine. 2020. № 1 (38). P. 166-175. Institute of Industrial Economics of the National Academy of Sciences of Ukraine, Academy of Economic Sciences of Ukraine.

4. D.Bugayko, Yu. Kharazishvili, M.Hryhorak, Z.Zamiar. Economic Risk Management of Civil Aviation in the Context of Ensuring Sustainable Development of the National Economy. Logistics and Transport– Wroclaw: International School of Logistics and Transport in Wroclaw. – 2020. - №1-2(45-46). – P.71– 82.

5. Yu Kharazishvili, D Bugayko, V Lyashenko, V Sokolovskiy, V Baranov. Strategizing for sustainable development of transport systems in the safety dimension. IOP Conference Series: Earth and Environmental Science. IOP Publishing. P. 012025.

6. D.Bugayko. Safety and Effectiveness of Civil Aviation in Conditions of Air Traffic Globalization. Proceedings the fifth World Congress «Aviation in the XXI-st century»,«Safety in Aviation and Space Technologies. 2012. p. 25-27.

7. Dmytro Bugayko, Yuliya Ierkovska, Fariz Aliev, Danylo Bugayko. Modern challenges of air transport: safety, regulations, operations and infrastructure. Intellectualization of Logistics and Supply Chain Management. The electronic scientifically and practical journal v.11 (2022). P.15 – 28. ISSN 2708 -3195. https://smart-scm.org.

8. Dmytro Bugayko, Yuliya Ierkovska. Institutional Measures of Air Transport Safety Strategic Management at the Level of State Regulation. Intellectualization of Logistics and Supply Chain Management. The electronic scientifically and practical journal v.9 (2021). P.6 – 19. ISSN 2708 - 3195. https://smart-scm.org.

9. Dmytro Bugayko, Yuliya Ierkovska, Fariz Aliev, Mariia Bahrii. The Concept of National Integrated Risk Management of Aviation Transport of Ukraine. Intellectualization of Logistics and Supply Chain Management. The electronic scientifically and practical journal v.10 (2021). P.6 – 18. ISSN ISSN 2708-3195 https://smart-scm.org.

10. Bugayko, D., Isaienko, V., Hryhorak, M., Zamiar, Z. Ecosystem Approach to the Formation of Goods Express Delivery Supply Chains in Aviation Logistics. Logistics and Transport, 45 (2020), P.19-42.

11. Bugayko D.O., Tereshchenko A.V. Interaction of transport market participants in international airports. Science-intensive technologies. 2009. № 2. pp. 29-32.

12. Bugayko D.O., Tereshchenko A.V. The development of airports in the context of the globalization of the economy. Current problems of global processes in the world economy: Proceedings of scientific and practical conference. 2007. P.20-21.

UDC 311.3:330.4:332.1+711:519.7:658.8
JEL Classification: C50, C53, M31, O18, R10.
DOI: https://doi.org/10.46783/smart-scm/2022-12-2
Received: 12 March 2022

Hryhorak M.Yu. Doctor of Economics, Associate Professor, Senior Research Fellow in Institute of Cybernetics of the National Academy of Sciences of Ukraine (Ukraine)

ORCID – 0000-0002-5023-8602
Researcher ID –
Scopus author id: 57208222758

Zaloznova Yu. Corresponding Member of the NAS of Ukraine, Doctor of Economics, Professor, Director (Head), Institute of Industrial Economics of the National Academy of Sciences of Ukraine (Ukraine)

ORCID – 0000-0003-3106-1490
Researcher ID –
Scopus author id: – 57202317183

Trushkina N.V. PhD (Economics), Senior Research (, Senior Research Fellow, Department of Regulatory Policy and Entrepreneurship Development Institute of Industrial Economics of the National Academy of Sciences of Ukraine (Ukraine)

ORCID – 0000-0002-6741-7738
Researcher ID – C-1441-2018
Scopus author id: – 57210808778

MODELING AS A TOOL OF STRATEGIC DEVELOPMENT OF THE REGIONAL LOGISTICS SYSTEM

Hryhorak Mariia, Zaloznova Yuliya, Trushkina Nataliia. «Modeling as a tool of strategic development of the regional logistics system». *The article examines the influence of the main factors of production on the development of the regional logistics system (on the example of the Black Sea economic region). Forecast estimates of factors of production are made and models of economic growth of the logistic system of the region with the use of economic and mathematical tools are developed. Based on the calculations, a conclusion was made about the inefficiency of the use of the main factors of production. This has led to a decline in freight traffic across the logistics system.*

The analysis of the impact assessment of the main factors of production and their efficiency makes it possible to develop strategic directions for the development of the transport and logistics system while taking into account certain regularities. A more detailed analysis of directly unidentified factors that determine the scale effect, including those mentioned above, and factors related to the implementation of modern innovation, green, digital technologies and the assessment of opportunities to enter international markets, formation of qualitatively new marketing strategies and cluster model of logistic activity in the Black Sea economic region.

***Keywords**:* regional economy, logistics system, features, patterns, trends, strategic development, strategizing, factors of production, tools, statistical analysis, modeling, models of economic growth, forecasting, economic and mathematical methods.

Григорак Марія, Залознова Юлія, Трушкіна Наталія. «Моделювання як інструмент стратегічного розвитку регіональної логістичної системи». *У статті досліджено вплив основних факторів виробництва на розвиток регіональної логістичної системи (на прикладі Чорноморського економічного району). Зроблено прогнозні оцінки факторів виробництва та розроблено моделі економічного зростання логістичної системи регіону з використанням економіко-математичного інструментарію. На основі проведених розрахунків зроблено висновок про неефективність використання основних факторів виробництва. Це призвело до зниження вантажоперевезень у логістичній системі.*

Аналіз оцінки впливу основних факторів виробництва та їх ефективності дає змогу розробити стратегічні напрями розвитку транспортно-логістичної системи з урахуванням певних закономірностей. Більш детальний аналіз безпосередньо неідентифікованих факторів, що визначають ефект масштабу, у тому числі згаданих вище, та факторів, пов'язаних із впровадженням сучасних інновацій, зелених, цифрових технологій та оцінкою можливостей виходу на міжнародні ринки, формуванням якісно нових маркетингових стратегій та кластерна модель логістичної діяльності в Чорноморському економічному регіоні.

Ключові слова: регіональна економіка, логістична система, особливості, закономірності, тенденції, стратегічний розвиток, стратегування, фактори виробництва, інструменти, статистичний аналіз, моделювання, моделі економічного зростання, прогнозування, економіко-математичні методи.

Григорак Мария, Залознова Юлия, Трушкина Наталья. «Моделирование как инструмент стратегического развития региональной логистической системы». *В статье рассматривается влияние основных факторов производства на развитие региональной логистической системы (на примере Черноморского экономического района). Выполнены прогнозные оценки факторов производства и разработаны модели экономического роста логистической системы региона с использованием экономико-математического аппарата. На основании расчетов сделан вывод о неэффективности использования основных факторов производства. Это привело к снижению грузопотока в логистической системе.*

Анализ оценки воздействия основных факторов производства и их эффективности позволяет разработать стратегические направления развития транспортно-логистической системы с учетом определенных закономерностей. Более детальный анализ непосредственно не выявленных факторов, определяющих эффект масштаба, в том числе упомянутых выше, и факторов, связанных с внедрением современных инновационных, зеленых, цифровых технологий и оценка возможностей выхода на международные рынки, формирование качественно новых маркетинговых стратегий и кластерная модель логистической деятельности в Черноморском экономическом районе.

Ключевые слова: региональная экономика, логистическая система, особенности, закономерности, тенденции, стратегическое развитие, стратегирование, факторы производства, инструменты, статистический анализ, моделирование, модели экономического роста, прогнозирование, экономико-математические методы.

Introduction. The strategic task of managing economic systems in the regions of Ukraine is to improve the quality and accessibility of transport and logistics services, taking into account internal and interregional ties. This can be achieved by

modernizing the transport infrastructure and creating transport and logistics clusters as the "core" of the regional logistics system in the context of intensive development of the single European transport space. This is in line with the EU-Ukraine Association Agreement, which aims to develop a multimodal logistics network linked to the Trans-European Transport Network (TEN-T) and to improve regional policy to better identify and evaluate the effectiveness of infrastructure projects for different types of transport.

Literature and researches review. The study of issues related to the development of scientific approaches (systemic, integrated, logistics, etc.) in the theory of supply chain management and organization of logistics processes are: A. Beresford, S. Pettit, W. Whittaker [1]; A. Gunasekaran [2]; L. Huemer [3]; P. Blaik [4]; P. Kotler, K. Keller [5]; P. Murphy, D. Wood [6]; D. Bowersox, D. Closs [7]; H. Dźwigoł [8-9]; A. Kwilinski [10-11]; Ye. Krykavskyi et al. [12-14].

Theoretical and methodological provisions and practical recommendations for the formation of transport and logistics clusters are reflected in the work of scientists, in particular: J. Zrobek [15]; M. Szuster [16]; M. Kruczek, Z. Zebrucki [17]; M. Frankowska [18]; R. Dmukhovski [19]; S. Hrytsenko [20].

Much attention is paid to domestic and foreign researchers (V. Lyashenko, S. Ivanov, Yu. Kharazishvili [21-23]; O. Nykyforuk, O. Stasiuk, L. Chmyrova, N. Fediai [24-26]; S. Ilchenko, H. Karpenko [27], A. Kwilinski [28]) is devoted to the development of theoretical and methodological and applied principles of forming a management system for balanced development of the market of logistics services as part of the national logistics system; identifying areas for improving the efficiency of transport and logistics activities and key tasks and priorities for the development of the transport sector in Ukraine; evaluation of indicators of innovative development of the transport system of Ukraine to substantiate strategic guidelines; identification of global trends in digitalization, which include the use of big data and cloud technologies, the spread of the Internet of Things, the development of robotics, the spread of 3D printing, blockchain technology and crowdsourcing; development of a functional scheme of digital transformation of the transport sector in Ukraine; substantiation of conceptual provisions of the strategy of development of the transport system of Ukraine and measures of the state policy of its realization.

Scientists (O. Bakaiev, L. Bazhan, L. Kaidan et al. [29]; M. Denysenko, P. Levkovets, L. Mykhailova [30]; A. Kolomytseva, V. Yakovenko [31]; Yu. Goncharov, G. Kostyuk [32]; R. Korobskyi, R. Snihur [33]; N. Volosnikova [34]; O. Korniyetskyi [35]; V. Sysoiev [36]; Ye. Aloshynskyi, V. Meshcheriakov, H. Rudenko [37]; Z. Sokolovska, V. Andriienko, I. Ivchenko et al. [38]; Yu. Taranenko, I. Fedorenko [39]; V. Vostriakova [40]; H. Prymachenko, K. Yasenovskaya [41];V. Khoroshun, I. Naumenko [42]; I. Ivchenko, B. Pietukhov [43]; N. Potapova [44]; N. Makarenko [45]; V. Samostian [46]) have proved that the theory and practice of logistics systems require the involvement of various economic and mathematical and statistical tools for modeling, continuous forecasting, control and operational management of material, financial, information, transport flows and optimization of their movement.

I. Sakunova [47] considered the choice and practical application of means of formal description of material and information flows of logistics systems as universal algorithmic schemes that have a theoretically sound conceptual basis and take into account the stochastic nature of real systems.

Approaches to organizational modeling of logistics processes are analyzed and an improved method of distribution of organizational support for the functioning of logistics systems of enterprises is proposed, which includes conceptual, content, technological and reflective-evaluation

components (T. Kolodizeva, A. Panasyants [48]).

Necessity and expediency of modeling business processes of industrial enterprise are substantiated, recommendations on introduction of logistic management in its activity are given, the theoretical and applied model of target function of logistics of industrial enterprise is resulted (R. Larina, O. Lukyanova [49]).

At the same time, the scientific literature does not sufficiently study the impact of the main factors of production and their efficiency on the development of logistics systems in Ukraine, taking into account regional characteristics.

Aim and objectives. The purpose of this article is to develop models of economic growth of the regional logistics system using economic and mathematical tools (on the example of the Black Sea economic region).

The methodological basis of this study are: statistical analysis, economic and mathematical methods, factor models of the production function, forecasting methods, generalization.

Results, analysis and discussion. Economic growth of the logistics system is seen as long-term sustainable development, which is determined by the increase in production. The real economic growth of this system is primarily due to its production capacity and the main factors of production – the resources of living and materialized labor.

Mathematical models of economic growth [50-56] reflect the logical model that characterizes economic growth as a process of combining the main factors of production. The essence of factor models of economic growth is to determine the quantitative relationships between the volume and dynamics of production and the volume and dynamics of factors of production. The most common form of models of economic growth are two-resource and multi-resource production functions of the following type:

two-resource

$$\hat{y}_t = AK^{\alpha}L^{\beta} \quad (1)$$

multi-resource

$$\hat{y}_t = AK^{\alpha}L^{\beta}e^{\gamma t} \quad (2)$$

$$\hat{y}_t = AK^{\alpha}L^{\beta}e^{\gamma x t} \quad (3)$$

where

$\hat{y}_t$ – production volumes;

K – volumes of capital investments;

L – average annual number of employees;

x – a factor of scientific and technological progress and innovation;

t – time factor;

α, β – parameters of economic efficiency of the use of factors of production in ensuring economic growth; coefficients of elasticity;

γ – growth rates of production volumes as a result of the influence of unidentified factors (institutional, scientific and technical, innovation, logistics [57-63], market, marketing [64-67], investment and financial, environmental, information, etc.).

Approbation of models of economic growth of the regional logistics system [68-72] (in this case on the example of the Black Sea economic region) is carried out on the basis of indicators of changes in production volumes and factors of production for 2012-2020, which are given in Table 1.

Table 1 – Changes in the volume of cargo shipments by the logistics system of the Black Sea region and the main factors of economic development

Years	Volumes of cargo transportation by rail, road and sea ports *(y)*, *million tons*	Capital investments (in actual prices) *(K)*, *million UAH*	Average number of full-time employees *(L)*, *thousand people*
2012	198.1	4043.1	101.3
2013	197.0	2912.8	96.3
2014	198.3	3333.4	94.3
2015	205.9	3614.8	90.7
2016	201.3	4586.4	92.1
2017	206.7	5390.0	91.4
2018	219.8	5519.8	91.2
2019	218.2	5346.3	90.1
2020	216.5	4958.8	89.0

Source: compiled and calculated based on statistical information materials of the State Statistics Service of Ukraine and the Main Departments of Statistics in Mykolayiv, Odesa and Kherson regions.

The two-factor model of the production function is as follows:

$$\hat{y}_t = 530.185 \cdot K^{0.091} \cdot L^{-0.378}; \quad (4)$$

$$D_{y,K,L} = 0.661; \ \varepsilon_{відн.} = 1.6\%; \ F_p = 9.8;$$

$$F_\alpha \begin{Bmatrix} \alpha = 0.1 \\ V_1 = 1 \\ V_2 = 5 \end{Bmatrix} = 3.9; \ F_p > F_\alpha$$

The statistical reliability and accuracy of the model ensure the objectivity of meaningful conclusions on the assessment of the impact of factors of production. For example, the value of the parameter α =0.091 indicates that each percentage increase in capital investment is accompanied by an increase in production by 0.091%. For the entire period from 2012 to 2020, there was a fairly low level of capital investment efficiency. In our opinion, this is due primarily to the fact that about 90% of the annual investment was invested in those facilities or processes that have a fairly long level of payback, or not directly related to the expansion of production capacity logistics system.

In the conditions of 2014-2020, due to the significant disruption of transport links and connections with Russia, such a low level of efficiency can be associated with both small capital investments and the loss of significant volumes of traffic.

