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Contents

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.

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Chief Editor

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SUBSTANTIATION OF EXPEDIENCY OF THE COMPLEX APPROACH FOR SUPPLY CHAINS MANAGEMENT IN THE COVID-19 CONDITIONS

Mariia Hryhorak, Henryk Dzwigol, Nataliia Trushkina, Yuliya Shkrygun "Substantiation of expediency of the complex approach for supply chains management in the COVID-19 conditions". *The transformations of management approaches to global supply chain management under the influence of a pandemic were analyzed. Key barriers to supply chain development in the context of the COVID-19 pandemic have been identified: non-diversification of supply chains; instability of the logistic activity organization; stretched supply chains; lack of flexibility and a single information space for all sections of global logistics networks; the dominant role of China as a "world factory".*

Based on the analysis of development indicators of global supply chains dynamics new trends and patterns for the post pandemic period were revealed. While transparency from start to finish (end-to-end). The

application of new technologies to ensure the transparency of supply chains was considered. Peculiarities and tendencies of supply chain development in Ukraine were researched. The expediency of applying an integrated approach to supply chain management taking into account global economic changes substantiated.

The directions of transformation of global logistics networks determined in the post coronavirus epoch among them we can note the following: increasing the volume of special air cargo transportation – airlines are already redeploying the fleet for exceptional air freight services; increasing the number of cargo inspections and border control protocols; intensification of the introduction of digital technologies and e-commerce; reconfiguration of global chains.

***Keywords**:* global supply chains, logistics networks, supply chain management, COVID-19, barriers, threats, consequences, management approaches, integrated approach, transformation, globalization, digital technologies, synergetic effect.

Мрія Григорак, Дзвігол Гендрик, Наталія Трушкіна, Юлія Шкригун "Обґрунтування доцільності застосування комплексного підходу до управління ланцюгами постачань в умовах COVID-19". *Проаналізовано трансформації управлінських підходів до управління глобальними ланцюгами поставок під впливом пандемії. Виявлено ключові бар'єри для розвитку ланцюгів постачань у контексті пандемії COVID-19: недиверсифікованість ланцюгів постачань; нестабільність організації логістичної діяльності; розтягнутість ланцюгів постачань; відсутність гнучкості та єдиного інформаційного простору для всіх ділянок глобальних логістичних мереж; домінуюча роль Китаю як «світової фабрики».*

На підставі аналізу динаміки показників розвитку глобальних ланцюгів постачань виявлено нові тренди і закономірності для постпандемічного періоду. Встановлено, що на перший план виходить видимість і прозорість ланцюгів поставок, при цьому прозорість від початку до кінця (end-to-end). Розглянуто застосування нових технологій для забезпечення прозорості ланцюгів постачань. Досліджено особливості й тенденції розвитку ланцюгів постачань в Україні. Обгрунтовано доцільність застосування комплексного підходу до управління ланцюгами постачань з урахуванням глобальних економічних змін.

Визначено напрями трансформації глобальних логістичних мереж в епоху посткоронавірусу, серед яких можна відзначити такі: збільшення обсягу спеціальних вантажних авіаперевезень – авіакомпанії вже перерозподіляють флот для виняткового обслуговування вантажних авіаперевезень; зростання кількості перевірок вантажів і протоколів прикордонного контролю; активізація впровадження цифрових технологій та електронної комерції; реконфігурація глобальних ланцюгів.

Ключові слова: глобальні ланцюги поставок, логістичні мережі, управління ланцюгами постачань, COVID-19, бар'єри, загрози, наслідки, управлінські підходи, комплексний підхід, трансформація, глобалізація, цифрові технології, синергетичний ефект.

Мария Григорак, Дзвигол Гендрик, Наталия Трушкина, Юлия Шкригун "Обоснование целесообразности использования комплексного подхода в управлении цепями поставок в условиях COVID-19". *Проанализировано трансформацию управленческих подходов в управлении глобальными цепями поставок в условиях пандемии. Выявлено ключевые барьеры для развития цепей поставок при влиянии пандемии COVID-19: недиверсифицированость цепей поставок; нестабильность организации логистической деятельности; растянутость цепей поставок; отсутствие гибкости и единого информационного пространства для всех участков глобальных логистических сетей; доминирующая роль Китая в качестве «всемирной фабрики».*

На основе анализа динамики показателей развития глобальных цепей поставок выявлено новые тренды и закономерности для постпандемического периода. Определено, что на первый план выходит видимость и прозрачность цепей поставок, при этом прозрачность от начала до конца (end-to-end). Рассмотрено применение новых технологий для обеспечения прозрачности цепей поставок. Исследовано особенности и тенденции развития цепей поставок в Украине. Обосновано

целесообразность использования комплексного подхода в управлении цепями поставок с учетом глобальных экономических изменений.

Определены направления трансформации глобальных логистических сетей в эпоху посткоронавируса, среди которых можно выделить следующие: увеличение объемов специальных грузовых авиаперевозок – авиакомпании уже перераспределяют флот для исключительного обслуживания грузовых авиаперевозок; рост количества проверок грузов и протоколов пограничного контроля; активизация внедрения цифровых технологий и электронной коммерции; реконфигурация глобальных цепей.

Ключевые слова: глобальные цепи поставок, логистические сети, управление цепями поставок, COVID-19, барьеры, угрозы, последствия, управленческие подходы, комплексный подход, трансформация, глобализация, цифровые технологии, синергетический эффект.

Introduction. The world economy has tended to globalize, which has contributed to the formation and development of global supply chains. However, the COVID-19 pandemic has led to an unprecedented halt or slowdown in production in virtually all industries around the world. This in turn has threatened the functioning of global supply chains. Currently global supply chains characterized by complexity and a large number of intermediary companies that according to some specialists is one of the barriers that hinder the development of chains in a COVID-19 pandemic. This opinion is shared by D. Simchi-Levy [1], a specialist in logistics from Massachusetts Institute of Technology (MIT), who argues that in the 1980s, a significant number of companies relocated production to Asia, particularly China, in the short term to reduce costs. As well, one of the main lacks of the stretched supply chains showed in the pandemic conditions – the ability to "break" at any time and in any area, which directly affects the entire supply system.

Analysis of recent researches and publications. A significant number of scientific papers are devoted to conceptual principles, scientific and methodological approaches and practical recommendations for improving supply chain management.

As the analysis of foreign and domestic scientific sources on the problems of logistics shows, scientists have paid much attention to the justification and development of:

- a logistics model of distribution, a rational structure of sales channels, an effective marketing policy of distribution at the enterprise [2];
- the offers for improving supply management [3; 4];
- the methodical approaches to determining the optimal volume of the delivery party [5];
- the measures to improve the level of services and customer service [6-10];
- the concepts, models of optimization and supply chain management strategies [11-18];
- the recommendations for the use of digital technologies (Internet of Things, artificial intelligence, blockchain, logistics 4.0, robotics, 5G) to improve the efficiency of supply chain management in the context of the Industry 4.0 [19-30].

However, despite such close attention to the outlined problem by scientists, it remains relevant to conduct research in the direction of transforming management approaches to the management of global supply chains, taking into account new challenges and threats, one of which is COVID-19.

The purpose and objectives of the study is to study the features and trends of global supply chains; identifying key barriers to the development of supply chains in the context of the COVID-19 pandemic; determining the directions of transformation of global logistics networks in the post coronavirus era; substantiation of an integrated approach to supply chain management.

Basic material and results. Supply chain management carried out using such basic

management approaches as quantitative, process, system, situational (Table 1).

Table 1. Characteristics of management approaches to supply chain management

Approach	Content	Advantages
Quantitative	Transition from qualitative to quantitative assessments using mathematical, statistical methods, engineering calculations, expert assessments. The essence is to use in the decision-making process of mathematical and statistical analysis methods. This approach calls an operations research (the use of research methods to the operational processes of the organization). In other words it is an application of economic and mathematical methods to solve management problems	- an accuracy; - a possibility of forecasting; - a selection of the best option from possible in solving management problems; - a speed of information processing and management decisions
Process	The essence is to build a system of organizational processes and management of these processes to achieve maximum efficiency of companies in supply chains. Management is sees as a process in other words a set of continuous interconnected actions that call management functions.	- the optimization and maximum automation of the general corporate governance system; - a transparency of the general corporate governance system for management and its ability to respond flexibly to changes in the external environment; - a constant increase of efficiency of the management system and the maximum consideration of needs of stakeholders; - an effective use of the information system of the enterprise
Systemic	The way of thinking about organization and management, but in no way it is a set of instructions or principles for managers. It allows only conditionally to represent the organization in the unity of its constituent elements	- an efficiency of the management process
Situational	Close relationship with the systems approach. The key point is the situation, so a specific set of circumstances significantly affect the company at this time.	- a better understanding of what techniques will be more conducive to achieving the company's goals in a particular situation

Source: revised by the authors on the basis of [31; 35; 36; 37; 38]

The system approach allows to consider any more or less difficult object as rather independent system with the features of functioning and development [31, p. 27]. According to the methodology of scientific knowledge, the basis of this approach is the consideration of objects as systems consisting of regularly structured and functionally organized elements [32, p. 32].

The application of the system approach allows to investigate the functioning, development, structure of the whole (object), to establish the properties of its parts (elements), to trace the interactions and relationships between them [33, p. 157].

While the relationship management system within the functional approach, as noted in [34, p. 63], is a hierarchical structure of interconnected processes of implementation of management functions. It allows to optimize the overall corporate governance system, make it transparent to management and able to respond flexibly to changes in the external environment.

It is worth noting that management approaches to managing global supply chains are being transformed under the influence of the COVID-19 pandemic. The consequences of its impact on the development of global supply chains can be viewed through the prism of a new vector of the world economy, namely: regionalization of production, market diversification, which will lead to the localization and reduction of supply chains.

Key barriers to the development of supply chains in COVID-19 include:

- non-diversification of supply chains, which, in turn, leads to instability in the organization of logistics activities;
- the factor of stretched supply chains, lack of flexibility and a single information space for all sections of global logistics networks;
- China's dominant role as a "global factory" that leads to the fact that a serious disturbance in the Chinese market directly threatens global supply chains. It is evidenced by the fact that more than 200 Fortune Global 500 companies [39] operate in Wuhan, the highly industrialized province where the outbreak originated and which has suffered the most from the spread of the virus.

Due to the rapid spread of the virus and the announcement of quarantine around the world, supply chains have already suffered serious disruptions. Supply chains play a crucial role in the organization of fast, safe and uninterrupted delivery of goods and services. It is important for company executives to make decisions quickly and immediately implement a set of measures to maintain business continuity to meet the demands of consumers and customers, as well as to protect and support their employees [40]. The 94% of Fortune 1000 companies report supply chain failures through COVID-19 [41]. The 75% of companies have already experienced a negative or very negative impact on their business. The 55% of companies plan to revise their growth forecasts downwards (or have already done it). Well-known scientist D. Simchi-Levy draws attention to the significant growth of China's role in world trade. According to him, "If in 2002, during the SARS epidemic, China's share in global GDP was 4.3%, so today it is 16%" [1] (Figure 1).

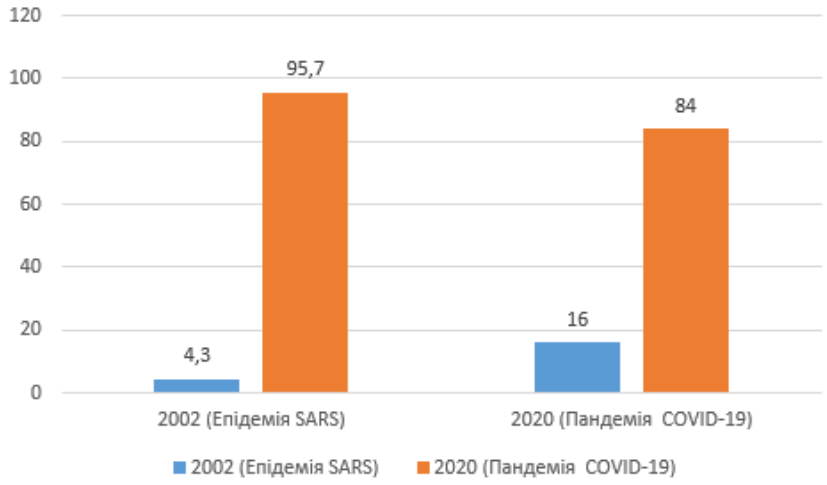

Figure 1 – China's share of global GDP
Source: developed by the authors on the basis on [1]

The rapid spread of COVID-19 and the measures taken by governments to contain it have serious consequences for the world's largest economies. According to the World Bank, it expects that world GDP will be characterized in 2020 by the sharpest decline since World War II [42]. The economic shock which caused by the coronavirus has been compared to the financial crisis of 2009 [43].

In a pandemic situation, the International Monetary Fund expects the Eurozone economy to shrink by 10% in 2020 and recover by 6% in 2021. According to Eurostat, in January-May 2020, compared to the same period in 2019, international trade between EU member states decreased by 13.9%. Should note that the transport and logistics sector is particularly vulnerable to economic shocks. It is dues to the fact that more than 80% of world trade are accounting for by commercial transportation [44].

The further condition of transport and logistics companies depends on types of economic activity and scales of business of clients. It will affect the transformation of the customer relationship management system and the quality of logistics service [45-51].

The COVID-19 pandemic has also significantly affected the road transport sector. Consider this aspect on the example of Polish carriers. Thus, in 2019, they became the EU leader in terms of traffic, increasing them by 14%. And the share of Polish traffic increased to 32% of total cross-border traffic in the EU. During the pandemic from January to May 2020, the tonnage of goods transported by Polish carriers decreased by 8.3%. This is primarily due to the decline in production and trade activity in Poland and the EU [52].

The impact of the pandemic on the general processes in the world economy, in particular on logistics, the WTO Secretariat considers through the analysis of trends in world trade for the pre-coronavirus period and forecasting indicators for the coming years. They based on the current unstable situation in the world, which leads to the need to consider both optimistic and pessimistic scenarios for further development of the situation (Figure 2, Table 2).

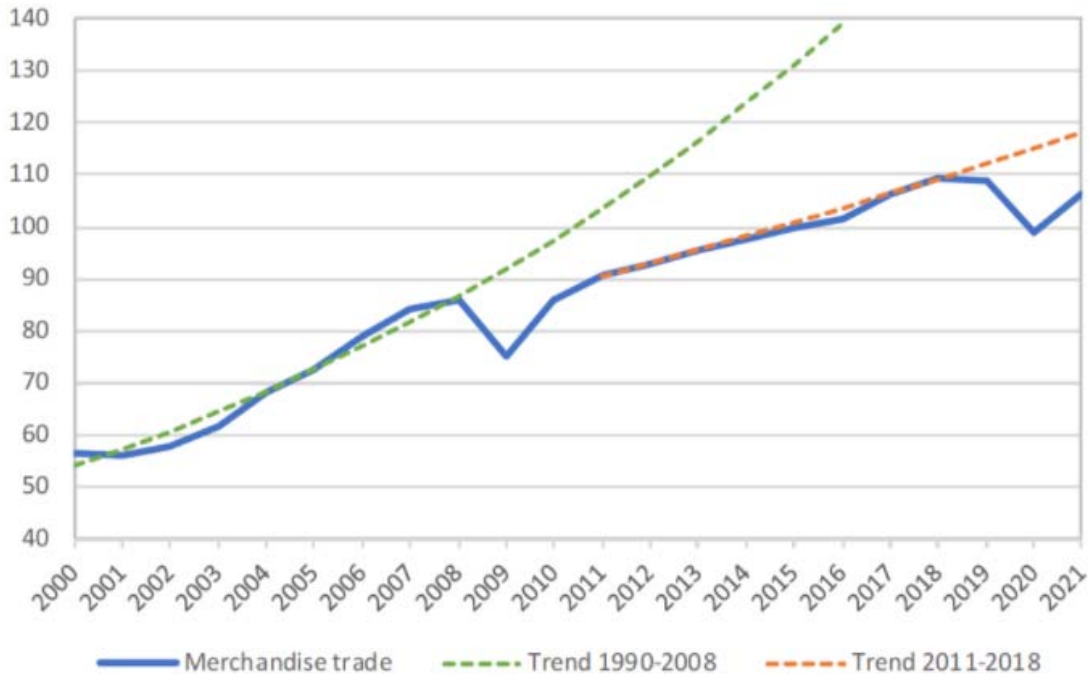

Figure 2 – Dynamics of world trade in goods in 2000-2021
Note: Figures for 2020 and 2021 are forecasts. Indices, 2015 = 100
Source: developed by the authors on the basis on [53]

Table 2. The dynamics of trade in goods for 2015-2021

Indicators	Years						
	2015	2016	2017	2018	2019	2020	2021
World trade volume (b)	2,3	1,4	4,7	2,9	-0,1	-9,2	7,2
Export							
North America	2,6	0,7	3,4	3,8	1	-14,7	10,7
South and Central America	0,6	1,3	2,9	0,1	-2,2	-7,7	5,4
Europe	2,9	1,1	3,7	2	0,1	-11,7	8,2
Asia	1,3	2,3	6,7	3,7	0,9	-4,5	5,7
Other regions (c)	1,8	3,5	0,7	0,7	-2,9	-9,5	6,1
Imports							
North America	5,2	0,3	4,4	5,2	-0,4	-8,7	6,7
South and Central America	-7,6	-9	4,3	5,3	-2,1	-13,5	6,5
Europe	3,6	3	3	1,5	0,5	-10,3	8,7
Asia	2,1	2,2	8,4	4,9	-0,6	-4,4	6,2
Other regions (c)	-3,9	-4,5	3,4	0,3	1,5	-16	5,6

Notes: Figures for 2020 and 2021 are projections (a); Average of exports and imports (b); Other regions comprise Africa, Middle East and Commonwealth of Independent States (CIS), including associate and former member States (c). Annual change – in %.

Source: developed by the authors on the basis on [53]

The WTO considers 2 scenarios of changes in the volume of commodity trade depending on the factors considered (Figure 3).

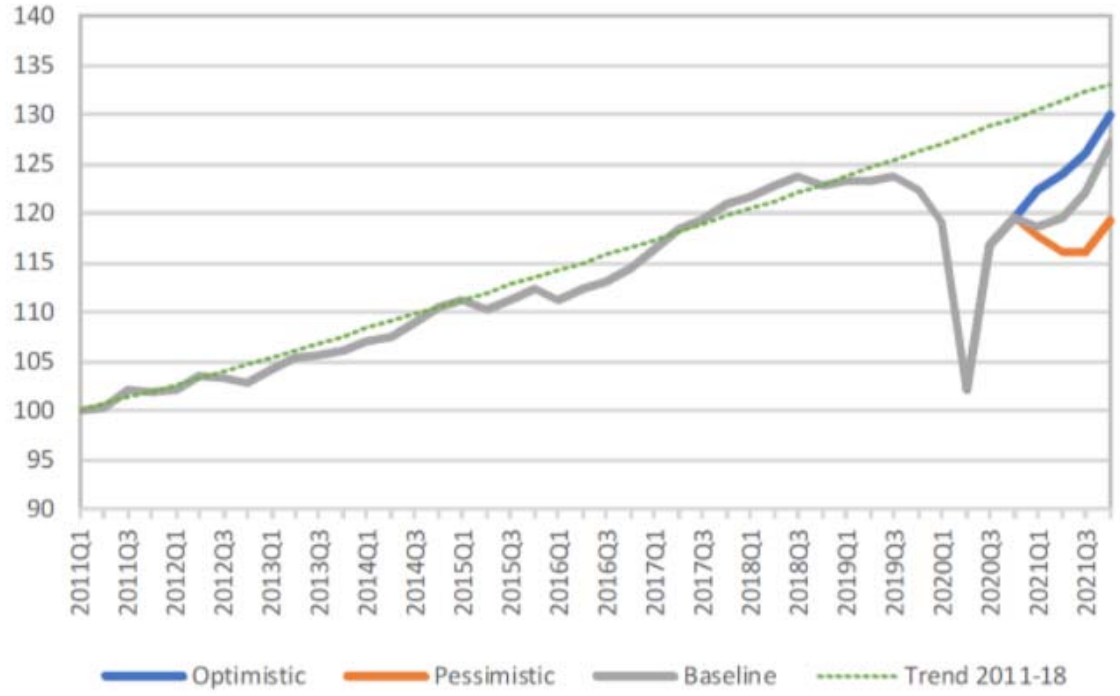

Figure 3 – Optimistic and pessimistic scenarios of trade volume

Note: Index, 2011Q1 = 100

Source: developed by the authors on the basis on [53]

In the event of a second outbreak of COVID-19, a number of further blockades will be required, which should affect fiscal policy and exacerbate problems in the labor market.

On the other hand, the emergence of an effective vaccine will promote rapid and confident growth in production and trade. Other positive factors include the emergence of new technology sectors, such as artificial intelligence and e-commerce, and the increasing use of innovation in traditional industries, that had forced to make greater use of information technology to deliver goods and services to customers during a pandemic.

The WTO comments that from early January to mid-April 2020, the number of flights worldwide fell by about 80%, the number of international flights decreased significantly than domestic. Since that period, the total number of flights has gradually recovered, rising to 57% of its level at the beginning of the year (Figure 4). The recovery was more successful in the European Union, with the number of flights within the EU rising to 95% from January.

According to the transport company Bollore Logistics, the global introduction of the vaccine will not have a significant impact on air traffic. It is expected that the introduction may generate about 65 thousand tons of air traffic, that equivalents to 0.3% of air trade in 2019, but the impact may be more significant if the vaccine will be released in batches [54].

Barthelme Bonadio from the Michigan University and 3 co-authors point out that when considering placement chains, it is necessary to separate the criteria of reliability of creation chains (possibility of continuing work in crisis conditions) from the criteria of stability (ability to be responsible for crises) [55].

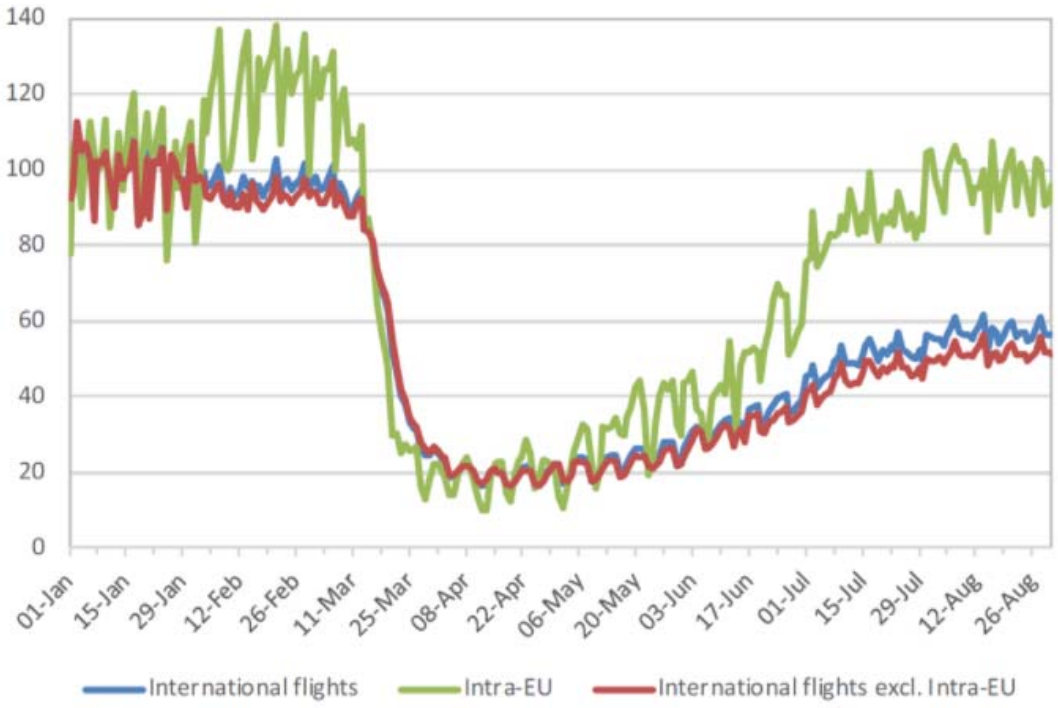

Figure 4 – International commercial flights January 1, 2020 - August 31, 2020
Note: Index, week 1 January = 100
Source: developed by the authors on the basis on [53]

The increased digitalization caused by COVID-19 can significantly increase the size of the services market, despite the fact that the goods market continues to slow down (Fig. 5). However, it should be noted that the growth of the services market directly depends on the nature of the long-term impact of the pandemic on the labor market.

According to D. Payne, an economist at business magazine Kiplinger, supply chain

disruptions affect more than just China. Enterprises that import spare parts or raw materials from Southeast Asia face the fact that their suppliers, in turn, depend on supplies of raw materials from China, for example, garment factories in Cambodia have stopped due to a shortage of fabric in China.

Simchi-Levy thinks that companies around the world need to invest more in logistics [1]. On his opinion, they should know not only their suppliers but also suppliers. You need to make sure that the supplier has different sources in different regions, or there must be multiple suppliers that can be replaced if necessary.