The coefficient of elasticity of the factor that determines the cost-effectiveness of living labor β =–0.378, ie determines, at first glance, the feedback.

But given that the factor L (average number of full-time employees) has a declining trend, its meaningful interpretation will be as follows: each percentage decrease in the number is accompanied by an increase in production by 0.378%, i.e. this increase is due to increased productivity.

However, in general ($\alpha+|\beta|=0.091+0.378=0.469$<1) shows that the transport and logistics system has developed a deintensive rate of economic growth.

The identified two-factor model of economic growth (4) can be used for forecast estimates of output for the short term (until 2023), provided, first, maintaining the levels of efficiency in the use of production resources, which developed in 2012-2020 (= 0.091; = -0.378), then, secondly, the tendency to change directly the resources of production.

Forecast estimates and optimal models of their approximation are given in Table 2. According to forecast estimates, in three years (as of 2023) the volume of shipments by the logistics system may increase to 223.7 million tons, ie only by 3.3%. This assessment of development prospects is quite pessimistic – in practice, the system may enter a period of stagnation, but not development. To identify the reasons and conditions for overcoming such a pessimistic outlook, it is necessary to further determine the factors that ensure economic growth.

Based on the identified model, economic growth can be broken down into components - as a result of the efficiency of factors of production ($\overline{T}_{KL}$) and due to the scale of production, which accumulates the influence of all factors not included in the model ($T_{масшт.}$):

$$\overline{T}_{KL}=\sqrt[(\alpha+\beta)]{T_K^{\alpha}\cdot T_L^{\beta}} \tag{5}$$

$$\overline{T}_{y}=\overline{T}_{KL}\cdot\overline{T}_{масшт.};\ \ \overline{T}_{масшт.}=\frac{\overline{T'}_{y}}{\overline{T}_{KL}} \tag{6}$$

Table 2 – Forecast estimates of factors of production and models for their determination

Factors of production	Forecasting model, relative approximation error ($\varepsilon_{відн.}$)	Fact 2020	Forecast values of the indicator by years		
			2021	2022	2023
Capital investments (K), *UAH million*	Integrated auroregression model of Box-Jenkins; $\varepsilon_{відн.}=5.7\%$	4958.8	5036.2	5114.7	5194.5
Average number of full-time employees of enterprises in the field of transport and warehousing (L), *thousand people*	Integrated auroregression model of Box-Jenkins; $\varepsilon_{відн.}=1.5\%$	89.0	88.0	87.0	86.1
Volumes of cargo shipment by the logistics system ($\hat{y}_t$), *million tons*	Model of production function: $\hat{y}_t=530.185\cdot K^{0.091}\cdot L^{-0.378}$	216.5	218.9	221.4	223.7

Source: compiled and calculated by the authors

Statistical methods of modeling time series are based on the definition of the initial components that form the change of levels of time series. In most cases, the levels of time series (y_t) can be represented as the sum of components that reflect the regularity and randomness of the laws of development:

$$y_t = f_{(t)} + V_t + S_t + \varepsilon_t, \qquad (7)$$

where

$f_{(t)}$ – long-term development trend, which is determined by time or previous levels;

V_t – periodic component;

S_t – seasonal component;

ε_t – random component.

In turn, the formation of long-term or deterministic evolution of development is determined by the laws of three types: the inertia of development, the inertia of the relationship between successive levels and the inertia of the relationship between the indicator under study (y_t) and external factors. The determined regularities are modeled on the basis of trend models (inertia of development), autoregressive (inertia of interrelation between successive levels) and regressive (paired or multiple) in the presence of external factors [54].

According to the meaningful analysis of time series, which assess the change in turnover, we can assume that the main components of the formation of trends are related to two components – the inertia of development and the inertia of the relationships between successive levels. Under these conditions, trend and mixed autoregressive models are used to model time series. When applying trend models, the parameters are unchanged for the entire period for which the values of the levels are given.

But with a fairly long period of observation, and especially if the external conditions for the formation of time series levels change significantly, it is reasonable to assume that the parameters of the models can change throughout the period. In this case, the original trend models can be represented as follows. For example, a linear trend is used to model the main trend: $\hat{y}_t = a_0 + a_1 t$. In turn, we assume that the parameter also changes annually by a linear function, i.e. $a_1 = b_0 + b_1 t$. Then the general trend model of this series of dynamics will correspond to the parabolic model of the following form:

$$\hat{y}_t = a_0 + (b_0 + b_1 t)t = a_0 + b_0 t + b_1 t^2 \qquad (8)$$

Modeling of the autoregressive component in most cases is based on the use of integrated autoregressive models – Box-Jenkins model or ARIX model and OLYMPUS model as a modified version of ARIX/ARMA model [50-56].

The choice of the optimal variant is based on the combination of the meaningful analysis of the model parameters and the formal approximation criteria by the following combination of them:

least value of least squares criterion – $min \sum (y_t - \hat{y}_t)^2$,

the smallest value of the relative error of the approximation – $min\, \varepsilon_{відн.}$, thus $\varepsilon_{відн.} \leq 15{,}0\%$;

the greatest value of the Fischer-Snedekor criterion, thus $F_p > F_\alpha$, where:

y_t – calculated (theoretical) values of the levels of a number of dynamics;

t – serial number of the year; $t = \overline{1,n}$;

n – length of observation period;

F_p, F_α – respectively, the estimated and tabular value of the F-criterion;

α – the level of reliability of the model.

According to the above algorithms, the estimated estimates of all indicators of freight turnover of the Odessa Railway and road transport are given in Table 3.

Table 3 – Forecast models and forecasting results for 2021-2023

Indicator, symbols	Optimal model of approximation ($\varepsilon_{відн.}$)	Fact 2020	Forecast values of the indicator by years		
			2021	2022	2023
Railway transport – Odesa railway					
Shipment of goods (y_1), *million tons*	Parabolic trend: $\hat{y}_1 = 25,55 + 0,572t - 0,011t^2$; $\varepsilon_{відн.} = 6,6\%$; $F_p = 28$	31.9	32.2	32.3	32.4
Freight turnover (y_2), *billion tkm*	$\hat{y}_2 = 49,68 + 2,26t - 0,106t^2$; $\varepsilon_{відн.} = 4,3\%$; $F_p = 5,07$	58.7	57.4	56.0	54.3
Road transport					
Volumes of cargo transportation in the area (y_3), *million tons*	$\hat{y}_3 = 73,37 - 3,025t + 0,141t^2$; $\varepsilon_{відн.} = 4,7\%$; $F_p = 6,0$	61.2	62.8	64.7	66.9
including: Odesa region (y_4)	Auroregression model of Box-Jenkins; $\varepsilon_{відн.} = 7,4\%$	29.8	30.1	30.5	30.8
Mykolaiv (y_5)	$\hat{y}_5 = 34,86 - 2,903t + 0,141t^2$; $\varepsilon_{відн.} = 4,1\%$; $F_p = 4,7$	24.5	26.3	28.3	30.7
Kherson (y_6)	Autoregressive model (AM) OLYMPUS; $\varepsilon_{відн.} = 7,1\%$; $F_p = 3,1$	13.5	13.0	12.8	12.9
Cargo turnover of the Black Sea region (y_7), *million tkm*	Logarithmic trend: $\hat{y}_7 = 2779,04 + 1274,42 \ln t$; $\varepsilon_{відн.} = 6,9\%$; $F_p = 60,1$	6312.5	6389.7	6462.6	6531.5
including: Odesa region (y_8)	$\hat{y}_8 = 1123,22 + 762,5 \ln t$; $\varepsilon_{відн.} = 9,3\%$; $F_p = 49,5$	3237.3	3283.5	3327.1	3368.1
Mykolaiv (y_9)	Integrated auroregression model; $\varepsilon_{відн.} = 8,9\%$; $F_p = 18,2$	1483.8	1522.4	1506.2	1514.0

Kherson (y_{10})	Integrated auroregression model; $\varepsilon_{відн.} = 5{,}9\%;\ F_p = 16$	1361.5	1312.0	1363.4	1363.9

Source: compiled and calculated based on statistical information materials of the State Statistics Service of Ukraine and the Main Departments of Statistics in Mykolayiv, Odesa and Kherson regions.

For example, the indicators of change in the volume of shipments by Odessa Railway correspond to the laws of change of the parabolic trend, which is given to the model:

$$\hat{y}_1 = 25{,}55 + 0{,}572t - 0{,}011t^2; \quad (9)$$

$$\varepsilon_{відн.} = 6{,}6\%;\ F_p = 28{,}2;\ F_\alpha \begin{cases} \alpha = 1 \\ V_1 = 2 \\ V_2 = 11 \end{cases} = 2{,}81;\ F_p > F_\alpha$$

This equation meets the criteria of statistical accuracy ($\varepsilon_{відн.} \leq 15{,}0\%$) and reliability ($F_p > F_\alpha$, при $\alpha = 0{,}1$), which ensures the objectivity of forecast estimates for short-term bias (up to five years). As can be seen from the above estimates, the volume of cargo shipments by Odessa Railway is practically not growing – the average annual growth rate will be only 0.63%. A similar pattern has developed in terms of freight turnover, but with a slight regressive trend – by 2023, it is possible to fall by 1.8% annually. A comparison of the patterns of change in the volume of shipments and cargo turnover shows that in the coming years the distance of shipments will decrease. For example, as of 2018, the average distance was about 1890 km, and according to forecasts, they will decrease by an average of 200-220 km and will be 1670 km. Approximately the same situation has developed with the volume of road transport of the Black Sea economic region. On volumes of transportation of freights as a whole across area insignificant growth is possible, – only on 4% thus the greatest rates of growth, can develop on the Nikolaev region – almost on 44,1%. In the Odessa region, growth of 6.2% is possible. According to Kherson, according to forecast estimates, there are negative trends that could lead to a decrease in freight traffic by 2023 by almost 8%.

Forecast estimates of changes in the volume of freight turnover by road both in the Black Sea economic region as a whole and in some of its regions (Table 3) show that given the current trends, there will be a reduction – the average annual rate of decline for the next five years will range from 97.5 to 99.0%. Based on the fact that there are positive trends in the volume of traffic, this pattern indicates a simultaneous reduction in the distance of their transportation.

In general, the railway and road transport of the Black Sea economic region, according to the forecast estimates of traffic and freight turnover, shows that there are almost no positive changes. Even those insignificant positive tendencies testify that if those conditions of functioning of these types of transport remain, the resources of their development are practically exhausted. This situation leads to the formation of strategic programs for the transformation of the transport and logistics system, primarily related to ensuring the investment attractiveness of transport and logistics, development of infrastructure projects using innovative and information technologies and more.

An important place in the transport connection of the Black Sea economic region is occupied by sea transport. According to forecast estimates, which are given in Table 4, the total volume of cargo handling by stevedoring companies in the district as a whole will increase by 2023 by almost a third (+ 28.7%) with an annual growth rate of 105.2%. But this increase will be provided as a result of a significant increase in volumes at three seaports: the Black Sea, Mykolaiv and Odessa.

Table 4 – Forecast estimates of the total volume of cargo handling by stevedoring companies in the seaports of the Black Sea Economic Region

Seaports	Forecasting model, relative approximation error ($\varepsilon_{відн.}$)	Fact 2020	Forecast values of the indicator by years		
			2021	2022	2023
Izmail (y_{11}), *thousand tons*	Integrated autoregression model OLYMPUS; $\varepsilon_{відн.} = 8{,}8\%$	4257.7	4373.8	4533.8	4628.7
Black Sea (y_{12}), *thousand tons*	Parabolic trend: $\hat{y}_{12} = 19063{,}22 - 1758{,}3t + 278{,}4t^2$;	25788.6	29319.8	33407.8	38052.5
Mykolaiv (y_{13}), *thousand tons*	Integrated autoregression model of Box-Jenkins; $\varepsilon_{відн.} = 5{,}7\%$	38992.1	42171.5	45030.2	47756.0
Odessa (y_{14}), *thousand tons*	Integrated autoregression model OLYMPUS; $\varepsilon_{відн.} = 3{,}0\%$	26657.2	25250.5	22704.7	24017.6
Rhine (y_{15}), *thousand tons*	Integrated autoregressive model OLYMPUS; $\varepsilon_{відн.} = 4{,}5\%$	1148.2	1119.9	1139.9	1148.6
Kherson (y_{16}), *thousand tons*	Integrated autoregression model OLYMPUS; $\varepsilon_{відн.} = 4{,}6\%$	2829.6	2729.5	2662.2	2586.2
South (y_{17}), *thousand tons*	Integrated autoregression model of Box-Jenkins; $\varepsilon_{відн.} = 7{,}5\%$	41987.3	41752.0	41520.9	41290.6
Total (Z), *thousand tons*	Additive model: $Z = y_{11} + y_{12} + y_{13} + y_{14} + y_{15} + y_{16} + y_{17}; (10)$	141660.7	144217.0	151000.0	159480.2

Source: compiled and calculated based on information materials of the Seaports Administration of Ukraine.

At the same time, the greatest potential opportunities for increasing the volume of cargo processing were in the seaport of Chernomorsk – by 76.7% and Mykolaiv – by 63.5%. At the same time, other ports (Izmail, Rhine, Kherson and South) have developed negative trends that could lead to a significant reduction in processing volumes. Thus, in the port of Kherson, this decline could reach almost 16%, in the Rhine – by 13.8%. A decrease of 3.3% and 1.2%, respectively, in the Southern and Izmail seaports. According to the above calculations, it can be concluded that the prospects of the Rhine and Kherson seaports for this type of activity are virtually absent, the redistribution will take place in favor of more powerful, such as Mykolaiv, Black Sea and Odessa.

In terms of volumes of export cargo processing by stevedoring companies, some seaports also have multi-vector trends of change. export cargoes at the Nikolaev

seaport, about 40% of their growth can be achieved in the port of Kherson and the Black Sea, at 8% will increase volumes in the ports of South and Odessa. Prospects for the processing of export cargo in the Rhine port are practically lost. As a result of certain changes the structure on separate ports also changes, thus the share of the Nikolaev seaport in total volume of processing of export cargoes will change by almost 11%.

The dynamics of changes in the indicators that characterize the volume of processing of imported goods by stevedoring companies, shows that their regularity is significantly related to the events of 2014-2020, when there was a significant decline in all seaports in the area. Some of them have a fairly high level of variation. For these reasons, most models do not meet the criteria of statistical accuracy and reliability - these are models for ports such as Izmail, Black Sea, Rhine and Kherson.

Therefore, a meaningful analysis of models that can be used for forecast estimates is conducted only on those that meet the above criteria. The total volumes of processing of imported cargo in the Black Sea economic region as a whole are approximated on the basis of the integrated autoregressive model, which is calculated according to the algorithm of the OLYMPUS model with a relative error of 10.6%. These conditions ensure the objectivity and reliability of forecast estimates for the period up to 2023. According to estimates, the volume of processing may increase by 44.4% or 7.6% annually, and as of 2023 to reach 32,812.4 thousand tons. Quite high growth rates are in the South Port (150.0%), Mykolaiv (117.0%) and Odessa (105.1%). On the other hand, the statistical inaccuracy of individual models does not make it possible to assess changes in the structure of individual ports in the processing of imported cargo.