The research, prepared by experts from the consulting company Bain & Company [56], reflects the ineffectiveness of the basic principles of supply chain management, which have been in place for the past few decades and are to minimize costs and inventories. The research notes as well that the construction of flexible and adaptive supply chains is a necessary condition for the successful operation of logistics networks in the current realities of the economic crisis.

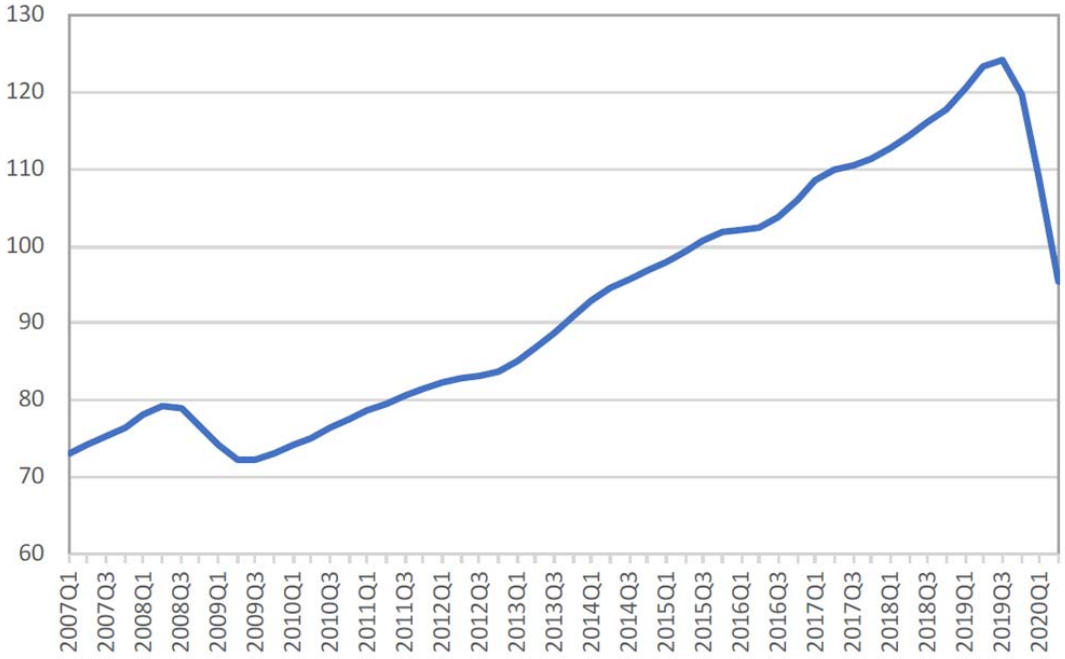

Figure 5 – Index of activity in world trade in services for the I quarter 2007 – II quarter 2020
Note: Index, 2015 = 100
Source: developed by the authors on the basis on [53]

The COVID-19 pandemic is a short-lived crisis. Its impact on the functioning of supply chains in companies will be long-term. Therefore, businesses need to increase long-term resilience throughout the value chain to effectively address the challenges of the future. It requires an integrated approach to supply chain management (Figure 6). So, companies need to have enough flexibility to protect themselves from future crises. They should also consider creating a reliable system that has the necessary tools for rapid and flexible risk management. The latter should be a technological solution using platforms that offer access to applied analytics, solutions using artificial intelligence and machine learning. It is necessary to ensure end-to-end transparency throughout the supply chain. In the long-term run, responding to situations that involve certain risks should become an integral part of traditional work standards. It is worth noting that the current crisis situation encourages businesses to reconsider existing supply chains with a focus on more adaptable and flexible systems.

For decades, cheap supply and minimum stocks have been key principles in supply

chain management. However, in a changing world, supply chains that are overly dependent on the supplier with the lowest prices and the lowest level of inventory can put businesses at risk.

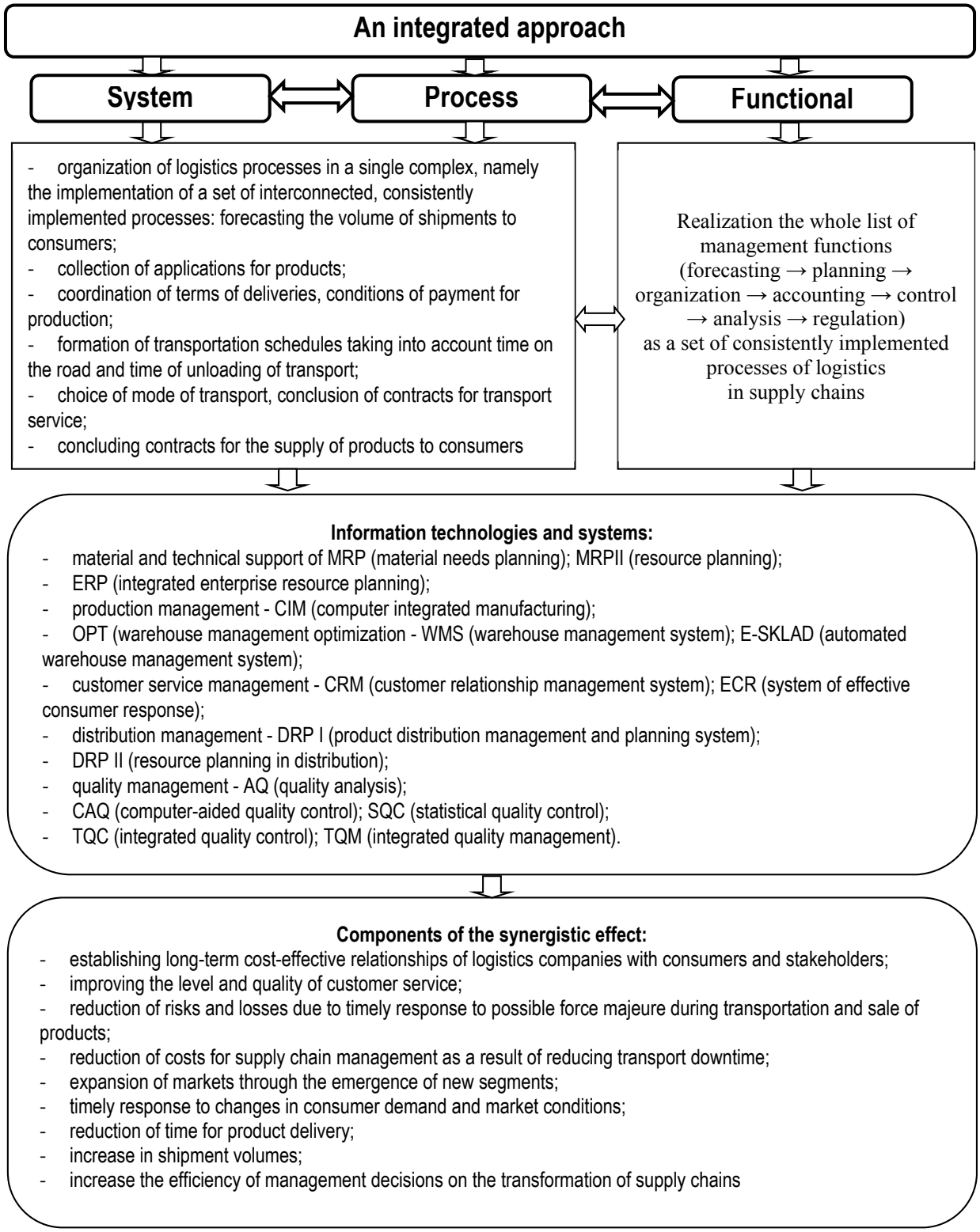

Figure 6 – An integrated approach to supply chain management
Source: developed by the authors

During the tense trade relationship between the United States and China, many leading companies have already begun to reconsider the cost of network risk and invest

in more flexible and adaptive supply chains. Flexible networks help to adapt quickly in times of crisis, allowing production facilities to respond quickly to changes in market demand. This in turn is a significant competitive advantage.

According to experts, companies with flexible supply chains are growing faster due to greater mobility and the company's ability to meet volatile demand and customer needs. In addition, for such companies there is an increase in orders by 20-40% and an increase in customer satisfaction by 30% [57].

Currently, some companies are investing in the flexibility and reliability of supply chains in order to minimize risks and make a profit by improving their efficiency. For example, Procter & Gamble used cloud technology to provide real-time production and demand information. The use of advanced tools of broad analytics allowed Hurricane Sandy, which hit New Jersey in 2012, to make operational decisions and reduce downtime to 2.5 days. In turn, the experience gained in the use of digital tools allowed Procter & Gamble to prepare for Hurricane Irma, which was approaching in 2017. So, the company was able to guess which suppliers, production facilities and distribution centers might be at risk of loss, and take inventory management measures in a way that helped avoid disruptions and financial losses. Flexible supply chains enabling rapid reorientation of production processes have allowed Giorgio Armani, Gucci, Prada and other world fashion leaders to launch the production of hygienic and medical products used in the fight against the COVID-19 pandemic.

Companies that invest in the adaptability and sustainability of supply chains reduce the production cycle of the final product by 40-60%. They primarily are able to do it due to rapid response and adaptation to changes in market demand and the corresponding acceleration of revenue growth. Flexible supply chains are able to increase production from 15% to 25%, which achieved by optimizing processes [56].

The economic crisis caused by the COVID-19 pandemic and its aftermath has shown that a number of companies already have flexible production lines. With the spread of coronavirus infection in Europe, in particular in France and Italy, the haute couture and luxury industry has rapidly restructured the production process for the production of medical and hygienic products. In particular, the manufacturer of luxury perfumes LVMH within 72 hours after the French government's appeal to the business established the production of disinfectants. Giorgio Armani, Gucci and Prada repurposed their designer clothing factories to produce protective overalls, and Burberry began producing protective masks and gowns. Obviously, the reorientation of production required not only the re-equipment of factories and production lines. However, the crucial role played flexible supply chains, which allow for a rapid search for raw materials, design and development of finished products. Thus, companies that invest in flexible supply chains are in a better position in times of crisis than those who do not pay due attention to it.

Gartner [58] has released another ranking of the top 25 companies in the supply chain. According to the results of 2020, the first place was taken by Cisco Systems (in 2019 – the 5th place). The top 25 includes companies such as AbbVie, British American Tobacco, Reckitt Benckiser and Biogen, and Lenovo and Kimberly Clark returned after a short break.

There have been no changes in the category of "masters" of supply chains: they have included Amazon, Apple, McDonald's, Unilever in terms of their merits over the past 10 years. Given the temporary closure of many businesses as a result of the COVID-19 coronavirus pandemic, ranking leaders need to have a flexible strategy. This allows supply chains to respond to changes in the context of the business environment.

Among the key features that allowed leaders to overtake competitors in 2020 during the pandemic and crisis, we can name [58]:

1) Target management model is the most successful supply chain management teams build their activities based on the goals. They form supply chains based on the expansion of partnerships and the principle of transparency;

2) Transformation of business models is one of the main external factors influencing corporate supply chains is a dynamic competitive landscape. It determines by expectations of consumers, the entry into the market of new players from existing industrial ecosystems, the emergence of non-traditional competitors;

3) Leadership in digitalization is the leaders of the ranking of supply chains are among the first to introduce the latest digital technologies. These investments help to succeed even in difficult economic conditions.

Under today's circumstances, most companies naturally reduce costs, including the cost of digital transformation programs. However, leading companies continue to develop supply chains and even boost investment in their cross-cutting visibility, improved real-time planning and flexibility, helping them to overcome fluctuations in demand.

As a result of the spread of the COVID-19 threat, companies may implement a set of measures to protect their supply chain operations. For companies operating or having business relationships in China and other affected countries, steps can include: informing employees about the symptoms and prevention of COVID-19; strengthening screening protocols; restriction of insignificant trips and encouragement of flexible work schedule; harmonization of IT systems and support with changing work requirements; preparation of succession plans for key management positions; focus on cash flow.

For companies that manufacture, distribute or supply suppliers in China and other affected countries, steps can include: increasing attention to staff / workforce planning; focusing on the risks of first tier suppliers; illustration of the expanded supply network; understanding and using alternative sources of supply; updating inventory policy and planning parameters; preparation for plant closure; focus on production planning flexibility; evaluation of alternative options for outbound logistics and reliable throughput; conducting global scenario planning.

For companies that sell goods to China or other countries, the steps can include: understanding the impact of demand on business; confirmation of the short-term strategy of synchronization of supply and demand; preparation for potential channel shifts; evaluation of alternative logistics options; opening communication channels with key customers; preparation for a "jump"; conducting global scenario planning.

Today it expects to accelerate the transformation of the traditional logistics model of the linear supply chain into digital networks, which provide end-to-end visibility, responsiveness, the ability to optimize current processes. It should note that in modern conditions a qualitatively new model of supply chains need. Many years of emphasis on supply chain optimization to minimize costs, reduce inventory, and increase asset utilization have eliminated buffers and flexibility to reduce disruptions. COVID-19 shows that many companies are not fully aware of the vulnerability of their supply chain relationships to global shocks.

That's why new technologies for the development of global supply chains are now emerging, which significantly improve the transparency of the entire chain and support the ability of companies to withstand such shocks. The traditional linear supply chain model transforms into digital supply chains (DSNs), in which functionally disparate blocks shared and organizations connect to their complete supply chain to provide end-to-end visibility, collaboration, flexibility and optimization.

From the experience of responding to the COVID-19 event, digital supply networks provide the ability to respond quickly to a wide range of possible problems: from

military action and the threat of terrorism to the bankruptcy of a supplier or a sudden and abrupt change in market conditions.

The further development of the logistics sector is connected with the general scenario according to which the world economy and in particular trade activity will recover. Today the emergence of an effective and widely available vaccine against COVID-19 and the elimination of real threats of a re-global outbreak of the virus is the main basis for the functioning of logistics and the global economy as a whole.

Experts of the logistics company Corex Logistics [59] based on the developed forecasts identified trends in the development of the logistics market in the post-corona crisis:

- price dumping in the freight market;
- exit of weak players from the market;
- development of collaborations, cooperation, association of services;
- refusal to purchase, increasing demand for repair and maintenance services of fleets;
- introduction of the latest IT technologies;
- the transition of employees mostly to remote work;
- order transportation from a mobile device; emergence of a separate industry "mobile carriers";
- development of domestic freight and logistics chains;
- development of outsourcing;
- emergence of demand for delivery of goods to small towns and villages;
- contactless courier delivery;
- development of delivery of parcels by drones;
- development of "autopilot" deliveries;
- "Last mile" delivery, etc.

According to the CEO of the Association for Supply Chain Management (ASCM) [60], one of the key approaches to the restructuring of supply chains should be the so-called "mapping" (supply chain mapping) as a visualization of the entire supply chain of the company ("maximum supply chain"). It should do in order to analyze not only their counterparties (level 1), but also the suppliers of their counterparties (levels 2-3). That is to see the whole supply chain from raw materials to the production and distribution of final products.

Thus, "mapping" supply chains allows to systematically assessing the geographical location of suppliers, distribution centers, transport routes and major markets.

"Mapping" includes information about the actions performed on each section of the supply chain, the time of change, frequency of use, association and volume of products, delivery efficiency. This allows assessing the potential risks and "weak" areas in the supply chain.

According to experts of the consulting portal Future Purchasing.com, to increase its resilience in unforeseen situations, businesses in addition to "mapping" supply chains, it is also necessary to explore approaches to supply to contractors and conduct stress testing of business continuity. The first direction allows you to assess the quality of interaction of their counterparties with their suppliers at 2-3 levels and jointly determine which supply strategies can change to reduce the risks of their counterparties. The second direction allows businesses to assess what can happen to supply chains for each product in the case of the implementation of scenarios of so-called "black swans". A similar assessment will help to prepare an action plan for each stress scenario and build supply chains based on the identified risks.

In order to effectively adapt supply chains the following step-by-step approach can be used [60]:

1) creation of a center for supply chain management, the main tasks of which will be to organize work on preparing supply chains for emergencies, identifying priority transformation initiatives, distribution of roles between structural units, the implementation of the necessary communication with all parties;

2) adaptation of current business processes of logistics activities under the conditions of remote work;

3) "Mapping" the supply chain and identifying its most vulnerable areas, both geographically and in terms of suppliers; research of approaches to supply from counterparties;

4) conducting stress testing of supply chains and developing approaches to responding in the event of stress scenarios or deterioration (the transition from demand forecasting to scenario threat forecasting is underway at this stage); when conducting qualification selection of suppliers, it is necessary to shift the emphasis from minimizing costs to minimizing risks; when drawing up contracts it is necessary to consider risks of a rupture of supply chains and to form requirements to terms and ways of recovery in case of failures.

5) monitoring the effectiveness of new approaches to supply chain management and their transformation in a case of necessary

It should note that the visibility and transparency of supply chains come to the fore, with end-to-end transparency. There is a difference between visibility and transparency. The visibility of the supply chain allows you to see a specific action with access to data in a particular node (hub). Transparency opens the supply chain to see all nodes and share data throughout the supply chain. In addition, transparency transmits internal and external data at a certain desired level [61]

The advantages of transparency are huge. This can improve the reputation of company among consumers, increase productivity and reduce operating costs. According to researchers from the MIT Sloan School of Management [62], companies can increase profits from 2% to 10% by improving end-to-end transparency from start to finish with innovative tools that reduce diversity.

Thus, companies can use supply chain transparency as a key factor for identifying, recording, sharing and forecasting events and transactions, as well as for the ability to translate data into useful information, ensure the flow of goods, gain more control over supply chains.

Due to the need for technologies that bring together stakeholders and systems, investment in innovation has begun to develop a technology tool with real-time capabilities to make changes and eliminate losses in supply chains. The tool collects data from all stakeholders in one place and provides analytics that can begin to anticipate and help make better decisions about how continuously manage supply chains from end to end and with maximum performance. For example, a truck delays due to traffic jams on the way to the retailer. With this new transparency technology, all parties notify of the delay in real time and can control it immediately rather than through a few phone calls that used to take hours. For a truck, you can change the route, calculate the time of arrival, and then send to the seller. It allows the seller to better plan the activities of employees, increase the level and quality of service and reduce operating costs.

To take full advantages of transparency technology, it have to link to people and processes. Platforms including the best business intelligence tools are able to apply predictive machine learning as well as real-world supply chain experience. These ideas and analysts communicate future decisions, prepare supply chains for unexpected events and rapid recovery from failures. All this leads to increased flexibility.

As an example is deliveries that do not have documents of origin. These are results in shipments detained at receiving docks, causing supply chain disruptions. However, due to the transparency of technology, stakeholders can see the goods as they move through the supply chain. That is why companies can avoid this failure. Delivery process documents can transmitted digitally in real time from sender to recipient, eliminating any "bottlenecks" in the nodes. It ensures full transparency for all parties.

Transparency increases value through the ability to gather and share information in

supply chains and logistics networks, improving business processes that support work. Transparency allows companies to prepare for possible failures and respond quickly to emerging situations. It is relevant in the case of a violation is a single event, a seasonal peak in sales or a pandemic. As a result, supply chain operators can respond to failures faster than ever before.

Thus, transparency expands the possibilities of routing, tracking and inventory management, return support and authentication and quality of goods. It also makes all participants in supply chains more reliable and efficient. It leads to a more flexible process of transporting goods, logistics that are more efficient, greater customer satisfaction and stability of the supply chain.

In developing the Logistics Trend Radar to determine supply chain management actions at the future, the DHL Innovation Center [63] relied on three core values: close to customers, close to new technologies, and close to operations.

Possible technologies to ensure the transparency of supply chains include [62]:

- Internet of Things (IoT) can assign logistics based on data. Now everyday objects can send, receive, process and store information and thus take an active part in event-driven logistics processes. The Internet of Things allows logistics service providers to benefit by generating ideas that drive change and new solutions.

- Transport marketplaces are logistics markets combining the demand of shippers and the supply of carriers in an increasingly complex network of supply chains. Providers of these digital brokerage services offer a centralized trading platform to manage not only tariffs and delivery schedules, but also additional services such as shipment control and customs document management, providing clients with an expanded and individual digital experience.

- "Supergrid" logistics – beyond the 4PL logistics and logistics markets, the "supergrid" logistics trend refers to the next measurement of consolidation and optimization of global supply chain networks, integration of many different manufacturing companies and logistics service providers. This opens up new business opportunities for a variety of players, including existing 4PLs, specialist companies and small startups.

- Big data analytics is logistics which transformed by the power of databased insights. Owing to the significant digital transformation and the Internet of Things, it is possible to obtain unprecedented amounts of data from various sources in the supply chain. Capitalizing on its value opens up huge potential for improving operational efficiency, improving customer service, reducing risk, and creating new business models.

- Blockchain is an eliminating the complexity of global supply chains. Blockchains, and other distributed registry technologies (DLTs) can help increase trust and transparency between stakeholders and customers by supporting the automation of administrative and commercial processes.

Regarding the situation in Ukraine, transformational transformations of supply chains are also taking place at present. Consider this on the example of the logistics operator "Raben Ukraine" [64]. At the beginning of the COVID-19 pandemic, the company decided to freeze the expansion of the goods storage area under controlled temperature conditions (+ 14-18 ° C). Now work in this direction resumed. At the beginning of 2020, the expansion of its own fleet was suspended, although it was planned to increase the number of trucks by 17%. Instead, they began to attract more third-party carriers. In addition, the introduction of digital technologies has been accelerated, namely the use of electronic document management has been significantly expanded (85% of all invoices and acts of work performed by clients have already been translated into electronic format). Electronic document management helps to optimize resources and reconfigure the process management system. Digitization, even at the

level of primary document flow, reduces costs by six times. Reconstruction and modernization of video surveillance systems is planned, the website of the company is updated.

In addition, digital technologies have been introduced to improve the quality of service. For example, drivers are equipped with special Panasonic FZ-N1 devices that use TISLog solutions that work as scanners, as well as in real time to track the movement of goods. With this system, customers receive data on the estimated time of arrival of the machine (ETA: Estimated Time of Arrival) with a time interval of +/- 2 hours. If it is a temporary vehicle, drivers can install a special application on the smartphone, which allows you to perform almost the same functions. For a B2B logistics operator, only the Raben Group uses this truly new solution in Europe. And the technical capabilities of the devices in the future will be used to further automate electronic trade.

Conclusions. Depending on the current changes, the organization of the work process has been modernized (70% of office workers already perform their duties remotely). Rules for compliance with the existing sanitary norms have been developed for warehouse staff, conditions for staff rotation have been created, and the delivery scheme for employees has been reorganized. The approach to meetings with clients and contractors is reconsidered. The online mode of communication is using to the maximum. The staff-training program has also been made online. One of the interesting projects worth mentioning is the Manager-Choice learning game. This is an innovative management development program involving about 1,000 managers from 13 countries. The aim of the game is to master the best management practices. In addition, attention is focused on the development of contract logistics.

Raben Ukraine strengthened the direction of international transportation, including groupage cargo. The volume of cargo transportation in the direction of Poland-Ukraine increased in 2020 by 4 times compared to 2019. Accordingly, the volume of services provided for customs clearance of imported goods increased. Warehouse logistics and e-commerce are developing. The main changes concern innovative IT-technologies. Thus, several projects successfully implemented together with leading international clients. This allowed to ensure the maximum integration of the individual client system into the Warehouse Management System (WMS) of Raben Ukraine. The process of transmitting information to courier services is also automated. There is a special software product for this is the Last Mile Connector.

It should note that today Ukrainian companies are just beginning to realize the importance of procurement. Entrepreneurs focus on procurement relates to the awareness of their strategic importance and with the need to optimize costs and economic crises of recent years as well. According to the procurement and supply chain expert of IPSM CEO [65], the Ukrainian procurement sector has begun to take modern forms. Among them: allocation of the procurement function and certain areas of procurement; creation of educational platforms for procurement specialists; focus on supply chains and strategic procurement function; digitalization of procurement; consulting and outsourcing in procurement. The right approach to procurement provides businesses with up to 30% budget savings. This is not only due to lower supplier prices, but also due to the optimization of the procurement process as well.

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APPROACH TO INTELLECTUALIZATION OF COMPLETE SUPPLY CHAIN MANAGEMENT PROCESSES USING FUZZY EXPERT SYSTEMS

Yuri Romanenkov, Yashar Rahimi, Danova Mariia, Feoktystova Olena, Shostak Igor "Approach to intellectualization of complete supply chain management processes using fuzzy expert systems". *It is shown that in order to increase the efficiency of the functioning of complete logistical supply chains (CLSC), it is*

necessary to develop special methodological tools, and, on their basis, software to facilitate decision-making on the timely formation of liquid consignments at the terminal sections of the chain of liquid goods. The article describes a fuzzy network of CLSC in the form of a hierarchical two-level nested Petri net (NPN), the upper level of which reproduces the process of functioning of the focal company as the central element of the CLSC, and each of the components of the lower level of the network model is an elementary Petri net reflecting the logistic processes at the terminal sections of the CLSC production of raw materials and sale of finished products. This article also gives a description of the procedure for creating a fuzzy network model for representing information about business processes that take place during the functioning of the CLSC, taking into account the existing time and resource constraints, in the form of a NPN, which is expanded by introducing fuzzy and temporal statements. Special methods of automated decision- making on the sustainable functioning of CLSCs are described and justified in terms of making a choice on the transport mode and optimal routing. Based on the developed methodological tools, the process of forming and providing the stable functioning of the CLSC for typical food products of the grocery group, namely dried fruits, is considered.