The next type of transport work is related to the volume of processing of transit cargo by stevedoring companies in the seaports of the Black Sea economic region. Initial data show that as of 2018, the port of Kherson does not perform these types of work, so it will be excluded from the general analysis of trends and forecasts. Due to the unreliability of the models for the port of Mykolaiv and the Black Sea, the estimated estimates of changes in volumes are questionable and excluded from the substantive analysis. The determined forecast estimates of volumes of transit cargo handling by stevedoring companies by all seaports indicate their general reduction in the following years by 2.4% with an annual decline in volumes of 0.5%. The largest decrease may occur in the port of Odessa – by almost 40.7%, ie the annual decline during 2018-2023 will be about 10%, 18.5% reduction in the volume of transit cargo processing in the Rhine, and 15.4% – by South port. At the same time in Izmail it is possible to increase these types of work by 18.6%.

Conclusions. These calculations confirm the conclusions about the inefficiency of the main factors of production. The average rate of decline in freight traffic throughout the regional logistics system for 2012-2020 due to reduced efficiency in the use of basic factors of production is 79.3%. Thus, the main growth factors are not related to these factors at all – they provide an increase in freight traffic by 37.7%.

Based on the above, we can conclude the following. Analytical assessment of the impact of the main factors of production and their efficiency provides an opportunity to develop strategic directions for the development of the regional logistics system, but taking into account certain features, patterns and trends. It is necessary to carry out a more detailed diagnosis and analysis of directly unidentified factors that generally determine the effect of scale. Among them, as mentioned above, are factors related to the introduction of modern innovation and technology, "green", digital technologies, assessing opportunities to enter international markets, the formation of fundamentally new marketing strategies and cluster model of logistics in the Black Sea region. However, this

requires the creation of appropriate institutional conditions, namely:

to improve the legal regulation of the development of the transport sector and the organization of logistics activities, taking into account the regional component;

to develop a Strategy for integrated development of the regional logistics system based on the modernization of transport infrastructure and the creation of a transport and logistics cluster;

to increase the efficiency of the organization of logistics activities and the functioning of port infrastructure in sea trade ports;

to form optimal multimodal logistics chains and to substantiate the regional cluster model of organization of logistics activities in the Black Sea economic region;

to develop and implement an organizational and economic mechanism for managing the development of the logistics system of the economic region using the tools of digital logistics and green logistics;

to improve the mechanism of financial support for the development of transport and logistics system through the use of financial instruments such as venture capital, crowdfunding, factoring, international public-private partnership based on private investment, credit institutions, foreign investment resources, grants from international financial organizations.

The Public-Private Partnership in Infrastructure survey, conducted by the Center for Transport Strategies and Deloitte, shows that 85% of respondents (experts from international financial organizations (IFIs), shippers, and current port and railway operators control more than 90% of Ukraine's freight traffic).) consider attracting private capital as a key goal of public-private partnership (PPP) for the development of large infrastructure projects. 77% of respondents consider PPP as an option when the state cannot implement the project on its own. Other project objectives include improving the quality of infrastructure (35%); reduction of corruption (35%); improving the level and quality of infrastructure services (31%); reduction of project cost (19%); reduction of the level of state risks and simplification of implementation (12%).

All participants in the transport services market recognize PPP as the best mechanism for financing projects. However, the respondents did not agree on the advantages of PPP compared to budget funding. Shippers, port operators and MFIs call the most significant factor in reducing the risks of inefficient and excessive spending of budget funds (58% of experts); railway operators – rapid implementation of transport infrastructure modernization plans (46%). At the same time, 35% of respondents say that PPP will be an important factor in increasing the investment attractiveness of the country. 46% of respondents consider the quality of constructed facilities and terms of implementation to be clear advantages. Also, business (50% of respondents) prefers PPP as the most transparent investment mechanism compared to the budget, but MFIs do not share this view.

It should be noted that 85% of respondents say that sea and river ports have the highest potential for PPP development in Ukraine. 65% of respondents see the development of PPP in the railway industry; 54% – in the field of road transport. And only 27% named airports and 8% – municipal transport.

The majority of respondents (92%) call concession the main form of partnership between the state and business: port operators and MFIs (100%), shippers (89%), railway operators (83%). Despite the fact that the concession is recognized as a priority tool, for each infrastructure project the choice of cooperation mechanism should be individual: 50% of respondents consider the optimal form of PPP joint activity; 44% – property lease; 35% – privatization of state property. At the same time, 23% of respondents agree that the management of state property is not the best example of PPP.

According to the results of the study "Improving the management of the port industry of Ukraine" conducted by the World Bank, for the management of the port industry in the regions it is advisable to implement the "Port Landlord" model used in some countries (e.g. Antwerp, Rotterdam, Singapore). This management model provides for the existence of a port administration that controls port property, which allows it to develop land use policy and consistent planning, transferring access to property to service providers and investors through contracts (concessions).

The Port Landlord model is based on the following principles: the port administration, which has ownership or otherwise controls the use of port areas, is responsible for the planning and integrated development of ports; private operators carry out stevedoring activities under a concession or lease agreement for assets and land with the port administration.

Implementation of the mechanism of international-private-public partnership will contribute to the successful planning of transport infrastructure development and the provision of integrated multimodal logistics services in the Black Sea economic region; effective provision of connectivity between different modes of transport and their integration with cities and local communities; increasing the economic potential of transport and logistics infrastructure facilities to attract private investment; reducing the cost of organizing logistics activities in the region.

Prospects for further research are to substantiate the theoretical and methodological foundations of strategizing the development of the national logistics system of Ukraine, taking into account world practice.

References

1. Beresford, A. K. C., Pettit, S. J., Whittaker, W. (2005). Improving supply chain performance through quality management in a global distribution environment. International Journal of Services and Operations Management, 1(1), 75-89. https://doi.org/10.1504/ IJSOM.2005.006319.

2. Gunasekaran, A. (2005). Editorial: New service and manufacturing environments: challenges for operations management researchers and practitioners. International Journal of Services and Operations Management, 1(1), 1-6. https://doi.org/10.1504/IJSOM.2005.006313.

3. Huemer, L. (2006). Supply Management: Value creation, coordination and positioning in supply relationships. Long Range Planning, 39(2), 133-153. DOI: 10.1016/j.lrp.2006.04.005.

4. Blaik, P. (2010). Logistyka. Koncepcja zintegrowanego zarzadzania. Warszawa: Polskie Wydawnictwo Ekonomiczne.

5. Kotler, P., Keller, K. L. (2014). Marketing Management. 14th ed. Upper Saddle River, New Jersey: Prentice Hall.

6. Murphy, P. R., Wood, D. F. (2017). Sovremennaja logistika [Modern Logistic]. 8th ed. Moscow: I. D. Williams LLC. (in Russia)

7. Bowersox, D. J., Closs, D. J. (2017). Logistika: integrirovannaja cep' postavok [Logistic: Integrated Supply Chain]. 2nd ed. Moscow: Olymp-Business. (in Russia)

8. Dźwigoł, H., Dźwigoł-Barosz, M. (2018). Scientific research methodology in management sciences. Financial and credit activity: problems of theory and practice, 2(25), 424-437.

9. Dźwigoł, H. (2019). Research methods and techniques in new management trends: research results. Virtual Economics, 2(1), 31-48. https://doi.org/10.34021/ve.2019.02.01(2).

10. Kwilinski, A. (2018). Mechanism of modernization of industrial sphere of industrial enterprise in accordance with requirements of the information economy. Marketing and Management of Innovations, 4, 116-128. https://doi.org/10.21272/mmi.2018.4-11.

11. Kwilinski, A. (2018). Mechanism for assessing the competitiveness of an industrial enterprise in the information economy. Research Papers in Economics and Finance, 3(1), 7-16. https://doi.org/10.18559/ref.2018.1.1.

12. Krykavskyi, Ye.V., Pokhylchenko, O.A., Chornopyska, N.V. et al. (2014). Ekonomika lohistyky [Economics of logistics]. Lviv: Lviv Polytechnic Publishing House. (in Ukrainian)

13. Krykavskyi, Ye.V., Vasyltsiv, N.M., Falovych, V.A. (2015). Materialni potoky u lohistytsi promyslovoho pidpryiemstva [Material flows in the logistics of an industrial enterprise]. Lviv: Lviv Polytechnic Publishing House. (in Ukrainian)

14. Krykavskyi, Ye., Liulchak, Z., Tsyran, Ya., Petetskyi, I. (2015). Partnerski vidnosyny na rynku B2B ta B2C [Partnerships in the B2B and B2C market]. Lviv: Lviv Polytechnic Publishing House. (in Ukrainian)

15. Zrobek, J. (2011). Marketing w klastrach logistycznych. Acta Universitatis Lodziennsis. Folia Oeconomica, 251, 5-16.

16. Szuster, M. (2012). Rola klastrow we wspieraniu innowacyjnosci [The role of clusters in innovation supporting]. Ekonomiczne Problemy Uslug, 94, 311-325.

17. Kruczek, M., Zebrucki, Z. (2014). Koncepcja klastrow logistycznych. Zeszyty naukowe Politechniki Slaskiej. Ser.: Organizacja i zarzadzanie, 70, 229-241.

18. Frankowska, M. (2015). Klastry logistyczne jako ogniwa globalnych lancuchow dostaw. Logistyka, 3, 5633-5637.

19. Dmukhovski, R. (2019). Poniattia lohistychnykh klasteriv ta efektyvnosti ekonomichnykh pidpryiemstv [The concept of logistics clusters and efficiency of economic enterprises]. Journal of the European Economy, 18(3(70)), 296-306. https://doi.org/10.35774/ jec2019.03.351. (in Ukrainian)

20. Hrytsenko, S. I. (2019). Modeliuvannia systemy tsinnostei ekolantsiuha postachan yak dominanta transportno-lohistychnykh klasteriv [Modeling the system of values of the ecological supply chain as the dominant transport and logistics clusters]. Bulletin of Economic Science of Ukraine, 1(36), 31-34. (in Ukrainian)

21. Kharazishvili, Yu.M., Lyashenko, V.I. (2017). Problemy otsinky ta intehralni indeksy staloho rozvytku promyslovosti Ukrainy z pozytsii ekonomichnoi bezpeky [Evaluation problems and integrated indices of sustainable development of Ukrainian industry from the standpoint of economic security]. Economy of Ukraine, 2, 3-23. (in Ukrainian)

22. Ivanov, S. V., Kharazishvili, Ju. M. (2017). Innovacijni faktory rozvytku transportnoji systemy Ukrajiny [Innovative factors of development of the transport system of Ukraine]. Bulletin of Economic Science of Ukraine, 2, 47-55. (in Ukrainian)

23. Kharazishvili, Yu.M. (2019). Systemna bezpeka staloho rozvytku: instrumentarii otsinky, rezervy ta stratehichni stsenarii realizatsii [System security of sustainable development: assessment tools, reserves and strategic implementation scenarios]. Kyiv: Institute of Industrial Economics of the NAS of Ukraine. (in Ukrainian)

24. Nykyforuk, O. I. (2014). Modernizatsiia nazemnykh transportnykh system Ukrainy [Modernization of land transport systems of Ukraine]. Kyiv: Institute of Economics and Forecasting of NAS of Ukraine. (in Ukrainian)

25. Nykyforuk, O. I. (Ed.) (2017). Rozvytok infrastrukturnykh sektoriv yak chynnyk realizatsii priorytetnykh napriamiv ekonomichnoi polityky Ukrainy [Development of infrastructure sectors as a factor of realization of priority directions of economic policy of Ukraine]: collective monograph. Kyiv: Institute of Economics and Forecasting of NAS of Ukraine. (in Ukrainian)

26. Nykyforuk, O. I., Stasiuk, O. M., Chmyrova, L. Yu., Fediai, N. O. (2019). Tsyfrovizatsiia v transportnomu sektori: tendentsii ta indykatory rozvytku. Chastyna 1 [Digitization in the transport sector: trends and indicators of development. Part 1]. Statistics of Ukraine, 3, 70-81. https://doi.org/10.31767/su.3(86)2019.03.08. (in Ukrainian)

27. Ilchenko, S. V., Karpenko, H. Yu. (2017). Assessment of the transport infrastructure impact on the regional development. Economic Innovations, vol. 65 (pp. 67-72). Odessa: IPMEER NAS of Ukraine. https://doi.org/10.31520/ei.2017.19.3(65).67-72.

28. Kwilinski, A. (2019). Implementation of Blockchain Technology in Accounting Sphere. Academy of Accounting and Financial Studies Journal, 23(SI2), 1-6. Retrieved from https://www.abacademies.org/articles/Implementation-of-Blockchain-Technology-in-Accounting-Sphere-1528-2635-23-SI-2-412.pdf (accessed 27 March 2022).

29. Bakaiev, O.O., Bazhan, L.I., Kaidan, L.I. et al. (2007). Ekonomiko-matematychne modeliuvannia i informatsiini tekhnolohii v upravlinni ekonomichnymy systemamy riznykh rivniv iierarkhii [Economic and mathematical modeling and information technologies in the management of economic systems of different levels of the hierarchy]. Kyiv: Lohos. (in Ukrainian)

30. Denysenko, M.P., Levkovets, P.R., Mykhailova, L.I. (2012). Orhanizatsiia ta proektuvannia lohistychnykh system [Organization and design of logistics systems]. Kyiv: Center for Educational Literature. (in Ukrainian)

31. Kolomytseva, A.O., Yakovenko, V.S. (2012). Modeliuvannia protsesiv optymalnoho upravlinnia lohistychnymy rozpodilchymy systemamy [Modeling of processes of optimal management of logistics distribution systems]. Business Inform, 7, 18-21. (in Ukrainian)

32. Goncharov, Yu.V., Kostyuk, G.V. (2012). Metodolohichni aspekty formuvannia lohistychnoi systemy na pidpryiemstvakh lehkoi promyslovosti [Methodological aspects of the formation of the logistics system in light industry enterprises]. The Problems of Economy, 3, 97-107. (in Ukrainian)

33. Korobskyi, R.V., Snihur, R.V. (2012). Osnovni aspekty imitatsiinoho modeliuvannia u suchasnykh ekonomichnykh systemakh [The main aspects of simulation in modern economic systems]. Aktualni problemy ekonomichnoho i sotsialnoho rehionu – Current issues of economic and social region, 159-164. (in Ukrainian)

34. Volosnikova, N.M. (2013). Imitatsiine modeliuvannia yak instrument optymizatsii prymyrennia lohistychnykh pidsystem [Simulation modeling as a tool for optimizing the reconciliation of logistics subsystems]. Bulletin of Socio-Economic Research, 1(48), 189-195. (in Ukrainian)

35. Korniyetskyi, O.V. (2014). Lohistychna systema rozpodilu produktsii v umovakh transportno-lohistychnoho kompleksu [Logistic system of product distribution in terms of transport and logistics complex]. Economic analysis: collection sciencific works (pp. 35-41). Ternopil: Publishing and Printing Center of Ternopil National University of Economics " "Ekonomichna dumka", vol. 17, no. 3. (in Ukrainian)

36. Sysoiev, V.V. (2015). Kontseptsiia modeliuvannia lohistychnoho upravlinnia postachanniam syl sektoru bezpeky i oborony derzhavy [The Concept of Simulating the Logistics

Management of Supplying the Forces of the State Security and Defense Sector]. The Problems of Economy, 3, 342-351. (in Ukrainian)

37. Aloshynskyi, Ye.S., Meshcheriakov, V.V., Rudenko, H.S. (2016). Development of methods for increase of work indices of logistic chain within transport and logistics cluster. Technology audit and production reserves, 5/2(31), 48-52.

38. Sokolovska, Z.M., Andriienko, V.M., Ivchenko, I.Yu. et al. (2016). Matematychne ta kompiuterne modeliuvannia ekonomichnykh protsesiv [Mathematical and computer modeling of economic processes]. Odesa: Astroprynt. (in Ukrainian)

39. Taranenko, Yu., Fedorenko, I. (2016). Imitatsiine modeliuvannia lohistychnykh protsesiv [Simulation modeling of logistics processes]. Bulletin of the Taras Shevchenko National University of Kyiv, 8(185), 38-44. https://doi.org/10.17721/1728-2667.2016/185-8/5. (in Ukrainian)

40. Vostriakova, V. (2017). Metodychni pidkhody modeliuvannia ta analizu lohistychnykh system rozpodilu produktsii APK [Methodical approaches to modeling and analysis of logistics systems for the distribution of agricultural products]. Agrosvit, 11, 56-61. (in Ukrainian)

41. Prymachenko, H., Yasenovskaya, K. (2018). Modeliuvannia lohistychnoi systemy upravlinnia shvydkisnymy zaliznychnymy perevezenniamy [Modeling of logistics system of high-speed railway transportation management]. Collection of scientific works of the Ukrainian State University of Railway Transport (pp. 127-136). Kharkiv: USURT, iss. 180. (in Ukrainian)

42. Khoroshun, V.V., Naumenko, I.A. (2018). Economic and mathematical methods and models for forecasting sales logistics of a commercial enterprise. Black Sea Economic Studies, 28-2, 179-183. (in Ukrainian)

43. Ivchenko, I.Yu., Pietukhov, B.V. (2018). Modeliuvannia lohistychnykh system [Modeling of logistics systems]. Ekonomichna kibernetyka: teoriia, praktyka ta napriamky rozvytku [Economic cybernetics: theory, practice and directions of development]: materials of Scientific and Practice Conference (Odesa, November 28-29, 2018) (pp. 69-71). Odesa: Odesa Polytechnic State University. (in Ukrainian)

44. Potapova, N.A. (2019). Prohnozuvannia dynamiky potochnykh lohistychnykh materialnykh vytrat silskoho hospodarstva Ukrainy [Forecasting the dynamics of current logistical material costs of agriculture in Ukraine]. Economy. Finances. Management: current issues of science and practice, 4, 41-52. (in Ukrainian)

45. Makarenko, N. (2020). Modeliuvannia stsenariiv rozvytku lohistychnykh system ahrarnykh pidpryiemstv [Modeling of scenarios for the development of logistics systems of agricultural enterprises]. Bulletin of Sumy National Agrarian University. Ser.: Economics and Management, 3(85), 61-68. (in Ukrainian)

46. Samostian, V. (2020). Efektyvne vykorystannia pidkhodiv dlia imitatsiinoho modeliuvannia lohistychnykh protsesiv [Efficient use of approaches for simulation modeling of logistics processes]. Modern technologies in mechanical engineering and transport, 2(15), 127-133. https://doi.org/10.36910/automash.v2i15.400 (in Ukrainin)

47. Sakunova, I.S. (2009). Imitatsiine modeliuvannia v zadachakh doslidzhennia materialnykh potokiv lohistychnykh system [Simulation modeling in the problems of research of material flows of logistics systems]. Ekonomiko-matematychne modeliuvannia sotsialno-ekonomichnykh system [Economic and mathematical modeling of socio-economic systems]: a collection of scientific papers (pp. 91-114). Kyiv: ISTC ITiS, iss. 14. (in Ukrainian)

48. Kolodizeva, T.A., Panasyants, A.S. (2012). Modeliuvannia orhanizatsiinoho zabezpechennia funktsionuvannia lohistychnykh system promyslovykh pidpryiemstv [Modeling

of Organizational Support for Logistical System Enterprise Functioning]. Business Inform, 10, 254-259. (in Ukrainian)

49. Larina, R.R., Lukyanova, O.Y. (2013). Modeliuvannia biznes-protsesiv promyslovoho pidpryiemstva v napriamku rozvytku yoho lohistychnoho menedzhmentu [Modeling of business processes of an industrial enterprise in the direction of development of its logistics management]. Ekonomika ta derzhava – Economy and State, 7, 17-22. (in Ukrainian)

50. Box, J., Jenkins, G. (1974). Analiz vremennykh ryadov: prognoz i upravlenie [Time Series Analysis: Forecast and Management]. Moscow: World, iss. 1. (in Russian)

51. Shelobaev, S. I. (2000). Matematicheskie metody i modeli v ekonomike, finansakh, biznese [Mathematical methods and models in economics, finance, business]. Moscow: UNITY-DANA. (in Russian)

52. Yerina, A. M. (2001). Statystychne modeliuvannia ta prohnozuvannia [Statistical modeling and forecasting]. Kyiv: KNEU. (in Ukrainian)

53. Heiets, V.M., Klebanova, T.S., Cherniak, O.I., Ivanov, V.V., Dubrovina, N.A., Stavytskyi, A.V. (2005). Modeli i metody sotsialno-ekonomichnoho prohnozuvannia [Models and methods of socio-economic forecasting]. Kharkiv: INZhEK. (in Ukrainian)

54. Shamileva, L. L. (2008). Statisticheskoe modelirovanie i prognozirovanie [Statistical modeling and forecasting]. Donetsk: DonNU. (in Russian)

55. Kulynych, R.O. (2008). Statystychni metody analizu vzaiemozviazku pokaznykiv sotsialno-ekonomichnoho rozvytku [Statistical methods of analysis of the relationship between indicators of socio-economic development]. Kyiv: Format. (in Ukrainian)

56. Kulynych, O.I., Kulynych, R.O. (2014). Statystychni metody prohnozuvannia makroekonomichnykh pokaznykiv ta sposoby yikh otsinky [Statistical methods of forecasting macroeconomic indicators and methods of their evaluation]. Universytetski naukovi zapysky – University scientific notes, 4, 283-295. (in Ukrainian)

57. Hryhorak, M.Yu. (2016). Analiz biznes-modelei ta stratehii innovatsiinoho rozvytku postachalnykiv lohistychnykh posluh [Analysis of business models and strategies innovative development of logistics service providers]. Technological audit and production reserves, 2/5(28), 29-38. (in Ukrainian)

58. Hryhorak, M.Yu. (2017). Kontseptualni polozhennia rozroblennia natsionalnoi lohistychnoi stratehii v heoekonomichnomu vymiri [Conceptual provisions for the development of a national logistics strategy in the geoeconomic dimension]. Intelligence XXI, 4, 58-64. (in Ukrainian)

59. Hryhorak, M.Yu. (2017). Intelektualizatsiia rynku lohistychnykh posluh: kontseptsiia, metodolohiia, kompetentnist [Intellectualization of the logistics services market: concept, methodology, competence]. Kyiv: Sik Group Ukraine. (in Ukrainian)

60. Grygorak, M.Yu. (2017.) Comparison of economic indicators of using the Ukrainian logistics potential. Technological audit and production reserves, 3/5(35), 49-57.

61. Hryhorak, M., Karpenko, O., Semeriahina, M. (2020). Formation of the multimodal transportation ecosystem in Ukraine. Intellectualization of logistics and Supply Chain Management, 2, 111-130. https://doi.org/10.46783/smart-scm/2020-2-9.

62. Hryhorak, M., Dzwigol, H., Trushkina, N., Shkrygun, Yu. (2021). Substantiation of expediency of the complex approach for supply chains management in the COVID-19 conditions.

Intellectualization of logistics and Supply Chain Management, 5, 6-25. https://doi.org/10.46783/smart-scm/2021-5-1.

63. Hryhorak, M., Lyakh, O., Sokolova, O., Chornogor, N., Mykhailichenko, I. (2021). Multimodal freight transportation as a direction of ensuring sustainable development of the transport system of Ukraine. IOP Conf. Series: Earth and Environmental Science, 915, Article 012024. https://doi.org/ 10.1088/1755-1315/915/1/012024.

64. Zaloznova, Yu.S., Trushkina, N.V. (2016). Metodychni pidkhody do prohnozuvannia pokaznykiv zbutovoi diialnosti vuhledobuvnykh pidpryiemstv [Methodical approaches to forecasting the performance of coal mining enterprises]. Business Inform, 9,105-111. (in Ukrainian)

65. Kashchena, N., Solokha, D., Trushkina, N., Potemkin, L., Mirkurbanova, R. (2019). Use of multi-agent simulation modeling for predicting the sales of wholesale trade companies. Journal of Management Information and Decision Sciences, 22(4), 483-488.

66. Zaloznova, Yu.S., Trushkina, N.V. (2020). Udoskonalennia orhanizatsii zbutovoi diialnosti vuhledobuvnykh pidpryiemstv Ukrainy v umovakh nestabilnosti popytu: teoriia i praktyka [Improving the organization of sales activities of coal mining enterprises of Ukraine in conditions of demand instability: theory and practice]. Kyiv: Institute of Industrial Economics of the National Academy of Sciences of Ukraine. (in Ukrainian)

67. Kwilinski, A., Zaloznova, Yu., Trushkina, N., Rynkevych, N. (2020). Organizational and methodological support for Ukrainian coal enterprises marketing activity improvement. E3S Web of Conferences, 168, Article 00031. https://doi.org/ 10/1051/e3sconf/202016800031.

68. Ivanov, S.V., Liashenko, V.I., Shamileva, L.L., Trushkina, N.V. (2019). Tendentsii rozvytku transportno-lohistychnoi systemy Prydniprovskoho ekonomichnoho raionu [Trends in the development of the transport and logistics system of the Dnieper economic region]. Visnyk ekonomichnoi nauky Ukrainy – Bulletin of Economic Science of Ukraine, 2(37), 143-150. https://doi.org/ 10.37405/1729-7206.2019.2(37).143-150. (in Ukrainian)

69. Trushkina, N.V. (2020). Prohnozuvannia rozvytku rehionalnoi transportno-lohistychnoi systemy Prychornomorskoho ekonomichnoho raionu [Forecasting the development of the regional transport and logistics system of the Black Sea economic region]. Black Sea Economic Studies, 51, 155-165. https://doi.org/10.32843/bses.51-25. (in Ukrainian)

70. Ivanov, S.V., Liashenko, V.I., Trushkina, N.V. (2020). Prohnozna otsinka pokaznykiv rozvytku rehionalnoi transportno-lohistychnoi systemy Prydniprovskoho ekonomichnoho raionu [Forecast assessment of indicators of development of the regional transport and logistics system of the Dnieper economic region]. Administrative-territorial vs economic-spatial borders of regions: materials International Scientific and Practical Conference (Kyiv, March 19-20, 2020) (pp. 445-451). Kyiv: KNEU. (in Ukrainian)

71. Trushkina, N.V. (2020). Rozroblennia modeli ekonomichnoho zrostannia rehionalnoi transportno-lohistychnoi systemy (na prykladi Prychornomorskoho ekonomichnoho raionu) [Development of a model of economic growth of the regional transport and logistics system (on the example of the Black Sea economic region)]. Black Sea Economic Studies, 58-2, 76-80. https://doi.org/10.32843/bses.58-3. (in Ukrainian)

72. Liashenko, V., Ivanov, S., Trushkina, N. (2021). A Conceptual Approach to Forming a Transport and Logistics Cluster as a Component of the Region's Innovative Infrastructure (on the Example of Prydniprovsky Economic Region of Ukraine). Virtual Economics, 4(1), 19-53. https://doi.org/10.34021/ve.2021.04.01(2).

UDC 656.7
DOI: https://doi.org/10.46783/smart-scm/2022-12-3
JEL Classification: C38, H56, L93, O33.
Received: 20 March 2022

Gritsenko S.I. Doctor of Economics, Professor, Professor of Logistics Department of National Aviation University (Ukraine)

ORCID – 0000-0002-3322-3986
Researcher ID –
Scopus author id: –

Dovgan T.I., Students of Logistics Department National Aviation University (Ukraine)

ORCID –
Researcher ID –
Scopus author id: –

Ninich V.Z. Students of Logistics Department National Aviation University (Ukraine)

ORCID –
Researcher ID –
Scopus author id: –

CLUSTER PROSPECTS OF THE USE OF UNMANNED AERIAL SYSTEMS IN SUPPORTING THE LIVING ACTIVITY OF CRITICAL INDUSTRIES

Sergiy Gritsenko, Taisiya Dovgan, Veronika Ninich. «Cluster prospects of the use of unmanned aerial systems in supporting the living activity of critical industries ». *The article considered the prospects for the use of unmanned aerial systems in transport and logistics clusters for the delivery of cargo to critical locations, humanitarian assistance to community members, etc. Identified the main advantages and disadvantages of using unmanned aerial vehicles (UAVs) in peacetime and wartime. The main idea of the article is the use of unmanned aerial systems (UAS) in ensuring the viability of critical industries in cooperation with the Association of Industrial Automation of Ukraine (APPAU), National Aviation University (NAU), joining the Ukrainian Cluster Alliance (UCA) as a regional transport. logistics cluster of unmanned aerial systems and complexes of NAU. Presented the classification of UAS by mass, altitude, flight duration, and range. Determined the composition of units of the unmanned aerial system. Given the characteristics of the designs of air drones (drones) of the manufacturers of world companies and the staff of the National Aviation University. The key priority of formation in the Ukrainian cluster alliance of the regional transport and logistics cluster of unmanned aerial systems and complexes based on the Scientific and Production Center for Unmanned Aviation "Virage ", departments: organization of air transportation, organization of aviation works, and services, logistics National Aviation University and other partner organizations. This will expand its opportunities to enter the European and world aviation markets.*

***Keywords**:* Unmanned aerial vehicle (UAV); drone; transport and logistics cluster; unmanned delivery; areas of critical industries; navigation; quadcopter; aircraft; delivery of the last mile; navigation satellite systems.

Сергій Гриценко, Тетяна Довгань, Вероніка Нініч. «Кластерні перспективи використання безпілотних авіаційних систем в забезпеченні життєдіяльності критичних індустрій». *У статті розглянуто перспективи використання безпілотних повітряних систем у складі транспортно-логістичних кластерів щодо доставки вантажів до критичних локацій, гуманітарної допомоги учасникам спільноти тощо. Визначено основні переваги та недоліки використання безпілотних повітряних суден (БПС) в умовах мирного та воєнного часу. Основною ідеєю статті є використання безпілотних авіаційних систем (БАС) в забезпеченні життєдіяльності критичних індустрій в співпраці з Асоціацією «Підприємств Промислової Автоматизації України» (АППАУ), Національним авіаційним університетом (НАУ), приєднання до Українського кластерного альянсу (УКА) у статусі регіонального транспортно-логістичного кластера безпілотних авіаційних систем та комплексів НАУ. Представлена класифікація БПС за масою, висотою, тривалістю польоту та радіусом дій. Визначено склад підрозділів безпілотної авіаційної системи. Надано характеристики конструкцій повітряних безпілотників (дронів) виробників світових компаній і колективу Національного авіаційного університету. Визначено ключовий пріоритет утворення у складі Українського кластерного альянсу регіонального транспортно-логістичного кластера безпілотних авіаційних систем та комплексів на базі Науково-виробничого центру безпілотної авіації (НВЦБА) «Віраж», кафедр: організації авіаційних перевезень, організації авіаційних робіт та послуг, логістики, зацікавлених підрозділів Національного авіаційного університету та інших партнерських організацій. Це розширить його можливості виходу на європейський та світовий ринки авіаційної техніки.*

Ключові слова: Безпілотне повітряне судно (БПС); дрон; транспортно-логістичний кластер; безпілотна доставка; зони критичних індустрій; навігація; квадрокоптер; літальний апарат; доставка останньої милі; навігаційні супутникові системи.