***Keywords**:* complete supply chain, transport logistics, focal company, retailers. Nested Petri net, temporal statement theory, fuzzy theory, expert system.

Романенков Юрій, Яшар Рахімі, Данова Марія, Феоктістова Олена, Шостак Ігор "Підхід до інтелектуалізації процесів управління повними ланцюгами поставок з використанням нечітких експертних систем". *Показано, що для підвищення ефективності функціонування повних логістичних ланцюжків поставок (CLSC) необхідно розробити спеціальні методичні інструменти і на їх основі програмне забезпечення для полегшення прийняття рішень щодо своєчасного формування наливних партій вантажів. На кінцевих ділянках ланцюжка наливних вантажів. У статті описується нечітка мережа CLSC у вигляді ієрархічної дворівневої вкладеної мережі Петрі (NPN), верхній рівень якої показує процес функціонування фокальної компанії як центрального елементу CLSC, а кожен з компонентів нижнього рівня мережевої моделі є елементарна мережа Петрі, яка відображатиме логістичні процеси на термінальних ділянках CLSC з виробництва сировини та реалізації готової продукції. У цій статті також дається опис процедури створення нечіткої мережної моделі для представлення інформації про бізнес-процеси, що відбуваються під час функціонування CLSC, з урахуванням існуючих тимчасових і ресурсних обмежень, в формі NPN, яка є розширенням за рахунок введення нечітких і тимчасових тверджень. Описані та обгрунтовані спеціальні методи автоматизованого прийняття рішень про стійке функціонування CLSC з точки зору вибору виду транспорту та оптимального маршруту. На основі розробленого методичного інструментарію розглядається процес формування та забезпечення стабільного функціонування CLSC для типових харчових продуктів продуктової групи - сухофруктів.*

Ключові слова: повний ланцюжок поставок, транспортна логістика, головна компанія, роздрібні торговці, вкладена мережа Петрі, теорія часових рядів, нечітка теорія, експертна система.

Романенков Юрий, Яшар Рахими, Данова Мария, Феоктистова Елена, Шостак Игорь "Подход к интеллектуализации процессов управления полными цепями поставок с использованием нечетких экспертных систем". *Показано, что для повышения эффективности функционирования полных логистических цепочек поставок (CLSC) необходимо разработать специальные методические инструменты и на их основе программное обеспечение для облегчения принятия решений по своевременному формированию наливных партий грузов. На конечных участках цепочки наливных грузов. В статье описывается нечеткая сеть CLSC в виде иерархической двухуровневой вложенной сети Петри (NPN), верхний уровень которой показывает процесс функционирования фокальной компании как центрального элемента CLSC, а каждый из Компонентов нижнего уровня сетевой модели представляет собой элементарную сеть Петри, отражающую логистические процессы на терминальных участках CLSC по производству сырья и реализации готовой продукции. В этой статье также дается описание процедуры создания нечеткой сетевой модели для представления информации о бизнес-процессах, происходящих во время функционирования CLSC, с учетом существующих временных и ресурсных ограничений, в*

форме NPN, которая является расширением за счет введения нечетких и временных утверждений. Описаны и обоснованы специальные методы автоматизированного принятия решений об устойчивом функционировании CLSC с точки зрения выбора вида транспорта и оптимального маршрута. На основе разработанного методического инструментария рассматривается процесс формирования и обеспечения стабильного функционирования CLSC для типичных пищевых продуктов продуктовой группы - сухофруктов.

Ключевые слова: полная цепочка поставок, транспортная логистика, координационная компания, розничные торговцы, вложенная сеть Петри, теория временных рядов, нечеткая теория, экспертная система.

Introduction. In the modern world, the efficiency of business processes at the regional, national and global levels largely depends on the quality of the of logistical systems development. The typical object here is the complete food supply chain (CLCS), which is a complex socio-economic system consisting of a large number of raw material suppliers, a focal company (processing and packaging), warehouse terminals, distributors, customs brokers, 3PL and 4PL providers, retailers. The interaction between the participants of the CLCS is reflected by a multitude of continuous material, financial, and information flows and services from sources of raw materials to the end consumer. The variety of regions of the world from which supplies are made, a wide range of goods, yields, fluctuations in exchange rates, customs tariffs, seasonality, cause a high level of uncertainty in the processes of formation and decision-making by the participants of the CLCS. By its nature, CLCS is a complex stochastic system which functioning is characterized by the following features: a relatively large number of independent participants in business processes; difficulty to formalize the nature of the interactionы among the CLCS participants who are often competitors; high dynamics of changes within the system; non-stationarity of the majority of processes that take place during the functioning of the CLCS.

These circumstances determine the insufficient effectiveness of the existing means of information support for the CLCS, and necessitate their modernization, by expanding the concept of SCM (supply chain management), by supplementing knowledge with oriented methods, to achieve a conjunctive consensus between the participants of the CLCS.

A significant contribution to the development of issues related to the information technologies and systems use for the CLCS life cycle managing was made by such national and foreign scientists as: A.K. Pokrovsky, A.N. Kotlubay, V.A. Zubenko, R.S. Bespalov, L. Brodetsky, M. Christopher, J. Stock, J. Kloss, D. Bowersox, M. Wagner and others. Outstanding results in this direction have been obtained by several research centers such as Dassault Systemes (France), Siemens PLM Software (Germany), Unigraphics (USA), etc. Along with this, the specifics of the CLCS functioning does not allow the direct using of the corresponding standard means of automating the processes of interaction among the participants in the chain, since these developments do not provide an effective solution to the entire complex of tasks of information support of processes within the entire chain. In addition, the presence of a theoretical basis in the form of elements of the theory of Petri nets, the theory of temporal statements and fuzzy mathematics makes it possible, through theoretical generalization, to create a methodological basis for organizing transportation between the elements of the CLCS in the "just-in-time" mode. Based on this, there is a need for further development of methods and means of information support for CLCS management processes, in terms of ensuring transportation, in order to create a special applied information technology. Thus, increasing the efficiency of PCP functioning by ensuring the timeliness of deliveries within the chain, through the development and implementation of information support

technology for the transportation of goods in terms of ensuring the "just-in-time" mode, is an urgent scientific task to be solve for achieving a par5ticular benefit in application.

The purpose of the article is to outline an approach to the rational organization of business processes associated with the most important aspect in the life cycle management of the CLCS - namely ensuring efficient transportation of goods within the entire supply chain.

Problem Statement. Improving the efficiency of cargo transportation within the framework of the CLCS based on the methods and means of artificial intelligence is a complicated and complex problem. One of the options for solving this problem is to implement a set of the following particular tasks consistently.

1. Develop a network model of the complete supply chain that would adequately reflect the hierarchy of the chain, namely its upper level (a focal company for the processing of raw materials) and lower levels reflecting the activities of suppliers of raw materials and finished products distributors.

2. Develop a method for representing time dependencies between business processes in the complete supply chain, which would provide an opportunity to identify deviations in the functioning of the chain and assess the extreme values of these deviations in order to comply with the principle of "just- in- time".

3. Synthesize a method for making decisions on the choice of a optimal transportation route within a complete logistical chain, which would provide an opportunity to reduce the level of uncertainty on time and financial costs in the supply chain operation.

The solution of the above tasks will make it possible to develop an intelligent technology of information support for the functioning of the complete logistics supply chain in terms of organizing cargo transportation.

Basic material and results. Effective supply chain management is not possible without analyzing them at various levels - strategic, tactical and operational [1].

At the strategic level, the tasks of designing the CLCS and determining the size of service facilities are solved, taking into account international, national and regional features of the development of transport systems. As part of the CLCS, the main terminals, distribution centers, consolidation warehouses are determined, between which regular transportation of raw materials and finished products is carried out (main routes). Other objects in the CLCS are served using a variety of secondary transportation routes.

Based on demand forecasting, the tasks of purchasing and distributing within the service network are solved, taking into account the urgency of supplies, the range of supplied raw materials and the distribution of finished products, the seasonality of production and sale of food products, and the level of transport costs in the supply chains. Based on the amount of transport costs, the problem of determining tariffs for transport services is solved, taking into account the "price / quality" ratio and the dynamics of the use of rolling stock.

At the tactical level of providing transport and logistical services, the plans for the transportation of goods are adjusted taking into account the Bullwhip effect, uneven demand, the presence of rolling stock at the nodes of supply chains. At this stage, based on the chosen strategy for distributing products through sales channels, the scheduling of product delivery by main and subordinate routes is carried out, taking into account the frequency of service, the capacity of warehouses and terminals, and the compatibility of the transported products.

Network management methods can be used while developing models of supply chains, [2-4].

Figure 1 shows the structure of a typical CLCS. The focal company (node # 8) receives material resources from three suppliers (nodes # 1, 3, 7). The first supplier works through intermediaries, the third supplier works through intermediaries and directly,

the seventh supplier carries out direct deliveries. The focal company (node # 8) uses both direct and indirect channels to market finished products. Nodes ## 9, 10, 11 and 14 represent sales resellers, and Nodes ## 12, 13 and 15 represent retailers.

When analyzing the functioning of the CLCS using network models, the concepts of "central node" of the network and "subnet" form the foundation. The central node of the network is the focal company. A subnet is a part of a network, a collection of connected links. The left and right subnets in the network are selected. The left subnet is formed by the central link and all the links that are involved in the supply of raw materials (primarily fresh fruit) to the focal company. The right subnet is formed by the central link, sales intermediaries and retailers.

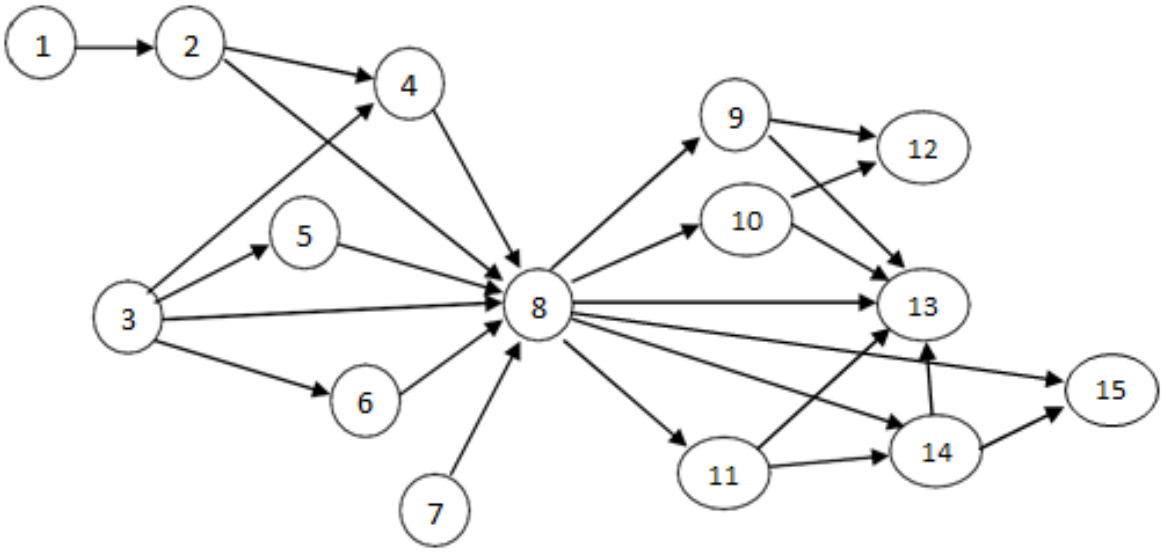

Figure 1 –Network model of a typical CLCS

Unlike the classical network model of management, the network model of the CLCS has a number of the specific features: the main elements of the supply chain are nodes and material flows; the goals of the subnets in the CLCS are different; the CLCS network model always has the central node and subnets; there is no concept of "critical path" for the CLCS network model; the supplies of one subnet within the CLCS are relatively independent of the supplies of the other subnet.

The development of an effective CLCS involves solving a set of tasks related to minimizing logistical costs for both the focal company and other participants in the chain. To formalize the problem under consideration, we will separately consider the planned indicators of purchases, sales, and costs for the left and for the right subnets of the CLCS. Let the size of the production program of the focus company be equal to the plan for selling products by retailers. Assume that the prices on the purchased raw materials and sold finished products are stable [5].

The planned demand of the focal company for the raw materials is:

$$M_l = \sum_{i=1}^{m} R_{li} \times Q_i,$$

where R_{li} – consumption rate of l-th type of raw material for production of the i-th type of the product; m – product range of the focal company moved within the logistical chain; Q_i – product volume required to fulfil the production plan of the focal company.

The planned volume of products manufactured by the focus company is determined based on the production (sales) plan, taking into account a set of factors that

determine the current and future demand for products:

$$Q_i = \sum_{j=1}^{n} P_j \times k_{ij},$$

where Pj – production plan (sales) of the j-th product ; kij – volume of the i-th type of raw material used in production of the j-th type of product; n – number of items in the range of sold products. Logistic costs associated with the procurement of raw materials (costs of the left subnet of the supply chain):

$$Z_1 = \sum_{p=1}^{u} \sum_{l=1}^{t} Z_{lp},$$

where Z_{lp} – delivery costs of the l-th type of raw materials from the p-th supplier; u – number of suppliers; t – range of supplied raw materials.

The sales plan is determined based on research of target market segments:

$$P_j = \sum_{k=1}^{s} P_{jk},$$

where P_{jk} – sales plan of the j-th type of product for the k-th segment; s – the number of segments.

Delivery costs associated with the sales of finished products (costs in the right subnet):

$$Z_2 = \sum_{k=1}^{s} \sum_{j=1}^{n} Z_{jk},$$

where Z_{jk} – delivery costs on the j-th type of product in the k-th segment.

The objective function, which assumes minimization of the total logistical costs of the focal company related to procurement and sales, is:

$$Z = Z_1 + Z_2 \to min.$$

The solution to this problem is the selection of suppliers of raw materials and the volumes of these supplies, as well as the selection of links in the distribution network and the distribution of batches of finished products among them.

The process of creating, deploying and supporting the functioning of a CLCS can be adequately represented in the form of a hierarchical two-level nested Petri net framework (NPN) [6]:

$$IPN =< SN^{(1)}, EN_1^{(2)}, ..., EN_m^{(2)} >$$

where $SN^{(1)}$ – system network simulating the process of functioning of a focal company; $EN_1^{(2)}, \ldots, EN_m^{(2)}$ – a set of elementary Petri nets each of which simulates the processes of raw material procurement, production and packaging of finished products.

In this case, the network model of the CLCS is a tuple:

$$IPN =< N, C, W, G, \Omega, M_0 >$$

where $N = (P, T, F)$ – finite network with multiple positions P, the set of transitions T_i by the incidence relation F; $C : P \to \Omega$ - position coloring function that maps each position of $p \in P$ its color $C(p)$; W- a function that assigns to the arrows of network N the expressions of the type

$$((p,t),(t',p')) \in F : (Type(W(p,t)) = M(C(p))) \vee$$
$$\vee (Type(W(t',p')) = M(C(p')));$$

where $G : T \to L$ - the function which matches every transition $t \in T$ and some expressions of Boolean logics which reflect the corresponding event; M_0 – the function which matches every position of $p \in P$ the following expression:

$$\forall p \in P : (Type(M_0(p) = M(C(p))))$$

The function M_0 determines the initial markup of the NPN that includes the determination of the color of the markers and

reflects a specific production situation because the focal company has the finished products in the warehouse.

The NPN class gives an opportunity to reflect the hierarchical structure of the CLC in an adequate manner. At the same time, there is no mechanism for reflecting time in this kind of Petri nets. Based on this, in order to comply with the 'just-in-time' principle, it is critically important to expand the model presented in the form of NPN in the aspect of taking into account time dependences.

To build a model for the explicit representation of time during the functioning of the CSC, it is necessary to implement the following steps [7]:

1. Select base primitives of time and define base relationships between them
2. Introduce the necessary elementary functions for transforming primitives and relations.
3. Represent the properties of the structure of time using axioms that determine the basic properties of time and the properties of basic relations.
4. Describe a way to represent time dependencies.
5. Choose a method to associate logical statements with time.
6. Synthesize the theory of temporary statements.

At the first stage of the knowledge model synthesis, taking into account time dependencies, moments and / or time intervals are used as basic primitives. If necessary, time constants are used to indicate the moments of time and intervals (seconds, minutes, hours, days, dates, time, etc.), besides, the primitive "Duration" is used, with the help of which the distance between the moments of time is set up.

The second stage: some of the functions are built on the basic relations and are their functional version; the functions allow converting between temporary primitives.

At the third stage of the model synthesis, it is necessary to specify the connection among several primitives of time in the form of the corresponding axioms, taking into account the properties (discreteness / continuity) of time, characteristics of individual elements of the CLSC; at the fourth stage, a method for describing time dependences (time model) is chosen.

The fifth stage of the synthesis of the model of time dependencies involves the use of approaches that have good expressiveness.

At the last, sixth stage, it is necessary to define the basic temporary statements, and set up their properties using a set of axioms.

The information about the current state of tasks scheduled for execution is updated in the model $\mathrm{SN}^{(1)}$ based on data from the lower-level models $\mathrm{EN}_1^{(2)}, \ldots, \mathrm{EN}_m^{(2)}$. According to the rules for the functioning of the CSC, the tasks are checked in order to determine the facts of deviations and the magnitude of the task delays.

The set of all planned tasks will be denoted by Z. In this case, there is a mapping $ZP: Z \rightarrow P$, which specifies the correspondence of the state of production tasks to the network positions $\mathrm{SN}^{(1)}$. The current status of a task $z_i \in Z$ has the *Status* attribute, which determines whether it belongs to the set of started Φ^n, in the process of execution of Φ^w, or completed Φ^r tasks.

The timeliness of the implementation of tasks is characterized by the attribute *Timeliness*, which determines task affiliation of z_i to $\overline{W}$ or $\widetilde{W}$, where $\overline{W}$ is a set of issued or completed assignments within the predetermined delivery schedule, and $\widetilde{W}$ is a set of tasks which execution or delivery time was delayed due to the influence of various kinds of external or parametric disturbances, moreover $\overline{W} \cap \widetilde{W} = \varnothing$ and there is a reflection such that $ZW : Z \rightarrow (\overline{W} \cup \widetilde{W})$. Tasks are divided into procurement-related Z^k (procurement of raw materials, production and packaging) and

transportation-related Z^a, $Z = \{Z^k \cup Z^a\}$, where $Z^k \cap Z^a = \varnothing$. There are such bijective mappings $Z^k \to B$ and $Z^a \to ((P \setminus B) \setminus R)$.

In order to activate the $\mathrm{SN}^{(1)}$ set of events, which are the results of the tasks' performance in the process of their functioning of CLSC, is reflected by the elements of the set of all the events $E^a = \{E^{p\phi} \cup E^d\}$, where $E^{p\phi}$ are the events of actual and planned start/|end of a task while $E^{p\phi} \to E$, where E^d are job status check events at the beginning of each monitoring cycle. The events from the set E^a change the features of tasks at the time moments from the set $T = \{T^p \cup T^f\}$, $T^p \cap T^f = \varnothing$, where T^p is a set of the check time moments at the beginning of every monitoring cycle which have taken place since the CLSC started, and T^f is a set of check time moments at the beginning of every monitoring cycle of the current state of the CLCS.

The purpose of the developed method is to identify deviations from the schedule when performing tasks during the functioning of the CLCS and to formulate instructions for stabilizing the current state of the chain.

The first stage of the method (steps 1-4) is carried out in parallel, asynchronously and cyclically during each cycle of monitoring the links of the logistics chain, this makes it possible to take into account the current state of its individual links in the process of supporting decision-making on the implementation of CLCS.

The second stage of the method (steps 5-7), in the case of time delays, makes it possible to form solutions to stabilize the CLCS functioning.

The initial state (CLCS start) is assigned as follows: $\forall z_i \in \overline{W} \wedge \forall z_i \in \Phi^n$, $\exists Z^p : Z^k \to Z^a$.

1. In case of the events $e_{\mathrm{j}}^{\phi} \in E^{p\phi}$ of actual tasks changes state, where $j \in \{нач, оконч\}$, $нач$ is a task's start and $оконч$ is the task's end:

- if $e_{нач_{z_i}}^{\phi}$ is the change of Φ^n and Φ^w sets' content occurs through: $\Phi_k^n = \Phi_{k-1}^n - \varphi_{z_i}^{\Phi^n} \wedge \Phi_k^w = \Phi_{k-1}^w + \varphi_{z_i}^{\Phi^n}$, where k is the next cycle of monitoring the current state of CLCS;
- if none of these events occurs for any task, go to step 2.

2. In case of events $e_{\mathrm{j}}^{pl} \in E^{p\phi}$ of the planned changes of tasks' state, where $j \in \{нач, оконч\}$, $нач$ – the start of task's performance and $оконч$ – the end of a task's performance:

- if $e_{нач_{z_i}}^{pl}$ for $\forall z_i | z_i \in \overline{W} \wedge z_i \in \Phi^n \wedge t_{нач_{z_i}}^{pl} \in T^p \wedge t_{нач_{z_i}}^{\phi} \in T^f$ the change in the composition of the sets $\overline{W}$ and $\widetilde{W}$ occurs through: $\overline{W}_k = \overline{W}_{k-1} - \omega_{z_i}^{\overline{W}} \wedge \widetilde{W}_k = \widetilde{W}_{k-1} + \omega_{z_i}^{\overline{W}}$
- if $e_{оконч_{z_i}}^{pl}$ for $\forall z_i | z_i \in \overline{W} \wedge \forall z_i \in \Phi^w \wedge \wedge t_{оконч_{z_i}}^{pl} \in T^p \wedge t_{оконч_{z_i}}^{\phi} \in T^f$ the change in the composition of the sets $\overline{W}$ and $\widetilde{W}$ occurs through: $\overline{W}_k = \overline{W}_{k-1} - \omega_{z_i}^{\overline{W}} \wedge \widetilde{W}_k = \widetilde{W}_{k-1} + \omega_{z_i}^{\overline{W}}$;
- if $e_{оконч_{z_i}}^{pl}$ for $\forall z_i | z_i \in \widetilde{W} \wedge z_i \in \Phi^r \wedge \wedge (t_{\text{оконч}_{z_i}}^{\phi} \le t_{оконч_{z_i}}^{pl})$ – the change in the composition of the sets $\overline{W}$ and $\widetilde{W}$ occurs through: $\widetilde{W}_k = \widetilde{W}_{k-1} - \omega_{z_i}^{\widetilde{W}} \wedge \overline{W}_k = \overline{W}_{k-1} + \omega_{z_i}^{\widetilde{W}}$
- if none of these events occurs for any task, go to step 3.

3. In case of events' initiation of $e_{\mathrm{K}_j}^{ch} \in E^d$ task's status check, where K is a set of indices, $\mathrm{K} = \{\varphi\varphi, \omega\omega, bb\}$, $\varphi\varphi$ – task's status check, $\omega\omega$ – task's timeliness check, bb - task's delay check: ‘

- if $e^{ch}_{\varphi\varphi_{z_i}}$ for $\forall z_i | z_i \in \Phi^w \wedge t^{pl}_{оконч_{z_i}} \in T^f \wedge$ $\wedge t^{\phi}_{оконч_{z_i}} \in T^f \wedge t_{проверки_{z_i}}$ calculating the current duration of the task goes as $dur^w_{z_i} = t_{проверки_{z_i}} - t^{\phi}_{нач_{z_i}}$;

- if $e^{ch}_{\omega\omega_{z_i}}$ for $\forall z_i | z_i \in \Phi^w \wedge z_i \in \widetilde{W} \wedge$ $\wedge t_{проверки_{z_i}}$ calculating the current duration of the task with delay goes as $dur^r_{z_i} = t_{проверки_{z_i}} - t^{pl}_{оконч_{z_i}}$;

- if $e^{ch}_{bb_{z_i}}$ for $\forall z_i | z_i \in \Phi^r \wedge z_i \in \widetilde{W} \wedge$ $\wedge (t^{pl}_{оконч_{z_i}} \le t^{\phi}_{оконч_{z_i}})$ the change in the composition of the sets $\overline{W}$ and $\widetilde{W}$ occurs through: $\widetilde{W}_k = \widetilde{W}_{k-1} - \omega^{\widetilde{W}}_{z_i} \wedge \overline{W}_k = \overline{W}_{k-1} + \omega^{\widetilde{W}}_{z_i}$.

- if none of these events occurs for any task, go to step 4.

4. For every task $z_i \in Z^a$, which must be performed during the functioning of the CLCS, the execution lag is checked through $dur^r_{z_i}$ of the tasks which compose it, the delay value is calculated as $dur_{max} = \max_i (dur^r_{z_i})$ and determined that dur_{max} will constitute the overall delay within the complete supply chain (CSC).