Сергей Гриценко, Татьяна Довгань, Вероника Нинич. «Кластерные перспективы использования беспилотных авиационных систем в обеспечении жизнедеятельности критических индустрий». *В статье рассмотрены перспективы использования беспилотных воздушных систем в составе транспортно-логистических кластеров относительно доставки грузов к критическим локациям, гуманитарной помощи участникам сообщества и тому подобное. Определены основные преимущества и недостатки использования беспилотных воздушных судов (БВС) в условиях мирного и военного времени. Основной идеей статьи является использование беспилотных авиационных систем (БАС) в обеспечении жизнедеятельности критических индустрий в сотрудничестве с Ассоциацией «Предприятий Промышленной Автоматизации Украины» (АППАУ), Национальным авиационным университетом (НАУ), присоединение к Украинскому кластерному альянсу (УКА) в статусе регионального транспортно-логистического кластера беспилотных авиационных систем и комплексов НАУ. Представлена классификация БВС по массе, высоте, длительности полета и радиусу действий. Определен состав подразделений беспилотной авиационной системы. Предоставлены характеристики конструкций воздушных беспилотников (дронов) производителей мировых компаний и коллектива Национального авиационного университета. Определен ключевой приоритет образования в составе Украинского кластерного альянса регионального транспортно-логистического кластера беспилотных авиационных систем и комплексов на базе Научно-производственного центра беспилотной авиации (НПЦБА) «Вираж»,*

36-44
v.12 (2022)
https://smart-scm.org

кафедр: организации авиационных перевозок, организации авиационных работ и услуг, логистики, заинтересованных подразделений Национального авиационного университета и других партнерских организаций. Это расширит его возможности выхода на европейский и мировой рынки авиационной техники.

Ключевые слова: Беспилотное воздушное судно (БВС); дрон; транспортно-логистический кластер; беспилотная доставка; зоны критических индустрий; навигация; квадрокоптер; летательный аппарат; доставка последней мили; навигационные спутниковые системы.

Introduction. More than a month ago, the topic of this article could be any topic related to transport, warehousing or logistics in general, but today Ukraine is faced with a different reality. An open military attack by Russia with the support of Belarus on Ukraine was launched at 5:00 am on February 24, 2022. The invasion is part of the Russian-Ukrainian war waged by Russia in 2014, in which Russia has tried to deny participation. In its resolution of March 2, 2022, the UN General Assembly condemned the Russian invasion of Ukraine and called it the aggression of the Russian Federation against Ukraine.

Today, thousands of homes have been destroyed, and tens of thousands of people killed and injured. Most of the transport connections in Kyiv, Kharkiv, Chernihiv, Sumy, Donetsk, Luhansk, and other regions have been destroyed. Thanks to the staff of the Security Service of Ukraine and units of the SES of Ukraine, the liberated territories are quickly processed (this refers to demining, removal, and dismantling ruins, etc) and try to assist those who need it and not always have access to each of the locations. Effective access to these critical locations is possible using unmanned aerial systems.

The main idea of the article is to use unmanned aerial systems (UAS) in ensuring the viability of critical industries in cooperation with the Association of Industrial Automation of Ukraine (APPAU), National Aviation University (NAU), joining the Ukrainian Cluster Alliance (UCA) as a regional transport- logistics cluster of unmanned aerial systems and complexes of NAU. Determining the main activities of UAS within the UCA are humanitarian aid, delivery of food, emergency care, medical supplies, services for internally displaced persons, support to charitable and volunteer organizations, and delivery of equipment to restore the infrastructure of destroyed cities and regions, and more.

The purpose and objectives of the study. Explore the possibility of delivering essentials and medicines using unmanned aerial vehicles and their main driving force, unmanned aerial vehicles (UAVs), to critical industries, bringing together university, industry, and high-tech communities within regional aviation clusters to win.

The unmanned aerial vehicle system consists of the BPS, ground (air, surface) control point, and communication lines.

Basic material and results. Together with regional clusters and other partners, APPAU [1] launched the Clusters4Ukraine initiative, which aims to establish broad cooperation between the European and other world communities and Ukrainian clusters of industrial and high-tech sectors [2-5] in ensuring the viability of critical industries. These industries include:

1 - industries that provide the population with basic necessities (food, medicine, clothing, etc.);

2 - critical infrastructure facilities.

The initiative aims to clarify the needs of these industries and meet them by:

1. Mobilization and unification of members of cluster communities at the regional and sectoral level, with clarification of their own needs, free resources, and opportunities. Ensuring evacuation - relocation of companies, members of our community, and their families to safe regions.

2. Involvement - assistance to service providers to support the production of critical industries and infrastructure: supply of components, products, individual technologies, and technical assistance.

3. Establishment of logistics for humanitarian aid.

4. Integration - liaison with local administrations and other field coordinators.

In addition, the continuation of projects with the EU also requires the cooperation and support of our startups, SMEs, and universities, as the EU is ready to continue many projects, but we need consolidated efforts and some guarantees from us on the ability to implement them in wartime. It is necessary to determine the strategies of international economic activity of clusters in the global and regional markets [2, p. 6] using unmanned aerial vehicles (UAVs).

Analysis of the development of the world's unmanned aerial vehicles (UAVs) as components of UAS over the past 20 years shows a steady trend to increase their size and weight, as well as range, altitude, and duration of the flight (Table 1).

Table 1 – Classification of UAV by mass, height, flight duration and range [6, p.15]

Code	Name	Mass, kg	Action radius, km	Flight height, m	flight duration, h
TACTICAL					
micro	Micro	≤ 5	≤ 10	250	1
mini	Mini	≤ 20/25/30/150	≤ 10	150/250/300	≤ 2
CR	Very short range	25-150	10-30	3000	2-4
SR	Short-range	50-250	30-70	3000	3-6
MR	Medium range	150-500	70-200	5000	6-10
MRE	Medium range and long duration	500-150	≥ 500	8000	10-18
LADP	Low altitude	250-2500	≥ 250	50-9000	0,5-1
LALE	Low altitude with a long flight duration	15-25	≥ 500	3000	≥ 24
MALE	Medium altitude with a short flight duration	1000-1500	≥ 500	5000-8000	24-28
STRATEGICAL					
HALE	High-altitude with a long flight duration	2500-5000	≥ 2000	20000	24-48
Strato	Stratospheric	≥ 2500	≥ 2000	≥ 20000	≥ 48
EXO	Outside the stratosphere	-	-	≥ 30500	-
SPECIAL					
UKAV	Combat UAV	≥ 1000	+/- 1500	12000	2
LET	Disposable UAV	-	300	4000	3-4
DEC	UAV-targets	150-500	0-500	50-5000	≤ 4

In order for the UAV to be able to fly, an unmanned aerial vehicle (UAS) is required, which consists of the following elements: the UAV itself; UAV control (management) stations; software and systems for monitoring the condition of the UAV; means of communication (ground/air and air/ground) for air traffic control and payload of UAV; data processing terminals; landing system; launch systems and in-flight recovery systems; equipment for maintenance and upkeep of the UAV and its systems; UAS storage and transportation systems. At the same time, UAS should be serviced by qualified ground personnel [6, p. 16].

Delivery by so-called «smart drones» to hard-to-reach points is a method of delivering cargo by unmanned aerial vehicles (UAVs),

which are used to transport packages, medicines, food, or other goods.

«The Economist» recently named the civilian drone industry one of the most promising industries for business. Let's find out in what areas drones are currently used and what is the secret of the popularity of flying robots. Last summer, scientists launched a trial version of the giant Aquila drone, a drone that is powered by solar panels and can therefore fly for three months without interruption.

Drones have also begun to be used as a delivery service tool. The Wing project, developed by Google Alfabet, will work with two Australian companies - medical and restaurant. The Guzman y Gomez network of Mexican establishments and the Chemist Warehouse pharmacy company use Alfabet drones to deliver food and medicine to rural customers. Typically, such customers have to drive 40 minutes by car to get an order, since the nearest grocery store, restaurant, or pharmacy is far from their home.

The project is experimental; meaning those who will use its services will participate in the study of the efficiency of drone delivery. This method is not yet ideal, because, despite a system that can pre-configure routes, drones rely on onboard sensors to avoid interference. However, the more routes traveled, the more information drones will be able to gather, and the better the sensors will work on the ground which will be able to protect drones from collisions. This method is also convenient for businesses - restaurant owners say that such delivery will help them fine-tune the logistics of sending products to customers while they are still hot. It will also help them understand how much time it takes to prepare, pack and load food as quickly as possible. At the same time, unmanned delivery of over-the-counter medications and vitamins will help pharmaceutical companies find the best way to package different drugs and optimize the number of items that can be delivered in one flight [7].

Commenting on the possibilities of drone deliveries, it can be noted that this project is promising and interesting, however, despite the publicity and the illusion of mass use of technology, it is not perfect and is still under development. Practical examples of regular cargo delivery routes in the world are scarce. Such projects exist in artificially created conditions, within a clearly defined space, and they cannot be transferred to other territories.

The problems with delivery now are not in the technological sphere, because it is possible to send a loaded drone from point A to point B without obstacles, but in the legal one. Currently, the use of drones is allowed only in the line of sight, meaning when the pilot of the drone sees the device throughout the flight. EU countries are developing regulations that will allow drones to be used out of sight. Such introductions will affect the drone delivery industry. There is also the problem that the drone, using automatic navigation, must follow specific rules and altitudes to avoid collisions with other flying objects [8]. However, such laws have not yet been defined.

Mass drone deliveries are the creation of a large regional aviation infrastructure above ground level, rather than one-day delivery by one drone in one hand. Therefore, it is necessary to create many legislative initiatives, and change many documents, not only in Ukraine but all over the world. In Ukraine, everything is complicated because the legal framework doesn't define drones as an independent transport unit [9].

Advantages and disadvantages of using UAV for cargo delivery

Delivery of cargo by quadcopters and other such aircraft has many advantages. However, there are several shortcomings, without which such a solution is unlikely to become widespread. Let's take a closer look at the main pros and cons [10].

The main advantages of this method of cargo delivery include:

- complex terrain (mountains, jungles, etc.) is not a problem. Drones overcome it

relatively easily, which in many cases significantly reduces the route, speeding up delivery time;

- independence from transport infrastructure restrictions. For example, old railways or a broken road that negatively affect the movement of conventional land transport;

- high speed of delivery is provided since drones aren't affected by situations on the road (traffic jams, accidents, and other possible problems);

- Quadcopters have such an interesting feature as the possibility of vertical landing, which allows to ensure very high delivery accuracy thanks to the GPS sensor;

- Compact drone, powered by an electric battery, has a much smaller negative impact on the environment than a truck or car;

- in the long run, the commercial use of drones, due to their high energy efficiency and the ability to work in hard-to-reach places, can have a positive impact on many sectors of the economy.

Some disadvantages prevent us from using drone delivery everywhere:

- small carrying capacity (up to 3-4 kg) does not allow the use of quadcopters for transporting large loads. Delivery of large household appliances or furniture in this way will not work;

- restrictions on battery life (up to 30 minutes) significantly limit the radius of possible delivery, and for the commercial use of technology you need to create an entire infrastructure from scratch;

- The issue of privacy remains relevant - the drone uses GPS to move to the exact destination, as well as a built-in camera that avoids interference during the flight and land safely;

- legal issues - in some countries the use of drones is not regulated, but in the United States and other Western countries, regulators are already actively working in this direction;

- Physical security is another potentially problematic issue, as it is unlikely that many city dwellers will be thrilled if hundreds of drones flying overhead, one of which could fail and hit one of the pedestrians.

They can also pose a potential hazard when used near airports due to the risk of collisions with aircraft [11].

Drones help with last-mile delivery because they can transport drugs and vaccines, as well as deliver medical specimens to and from remote or inaccessible areas.

So far, the delivery of goods by quadcopter is, rather, a test. Copters are readily used in advertising, for show delivery of goods during promotions, and to achieve a wow effect: passers-by are happy to record and photograph drones, distributing videos and photos on social networks. But logistics experts are confident that drone delivery will become commonplace in the future.

The main task is to quickly restore safe logistics chains in the liberated territories and to establish the supply of humanitarian aid to the affected cities of the region [12].

To accomplish this task, local authorities may involve medical response drones and search-and-rescue drones manufactured in North America. An innovative temperature-controlled medical cargo box will be included in medical drones. A payload box can hold up to 35 pounds of medical supplies, including blood, pharmaceuticals, insulin/medicine, vaccines, water, and wound care kits. It is also mounted on top for safer and more convenient delivery.

The army of air drones of some world manufacturers can deliver cargoes from 20 kg to 500 kg of critical cargoes across all of Ukraine. With a huge range of fixed-wing aircraft, helicopters, gyro-helicopters, and hybrid aircraft operating in a coordinated network of short and long-distance supply lines, we could provide an almost inexhaustible supply of everything that is needed by frontline troops or civilians, without risking any human life.

Night flights, close to the ground, and the use of specialized technologies that allow flights in areas where Global Navigation

Satellite Systems (GNSS) are jammed and the coverage is designed to significantly reduce the radar cross-section, could significantly improve supply lines to the front line, and locations and territories dominated by Russians. Of course, there would be losses, but the replenishment of these unmanned vehicles would be quick and cost-effective.

Drones can be used in many ways: fast, quiet airborne drones can be used in electronic warfare to disrupt Russian communications on the ground or confuse Russian planes; small systems can be used to deliver passive beacons to detect targets that increase the effectiveness of strikes against the enemy [13].

Relatively recently, the concept of «flying platform» was developed, according to which they began to build UAVs, connecting the payload with onboard systems, such as multi-purpose UAV «Proteus» (USA), which can compete with satellites [6, p. 30]. Unlike the satellite, the UAV monitors the observation point constantly. After completing the task at an altitude of 20 km for 24 hours, he returns to base, and he is replaced by another in the sky. Another UAV is in reserve. This is the main component of savings, as UAV is an order of magnitude cheaper than satellites.

In the world market, aviation equipment is gradually gaining its right to life qualitatively different from traditional aircraft without a pilot on board. Given the reasons stated above and awareness of its leading role in the development of aviation technology, the staff of the National Aviation University (NAU) over the past decade has made a worthy contribution to the development of unmanned aerial vehicles. More than 40 different designs of unmanned aerial vehicles (UAVs) were developed and implemented [6, p. 240-247].

Unmanned aerial vehicles and their complexes made by NAU have a wide range of applications: for cargo transportation - it is an unmanned four-engine helicopter PKM-14 «Saturnia» for the transportation of small cargo at a distance of 3 km in automatic mode; for reconnaissance, monitoring, and other purposes - this is the unmanned aerial vehicle complex (UAVC) «Ovod» M106 designed to perform reconnaissance from the air day and night with the transmission and recording of video or infrared images in the «online» mode; unmanned aerial vehicle M-6 «Zhayvir» for technologies of biological protection of crops; unmanned aerial vehicle system M-56 «Module» in law enforcement agencies can be used as a carrier of high-precision weapons; planning self-propelled mini-ammunition PMB-03, which is dropped from the aircraft carrier, achieving the goal in the planning mode on the battlefield, and during special operations [6, p. 114-181].

It is known that the modern market of «clean» UAVs is volatile and is activated mainly in the event of hostilities. It takes a long time (about 4-6 years) to bring a clean UAV project to sales, because of significant expense and struggle with the corporations of the leading countries, which have been long known in the «clean» UAV market and hold most of it.