5. Defining a consumer for a task $z_i \in Z^a$, by analyzing the delivery route and transmitting information about the fluctuations during the CSC functioning to the decision-maker.

6. Determining the presence of a critical situation by comparing the duration of the delay dur_{max} of the task $z_i \in Z$ with the critical values of the task's slack.

7. Enabling the rules of the critical node in the network diagram $SN^{(1)}$ and developing decisions on the stabilization of the CSC status.

8. The execution of the method will end under the conditions if the current state of all tasks has the status "Completed", that is, the functioning of the CSC is completed.

To determine the mode of transport for the dried fruits delivery, it is necessary to take into account the six main factors influencing decision-making process: delivery time; transportation costs; compliance with the delivery schedule; frequency of departures; variety of good to be shipped, and the ability to deliver cargo anywhere. In the process of purchasing and delivering material resources within the CSC, as well as distributing finished products to consumers, a focal company can use various types of transport, various logistical partners and various transportation options [6].

The selection of the optimal mode of transport for the formation of the CSC will be carried out while considering that the delivery time and costs are the optimization criteria. The choice of the type of transport will be carried out using artificial intelligence methods, namely fuzzy modeling.

Let us make a choice of the mode of transport for the supply of raw materials and supplies from raw material suppliers to the focal company (the left side of the network). For this purpose, we construct a fuzzy model [8] based on two binary fuzzy relations S and T. The first of these fuzzy relations is built on two basic sets X and Y, and the second - on two basic sets Y and Z. Here X describes the set of modes of transport by which the transportation can be carried out, Y - the set of transport options, and Z - transport characteristics. The fuzzy relation S meaningfully describes the relationship between the mode of transport and the transportation option, and T describes the assessment of various transportation options for each of the factors.

Specifically:

a) $X = \{x_1, x_2, x_3, x_4, x_5, x_6\}$;

b) $Y = \{y_1, y_2, y_3, y_4, y_5, y_6\}$;

c) $Z = \{z_1, z_2, z_3, z_4, z_5, z_6\}$.

The elements of the universes have the following meaning:

a) x_1 – «railway transport», x_2 – «roadway transportation», x_3 – «waterway transportation», x_4 – «pipeline transportation», x_5 – «air transportation», x_6 – «maritime transportation»;

b) y_1 – «unimodal», y_2 – «mixed», y_3 – «combined», y_4 – «intermodal», y_5 – «terminal», y_6 – «multimodal»;

b) z_1 – «delivery time», z_2 – «delivery frequency», z_3 – «schedule reliability», z_4 – «handling variety of cargo», z_5 – «ability to deliver goods in any geographical point», z_6 – «delivery costs».

Specific values of membership functions $\mu_S(<x_i, y_j>)$ and $\mu_T(<y_j, z_k>)$ of the considered fuzzy relations are presented in matrices (1) and (2).

The matrices of these fuzzy relations are as follows:

$$M_S = \begin{bmatrix} 0,5 & 0,7 & 0,3 & 0,2 & 0,3 & 0,3 \\ 0,1 & 0,8 & 0,8 & 0,3 & 0,7 & 0,5 \\ 0,8 & 0,7 & 0,8 & 0,3 & 0,3 & 0,3 \\ 0,3 & 0,3 & 0,2 & 0,2 & 0,2 & 0,2 \\ 0,8 & 0,3 & 0,4 & 0,3 & 0,3 & 0,3 \\ 0,1 & 0,8 & 0,9 & 0,4 & 0,7 & 0,5 \end{bmatrix}, \quad (1)$$

$$M_T = \begin{bmatrix} 0,8 & 0,6 & 0,4 & 0,3 & 0,3 & 0,3 \\ 0,4 & 0,6 & 0,5 & 0,7 & 0,3 & 0,5 \\ 0,3 & 0,7 & 0,7 & 0,9 & 0,3 & 0,6 \\ 0,4 & 0,5 & 0,6 & 0,8 & 0,9 & 0,7 \\ 0,4 & 0,5 & 0,6 & 0,8 & 0,9 & 0,8 \\ 0,4 & 0,5 & 0,6 & 0,8 & 0,9 & 0,7 \end{bmatrix} \quad (2)$$

The result of a fuzzy composition of fuzzy relations (1) and (2) can be presented as a matrix of the resulting fuzzy relationship:

$$M_{S*T} = \begin{bmatrix} 0,5 & 0,6 & 0,5 & 0,7 & 0,3 & 0,5 \\ 0,4 & 0,7 & 0,7 & 0,8 & 0,7 & 0,7 \\ 0,8 & 0,7 & 0,7 & 0,7 & 0,3 & 0,6 \\ 0,3 & 0,3 & 0,3 & 0,3 & 0,3 & 0,7 \\ 0,8 & 0,6 & 0,4 & 0,4 & 0,3 & 0,3 \\ 0,4 & 0,7 & 0,7 & 0,9 & 0,7 & 0,7 \end{bmatrix}. \quad (3)$$

As an example, consider the procedure for calculating one of the values of the membership function, specifically, $\mu_{S*T}(<x_1, z_1>)=0,5$. First, the minimum values of the membership function of all pairs of elements of the first row of the matrix (6) are given and the first column of the matrix (7) is calculated as $min\{0,5\ 0,8\}=0,5;$ $min\{0,7\ 0,4\}=0,4;$ $min\{0,3\ 0,3\}=0,3;$ $min\{0,2\ 0,4\}=0,2;$ $min\{0,3\ 0,4\}=0,3;$ $min\{0,3\ 0,4\}=0,3.$ After that, the maximum of 6 obtained values is determined, which will be the desired value of the membership function: $\mu_{S*T}(<x_1, z_1>)=max\{0,5\ 0,4\ 0,3\ 0,2\ 0,3\ 0,3\}=0,5.$ The rest of the values of the membership function are found in a similar manner.

As a result of the analysis of the calculated values of the membership function, the best option according to the criteria "Delivery time" and "Delivery cost" will be the use of road transport, since the membership functions are equal to $\mu_{S*T}(<x_3, z_1>)=0,8$, $\mu_{S*T}(<x_3, z_6>)=0,6,$ respectively.

The solution to the problem of choosing a mode of transport does not in itself ensure the efficiency of the processes of dried fruits transporting within the CSC framework; the quality and speed of transportation is directly influenced by the optimal choice of the route. The safety of the cargo and the extraction of the actual maximum profit is achieved by drawing up an optimal route [5]. When drawing up an optimal route, it is necessary to take into account the location of the final point of delivery, the dimensions and weight of the cargo, as well as its characteristics. Taking into account the listed parameters, a necessary transportation vehicle is selected.

While designing the CLCS, a route which takes into account all the driver's possible stoppage places for meals and overnight accommodation as well as the customs control points is drawn up. In addition, it is necessary to take into account the state of the road surface and the time required for crossing the borders of other states as well as the characteristics of each region on the route of the cargo transportation. Also it is necessary to take into account the road's width. The quality of the pavement's surface and the weather conditions that affect the

conditions of the road. To ensure just-in-time delivery, the speed limits on certain segments of the route must be considered.

In order to choose the optimal transportation route, it is recommended to build a fuzzy model in the MATLAB tool environment and develop an expert system while functionality will be based on fuzzy inferences. The interactive mode is provided by using the Fuzzy Logic Toolbox package, which is a part of the MATLAB environment [9].

Four fuzzy linguistic variables must be used as input parameters of the fuzzy inference system to determine the rational transportation route: weather conditions; the quality of the pavement surface; the number of speed limits encountered; time required for passing the customs post. In this case, the output variables will be: transportation time and transportation cost.

The Mamdani method is used as a fuzzy inference scheme; therefore, the activation method will be MIN [8]. The center of gravity method was used as a defuzzification method for the obtained result.

To build a fuzzy model for choosing an optimal transportation route, it is assumed that all considered input variables are measured in points in the range of real numbers from 0 to 10, where the lowest estimate of the value of each of the variables is 0, and the highest is 10.

Term set for the first input linguistic variable "Weather conditions" (Pogoda) are: T_1 ={"fair", "good", "excellent"}. For the second input variable "Pavement quality" (Pokrutie): T_2 ={"bad", "medium", "excellent"}. For the third input linguistic variable "Speed limits" (Ogran_skorosti) T_3 ={"very many", "many", "a few"}. For the fourth input linguistic variable "The customs post passing" (Tamozhen_postu): T_4 ={"slowly", "fast", "very fast"}.

As a term set of the first output linguistic variable "Delivery time" (Vrema): T_5 ={"excellent", "good", "medium", "bad", "very bad"}. As a term set of the second output linguistic variable "Transportation cost" (Stoimost): T_6 ={"very low", " low ", "medium", "high ", "very high"}.

The problem of fuzzy modeling was solved based on the Mamdani rule, while the parameters of the developed fuzzy model were proposed by MATLAB on default were the following items remained unchanged: logical operations (min for a fuzzy logical "AND", max for a fuzzy logical "OR"), implication method (min), aggregation method (max) and defuzzification method (centroid). After that, while solving the problem, the membership functions of the terms were determined for each of the four inputs and one output variable of the considered fuzzy inference system. Further, for the developed expert system, a knowledge base of 30 rules was formed. Figure 2 shows the editor of the rules included in the fuzzy knowledge base of the expert system, called by the *ruleedit* ('marschrut') function. Then the analysis of the constructed fuzzy inference system for the considered problem of choosing a rational route for the transportation of a batch of dried fruits along the international route is carried out. By entering the value of the input variables for the first option of the route, the value of the input variable "weather conditions" is set up as 5 points, the value of the input variable "Pavement quality" is 4 points, the value of the input variable "speed limit" is 6.8 points, and the value of the input variable "The customs post passing" is 7 points.

As a result, the fuzzy inference procedure implemented using the MATLAB system for the developed fuzzy model, gives the value of the output variables "Delivery time" and "Transportation cost", equal to 41.5 hours and 12.7 thousand UAH respectively.

Figure 2 – The editor of the rules of the expert system of fuzzy knowledge base for selecting optimal transportation routes within the CSC framework.

For the second route, the value of the input variable "Weather conditions" was estimated as 5 points, the value of the input variable "Pavement quality" as 7 points, the value of the input variable "Speed limit" as 4.5 points, and the value of the input variable "The customs post passing" as 3.5 points. As a result, the fuzzy inference procedure made it possible to obtain the values of the output variables "Delivery time" and "Transportation cost" equal to 49.2 hours and 15.6 thousand UAH respectively. Obviously, based on the results obtained for this example, it is more profitable to transport goods within the framework of the CSC using the first route option.

The considered fuzzy model produces sufficiently adequate results. However, for achieving a higher level of precision, it is necessary to use additional rating methods of individual quantitative values for input and output linguistic variables. In practice, to solve this problem, it is reasonable to use such tools that would be highly transparent and visual and would facilitate an interface with the software system without having advanced knowledge and skills in the field of software engineering.

Figure 3 shows the visualization process of the fuzzy inference surface of the considered model for the input variables "Speed limits" and "The customs post passing". This visualization tool facilitates establishing the relationship between the output variable values and the individual input variables values of the fuzzy model. The analysis of these relationships serves as the basis for changing the membership functions of input variables or fuzzy rules in order to improve the adequacy of the fuzzy inference system.

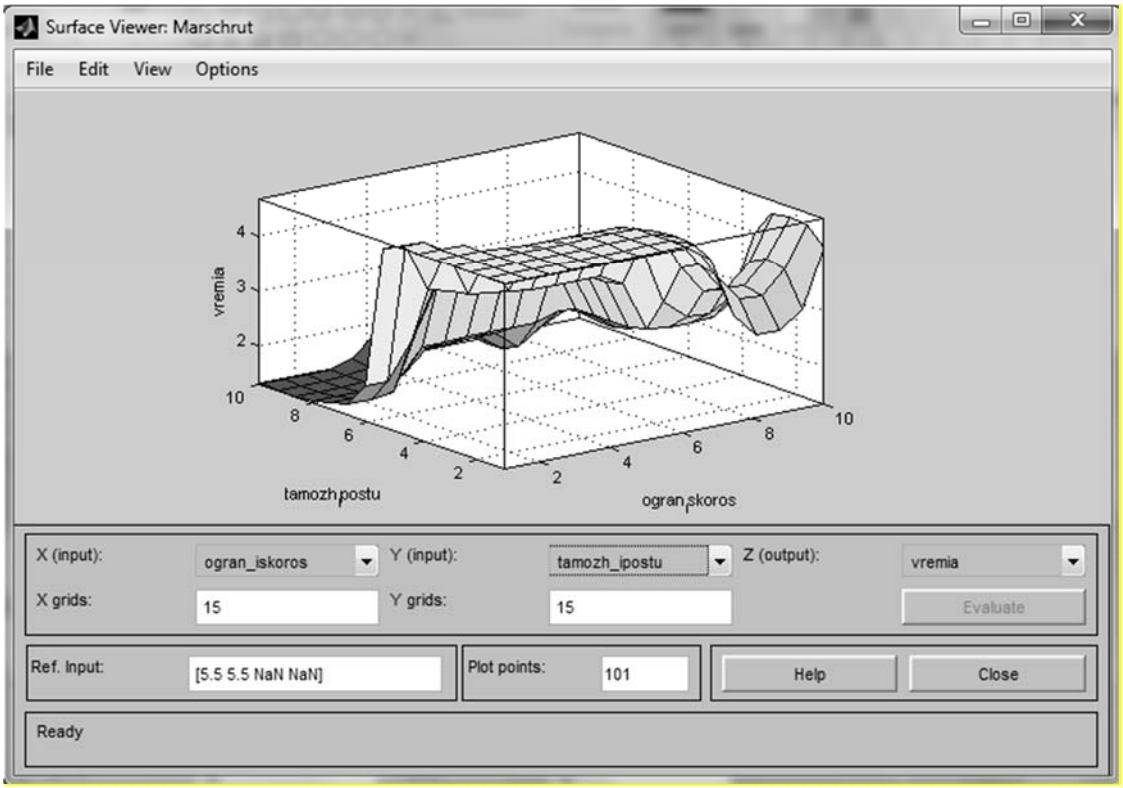

Figure 3 – Visualization of the fuzzy inference surface for the output variable "Delivery time".

The visualization tools applied in Figure 3 enable the decision-maker to comprehensively assess the quality of the settings of the parameters in the fuzzy model, which, in fact, is an inference machine of the expert system and, if necessary, correct the parameter values.

Conclusions.

1. A model of the complete supply chain has been created in the form of a nested Petri net, which reflects the hierarchy of the chain structure, namely its upper level (focal company), and lower levels - raw material suppliers, providers and retailers.

2. A method is proposed for representing time dependences on the network model of the CSC, which makes it possible to identify fluctuations from the schedule during the operation of the circuit, and to assess the influence level of these fluctuations in order to comply with the "just-in-time" principle.

3. An advanced method for the formation of rational routes of cargo transportation within the framework of the CSC is described, which is based on fuzzy mathematics, and makes it possible to reduce the level of uncertainty of time and financial costs during the operation of the supply chain

4. The methodological tools developed in the course of the study served as the basis for the development of intelligent information technology to support the adoption of rational decisions on the organization of cargo transportation between the participants of the CSC, which enables to reduce financial and time risks.

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EFFICIENCY OF "LEAN MANAGEMENT" APPLICATION IN BUSINESS PROCESSES MANAGEMENT OF REFRIGERATION EQUIPMENT SUPPLY CHAIN DURING THE COVID CRISIS

Mariia Hryhorak, Shevchuk Liliya "Efficiency of "lean management" application in business processes management of refrigeration equipment supply chain during the COVID crisis". *The article reveals the main trends in the functioning of global supply chains in the context of the COVID-19 pandemic and their impact on the activities of Ukrainian enterprises are identified. It is noted that the closure of borders between countries and the introduction of self-isolation regime caused a significant reduction in production capacity and the volume of international trade. Global supply chains have become very vulnerable and necessitate their revision and the search for alternative ways to deliver goods to end users. Since Ukraine is a country with an open market economy, this article summarizes the main challenges for import-dependent supply chains and makes proposals on ways to overcome them. The expediency of applying the concept of Lean-management in business processes management of refrigeration supply chains during a pandemic as a means of overcoming crisis situations and ensuring sustainable development are proved. The dynamics and structure analysis of the company LLC "Holod Engineering" income and expenses allowed to establish a tendency to reduce the profitability of the company's business and capital turnover, as well as increase the share of logistics costs in the production costs. The greatest impact on the growth of logistics costs have the inventory costs due to the processes of storage and orders completion and delivery delays, which lead to customer dissatisfaction and complaints. Methodical approaches to estimating the level of processes coordination in the supply chains of refrigeration equipment, calculation of supply lots optimal parameters, levels of raw materials and components stocks, production and storage capacity rationalization of the enterprise are substantiated. With the help of Shewhart's control charts, the coordination of business processes in the equipment supply chains were assessed and the sources of potential losses were identified. The technological and logistics processes optimization in terms of their cost, duration and quality of results takes into account not only individual processes of enterprises, but also interprocess connections between supply chain links. It is proposed to implement a number of organizational measures using the concept of lean management, which involves market integration, production process, procurement and sales in order to provide a high level of customer*

40-52
v.5 (2021)
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service. The efficiency of the proposed organizational changes and their impact on business profitability, inventory turnover, the amount of logistics costs and the quality of customer service are determined.

***Keywords**:* supply chain management, business process, lean management, lean supply chain, cost management.

Мрія Григорак, Шевчук Ліля "Ефективність застосування "бережливого управління" в управлінні бізнес-процесами ланцюга постачання холодильного обладнання під час кризи COVID". *У статті розкрито основні тенденції у функціонуванні глобальних ланцюгів постачання в умовах пандемії COVID-19 та визначено їх вплив на діяльність українських підприємств. Відзначено, що закриття кордонів між країнами та введення режиму самоізоляції спричинили значне скорочення виробничих потужностей і обсягів міжнародної торгівлі. Глобальні ланцюги постачання стали дуже вразливими і обумовлюють необхідність їх перегляду та пошуку альтернативних шляхів доставки товарів до кінцевих споживачів. Оскільки Україна є країною з відкритою ринковою економікою, то в даній статті узагальнено основні виклики для імпортозалежних ланцюгів постачання та зроблено пропозиції щодо шляхів їх подолання. Доведено доцільність застосування концепції Lean-менеджменту в управлінні бізнес-процесами ЛП холодильного обладнання під час пандемії як засобу виходу з кризових ситуацій та забезпечення сталого розвитку. Аналіз динаміки і структури доходів і витрат підприємства ТОВ «Холод-інжиніринг» дозволив встановити тенденцію до зменшення прибутковості бізнесу компанії і оборотності капіталу, а також збільшення частки логістичних витрат в собівартості продукції. Найбільший вплив на зростання логістичних витрат мають витрати на утримання запасів, що обумовлено процесами зберігання і комплектації замовлень і затримками в доставках, що призводять до незадоволеності і скарг клієнтів. Обґрунтовано методичні підходи до оцінювання рівня скоординованості процесів в ланцюгах постачання холодильного обладнання, розрахунку оптимальних параметрів партій постачання, рівнів запасів сировини і комплектуючих, раціоналізації використання виробничих та складських потужностей підприємства. За допомогою контрольних карт Шухарта зроблено оцінку скоординованості бізнес-процесів в ланцюгах постачання обладнання та визначено джерела потенційних втрат. Оптимізація технологічних та логістичних процесів за їх вартістю, тривалістю та якістю результату враховує не лише окремі процеси підприємств, а й міжпроцесні зв'язки між ланками ланцюгів постачання. Запропоновано здійснити ряд організаційних заходів з використанням концепції lean-менеджменту, що передбачає об'єднання ринку, виробничого процесу, закупівель і збуту з метою високого рівня обслуговування клієнтів. Визначено ефективність запропонованих організаційних змін та їх вплив на прибутковість бізнесу, оборотність запасів, величину логістичних витрат та якість обслуговування споживачів.*

Ключові слова: управління ланцюгами постачання, бізнес-процес, lean-менеджмент, lean-ланцюг постачання, управління витратами.

Мария Григорак, Шевчук Лиля " Эффективность применения "бережливого управления" в управлении бизнес-процессами цепи поставки холодильного оборудования во время кризиса COVID ". *В статье раскрыты основные тенденции в функционировании глобальных цепей поставок в условиях пандемии COVID-19 и определено их влияние на деятельность украинских предприятий. Отмечено, что закрытие границ между странами и введение режима самоизоляции вызвали значительное сокращение производственных мощностей и объемов международной торговли. Глобальные цепи поставок стали очень уязвимыми и обусловливают необходимость их пересмотра и поиска альтернативных путей доставки товаров до конечных потребителей. Поскольку Украина является страной с открытой рыночной экономикой, то в данной статье обобщены основные вызовы для импортозависимых цепей поставок и сделаны предложения о путях их преодоления. Доказана целесообразность применения концепции Lean-менеджмента в управлении бизнес-процессами ЦП холодильного оборудования во время пандемии как средство выхода из кризисных ситуаций и обеспечения устойчивого развития. Анализ динамики и структуры доходов и расходов предприятия ООО «Холод-инжиниринг» позволил установить тенденцию к уменьшению прибыльности бизнеса компании и оборачиваемости капитала, а также увеличение доли*

логистических затрат в себестоимости продукции. Наибольшее влияние на рост логистических издержек имеют расходы на содержание запасов, что обусловлено процессами хранения и комплектации заказов и задержками в поставках, приводящие к неудовлетворенности и жалобам клиентов. Обоснованы методические подходы к оценке уровня скоординированности процессов в цепях поставок холодильного оборудования, расчета оптимальных параметров партий поставки, уровней запасов сырья и комплектующих, рационализации использования производственных и складских мощностей предприятия. С помощью контрольных карт Шухарта произведена оценка скоординированности бизнес-процессов в цепях поставок оборудования и определены источники потенциальных потерь. Оптимизация технологических и логистических процессов по их стоимости, продолжительности и качеству результата учитывает не только отдельные процессы предприятий, но и межпроцессные связи между звеньями цепей поставок. Предложено осуществить ряд организационных мероприятий с использованием концепции lean-менеджмента, что предусматривает объединение рынка, производственного процесса, закупок и сбыта с целью высокого уровня обслуживания клиентов. Определена эффективность предложенных организационных изменений и их влияние на прибыльность бизнеса, оборачиваемость запасов, величину логистических издержек и качество обслуживания потребителей.

Ключевые слова: управление цепочками поставок, бизнес-процесс, lean-менеджмент, lean-цепь поставок, управление затратами.

Introduction. Global pandemic, due to the rapid spread of the rapid spread of the Covid-19 virus has exacerbated global and regional economic development challenges. In addition to the usual negative factors associated with the existence of military conflicts, the introduction of mutual trade restrictions, which contradicts the principles of open markets and free competitive access, climate change and increasing the frequency of extreme weather events, additional quarantine restrictions cause significant risks in global supply chain management, reduce their stability and change the configuration. Thus, the introduction of lockdown, closure and reopening of production centers in China has significantly affected the relationship between suppliers, manufacturers and consumers. The authors [1] defined such a state as the supply side shock for European and American companies. Consumer needs have changed significantly: in the conditions of quarantine measures and teleworking, the demand for food, household and medical goods, Internet communication and electronic means of communication has increased.

An interesting study of the company's activities concluded that in the post-Covid period supply chains will be revised not to reduce costs, but to achieve greater sustainability, which will lead to diversification of production, storage and procurement, as well as the return of production from abroad and the active use of outsourcing in the near abroad [2]. The authors emphasize the need to reorganize workplaces in accordance with the requirements of social distancing and hygiene, which determines the feasibility of digitization and automation of existing processes in supply chains and, accordingly, adaptation to new standards: in particular, provide one-way freight systems packing areas in compliance with the requirements of social distancing.

This indicates the relevance of research on the impact of these geoeconomic changes on business processes in supply chains, the search for new methodological approaches to their optimization and the organization of cross-functional interaction of business partners to reduce logistics costs and increase sustainability.

The experience of leading companies shows that synchronization of processes and effective partnership in supply chains reduces delays in the delivery of goods and creates added value for customers. One of the effective mechanisms to improve the efficiency and effectiveness of supply chains is lean-management, the essence of which is

that all participants in the supply chain try to reduce their costs while increasing the speed and flexibility of doing business. That is, there is a directly proportional relationship - the more flexible business processes in supply chains, the better the performance of all its participants. As the functioning of specific supply chains is influenced by various factors of the external and internal environment, there is a need to quickly find opportunities to improve business processes and increase the stability of the management system. High adaptability, economy of the supply chain and speed of decision-making, which is formed during the introduction of lean-management tools, will allow the business to survive. Thus, the trends outlined above, respectively, determined the topic of the study.

Analysis of research problems. Problems of efficiency of management of financial, material and information flows from the supplier to the final consumer in SC are deeply investigated by leading foreign and domestic scientists, in particular, M. Linders, H. Firon, V. Sergeev, E. Krykavsky, N. Chukhrai, T. Kolodizeva and others. Among the recent publications used in the preparation of this article, it should be noted the scientific works of N. Bocharova, S. Dubovik, H. Sigida [4; 5], and foreign, J. Ganstedt, K. Lysons, M. Reynolds [6; 7; 8], scientists.

Most experts believe that the concept of lean is based on the ideas of Kaizen, but it has a wider application in SC, as it focuses on optimizing the processes of the entire supply chain. Thus, R. Shah and P. Ward [14, p.55] highlight the following positive effect of the introduction of LEAN-concept in SC: statistical control of processes; reduction of time for reconfiguration; feedback from suppliers; consumer involvement; introduction of PULL-system; flow continuity.

Thus, if we consider lean as a philosophy, as a well-thought-out and tested optimization, cooperation with customers and suppliers on the basis of partnership, mutual assistance in solving problems, then it can be an effective solution in such a difficult situation. The implantation of lean-practice helps to organize a steady flow in SC, and enterprises to become both innovative, competitive and more stable in rapidly changing conditions. This, in turn, has increased interest in the concept of lean by domestic companies, most of which have suffered significant losses during the crisis and are looking for alternative sources to increase business profitability.

While some companies have suffered significant losses during the pandemic, there are a number that have successfully passed the adaptability test and taken a decisive step forward. Most of these companies use and continue to implement quality management tools and lean management techniques. An example of such companies is the world-famous clothing and fashion retail chain Zara, which, despite declining demand for industrial products, thanks to well-established processes, fixed principles of economy and flexibility, was able to withstand difficult modern conditions and increase the efficiency of SC [13].

Many domestic authors and foreign scholars agree that it is possible to gain significant benefits associated with the introduction of lean management methods in crisis conditions. D. Demakhin noted that Toyota's production system, which is based on the principles of lean strategy, arose just in response to the crisis and since its inception is anti-crisis, which confirms the feasibility and effectiveness of its implementation [9]. M. Ballet, Lean author, Lean coach and co-founder of Lean Institut France, considers the feasibility of applying the concept: "When a business is in a crisis, we need to change the way of thinking to Lean-style thinking to find a way out" [10]. In the works of G.Tkachenko the advantages of implementing the Lean concept are noted, which are that "Lean implementation is aimed at optimizing the processes of the entire supply chain" [11]. Due to the implementation of the principles of Lean-management, it is possible to find bottlenecks and identify processes that do not create added consumer value, but only

burden SC with unproductive costs, which is especially relevant in the current unstable conditions.

M. Porter in his research found that the company can gain additional competitive advantages by increasing process productivity and minimizing costs, which in turn will increase competitive position in the market and ensure economic stability, which is especially important in a pandemic conditions. Lean Global Network (LGN) research shows that the positive factors behind the introduction of the lean concept are the system of continuous improvement, which means that the company constantly improves its performance indicators, such as [12]: reduction production time by 2-3 times; increase in inventory turnover by 1.5-2 times; increase the return on investment by 3 times.

Therefore, an integrated approach using Lean-management takes to a qualitatively new level of supply chain management with the aim of creating a more efficient and sustainable SC. At the same time, despite the sufficiently developed issues of optimizing the management of business processes of the SC, it requires a broader theoretical and practical study of the SC development and its functioning in crisis conditions of a pandemic. Because, cost-effective strategies and program of events in supply chain management are needed to be able to hold on to the positions that a lean concept can serve.

Purpose and objectives of the article. The aim of the study is to generalize transformational changes in supply chain management under the influence of a global pandemic improving the business process management system in the supply chain of refrigeration equipment based on the concept of lean management to reduce overall logistics costs.

Basic material and results. Ukraine is a country with an open market economy, and therefore dependent on the global system of trade. Export- and import-oriented supply chains of domestic producers were significantly affected by global factors and led to a substantial reduction in production by individual industries. Table 1 identifies five key pandemic challenges for Ukrainian enterprises and summarizes possible ways to overcome these challenges, taking into account the concept of Lean Supply Chain.

Consequently, the main purpose of using the concept of Lean Supply Chain is to use savings tools to implement organizational and economic activities to increase the competitiveness of domestic enterprises in regional and global supply chains. To gain a competitive advantage in the new post-pandemic economic environment of trade movement, it is necessary to combine partnerships to reduce levels of uncertainty and risk, as well as to reorganize internal business processes. Note that the imperfect operating activities of Ukrainian enterprises leads to a lack of profit in the supply of products to foreign markets, also to the increase in costs of importing goods associated with significant dependence on logistics decisions of logistics service providers, which are not always focused on domestic processes.

Consider in more detail the activities of the Ukrainian company LLC "Holod-Engineering", which specializes in providing services for the supply of industrial, commercial, agricultural and technological refrigeration equipment in the Ukrainian market. The main consumers (customers) of products (services) are enterprises of various activities, from farms, shops to large retail chains and industrial enterprises, such as: LLC "Novus", LLC "ATB", LLC "Ostersky meat-packing plant" , LLC "Zhytomyr Dairy", JSC "Roshen", LLC "Upscale Logistics" and many others [15].

Table 1. Challenges of the global pandemic for SC and ways to overcome them

№	Challenges	Ways to solve
1	The risk of weak players leaving the market.	• Introduce a policy of continuous improvement, risk monitoring and appropriate corrective action to quickly eliminate and identify the root causes of problems. • Identify the most important links and bottlenecks in the SC, their possible sources of optimization and minimization of losses.
2	Failures and delays in global enterprise supply networks due to quarantine restrictions.	• Establish a strategy for continuous lean extraction, by introducing a continuous flow of goods in chains, in order to reduce failures and delays. • Align the takt time with the customer's expectations and optimize the duration of the logistics cycle.
3	Increased costs for supply, production and sales.	• Using Lean's main tools, identify value-added streams and activities that consume resources but do not create value for consumers. • Standardize the algorithm of actions at each stage of the goods or services movement in the chain, to minimize all possible losses
4	The uneven demand.	• Carry out constant monitoring of demand and act in accordance with consumer behavior. • Evaluate the available inventory, to maintain business continuity, in accordance with consumer demand. • Introduce a flow quality control system at each stage of goods or services movement in the chain.
5	Low adaptability and crisis response of SC.	• Implement the system of adaptation and rapid readjustment, for a flexible production process depending on changing market demand conditions. • Conduct research on the flow of value creation and stress testing of SC with the aim of continuous improvement.

Source: Generalized by the author on the basis [1-3].

The main competitive advantages of Holod -Engineering are availability of highly qualified professionals and engineering staff that provides support to its partners at all stages from order design to post-warranty and after-sales service, the status of a comprehensive supplier of equipment and high-tech turnkey design solutions focused on individual customer needs. It should be noted that the market of refrigeration equipment in Ukraine is currently developing dynamically. This is facilitated by the constant increase in demand for products from the food processing industry. Most companies in this industry are dominated by outdated refrigeration equipment, which needs to be upgraded to store finished products. Trading companies are also constantly increasing the capacity of refrigeration chambers using industrial cold.

Thus, the existing competitive advantages and stable demand for the products LLC "Holod-Engineering" ensure the company's profitability. At the same time, the analysis of financial indicators for the last five years revealed a trend of decreasing net profit, which indicates a decrease in operating efficiency (Fig. 1).

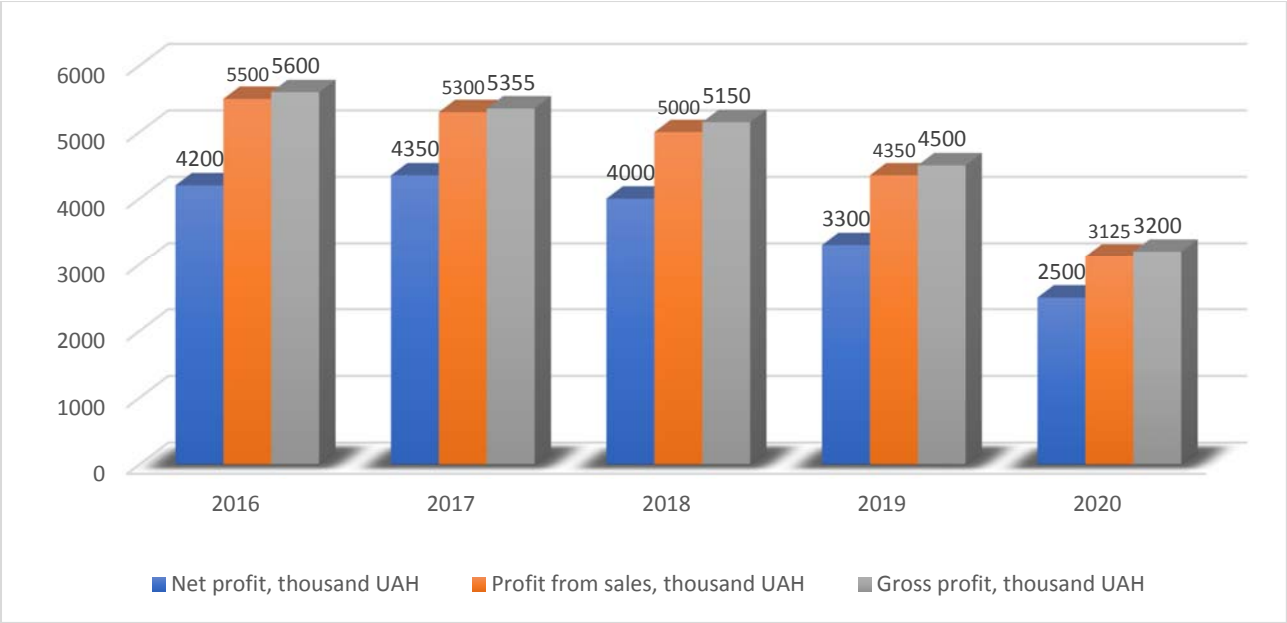

Figure 1 – Dynamics of profit indicators of LLC " Holod Engineering" for 2016-2020

Therefore, the presence of internal factors, such as rising costs for the purchase, transportation and storage of components, as well as the impact of external factors related to the effects of the global pandemic, necessitated of business processes reengineering in refrigeration supply chains. That is why the main purpose of the study was to find ways of revolutionary elimination of crisis phenomena, create the conditions and maintain a system of business performance continuous improvement.

Figure 2 graphically shows the influence of external and internal factors on the formation of competitive advantages of the company, among which the most important is the level of interaction between the departments of supply, sales and production infrastructure, which directly affects the speed of response to changes in market trends (Fig. 2). It was also found that significant losses in the company's efficiency were due to the supply of low quality raw materials.

The analysis of the refrigeration equipment supply chains configuration allowed to identify and assess the impact on their operation efficiency of the following factors:

- procurement processes efficiency and interaction with suppliers,
- costs for the purchase and stocks storage,
- quality of incoming raw materials and equipment,
- delivery time and order execution time,
- the cost of manufactured parts and equipment,
- quality of internal production operations and equipment operation reliability,
- demand for manufactured products, cost and equipment quality,
- market segment, economic and political situation.

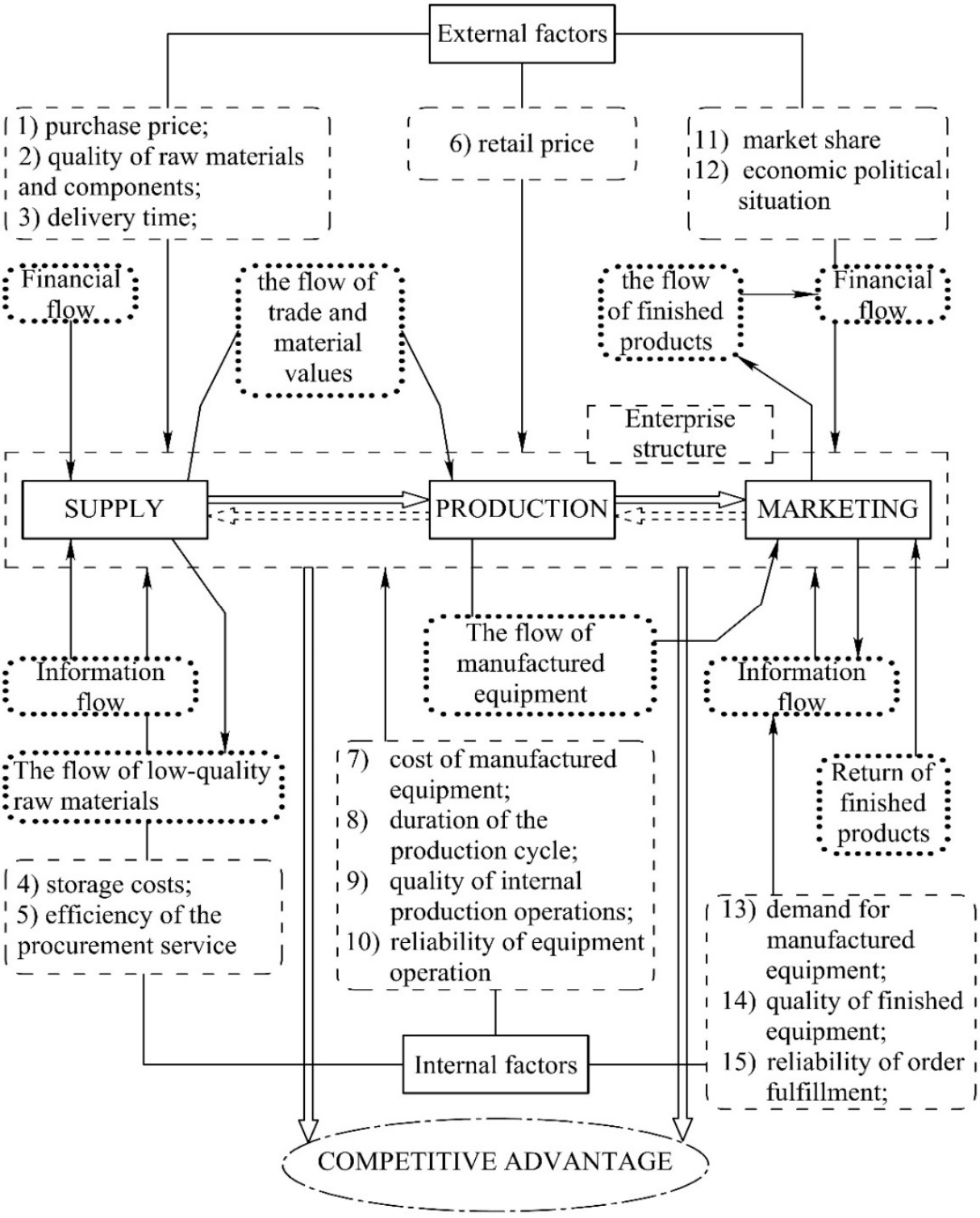

Figure 2 – Influence of external and internal factors on the business processes organization in the LLC " Holod Engineering" supply chain

LLC "Holod Engineering", like most manufacturing companies, works on the principle of custom production. In this case, delivery plans are quite a conditional document, because the bulk of material resources are obtained quickly (as orders are received). Figure 3 schematically shows the main business processes associated with consumer orders execution.

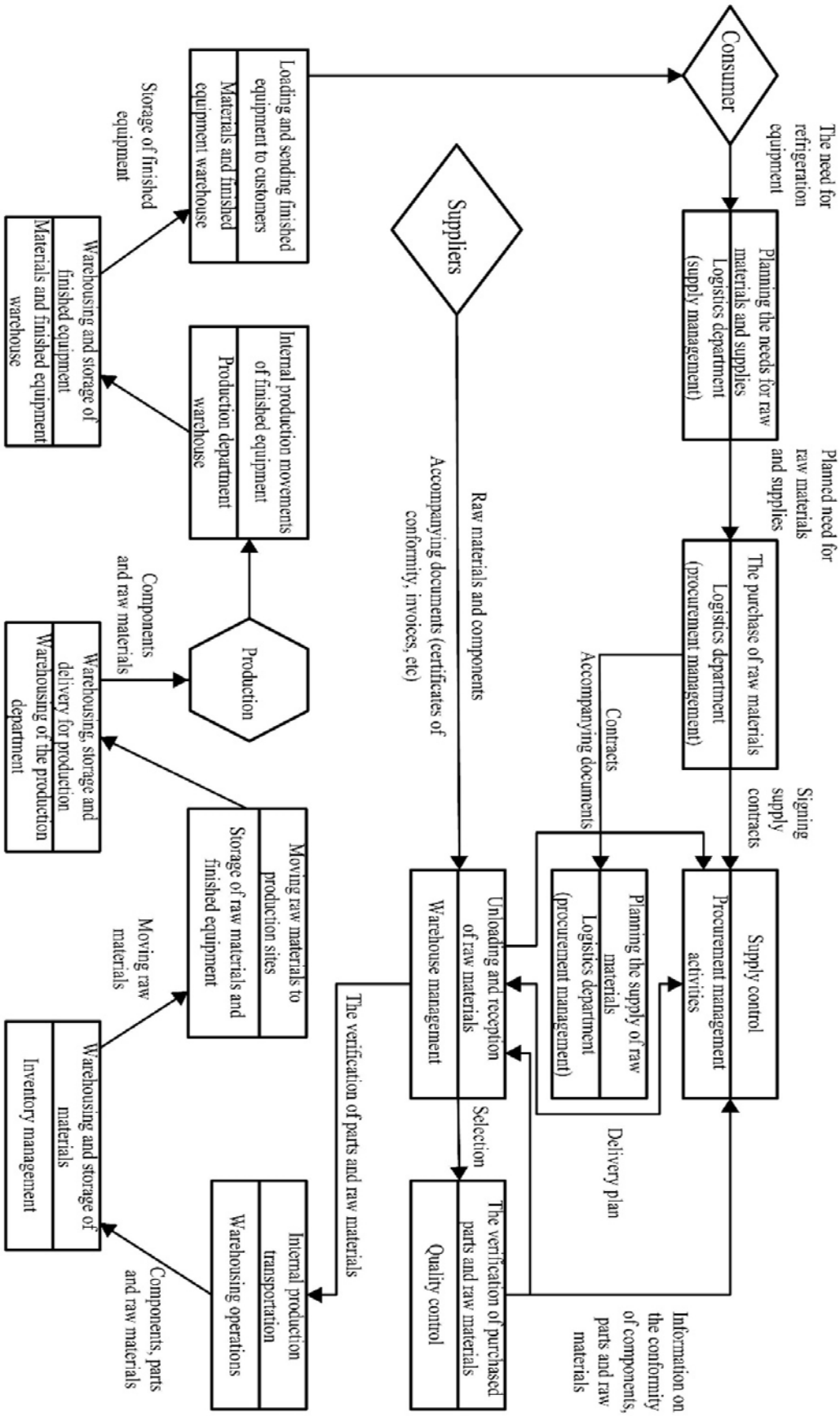

Figure 3 – The interrelations and mutual influences scheme of business processes in LLC "Holod Engineering" refrigerating equipment supply chains

As a result of the refrigeration equipment supply chain analysis at the enterprise, the following bottlenecks were identified:

1) reduction of inventory turnover associated with falling sales of the enterprise, which leads to an increase in storage costs and an increase in losses due to the freezing of working capital;

2) problems with inventory planning, which lead to the accumulation of their volumes, also in warehousing operations activities and lack of storage space;

3) lack of an effective planning system, sales analysis and monitoring of resource balances in the warehouse, leads to errors in the procurement management of material resources and components. This bottleneck leads to unnecessary costs for the urgent purchase of additional resources and thereby increase the duration of the order;

4) Non-liquid stock accumulation that exceeded the normal stay period in the warehouse. The reason for this bottleneck is errors in forecasting and calculating the required batches of materials, and because of falling demand, which is observed in recent years of the enterprise.

Lean tools were used to cover the identified bottlenecks, which include the search for alternative savings sources, minimization of possible losses with limited market capacity and the inability to increase equipment sales. For this purpose, a complex of mathematical models to substantiate logistics decisions was developed, related to the choice of suppliers, to determining the optimal delivery batch size and the minimum and maximum stocks levels, placement in the warehouse and warehousing processes optimization (Table 2).

The result of the implementation of the tasks is a built-in extraction strategy, which unites all enterprises involved in the flow of value creation of refrigeration equipment. For its successful implementation it is recommended to introduce a quick and flexible response, as follows:

- association of all business processes participants on the "win-win" principle for mutual information exchange and receiving the maximum benefits;

- use of modern information and communication technologies (barcode scanner and electronic data interchange);

- optimization of internal business processes: visual management; additional marking of goods and work areas; minimization of unnecessary intra-warehouse movements of goods and staff; automatic replenishment of orders, etc.;

- determination of stock storage standards, monitoring of their condition in real time, clear instructions on work with illiquid stocks and their prevention;

- zoning of warehouses and production areas on the "hot and cold zones" principle;

- formation of direct channels of communication with consumers, using databases to evaluate customers and formation of loyalty programs.

The implementation of the proposed measures allows to obtain the following intermediate results:

- introduction of logistics costs monitoring, timely analysis of deviations "plan-fact" and cost structure for logistics operations increases the accuracy of forecasting the company financial results, promptly manage liquidity and inventory turnover, develop measures to reduce accounts receivable;

- optimization of spare parts supply lots and rationing of maximum and minimum levels of stocks allows to reduce the share of costs for their maintenance by 8.99% per month in the goods sold cost;

- The Lean-management and 5S principles introduction, minimizes the risks of creating excess stocks, which will save the company about 3 million UAH per year;

- standardization of warehouse processes contributes to an increase in labor productivity in order picking by 16%, reducing the duration and cost of processing one unit of goods by 2.5%;

- due to optimization the volumes and structure of refrigeration equipment components stocks and rationalization of

40-52
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their placement in a warehouse it is possible to release to 30% of warehouse areas of the enterprise.

Table 2. The list of actual tasks to increase the business processes efficiency in LLC "Holod Engineering" SC and methodical approaches to their decision

№	Actual tasks	Integral indicators
1.	*Supply management improvement*	
1.1.	Suppliers evaluation and selection.	$OTIF = \frac{\sum N_t}{\sum N_o}$, where $OTIF$ - business process management system "In time in full", Nt - the quantity of goods delivered on time; No - the total quantity of the ordered goods [16].
1.2.	Improved algorithm of the material resources procurement process in terms of procurement planning.	$EOQ = \sqrt{\frac{2*3*C_i}{C_2}}$, where EOQ - the optimal batch size of the products supply to the enterprise; 3 - sales volume of products in this period; Ci - the average cost of placing one order; C2 - the cost of maintaining a unit of product in this period [17].
2	*Inventory management system improvement*	
2.1.	Division of stocks into groups.	Analysis of stocks by the ABC method and their division into groups according to the Pareto 80/20 principle (80% - revenue, form 20% - stocks).
2.2.	Algorithm for working with illiquid stocks.	$Z = \frac{N}{C}$, where Z - the percentage of inventories in the cost per month; N– total amount of stocks; C - finished product cost, %. [18, p.77]
3	*Optimization of the warehousing system and production areas placement.*	
3.1.	Organization of storage areas and production areas.	$n = \frac{DT(1+S)}{V}$, where n - number of kanban cards (pcs.); DT - projected demand during the order fulfillment period (pcs.); D - the number of parts that are delivered to the next section per unit time (pcs.); T - order fulfillment time (hrs); S - insurance stock, as a percentage of demand for the period of order fulfillment (%); V - the container volume for transporting parts (m3) [19, p.85].
4	*Optimization of logistics cost management*	
4.1.	Information processing on logistics costs and their optimization.	Comparison with Shewhart's control cards "as is" and projected "as it should be", according to the logistics costs indicators of the enterprise [20, p.169].
5	*End-user demand analysis.*	
5.1.	Work with sales and operational planning.	Коефіцієнт сервісу як вартість загальних поставок за місяць в порівнянні з вартістю загальних замовлень за місяць $CS\% = \frac{\sum O_r + O_{sh}}{C_o}$, where $CS\%$ - coefficient of service as the cost of total deliveries per month compared to the cost of total orders per month; O_r - orders received; O_{sh} - orders shipped; C_o - cost of all orders [18,p.27].

Consequently, through the proposed organizational measures, the company LLC "Holod Engineering" will be able to increase the profitability of its own business, and create new competitive advantages in unstable, rapidly changing conditions. The proposed methodological provisions for reengineering business processes in the refrigeration equipment supply chain using the Lean-concept have significantly improved the various departments coordination of the enterprise, to improve the customer service quality, synchronize the supply, production and marketing of products, reduce total

logistics costs by making optimized logistics solutions.

Conclusions. In the course of the study, the expediency of business processes integrated management in the refrigeration equipment supply chains, in the context of instability and risks associated with the global coronavirus pandemic was substantiated. The generalization of global trends, conditions of external and internal environments made it possible to conclude that it is necessary to constantly improve both individual business processes in supply chains and their coordination and synchronization in real time using the Lean Supply Chain concept.