Our key priority in this initial organizational period of the UAV market is to pool and mobilize resources within aviation clusters in global and regional markets. Thus, on March 24, 2022, 16 clusters and cluster organizations of Ukraine merged into the Ukrainian Cluster Alliance (UCA) and this growth continues. This is the first association of clusters in Ukraine, which undertakes the mission of developing the entire cluster movement [14]. The Ukrainian Cluster Alliance (UCA) has started a series of meetings with European clusters. Traditionally, this format of communication is called C2C (clusters2clusters) and it is more effective because it offers a direct dialogue between the parties. A special marketplace of assistance to Ukrainian clusters and SMEs has been launched on the European Cluster Cooperation Platform (ECCP). This is an initiative of the European Cluster Alliance (ECA) for humanitarian aid to Ukrainian clusters, launched in late February 2022 in

conjunction with the cluster committee Industry4Ukraine, the predecessor of UCA. Europeans offer mostly humanitarian and other assistance to refugees, while our clusters need help to restore supply chains and added value.

The mission of the association is to accelerate the clustering of economic sectors of Ukraine by consolidating and growing members of the cluster movement, and their development following European best practices and standards. During the war, UCA's priority was to support clusters of critical industries responsible for food security, drug production, clothing, health care, and critical infrastructure.

Transport and logistics clusters with their active component of unmanned aerial systems, which will help to restore the chains of unmanned aerial vehicles, should become a connecting link in the Ukrainian cluster alliance.

Conclusions. The formation of a regional transport and logistics cluster of unmanned aerial systems and NAU complexes will help integrate unmanned aerial vehicles to solve many scientific and applied problems related to geology, ecology, meteorology, zoology, agriculture, climate research, mining, etc. Unmanned aerial vehicles can optimize the tracking of migration of birds, mammals, and fish, changes in meteorological conditions and ice conditions on rivers, the movement of ships, the movement of vehicles and people, radar reconnaissance, aerial, photographic and cinematographic, multispectral up to 100 meters, etc. [6, p. 31].

The Regional Transport and Logistics Cluster of Unmanned Aerial Systems and Complexes of NAU within the Ukrainian Cluster Alliance (UCA) will provide conditions at the stage of formation of transitional aviation to initiate competitive flagship projects of unmanned aerial vehicles aimed at helping critical industries. European clusters are expected to help with supply, new projects and orders, and integration into innovative projects. To intensify its activities, the Regional Transport and Logistics Cluster of Unmanned Aerial Systems and NAU Complexes needs to agree on its positions, priorities, action program, and key messages and submit them to the UCA Coordination Center to prepare for C2C meetings with a group of stakeholders. Commission on the European Cluster Cooperation Platform (ECCP).

References

1. Clusters4Ukraine - uniting industrial and high-tech communities to win. URL. https://mail.google.com/mail/u/0/?tab=rm&ogbl#inbox/FMfcgzGmvLRqsFWZptddXDpTqlPkDCxH

2. Gritsenko S.I., Taranich A.V. Strategy of foreign economic activity of cluster formations in the information economy: monograph. DonNU. Donetsk, 2010. 227 p.

3. Gritsenko S.I. Paradigm of innovative development of the economy of Ukraine in the context of transport and logistics clusters: monograph. Innovative development of the economy: global trends and national features. Collective monograph. Lithuania: Publishing House «Baltija Publishing», 2018. 716 p. (P. 114-128).

4. Gritsenko S.I., Karpun O.V. Creation of aviation transport and logistic clusters network. Intellectualization of logistics and Supply Chain Management. [Online], vol.2, pp.7-15, available at: https://smart-scm.org/en/journal-2-2020/gritsenko-sergiy-karpun-olga-creation-of-aviation-

transport-and-logistic-clusters-network/ (Accessed 21 Jul 2020). DOI: https://doi.org/10.46783/smart-scm/2020-2-1.

5. Gritsenko S.I. Formation of ecologically oriented activity of transport and logistics clusters with the use of innovative intellectual technologies. Cluster Policy of Innovative Development of the National Economy: Integration and Infrastructure Aspects: collective monograph. Poznań: WSPIA Scientific Publishing House, 2020. 382 p. (P 335-351).

6. Unmanned aerial systems and complexes of the National Aviation University: teaching method. manual / M.G. Lutsky, M.P. Matiychyk, O.Y. Mikhatsky, M.I. Fuzik [etc.]; for the head ed. M.G. Lutsky. Kyiv: Lira-K Publishing House, 2022. 248 p.

7. Review of the areas of use of UAVs in modern life. URL. http://www.50northspatial.org/ua/uavs-everyday-life/

8. Maladyka I.G., Dendarenko Y. Y., Myroshnyk O.M., Bychenko A.O., Fedorenko D.S., Slovinsky V.K. and others. Handbook of Fire Extinguisher. - Ukrainian Research Institute of Civil Defense. - Kyiv: Litera-Druk LLC, 2016, - 320 p.

9. Energy sources of Ukraine. URL. https://enerhodzherela.com.ua/analityka/

10. Drones. Advantages, disadvantages, threats. URL. https://uain.press/blogs/drony-perevagy-nedoliky-zagrozy-1102658

11. The Committee on Transport and Infrastructure reports on road management and postal services. URL. https://www.rada.gov.ua/news/razom/221650.html

12. Commercial drones could be the answer to Ukraine's logistics nightmare. URL. https://fortune.com/2022/04/26/commercial-drones-invasion-tech-ukraine-russia-putin-war-logistics-supply-lines-mariupol-civilians-international-robert-garbett/

13. Using of drones in the wartime. URL. https://www.fierceelectronics.com/electronics/airborne-drones-deliver-medical-supplies-kiev-kharkiv-war-rages

14. UCA - rapid growth in all areas. URL. https://mail.google.com/mail/u/0/?tab=rm&ogbl#inbox/FMfcgzGpFWTLbZjZwtbtBddMhfqBNWxM

UDC 658.45; 339.182
DOI: https://doi.org/10.46783/smart-scm/2022-12-4
JEL Classification: L15, O11, Q13, O32.
Received: 24 March 2022

Kulik V.A. PhD (Economics), Professor, Professor of Logistics Department National Aviation University, Honored Worker of National Education of Ukraine, Honorary employee of aviation transport of Ukraine (Ukraine)

ORCID – 0000-0002-3975-9036
Researcher ID – S-7356-2018
Scopus author id: –

Marchuk V.Ye. Doctor of Engineering, Professor, Professor of Logistics Department National Aviation University (Ukraine)

ORCID – 0000-0003-0140-5416
Researcher ID – S-6514-2018
Scopus author id: – 56246790900

Harmash O.M. PhD (Economics), Associate Professor, Associate Professor of Logistics Department National Aviation University (Ukraine)

ORCID – 0000-0003-4324-4411
Researcher ID – I-4542-2018
Scopus author id: – 57218381499

Karpun O.V. PhD (Economics), Associate Professor, Associate Professor of Logistics Department National Aviation University (Ukraine)

ORCID – 0000-0003-2058-9070
Researcher ID – S-6428-2018
Scopus author id: –

Perederii N.M. PhD in Economics, Docent of the Air Transportation Management Department National Aviation University (Ukraine)

ORCID – 0000-0003-4173-9445
Researcher ID –
Scopus author id: –

SECURITY MANAGEMENT OF INTERMODAL TRANSPORTATION IN CONDITIONS OF SUSTAINABLE DEVELOPMENT OF GLOBAL SUPPLY CHAINS

Kulik Volodimir, Marchuk Volodimir, Harmash Oleh, Karpun Olga, Perederii Nadiia. «Security management of intermodal transportation in conditions of sustainable development of global supply

chains». *The article considers the complex problem of ensuring the security of supply chains of various kinds, including dangerous, when they are transported by different modes of transport with the necessary transshipment in a single logistics flow. At the same time, the authors tried to take into account both the general concept of sustainable development of the system of global supply chains (consumer goods) and the dynamics of change of supply objects depending on specific needs and situations in the world. Therefore, given the current tense military situation in the world, the main focus was on intermodal transport of dangerous goods and systemic security risks and threats of man-made nature and their consequences for the generalized characteristics of economic and social security.*

The research was based on the United Nations World Development Program to 2030, scientific and theoretical foundations of supply chain management and security, SCM, the concept of advanced risk management, as well as standards and practical recommendations of leading international organizations (ISO, BTO, ICAO and others) issues of economic security and protection of components of the world transport system from threats and exacerbation of risks.

The practical result of scientific research is the development of recommendations for ensuring man-made safety of intermodal transport in the supply chain of dangerous goods under the programs of preventive, compensatory and remedial measures.

Keywords*:* security of supply chains, transport and logistics risks, dangerous goods, technical means, international terrorism, man-made threats, intermodal transportation, sustainable development.

Кулик Володимир, Марчук Володимир, Гармаш Олег, Карпунь Ольга, Передерій Надія. «Управління безпекою інтермодальних перевезень в умовах сталого розвитку глобальних ланцюгів постачань». *В статті розглянута комплексна проблема забезпечення безпеки ланцюгів постачань вантажів різного роду, в тому числі і небезпечних, при їх перевезенні різними видами транспорту з необхідними перевалками в єдиному логістичному потоці. При цьому автори намагались враховувати як загальну концепцію сталого розвитку системи глобальних ланцюгів постачань вантажів (продукції) широкого вжитку, так і динаміку зміни об'єктів поставок в залежності від конкретних потреб і ситуацій в світі. Тому, зважаючи на існуючу напружену військову ситуацію в світі основну увагу було приділено інтермодальним перевезенням небезпечних вантажів та системним безпековим ризикам і загрозам техногенного характеру і їх наслідкам для узагальнених характеристик економічної та соціальної безпеки.*

Базою виконаних досліджень була Програма ООН щодо світового розвитку до 2030 року, науково-теоретичні основи управління ланцюгами постачань та їх безпекою, SCM, концепція випереджаючого управління ризиками, а також стандарти і практичні рекомендації провідних міжнародних організацій (ISO, BTO, ICAO та інші) з питань економічної безпеки і захисту складових світової транспортної системи від загроз і загострення ризиків.

Практичним результатом наукових досліджень є розробка рекомендацій забезпечення техногенної безпеки інтермодальних перевезень в ланцюгах постачань небезпечних вантажів за програмами превентивних, компенсаційних та відновлювальних заходів.

Ключові слова: безпека ланцюгів постачань, транспортно-логістичні ризики, небезпечні вантажі, технічні засоби, міжнародний тероризм, техногенні загрози, інтермодальні перевезення, сталий розвиток.

Кулик Владимир, Марчук Владимир, Гармаш Олег, Карпунь Ольга, Передерий Надежда. "Управление безопасностью интермодальных перевозок в условиях устойчивого развития глобальных цепей поставок". *В статье рассмотрена комплексная проблема обеспечения безопасности цепей поставок грузов разного рода, в том числе и опасных, при их перевозке разными*

видами транспорта с необходимыми перевалками в едином логистическом потоке. При этом авторы пытались учитывать, как общую концепцию устойчивого развития системы глобальных цепей поставок грузов (продукции) широкого потребления, так и динамику изменения объектов поставок в зависимости от конкретных потребностей и ситуаций в мире. Поэтому, учитывая существующую напряженную военную ситуацию в мире, основное внимание было уделено интермодальным перевозкам опасных грузов и системным рискам безопасности и угрозам техногенного характера и их последствиям для обобщенных характеристик экономической и социальной безопасности.

Базой выполненных исследований была Программа ООН по мировому развитию до 2030 года, научно-теоретические основы управления цепями поставок и их безопасностью, SCM, концепция опережающего управления рисками, а также стандарты и практические рекомендации ведущих международных организаций (ISO, ВТО, ICAO и другие) с вопросов экономической безопасности и защиты составляющих мировой транспортной системы от угроз и обострения рисков.

Практическим результатом научных исследований разработка рекомендаций обеспечения техногенной безопасности интермодальных перевозок в цепях поставок опасных грузов по программам превентивных, компенсационных и восстановительных мероприятий.

Ключевые слова: безопасность цепей поставок, транспортно-логистические риски, опасные грузы, технические средства, международный терроризм, техногенные угрозы, интермодальные перевозки, устойчивое развитие.

General statement of the problem and its connection with scientific and practical tasks. In today's global transformations of international business, its cross-border and logistisation, especially in the extreme circumstances of Russia's military aggression on the territory of sovereign Ukraine and the threat to the whole of Europe, the problem of strategic security management of intermodal transport in global supply chains is becoming increasingly important. It requires unprecedented in scale and effectiveness measures to reorient the structure of specific transportation facilities, atypical use of modes of transport and their routes, increase the risks of safe implementation of systemic transport processes, procedures and actions. Ensuring the reconstruction of sustainable development of the global, regional and national economy not only in Ukraine but also in the EU as a whole directly depends on the comprehensive solution of this task in the future. The Sustainable Development Agenda 2030 remains a strategic document of the UN global level. It is an action plan aimed at ensuring global sustainable development in economic, social and environmental areas, which ensures that no UN member state is left behind. The 17 Sustainable Development Goals on the agenda for 2030 can be used as benchmarks for the coherent and balanced development of UN member states. Achieving such levels of safety and efficiency of intermodal transport in the system of world transport communications directly or indirectly depends on the achievement of such Global Goals for Sustainable Development (SDG) as: 4. Quality education; 8. Decent work and economic growth; 9. Industry, innovation and infrastructure; 11. Sustainable cities and societies; 13. Climate change. This list of Sustainable Development Goals, in which intermodal transport is involved, is not exhaustive. The number of states expanding the range of UN Sustainable Development Goals, including Objectives 4, 8, 9, 11, 13, 14, 16 and 17, is growing every year. In the future, this list will only grow [2]. Threats to supply chain security will arise at both global, regional and national levels. Accordingly, the requirements of strategic and operational coordination, harmonization and partnership between the United Nations as a whole and economic specific economic entities, as well as such international real and

45-56
v.12 (2022)
https://smart-scm.org

virtual entities as global networks of supply channels and chains, international transport corridors (ITC) passenger and freight traffic [4. 5]. In conditions of increased danger, such formations act as integral objects of end-to-end security management of synchronized flow processes of integrated logistics systems.

The practical problem #1 of ensuring security for all mankind is protection from various threats caused by:

 high rates of change in all areas of life;

 the constant emergence of new dangers in a dynamic environment of transport activities;

 growing instability of the economic and socio-political environment;

 huge complexity and volumes of production and technological capacities;

 weak structure of security threats critical factors.

The growth of threat factors in supply chains is realized through:

- vulnerability of interdependence relations of chain subjects;

- insufficient structure of the resources of the information platform chain as a single integrated economic entity;

- growing unpredictability of development and forecasting of the global chain as a highly complex dynamic system;

- lack of time for decision-making on counteraction to danger in the conditions of high-speed electronic communications and vehicles of LP [3];

- the threatening nature of some technological advances due to their expected consequences;

- illegal activities of criminal organizations.

Security of supply chains provides their integral and systemic protection against internal and external threats of deviation and destruction of stable functioning and development of all interacting elements of the chain.

Review of publications and results of the analysis. Transportation can be defined as a key logistics activity related to the movement of products by a particular vehicle on a particular technology in the logistics chain, and which consists of complex and basic logistics operations and functions, including forwarding, cargo handling, packaging, transfer of ownership, insurance risks, customs procedures, etc. Intermodal in this case is the system of delivery of goods by several modes of transport on a single transport document with their reloading at transshipment points from one mode of transport to another without the participation of the goods owner.

An important issue is the classification of types and directions of ensuring the supply chains security. Focusing on economic security is necessary but not enough. Today, the environmental and technogenic safety of both logistics processes and technologies, as well as the goods themselves, which are transported in global supply chains, are equally important. Particularly dangerous threats of international terrorism exist in intermodal transportation systems [1, 9]. After all, the supply chain and its movement are connected with the rich infrastructure of vehicles and the paths of extensive warehousing, loading and unloading equipment, communication systems, computer technology and information technology. Figure 1 shows the relationship of structural elements of sustainable development with the security of intermodal transport of global supply chains [6].