The analysis of refrigeration equipment SC configuration for the company LLC "Holod Engineering" revealed weaknesses associated with a decrease in asset turnover, ineffective procurement planning and the lack of an effective inventory management system. The dynamics and structure analysis of income and expenses revealed a downward trend in profitability of the company's business, and also showed a significant share in their structure of logistics costs and inventory costs due to losses in storage and ordering as a consequence to delays in delivery, leading to customer dissatisfaction and complaints. To improve the business process management system in the supply chain of LLC "Holod Engineering", to undertake a number of activities using the lean management concept, which involves market, production process, procurement and sales integration for high quality customer service level were proposed.

It is proved that the advantages of the lean tools introduction are the potential losses minimization, increasing the production productivity and warehousing operations of the company. With the help of Shewhart's control charts, the coordination of business processes in the equipment supply chains was assessed and the sources of potential losses were identified. The methodical approach and a complex of administrative decisions which have allowed to calculate optimum processes parameters of raw materials purchases, stocks levels and conditions of their placement in a warehouse of the enterprise are developed. Optimization of technological and logistics processes in terms of their cost, duration and quality of results takes into account not only individual processes of enterprises, but also interprocess connections between supply chain links.

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EVALUATION OF THE INVESTMENTS EFFICIENCY IN THE DEVELOPMENT OF THE KEY COMPONENT OF THE SUPPLY CHAIN

Olexander Sumets "Evaluation of the investments efficiency in the development of the key component of the supply chain". *Supply chains are unique logistics systems. Typically, such systems include a number of components. The key component is considered to be the producer enterprise, around which supply chains are organized. The efficiency and effectiveness of the supply chain largely depends on the level of development of the key component. In turn, the latter depends on effective investment. It is established that the practice of enterprises-producers, which are key components of supply chains, requires a qualitative economic justification of investment measures, which must be forecasted for the long term before their implementation.*

The article substantiates the need to assess the effectiveness of investment in the development of a key component of the supply chain based on a targeted approach. It is indicated that to assess the effectiveness of investment in the development of industrial enterprises should use absolute and relative cash flows, the values of which are used in the calculations of absolute and comparative effects, respectively. With this in mind, a targeted approach should be applied to improve the quality of assessing the effectiveness of investment in the development of manufacturing enterprises. The essence of the criterion indicator of net cash flow is thoroughly described.

It is stated that the economic assessment of the comparative economic effect should be based on the definition of incremental indicators that reflect changes in the activities of the enterprise due to the investment of additional investments in the assets of its logistics system.

The tree of maximizing the efficiency of investments in the main assets of the production logistics system of the enterprise is formalized. An approach to evaluating the effectiveness of investing funds in the production and logistics system of the enterprise is proposed.

Keywords*:* supply chain, key component of supply chain, production enterprise, production logistics system, logistics activity, efficiency, evaluation, investment.

Олександр Сумець. "Оцінка ефективності інвестицій в розвиток ключового компоненту ланцюга постачання". *Ланцюги постачання являють собою унікальні логістичні системи. Як правило, такі системи включають в себе певну кількість компонентів. Ключовим компонентом вважається підприємство-продуцент, навколо якого і організуються ланцюги постачання. Ефективність і результативність ланцюга постачання багато в чому залежить від рівня розвитку ключового компонента. Своєю чергою, останній залежить від ефективних інвестицій. Встановлено, що практика діяльності підприємств-продуцентів, які є ключовими компонентами ланцюгів постачання, потребує якісного економічного обґрунтування інвестиційних заходів, які необхідно прогнозувати на довгостроковий період ще до терміну їхнього впровадження.*

53-61
v.5 (2021)
https://smart-scm.org

У статті обґрунтовано необхідність оцінки ефективності інвестицій в розвиток ключового компоненту ланцюга постачання на основі цільового підходу. Вказано, що для оцінювання ефективності інвестицій в розвиток виробничих підприємств варто використовувати абсолютні й відносні грошові потоки, значення яких застосовують відповідно у розрахунках абсолютного й порівняльного ефектів. З огляду на це для підвищення якості оцінювання ефективності інвестицій в розвиток виробничих підприємств слід застосувати цільовий підхід. Ґрунтовно описана сутність критеріального показника чистого грошового потоку.

Констатовано, що економічна оцінка порівняльного економічного ефекту повинна ґрунтуватися на визначенні приростних показників, які відображають зміни у діяльності підприємства, що зумовлені вкладенням додаткових інвестицій в активи його логістичної системи.

Формалізовано дерево максимізації ефективності інвестицій в основні активи виробничої логістичної системи підприємства. Запропоновано підхід до оцінки результативності інвестування коштів у виробничу логістичну систему підприємства.

Ключові слова: ланцюг постачання, ключовий компонент ланцюга постачання, виробниче підприємство, виробнича логістична система, логістична діяльність, ефективність, оцінка, інвестиції.

Александр Сумец. "Оценка эффективности инвестиций в развитие ключевого компонента цепи поставок". *Цепи поставок представляют собой уникальные логистические системы. Как правило, такие системы включают в себя определенное количество компонентов. Ключевым компонентом считается предприятие-продуцент, вокруг которого и организуются цепи поставок. Эффективность и результативность цепи поставок во многом зависит от уровня развития ключевого компонента. В свою очередь, последний зависит от эффективных инвестиций. Установлено, что практика деятельности предприятий-продуцентов, которые являются ключевыми компонентами цепей поставок, требует качественного экономического обоснования инвестиционных мероприятий, которые необходимо прогнозировать на долгосрочный период еще до срока их применения.*

В статье обоснована необходимость оценки эффективности инвестиций в развитие ключевого компонента цепи поставок на основе целевого подхода. Указано, что для оценки эффективности инвестиций в развитие производственных предприятий следует использовать абсолютные и относительные денежные потоки, значение которых применяют соответственно в расчетах абсолютного и сравнительного эффектов. Учитывая это, для повышения качества оценки эффективности инвестиций в развитие производственных предприятий следует применить целевой подход. Основательно описана сущность критериального показателя чистого денежного потока.

Констатировано, что экономическая оценка сравнительного экономического эффекта должна основываться на определении приростных показателей, отражающих изменения в деятельности предприятия, обусловленные вложением дополнительных инвестиций в активы его логистической системы.

Формализовано дерево максимизации эффективности инвестиций в основные активы производственной логистической системы предприятия. Предложен подход к оценке результативности инвестирования средств в производственную логистическую систему предприятия.

Ключевые слова: цепь поставок, ключевой компонент цепи поставок, производственное предприятие, производственная логистическая система, логистическая деятельность, эффективность, оценка, инвестиции.

Introduction. Supply chains combine a large number of components in their structure. The number of the latter depends on the characteristics of the chain, namely the width and length. A production enterprise is considered to be the core-forming or key component of a full-fledged supply chain. The same hypothetically it can be argued that this key component (manufacturing enterprise) is the master generator of capacity, efficiency and effectiveness of the supply chain (SC) within a defined logistics site. Therefore, the

development of the enterprise is important for the formation of the appropriate level of competitiveness of the enterprise, which requires timely and effective investments. As a result, it will provide an opportunity to significantly increase the economic efficiency of logistics activities of a key component of the supply chain.

In order to increase the economic efficiency of logistics activities (LA) of enterprises, which is to increase the level of use of assets of their production logistics systems (PLS), it is necessary to scientifically substantiate the type of efficiency assessment indicators used. Therefore, the theory and practice of LA management at industrial enterprises, which are a core-forming component of SC, requires a qualitative economic justification of investment measures, which must be forecasted for the long term before their implementation. This problem can be solved by using a targeted approach in the process of such assessment.

Analysis of recent research. Review of the numerical amount of professional literature devoted to the issues of economic efficiency of investments [1-9; 13; 16], and its thorough analysis provided an opportunity to reach such a conclusion. At this time in terms of attitudes to investment methods and performance indicators of all researchers can be divided into three groups:

1) apologists for the indicator of the so-called reduced costs and its use as a criterion for choosing effective investment decisions [1-3; 5; 8];

2) supporters of the concept of cash flow, taking into account the time factor [10];

3) supporters of the simultaneous use of both the first and second approaches to comparing investment options [7; 13].

The principles of determining the economic effect as a useful result, the division of effects into two types – absolute and comparative, and methods for calculating these effects are considered in modern publications, for example, in [2; 3; 8; 10]. It is known that the economic efficiency of investments, including in the PLS of enterprises, is assessed using a certain set of efficiency indicators, which are divided into static and dynamic. The static indicators that do not take into account the time factor include: net profit (Prn), return on equity (R), payback period (Tbp). Dynamic indicators that take into account the time factor include: net cash flow (NCF), profitability index (PI), internal rate of return (IRR), payback period taking into account the time factor (discounted) (Tpb.d). At the same time, the need to create such a system of evaluation indicators of the investments effectiveness in the development of PLS of enterprises is urgent, which will necessarily have to be combined with causal links.

The analysis of modern literature provided an opportunity to identify the existence of different approaches to assessing the effectiveness of investment in economic activities of manufacturing enterprises, which are key components of supply chains. It is established that scientists mainly focus on performing calculations of the economic effect of investment, which is to compare results and costs. In this case, regardless of the type of evaluation indicators used in the process of comparing results and costs, operations can be used to deduct costs from the results obtained or divide the result by costs. Thus, from the author's point of view, to assess the effectiveness of investment in the development of industrial enterprises should use absolute and relative cash flows, the values of which are used in the calculations of absolute and comparative effects, respectively. With this in mind, a targeted approach should be applied to improve the quality of assessing the effectiveness of investments in the development of manufacturing enterprises.

The purpose and objectives of the research. The purpose of the article is to substantiate the evaluation of the effectiveness of investment in the development of manufacturing enterprises, which are key components of supply chains, using a targeted approach.

53-61
v.5 (2021)
https://smart-scm.org

The main material and results of the research. The essence of the criterion of net cash flow (NCF) is to compare the current value of future cash flow from the project with the investment costs necessary for its implementation. The value of NCF is determined by formula (1):

$$NCF = \sum_{t=1}^{T} CF_t k_{\partial t} - I_0 \quad , \quad (1)$$

where CF_t – is the cash flow of the t-th year; k_{dt} – is the discount rate of cash flow of the t-th year; I_0 – is one-time investment (so-called zero year); T – is the duration of the settlement period (investment cycle).

Researchers point to the following advantages of the NCF indicator compared to other evaluation indicators:

a) it is an absolute indicator and measures the additional return on invested capital, taking into account the time factor;

b) it has the property of additivity;

c) it can be used to rank (streamline) investment decisions. Therefore, investment management experts recommend using the NCF (also called the present effect) and the internal rate of return to assess the effectiveness of investment. Moreover, in case of discrepancies between these indicators, researchers recommend to prefer the criterion of NCF [2, p. 351].

The cash flow of the t-th year is calculated as the sum:

$$CF_t = \mathrm{Pr}_{nt} + A_t - K_t + K_{liqT}, \quad (2)$$

where Pr_{nt} – net profit of the t-th year; A_t – depreciation in the t-th year; K_t – capital investment of the t-th year; K_{liqT} – liquidation value of fixed assets in the last (t-th) year of the settlement period.

A similar method of calculation is to determine the increase in cash flow (ΔCF_t) as the sum of the increments of its components, the most important of which are the increase in net profit (ΔPr_{nt}) and depreciation (ΔA_t).

In turn, the increase in net profit from investing in certain logistics activities will be:

$$\Delta \mathrm{Pr}_n = \Delta C + \Delta \mathrm{Pr}_q + \Delta \mathrm{Pr}_s - P_{tax}, \quad (3)$$

where ΔC – savings of current costs (cost of products or services); ΔPr_q – growth of profit from sales due to improving product quality; ΔPr_s – growth of profit from sales due to growth in sales; P_{tax} – tax on taxable profit.

The economic efficiency of logistics solutions for the development of key components of SC consists in the possible reduction of costs for transportation and storage of raw materials, which leads to lower costs of products, manufactured by the enterprise or its services, reduced inventories, increased contractual discipline. All these factors affect the operating and balance sheet profits of the enterprise, and therefore the impact of logistics decisions on the economy of the enterprise should be assessed through known factors (sources) of profit growth.

The cost of production, its reduction – the most important factors in the formation of enterprise profits, quantitative assessment of the impact of which on the results of its activities should be performed taking into account the provisions of current regulations on accounting and calculation of products. At the same time, it should be taken into account that logistics costs are components of the cost of production.

Absolute cash flows occur when cash flows are compared with zero, and relative (comparative) cash flows – when comparing options for financing certain activities [2, p. 132–133].

To determine the impact of changes in economic conditions on the economic effect as the end result of the enterprise determines the so-called comparative effect (ΔNCF), this is equal to the difference of absolute economic effects for the two comparing options – evaluation (2) and base (1):

53-61
v.5 (2021)
https://smart-scm.org

$$\Delta NCF = NCF_2 - NCF_1 = (\sum CF_2 \cdot k_{dt} - I_2) - (\sum CF_1 \cdot k_{dt} - I_1), \quad (4)$$

where ΔCF_t – increase in cash flow in the t-th year; $k_{\partial t}$ – cash flow discount rate of the t-th year; ΔI – increase in investment (or investment) by comparing options (basic and new).

If the increase in cash flows is an annuity, the formula for calculating the comparative economic effect is simplified to the form:

$$\Delta NCF = \Delta CF \cdot k_{d.an} - \Delta K, \quad (5)$$

where ΔCF – cash flow increase (constant in each year of the settlement period); $k_{d.an}$ – annuity discount rate; ΔK – increase in one-time investments in the option that is evaluated and compared with the baseline.

Economic assessment of the comparative economic effect is to determine the incremental indicators that reflect changes in the activities of the enterprise due to the investment of additional investments in the assets of its PLS. Such indicators, as mentioned above, can also be static or dynamic.

A significant part of economic indicators that measure the costs and results of production and logistics activities of the enterprise is characterized by the property of additivity (the possibility of summation). For example, such indicators include: logistics costs, operating costs, cost of goods or services, investments, net cash flow, and so on. This means that these indicators can be summarized by the production and economic process as a whole, operations, products, divisions of the enterprise, planned or implemented measures, investment decisions, and so on. At the same time, these economic indicators can be detailed by distribution by certain levels and measures.

At such detailing it is offered to use methods of the target approach to acceptance of logistic decisions [10; 11; 14; 15].

It should be noted that almost all decisions that are made in the process of managing the enterprise, the content is economic or technical and economic. As a rule, such decisions can be classified as situational by reason, strategic in duration, rational in the way of substantiation, single- or multi-criteria in the number of evaluation criteria under consideration.

To make logistics decisions it is needed:

1) to substantiate the choice of methods and indicators for assessing the economic efficiency of investments in the PLS of the enterprise and apply in practice the criteria for selection of investment decisions;

2) to pre-build a tree of goals and solutions in the process of managing real investment.

To reveal the content of the target approach to solving the management problem, consider the essence of goals, their types and rules for building goal trees.

Currently, the following two definitions of purpose are known, which reveal the essence of economic management methods in the process of managing the enterprise:

1) the purpose is a qualitative description of the desired result of activity of the production and economic organization or its divisions;

2) the goal is a specific end position or the desired result of the object of management, which is obtained after the implementation of the management decision.

The main thing when building goal trees is the ability to identify (and then reflect) causal relationships in the process of detailing targets at each subsequent level. In this case, the purpose of each upper level is a consequence in relation to the purpose of each lower level.

To avoid confusion in establishing such relationships, it should be accepted as a rule that each new level is a cause that leads to a consequence, i.e. consequence-cause relationships should be implemented in the process of detailing goals from top to bottom (the sequence is as follows: from the trunk trees to its branches). Then, in a directed

53-61
v.5 (2021)
https://smart-scm.org

graph, which is a goal tree, when conditionally changing the directions of the goal tree to the opposite, on the contrary, we obtain causal relationships between phenomena and indicators considered in a particular tree (here we choose the sequence from tree branches to its trunk).

It should be noted that both in theory and in practice, it is not the term "consequential and causal relations" that is more common, but rather "causal and consequential relations". The latter connection is more natural and therefore common in various sciences. At the same time, there is no need to prove that these types of relationships are inverse: consequential and causal relations are "from partial to general" relationships, but causal and consequential relations are "from general to partial" relationships. In the first type of connection, is used such a method of scientific research as induction, and in the second – deduction. For example, the growth of production and sales (ΔPS) leads to an increase in working capital turnover (Δn_{to}), to the subsequent release of capital investment (ΔK_{ci}) and reduction of logistics costs (ΔLC), and in general to reduce the cost of production (ΔC) and, finally, to increase net profit (ΔPr_n) and return on capital invested in production (ΔR). This sequence of changes can be represented as a so-called "chain of communication", where the symbol "→" should be read as the verb "determines":

$$\Delta PS \to \Delta n_{to} \to \Delta K_{ci} \to \Delta LC \to \Delta C \to \Delta \mathrm{Pr}_n \to \Delta R. \qquad (6)$$

If in the given "chain of communication" to change the direction of arrows on the return, we will receive one of branches of a tree of the purpose directed on increase of return on capital.

As can be seen from the list of indicators of the chain (6), all of them, both natural and generalized – cost and are a quantitative measure that characterizes only LA and its impact on change (growth) of economic activity of the enterprise as a whole – production and sales (ΔPS) – on the final financial indicator of growth of profitability of production – ΔR.

Using the property of additivity of economic indicators, consider an example of building a tree of investor goals, the achievement of which will provide maximum effect from the implementation of the investment project, based on formulas for calculating net cash flow (NCF), profitability index (PI), capital price (CP), net profit (Pr_n), cost of the product unit (C_{pu}). When constructing the tree of goals for maximizing the economic effect and the profitability index of investments, the formulas for calculating these indicators are used to assess the effectiveness of investments in fixed assets for logistics purposes. The goal tree (fig. 1) takes into account that the criteria of maximum NCF and profitability index (PI) are consistent with each other. The growth factors of NCF and PI coincide – it is an increase in cash flows and a decrease in investment.

Capital price is the debt of the investor as a percentage of the amount of investment, which is defined as a weighted average. It is the sum of multiplications of the prices of the i-th sources of financing P_i, by their share in total investments d_i:

$$CP = \sum P_i \cdot d_i.$$

It is necessary to minimize the CP because it is accepted as a discount rate and this process causes the growth of NCF. Ways to achieve this goal are the minimum borrowing of capital $(p_{bor} \to \min)$ and its minimum share (in units) in the amount of investment $(d_{bor} \to \min)$.

In fig. 1, in addition to the above, the following notation values are accepted: $k_{d.t}$ – cash flow discount rate, N – sales volume;

P_{pu} – product unit price; C_{pu} – product unit cost; $C_{m.pu}$ – the cost of materials for the manufacture of a product unit; $C_{w.pu}$ – the cost of wages in the unit cost of production; R_d – the rate of depreciation; T_d – the period of depreciation of fixed assets of the enterprise PLS.

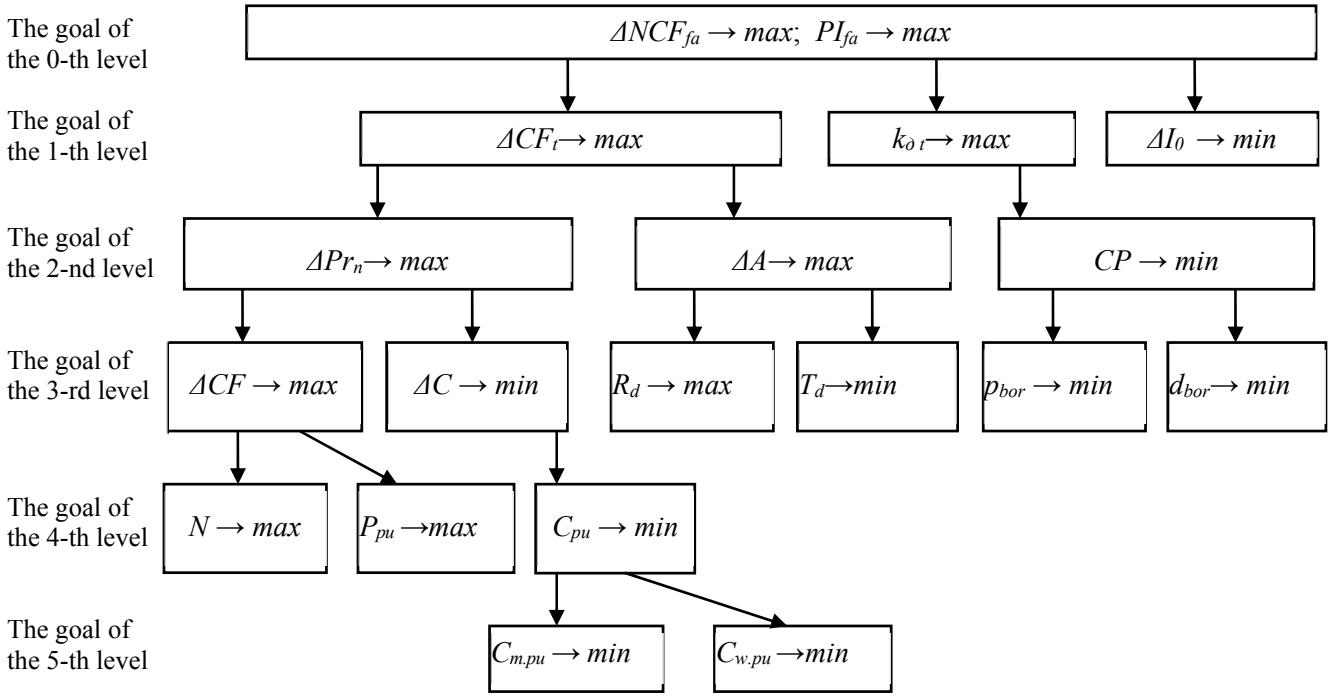

Figure 1 – Tree of maximizing the efficiency of investment in the main assets of the enterprise PLS

The considered tree of goals has five levels of detail of the algorithm for calculating the comparative economic effect – from the integrated indicator to the generalizing, and then – to the partial cost. Detailing can be continued further, passing to indicators of higher (in the sense of disaggregation) level: change of norm of an expense of materials and their cost, change of labor intensity of production, etc.

To assess the effectiveness of investing in the assets of the PLS of the enterprise as a whole on the so-called dynamic indicators that take into account the time factor, by analogy, use the above approaches. Thus, the increase in net cash flow (ΔNCF) when investing in the assets of the enterprise LS is equal to the sum of the increments of the NCF by type of assets (fixed assets (ΔNCF_{fa}), working capital (ΔNCF_{wc}), intangible assets (ΔNCF_{ia}) enterprise PLS):

$$\Delta NCF = \Delta NCF_{fa} + \Delta NCF_{wc} + \Delta NCF_{ia}. \quad (7)$$

In view of the above, the general goal $\Delta NCF \rightarrow \max$, in accordance with the additivity property of this indicator for any sources of its growth, can be considered as three independent branches of the tree of goals that implement the following requirements:

$$\Delta NCF_{fa} \to \max; \qquad \Delta NCF_{wc} \to \max; \qquad \Delta NCF_{ia} \to \max. \tag{8}$$

The most important position in the construction of target trees and further calculations of the economic effect is as follows: when maximizing the effect should use the method of elimination when calculating the growth of various indicators from changes in individual factors. For example, in determining ΔNCF_{fa} take into account changes in net income from the use of fixed assets of the PLS and the corresponding depreciation of these funds, in calculating ΔNCF_{wc} – increase in net profit from accelerating working capital turnover, and in determining ΔNCF_{ia} – corresponding increase in net income and depreciation of their value. Similar to changes in current expenses and annual profit, the calculations of each of the components of the total ΔNCF will include changes in only that part of the investment in the assets of the enterprise PLS, which is considered. This is the method of eliminating certain costs and revenues that change under the influence of a particular factor.

Conclusions. The economic efficiency of the enterprise within the supply chain largely depends on the level of use assets of its logistics system. This necessitates investment. Such investments must be effective. Given this, at the article was proposed the practical application of methodological tools to assess the effectiveness of investment in the development of a key component of the supply chain on the basis of a targeted approach.

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THE ROLE OF THE AIRLINE AS A LOGISTICS PROVIDER IN THE PASSENGER TRAVEL CHAINS INVOLVING AIR TRANSPORT

Myroslava Semeriahina, Mariia Hryhorak. "The role of the airline as a logistics provider in the passenger travel chains involving air transport". *The article is devoted to the classification of air carrier as a logistics provider. Therefore, in the outsourcing pyramid of logistics providing, the place of the air carrier was determined taking into account its business model: legacy, low-cost, hybrid. Based on this, insourcing pyramid of airline logistics services involving air transport was developed and varieties of 3PL providers were identified: 3^{-}PL, 3PL, 3^{+}PL air carriers. 3^{-}PL air carrier is a logistics provider that provides a range of services within the air supply / travel chain. 3PL air carrier is a logistics provider that provides a range of services in the full supply / travel chain, when booking individual components of such a chain is carried out through the websites of the air carrier and its partners. 3^{+}PL air carrier is a logistics provider that provides a range of services in the full supply / travel chain, when booking such services is carried out integrated through the air carrier's website, and business processes are performed by the air carrier and its partners.*

It was studied the websites of airlines in order to find out the providing level of modern global passenger airlines operating on legacy, low-cost and hybrid business models and to identify the main trends among air carrier to ensure a complete passenger travel chain. The main feature of the world's air carriers is that most of them provide services at the level of 3PL-provider, and only the world's leading air carriers provide the organization of the passenger travel chain at the level of 3^{+}PL-provider.

The generalized scheme of providing for a passenger travel chain involving air transport for the purpose of definition of a role of each type of logistics provider and their collaboration in such chains was constructed. For example, 3^{-}PL, 3PL, 3^{+}PL air carriers can involve 2 PL-companies in the performance of business processes in the passenger chain. At the same time, the air carrier of 4PL-level will involve performers from 2 PL 3^{-}PL, 3PL levels in the processes of the travel chain. On the virtual 5 PL platform, the passenger will independently choose performers from different levels of providing according to their own needs.

Keywords*:* logistics provider, air carrier, passenger travel chain, 3^{-}PL provider, 3^{+}PL provider, legacy business model, low-cost business model, hybrid business model.

62-79
v.5 (2021)
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Мирослава Семерягіна, Марія Григорак. "Роль авіакомпанії як логістичного провайдера в забезпечені ланцюгів подорожі пасажирів за участі повітряного транспорту". *Стаття присвячена проведенню класифікації авіакомпаній як логістичного провайдера. В зв'язку з чим в піраміді аутсорсингу логістичного провайдингу було визначено місце авіакомпанії з врахуванням її бізнес-моделі: традиційна, лоу-кост, гібрідна. На основі чого була розроблена піраміда інсорсингу логістичних послуг авіакомпанії за участі повітряного транспорту та виділені різновиди 3PL-авіакомпаній: 3⁻PL, 3PL, 3⁺PL-авіакомпанії. 3⁻PL-авіакомпанія є логістичним провайдером, що надає комплекс послуг в межах авіаційного ланцюга постачання / подорожі. 3PL-авіакомпанія є логістичним провайдером, що надає комплекс послуг в повному ланцюгу постачання / подорожі, при цьому бронювання / замовлення окремих складових такого ланцюга здійснюється через сайти авіакомпанії та її партнерів. 3⁺PL-авіакомпанія є логістичним провайдером, що забезпечує комплекс послуг в повному ланцюгу постачання / подорожі, при цьому бронювання / замовлення таких послуг здійснюється інтегровано через сайт авіакомпанії, а виконання за участі авіакомпанії та її партнерів.*

Досліджені сайти авіакомпаній з метою з'ясування рівня провайдингу сучасних світових пасажирських авіакомпаній, що працюють за традиційною, лоу-кост та гібрідною моделями та виявлення основних тенденцій серед авіакомпаній щодо забезпечення повного ланцюга подорожі клієнта. Головною особливістю світових авіакомпаній є те, що більша їх частина надає послуги на рівні 3PL-провайдера, і лише найбільш провідні світові авіакомпанії забезпечують організацію ланцюга подорожі пасажира на рівні 3⁺PL-провайдера.

Побудована узагальнена схема провайдингу для ланцюга подорожі пасажира за участі повітряного транспорту з метою визначення ролі кожного логістичного провайдера в таких ланцюгах, а також їх взаємодії. Наприклад, 3⁻PLP, 3PLP, 3⁺PLP можуть залучати компанії 2 PL-рівня до виконання процесів в ланцюгу подорожі пасажира. В той самий час авіакомпанія 4PL-рівня буде долучати до виконання процесів в ланцюгу подорожі виконавців з 2 PL 3⁻PL, 3PL рівнів. На віртуальній 5 PL платформі пасажир буде обирати самостійно виконавців з різних рівнів провайдингу відповідно до власних потреб.

Ключові слова: логістичний провайдер, авіакомпанія, ланцюг подорожі пасажира, 3⁻PL-провайдер, 3⁺PL-провайдер, традиційна модель, лоу-кост модель, гібрідна модель.

Мирослава Семерягина, Мария Григорак. "Роль авиакомпании как логистического провайдера в обеспечении цепочек путешествия при участии воздушного транспорта". *Статья посвящена проведению классификации авиакомпаний как логистического провайдера. В связи с чем в пирамиде аутсорсинга логистического провайдинга было определено место авиакомпании с учетом ее бизнес-модели: традиционная, лоу-кост, гибридная. На основе чего была разработана пирамида инсорсинга логистических услуг авиакомпании с участием воздушного транспорта и выделены разновидности 3PL-авиакомпаний: 3⁻PL, 3PL, 3⁺PL-авиакомпании. 3⁻PL-авиакомпания является логистическим провайдером, предоставляющая комплекс услуг в пределах авиационной цепи поставки / путешествия. 3PL-авиакомпания является логистическим провайдером, предоставляющая комплекс услуг в полном цепи поставки / путешествия, при этом бронирование / заказ отдельных составляющих такой цепи осуществляется через сайты авиакомпании и ее партнеров. 3⁺PL – авиакомпания является логистическим провайдером, обеспечивающей комплекс услуг в полном цепи поставки / путешествия, при этом бронирование / заказ таких услуг осуществляется интегрировано через сайт авиакомпании, а выполнение – при участии авиакомпании и ее партнеров.*

Исследованы сайты авиакомпаний с целью выяснения уровня провайдинга современных мировых пассажирских авиакомпаний, работающих по традиционной, лоу-кост и гибридной моделям и выявление основных тенденций среди авиакомпаний по обеспечению полной цепи путешествия клиента. Главной особенностью мировых авиакомпаний является то, что большая их часть предоставляет услуги на уровне 3PL-провайдера, и только ведущие мировые авиакомпании обеспечивают организацию цепи путешествия пассажира на уровне 3⁺PL -провайдера.

62-79
v.5 (2021)
https://smart-scm.org

Построена обобщенная схема провайдинга для цепи путешествия пассажира с участием воздушного транспорта с целью определения роли каждого логистического провайдера в таких цепях, а также их взаимодействия. Например, 3⁻PLP, 3PLP, 3⁺PLP могут привлекать компании 2 PL-уровня к выполнению процессов в цепи путешествия пассажира. В то же время авиакомпания 4 PL-уровня будет привлекать к выполнению процессов в цепи путешествия исполнителей с 2 PL 3⁻PL, 3PL уровней. На виртуальной 5PL-платформе пассажир сможет выбирать самостоятельно исполнителей из разных уровней провайдинга в соответствии с собственными потребностями.

Ключевые слова: логистический провайдер, авиакомпания, цепь путешествия пассажира, 3⁻PL-провайдер, 3⁺PL-провайдер, традиционная модель, лоу-кост модель, гибридная модель.

Introduction. The criticality of logistics supply chains is an important part of the successful implementation of logistics business processes in accordance with the eight rules of logistics "8R" (right product, right quantity, right quality, right time, right place, right customer, right cost, right information). Building optimal supply chains, their organization and further control of all stages is a complex multi-purpose task that requires effort in most cases by more than one company. Such logistics chains will include a large number of performers and it is their well-organized and coordinated work allows to create perfect supply chains from the logistics view point.

Considering air supply chains, it should be noted that a significant role in such chains is played the time of delivery, because mostly air carriers transport goods with special needs (perishable, valuable and urgent). In most cases, the main task of air carriers is limited to ensuring air delivery from the departure airport to the destination airport, during the organization and implementation of which must comply with the rule "8R" in full.

The aviation industry itself is a pioneer of innovative solutions among all modes of transport, just mention the first computer reservation systems in the 1960s or the transition to electronic document management among participants in aviation freight supply chains (e-freight). Implementation of e-freight began with the use of e-AWB in 2010 and in January 2021, according to IATA publications, 71.3% of air waybills were used electronically [1].

The aviation community's initiatives continue to improve and, based on e-freight, the Digital Cargo program has been launched to ensure the openness and transparency of door-to-door cargo movement. Note that all IATA programs are aimed at simplifying collaboration, standardization of procedures and transparency of the air cargo movement process with the participation of all parties in the air supply chain.

In addition, IATA initiatives are aimed at transforming the collaboration of participants in the air passenger chain, mostly now they are focused on simplifying the process of check-in and various types of state control through the use of biometric data of passengers.

Airlines from all over the world take an active part in all initiatives as leading participants in aviation cargo supply and passenger delivery chains. In this case, the role of airlines may vary only from the executor of the transportation process and to the organizer of the aviation chain of cargo delivery or passenger travel.

Analysis of recent research and publication. The role of logistics providers in supply chains is widely studied by as Ukrainian scientists: Hryhorak M.Yu. [2], Revutska T.V. [3], Kostenyuk Yu. B. and Kapitonets M.V. [4], Sharchuk T.V [5], Danyliuk T., Yushchyshyna L. and Mokhniuk A. [6], Glazun V.V. [7] and others, as well as foreign scientists: Fadile L. & Oumami M. & Beidouri Z [8], Hertz S. and Alfredsson M. [9], Bolumole and Yemisi A. [10], Jayaram J. and Tan K.-C. [11] and others.

In the publications, the researchers organized the classification of logistics providers and defined the role of each type of logistics providers, with a total of five main types of logistics providers, where first-level providers provide organization and

implementation of logistics business processes themselves, and fifth-level provider provides organization, coordination and control of all logistics processes, while not taking a physical part in their implementation, compared to other types of logistics providers, i.e. he is an intelligent think tank of supply chain management. In addition, it was studied the current state of logistics provider development and identified trends for their development [2, pp. 95-103; 4, pp. 120-121; 5, pp. 775-777; 6, pp. 59; 7, pp. 6-7; 8, pp.64-66].

Also, considerable attention is paid to the study of the mechanisms of information interaction of logistics providers with other participants in the supply chain [3, pp. 191-192].

Note that most foreign publications are aimed at studying the activities of 3PL-providers, which are the most common in today's market. At the same time, the largest number of recent publications, such as [12, 13] and others, are aimed at research of assessing the level of service provided by logistics providers in supply chains, including aviation.

The role of the air carrier as a participant in the supply chain, like the carrier in any mode of transport, in most scientific publications is traditionally considered only from the standpoint of the direct operator of air transport. The main role of the logistics provider, which provides complex of services, belongs freight forwarding companies, which in turn took on the status of logistics companies. At the same time, as noted by Revutska T.V. [3, pp. 190] most foreign companies entering the market of logistics services in another country (Ukraine), begin their journey from the providing of one or more logistics services and then diversify their activities to comprehensive logistics services providing. It should be pointed out that among Ukrainian logistics companies this way of development is the most common and allows logistics companies to enter the market with small initial capital.

At the same time, the transformation from a highly specialized logistics company to the level of a complex services logistics provider for air carriers is proved by Litvinenko S.L. [10, pp. 55-56]: talking about transformation of cargo air carrier engaged in the carriage of oversized and heavy cargoes, from the level of 2PL-providers (carrier that carries out only the carriage of goods by air) to the level of 3PL-providers (logistics provider-air carrier, which provides comprehensive door-to-door services). However, such a transformation is carried out by the air carrier of oversized and heavy cargoes only in specific cases, i.e. air cargo carrier is remaining 2PL-provider and only sometimes provides comprehensive logistics services, which only temporarily transfers him to the level of 3PL-provider [10, pp. 61-62].

The purpose and objectives of the study. Summarizing research on the current classification of logistics providers, it should be noted that in scientific publications, airlines play the role of air carrier only and are not considered as major players in the logistics market that can provide a wider range of services in supply chains. Therefore, the purpose of the study is modelling the role of the airline as a logistics provider from the second level to the fifth level of providing with the definition of its functional obligations to customers in supply chains and travel chains. To achieve this goal, the following research objectives are defined:

1) determining the place of each type of logistics companies in the pyramid of logistics outsourcing in supply / travel chains and building an insourcing pyramid of logistics services by airlines with a description of the range of services in accordance with modern levels of logistics providing;

2) analysis of existing practical examples in planning and organization of travel chains via air carriers and their partners;

3) development of a scheme of passenger travel chain providing with the participation of air transport, which will reveal the interaction between different levels of logistics providers.

Basic material and results. Determining the role of each logistics provider in supply

chains or passenger travel chains on the basis of a common pyramid of logistics outsourcing, we detailed the types of logistics companies that may correspond to a particular level of logistics provider in air supply chains and air passenger travel chains in Fig. 1. In addition, attention was paid to the air carrier like the main logistics provider, whose role can vary from 2 to 5 PL-level, in the inverse insourcing pyramid (see Fig. 1).

The main feature of outsourcing and insourcing pyramids is that the outsourcing pyramid reflects many possible logistics operations and specialized logistics companies, and with the upward movement of the pyramid reflects the services of a wider range of logistics companies involved in the providing of services for clients-companies. While the insourcing pyramid focuses on the growth of quantity of logistics business processes that can be performed by one logistics company (in our case, the air carrier), thus starting with only one logistics business process, namely air transportation and ending with full virtualization of the supply chain and travel chain management.

Note that these pyramids are appropriate both for the supply chain and for the travel chain involving air transportation, because the operations carried out during the delivery of passengers or cargo can be performed as by specialized companies (service is provided only cargo or mail or passengers) and by companies that provide comprehensive or integrated services for passenger, cargo and mail.

Let's analyze in more detail the pyramid of outsourcing and insourcing. 2PL-providers are defined:

– terminal providers that handle air cargo and provide storage and / or transhipment of air cargo from one mode of transport to another (one of which is necessarily air) or provide terminal passenger services;

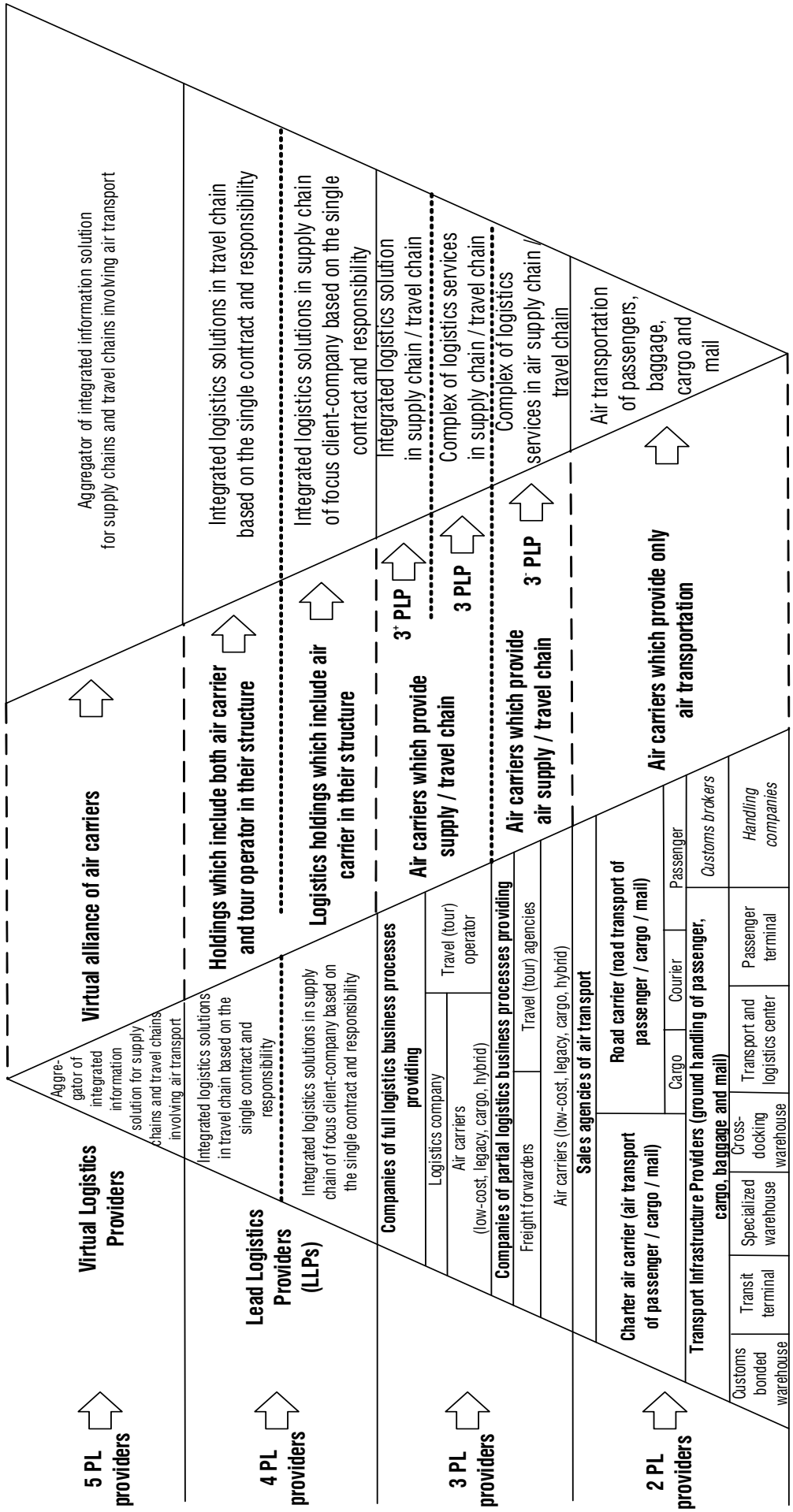
– airlines that are air carriers and carry out the main logistic operation of transportation of cargo mostly over long distances. Among all the air carrier models that exist, 2PL-providers are charter air carriers. The reason for referring to the 2PL-level is that, traditionally, in the organizational structure of such air carrier model there are no units that provide passenger and cargo services at airports, including base airports. So the logistics business operation provided by such air carrier is only air transportation;

– road carriers that transfer passengers, cargo and mail on the route "original point – departure airport / destination airport – final point". Such carriers in the supply chain scheme with air carriage participation are mandatory, as they ensure the delivery of "first and last mile" in the supply chain and travel chain by scheme "door to door";

– agencies of air transportation sales provide the customer with the booking and sale of a passenger tickets or air cargo space and may be provided by specialized companies IATA accredited;

– handling companies are a common type of specialized companies that carry out ground business processes of passenger and cargo services during the organization of air transportation. Namely, for example: handling companies can passenger check-in and accompany passengers from the terminal to the aircraft for air passenger travel chain or they can ensure the delivery of goods from the cargo terminal to the aircraft and loading of cargo into the aircraft or unloading from it for cargo supply chains;

– customs brokers are important participants in the customs clearance of goods in the organization of international supply chain.



Figures 1 – Outsourcing and insourcing pyramids of logistics services involving air transport

A broad basis was used to map 2PL providers in the outsourcing pyramid. This shows, first of all, that such providers can provide separately from each other all type of business processes in passenger travel chain and supply chain, but they need corrective action on the interaction between the customer in the travel / supply chains involving the air transportation.

At the same time, if we consider the insourcing pyramid of the air carrier logistics services, the pyramid was specifically pointed downwards. It should indicate the narrow specialization of the air carrier and consists only passenger, cargo and mail transport organization, as well as monitors only this business process in the full passenger travel chain and the full cargo supply chain. For example: 2PL air carriers, as described above, include charter air carriers or air carriers that act as a "actual carrier" according to an aircraft exchange agreement under the Montreal Convention 1999, operating on the principle of "airport of departure (aircraft) – airport of arrival (aircraft)" both in cargo supply chains and in passenger travel chains. In such cases ground support before and after air transportation is provided by the organizer of such charter flights or by the air carrier acting as "contracting carrier".

Considering the level of 3PL in the framework of the outsourcing pyramid, special feature is logistics services complex provided by such providers. Accordingly, such companies can provide only partial support for logistics business processes. For example, it may be freight forwarding services, including both the organization and control of land and air transportation (freight forwarding companies) in the supply chain.

In our opinion, 3PL providers are the better part of air carriers that independently carry out air transportation, or even for this purpose use other airlines under the aircraft exchange agreement as described above, and also provide independently or, again, use other 2PL companies to provide ground support during organization of air transportation at the airports of departure and arrival. At the same time, considering the passenger travel chain, it is possible to identify travel agents as 3PL-providers (3PLPs), because they sell a travel packages. The travel agencies are classified as 3PLPs by us, because their travel packages include air transportation and transfer (these two services are logistics services), hotel accommodation and other attractions (complex services) against sales agencies of air transportation (2 PLPs), which sell only one service (air transportation is one logistics service). But travel agencies are companies with partial support of logistics business processes, because they do not provide creation and accompanying of the passenger travel chain. This is done by the tour operators, that is why they are attributed by us to companies with full support of logistics business processes. Tour operators provide the creation of not only tourist travel chains, but also business travel chains, as well as conference travel chain, etc.

Air carriers, acting as a 3PLP, can also not only provide services for partial support of logistics business processes (i.e. in our case ground handling at airports of departure and arrival), but also provide "door-to-door" delivery with using of 2PLPs. This experience is common among the better part of legacy and cargo air carriers (operating flights on a regular basis). For example, on the websites of legacy passenger air carrier you can book a hotel room, car rental or a transfer "from the door" of original point to the airport of departure and / or from the airport of arrival "to the door" of the final point. While on the websites of cargo air carriers you can book the delivery of cargo "from the door" of consignor to the airport terminal and / or from the destination airport "to the door" of consignee.

We propose different categories of air carriers at the 3 PL level, depending on whether the air carrier provides partial or full support of logistics services. Performance of standard logistics business processes only in the air supply chain are done by 3-PLP-air carriers. For example: the air carrier provides full ground handling of passengers, cargo and

mail in airports, i.e. airline provides a range of services for passenger, cargo and mail from the time of their departure airport arrival until the time of their destination airport leaving. At the same time, part of such logistic operations can be performed by air carrier itself and part of them is provided by contracted 2PLPs. In this case, the air carrier, in our opinion, can be attributed to the 3^{-}PLP, which provides a range of services in the air cargo supply chain and / or in the air passenger travel chain. Among such air carriers are the better part of airlines of legacy and hybrid models.

If we can book a range of logistics services in air carrier website or air carrier's partner websites including such services like transfer delivery and storage and handling of goods in warehouses (if we talk about cargo), we must talk about another category of air carriers. Such air carriers are 3PLPs, i.e. air carriers provide complex logistics services in the supply / travel chain. Air carriers that can provide a range of logistics services in the supply / travel chain can be airlines of both freight and legacy and hybrid business models.

In the case when the air carrier provides the opportunity to book an integrated range of services directly on its website, we can talk about a higher level than just 3PL, i.e. it is already an intermediate level between 3 PL and 4 PL, respectively, we refer it to 3^{+}PL.

Speaking about 4PL providers, it should be noted that leading logistics providers have skills set and sufficient technical and information equipment (including advanced software) to provide integrated logistics solutions in supply chains for certain focus companies due to their evolutionary development.

To our opinion, there is not 4PL-provider-air carrier in its "pure" form at this moment. But large logistics holdings in which structure holds air carrier are 4PL-providers and they can provide integrated supply chains planning and management for their focus companies.

If we consider the passenger travel chain, the creation of an integrated logistics solution for traveller can be done with the help of modern reservation systems in both Global Distribution System (GDS) and Internet Distribution System (IDS). It is possible to create integrated logistics solutions in the passenger travel chain by air carrier staff via GDS, but this task is usually solved by tour operators' staff in the case of providing personalized solutions for customers. GDS doesn't only provide the best option in terms of cost and time for the flight, but also allows to book a car rental, hotel room, etc. in accordance with the specified parameters that are important to the client. In addition to booking, such system allows to do booking confirmation and payment, which helps to build travel chain of the client as a whole.

At the same time, 4PL-provider, in addition to integrated planning, must ensure integrated management and control over the performance of all processes.

The main feature of 5 PL-providers is the lack of material assets to provide logistics processes and the virtual platform to organize and monitor the performance of logistics business processes in supply chains. So, 5 PL-provider can best be described by the term "aggregator of integrated information solutions in supply chain / travel chain". This means that 5 PL-provider is company that manages and administers the virtual information platform on the Internet, which allows all clients (cargo owners, travellers) to find the best options for the organization of their supply chains / travel chains through the selection of optimal performers among 2PL, 3^{-}PL, 3PL, 3^{+}PL and 4PL providers, information about which is completely stored on the virtual platform of the aggregator.

The highest level of the insourcing pyramid of air carrier logistics services is defined by us as a virtual airline alliance, i.e. a "brain center" of air carriers for optimal planning of air services. This virtual platform should be integrated with airlines' management systems and optimally plan the use of aircraft, crews and other airline staff,

and most importantly create additional opportunities by expanding the range of services for other logistics operations in the supply / travel chain. Such virtual alliance is a real aggregator, as it receives information from various management systems of airlines, as well as other logistics providers and customers for the implementation of optimal planning and management of supply and delivery chains. So far, there are no such providers in the modern logistics market, including aviation logistics. Given the complete digitalization in the business environment, which contributes to the rapid development of information technology, it is possible in the near future to create new types of logistics companies. The main value of such companies will be knowledge and skills in the supply chain management, as well as the performance of virtual control of all logistics operations. Another important value of such companies will be the analysis and processing of factual data and the creation of up-to-date ranking of logistics providers in supply / travel chains, as well as customer rankings. If we talk about customer ranking, among the criteria of this ranking may be the accurate information about the cargo and in the accompanying documents, timely payment for the services of providers in accordance with the established agreements.