Decreased security in supply chains increases the risks of cargo theft, corruption, fraud, and organizational and management errors. In some countries, especially ITC routes, this is facilitated by open access to cargo traffic information via the Internet, the lack of a unified cargo incident information system, the ability to obtain confidential information about companies and organizations and other fraudulent activities, and the low level of legal regulation of illegal actions in the transportation of commercial goods, and especially dangerous goods. At the same time, security problems in Ukraine

45-56
v.12 (2022)
https://smart-scm.org

are exacerbated by the lack of a unified system of transport safety standards in the national transport network, deterioration of the criminogenic situation, a marked reduction in law enforcement response and especially the complexity of transport in the war zone and escalating threats in the uncontrolled Donbass and Crimea.

The system of ensuring the supply chains security in general is designed to solve a range of interrelated problems: resolving conflicts between the interests of participants; control of responsibility transfer; security strategy and tactics based on modern scientific concepts, rights, standards and best practices, new models, methods, technologies and techniques; taking into account modern international approaches to the organization and management of supply in accordance with the requirements of ISO 28.000 to the security of the global supply chain [7].

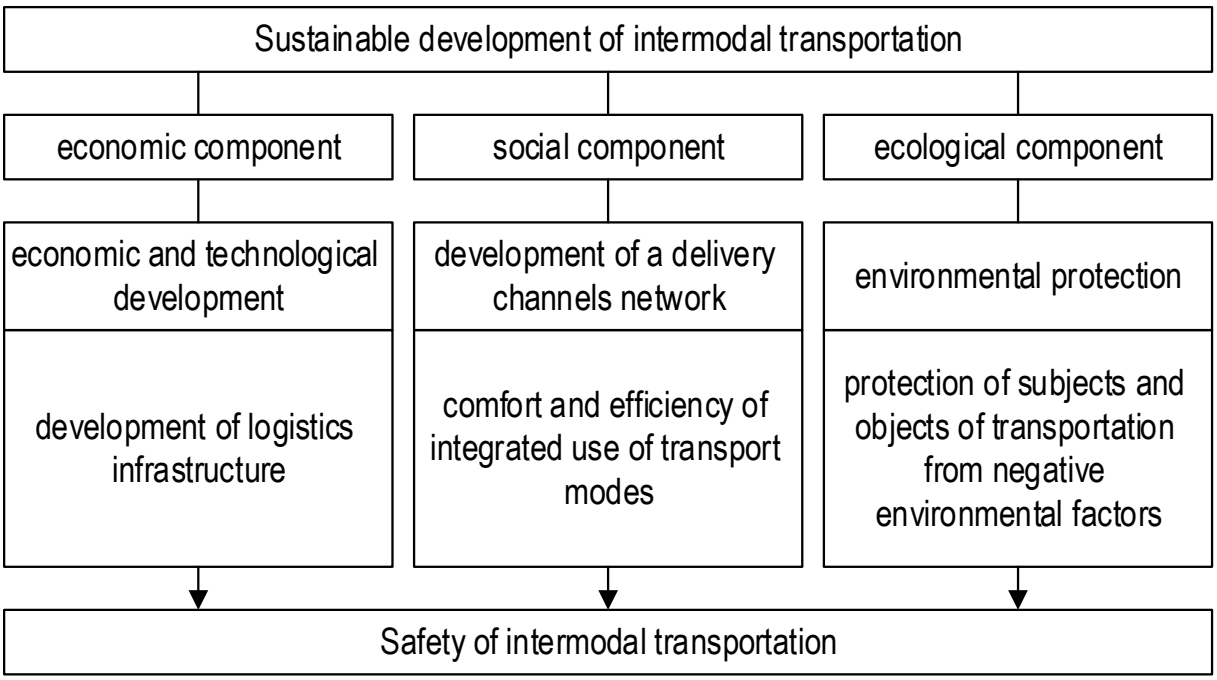

Figure 1 – The system of sustainable development of intermodal transportation in supply chains

World experience in building a supply chain security system draws attention to the most important elements in the activities of chain links, namely: services quality of supply chain participants; services quality of organizations that ensure the supply chain safety, territories and routes of movement; cargo categories; features of packaging and labeling; tracking and tracing technologies; cargo storage technologies; list of transport reserves by types of transport; chain information support; a list of characteristic obstacles in the way of logistics flows; a list of required internal flow processes covering all parts of the supply chain; characteristics of external conditions that affect the operation of the chain links; list of security threats in supply chains (updated); a list of significant problems that arise during the implementation of security threats [2, 9].

All trends in supply chain security management, discussed in the scientific literature [6], focus on economic security issues. In our opinion, this does not take into account the technogenic safety of supply chains, as the most complex technical entities with a very rich infrastructure of vehicles and roads, warehousing, handling equipment, telecommunications and computer technology [6].

One of the painful problems in the implementation of transport security policy in

45-56
v.12 (2022)
https://smart-scm.org

Ukraine in recent years has been the security of the ITC and their involvement in the unified international transport network. Russia's military aggression has effectively destroyed the transit capabilities of ITCs operating in Ukraine. World trends of globalization, new scientific and technological revolution, logistics and integration have enabled ITC, as a set of different modes of transport, to provide significant transportation of goods and passengers in the areas of their greatest concentration [1].

Presentation of the main material. In general, supply chain security covers three main areas:

- security of key infrastructure facilities - logistics enterprises of terminal and warehousing facilities, roads and highways;
- security of the moving part of the chain - all types of transport, packages, containers and, above all - the objects of supply - cargo;
- cybersecurity - information environment of IT technologies, databases of customers, suppliers, finance and programs.

Supply chain security management is identified as activities to maintain them at the level of stable operation (viability) and sustainable development, which includes the process of combating unauthorized actions, planning, monitoring and improving the system of comprehensive measures, including organizational and managerial, legal, physical, technical, technological, insurance, financial, economic and cultural aspects in order to reduce losses, identify and prevent offenses and other security threats, bring the perpetrators to justice, achieve goals and results [7].

Security management regulates security risks using a complex integrated mechanism of effective management depending on their risk category (Fig. 2).

Advanced management of integrated risks allows obtaining a positive synergetic effect at the level of supply chains sustainable operation.

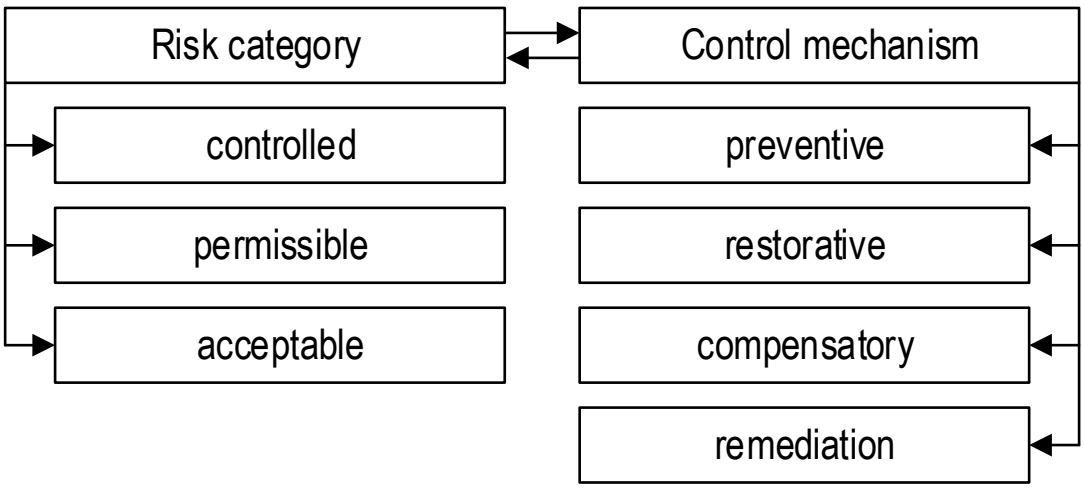

Figure 2 – Classification of risk management mechanisms

The concept of advanced risk management of intermodal transport in global supply chains. The leading link in the supply chain is transportation, and the most vulnerable stage of transportation is air transportation of cargo, as there are serious threats of hijacking, terrorist explosions, unauthorized transportation of plastic explosives, weapons and nuclear materials. In the system of advanced risk management, the threat has the maximum potential energy, which can directly damage the system of intermodal air transport in particular and indirectly cause negative consequences for the sustainable development of the national economy as a whole. With this vision, an effective mechanism for anticipating risk management of hierarchical systems is to

manage the degree of vulnerability of the system using the model of "Swiss cheese" by J. Rieson and structural analysis of deficiencies (GAP Analysis) at the level of active and passive systems to protect vulnerable component of intermodal transport (that is an aviation transport), namely: techniques and technologies, norms, rules and regulations and personnel training / retraining systems. Identifying vulnerable or underprotected places (GAPs) at the level of each protection system, as well as analyzing their interconnectedness or singularity with respect to the passage of a threat through protection systems, makes it possible to identify hierarchical and complex vulnerabilities to identified threats.

In fact, the answer is what part of the potential energy will be lost due to the opposition of each of the air transport protection systems and the synergistic effect of their integrated use. All residual energy is converted into kinetic energy and affects intermodal transportations due to spontaneous fractalization of negative impact factors, which is assessed as negative consequences of the threat impact after its passage through different hierarchical systems of active and passive protection. With such a question, risk can be assessed as a combination of threat, vulnerability and consequences (Fig. 3).

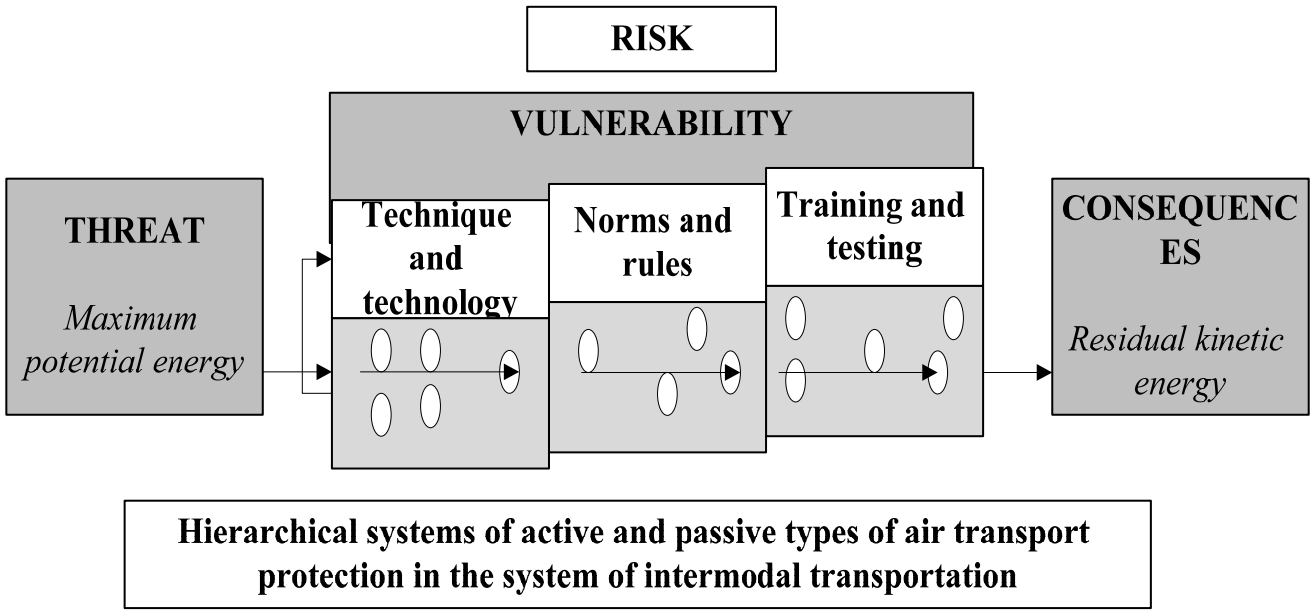

Figure 3 – The use of the "Swiss cheese" model by J. Rizon in the strategic management of air transport

Integrated air transportation risks are formed in the following areas: economic, environmental, social, technological, flight safety, aviation security and protection against terrorism, foreign policy, logistics and related sectors of the economy (Fig. 4).

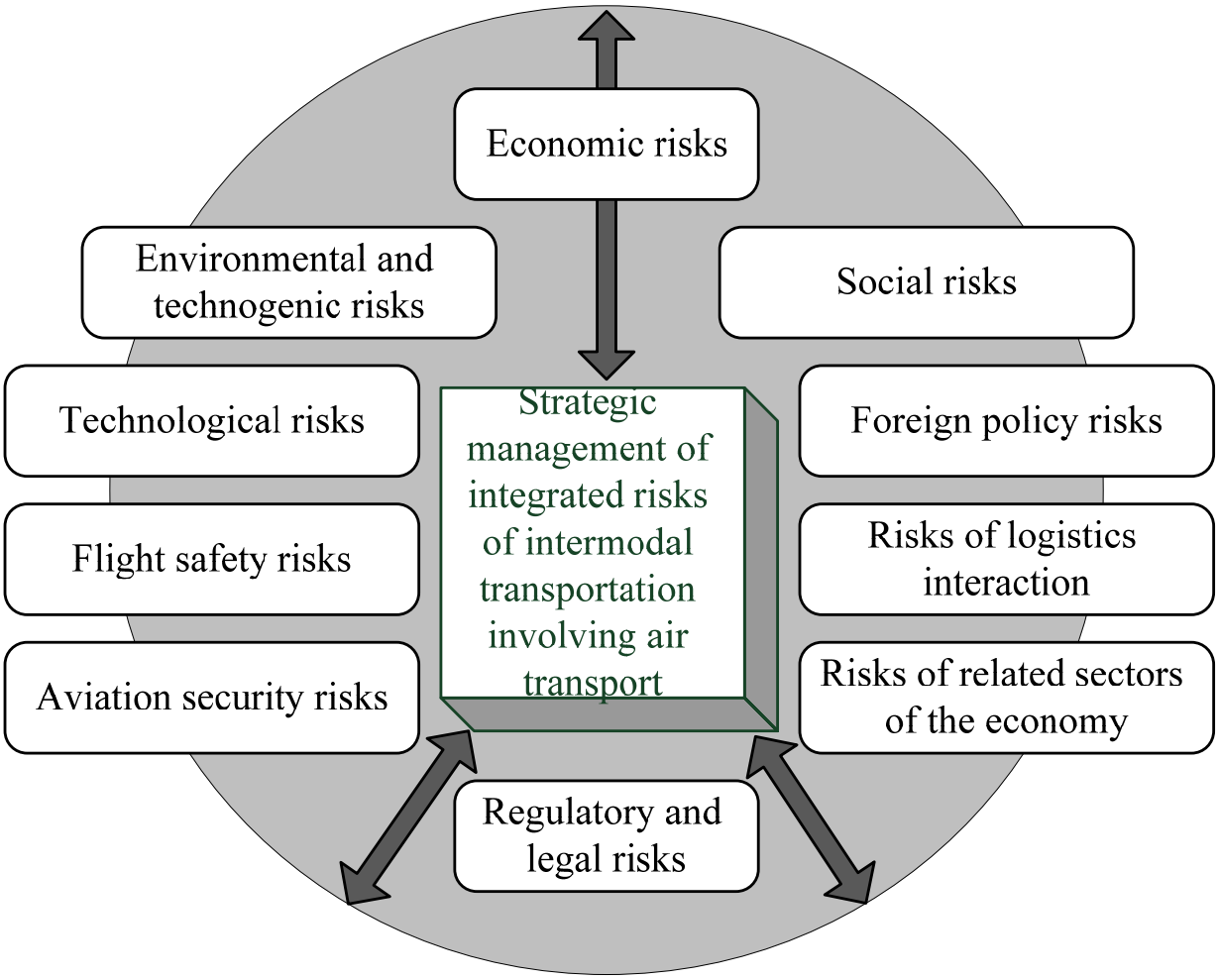

Figure 4 – Integrated risks of intermodal transportation involving air transport

Exacerbation of risks is facilitated by various economic factors - production, market, financial and investment - that reflect the specific situation and constantly changing state of supply chains (Fig. 5).