The aviation industry is a leading transport industry for the implementation of latest innovative development in the field of digitization and digitalization. The latter point concerns the creation of new innovative products. In our case it is the virtual platform that accumulates important information to create and ensure the smooth performance of supply / travel chains and where everybody can plan supply / travel chain based on past experience and reliability rating of each logistics provider. Such planning can be carried out via software by the client, where selection of optimum decisions on construction of supply chains will be provided by artificial intelligence with machine learning.

Consider the practical basis of the insourcing pyramid and classify modern airlines according to it.

Most Ukrainian air carriers can be classified as 2 PL-providers, as they perform charter transportation of passengers and cargo. For example, Aero Jet is a shining example of 2 PL-providers in air passenger transportation under charter agreements, as well as providing services ACMI leasing, which includes the providing of aircraft, crew, maintenance and insurance, to other airlines.

So, the 2 PL-providers are such charter air carriers that provide air passenger services as Anda Air, Bees Airlines, Challenge Aero Ukraine, Global Air Company.

Also, 2 PL-providers are airlines that perform charter cargo and passenger transportation as Antonov Airlines, Ukrainian Wings, Urga, Aviation Transport Agency "Kruk", Aviation Company Ukrainian Helicopters, Air Taurus, as well as cargo airlines as Aviation Company Eleron, AeroVis, Vulkan Air, Constanta Airline, Ukraine Air Alliance, aircompany ZetAvia, Maximus Airlines, CAVOK Air, Aircompany Rosavia.

Ukraine International Airlines (UIA) is considered to be the leading Ukrainian air carrier, having the most extensive network of scheduled air routes from Ukraine to the world. This company focuses on the passenger transportation, as well as cargo transportation on passenger aircraft. UIA can be classified as a 3PL provider with a full logistics services in the passenger travel chain, while all other Ukrainian airlines (regular passenger air carriers) provide a full logistics services in a purely air passenger travel chain. Let's explain this position in more detail.

UIA provides a full air logistics travel, consisting of passenger check-in, accompanying passengers on board the aircraft from the passenger terminal at the airport of departure, delivery of checked baggage on board the aircraft, air transportation of passengers and their baggage, accompanying passengers from the aircraft to the passenger terminal destination,

baggage delivery from the aircraft to the passenger terminal, baggage dispensing to passengers. As it is typical of 3PL providers, UIA involves handling companies (2PLPs) according to the ground handling service agreement to perform certain business processes that are not provided independently. In addition, UIA offers on its own website the transition to the websites of rental car agencies and booking.com, thus providing a complex of logistics services in the passenger travel chain.

Such regular passenger airlines of Ukraine as: Azur Air Ukraine, Bravo Airways, YANAIR, SkyUP Airlines, Jonika Airlines, Windrose Airlines, Motor Sich operate according to the scheme of providing only the air passenger travel chain (3^{-}PLP). At the same time low-cost carrier SkyUP Airlines offers in cooperation with a partner Istanbul Panoramic City Tour tours to Istanbul for three days. Windrose Airlines offers the opportunity to book a hotel through a link to booking.com. Motor Sich is developing booking of transfer service from/to airport now and has hotel booking services with partner booking.com. So, when the transfer service will be put into operation, the airline can be classified as a 3^{+}PL provider with the complex of logistics services in the passenger travel chain.

Researching foreign air carriers operating regular flights to Ukraine, it should be noted that Azerbaijan Airlines, Air Baltic, Belavia offer the opportunity to organize air passenger travel chain.

Low cost air carrier like Air Arabia, Pegasus Airlines, Ryanair, Flydubai, Wizz Air and legacy carrier like LOT Polish Airlines, Austrian Airlines, Qatar Airways, Lufthansa, SAS Scandinavian Airlines, CSA Czech Airlines, Turkish Airlines, Air France provides the opportunity to book on its own website or on the website of partners such services as hotel booking, rent a car, get a visa or vacation package. KLM does not directly provide online car rent or hotel booking services, but calculate points according to Frequent Flyer Program to passenger for using the services of their partners, which can be booked online on partners' websites.

For a broader analysis, we will also consider the organization of the passenger supply chain by the leading airlines included in the Forbes rating "Global 2000 The World's Largest Public" by revenue [15]: Delta Air Lines, Southwest Airlines, United Airlines, International Airlines (British Airways, Iberia, Vueling, Aer Lingus), China Eastern Airlines, China Southern Airlines, Air Canada, Japan Airlines, American Airlines, Turkish Airlines, All Nippon Airways, Singapore Airline, Cathay Pacific Airways, Alaska Air, Hainan Airlines, Korean Air, Latam Airlines, JetBlue Airway, Aeroflot-Russian Airlines. It should be noted that this list also includes such airlines as Lufthansa, Ryanair, Air France-KLM, Turkish Airlines, which were previously studied as airlines that operate regular flights to Ukraine.

The research results of services in passenger travel chain, which can be booking on air carriers' websites or with direct link on partners' websites are summarized in Table 1. Thus, the sample of air carriers that offer to book different services in the passenger travel chain amounted to 41 airlines, including UIA and Windrose Airlines as Ukrainian air carriers. The total number of European air carriers is 21 airlines, air carriers of Asian region and the Americas are 8 ones and the Middle East air carriers are 4 ones.

Collected statistics, which are presented in Table 2, shows that most air carriers, in addition to booking air flight, offer the opportunity to book hotels and rental car separately, thus ensuring the creation of a complete passenger travel chain.

It should be noted that the Rail&Fly or Bus&Fly service is popular in Western Europe, and most air carriers offer such a service only at the base airport(s) and there is no such service at all by airlines in other regions, although for economy class passengers it may be also a priority in the full travel chain.

At the same time, parking own car is popular on the European and American continents and, in most cases, is provided by direct link to the partner's website.

Table 1 – Services which can be booking on air carriers' websites or with direct link on partners' websites

No.	Air Carrier	Service booking is possible on air carrier's website or with direct link on partners' websites						Service booking is possible on air carrier's website					
		Rental car	Transfer	Rail & Fly	Hotels	Vacation packages	Parking	Rental car	Transfer	Rail & Fly	Hotels	Vacation packages	Parking
1	Air Arabia	+	+		+	+		+	+		+	+	
2	Pegasus Airlines	+	+		+		+	+			+		
3	Ryanair	+	+		+	+	+	+	+		+	+	
4	LOT	+	+		+	+			+				
5	Austrian Airlines	+	+		+		+	+	+				
6	Qatar Airways	+	+		+			+	+				
7	Flydubai	+	+		+	+		+	+			+	
8	Belavia	+		+	+								
9	Lufthansa	+	+	+	+	+	+	+	+				
10	Air Astana				+								
11	SAS	+	+		+			+	+		+		
12	CSA	+	+		+		+						
13	Turkish Airlines	+	+		+			+					
14	EL AL	+			+								
15	Swiss International	+	+	+	+	+							
16	KLM												
17	UIA	+			+								
18	Air France	+	+			+	+	+	+				+
19	Delta Air Lines	+	+		+	+		+	+		+	+	
20	Southwest Airlines	+	+		+	+		+	+		+	+	
21	United Airlines	+	+		+	+		+	+		+	+	
22	British Airways	+	+		+	+	+	+	+		+	+	
23	Iberia	+	+	+	+	+	+	+	+	+	+	+	
24	Vueling Airlines	+	+		+	+		+	+			+	
25	Aer Lingus	+	+		+	+	+	+	+		+	+	+

End of table 1

No.	Air Carrier	Service booking is possible on air carrier's website or with direct link on partners' websites						Service booking is possible on air carrier's website					
		Rental car	Transfer	Rail & Fly	Hotels	Vacation packages	Parking	Rental car	Transfer	Rail & Fly	Hotels	Vacation packages	Parking
26	China Eastern Airlines				+								
27	China Southern Airlines					+						+	
28	Air Canada	+	+		+	+	+	+	+		+	+	+
29	Japan Airlines	+	+		+	+							
30	American Airlines	+	+		+	+		+	+		+	+	
31	All Nippon Airways	+	+		+								
32	Singapore Airlines	+	+		+	+					+		
33	Cathay Pacific Airways	+	+		+			+	+		+		
34	Alaska Air	+	+		+			+	+		+		
35	Hainan Airlines				+								
36	Korean Air	+	+		+								
37	Latam Airlines	+	+		+			+	+				
38	JetBlue Airway	+	+		+	+					+	+	
39	Windrose Airlines				+								
40	Aeroflot	+	+		+	+							
41	Emirates Airlines	+	+		+	+						+	

Source: data were collected on the basis of airline websites.
Ryanair and Flydubai do not have a Frequent Flyer Program.
Wizz Air has a Wizz Discount Club membership, which does not provide points.

62-79
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In general, considering the airlines by region, the most advanced air carriers in providing the possibility of creating a complete travel chain (transfer – air flight – rental car – hotel – rental car – air flight – transfer) are the air carriers of the Middle East and the Americas. However, among the disadvantages is the lack of possibility to order such a travel chain for one booking, i.e. for each part of the chain is an independent booking. However, 75% air carriers of the Middle East and the Americas offer the possibility to create a complete travel chain in one booking when using booking of holiday / vacation packages, where you can add all the components of the travel chain step by step.

Table 2 – The ratio of air carriers by regions that provide booking of certain components of the passenger travel, except air flight booking (on its own website or with a link to the partner's website), %

No.	Region of Airlines	Rental car	Transfer	Rail & Fly	Hotels	Holiday packages	Parking
1	Total	85	78	10	93	54	24
2	Europe	90	75	20	95	50	45
3	The Middle East	100	100	0	100	75	0
4	Asia	63	63	0	88	38	0
5	The Americas	100	100	0	100	75	13

Let's consider the ratio of air carriers that provide the opportunity to create a complete travel chain on their own website / with a link to the partner's website / the lack of such opportunity (Fig. 2 and 3).

Analyzing the results presented in Fig. 2 and 3, it can be noted that most of the world's airlines simplify the passenger travel chain planning on the main services (options) on their own website or with link to partners' websites in order to create value-added passenger travel chain.

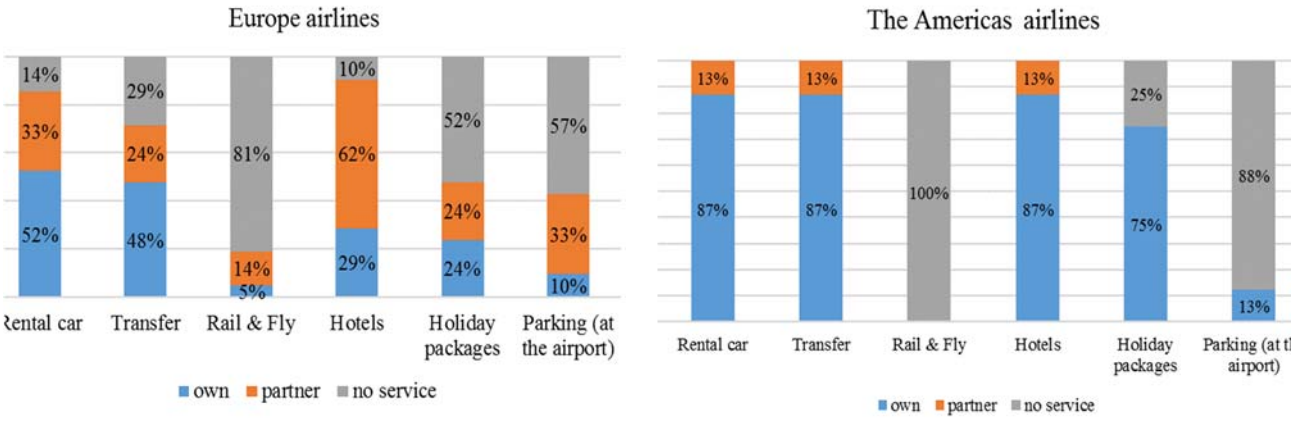

Figure 2 – The ratio of airlines that provide the opportunity to create a complete travel chain on their own website / with a link to the partner's websites / no such opportunity (Europe and the Americas air carriers)

In addition, airlines offer to earn points for frequent flyers according to Frequent Flyer Program to encourage such planning through their own website or the partner websites of each component of the travel chain.

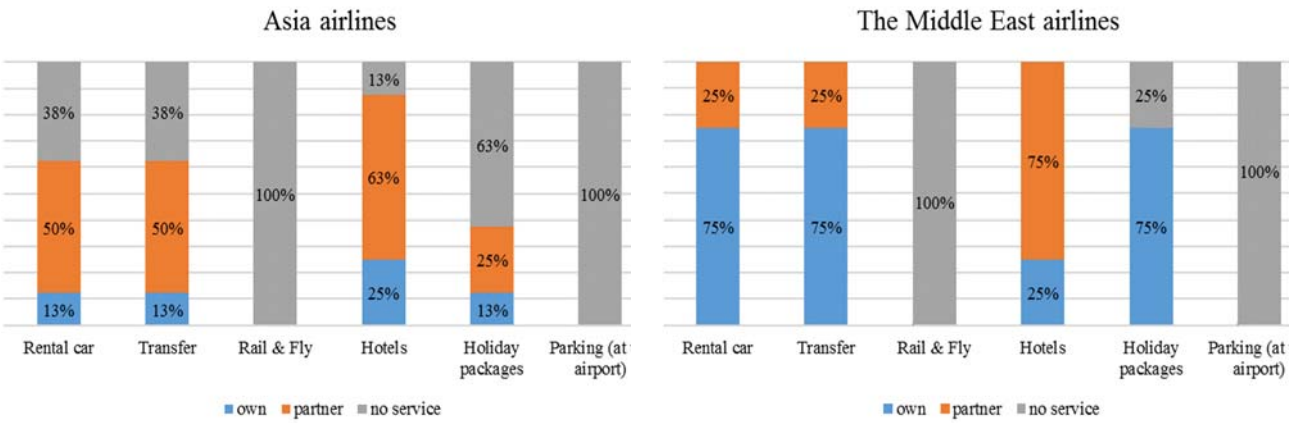

Figure 3 – The ratio of airlines that provide the opportunity to create a complete travel chain on their own website / with a link to the partner's websites / no such opportunity (Asia and the Middle East air carriers)

Ratio of airlines that offer to earn points for frequent flyers for travel chain planning on airline's or their partners' websites is represented in fig. 4.

Research shows that most air carriers encourage their frequent flyers to organize travel chains through the airline and its partners. At the same time, the largest share of carriers from Europe and the Americas, which encourage to plan the entire travel chain in "one click" via the holiday / vacation package service in airline's website.

It should be noted like disadvantages of the better part of world air carriers are unconnected booking services, which requires extra time for the client: at first, passenger books a flight on air carrier website, then he books car rental on air carrier website (website of air carrier's partner), as well as he books hotel room on air carrier website (website of other partner of air carrier). So, he must do three separate booking.

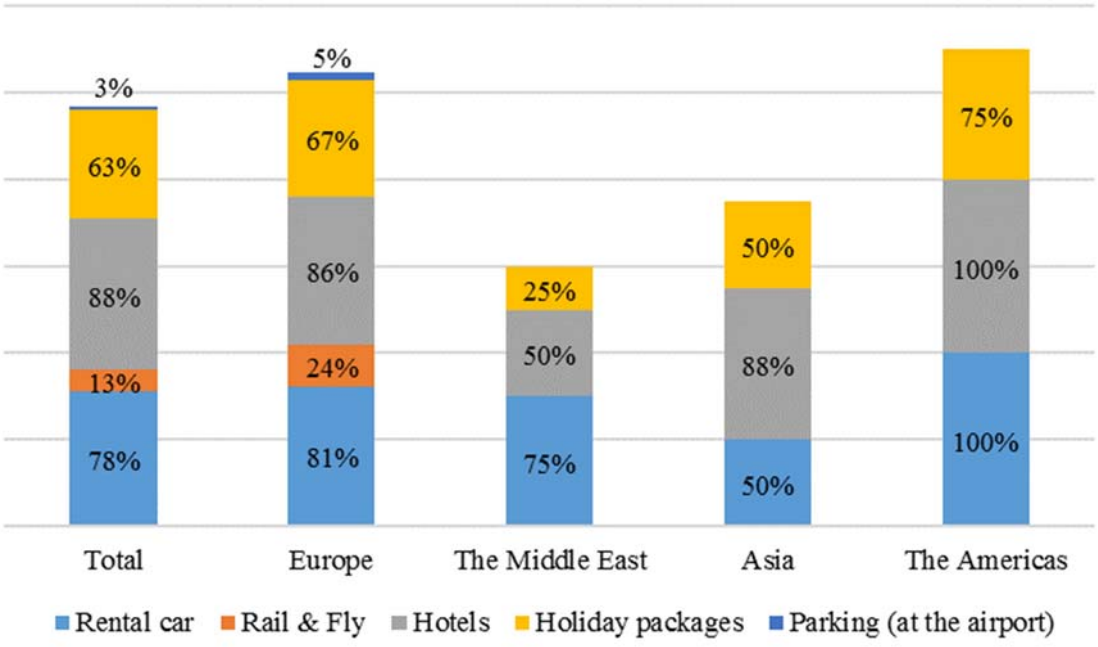

Figure 4 – Ratio of airlines that offer to earn points for frequent flyers for travel chain planning on airline's or their partners' websites

However, some air carriers allow passenger to plan the required travel components at "one click": Air + Hotel, Air + Car and Air + Hotel + Car. For example, Southwest Airlines has all mode of complete set of travel planning options described above. Some of them are presented on websites of British Airways, Iberia, Cathay Pacific Airways, JetBlue, Air Arabia.

In our opinion, the closest to the 4PL-provider are American airlines such as Delta Air Lines and Southwest Airlines, as they provide the opportunity to plan an integrated full travel chain for one booking (one click). But this level (4PL) should be characterized by a single responsibility of air carrier for the full travel chain of their client. So, Delta Air Lines and Southwest Airlines are 3^{+}PLP.

At the same time, today there is no company of 5PL-providing, because it must provide: a) integrated travel chain planning, b) a choice from all possible airlines and their partners in full supply chain / travel chain, c) creation optimal full travel chain according to time and cost, c) control of all processes performance and d) ranking of all participants.

The analysis allows to do the interaction scheme between separate levels of providers in passenger travel chain involving air transport (Fig. 5).

In most cases, the air carrier can act as both 2PL-provider and a 3PL-provider.

When air carrier provides:

– only air transportation, it is 2PLP;

– only air passenger travel itself or with partners, it is 3^{-}PLP;

– booking and performance of full passenger travel chain itself or with partners, it is 3PLP;

– booking of full passenger travel chain itself and performance of full passenger travel chain itself or with partners, it is 3^{+}PLP (Air Delta, Southwest Airlines, other air carriers, who provide booking of vacation packages on their websites).

4PLP should provide not only integrated travel chain planning, but also integrated management and sole responsibility for all segments of such passenger travel chain.

Turning to 5PLP, we note that this level should be provided by a virtual platform (can be provided by an alliance of air carriers), which will be attended by all airlines and other participants in the passenger supply chain, which will allow the customer performs to choose the best combination of passenger travel chains via integrated planning in one place. So, the difference between 4PLP and 5PLP is, that in the first case, planning can be done on the website (platform) of the interested party (in our case, the air carrier), which primarily offers air transportation on its own flights or flights of partner air carriers. At the same time, on the 5PL-platform, the customer has the opportunity to choose the best options for each segments of passenger travel chain among different airlines and other performers in accordance with the requirements of the trip.

It should be noted that to participate as a performer on the virtual 5PL-platform, all participants in the passenger travel chain must meet the criteria that ensure the quality of their services. Therefore, the entering of a contractor with its services on 5PL-platform requires careful selection, which will ensure the reliability of quality performance of planned, booked and paid services on this platform.

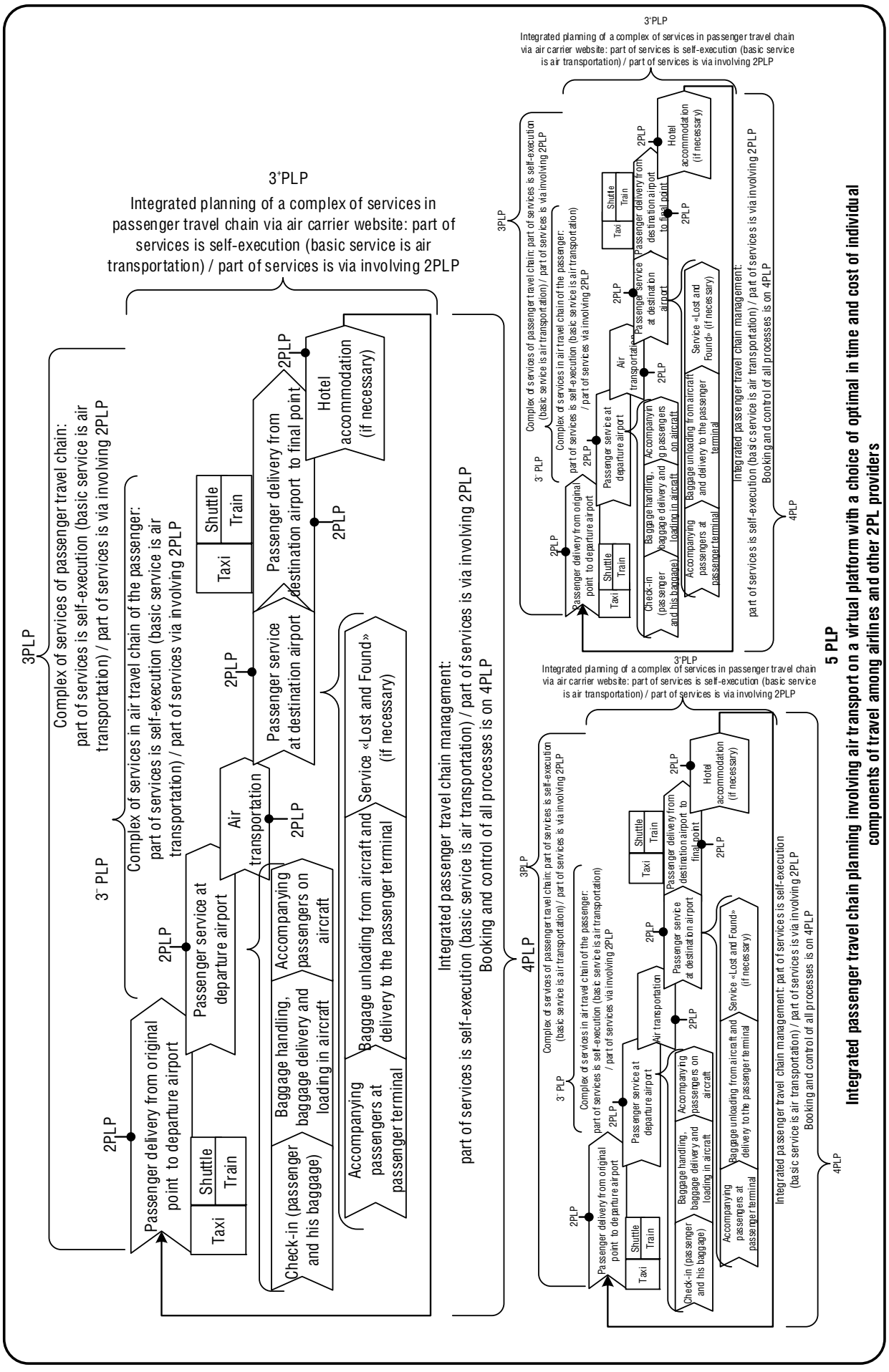

Figure 5 – Scheme of providing for passenger travel chain involving air transport

Conclusions. The analysis shows that most international air carriers of legacy, low-cost or hybrid business models actively cooperate with partners to provide a full range of logistics services in the passenger travel chain. According to this passenger can book such service like rental car on website of air carrier and hotel room on air carrier website or partner's website (for example: the most common partner of the air carrier is booking.com or hotels.com).

Ability of booking a range of services through the air carrier's website and by the direct link on partners' sites, the air carriers save customers' time on searching websites to book any other services in the passenger travel chain, thus creating added value for its customer. In this case, the air carrier provides full passenger travel chain together with partners, so this air carrier is 3PLP.

In the case of providing integrated travel chain planning to the client, the air carrier is contracting provider and becomes 3^{+}PL-provider.

Acting as an integrator of planning and booking a set of services in the passenger travel chain, as well as the person responsible for the full passenger travel chain, the air carrier is 4PL-provider.

At the same time, the air carrier cannot be 5PL-provider, primarily due to the fact that such a company cannot have material assets, which is a necessary condition for the air carrier (own or leased aircraft). The air carrier can become only one of the performers on the virtual 5PL-platform and thus increase its own sales, as such platform should provide the largest number of customers from around the world.

It should be noted that in order to determine the most optimal role of the air carrier (2PL, 3^{-}PL, 3PL, 3^{+}PL and 4PL-provider and 2PL or 3^{-}PL-provider on the virtual 5PL-platform), it is necessary to conduct an economic assessment for each logistics provider role. This will help to find out for each model of the air carrier the most optimum economic role of logistics provider.

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