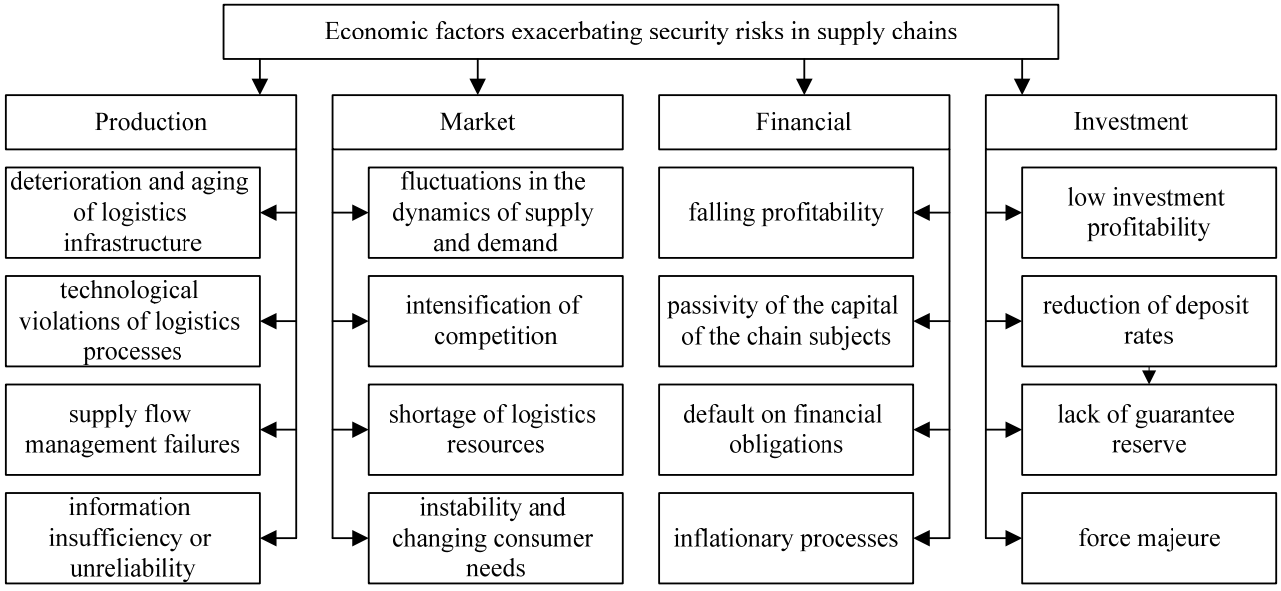

Figure 5 – System of risk exacerbation factors in supply chains

For intermodal transportation, the most problematic in terms of supply flows security is the delivery of dangerous goods.

Dangerous goods are raw materials, products, wastes of production or other activities, which due to their inherent qualities in the presence of certain factors may pose a risk of explosion, fire, damage to equipment, facilities and other objects, causing material damage to the environment and lead to death, injury, poisoning of people and animals. Deliveries of such goods today account for about 20% of the total volume of goods supplied, and the trend of their growth continues. It is impossible to completely rule out the possibility of threats, and the use of standard and proven measures is not enough. Obligatory accompaniment of especially dangerous cargoes, end-to-end patrol of all trajectories of the logistics flow, territories of commodity and sorting enterprises, use of mobile inspection complexes are still relevant.

Ecological and technogenic aspect of intermodal transportation in global supply chains. The ecological aspect is especially important in the transportation of dangerous goods. As hazardous substances during transport and emergencies can have a negative impact on the environment (irreversible changes in the ecological background, the death of some species of plants and animals) and cause significant damage to human life and health, in many countries there are special safety rules operate in the carriage of dangerous goods. That is why the transportation of such goods, as well as all intermediate operations with them (loading and unloading, temporary storage, etc.) are strictly regulated in accordance with the European Agreement International Carriage of Dangerous Goods by Road (ADR). It was drafted within the framework of a requirements single system for the transportation of dangerous goods, designed to simultaneously secure their transportation between countries and simplify customs formalities as much as possible. European Agreement International Carriage of Dangerous Goods by Road (ADR) was established at the initiative of the United Nations and concluded in Geneva on September 9, 1957.

The United Nations (UN) has created a special list of hazardous substances (more than 3,000 items). Each hazardous substance included in this list has a four-digit number, which is called the UN number. This number can be used to find out the exact name of the dangerous substance being transported. The list is divided into classes. It is allowed to transport a dangerous substance of one class only according to the rules assigned to it (Table 1).

Table 1 – Classification of Dangerous Goods

UN Class	Dangerous Goods	Sub-Divisions
I class	Explosives	1.1. Substances and articles which have a mass explosion hazard 1.2. Substances and articles which have a projection hazard but not a mass explosion hazard 1.3. Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both 1.4. Substances and articles which present no significant hazard; only a small hazard in the event of ignition or initiation during transport with any effects largely confined to the package 1.5. Very insensitive substances which have a mass explosion hazard 1.6. Extremely insensitive articles which do not have a mass explosion hazard

End of table 1

UN Class	Dangerous Goods	Sub-Divisions
II class	Gases	2.1. Flammable gases 2.2. Non-flammable, non-toxic gases 2.3. Toxic gases
III class	Flammable liquid	There are no subdivisions within Class 3
IV class	Flammable solids	4.1. Flammable solids 4.2. Substances liable to spontaneous combustion 4.3. Substances which, in contact with water, emit flammable gases
V class	Oxidizing substances, Organic Peroxides	5.1. Oxidizing substances 5.2. Organic peroxides
VI class	Toxic and Infectious substances	6.1. Toxic substances 6.2. Infectious substances
VII class	Radioactive materials	There are no subdivisions within Class 7
VIII class	Corrosive substances	There are no subdivisions within Class 8
IX class	Miscellaneous dangerous goods	There are no subdivisions within Class 9

It is in cases of transportation of dangerous goods that threats to technogenic safety acquire catastrophic consequences. All these technical and technological components of the supply chain actors become a potential and real danger both for the direct participants - the performers of logistics operations, and for the environment. In Fig. 6 systematized directions and mechanisms of technogenic supply chains safety management.

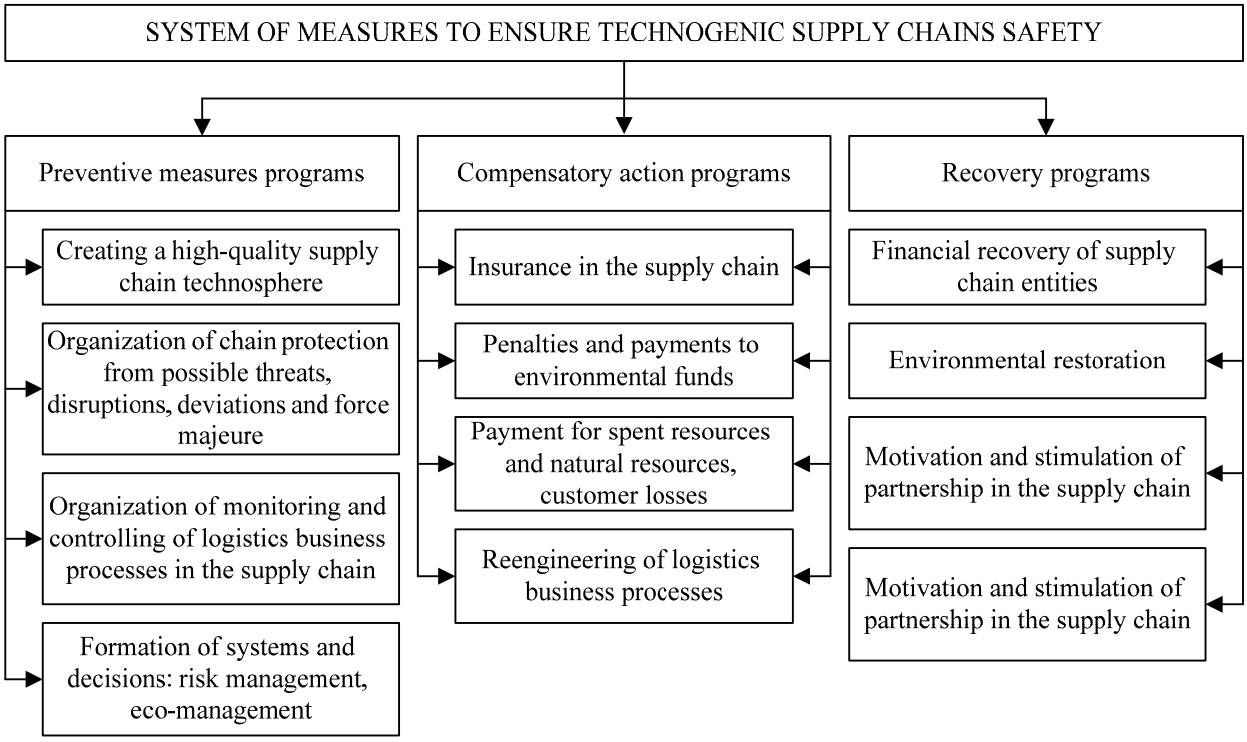

Figure 6 – The program of ensuring technogenic safety

First of all, it is necessary to develop a set of preventive measures that minimize the possibilities and conditions of technogenic disasters. It is not only about reducing or completely eliminating the problem of accidents due to violations of the operation rules of technical means and rules of transportation, but also about the system of monitoring the condition of dangerous goods at all stages of the supply chain. The US program of 100% container cargo scanning can be declared relevant and justified [7]. An obligatory component of the security program is a set of compensatory actions in the form of a logistics processes and operations reengineering system in response to new hazards and harmful effects, as well as fines and charges for deviations from standard requirements and regulations similar to the existing ICAO provisions on penalties for violations of the permissible noise level during aircraft landing and take-off. The program of technogenic safety measures should provide at the same time restoration projects of the territories, buildings, constructions and ecological environment affected as a result of technogenic situations.

The international requirements for the safety management system are based on a risk-oriented approach. The system must:

- to identify individual logistics processes of the supply chain;
- to determine the sequence of their interaction in the process of intermodal transportation;
- to define criteria and methods for effective operational control of data on security risks;
- to ensure the availability of resources, including information, for the sustainable operation of supply chains;
- to monitor, measure and analyze the risks of intermodal transport processes in supply chains to ensure their safety.

The nearest prospect of such systems development in the field of intermodal transportation will be a new quality of interaction of transport participants and logistics business on the basis of the developed models of integrated risks management in supply chains.

Risk management is, in essence, the economic mechanism of the regulation process and decision-making to reduce costs, improve productivity and quality of products and services in the integrated logistics chain. It provides an acceptable level of stability ("survival") of the system and its development, which is the safety of all economic processes.

The goals and principles of "absolute safety" or "zero risk", which have been used for many years in economic and technical systems, today give way to the principles of "acceptable risk" (ALARA - As Low As Reasonably Achievable). Following the world community, this approach is acceptable for Ukraine [4].

Today, Ukraine's transport system is not fully prepared to ensure the security of adequate volumes of international intermodal transportations. The main directions of solving this problem are:

- modernization of the unified transport system sections that limit their capacity;
- ensuring compliance of technical means and transport network with international standards;
- ensuring European standards of transportation quality - speed, safety, service, cargo storage and information services;
- signing and adherence to international documents that guide other European countries in regulating transport;
- development of infrastructure for all modes of transport.

Conclusions and proposals. In its activities to ensure the safety of intermodal transportation on all transport links of the supply chain it is necessary:

1. Harmonize and synchronize the standards requirements for all types of safety

for intermodal transportation at all links in the supply chain.

2. To create, by analogy with the United States, the Transportation Security Administration (ITA).

3. Introduce transport worker ID cards.

4. Introduce a cargo traffic control system with prior electronic notification of any imported or exported cargo.

5. Scan the contents of the container before loading on the vehicle and follow the tracing technology throughout the transport period.

6. Carry out mandatory certification under the C-TRAT system (Customs - Trade Partnerships Against Terrorism).

7. Organize a system of mandatory information from the importer of the carrier (10 + 2) for 12 items of safety standards [8].

References

1. Bakayev O.O. Mizhnarodni transportni korydory – priorytet ukrayins'koyi ekonomichnoyi perspektyvy / O.O. Bakayev, S.I. Pyrozhkov, V.L. Revenko // Sotsial'no-ekonomichni doslidzhennya v perekhidnyy period. Ukrayina v KHKHI stolitti: kontseptsiyi. 112 Visnyk Natsional'noyi akademiyi derzhavnoho upravlinnya ta modeli ekonomichnoho rozvytku: Vyp. KHKHIII: materialy dop. V Mizhnar. konhresu ukr. ekonomistiv, m. L'viv, 22-26 trav. 2000 r. / NAN Ukrayiny. In-t rehion. doslidzh.; L'viv, 2001. – S.495-514.

2. Buhayko D.O., Kharazishvili YU.M. Teoretychni zasady stratehichnoho upravlinnya bezpekoyu aviatsiynoyi haluzi u konteksti zabezpechennya staloho rozvytku natsional'noyi ekonomiky. Visnyk ekonomichnoyi nauky Ukrayiny. 2020. № 1 (38). S. 166-175.

3. Boychenko M.V. Upravlinnya lantsyuhamy postavok: shlyakhy vdoskonalennya. – Rezhym dostupu: URL: http://www.evd-journal.org/download/2020/3(61)/16-Boichenko.pdf

4. Merezha mizhnarodnykh transportnykh korydoriv na terytoriyi Ukrayiny. – Rezhym dostupu: URL: http://www.mintrans.gov.ua/uk/transports/print/42.html.

5. Miroshko V.M. Mizhnarodni transportni korydory i Ukrayina / V.M. Miroshko. – Rezhym dostupu: URL: http://www.rusnauka.com/ 12.APSN_2007/Economics.

6. Bugayko D., Kharazishvili Yu, Liashenko V., Kwilinski A. Systemic approach to determining the safety of sustainable development of air transport: indicators, level, threats. Journal of European Economy. [Ternopil]. 2021. Vol. 20. № 1 (76). January – March. P. 146-182.

7. Byrd E. Rules for Importing Cargo Security / E. Byrd // Customs and Border Protection Today. – 2004, March. – P. 5-10.

8. Edmonson R.G. 10+2 now / R.G. Edmonson // Journal of Commerce. – 2009. – June. – P.13.

9. www.mipt.org. – Terrorism Knowledge Base

10. Marchuk V.Ye., Harmash O.M., Ovdiienko O.V (2020) "World Trends in Warehouse Logistics". Intellectualization of logistics and Supply Chain Management. [Online], vol.2, pp.32-50, available at: https://smart-scm.org/en/journal-2-2020/marchuk-volodymyr-harmash-oleh-ovdiienko-oksana-world-trends-in-warehouse-logistics/ (Accessed 28 July 2020). DOI: https://doi.org/10.46783/smart-scm/2020-2-3

Scientific publication

INTELLECTUALIZATION OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT

The electronic scientifically and practical journal

№ 12 (2022)
April 2022

ISSN 2708-3195
DOI: https://doi.org/10.46783/smart-scm/2022-12